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Special Supplemental Issue: Reflections on 25 Years of Inflation Targeting

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Reflections on 25 Years of Inflation Targeting

Introduction to a Special Issue of the International Journal of Central Banking

This volume of the *International Journal of Central Banking* includes the proceedings from the joint conference titled "Reflections on 25 Years of Inflation Targeting," hosted by the Reserve Bank of New Zealand on December 1–2, 2014. In addition to the papers and discussions, this issue contains the prepared remarks given at the conference by Graeme Wheeler (Governor, Reserve Bank of New Zealand) and keynote speeches by Lars Svensson (Stockholm University) and Carl Walsh (University of California). The conference was organized by Özer Karagedikli, Güneş Kamber, and Yuong Ha of the Reserve Bank of New Zealand, and John Williams of the Federal Reserve Bank of San Francisco.

Reflections on 25 Years of Inflation Targeting*
Opening Remarks

Graeme Wheeler
Governor, Reserve Bank of New Zealand

It is now twenty-five years since the Reserve Bank of New Zealand (RBNZ) Act came into force. The Act established the operational independence of the Reserve Bank (Bank) in respect to monetary policy, and specified price stability as the single monetary policy objective. A month later, the minister of finance and the Reserve Bank governor signed the first Policy Targets Agreement (PTA), which specified an annual inflation target of 0 to 2 percent.

Through this reform, New Zealand became the first country to formally adopt inflation targeting as its monetary policy regime—that is, setting the Reserve Bank the explicit goal of maintaining inflation in a range consistent with overall price stability, giving the Bank the independence to pursue that goal, and holding it—through its governor in New Zealand's case—accountable for reaching the price stability objective.

In the lead-up to this reform, there was extensive debate within the Bank over the goals and transmission of monetary policy. Consistent with emerging international thinking, the concept of a long-run Phillips-curve trade-off was rejected, as were policy rules around monetary aggregates and targeting nominal GDP. The literature on policy credibility and time consistency was explored in depth, along with insights from writings on corporate governance. On the design front, considerable effort went into defining price stability, agreeing on a target range for inflation (as price-level targeting was ruled out), and establishing caveats whereby it might be acceptable for inflation to be outside the target range for short periods.[1]

At the time, these developments were highly controversial. The reforms were viewed by many here and overseas as ambitious yet

*Opening remarks given at the RBNZ/IJCB conference "Reflections on 25 Years of Inflation Targeting," hosted by the Reserve Bank of New Zealand, Wellington, New Zealand, December 1–2, 2014.

[1]For a full discussion of these issues, see Grimes (2013).

desirable. They were in line with efforts being pursued in many countries to rein in high inflation, and were consistent with domestic reforms under way to strengthen public-sector performance by holding public agencies accountable for reaching clear contractual objectives. But others questioned whether it was appropriate, or even feasible, to have the Bank pursue price stability as its primary responsibility, and to hold the governor accountable for an outcome not directly under the Bank's control.

Twenty-five years on, a new generation has grown up with low and stable inflation as the norm. Much the same has occurred elsewhere in the world, with all of the major central banks viewing low inflation as their main objective. But, beginning in the United States in 2007, and spreading globally during 2008, we saw the worst financial meltdown since the Great Depression. The Global Financial Crisis (GFC) presented major challenges to policymakers and raised important questions about the conduct and focus of monetary and financial policies.

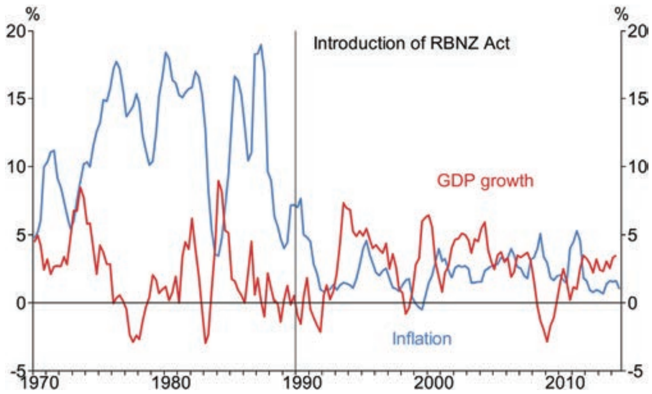
This then is an appropriate time to take stock of our experience with inflation targeting: how have monetary and financial policies moved forward over the last twenty-five years, including in the aftermath of the GFC, and what issues and challenges lie ahead? I will offer some insights from the past twenty-five years.

1. Inflation Targeting Has Delivered Price Stability without Reducing Our Long-Term Growth Rate

The Bank continues to hold firmly to the view that the most important contribution monetary policy can make to promoting efficiency and the long-run growth of incomes, output, and employment is the pursuit of price stability. Price stability preserves the purchasing power of the currency and enables producers and consumers to plan with greater certainty for longer periods, including by responding to relative price changes that would otherwise be obscured during times of high inflation. Price stability also reduces the inflation risk premium in interest rates; facilitates long-term borrowing, lending, and contracting; and reduces the need for speculative investments designed to protect against inflation risks.

It is uncertainty around the long-run price level that generates the costs associated with inflation. Inflation, particularly unexpected

Figure 1. Inflation and GDP Growth (annual)



inflation, is a hidden tax, affecting most severely those with fixed incomes and holders of cash rather than inflation-protected assets. Price stability cannot by itself resolve concerns about inequality, but it does reduce the insidious toll that inflation exacts on the more vulnerable and less financially sophisticated.

Unwinding deeply engrained inflation expectations and transitioning to the target band for inflation involved difficult adjustment costs. This adjustment contributed to the depth of the 1991 recession, which was also due to a marked slowdown in global growth. New Zealand's annual inflation rate fell from 7.4 percent at the start of 1990 to 2 percent two years later. Real GDP declined by 1.6 percent in 1991, and the unemployment rate increased from just over 7 percent in 1990 to 11 percent at the start of 1992.

Nevertheless, New Zealand's macroeconomic record before and after the Reserve Bank Act came into effect indicates that its price stability objective has been met without any diminution in our economy's *long-term* growth rate. See figure 1. In the twenty years before the Act, annual real GDP growth averaged 2.2 percent, while annual inflation was volatile around an average of 11.4 percent. Since 1990, annual inflation and real GDP growth have averaged 2.3 and 2.6 percent, respectively, and there has been a marked decline in inflation variability.

International experience points in the same direction. We see this, for example, in the number of countries that now place the maintenance of low inflation at the core of their overall policy framework.[2] Even in countries where central banks face multiple statutory objectives, the importance of the price stability goal as a precondition for reaching broader objectives is well accepted.

2. Low and Stable Inflation Expectations Increase Monetary Policy's Effectiveness

Like other central banks, the Reserve Bank pursues *flexible* inflation targeting. This approach has been reflected more explicitly through time in the Policy Targets Agreements—notably by emphasizing that, in pursuing its price stability objective, the Bank "should seek to avoid unnecessary instability in output, interest rates and the exchange rate" (included as of the 1999 PTA), and in specifying the inflation target as one to be met "on average over the medium term" (included as of the 2002 PTA).

The effectiveness of monetary policy measures in influencing the short-term path of variables in the real economy is linked closely to policy credibility, which is reflected in the Bank's record in achieving inflation goals and shaping expectations as to future inflation outcomes. Stabilizing and anchoring inflation expectations close to the price stability objective provides the Bank with greater freedom in addressing inflation shocks and scope to take policy actions that influence output and employment growth in the short term. This means that if economic shocks or a monetary policy action result in inflation moving outside its target range, wage and price setters will expect it to return to its target band within an acceptable period. Without this credibility, such shocks and policy actions would lead mainly to variations in the rate of inflation—as we tended to see in New Zealand in the past.

This flexible, medium-term approach to policy was drawn on at the onset of the GFC, when the Bank lowered the Official Cash Rate (OCR) by 575 points in 2008–9, even though headline inflation was initially well above the target band. By focusing on the medium-term inflation outlook, the policy stance was able to cushion the impact of

[2] Jahan (2012) states that in 2010, twenty-eight countries were inflation targeting, using the consumer price index as their monetary policy goal. She reports that several other central banks have adopted the main elements of inflation targeting, and many others are moving towards it.

the crisis. In a similar vein, the Bank "looked through" the October 2010 increase in the goods and services tax rate (from 12.5 percent to 15 percent) because it believed it would have limited impact on medium-term inflation expectations.

3. The Long-Term Path of the Real Exchange Rate Is Unaffected by the Monetary Policy and Exchange Rate Regimes

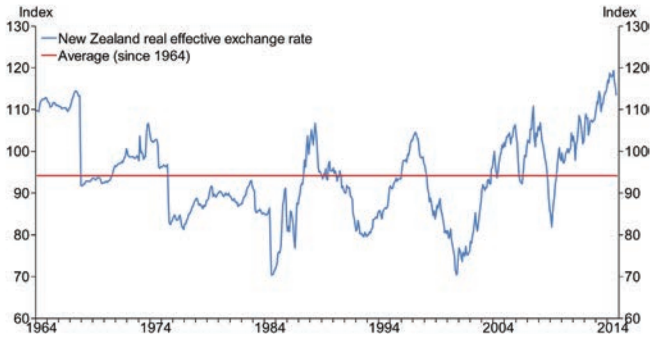
Monetary policy affects consumer and investor behavior through many channels, including the cost of borrowing, the tolerance for risk taking (which affects asset prices and borrowing capacity), expectations about future inflation, and movements in the exchange rate. In a small open economy like New Zealand, the exchange rate is a particularly important monetary policy transmission mechanism—albeit one that is often stronger and less predictable than we would wish. In recent years, New Zealand and many other economies have experienced an appreciation in their real effective exchange rate, driven in part by spillovers from the stimulative monetary policies pursued by the major central banks.[3] Despite a recent decline in the nominal rate, the high level of New Zealand's real effective exchange rate remains unjustified and unsustainable.

Real exchange rate appreciations produce mixed results. They benefit consumers by lowering inflation in the tradables sector; make it cheaper for firms to import capital goods and new technologies; and can thereby support growth in innovation and productivity. But real appreciation can make life difficult for exporting and import-competing firms, especially if they have little ability to adjust their prices to compensate for exchange rate changes. And exchange rate fluctuations impose significant uncertainties and costs on firms when they are forced to exit and reenter markets due to changes in their competitiveness.

Since the float of the New Zealand dollar in 1985, New Zealand has experienced four major exchange rate cycles, including the current cycle. Each cycle has been characterized by a significantly

[3]The real effective (or trade-weighted) exchange rate is a better measure of overall competitiveness than the nominal exchange rate. It corrects the nominal effective exchange rate for differences in relative prices (or relative unit labor costs) between New Zealand and its major trading partners.

Figure 2. New Zealand's Real Effective Exchange Rate



overvalued exchange rate, followed by an initial correction and then a rapid depreciation. See figure 2.

While we recognize the pressures associated with exchange rate overshooting, there is little the Bank can do to sustainably alleviate an overvalued real exchange rate, whether through monetary policy actions or the choice of exchange rate regime. New Zealand has tried various exchange rate regimes over the past forty years, including a fixed rate, crawling peg, and now a floating rate. We have found, however, that the choice of regime has had little impact on the medium-term level of the real effective exchange rate. Past policy attempts to give the exchange rate more weight in monetary policy decisions tended to generate more interest rate volatility, with little lasting effect on the real exchange rate.

Instead, the appropriate policy response often lies elsewhere—for example, through measures to improve domestic saving, boost competiveness, and raise the growth rate of potential output. I will take up these points next.

4. There Are Limits to What Monetary Policy Can Do: Supportive Structural and Fiscal Policies Are Also Needed

Monetary policy can complement but not substitute for other policies that influence long-term economic performance, including growth, employment, and the real exchange rate. Long-term growth is primarily a function of the economy's structural characteristics and policies, including the quality and quantity of labor and capital inputs available to the economy, coupled with the productivity and innovation associated with their deployment. Similarly, the level of employment over the long run reflects the characteristics of the labor market, including skill levels, productivity, and institutional practices.

Monetary policy cannot substitute for structural adjustment policies, nor can it deliver "desired" long-term social equity or distributional outcomes. Such policy considerations often arise with respect to the housing market. By influencing mortgage rates and the demand for credit, monetary policy can affect the demand for housing and thereby help ease imbalances in the market while housing supply is increased. But monetary policy cannot free up more land constrained by zoning regulations, address procedural and pricing issues around planning consents, or raise productivity in the construction sector.

Fiscal policy also plays an important role in the economy's long-term performance. For example, a constrained fiscal stance can help increase private saving, take pressure off interest rates and the exchange rate, and provide the economy with a buffer against shocks by restraining the buildup of public debt. The stance of fiscal policy also affects inflation expectations and investor judgments as to the degree of coordination among policymakers over macroeconomic policy.

New Zealand's varied economic experiences over the last forty years illustrate how policy choices interact to either hold back or support long-term growth. The prolonged period of weak growth that the economy experienced in the 1970s and 1980s was partly triggered by terms-of-trade shocks, and especially the rapid rise in international oil prices in the early 1970s and the decline in commodity export prices. But the inflexibility of the New Zealand economy, including its wage and price-setting practices and external trade constraints, hindered its capacity to counter these external pressures. In these circumstances, fiscal and monetary policies were relatively ineffective in preventing the slowdown. Instead, the main macroeconomic legacy was a substantial rise in public debt and double-digit inflation for most of the period from the mid-1970s to the late 1980s.[4]

[4]Over 1974–84, gross public debt increased from 40 percent to close to 60 percent of GDP, and net debt rose from $4\frac{1}{2}$ to 30 percent of GDP.

In contrast, reforms pursued since the mid-1980s—directed in particular at macroeconomic stabilization and wide-ranging market deregulation—increased the capacity of the economy to adjust and grow in response to changing external and domestic conditions. For example, the economy has responded well to the growing importance of East and South Asia in international trade and investment, and in recent years has withstood shocks such as the GFC, the Christchurch earthquakes, drought, and the shifting global demand for our dairy products and other commodities.

5. Monetary Policy Independence Requires a High Level of Accountability and Transparency

The widespread move towards inflation targeting around the world has been accompanied by reforms to increase central bank independence. To counterbalance their greater independence, central banks faced stronger demands for transparency and accountability—to government, markets, and the public in general—over their policy performance.

Transparency has two main dimensions. It enables governments and the public to assess whether the Bank has met its objectives and to hold it accountable. Transparency also increases the efficiency and effectiveness of monetary policy by boosting its predictability. Transparency is enhanced through regular publications such as the Monetary Policy Statement and Financial Stability Report, through publication of research and policy pieces, and through extensive communications outreach. A recent international survey ranked New Zealand second among 120 central banks for transparency.[5]

Multiple checks and balances are in place to monitor the performance of the Bank and hold the governor accountable. The Reserve Bank Board meets nine times a year to monitor and provide oversight on the Bank's operations and policy decisions, and the Bank's governors appear before the Finance and Expenditure Committee seven times a year. There are numerous other accountability measures: for example, the Board can recommend that the minister of finance remove the governor due to inadequate performance; the

[5] See Dincer and Eichengreen (2014).

Bank must have regard for any policy direction issued by the minister in relation to government policies; and the Bank places considerable weight on communications and, as part of these, publishes full economic projections, and since 1997, indicates an endogenous interest rate path.

The Bank has a broader set of responsibilities than most central banks, and although it has a single decision maker model, the Governing Committee was established in 2013 to make major policy decisions. The committee comprises the four governors, and it reviews all major monetary and financial policy matters falling under the Bank's responsibilities, including decisions on monetary policy, foreign exchange intervention, liquidity management policy, prudential policy (both micro and macro), and other regulatory policies. The governor retains a casting vote and, to date, formally retains sole decision-making power. Several policy committees, each chaired by a governor, provide advice to the Governing Committee.

The decision to establish the Governing Committee follows similar moves by the Bank of Canada, which also has a single decision maker model for monetary policy under its legislation. There is no evidence of the performance of the RBNZ, or other central banks where the governor is formally accountable for policy decisions, being any weaker or more volatile than that of central banks where accountability rests with a committee. However, the Governing Committee functions very effectively, and the case for decision making by committee rather than individuals is premised on the relative strengths afforded by groups and the possible risk-reducing attributes of group decision making.

6. Monetary Policy Needs to be Supported by Sound Prudential Policies

With the onset of the GFC, the world again witnessed the destructive power of dysfunctional financial markets. Financial-sector instability can arise from many sources, including unrealistic expectations as to the sustainability of future yields on financial assets, excessive risk taking by investors, poorly designed macroeconomic and regulatory policies, and regional or global contagion associated with failures in offshore financial systems.

The GFC showed how negative externalities can arise when financial institutions take on excessive leverage and do not bear the full cost of their activities. These externalities can have huge economic and policy consequences. For example, more than six years after the onset of the GFC, most of the advanced economies have policy rates close to zero and the major central banks have undertaken around US$7 trillion of quantitative easing. Although the Federal Reserve has discontinued its bond purchase program, global quantitative easing in 2015 is expected to be greater than at any time since 2011. Bank bailouts during the GFC have imposed enormous costs on taxpayers (close to 30 percent of GDP in the case of Ireland) and at home we saw the large fiscal costs associated with the support for South Canterbury Finance.

Sound prudential policies relating to capital adequacy, liquidity management, core funding, disclosure requirements, and stress testing of balance sheets cannot always prevent financial crises and the need for unconventional monetary policy, but they can lower the risk of systemic failure.

7. The Emergence of Macroprudential Policy

One of the insights from the GFC was how rapidly instability could develop even though an economy might be growing close to its potential and be experiencing sound fiscal policy and price stability.

An environment of low interest rates, rising leverage, aggressive competition among lending institutions, and a widespread search for yield by investors usually translates quickly into rising asset prices—especially when the global economy is growing at a rapid rate, as was the case during 2003–7. When financial crises occur, asset valuations decline, and the lower asset prices may be unable to support the debt that financed their acquisition.

We are currently seeing considerable appreciation in asset prices (including fixed-income securities, equities, and real estate) in many countries as a result of extensive monetary accommodation and investors aggressively searching for yield. Many central banks and regulatory agencies have turned to macroprudential policies in an attempt to reduce risks to financial stability, including those associated with an overheated housing market.

In view of these concerns, the Reserve Bank introduced macroprudential policy in the form of speed limits on high loan-to-value ratio (LVR) lending for existing residential property on October 1, 2013. House prices were already significantly overvalued based on historical and international indicators and were accelerating rapidly in Auckland and Christchurch (which account for around half of the national market) and gaining considerable momentum in several other regions. In addition, the ratio of household debt to household disposable income at 156 percent was high, and banks were competing aggressively to provide mortgages to borrowers with small deposits.

Macroprudential policy requires policymakers to be clear about its goals, the duration of the measures, and how such measures might interact with monetary policy. These measures often complement monetary policy when the real and financial cycles are in sync (i.e., with a strong outlook for inflationary pressures and the asset and credit cycle, or the opposite).[6] Although LVR speed limits were introduced for financial stability purposes, they have been an important consideration in our monetary policy assessment. We believe the dampening impact of LVRs on house price inflation and credit, and the diminished "wealth effects," have reduced consumer price inflation pressures by an amount similar to a 25- to 50-basis-point increase in the OCR. The introduction of LVR restrictions moderated excesses in the housing market, thereby enabling the Bank to delay tightening interest rates and reducing the incentive for further capital inflows into the New Zealand dollar in search of higher returns.

The impact of LVRs will weaken over time, and they will be eased when housing pressures moderate and the Bank is confident that there will not be a resurgence in house price inflation. But the Bank cannot prevent or control housing cycles. It can only hope to influence the demand for mortgage lending and the availability of credit, and buy time for the housing supply to increase. In the end, the challenge of rising house prices needs to be met through increases in housing supply. But this often requires other issues to be addressed, such as the approval procedures around land-use decisions and building consents, and other matters such as the tax treatment

[6] See Spencer (2014).

of savings, the taxation of investment in real estate, and ways to increase productivity and reduce costs in the building sector.[7]

8. Future Challenges

Considerable progress has been made in reducing inflation and lowering inflation expectations since the introduction of the RBNZ Act. However, the implementation of monetary policy continues to pose many challenges. These relate to the difficulties in fully understanding economic linkages and assessing the need for and scale of policy change. These policy judgments are particularly sensitive in light of the significance of cross-border financial flows and their impact on exchange rates and long-term interest rates.

As with many other central banks, the Reserve Bank developed a quantitative structural model (a dynamic stochastic equilibrium model) for forecasting purposes. However, irrespective of the complexity of their models, all central bank models are at best rudimentary in their capacity to model the financial sector and integrate it into the real economy.

Policy judgments involve assessments of the rate of growth of potential output and the output gap, and the extent to which the current policy rate differs from the neutral rate (or the policy rate that is neither stimulatory nor contractionary). Although the "rate of potential output growth" and "the neutral interest rate" are critical for evaluating the need for policy adjustment, they are model-based concepts and neither are observable. This means that policymakers often need to "feel their way" through an interest rate tightening phase, especially given uncertainties around the lags before policy adjustments affect inflation and output.

Global forces can have an enormous influence on inflation and other relative prices such as exchange rates and interest rates. Inflation pressures have been moderated by structural changes in the global economy such as the absorption of low-cost producers into the global trading system; the dramatic reductions in the costs of processing, storing, and transmitting information; falling capital goods

[7]Because investors' mortgage interest payments are tax deductible and those of an owner-occupier are not, investors face a lower cost of capital than owner-occupiers.

prices; new forms of competition (e.g., associated with online selling); and cost reductions associated with global supply chains. Productivity growth tends also to be higher among producers serving regional or global markets rather than domestic consumers only.

With integrated global capital markets, currency volatility and movements in long-term interest rates can be heavily influenced by cross-border transaction flows around capital movements, trade financing, remittances and price arbitrage, and risk-transfer instruments. Empirical studies show that changes in long-term interest rates are highly correlated across countries. This means that central banks operating in floating exchange rate regimes, particularly in smaller countries, are significantly constrained in their ability to run independent monetary policies. They can influence short-term rates but cannot set their own long-term rates. Instead, international investor activity has a greater influence over long-term rates.[8] We see this at present. The Reserve Bank raised short-term rates during the period from March to July 2014, but longer-term mortgage rates have fallen as a result of the decline in long rates in the major economies.

This means that macroprudential policies may need to be called on to help prevent asset price booms and complement monetary policy. But there is still much to be explored around the nature of the interaction of monetary and macroprudential policies, the costs and benefits of such interventions, and the circumstances where such policy initiatives are likely to be successful. Particularly important in this regard will be considerations as to how best to coordinate monetary policy and macroprudential policy decisions when economic and financial cycles are out of sync and the policies are not complementary.

9. Concluding Comments

Monetary policy's focus on price stability has played a vital role in the more stable and responsive economic climate that has emerged in New Zealand over the last twenty-five years. Under this climate, the economy has been able to take advantage of new trading

[8] For excellent discussions on this, see Rey (2014) and Turner (2014).

opportunities in Asia and elsewhere; there has been strong growth in new sectors of activity—including in the information technology area—and the economy has been resilient in the face of severe external and domestic shocks, notably from the GFC and the Christchurch earthquakes. Moreover, the ability of monetary policy to help offset short-term shocks to output and employment has grown as inflation expectations have stabilized at a low level and as policy credibility and transparency have increased. New Zealand is not alone in these experiences: all major central banks now see price stability as their main objective and the most important contribution they can make to stronger long-term economic performance.

While much has been achieved in these first twenty-five years of the Reserve Bank Act, important issues and challenges remain. The global economic environment remains difficult, we have experienced rapid increases in house prices, and we face the longer-term need to improve domestic productivity and savings and rein in the economy's external imbalances.

These global and domestic challenges serve as a reminder of what can and cannot be achieved through monetary policy to counter the sorts of pressures the economy may face in the years ahead. For example, monetary policy is relatively powerless to offset the spillovers that global economic and policy developments can impose on our exchange rate and commodity export prices. But monetary policy can complement structural and fiscal policies in supporting the economy's flexibility and adaptability, and help counter short-term economic fluctuations. Moreover, recent financial-sector reforms, including the new macroprudential policy framework, have given the Bank additional tools for containing systemic risks and promoting macroeconomic stability. There is still much to learn in this area, including in the interactions between prudential and monetary policies, but the Reserve Bank is now much better equipped to help build a stronger and more resilient economy than we were prior to 1991.

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Forward Guidance*

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Forward guidance about future policy settings, in the form of a published policy rate path, has for many years been a natural part of normal monetary policy for several central banks, including the Reserve Bank of New Zealand and the Swedish Riksbank. More recently, the Federal Reserve has started to publish FOMC participants' policy rate projections. The Swedish, New Zealand, and U.S. experience of a published policy rate path is examined, especially to what extent the market has anticipated the path (the predictability of the path) and to what extent market expectations line up with the path after publication (the credibility of the path). The recent Swedish experience is quite dramatic. In particular, it shows a case with a large discrepancy between a high and rising Riksbank path and a low and falling market path, with the market path providing a good forecast of the future policy rate. The discrepancy is explained by the Riksbank's leaning against the wind in recent years and related circumstances. The New Zealand experience is less dramatic but shows cases where the market implements either a substantially tighter or easier policy than intended by the RBNZ. There are also cases of the market being ahead of the RBNZ and the RBNZ later following the market. The U.S. experience includes a recent case of the market expecting and implementing substantially easier policy consistent with the FOMC projections, the possible explanation of which has been much discussed.

JEL Codes: E52, E58, G14.

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1. Introduction

"Forward guidance" in monetary policy means providing some information about future policy settings. In recent years, the Federal Reserve, the Bank of Canada, the European Central Bank (ECB), and the Bank of England have used different forms of forward guidance. The forward guidance by these central banks was introduced in the special context of a binding lower bound for the policy rate. It has been used as a way of implementing more expansionary policy when the policy rate has been restricted by a lower bound.

In contrast, for many years, some central banks have used forward guidance as a natural part of their normal monetary policy. This forward guidance has been in the specific form of a published forecast for the interest rate, either the policy rate or a ninety-day interest rate. The Reserve Bank of New Zealand (RBNZ) has published a path for the ninety-day rate from 1997, Norges Bank for the policy rate from 2005, Sveriges Riksbank and the Bank of Israel for the policy rate from 2007, and the Czech National Bank for a ninety-day rate from 2008. More recently, the Federal Reserve has published a forecast for its policy rate from 2012, in the form of the "dot plot" collecting individual Federal Open Market Committee (FOMC) participants' judgment of the appropriate level of the policy rate over three calendar years and the longer run.

In this paper, I look more closely at the Swedish, New Zealand, and U.S. experience of publishing an interest rate path. In particular, by comparing the published interest rate path with market expectations of future interest rates before and after the publication, one may assess both the predictability of monetary policy—that is, how well the market anticipated the new interest rate path—and the credibility of the published interest rate path—that is, to what extent the market expectations line up with the interest rate path after publication. Furthermore, if after the publication market expectations line up well with the published interest rate path, this indicates that the *actual* financial conditions, given by the actual market yield curve, are equal to the *intended* financial conditions, the yield curve consistent with the published interest rate path. Then, monetary policy is successful in managing expectations (Woodford 2005).

Regarding the predictability and credibility of the interest rate path, the Swedish experience includes examples of both great successes and great failures. In particular, the paper examines the circumstances of the great failure of September 2011, when the Riksbank announced a high and increasing policy rate path. It indicated a rise in the policy rate by about 75 basis points over the next six quarters. However, before and after the announcement, market expectations indicated a *fall* of about 75 basis points over the next six quarters. This was hence a situation when the published interest rate path completely lacked credibility, and the actual financial conditions were substantially easier than the intended ones. Ex post, the market expectations were right and the Riksbank interest rate path was wrong. The Riksbank actually lowered the policy rate by 100 basis points over the next six quarters. This failure is better understood once the complex broader picture of Swedish monetary policy at the time is explained. The Riksbank actually conducted a very controversial and aggressive leaning against the wind.[1] Furthermore, although this was a failure in view of the intended monetary policy, it was arguably not a failure in view of the rather weak economy, which very much needed the easy conditions delivered by the market.

Regarding the predictability and credibility of the interest rate path, the New Zealand experience of successes and failures is much less dramatic. This is not strange given that New Zealand's monetary policy appears to have been better focused on achieving its objectives.[2] There are no failures of predictability and credibility of the magnitude seen in Sweden. Still, I find a case when the actual financial conditions are clearly tighter than the intended ones, and

[1]During my period as Deputy Governor and Executive Board member of the Riksbank, I consistently dissented against this policy.

[2]However, the RBNZ arguably made a mistake in relying too much on a monetary conditions index (MCI) in the late 1990s. At the invitation of New Zealand's Minister of Finance, I conducted a review of the operation of monetary policy in New Zealand during the first ten years of inflation targeting (Svensson 2001). My overall conclusion was that "with regard to the operational framework and how monetary policy is managed in pursuit of the inflation target, I have found that the period (mid-1997 to March 1999) when the Reserve Bank used an MCI to implement monetary policy represents a significant deviation from best international practice. This has now been remedied, and monetary policy in New Zealand is currently entirely consistent with the best international practice of flexible inflation targeting, with a medium-term inflation target that avoids unnecessary variability in output, interest rates and the exchange rate. Only some marginal improvements, mostly of a technical nature, are recommended."

another when the actual financial conditions are substantially easier than intended. In the latter case, the market seems to have been ahead of the RBNZ, because the next published interest rate path was shifted down substantially, making the new intended financial conditions much easier and more or less in line with those previously anticipated by the market.

The U.S. experience of a published policy rate path is short, because it only started in January 2012. Furthermore, one must keep in mind that the "path" is not the outcome of a joint committee decision. In this paper, as in most discussions of the FOMC's dot plot, the policy rate path is constructed as the median of the FOMC participants' individual assessments for each specified year. But because the voters of the FOMC are a rotating subset of the participants, the policy rate path constructed this way is not necessarily the median of the voting participants' assessment. Even if the median of the voters' assessments were known, it would not necessarily be the case that a joint committee decision would correspond to that median. This would depend on the dynamics of the decision process of the FOMC; for instance, the Chair's assessment is likely to carry more weight. These qualifications must be kept in mind when the median policy rate path is used as an approximation to a joint FOMC decision. That said, during 2012 and 2013, market expectations have been either a bit below or well aligned with the FOMC policy rate path. For instance, the December 2013 policy rate path was very well anticipated by the market and highly credible after publication. During 2014, however, market expectations of future policy rates have fallen increasingly below FOMC participants' policy rate paths, the possible reasons for which have been much discussed and are further commented on below. Thus far during the short U.S. experience, there is no case where the actual financial conditions implemented by the market have been tighter than what is consistent with the FOMC participants' policy rate path.

Section 2 discusses forward guidance as a special or normal part of monetary policy and possible reasons why publication of an interest rate path would be a normal part of monetary policy. Section 3 discusses the practical experience of forward guidance in Sweden, in particular the large discrepancy between the Riksbank's policy rate path and market expectations of future policy rates in September

2011. Section 4 discusses some specific aspects of the discrepancy of September 2011, whereas section 5 discusses some broader aspects of the Riksbank policy at the time. Section 6 discusses the much less dramatic New Zealand experience, against the background of the broader picture of monetary policy in New Zealand, very different from that in Sweden. Section 7 discusses the short U.S. experience. Section 8 concludes.

2. Forward Guidance as a Special or Normal Policy

In recent years, the Federal Reserve, the Bank of Canada, the ECB, and the Bank of England have used different forms of verbal forward guidance—meaning some information in policy statements about future monetary policy settings in order to affect market expectations about future policy settings. The forward guidance by these central banks was introduced in the context of a binding lower bound for the policy rate. It has been used as a way of implementing a more expansionary policy when the policy rate has been restricted by a lower bound.

Forward guidance in the specific form of a published forecast for the interest rate has been used by the Reserve Bank of New Zealand from 1997, by Norges Bank from 2005, the Riksbank from 2007, the Bank of Israel from 2007, and the Czech National Bank from 2008. That kind of forward guidance is a normal part of the policy and communication of these central banks. These central banks all pursue flexible inflation targeting, meaning that the objective of the policy is to stabilize both inflation targeting around an announced inflation target and resource utilization around its long-run sustainable rate.[3] More recently, in January 2012, the Federal Reserve, with its "Statement on Longer-Run Goals and Monetary Policy Strategy" (Federal Open Market Committee 2012a), became a very transparent flexible inflation targeter. It also started to publish a forecast for its policy rate, in the specific form of a scatter

[3]In a public lecture at Victoria University, Wellington, given in the fall of 1997 (Svensson 1998), I argued that there was evidence from 1996–7 of the RBNZ being a flexible inflation targeter (stabilizing both inflation and resource utilization) rather than a strict inflation targeter (only concerned about stabilizing inflation, regardless of the stability of the real economy).

plot where each dot indicates the value of an individual FOMC participant's judgment of the appropriate level of the target federal funds rate at the end of three calendar years and over the longer run.

Which measure of resource utilization is most appropriate may vary from economy to economy. For concreteness, I here use the unemployment rate as the relevant measure of resource utilization. At least in Sweden, the unemployment rate and the gap to an estimated long-run sustainable rate are in my view a much more reliable indicator of resource utilization than the output gap, which relies on very shaky, arbitrary, and unverifiable estimates of potential output (Svensson 2011). In New Zealand, the RBNZ uses the output gap as the main measure of resource utilization. The Federal Reserve's mandate of promoting price stability and maximum employment makes it natural that, as measures of resource utilization, it focuses on the gap between employment and its assessment of the maximum level of employment and the gap between unemployment and the "longer-run normal rate of unemployment" (Federal Open Market Committee 2012a).

There are several reasons why forward guidance in the form of a published forecast for interest rate (a policy rate path or a path for a market ninety-day rate consistent with the central bank policy rate path) may be considered a natural part of a monetary policy in the form of flexible inflation targeting:

- *Transparency.* Because the economy reacts with a lag to monetary policy actions, monetary policy has to be guided by central bank forecasts for inflation and unemployment. A coherent forecast for inflation and unemployment requires a forecast for the policy rate. Coherent flexible inflation targeting requires "forecast targeting," that is, choosing a policy rate path such that the corresponding forecasts for inflation and unemployment "look good," meaning that they best stabilize both inflation around the target and unemployment around its long-run sustainable rate. Because the policy rate path is inherent in forecast targeting, transparency of policy requires the publication of forecasts for both the target variables (inflation and unemployment) and the policy rate.

- *Effectiveness.* A published policy rate should affect market expectations of future policy rates and thereby the yield curve and longer market rates that have an impact on economic agents' decision and this way contribute to a more effective implementation of monetary policy.[4] (The publishing of forecasts for inflation and unemployment should also affect the expectations of those variables and contribute to a more effective implementation of policy; see Svensson and Woodford 2005).
- *Informativeness.* Generally, the central bank should have better information about its plans for the future policy rate than any other agent. A published policy rate path should therefore provide useful information for the private sector and the public authorities about future policy rates, which should contribute to more informed decisions.
- *Justification.* Published forecasts for the policy rate, inflation, and unemployment allow a transparent and coherent way of justifying the policy choice by comparing the policy choice with the policy alternatives.
- *Accountability.* Published forecasts for the policy rate, inflation, and unemployment simplify an external evaluation of monetary policy and thereby increase the accountability of the central bank. They allow an external assessment of the trade-off between target variables and the consistency of the policy rate path with the forecasts for the target variables. If instruments other than the policy rate are also used, such as those of balance sheet policies, logic and consistency would demand the publication of forecasts for those as well.

In earlier parts of their inflation-targeting years, many inflation-targeting central banks assumed a constant policy rate path when they constructed their inflation forecasts. The idea was that a constant policy rate inflation forecast that overshoots (undershoots)

[4] If the central bank's implementation of its monetary policy allows a substantial difference between the central bank's policy rate and the market overnight rate, as has often been the case for the euro area, the relevant interest rate forecast is really the forecast for the overnight rate.

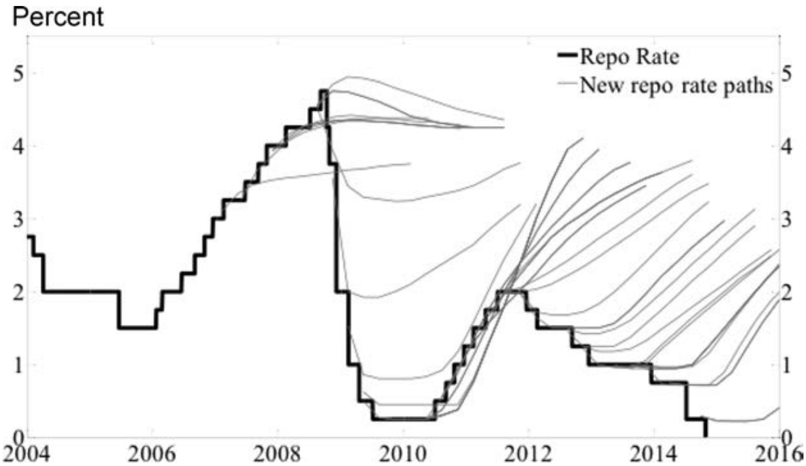
the inflation target at some horizon such as two years indicates that the policy rate needs to be increased (decreased) (Jansson and Vredin 2003; Vickers 1998). However, those central banks gradually became aware of a number of problems with the assumption of constant interest rates (Leitemo 2003; Woodford 2005). The assumption may often be unrealistic and therefore imply biased forecasts, and it may imply either explosive or indeterminate behavior in standard models of the transmission mechanism of monetary policy. In particular, even if a constant interest rate inflation forecast is on target at an appropriate horizon, it will typically overshoot or undershoot the target shortly after that horizon, meaning that the policy rate will have to be adjusted soon, thus violating the assumption of a constant future policy rate. This would make rational market expectations deviate from the constant policy rate. Furthermore, the forecasting process will use inputs such as asset prices that are conditional on market expectations of future interest rates rather than a constant interest rate and will therefore produce inconsistent and difficult-to-interpret forecasts.

Some inflation-targeting central banks then moved to a policy rate assumption equal to the market expectations of future interest rates, as they can be extracted from explicit forward rates and implied forward rates from the yield curve. This reduces the number of problems mentioned above but does not eliminate them fully. For instance, the central bank may have a view of the appropriate future policy rate path that differs from that of the market.

The move to publishing the central bank's own policy rate path solves all the above problems only if the policy rate path is credible, that is, if market expectations adjust to the policy rate path when it is published. If not, this means that some inputs in the forecasting process, such as the exchange rate and other asset prices, are still not consistent with the published policy rate path, making the forecasts for inflation and unemployment inherently inconsistent. As we shall see, this particular problem has been an issue in Sweden in the last few years.[5]

[5]Gosselin, Lotz, and Wyplosz (2008) provide a theoretical analysis of transparency and opaqueness of the central bank's policy rate path. The pros and cons of publishing a policy rate path are discussed in further detail in Svensson (2006, 2009) and Woodford (2005, 2007).

Figure 1. The Riksbank Policy Rate and Policy Rate Paths



Source: The Riksbank.

3. The Recent Swedish Experience of Forward Guidance

Figure 1 shows the Riksbank's policy rate (the repo rate) and the new policy rate path announced at each meeting, starting in February 2007 when the first policy rate path was published and ending with the new policy rate path in July 2014, when the policy rate was lowered from 0.75 percent to 0.25 percent. In October 2014, the policy rate was lowered to 0 percent. The new policy rate path (not shown) was shifted down to zero, with the first rise in the beginning of 2016. In February 2015, the policy rate was lowered to –0.1 percent, and in an extra policy meeting in March 2015, it was lowered to –0.25 percent, with a statement that it was expected to remain at that level at least until the second half of 2016 (not shown).

The recent Swedish experience during and after the financial crisis of 2008–9 provides an interesting case study of forward guidance in the form of a published policy rate path. By comparing the published policy rate path with market expectations of the future policy rate—which I will call the *market* policy rate paths—before and after the publication, one may assess both the predictability of monetary policy and the credibility of the policy rate path.[6]

(i) *Predictability.* Ideally, monetary policy should be so predictable that markets anticipate the new central bank policy rate path well. This should show up as the market policy rate path the day before the publication of the new central bank policy rate path being close to the published policy rate path.

(ii) *Credibility.* Furthermore, after the publication of the central bank policy rate path, its credibility with the market should ideally be so high that the market policy rate path shifts in the direction of the path and lines up well with it.

Note that "credibility" here refers only to the extent to which market expectations are in line with the published interest rate path, regardless of whether the interest rate path is appropriate in achieving the monetary policy objectives.

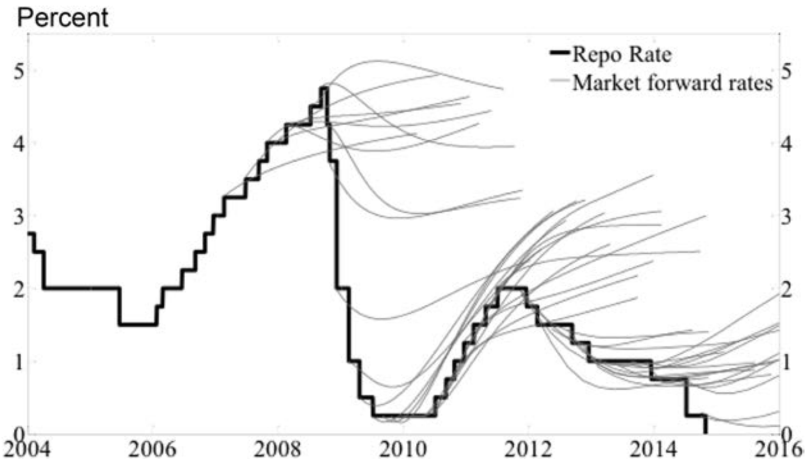
Figure 2 shows the Riksbank policy rate and the market policy rate paths after the announcement of the new policy rate and policy rate path.

The period from the start of the publication of the policy rate path in February 2007 until July 2009 was relatively successful regarding the predictability of policy and the credibility of the Riksbank policy rate path. In the fall of 2009 there was a period when the market expected the policy rate to be raised earlier than the published path implied. When the policy rate was raised, beginning with the June 2010 meeting, the market expected the policy rate to be raised at a slower pace than the published path. These cases are discussed in more detail in Svensson (2009, 2010) and Woodford (2012, 2013). Here I will focus on some recent problems.

Regarding predictability and credibility according to (i) and (ii) above, the Riksbank has had both successes and great failures in

[6]Market expectations of future policy rates are constructed at the Riksbank as implied forward rate curves. They are adjusted by the Riksbank staff for liquidity, credit, and term premia, so as to be the staff's best estimate of market expectations of future policy rates. Depending on the maturity, the implied forward rates are derived from the rates for STINA (Tomorrow-Next Stibor interest rate swaps) contracts, FRAs (forward rate agreements), or interest rate swaps.

Figure 2. The Riksbank Policy Rate and Market Policy Rate Paths



Source: The Riksbank.

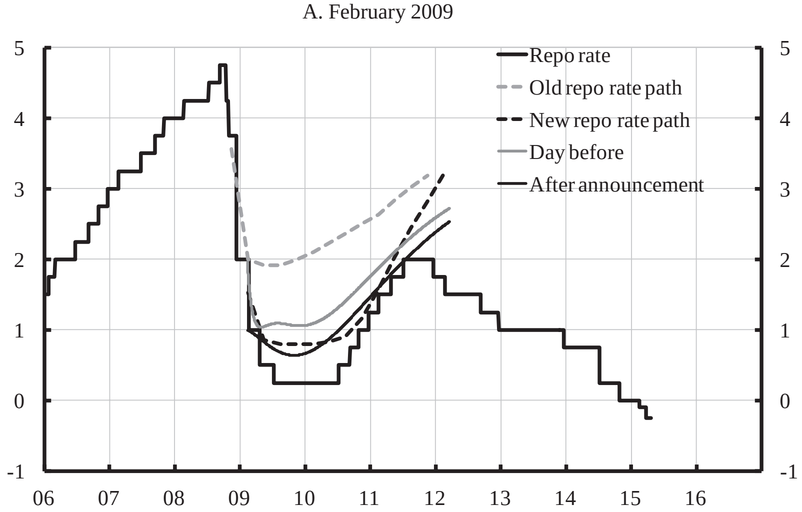
recent years. Figure 3 shows an example of a great success (panel A), at the policy meeting in February 2009, and an example of a great failure (panel B), at the policy meeting in September 2011. The dashed gray line shows the Riksbank policy rate path from the previous decision, the dashed black line shows the published new policy rate path, the solid gray line shows the market policy rate path the day before the publication, and the solid black line shows the market policy rate path after the announcement.[7]

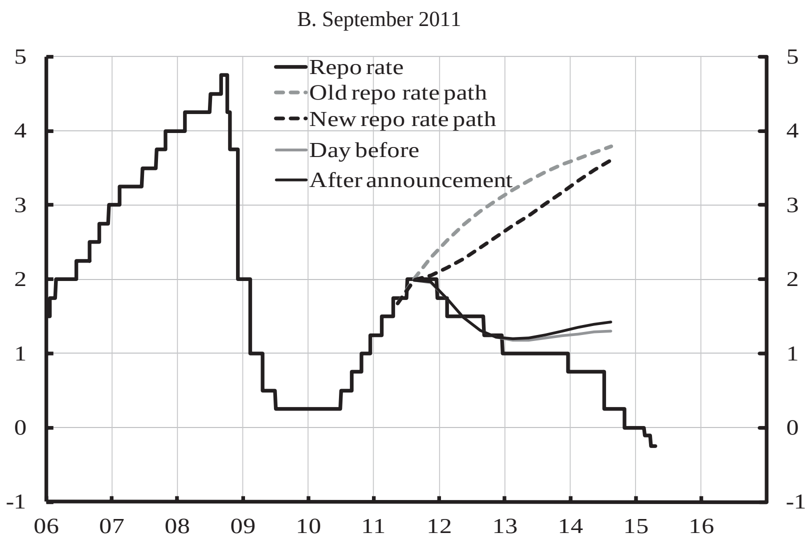
Figure 3A shows the very difficult situation at the meeting in February 2009, in the middle of the 2008–9 crises. The Swedish economy was in a free fall, the policy rate was reduced by 1 percentage point from 2 percent to 1 percent, and the Riksbank policy rate path was shifted down even further. The market anticipated this dramatic shift downwards quite well, and after the announcement, the market policy rate path lined up even closer to the repo rate path.

Figure 3B shows the very different situation in September 2011, when the Riksbank announced a "postponement" of further

[7]Figures like figure 3 for all (regular) policy meetings from February 2007 through September 2014 are available on my website, http://larseosvensson.se.

Figure 3. The Policy Rate, the Riksbank Policy Rate Path, and the Market Policy Rate Path Before and After the Announcement





Source: The Riksbank.

increases in the policy rate and the steeply rising policy rate path was shifted somewhat to the right. The discrepancy between the Riksbank path and the market path was exceptionally large. The Riksbank path indicated a rise in the policy rate by about 75 basis points over the next six quarters. The market path was not affected by the announcement and indicated a *fall* of about 75 basis points over the next six quarters, both before and after the announcement. Ex post, the market policy rate path was right and the Riksbank policy rate path was wrong. The Riksbank actually lowered the policy rate by 100 basis points over the next six quarters.[8]

Thus, in September 2011, the Riksbank policy rate path completely lacked credibility. The market apparently found the Riksbank path to be completely irrelevant. The market path did not move when the new Riksbank path was published. Furthermore, the market was predicting the actual future policy rate path quite well. The market apparently had a much better idea of what the Riksbank would be doing in the future than what the Riksbank itself communicated. The Riksbank policy rate path had apparently lost touch with reality.

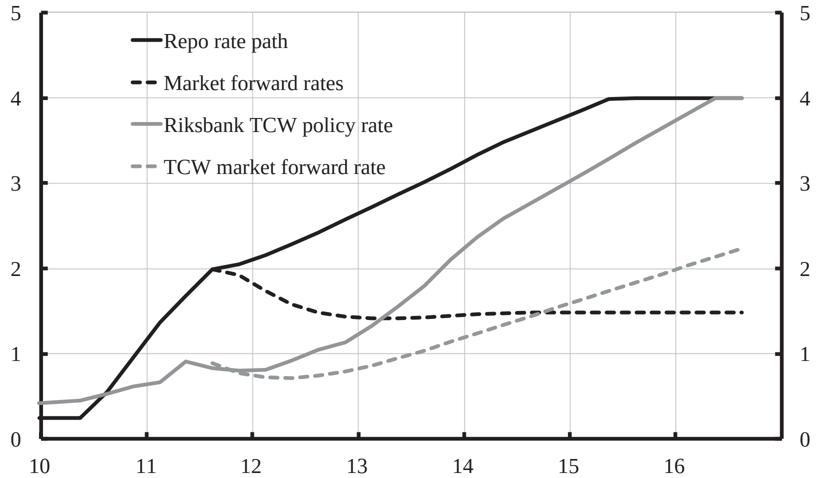
The exceptionally large discrepancy between the Riksbank's policy rate path and the market expectations, as well as the fact that the market was much better at predicting the policy rate for the next two years, warrants some closer study. What were the consequences of such a discrepancy between market expectations and the policy rate path? How does the discrepancy relate to the broader picture of monetary policy in Sweden at the time? What can explain such an unrealistic policy rate path?

4. What Were the Consequences of the September 2011 Discrepancy?

In order to understand the consequences of the discrepancy between market expectations and the policy rate path, we need to note another discrepancy, namely that between the Riksbank forecast for foreign policy rates and the market expectations of future foreign policy rates. This is something that was discussed at several policy

[8]The September 2011 case is further discussed in Woodford (2013).

Figure 4. Riksbank and Market Policy Rate Paths, Riksbank Forecast for Foreign Policy Rates, and Market Expectations of Foreign Policy Rates, September 2011



Source: Sveriges Riksbank (2011, figure 1).

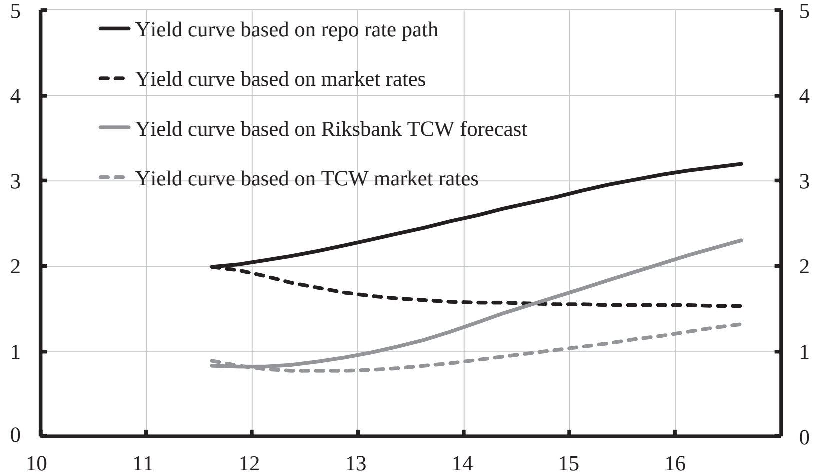
meetings, including the September 2011 meeting (Sveriges Riksbank 2011).[9]

In figure 4 below (Sveriges Riksbank 2011, figure 1), the solid gray line shows the Riksbank forecast for (TCW-weighted) foreign policy rates, whereas the dashed gray line shows (TCW-weighted) market expectations of foreign policy rates, extended to a five-year horizon.[10] We see that the Riksbank forecast is considerably above market expectations. The solid and dashed black lines in the figure show the Riksbank and market policy rate paths from figure 3B extended to a five-year horizon.

[9]The Riksbank's published minutes from the policy meetings are attributed and provide—at least for the meetings that I have attended myself—a correct and detailed record of the discussions at the meetings (including figures and tables that I brought to the meetings).

[10]The TCW index (Total Competitiveness Weights) is a geometric index. Its weights are based on the average aggregate flows of processed goods for twenty-one countries. The weights take into account exports and imports, as well as third-country effects. They are calculated by the International Monetary Fund.

Figure 5. Actual Swedish and Foreign Yield Curves and Yield Curves Consistent with Riksbank Forecasts



Source: Sveriges Riksbank (2011, figure 2).

The big discrepancy between the Riksbank path and the market path shown in figures 3B and 4 means that the market yield curve consistent with the market policy rate path was very different from the yield curve consistent with a credible Riksbank policy rate path. The discrepancy between the Riksbank forecast for foreign policy rates and the market expectations of foreign policy rates also means that the market yield curve for foreign interest rates was quite different from the yield curve consistent with the Riksbank forecast. This is illustrated in figure 5 (Sveriges Riksbank 2011, figure 2). The dashed black line shows the Swedish market yield curve, whereas the solid black line shows the yield curve consistent with a credible Riksbank policy rate path, both extended to a five-year maturity. The dashed gray line shows the foreign market yield curve, whereas the solid gray line shows the yield curve consistent with the Riksbank forecast for foreign policy rates.

In figure 5 it can be seen that a Swedish five-year market interest rate (that is, maturing in September 2016) was just over 1.5 percent. But the five-year interest rate compatible with the Riksbank policy rate path was about 3.2 percent, which is to say about 1.7 percentage points higher.[11] Furthermore, the foreign five-year market interest rate was about 1.3 percent whereas the foreign five-year interest rate consistent with the Riksbank forecast was about 2.3 percent, that is, about 1 percentage point higher.

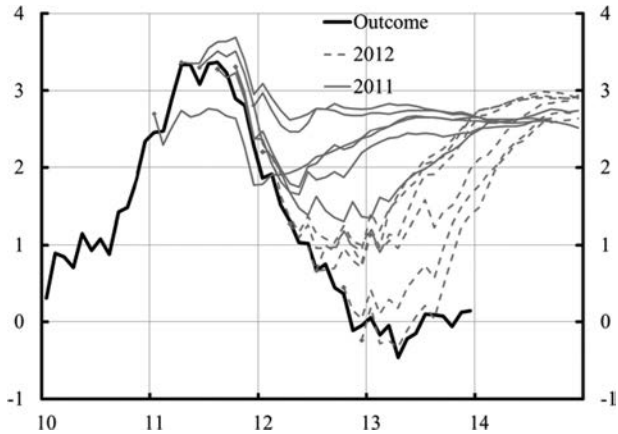
These discrepancies mean that the Riksbank forecast for inflation and unemployment was inherently inconsistent. The Swedish and foreign financial conditions *assumed* in the forecast and the models used to construct the forecast for inflation and unemployment were much tighter than the *actual* Swedish and foreign financial conditions. But inputs such as the exchange rate and other asset prices that are used in the forecast were conditional on the market's lower Swedish and foreign yield curves, not on the Riksbank's higher forecasts of the Swedish and foreign policy rates.

In particular, we realize that the Riksbank forecast for foreign policy rates had the effect of supporting a higher policy rate path. Suppose that the forecast for foreign policy rates had been shifted down to equal the market expectations of foreign policy rates, that is, shifted down from the solid gray to the dashed gray line in figure 4. For an unchanged Riksbank policy rate path, the forecasted interest rate differential between Swedish and foreign interest rates would have increased. This would have induced a forecast of a much stronger Swedish krona, which would have caused forecasted export and employment as well as the forecasted import price inflation to shift down. Then the forecast for inflation would also have shifted downwards, and that for unemployment would have shifted upwards. Everything else equal, there would have been a strong case for the policy rate and policy rate path to be shifted downwards. Such a shift down in the policy rate and policy rate path would have countered these shifts in the forecasts for inflation and unemployment and resulted in forecasts for inflation and unemployment that better stabilized inflation around the target and unemployment around its long-run sustainable rate.

Thus, everything else equal, the high forecast for foreign policy rates served to shift the inflation forecast upwards and shift the

[11] The yield curve consistent with a credible repo rate path is adjusted for normal liquidity, credit, and term premia.

Figure 6. Riksbank CPI Forecasts during 2011 and 2012 and the Outcome



Source: Statistics Sweden and the Riksbank (figure 2.6 of Sveriges Riksbank 2014a).

Notes: The gray and black thin lines show the Riksbank's forecasts 2011–12. The marks show the starting point of each forecast and may therefore deviate from the latest outcome at that point in time.

unemployment forecast downwards, thereby supporting a high policy rate path.

That Riksbank inflation forecasts became strongly biased upwards is apparent from figure 6. It shows the Riksbank's CPI inflation forecasts during 2011 and 2012 and the actual outcome of CPI inflation.

Obviously, the market did not agree with either the high forecast for foreign policy rates or the high policy rate path. The market apparently realized that the Riksbank's high policy rate path would bring too strong a krona, with the above consequences, and force the Riksbank to adjust its policy. In discussions that I had with market participants at the time, they indeed did express such views.

As noted, the big discrepancy between the market yield curve and the yield curve consistent with the policy rate path in figure 4 means that the *actual* financial conditions in the Swedish economy were much easier in September 2011 than if the policy rate path had become credible, what one may call the *intended* financial conditions. Suppose that the market had suddenly started to believe in the high policy rate path. That is, assume that the market policy rate path, the dashed black line in figure 4, had shifted up to the solid black line. This means that the dashed black yield curve in figure 5 would have shifted up to the solid black yield curve, which means that a five-year interest rate would have increased by 1.7 percentage points, and the krona would have appreciated considerably. As I argued at the September 2011 meeting (Sveriges Riksbank 2011), it would have been a devastating shock to the Swedish economy if the Riksbank policy rate path had suddenly become credible. It seems that it was the economy's good luck that the Riksbank policy rate path lacked credibility.[12]

5. The Broader Picture of Swedish Monetary Policy

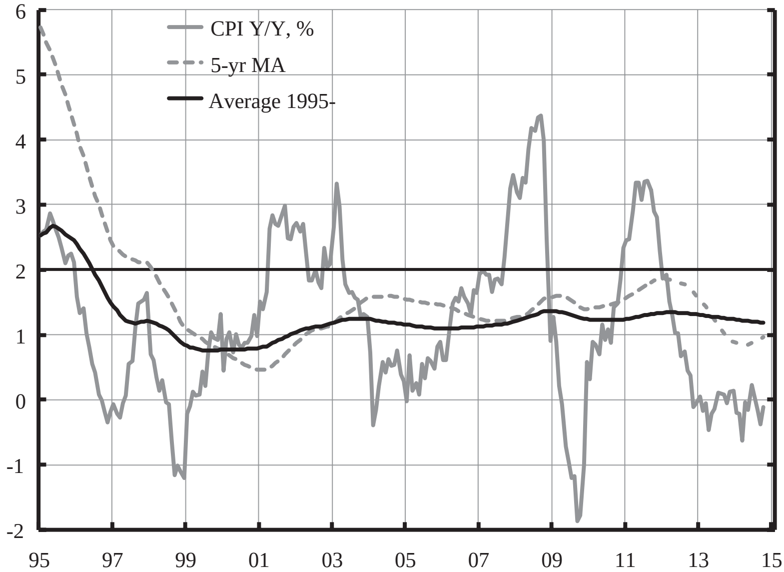
The September 2011 decision and policy rate path were part of a bigger picture. In the summer of 2010, the Riksbank had started a period of policy tightening, in spite of a low forecast for inflation and a high forecast for unemployment. This is discussed in detail in Svensson (2011, 2013). It led to CPI inflation dropping to zero and the unemployment rate getting stuck at around 8 percent. Both ex ante and ex post, the policy tightening appears to have been premature.

As can be seen in figure 7, CPI inflation has actually systematically undershot the inflation target in Sweden since the target of 2 percent CPI inflation started to apply in 1995. In spite of this, inflation expectations, including those of the social parties, have been anchored at the target, as can be seen in figure 8. As discussed in detail in Svensson (2015b), the fact that average inflation has undershot the target and inflation expectations has led to about 0.8 percentage point higher average unemployment during 1997–2011, compared to if average inflation had equaled the target.

As discussed in Svensson (2014), according to a counterfactual experiment with the help of the Riksbank's main DSGE model,

[12]The consequences of the market implementing more expansionary financial conditions than what is consistent with the policy rate path and apparently intended by the Riksbank are also discussed in Svensson (2011).

Figure 7. Annual CPI Inflation, Five-Year Moving Averages, and Average from 1995, Sweden



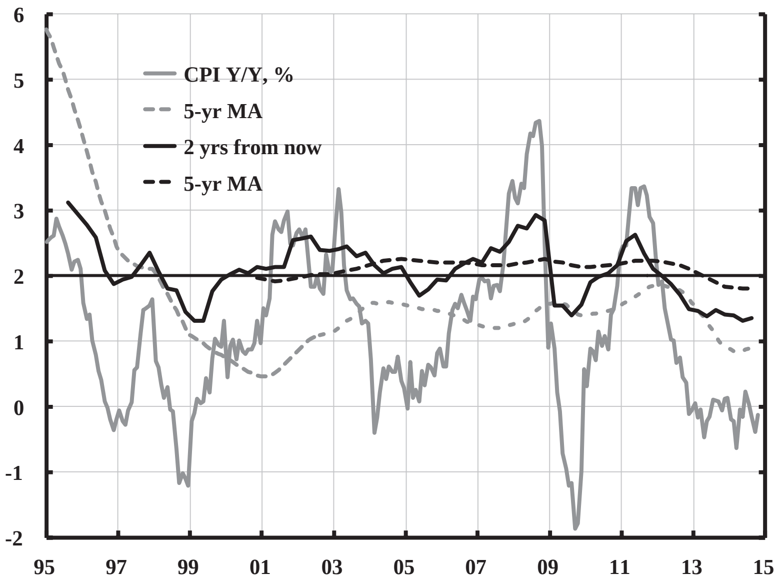
Source: Statistics Sweden.

Ramses, the aggressive leaning against the wind starting in the summer of 2010 has led to unemployment being about 1.2 percentage point higher in 2013 compared to if the policy rate had been kept unchanged at 0.25 percent from the summer of 2010. The solid black line in figure 9 shows the unemployment rate in Sweden, which has stayed up at around 8 percent after the tightening in 2010–11. The dashed black line shows how unemployment would have developed according to the counterfactual experiment.

The main reason for the leaning against the wind was concerns about increased risks associated with household debt, although this was not expressed very clearly until later. In the press release of July 1, 2010 (with the June 30 policy decision; Riksbank policy decisions are announced the day after the meeting), there is a paragraph with a somewhat cryptic reference to household debt:

> Inflationary pressures are currently low, but are expected to increase as economic activity strengthens. The repo rate now

Figure 8. CPI Inflation and Inflation Expectations Two Years from Now, Sweden

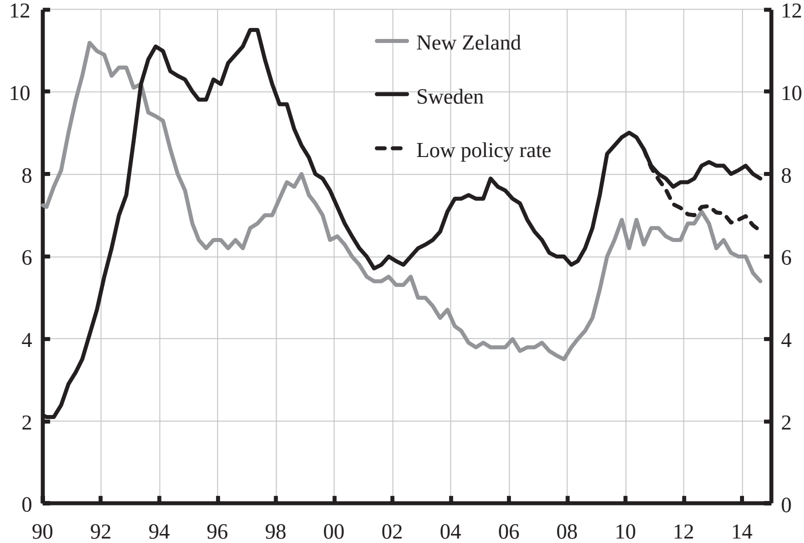


Source: Statistics Sweden and TNS Sifo Prospera.
Notes: Inflation expectations refer to expectations of annual inflation two years from now of all interviewees of the TNS Sifo Prospera survey commissioned by the Riksbank.

> needs to be raised gradually towards more normal levels to attain the inflation target of 2 per cent and at the same time ensure stable growth in the real economy. The Executive Board of the Riksbank has therefore decided to raise the repo rate by 0.25 of a percentage point to 0.5 per cent. *Another factor is that household indebtedness has increased significantly in recent years.* (Sveriges Riksbank 2010c, italics added)

However, the inflation forecast in the July 2010 Monetary Policy Report (Sveriges Riksbank 2010b) actually shows the CPIF inflation forecast (CPIF inflation is CPI inflation for unchanged mortgage rates) falling significantly below the inflation target except towards the end of the forecasting period when it hits the inflation target from below. The unemployment forecast was high and much above

Figure 9. Unemployment in Sweden and New Zealand and Counterfactual Unemployment in Sweden for a Low Policy Rate



Source: Datastream and own calculations.

Notes: Low policy rate refers to a counterfactual experiment with the Riksbank's main DSGE model, Ramses, with an assumption of a policy rate at 0.25 percent from June/July 2010.

the Riksbank's estimate of a long-run sustainable rate. Also, one could argue that GDP growth needed to be much above normal to remedy the large fall in output during the crisis.

Furthermore, the minutes from the June 30 meeting indicate the following statements by Governor Ingves:

> Mr Ingves further said that *an interest rate increase was also a signal to avoid new financial imbalances from building up and that household indebtedness ought not to rise too much.* Mr Ingves pointed out that this was something he had noted on several earlier occasions. *A low interest rate for too long* could lead to a troublesome situation beyond the forecast horizon as a result of a credit expansion. It is of course difficult to measure

> when house prices and the debt/equity ratio are reaching excessively high levels. But this does not mean it is less important to take them into account in monetary policy. By the time we know all the facts, it is often too late to slow down developments, and this often results in large costs to society. (Sveriges Riksbank 2010a, p. 18, italics added)

Thus, a higher policy rate (and a higher policy rate path) could be seen as a warning signal to households about their debt. The majority of the Executive Board that supported Ingves in this decision was arguably considering a high policy rate more or less an independent target for monetary policy besides inflation and resource utilization. One can say that the majority put more weight on normalizing the policy rate than on normalizing inflation and unemployment.

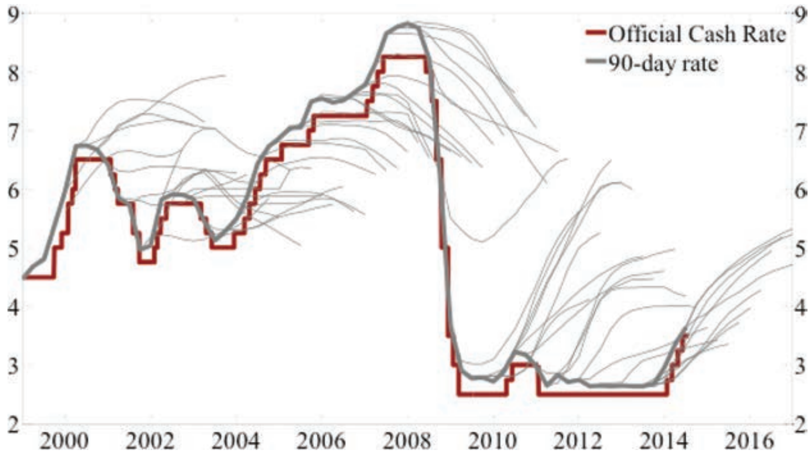
However, according to estimates later published by the Riksbank (Sveriges Riksbank 2014b), the policy rate effect on real debt and the debt-to-income ratio is very small, not significantly different from zero, and there is no evidence of any long-run effect. As discussed in detail in Svensson (2015a), with these estimates and those of Flodén (2014) and Schularick and Taylor (2012), one can show that the benefits of a higher policy rate, in terms of lower expected future unemployment because of a lower probability of a future crisis and a less deep crisis if it would occur, are about 0.4 percent of the cost in terms of higher unemployment the next few years. Thus, the benefits are completely insignificant compared to the costs. For the policy to be justified, the benefits should of course have been more than 100 percent of the cost.

In addition, in the last three years, the price level has fallen about 6 percent below what households have expected, substantially increasing the households' real debt burden and arguably increasing rather than decreasing any risks associated with household debt (Svensson 2015a).

6. The New Zealand Experience

The RBNZ has the longest experience of publishing a forecast for the interest rate, in this case the ninety-day rate, from June 1997. Figure 10 shows the RBNZ policy rate (the Official Cash Rate, or

Figure 10. The RBNZ Policy Rate, the Ninety-Day Rate, and the RBNZ Ninety-Day Paths, 1999:Q1–2014:Q3



Source: The RBNZ.

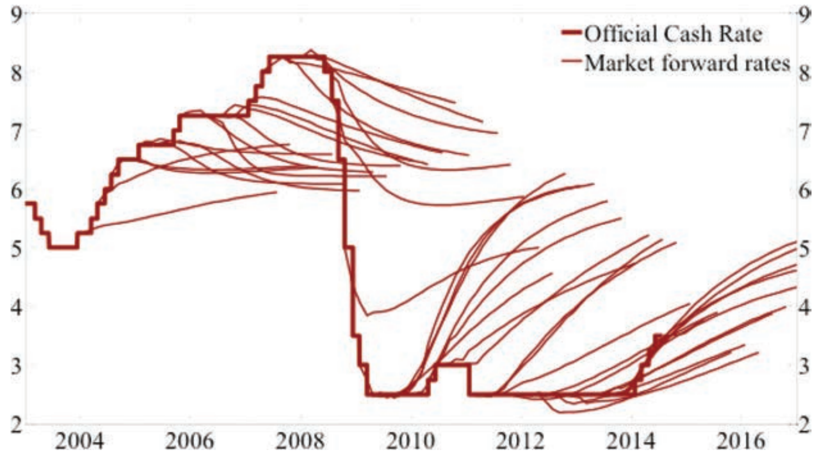
OCR), the ninety-day rate, and the RBNZ ninety-day paths from 1999:Q1 to 2014:Q3.[13]

Figure 11 shows the policy rate and market policy rate paths (market expectations of future policy rates) from 2004:Q1 to 2014:Q3.

The New Zealand experience of successes and failures regarding predictability and credibility is not at all as dramatic as the Swedish one. In particular, there are no failures of the same magnitude as the Swedish September 2011 one. This is not surprising, because the broader picture of monetary policy in New Zealand is quite different from that for Sweden.

[13]The RBNZ's publication of its policy instrument has led to some lively debate in the academic and policy circles (Andersson and Hofmann 2009, Archer 2005). Moessner and Nelson (2008), one of the earliest empirical studies of the RBNZ's interest rate path, found a statistically significant impact of the RBNZ forecasts on market interest rates. Detmers and Nautz (2012) extends on Moessner and Nelson (2008) and found that the information content of interest rate projections depends on the forecast horizon and on the degree of uncertainty about the economic outlook. Bergstrom and Karagedikli (2013) found that as long as the economic agents interpret the forecasts by the RBNZ as conditional forecasts as opposed to commitments, the RBNZ forecasts help them improve their forecasts for other macro variables.

Figure 11. The RBNZ Policy Rate and Market Policy Rate Paths, 2004:Q1–2014:Q3



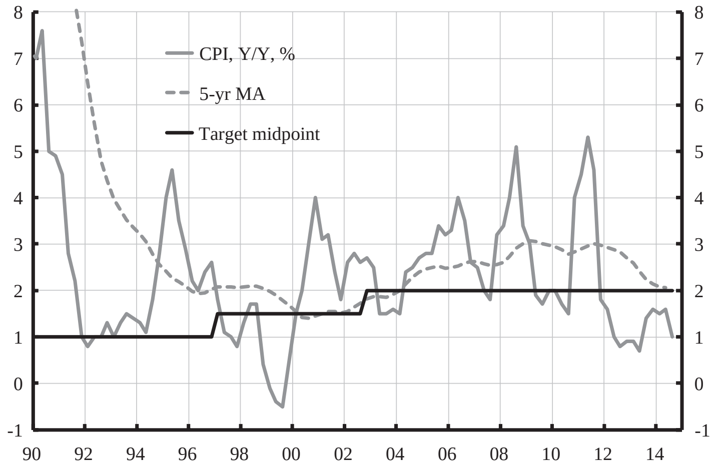
Source: The RBNZ.

Figure 12 shows CPI inflation, a five-year trailing moving average, and the target midpoint (the midpoint of the target range). The inflation target was changed from 0–2 percent to 0–3 percent in December 1996, and again to 1–3 percent in September 2002, shifting the target midpoint accordingly.

Whereas inflation systematically undershot the target in Sweden, in New Zealand it has been a bit on the high side. We see this more clearly in figure 13, where I show the deviation from the target midpoint, a five-year trailing moving average, and the average from 1992, two years after the target was starting to apply. As we can see, inflation has on average overshot the target midpoint by about half a percentage point.

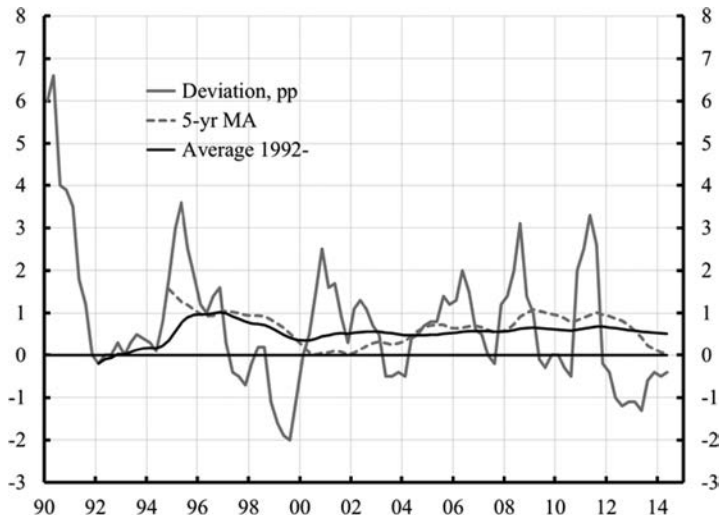
In Sweden, as mentioned, inflation expectations have been anchored at the target, in spite of inflation on average undershooting the target. Svensson (2015b) shows that this has led to higher average unemployment than if inflation had on average equaled the target. If inflation expectations in New Zealand had been anchored at the target midpoint, by the same logic we might have seen average unemployment actually being lower than if inflation had on average equaled the target midpoint. However, as is apparent from figure

Figure 12. Inflation, Five-Year Moving Average and Target Midpoint, New Zealand



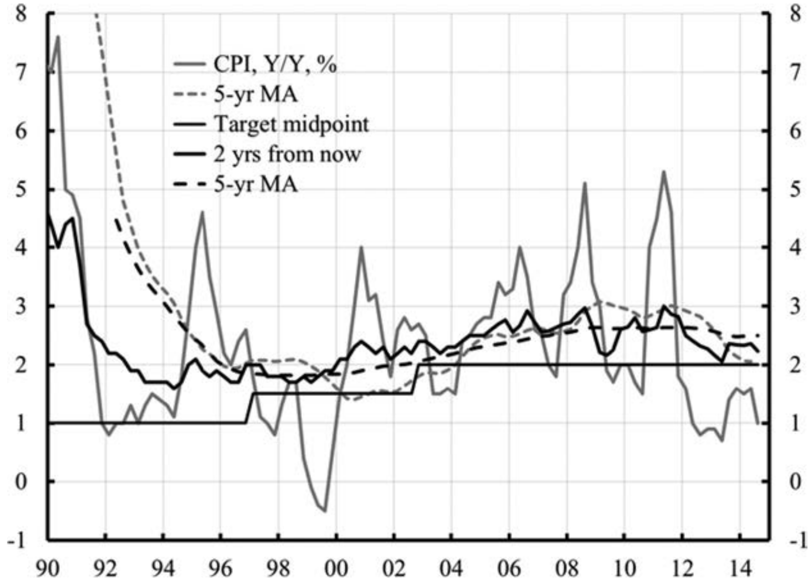
Source: Datastream.

Figure 13. Inflation Deviation from Target Midpoint, Five-Year Moving Averages, and Average from 1992, New Zealand



Source: Datastream.

Figure 14. CPI Inflation and Inflation Expectations Two Years from Now and Five-Year Moving Averages, New Zealand



Source: Datastream and RBNZ Business Surveys.

14, five-year moving averages of inflation expectations do not deviate much from those of inflation, so given this, there is no reason to expect any impact on average unemployment from inflation overshooting the target. In other words, this indicates that inflation expectations have adjusted to make the long-run Phillips curve vertical for New Zealand, in contrast to what I have shown during 1997–2011 for Sweden in Svensson (2015b).

However, we do see inflation undershooting the target midpoint during the last few years, although much less than in Sweden. Furthermore, figure 9 indicates that the unemployment performance is better in New Zealand, and in particular unemployment has come down recently whereas it has stayed up much higher in Sweden.

Before looking at some specific dates, we might note that the comparison of the new RBNZ ninety-day path and the market policy rate paths is complicated by the circumstance that the latter refers to market expectations of the policy rate, the Official Cash Rate. The average ninety-day rate during the period 1999:Q1 to 2014:Q3 is 0.24 percentage points higher than the average policy rate. This might be interpreted as a rough estimate of an average ninety-day premium over the OCR. According to the pure expectations hypothesis, the ninety-day rate should equal a leading ninety-day moving average of the expected policy rate. This means that the ninety-day rate should exceed the policy rate by more (less) if the policy rate is expected to rise (fall) over the next ninety days. Taking into account the average premium, the spread between the ninety-day rate and the policy rate would then exceed or fall short of 0.24 percentage points according to whether the market policy rate is upward or downward sloping. As we see in figure 10, the spread indeed seems to be on average larger when the policy rate is rising than when it is falling.

Furthermore, the comparison between the new and old policy rate path is not as straightforward as in the Riksbank case. This is because the RBNZ publishes a ninety-day path only after every second of its eight meetings per year, whereas the Riksbank publishes a policy rate path after each of its six meetings per year. Thus, the shift from the old to the new RBNZ ninety-day path is less informative in the New Zealand comparison, and it is difficult to assess how much of this shift was implicit at the previous meeting when no path was published.

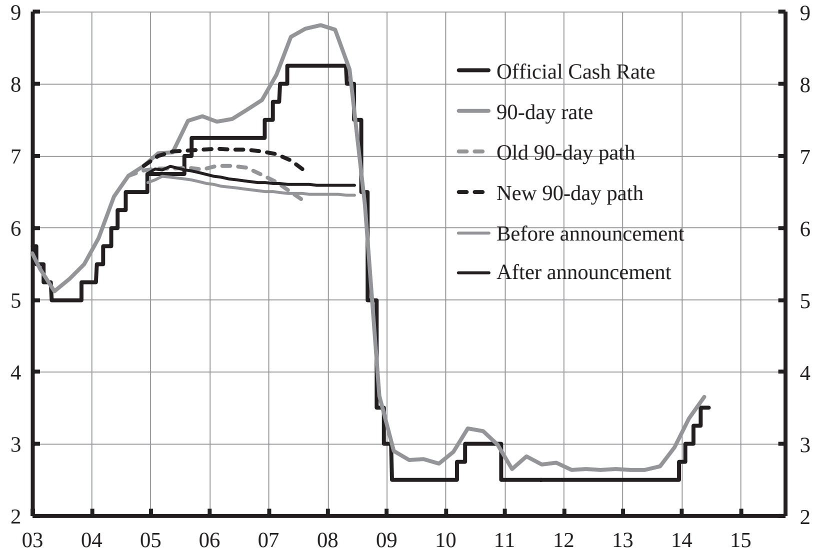
If we look at some specific dates, figure 15, from March 2005, is an example of a relative success, I believe. The RBNZ had in January 2005 kept its policy rate unchanged at 6.5 percent. In March, it increased the policy rate by 0.25 percentage points to 6.75 percent and shifted up the relatively flat ninety-day path relative to the path it had published in December.[14]

We see from the solid gray line that the increase in the policy rate and the new ninety-day path was relatively well anticipated. After the announcement, the market policy rate shifted up a little, remaining roughly parallel to the new ninety-day path, indicating relatively good credibility of the ninety-day path.

Figure 16 shows another example under the difficult circumstances in the beginning of the global financial crises, somewhat

[14]Figures like figure 15 for each quarter from March 2004 through March 2014 are available on my website, http://larseosvensson.se.

Figure 15. The Policy Rate, the Ninety-Day Rate, the New and Old Ninety-Day Path, and the Market Policy Rate Paths Before and After the Announcement, March 2005

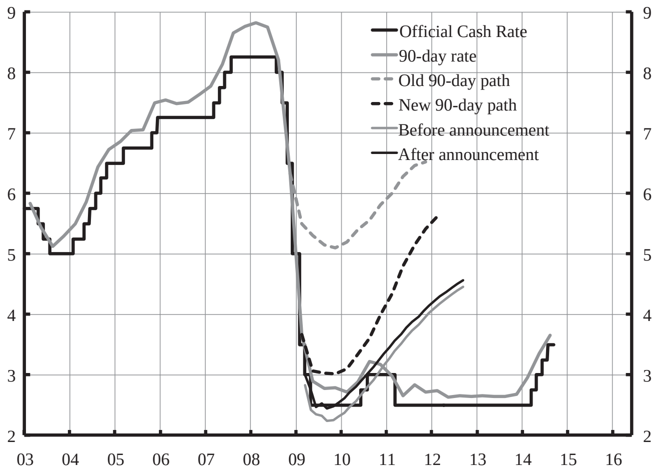


Source: The RBNZ.

similar to the Riksbank experience in figure 3A. The RBNZ had lowered the policy rate by 1.5 percentage points from 5 to 3.5 percent in January 2009 (without publishing a new policy rate path). In March, it lowered the policy rate by another 0.5 percentage points to 3 percent, and published a new ninety-day path. The solid gray line shows that this was well anticipated, although the market might have anticipated a somewhat larger cut. After the announcement, the market policy rate path shifted up a bit, indicating reasonably good credibility of the new ninety-day path.

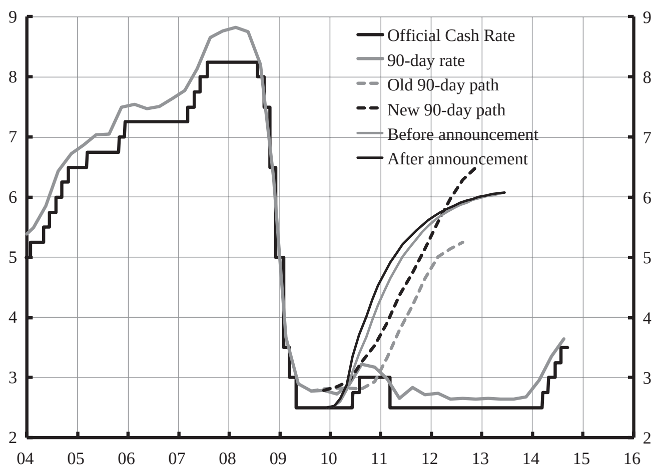
Figure 17, from December 2009, shows an example where, before and after the announcement, the market policy rate path indicates tighter policy than the RBNZ ninety-day path. Because the market policy rate path is upward sloping, the corresponding *market* ninety-day path (the path of market expectations of future ninety-day rates) would be more than 0.24 percentage points above the

Figure 16. The Policy Rate, the Ninety-Day Rate, the New and Old Ninety-Day Path, and the Market Policy Rate Paths Before and After the Announcement, March 2009



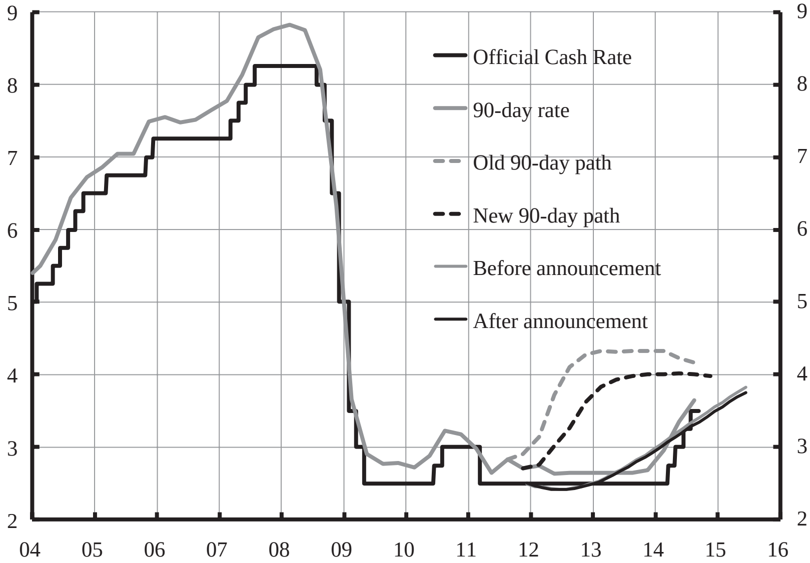
Source: The RBNZ.

Figure 17. The Policy Rate, the Ninety-Day Rate, the New and Old Ninety-Day Path, and the Market Policy Rate Paths Before and After the Announcement, December 2009



Source: The RBNZ.

Figure 18. The Policy Rate, the Ninety-Day Rate, the New and Old Ninety-Day Path, and the Market Policy Rate Paths Before and After the Announcement, December 2011



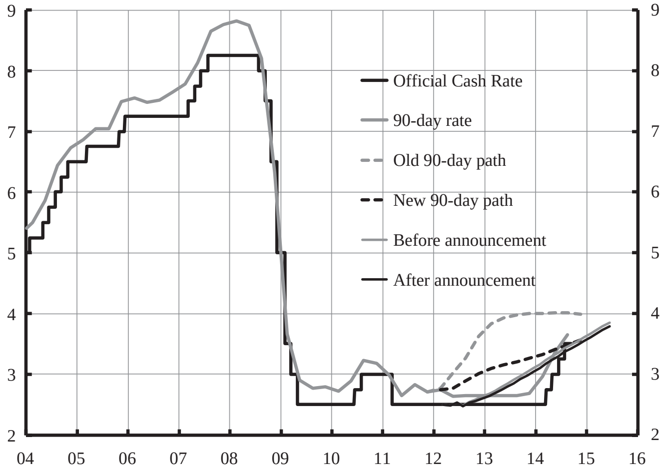
Source: The RBNZ.

market policy rate path, putting it significantly above the RBNZ ninety-day path. Thus, on this occasion, the *actual* financial conditions were substantially tighter than the *intended* ones.

Figure 18, from December 2011, gives an example of how the published ninety-day path has low credibility and that the actual financial conditions are much easier than the intended ones. Furthermore, figure 19 shows that the market seemed to anticipate quite well that a lower policy rate path and easier intended policy would be implemented in March 2012. During this time, all the action was in the RBNZ ninety-day path and market policy rate paths, because the policy rate was kept unchanged at 2.5 percent.

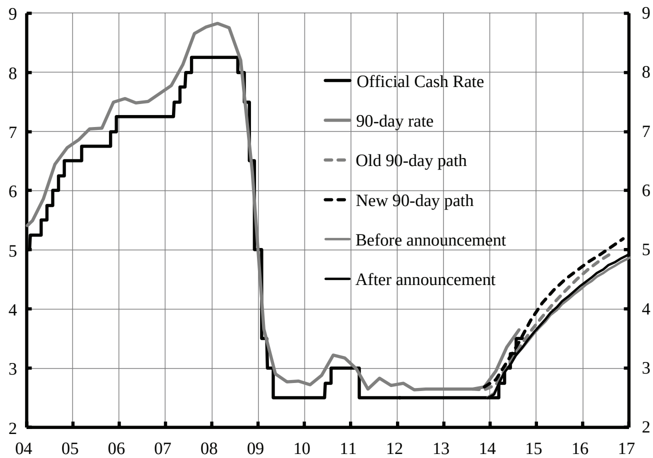
In figure 20, from December 2013, we again see an example of the RBNZ ninety-day path being well anticipated before the announcement and quite credible after the announcement.

Figure 19. The Policy Rate, the Ninety-Day Rate, the New and Old Ninety-Day Path, and the Market Policy Rate Paths Before and After the Announcement, March 2012



Source: The RBNZ.

Figure 20. The Policy Rate, the Ninety-Day Rate, the New and Old Ninety-Day Path, and the Market Policy Rate Paths Before and After the announcement, December 2013



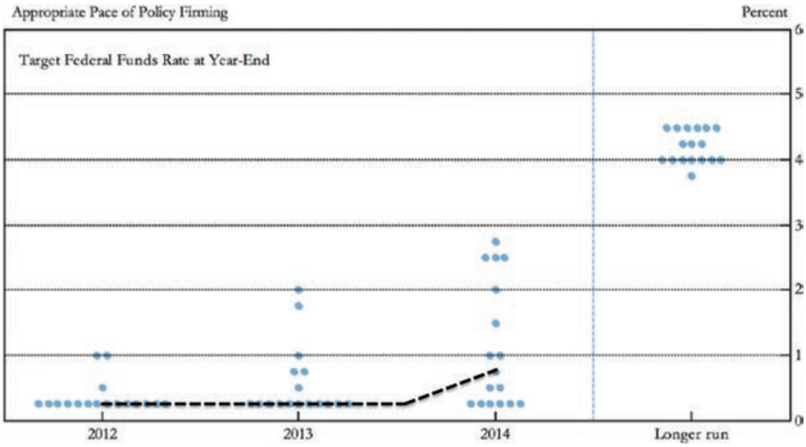
Source: The RBNZ.

7. The U.S. Experience

The FOMC has used verbal forward guidance about its likely future policy settings at various times in the past. As discussed by Williams (2012), in the summer of 2011 that forward guidance became more explicitly a tool to influence expectations of the future path of the policy rate and thereby longer-term interest rates and financial conditions. As an example, in August 2011, the FOMC stated that it "anticipates that economic conditions . . . are likely to warrant exceptionally low levels for the federal funds rate at least through mid-2013." This statement thus communicated that the FOMC was likely to keep the federal funds rate near zero for at least another two years, longer than many private-sector economists had been thinking. As a result, longer-term Treasury yields fell between 0.1 and 0.2 percentage points, a substantial fall.

In January 2012, the FOMC started to provide more specific information about FOMC participants' assessments of the appropriate future policy rate setting, in the form of the dot plot in the Summary of Economic Projections (SEP) (Federal Open Market Committee 2012b, figure 2, lower panel). It is shown in figure 21 (the dashed black line has been added and is discussed below). Each dot in the lower panel indicates the value (rounded to the nearest 1/4 percent) of an individual FOMC participant's judgment of the appropriate level of the target federal funds rate at the end of the specified calendar year or over the longer run. In figure 2 in the SEP, the upper panel (not shown in figure 21) shows the number of FOMC participants who judge that, under appropriate monetary policy and in the absence of further shocks to the economy, the first increase in the target federal funds rate from its current range of 0 to 1/4 percent will occur in the specified calendar year. This upper panel shows that the median of the participants' assessments in January 2012 of the date of the first rate increase was sometime in 2014. From this information and the dot plot, one can construct the participants' median policy rate path as the dashed black line in figure 21. One can interpret this policy rate path as the result of a hypothetical simultaneous vote among the participants about the appropriate federal funds target at the end of each specified year. Furthermore, I let the median of the assessments of the date of the first rate increase in 2014 be represented by an assumed

Figure 21. The FOMC Participants' Assessment of Appropriate Monetary Policy and Their Median Policy Rate Path, January 2012



Source: The FOMC and own calculations.

such date in mid-2014. (Note that the year labels on the horizontal axis in figure 21 refer to the *end* of the specified year, so mid-2014 corresponds to a point between the labels 2013 and 2014 in the figure.)

The FOMC *participants* consist of the Federal Reserve Board members and the twelve Federal Reserve Bank presidents. The FOMC *members* consist of the *voting* subset of the FOMC participants, that is, the Federal Reserve Board members and the seven voting Federal Reserve Bank presidents. The median of the members' assessments is arguably more relevant for actual policy decisions than the median of the participants' assessment. Furthermore, one may want to take into account the fact that different Federal Reserve Bank presidents vote each year. However, the information in the dot plot does not allow the median of the members' assessment to be calculated. A study of FOMC participants' speeches and announcements would allow several of the dots to be associated with specific members and go some way towards the calculation of the median of members' assessment. Furthermore, some members' votes, in particular the Chair's, may carry more weight than the other votes. A further refinement could take that into account, if the corresponding dots could be identified.

Furthermore, the dot plot reports the FOMC participants' *individual* assessments of the appropriate future policy rate setting, not the committee's *joint* assessment.[15] Similarly, the plots with real GDP growth, unemployment, and personal consumption expenditures (PCE) inflation in the SEP report the central tendencies and ranges of each participant's individual projection based on his or her assessment of the appropriate monetary policy. Thus, the SEP does not report a joint committee forecast of inflation, unemployment, and the policy rate similar to the forecasts reported by the Riksbank or the RBNZ. This obviously means that the median projections of inflation, unemployment, and the policy rate in the SEP may be less internally consistent than the forecasts reported by the Riksbank and the RBNZ.

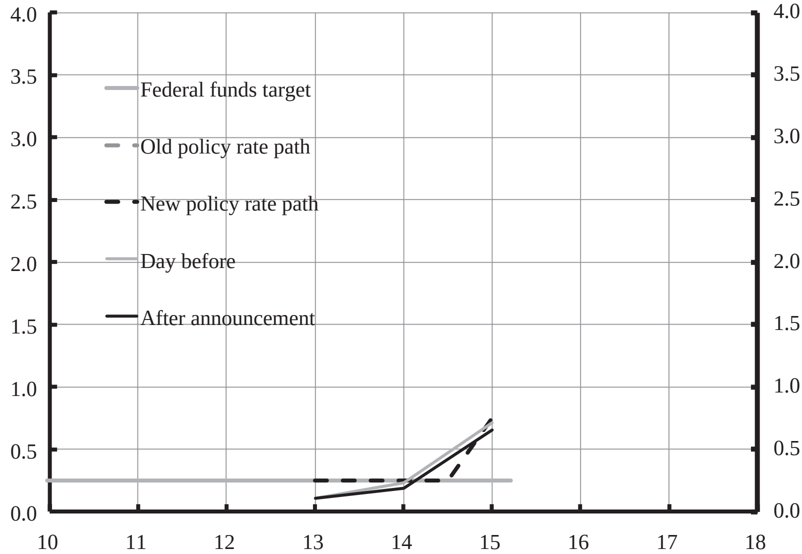
Figure 22 shows the federal funds target (plotted at 0.25 percent, the upper limit of the range 0 to 0.25 percent) up to early 2015, the policy rate path of January 2012 constructed as above, and the market policy rate paths the day before and after the announcement. (Note that the year labels on the horizontal axis in figure 22 refer to the *beginning* of the specified year, so mid-2014 here corresponds to a point between the labels 2014 and 2015 in the figure.) The market policy rate paths are constructed from overnight index swaps (OIS) rates for the end of the specified year. We see that this first dot plot of January 2012 implies a median policy rate path that was reasonably well anticipated by the market and reasonably credible with the market after the announcement.[16]

After this January 2012 publication, the FOMC have published these dot plots in the SEP in March, June, September, and December each year—that is, five plots in 2012 and four plots per year thereafter. An examination of the policy rate paths and the market policy rate paths before and after the announcement show that up through March 2013, the market expectations for the policy rate

[15] Also, because the dots in the dot plot are not connected, the dot plot does not report each participant's assessment of the appropriate *path* of the policy rate, only the appropriate separate *level* at the end of each year.

[16] See Bauer and Rudebusch (2014) for estimates of the market expectations of the date of the first rate increase.

Figure 22. The Federal Funds Target, the FOMC Policy Rate Path, and the Market Policy Rate Path Before and After the Announcement, January 2012



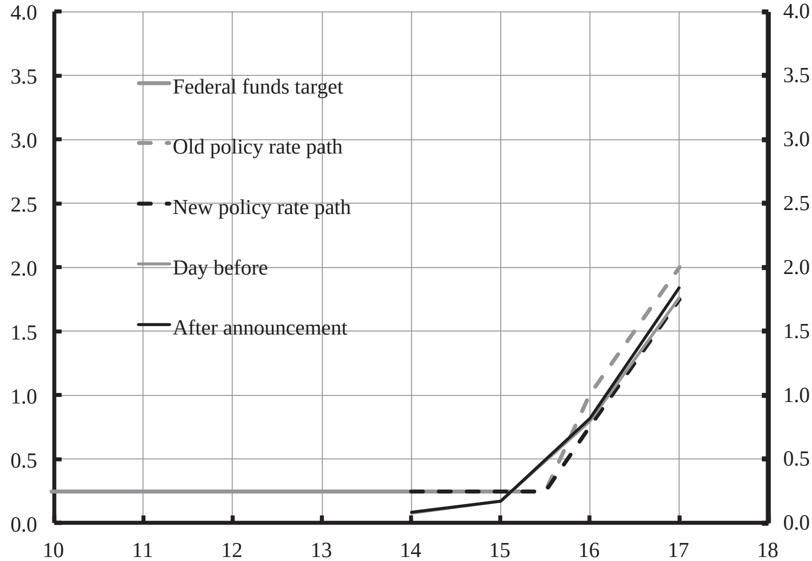
Source: Bloomberg, Haver Analytics, and own calculations.

at the end of 2015 were somewhat below the FOMC median policy rate.[17] After the so-called taper tantrum in May 2013, market expectations shifted up and were well aligned with the policy rate path from June through December 2013. Figure 23 shows the new FOMC policy rate path and the market policy rate paths before and after the announcement in December 2013 as well as the old policy rate path of September 2013. The market anticipated the new policy rate path very well and the new policy rate was highly credible after publication.

In March 2014, the policy rate path was shifted up, but market expectations stayed lower than the policy rate path. This discrepancy between the FOMC's median policy rate path and market

[17]Figures like figure 22 for all publication dates from January 2012 through March 2015 are available on my website, http://larseosvensson.se.

Figure 23. The Federal Funds Target, the New and Old FOMC Policy Rate Path, and the Market Policy Rate Path Before and After the Announcement, December 2013



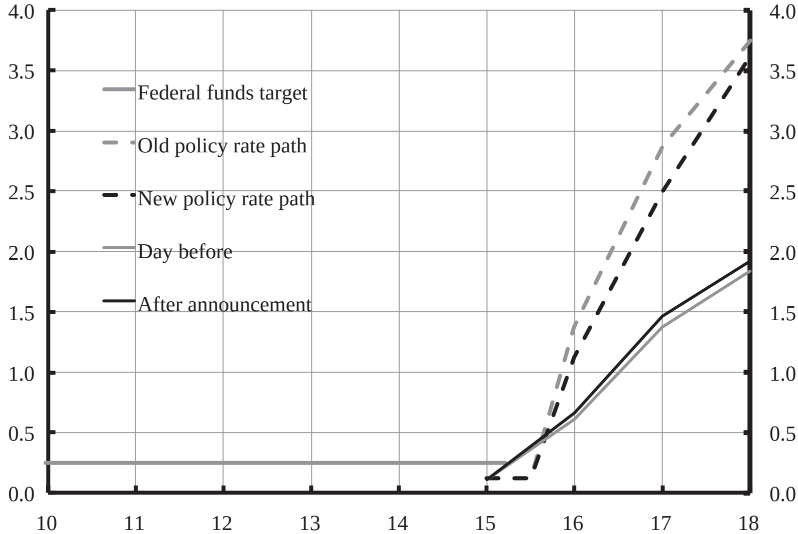
Source: Bloomberg, Haver Analytics, and own calculations.

expectations increased over the year and was quite large at the end of the year, in December 2014, as is shown in figure 24.[18]

As we can see, the December 2014 FOMC policy rate path reached a little above 3.5 percent at the end of 2017, whereas the OIS rate for the end of 2017 was a little below 2 percent, more than 150 basis points below the FOMC policy rate path. This large discrepancy between the participants' median policy rate path and the market policy rate path has been much noted and discussed recently (for instance, Christensen and Kwan 2014, Dudley 2015, Fleming and MacKenzie 2015, Wessel 2015, and Yellen 2015).

[18]From September 2014, the participants' assessments in the dot plot are rounded to the nearest 1/8 percent instead of the nearest 1/4 percent, making the policy rate start at 1/8 percent instead of 1/4 percent.

Figure 24. The Federal Funds Target, the New and Old FOMC Policy Rate Path, and the Market Policy Rate Path Before and After the Announcement, December 2014

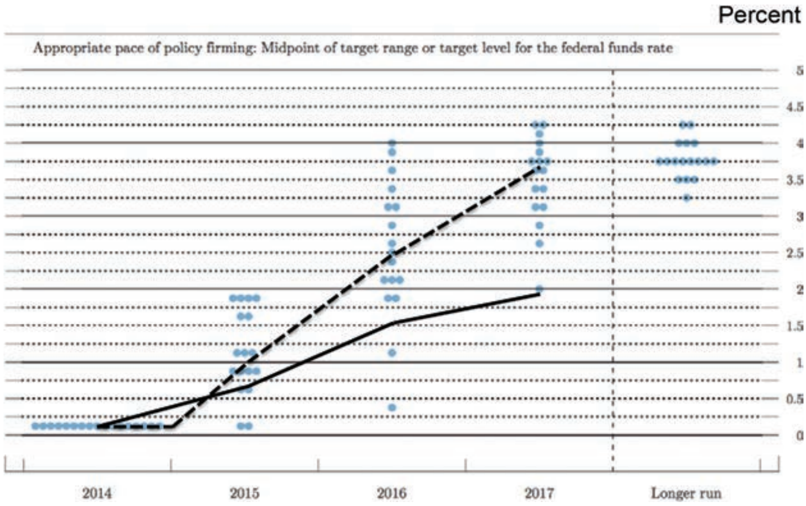


Source: Bloomberg, Haver Analytics, and own calculations.

Possible explanations suggested for the discrepancy include that the market may judge that some of the highest dots belong to non-voting participants and that the Chair's arguably more weighty dots may be below the median.

Figure 25 shows the December 2014 dot plot together with the median policy rate path and the market policy rate path as of December 2014 (the paths are plotted under the convention that the location of the year labels corresponds to the end of the specified year, so mid-2014 corresponds to the midpoint between the labels 2014 and 2015). We see that all dots for the end of 2017 except the lowest dot lie well above the market expectations (the OIS rate in December 2014 after publication, for the end of 2017). Thus, the discrepancy cannot be explained by the market inferring that the median of the voting members' assessments would be lower than that of the participants' assessments, or that a weighted median with more weight for the Chair would be lower (except in the extreme

Figure 25. The FOMC Participants' Assessment of Appropriate Monetary Policy, Their Median Policy Rate Path, and the Market Policy Rate Path after the Announcement, December 2014



Source: Bloomberg, the FOMC, and own calculation.

case that the lowest dot is considered to be the Chair's and *all* the weight is given to that one).

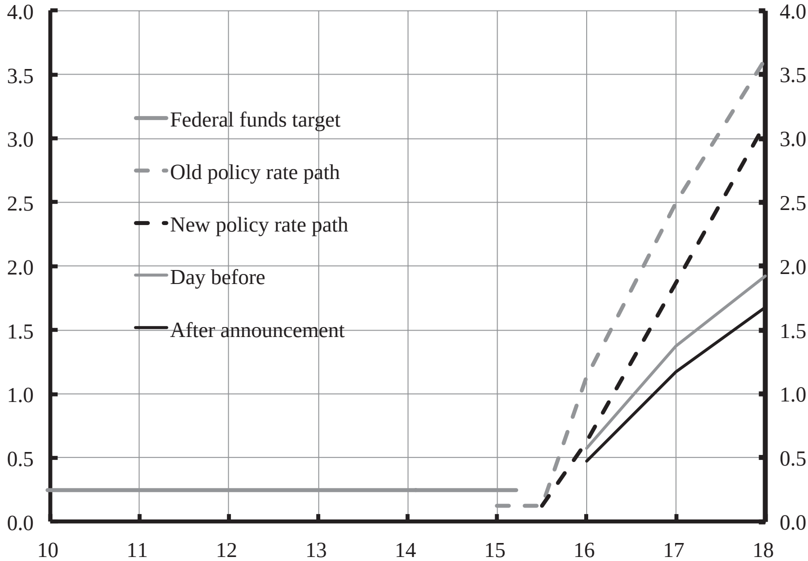
It may also be the case that the market is more pessimistic about the outlook for the U.S. economy than the FOMC participants, or that the market's estimate of the neutral (natural, equilibrium) interest rate is lower than the FOMC participants'. Federal Reserve Board Chair Yellen (2015) observes that many market participants appear to be more pessimistic than the FOMC participants about the outlook for the U.S. economy and notes that respondents to the Survey of Primary Dealers in late January thought that there was a 20 percent probability that, after the date of the first rate increase, the federal funds rate would fall back to zero sometime at or before late 2017 (Federal Reserve Bank of New York, Markets Group 2015). She also notes that the remarkably low level of long-term government bond yields in advanced economies suggests that financial markets place considerable odds on adverse scenarios that would necessitate a lower and flatter path for the federal funds rate than envisioned in the FOMC participants' projections.

The fact that market expectations are lower than the FOMC's policy rate path implies that the market yield curve is lower than a yield curve consistent with the FOMC's forward guidance. As discussed above for Sweden and New Zealand, this means that the *actual* monetary policy implemented by the market is more expansionary than the monetary policy *intended* by the FOMC. Furthermore, forward rates at long time horizons are significantly lower than the FOMC's median longer-run policy rate at 3.75 percent. Federal Reserve Bank President Dudley (2015) has concluded that this may warrant a more aggressive path of policy normalization:[19]

> One significant conundrum in financial markets currently is the recent decline of forward short-term rates at long time horizons to extremely low levels—for example, the 1-year nominal rate, 9 years forward is about 3 percent currently. My staff's analysis attributes this decline almost entirely to lower term premia. In this case, the fact that market participants have set forward rates so low has presumably led to a more accommodative set of financial market conditions, such as the level of bond yields and the equity market's valuation, that are more supportive to economic growth. If such compression in expected forward short-term rates were to persist even after the FOMC begins to raise short-term interest rates, then, all else equal, it would be appropriate to choose a more aggressive path of monetary

[19] Dudley is making these comments in the context of his criticism of a mechanical instrument rule such as a Taylor rule. He mentions the discrepancy between the FOMC's forward guidance and market expectations as an example of the loose relation between the federal funds rate, financial conditions, and economic outcomes, making the use of a mechanical instrument rule inappropriate. I have criticized Taylor rules and other instrument rules myself (for instance, in Svensson 2003), arguing that the use of judgments is a necessary input in good monetary policy. This precludes the reliance on mechanical instrument rules such as the Taylor rule and instead justifies the use of targeting rules and forecast targeting (choosing the policy rate and the policy rate path such that the forecasts of the target variables "look good," where "looking good" means stabilizing inflation around the inflation target and resource utilization around a long-run sustainable rate.

Figure 26. The Federal Funds Target, the New and Old FOMC Policy Rate Path, and the Market Policy Path Before and After the Announcement, March 2015



Source: Bloomberg, Haver Analytics, and own calculations.

policy normalization as compared to a scenario in which forward short-term rates rose significantly, pushing bond yields significantly higher.

Because at the time of writing (March 2015) inflation and inflation forecasts are low relative to the target and unemployment, and unemployment forecasts are not very low relative to a long-run sustainable unemployment rate (especially when possible additional slack is indicated by an involuntary part-time work and a cyclical part of the participation rate), it seems that the U.S. economy is far from any risk of overheating (Evans 2015). Given this, it may perhaps be a good thing and contribute to better target achievement if actual monetary policy is looser than the FOMC participants' policy rate path.

As shown in figure 26, at the FOMC meeting in March 2015, the median FOMC policy rate path shifted down considerably, that is, towards the market policy rate path. The market policy rate path also shifted down, but less. Thus, the discrepancy between the FOMC path and the market path shrank a bit, but it remained substantial. The fact that two FOMC members known to favor higher policy rates had retired from the FOMC before the March meeting may explain part of the shift down but not all. Somewhat weaker data has probably contributed. Nevertheless, the market is still expecting and implementing a substantially more expansionary monetary policy than is consistent with the FOMC policy rate path.

8. Conclusions

I believe there are good reasons why forward guidance in the form of publishing a policy rate path has become a normal part of flexible inflation targeting for several central banks. These reasons have been listed above under the headings of transparency, effectiveness, informativeness, justification, and accountability of monetary policy. In this paper, I have assessed the predictability of monetary policy and the credibility of the policy rate path for the Riksbank, the RBNZ, and the Federal Reserve. Here, predictability of monetary policy refers to the extent to which the market anticipates the central banks' policy rate path, and credibility of the policy rate path refers to the extent to which market expectations line up with central bank policy rate path after the publication.

The Swedish experience of publishing a policy rate path has been quite dramatic and special in recent years. In spite of very difficult circumstances during the crisis, in February 2009, the market anticipated a big downward shift in policy rate path quite well, and after publication the market expectations of the future policy rate lined up quite well with the published policy rate path. In contrast, in September 2011, the Riksbank published a high and increasing policy rate path that was completely disregarded by the market. Market expectations before and after publication instead indicated a fall in the policy rate, expectations that predicted the actual outcome of the policy rate very well. This means that the *actual* monetary policy that the market implemented through its actual yield curve was much easier than *intended* monetary policy, the yield curve consistent with the Riksbank policy rate path. The market apparently predicted that the Riksbank would have to make a major policy shift towards easier policy.

This very special situation can be understood with reference to the aggressive leaning against the wind and policy tightening that the Riksbank initiated in June/July 2010, because of concerns about household debt. A high policy rate and policy rate path effectively got priority over the standard objectives of flexible inflation targeting, that is, stabilizing inflation around the inflation target and resource utilization around its long-run sustainable path. High difficult-to-justify Riksbank forecasts of foreign policy rates contributed to supporting a high policy rate path but caused a strong positive bias in Riksbank inflation forecasts. As a result of the Riksbank's leaning against the wind, inflation had fallen much below the target and unemployment remained high and much above its long-run sustainable rate. The Riksbank was then forced to lower the policy rate all the way down to the negative range.

The New Zealand experience is much less dramatic. Monetary policy has been better focused on the standard monetary policy objectives. In many cases the market has anticipated the RBNZ policy rate path quite well, and market expectations have lined up well with the path after publication. There are cases when the market has implemented a substantially tighter policy than the one consistent with the RBNZ policy rate path. There are also cases when the market has implemented a much easier policy—for instance, in December 2011. Furthermore, on that occasion the market seems to have been well ahead of the RBNZ, in the sense that the RBNZ in March 2012 followed the market by shifting down its policy rate path to line up well with the market expectations.

The U.S. experience of a published policy rate path in the form of the dot plot is quite short, starting in January 2012. The dot plot reports each FOMC participant's assessment of appropriate monetary policy rather than a joint committee projection. If the median of the dot plot nevertheless is interpreted as an approximation to a joint committee projection and an FOCM policy rate path, the U.S. experience includes cases where the market has anticipated the FOMC path quite well and market expectations have lined up well with the path after publication. More recently, the market path lies significantly below the FOMC path and the market is thus implementing a significantly easier policy than what is consistent with the

FOMC path. The reasons for this discrepancy between the FOMC and market paths have been much discussed, but no consensus about the reasons have been reached at the time of writing. Thus far during the short U.S experience, there is no case when the actual financial conditions implemented by the market have been tighter than what is consistent with the FOMC participant's policy rate path.

Even though the New Zealand and U.S. experiences are less dramatic than the Swedish one, it may certainly be interesting and worthwhile to examine more closely what particular circumstances explain when the policy rate path was well anticipated and when it was not, and when the published path was credible after publication and when it was not. This may help in improving the effectiveness and informativeness of the policy rate path.

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Trend Inflation in Advanced Economies*

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We derive estimates of trend inflation for fourteen advanced economies from a framework in which trend shocks exhibit stochastic volatility. The estimated specification allows for time variation in the degree to which longer-term inflation expectations are well anchored in each economy. Our results bring out the effect of changes in monetary regime (such as the adoption of inflation targeting in several countries) on the behavior of trend inflation.

Our estimates represent an expansion of those in the previous literature along several dimensions. For each country, we employ a multivariate approach that pools different inflation series in order to identify their common trend. In addition, our estimates of the inflation gap (that is, the difference between trend and observed inflation) are allowed to exhibit considerable persistence—a treatment that affects the trend estimates to some extent. A forecast evaluation based on quasi-real-time estimates registers sizable improvements in inflation forecasts

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at different horizons for almost all countries considered. It remains the case, however, that simple random-walk forecasts of inflation are difficult to outperform by a statistically significant amount.

JEL Codes: C53, E37, E47, E58.

1. Introduction

Measures of trend inflation play an important role in the study of inflation in many countries. In the context of policy analysis, the level and variability of trend inflation can be viewed as summaries of the degree to which inflation expectations in a particular country have remained anchored over time. Application of New Keynesian analysis to inflation data over long samples may also benefit from the availability of estimates of trend inflation, as the New Keynesian approach to the Phillips curve typically specifies inflation dynamics in terms of the deviation of inflation from a steady-state or trend-inflation rate, with this trend rate possibly varying over time (see, for example, Cogley and Sbordone 2008). Furthermore, an estimate of trend inflation can serve as a useful centering point in the construction of inflation forecasts at various horizons. Still another reason for interest in estimates of trend inflation is the fact that the existing literature has found that a substantial portion of the observed persistence of international inflation data is accounted for by variations in trend inflation, which are in turn often related to changes in monetary regimes; see, for example, Levin and Piger (2004), Cecchetti et al. (2007), Ireland (2007), Stock and Watson (2007, 2010), Wright (2011), and Morley, Piger, and Rasche (2015).

In this paper, we provide estimates of the level of, and time-varying uncertainty of, trend inflation for fourteen advanced economies. The estimates are derived from a multivariate statistical model that pools information from different inflation series for each country. The model is applied on a country-by-country basis.[1] Our motivation for this choice is twofold. First, the country-by-country approach is most amenable to a comparison, for the full sample

[1]This approach contrasts with the procedure of pooling information across countries, as in Mumtaz and Surico (2009, 2012), Ciccarelli and Mojon (2010), and Mumtaz, Simonelli, and Surico (2011), for example.

period as well as for subsamples, of alternative models of trend. Second, although there are clearly some cross-country co-movements in overall inflation, the reason that inflation rates move together across countries does not appear to lie solely in common behavior of the trend component of a "trend/cycle" decomposition—a complication that is underscored in, for example, Ciccarelli and Mojon's (2010) analysis of cross-country inflation behavior. On this score, our results confirm that there do, in fact, tend to be considerable differences across countries in estimates of trend inflation, very likely reflecting country-specific developments in monetary regimes.

Formally, we adopt the definition of trend inflation as the infinite-horizon forecast of inflation. This trend definition corresponds to the Beveridge-Nelson (1981) concept. This concept has been applied to inflation data in a number of studies, including Cecchetti et al. (2007), Stock and Watson (2007, 2010), Clark and Doh (2011), Cogley, Sargent, and Surico (2014), Cogley and Sargent (2015), and Morley, Piger, and Rasche (2015), with variants of the approach also employed by Cogley and Sargent (2005), Cogley, Primiceri, and Sargent (2010), and Kozicki and Tinsley (2012).[2] Our multivariate model incorporates the assumption that, for any particular country, different inflation measures share the same common trend. Specifically, we consider percentage changes in core and headline CPI, as well as percentage changes in the GDP deflator, proceeding throughout on the premise that the deviations that these inflation series exhibit from the common trend are dynamically stable.

Our multivariate model, designated the "MVSV" model, nests the popular unobserved-components model with stochastic volatility, designated the "UCSV" model, of Stock and Watson (2007, 2010) that has been applied to inflation data for the G7 countries by Cecchetti et al. (2007). The application of a multivariate extension of the UCSV model to different countries, and the comparison between UCSV and MVSV models across these economies, constitute specific

[2]Cogley and Sargent (2005) and Cogley, Primiceri, and Sargent (2010) derive their measure of trend inflation from a non-linear function of time-varying VAR coefficients, a measure that approximately corresponds to a Beveridge-Nelson (1981) trend. Kozicki and Tinsley (2012) refer to their measure as the "shifting endpoint of inflation expectations." In a similar spirit, Levin and Piger (2004) relate time variation in inflation persistence to structural breaks in the coefficients of autoregressive time-series representations of inflation.

contributions of this paper. The multivariate model used in this paper represents an extension of the UCSV approach along two dimensions. The first dimension pertains to our reliance on multiple inflation series: as in Mertens (2011), the model extracts its trend estimates from a set of inflation series, instead of drawing information from a single inflation measure. The second dimension pertains to the treatment of the difference between trend and observed inflation—the *inflation gap*, in the terminology of Cogley, Primiceri, and Sargent (2010). Inflation-gap fluctuations are assumed to be serially uncorrelated in the UCSV model. In contrast, we allow the inflation gap to exhibit considerable persistence, while constraining the gap fluctuations to be dynamically stable, governed by a vector autoregression with time-invariant parameters. In this way, we allow for the possibility of persistence in the inflation gap, as in, for example, Kang, Kim, and Morley (2009) or Cogley, Primiceri, and Sargent (2010). Unlike these authors, however, we do not permit inflation-gap persistence to vary over time. The more parsimonious approach to the treatment of inflation-gap persistence that we adopt has advantages that we discuss below.

As in the UCSV model, we keep track of different measures of stochastic volatility that affect different components of the inflation process: one for trend shocks and one capturing changes in gap volatility for each of the different inflation measures used in our multivariate model. Although we allow for time-varying persistence in each inflation measure by letting the magnitude of shocks to the inflation trend and gap vary, we have also chosen to keep the coefficients governing inflation-gap persistence constant in order to limit time variation in model parameters. Such a restriction is especially warranted in view of the fact that we lack observations on several input series in the earlier part of our sample.

In the spirit of the UCSV model, our procedure does not involve taking a stand on the issue of potential statistical linkages between inflation and other economic variables. For example, we do not investigate connections between persistent behavior of inflation and persistence in resource slack (such as those considered in, for example, Morley, Piger, and Rasche 2015). In so limiting the scope of our analysis, we in no way deny that such linkages are of economic interest. On the contrary, real/nominal interactions are crucial to monetary policy analysis. But trend estimates of the kind we derive are closely related to a model's forecasting properties, and the contribution that real variables make to the forecasting of inflation has frequently been established to be modest—as documented in, for example, Stock and Watson (2009) and Faust and Wright (2013). Accordingly, attention is confined here to models of the inflation process that do not draw upon data other than on inflation. Therefore, when we speak of our estimates being "multivariate," we mean that we use multiple measures of inflation in estimation; we do not use series other than inflation to inform our estimates.[3]

Because our estimation relies on state-space methods and involves a limited number of time-varying parameters, we can handle cases in which observations are missing for particular inflation series. Throughout our estimation, we use data beginning in 1960. Associated with this early start date for the sample is the fact that, for some countries, subsets of the series used may have missing observations, reflecting a later initial date for those series or other data-availability problems. In addition to providing estimates that take this data issue into account, we also consider estimates that are conditioned on data sets for which available observations on inflation have been discarded for certain dates for judgmental reasons. These reasons reflect our concern that the variations in inflation recorded in certain periods arose from "price shifts," with the latter attributable to non-market factors—such as outright governmental price controls or tax changes that bore directly on measured inflation. In taking this approach regarding price shifts, we expand on a number of earlier studies, including Gordon (1983), Levin and Piger (2004), Neiss and Nelson (2005), and Morley, Piger, and Rasche (2015), to name only a few.[4] In comparing estimates with and without allowance for price shifts, we find that the shifts tend to have an

[3]We believe, however, that the approach to the data we take here has elements that could be usefully applied to the study of the inflation/resource slack connection. For example, our concern with controlling for episodes in which price controls distorted measured inflation series is highly relevant for the task of obtaining valid estimates of the inflation trend in a context in which resource-slack series are among the variables used in the computation of the trend.

[4]Cecchetti et al. (2007, p. 14) adjusted their data on real GDP growth for France for a strike-affected observation. In so doing, they recognized the principle that disruptions to market activity should not be permitted to affect trend estimates. They did not, however, apply this principle to their estimation of trend inflation.

appreciable effect on trend estimates—especially so for the UCSV model—a result that suggests that the shift-affected inflation observations should be excluded when estimating trend inflation. On the other hand, our multivariate estimates of the inflation trend show signs of being more robust to the inclusion of such periods in the estimation.

Finally, we compare the forecast performance of our multivariate model with that of the UCSV model and (as in Atkeson and Ohanian 2001) random-walk forecasts of inflation, in a context of quasi-real-time forecasts from 1985 through 2013. Across forecast horizons ranging from one quarter to sixteen quarters ahead, our multivariate extensions generally deliver lower root mean squared errors (RMSEs) for predictions of inflation, in some cases by 20 percent or more. The improvements are, however, statistically significant in only a few instances—perhaps most notably in the case of medium-term inflation forecasts for the United States.

The remainder of this paper proceeds as follows. Section 2 describes our data set of fourteen industrialized countries. Section 3 lays out the empirical models used throughout the paper. Section 4 presents estimates for level and variability of trend inflation derived from univariate and multivariate models. Section 5 reviews periods in which price shifts occurred and their influence on the estimates. Section 6 evaluates quasi-real-time estimates of trend inflation derived from the UCSV model and our preferred MVSV alternative, and section 7 analyzes the forecast performance of our model in “quasi-real time.” Section 8 concludes the paper.

2. International Inflation Data

Our data set consists of quarterly inflation series for fourteen developed countries from 1960:Q1 through 2013:Q4. Whenever data availability permits, we have used three different inflation measures for each country: headline CPI, core CPI, and the GDP deflator, all computed as annualized quarterly log-differences. Details on the available data for each country are provided in table 1. CPI data, including the core CPI series (typically defined as the CPI excluding prices of food and energy) are obtained from the Main Economic

Table 1. Data Overview

Inflation Rates			
Country	**Headline CPI**	**Core CPI**	**GDP Deflator**
Australia	1960:Q1	1976:Q3	1960:Q1
Belgium	1960:Q1	1976:Q3	1980:Q1
Canada	1960:Q1	1961:Q1	1960:Q1
France	1960:Q1	1960:Q1	1960:Q1
Germany	1960:Q1	1962:Q1	1960:Q1
Ireland	1960:Q2	1976:Q1	1980:Q1
Italy	1960:Q1	1960:Q1	1960:Q1
Japan	1960:Q1	1970:Q1	1960:Q1
New Zealand	1960:Q1	1969:Q1	1987:Q2
Spain	1960:Q1	1976:Q1	1970:Q1
Sweden	1960:Q1	1970:Q1	1980:Q1
Switzerland	1960:Q1	1960:Q1	1970:Q1
United Kingdom	1960:Q1	1970:Q1	1960:Q1
United States	1960:Q1	1960:Q1	1960:Q1

Inflation Goals		
Country	**Inflation Goal**	**Dates**
Australia	2.0–3.0	1993:Q2[a]–EOS
Canada	2.0	1991:Q1–EOS
Euro Area[b]	2.0	1998:Q2–EOS
New Zealand	3.0–5.0	1990:Q1–1990:Q4
	1.5–3.5	1991:Q1–1991:Q4
	0.0–2.0	1992:Q1–1996:Q4
	0.0–3.0	1997:Q1–2001:Q4
	1.0–3.0	2002:Q1–EOS
Spain	3.0	1994:Q4–1998:Q1
Sweden	2.0 ± 1	1993:Q1–EOS
Switzerland	< 2.0	2003:Q3–EOS
United Kingdom	2.5	1992:Q4–2003:Q3
	2.0	2003:Q4–EOS
United States	2.0	2012:Q1–EOS

[a]Some sources (for example, Bernanke et al. 1999) give a later date for the inception of inflation targeting in Australia.
[b]Belgium, France, Germany, Ireland, Italy, and Spain have all been euro-area countries since the currency area's inception.
Notes: The model uses quarterly observations from 1960:Q1 through 2013:Q4. Countries with inflation goals continuing through the end of the sample are marked with "EOS." All inflation series are annualized and expressed as log-changes. Section 2 provides more information on the data sources.

Indicators database produced by the OECD.[5] With a few exceptions, GDP deflator data are obtained from the International Financial Statistics (IFS) electronic database maintained by the International Monetary Fund.[6]

Following Faust and Wright (2013), we applied the X-12-ARIMA filter, maintained by the U.S. Census Bureau, to each inflation series analyzed in this paper.[7] The GDP deflator data tended to display strong seasonal components—notwithstanding the label “seasonally adjusted.”[8] As a precaution, therefore, we ran the filter over these series.

We have also obtained results with an alternative CPI series for the United States, the “Consumer Price Index Research Series Using Current Methods” (CPI-U-RS). In common with the standard CPI measure for the United States, this alternative series has been constructed by the Bureau of Labor Statistics. In contrast to the regular CPI, whose values do not undergo historical revisions as official measurement procedures change, the CPI-U-RS applies current methods backward to 1978. We use the latest available version at the time of our study, giving us data through the end of 2013. Our trend estimates for the United States are not appreciably altered by the use of this series, and we defer a summary of our results using the CPI-U-RS to section 7.

For many countries, our estimation sample encompasses periods over which recorded price series were likely significantly distorted

[5]The only exception pertains to the data for Ireland’s headline CPI, which were compiled from the International Monetary Fund’s International Financial Statistics electronic database.

[6]In the case of Sweden, the source is the OECD’s Main Economic Indicators. GDP deflators for Italy and Japan in IFS exhibited rebasing problems, so deflator series from Stock and Watson (2003) starting in 1960:Q1 were spliced together with IFS data from 2000:Q1 to 2013:Q4. Conefrey Thomas and Stefan Gerlach kindly supplied us with data for Ireland’s GDP deflator for the period 1980–1997, a sample that precedes the series’ commencement in the IFS database.

[7]Complete documentation on the X-12-ARIMA seasonal adjustment program can be found in “X-12-ARIMA Reference Manual, Version 0.3, February 28, 2011” at http://www.census.gov/srd/www/x12a/. The filter is implemented in IRIS (an open-source toolbox for MATLAB), which can be obtained from http://www.iris-toolbox.com.

[8]Stock and Watson (2003, p. 803) report the same phenomenon in their study of international data.

by non-market forces, like government-imposed price controls and major changes in indirect taxes.[9] We discuss these episodes, and their effects on our estimates, in detail in section 3. An overview of these "price-shift" dates is given in table 2.

3. Model Description

Our paper uses two different statistical models for the estimation of measures of trend levels and variability and to construct inflation forecasts. Both models rest on time-series approaches that deploy the same trend concept. The models mainly differ in the data on which their estimates are conditioned. The first model is the univariate, "UCSV," model of Stock and Watson (2007, 2010), which is applied to data for each country's CPI inflation (i.e., the headline rate). The second model is a variant of the multivariate common-trend model of Mertens (2011), which we estimate using data on three inflation series for each country, employing headline and core CPI inflation as well as percentage changes in the GDP deflator. Both models utilize the trend concept of Beveridge and Nelson (1981), as discussed presently, and both allow for time-varying volatility in trend shocks. The UCSV model embeds the assumption that deviations between actual inflation and trend have no persistence. In contrast, the multivariate model uses a (time-invariant) vector autoregression to describe the dynamics of deviations between inflation and its trend.

Throughout this paper, we employ a statistical "trend/cycle" decomposition of inflation into a trend level, τ_t, and inflation gap, $\tilde{\pi}_t$. In the tradition of Beveridge and Nelson (1981), the inflation trends that we consider correspond to long-run—that is to say, distantly

[9] Some dates were excluded only from the GDP deflator series because of rebasing errors. The series for Belgium, Canada, Germany, Italy, Spain, and Switzerland all included large, discrete escalations in the price level that are not present in corresponding data reported in other studies such as Stock and Watson (2003). These data points are not included in any of the estimation results below. The dates for which observations are omitted from all estimations are 1966:Q1 (Italy), 1981:Q1 (Spain), 1991:Q1 (Germany), 1995:Q1 (Canada), and 1999:Q1 (Belgium and Spain).

Table 2. Omitted Price-Shift Dates

Country	Date	Event
Australia	1975:Q3	Universal Health Insurance[a]
	1975:Q4	Sales Tax Increase[a]
	1976:Q4	Removal of Universal Health Insurance[a]
	1984:Q1	Medicare Introduction[a]
	2000:Q3	GST Introduction[b]
Canada	1991:Q1	GST Introduction[b,c]
	1994:Q1–1994:Q2	Cigarette Tax Change[b,c]
France	1963:Q3–1963:Q4	Price Freeze and Strict Controls[d]
	1969:Q3–1969:Q4	Price Freeze[d]
	1973:Q1	VAT Decrease[d]
	1976:Q4	Price Freeze[d]
	1977:Q1	VAT Decrease[d]
	1995:Q3	VAT Increase[d]
	2000:Q2	VAT Decrease[d]
Germany	1991:Q1–1991:Q4	Reunification[b]
	1993:Q1	VAT Increase[b]
Ireland	1975:Q3	Indirect Tax Cut[e]
	2012:Q1	VAT Increase[f]
Japan	1997:Q2	Consumption Tax Increase[b]
New Zealand	1982:Q3–1984:Q3	Price Controls[e]
	1986:Q4	GST Introduction[b]
	2010:Q4	GST Introduction[e]
Spain	2012:Q3	VAT Increase[f]
Sweden	1990:Q1	VAT Increase[b]
	1991:Q1	VAT Increase[b]
United Kingdom	1972:Q4–1974:Q2	Price Controls[a]
	1979:Q3	VAT Increase[a]
	1990:Q2	Poll Tax Introduction[b]
	1991:Q2	VAT Increase[g]
United States	1971:Q3–1974:Q2	Nixon Price Controls[h]

[a]Neiss and Nelson (2005).
[b]Levin and Piger (2004, table A2).
[c]We do not include Canada's controls program of 1975–8 among our price-shift dates, on the grounds that that regime was primarily one of wage control (see Braun 1986, pp. 48, 244).
[d]Our dates for France price control are derived from the accounts in Berstein (1993, p. 119), Braun (1986, p. 43), Salin and Lane (1977, p. 577), and Ungerer (1997, p. 61).
[e]From our own analysis of news records.
[f]Klitgaard and Peck (2014).
[g]Debelle and Wilkinson (2002).
[h]Gordon (1983).

far-ahead—forecasts for the level of inflation.[10] As described below, the two models used in this paper differ in their implied dynamics for the inflation gap. In both models, the long-run forecast of inflation corresponds to the Beveridge-Nelson trend concept:

$$\pi_t = \tau_t + \tilde{\pi}_t \qquad \tau_t = \lim_{k\to\infty} E_t \pi_{t+k}. \tag{1}$$

As the trend is defined as a martingale, its law of motion is a random-walk process that cumulates (the current and past values of) serially uncorrelated disturbances $\overline{e_t}$:

$$\tau_t = \tau_{t-1} + \overline{e_t}. \tag{2}$$

This specification necessarily imparts a random-walk component to inflation. Whether this non-stationary component has appreciable effects on observed inflation dynamics depends on the relative magnitude of fluctuations in the inflation trend and the inflation gap. In this connection, we seek estimates that are well suited to environments in which inflation expectations are well anchored and trend changes are near zero, *as well as* episodes in which expectations became unhinged and trend changes were large. To that end, the random-walk disturbances are assumed to have stochastic volatility, with drifting log-variances, following the specification used, for example, by Cogley and Sargent (2005) as well as Stock and Watson (2007). That is,

$$\overline{e_t} \sim N\left(0, \overline{\sigma}_t^2\right) \qquad \log \overline{\sigma}_t^2 = h_t = h_{t-1} + \varphi_{\overline{h}} \xi_t \qquad \xi_t \sim N(0,1). \tag{3}$$

This trend definition is then embedded into two models of inflation dynamics, to which we now turn.

[10] In contrast to the original Beveridge-Nelson decomposition—and in keeping with the approach of Stock and Watson (2007)—our trend estimates are derived in the context of an unobserved-components model. In this class of models, the distinction between filtered and smoothed trend estimates—that is, the distinction between estimates that condition only on a *subset* of observations and those that condition on the full data sample—becomes highly relevant. For further discussion see, for example, Harvey (1989, ch. 6) and Morley (2011).

3.1 Univariate UCSV Model

The UCSV model of Stock and Watson (2007) takes the inflation gap as exhibiting no persistence and also embeds the principle that the gap is itself governed by a separate process for stochastic volatility. That is,

$$\tilde{\pi}_t \sim N\left(0, \tilde{\sigma}_t^2\right) \qquad \log \tilde{\sigma}_t^2 = \tilde{h}_t = \tilde{h}_{t-1} + \varphi_{\tilde{h}} \tilde{\xi}_t \qquad \tilde{\xi}_t \sim N(0,1). \quad (4)$$

Disturbances to the inflation trend and to the inflation gap, as well as the shocks to stochastic volatility, are assumed to be serially and mutually uncorrelated. Stock and Watson (2007) fix the volatility of shocks to the log-variance processes in gap and trend, $\varphi_{\bar{h}}$ and $\varphi_{\tilde{h}}$, to constant values—equal to 0.20 for both parameters, which is close to typical estimates obtained for U.S. data. We, however, estimate these two parameters, using a relatively loose prior as our starting point.[11]

3.2 Multivariate Model (MVSV)

As an alternative to the univariate UCSV model, we also study trend estimates derived from a multivariate model with stochastic volatility (MVSV), which jointly conditions on three inflation measures for each country. A variant of the model has been applied by Mertens (2011) to U.S. data. The model incorporates time-varying volatility in both the trend and the gap component of inflation; accordingly, it nests the UCSV case. In our application, the model uses observations on inflation in headline CPI, core CPI, and the GDP deflator—all stacked into a vector, Y_t—and applies a "trend/cycle" decomposition, along the lines of the UCSV model described above:

$$Y_t = \tau_t + \tilde{Y}_t \qquad \tau_t = \lim_{k \to \infty} E_t Y_{t+k}. \quad (5)$$

The key assumption underlying the multivariate model is that all variables in Y_t share the same common trend, with their trend

[11] Specifically, we specify an inverse-Wishart prior for each parameter with a mean equal to the Stock-Watson value of 0.2; for the gap and trend parameter, we use three and thirty degrees of freedom, respectively.

levels differing only up to a constant.[12] Crucially, trend changes in all three inflation measures are driven by a single shock, for which the stochastic-volatility behavior applies as in equation (4) above.

In contrast with the UCSV model, and in keeping with the more recent literature on estimation of inflation trends, inflation gaps are permitted to be persistent in the multivariate model, subject to the condition that the law of motion governing the inflation gap has convergent dynamics. Specifically, the inflation gaps are assumed to follow a dynamically stable VAR with constant parameters and constant correlations and a common volatility factor. That is,

$$A(L)\tilde{Y}_t = \tilde{e}_t \qquad \tilde{e}_t \sim N(0, \Sigma_t) \qquad \Sigma_t = L\,diag\widetilde{(\sigma_t^2)}\,L \tag{6}$$

$$\log \tilde{\sigma}_t^2 = \tilde{h}_t = (I - 0.951)^{-1}\tilde{h} + 0.95\tilde{h}_{t-1} + \Theta_{\tilde{k}}\tilde{\xi}_t$$

$$\tilde{\xi}_t \sim N(0,1), \tag{7}$$

where L is a lower triangular matrix of constant parameters and every element of the vector of log-variances $\tilde{h}_t$ follows a highly persistent AR(1) process, each with an autoregressive coefficient equal to 0.95, as indicated, but with correlated shocks.[13] The AR(1) specification for the variances was chosen over the random walk in light of the existence of extended periods, in the earlier part of our sample, of missing data for some of our input series; estimates obtained from a random walk would quickly lead to unbounded variance estimates over those periods.[14] Importantly, shocks to the

[12]Within the Y_t vector, *average* levels of trend inflation are allowed to differ in recognition of discrepancies across the various inflation series in the average rate (for example, the existence of a different mean rate for CPI inflation from that for GDP deflator inflation).

[13]The diagonal elements of L are normalized to unity, and the lower triangular elements have been assigned standard normal priors. Analogously to the UCSV model, the variance-covariance matrix of the stochastic volatility shocks has an invariant-Wishart prior with mean equal to $0.2^2 \cdot I$ and five degrees of freedom—this value for the degrees of freedom is the lowest possible value that ensures the existence of a prior mean for a 3x3 matrix of random variables, drawn from the inverse-Wishart distribution.

[14]Grassi and Proietti (2010) modify the UCSV model of Stock and Watson (2007) to permit an AR(1) specification for stochastic volatility, doing so in part on *a priori* grounds of the unattractiveness of the unboundedness associated with the random-walk model. Clark and Ravazzolo (2014) compare the forecasting performance of different specifications for stochastic volatility—including the cases of a random walk and an AR(1) process—for various macroeconomic variables.

individual gap volatilities are allowed to be correlated with one another. In many cases, our estimates will imply generally high levels of such cross-correlation. It will emerge, however, that, notwithstanding the substantial co-movement in gap volatilities, there are also notable episodes of *idiosyncratic* changes in volatility of a particular inflation-gap series. This phenomenon reflects the behavior of individual inflation measures, most particularly the GDP deflator inflation rate, which would not be adequately captured had we assumed a uniform pattern of behavior for the volatilities of the different inflation series for a particular country.

As in the UCSV model, shocks to the volatility of trend and gap components are assumed to be uncorrelated. The roots of the VAR polynomial $A(L)$ are required to lie outside the unit circle, thereby ensuring that the gaps exhibit convergent dynamic properties.[15] Shocks to the gap levels are allowed to be mutually correlated. However, in our baseline specification, all gap shocks are assumed to be *uncorrelated* with trend shocks.[16] The multivariate model therefore nests the UCSV model, at the same time extending it to multiple input series and persistent gap dynamics. Missing observations in Y_t are handled by casting the model in state-space form with (deterministic) time variation in measurement loadings. Instances of missing observations lead to the appropriate elements of Y_t being assigned a value of zero, and the same is true of their loadings on the model's states. See, for example, Mertens (2011) for details.

[15]The VAR coefficients have been assigned a prior distribution that is multivariate normal (subject to the stationarity constraint) and that is centered on a prior mean of zero. For the variances, we have experimented with several relatively small values. This is in order that most of the prior mass of the vector of VAR coefficients satisfies the stationarity constraint and to ensure convergence of the model estimates across all countries and all of the quasi-real-time estimation samples analyzed in sections 6 and 7 below. Results shown here were obtained from a multivariate normal prior for the VAR coefficients with mean zero, zero covariances, and prior volatilities equal to 0.20 for own-lag coefficients and 0.10 for all other coefficients. Although this prior is quite tightly centered on zero, our posterior estimates of the VAR coefficients imply substantial inflation-gap persistence, as shown below. Largely similar results were also obtained when the scale of prior volatilities was doubled.

[16]Mertens (2011) allows the shocks to trend and gap to be correlated in the MVSV case. For simplicity, however, we impose orthogonality between the two classes of shocks for both our UCSV and MVSV estimates.

3.3 Alternative Specifications of the Multivariate Model

We also considered several alternative specifications of the MVSV model. In its baseline version, described above, the MVSV model embeds the assumptions that shocks to inflation trend and gaps are uncorrelated and that the VAR dynamics of the gaps are time invariant. We separately relax each assumption. To model correlation between shocks to the inflation trend and gaps, we rewrite the gaps' equation as

$$A(L)\tilde{Y}_t = e_t \qquad e_t = \bar{\beta}\bar{e}_t + \tilde{e}_t, \tag{8}$$

where $\tilde{e}_t$ is specified as before.[17]

We have also considered time variation in the VAR coefficients, of a kind that implies an inflation-gap equation of $A_t(L)\tilde{Y}_t = \tilde{e}_t$. The VAR coefficients are modeled as drifting random walks, subject to the stationarity condition for each polynomial $A_t(L)$ with correlated shocks.[18]

As a third alternative, we explicitly incorporate information regarding a country's inflation goal in the data set used for conditioning our model estimates. This version of the model will also be labeled "MSVS-T." With the exception of Japan, each country in our data set had by 2013 (the end of our sample) introduced some form of explicit inflation goal. (See table 1.) For these countries, we have augmented the measurement equation of the MVSV model with a fourth variable that is equal to each country's inflation goal—or

[17]The choice of the prior for $\bar{\beta}_t$ turned out to be important for the convergence of the Markov chain Monte Carlo (MCMC) algorithm used in the estimation. Results reported below were generated from a standard normal prior, which led to satisfactory convergence for almost all countries considered. In the case of less informative normal priors with larger variances, the MCMC estimation typically failed to achieve convergence in our experience.

[18]In contrast to its application to the stochastic gap volatilities, the random-walk assumption for the VAR coefficients does not lead to unbounded posterior draws when there is missing data. This reflects the additional restriction that all draws of $A_t(L)$ must have all roots outside the unit circle. The variance/covariance matrix of random-walk shocks to the vector of VAR coefficients is given a vaguely informative inverse-Wishart prior with $N+2$ degrees of freedom, where N is the number of VAR coefficients, and the prior is given a mean of $0.05^2 \cdot I$. The scale of this prior reflects has been chosen to allow for considerable range of possible persistence, within the region of coefficient values that are consistent with a dynamically stable VAR structure.

the midpoint of its goal range—and that is treated as missing data in the absence of an official inflation objective. This variable will be interpreted as a direct reading of the trend level for headline CPI inflation.[19]

3.4 Estimation Methods

The models are estimated with Markov chain Monte Carlo methods, similar to those described in Mertens (2011). The algorithm yields not only estimates of the latent factors. The sampling algorithm recovers the posterior distribution of missing data entries, conditional on the model and all observed data values. Convergence is assessed with scale-reduction tests (see Gelman and Rubin 1992), applied to the output of multiple chains that started from dispersed initial conditions.

4. Inflation Trends: Levels and Uncertainty

This section reports country-by-country estimates of inflation trends and gaps as well as their evolving variability, as generated from our application of the UCSV model of Stock and Watson (2007) and our MVSV model. In essence, these UCSV estimates complement and extend the results reported by Cecchetti et al. (2007), whose estimates are conditioned on the GDP deflator inflation rates for the G7 economies. The UCSV estimates reported below are conditioned on the CPI inflation headline rate. We report the inflation-gap estimates only for CPI (headline) inflation for the MVSV model, taking this measure of inflation as the one of greatest interest, particularly in the context of the targeting and forecasting of inflation. Generally speaking, the estimates reported below are conditioned on all available data from 1960:Q1 through 2013:Q4, the only major qualification being that we remove from estimation certain dates, specified in table 2, when price shifts occurred.[20]

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[19] After the introduction of an inflation goal, trend changes are treated as deterministic by the MVSV-T model. No country in our data set has abandoned its inflation goals after inception, except for changes in the goal's value.

[20] The effects of these price shifts on our estimates are discussed in section 5.

A comparison of estimates from the UCSV model and the MVSV for each country indicates that while there are broad similarities, there also plainly exist notable differences. Estimates from both models capture very similar low-frequency movements. By and large, estimates of the inflation trend and its stochastic volatility from the two models are quite similar. That said, in several instances—especially around the time of the global financial crisis in 2008–9—the effects of the UCSV model's assumption of serially uncorrelated inflation gaps are also quite apparent. For example, in the cases of Belgium, France, Italy, Japan, Spain, Switzerland, the United Kingdom, and the United States, the UCSV estimates seem to be affected by transitory fluctuations in inflation—fluctuations from which the MVSV model essentially insulates its inflation-trend estimates.

A notable aspect of the results for the United States is that the trend-inflation estimate tracks actual inflation quite closely in the 1970s. In particular, the trend estimate reaches double digits in the mid-1970s. In the case of the UCSV model, this result, for CPI inflation, is similar to that obtained for U.S. GDP deflator inflation by Cecchetti et al. (2007). The fact that trend inflation closely matches actual inflation during the 1970s in the UCSV case is consistent with the notion that actual U.S. inflation behavior resembled that of a random walk during those years; it is therefore natural for the UCSV model, in which the trend rate corresponds to the predictable component of inflation, to attribute much of the observed fluctuations in inflation to variations in the trend rate.

In the case of the MVSV model, which allows for persistent inflation-gap dynamics, it may appear surprising that we find, once again, that trend inflation in the mid-1970s largely mirrors actual inflation. Our estimates differ on this score from those in Cogley, Sargent, and Primiceri (2010), who find that trend U.S. inflation was well below actual inflation in the mid-1970s.[21] One major reason for the difference in findings is that in Cogley, Sargent, and Primiceri (2010), a long-term interest rate was included among the variables with which inflation was assumed to share a trend. Long-term interest rate data in the United States in the mid-1970s implied

[21] However, Morley, Piger, and Rasche (2015, figure 1) find that trend inflation tracks actual CPI inflation quite closely in the United States during the 1970s.

longer-term inflation expectations far below actual inflation in the mid-1970s, and so inclusion of these interest rates in the analysis would point toward a conclusion that the surge in inflation during that period largely amounted to an increase in the inflation gap.[22] In our analysis, however, the variables with which we assume CPI inflation has a common trend do not include long-term interest rates but do include the GDP deflator inflation rate. In the mid-1970s, the GDP deflator inflation rate exhibited a rise that largely conformed to that of the CPI inflation rate, and so our assumption that these two inflation series have a common trend makes the MVSV model more likely to regard the mid-1970s rise in inflation as a rise in the inflation trend. In contrast, the late-1970s upsurge in inflation was much steeper for CPI inflation than for the GDP deflator rate. Consequently, our MVSV estimates imply a sharp rise in the CPI inflation gap for this period, as opposed to a surge in trend inflation: see figure 14.

As noted earlier, a great number of countries have introduced formal inflation goals during the sample period. In the majority of cases, estimated trend levels from both models tend to hover around the numerical value for the inflation goal. But there are some notable exceptions, as discussed below. In the wake of the formal introduction of an inflation target, the stochastic volatility of trend shocks—our measure, alongside the inflation-trend estimate itself, of the degree to which inflation expectations are anchored—decreases in many cases only after some time, about five to ten years. This result likely reflects the fact that our measure is conditioned solely on the realized inflation experience of a given country.

Among those cases in which countries have explicit inflation goals, the trend estimates for Sweden, shown in panels A and B of figure 11, stand out, as the trend has regularly moved below the Riksbank's inflation target of 2 percent by half a percentage point or more since the target was introduced in 1993—a finding that

[22]Likewise, in Mertens's (2011) estimates of trend inflation for the United States, both longer-term interest rates and inflation expectations survey data are assumed to have a common trend with inflation. As both expectations data and longer-term interest rates registered a much milder rise in the mid-1970s than actual inflation, their inclusion in the analysis held down the estimated peak of trend inflation in Mertens (2011).

is consistent with Svensson's (2015) characterization of the behavior of inflation expectations in Sweden. In the same vein, late in the sample the inflation-trend estimates for Germany and France, joined by Ireland, Italy, and Spain, exhibit inflation-trend estimates somewhat below the European Central Bank's target rate of "close to but below 2 percent."

A noteworthy comparison between the MVSV and UCSV estimates is offered by the case of the United Kingdom, estimates for which are displayed in figure 13. For several years late in the sample period, U.K. inflation often persistently exceeded the Bank of England's 2 percent target, and these overshoots influence our estimates in varying degrees. In particular, the UCSV estimates of trend inflation tend to increase in the final years of the sample, with the estimate moving up to levels near 4 percent, and the 90 percent range for the estimate of trend inflation barely includes the target rate of 2 percent. In contrast, the MVSV model implies a much more limited increase in trend inflation for the United Kingdom, because the persistence embedded in the model's specification of inflation-gap dynamics separates the phenomenon of sustained overshoots of the inflation target from the phenomenon of a shift up in trend inflation.

The estimated trend levels of inflation for Japan (shown in figure 8) are, for the latter part of the sample, among the lowest for the countries we study. Both the MVSV and UCSV estimates put trend inflation for Japan at levels generally below zero for the last decade; in particular, the trend estimate derived from the MVSV model has been below zero, and even the upper bound of the 90 percent credible set for the trend barely covers values above zero from about 2000 through 2011. Concerns about elevated risks of deflation are also raised by our trend estimates for Switzerland, shown in figure 12, which have steadily been falling, and even moved briefly below zero, over the last few years, after having remained stable near 2 percent for most of the prior fifteen years.

For most countries, very similar trend estimates are also obtained if the MVSV model is replaced by a variant that allows for correlation between shocks to inflation trend and gaps, in the manner described in section 3. However, for some countries, this alternative specification generated noticeably different trend estimates. This has been the case for Germany, Sweden, and Switzerland, results for which are depicted in figure 15. For each of these three countries, the assumption of correlation in the shocks to trend and gaps generates trend estimates that are somewhat less volatile than in the baseline case—at least when judged by the paths for the pointwise posterior means. At the same time, uncertainty around these estimates, as measured by the width of the 90 percent confidence sets, is considerably wider than in the baseline case, as can be seen from comparison of figure 15 with the top-left panels in figures 5, 11, and 12.

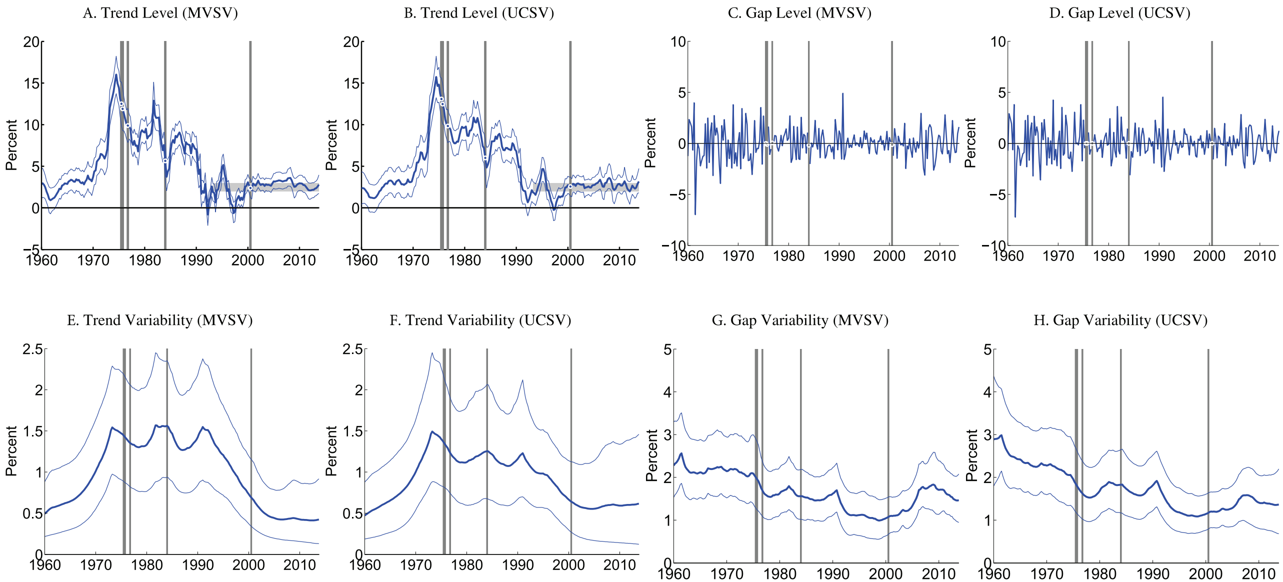
For each country, we also derived trend estimates from a further variant of the MVSV model, one featuring time variation in the VAR parameters that govern the evolution of the inflation gaps. The results for this variant are very similar to the baseline estimates shown in figures 1–14. For brevity, the estimates for this variant are not shown here. The MVSV model with time-varying VAR coefficients does, however, generate sizable variation in the estimated degree of gap persistence, a result brought out in figure 16. For each country, gap persistence is measured by the largest absolute eigenvalue of the gap VAR's companion form. There is no uniform pattern in the changes of gap persistence implied by these estimates. For some countries, like Canada, New Zealand, and Japan, gap persistence seems to have decreased over the latter part of our sample. For other countries, such as France, Ireland, Italy, Sweden, and Switzerland, gap persistence has rather increased.

Trend estimates from the MVSV-T model are very similar to our baseline estimates, except for the periods when the official inflation goal was different from the baseline trend estimates as shown in figures 1–14 (and not shown separately). The MVSV-T model will be discussed further in section 7 in the context of forecast evaluation.

5. The Effects of Price-Shift Dates on Trend Estimates

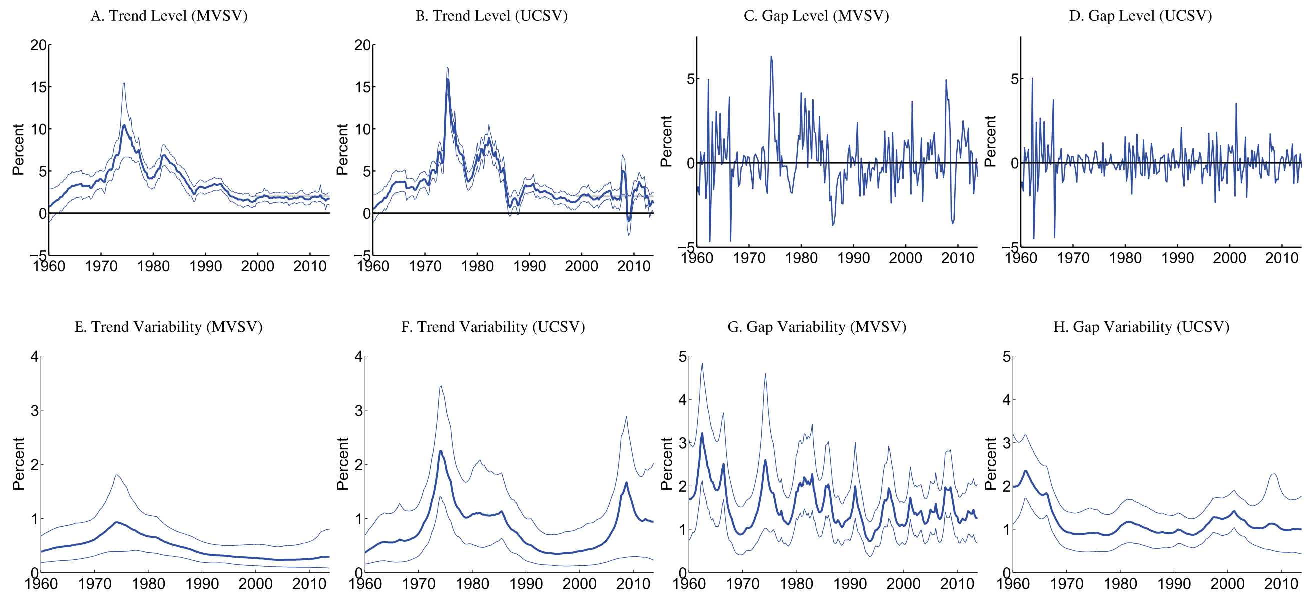
In general, the estimates presented in the previous section are derived from data sets that excluded the observations associated with dates at which major price-level shifts occurred due to nonmarket factors. The results shown in figures 1 to 14 were generated from inflation data for which periods of price shifts are treated as

Figure 1. Australia



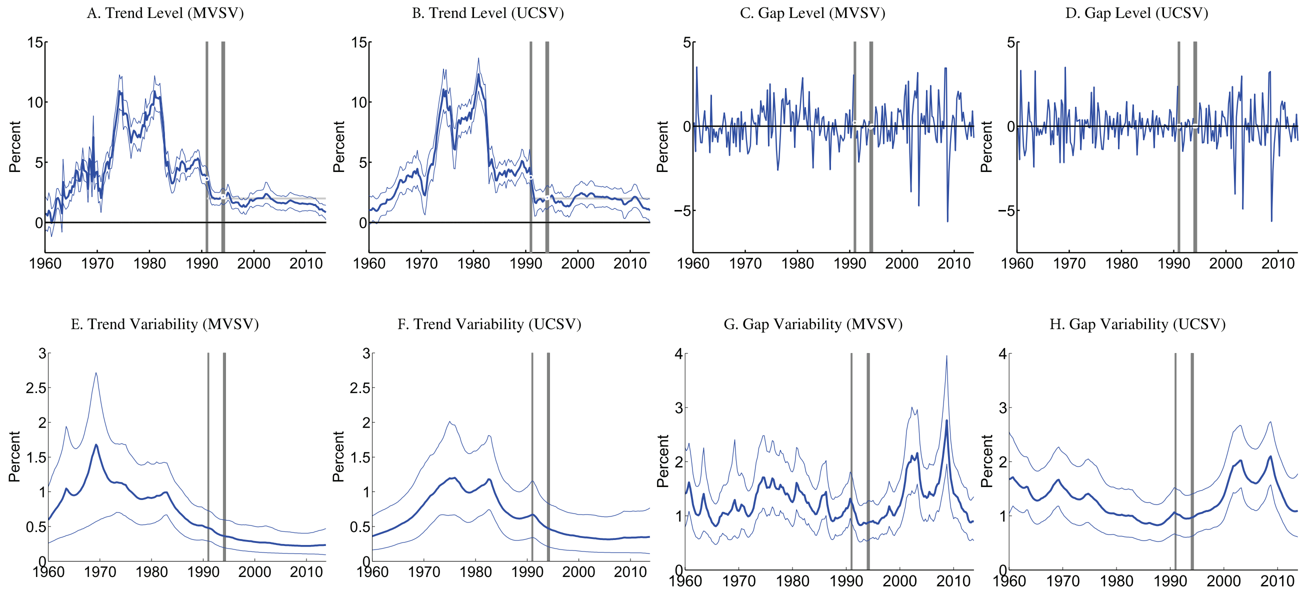
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the light gray area marks the range assigned for an officially stated inflation goal.

Figure 2. Belgium



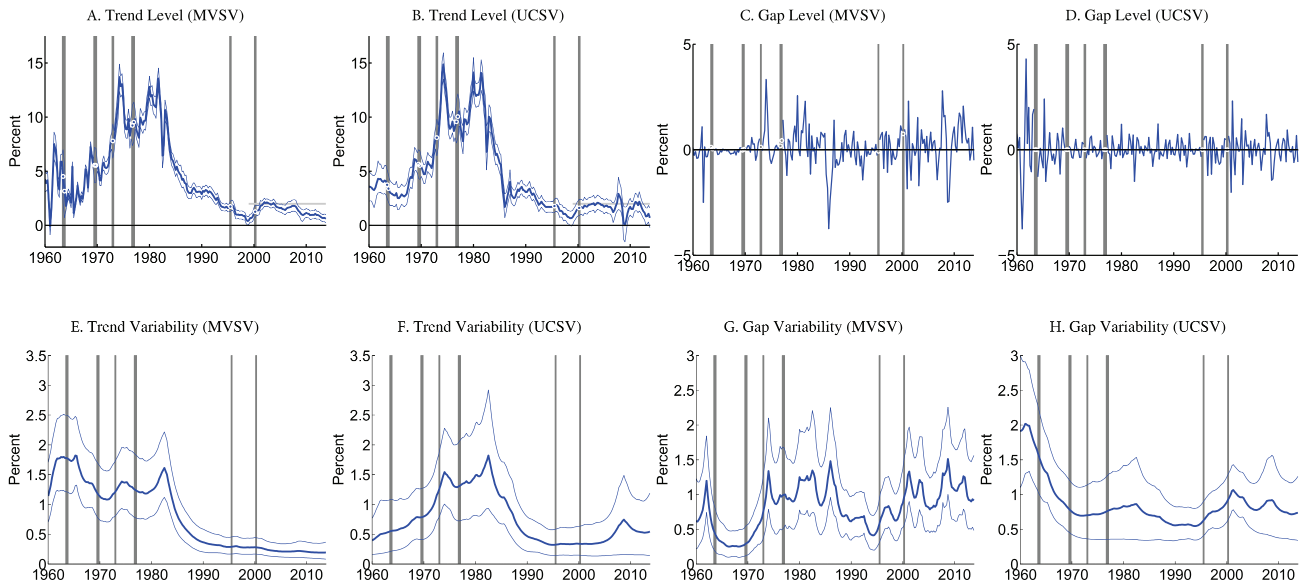
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 3. Canada



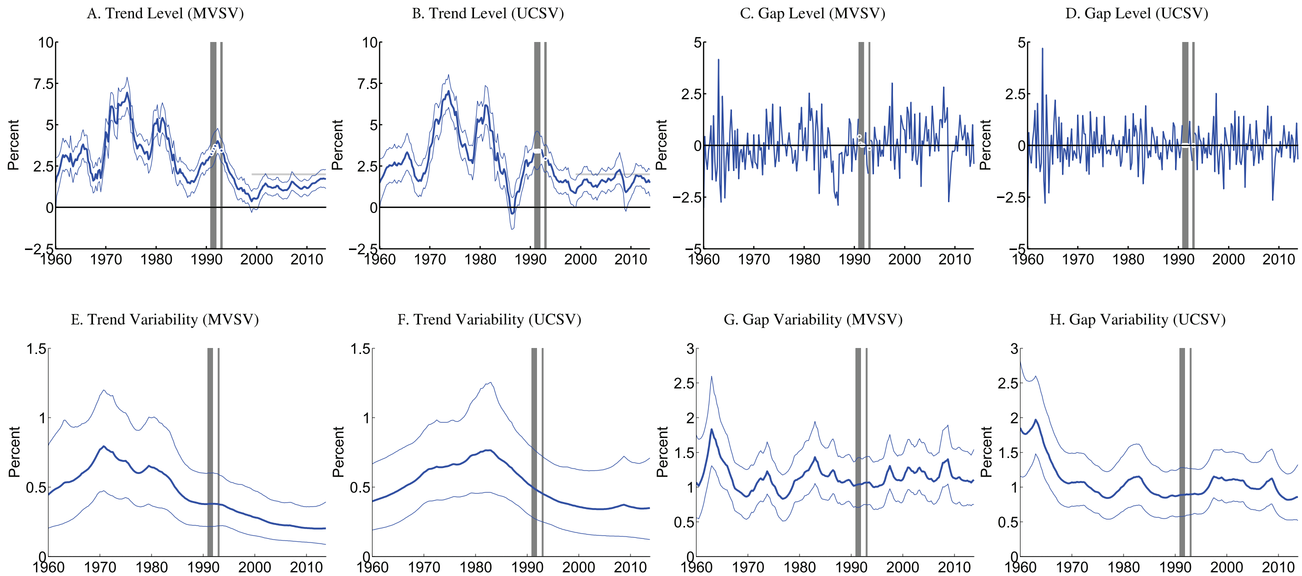
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 4. France



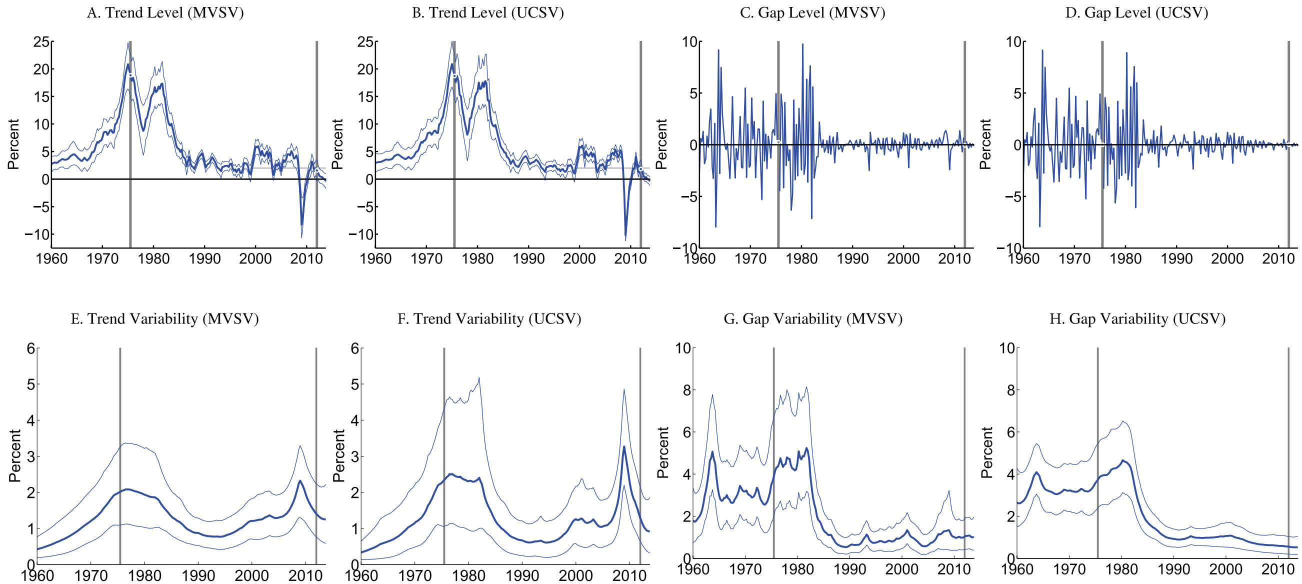
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 5. Germany



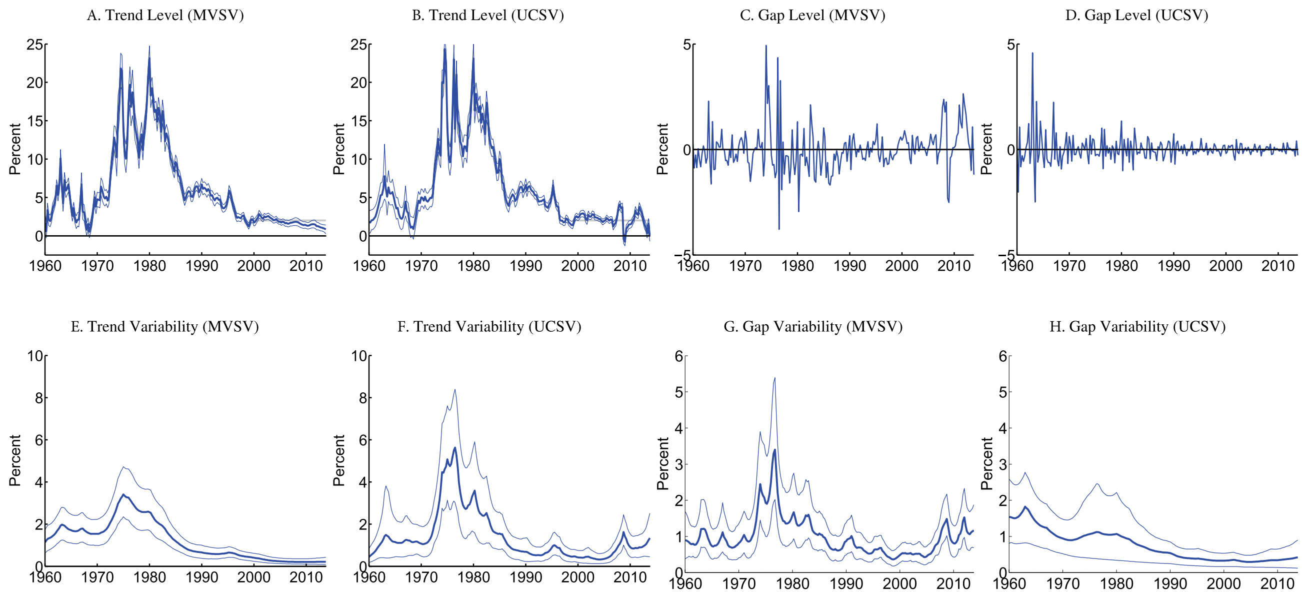
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 6. Ireland



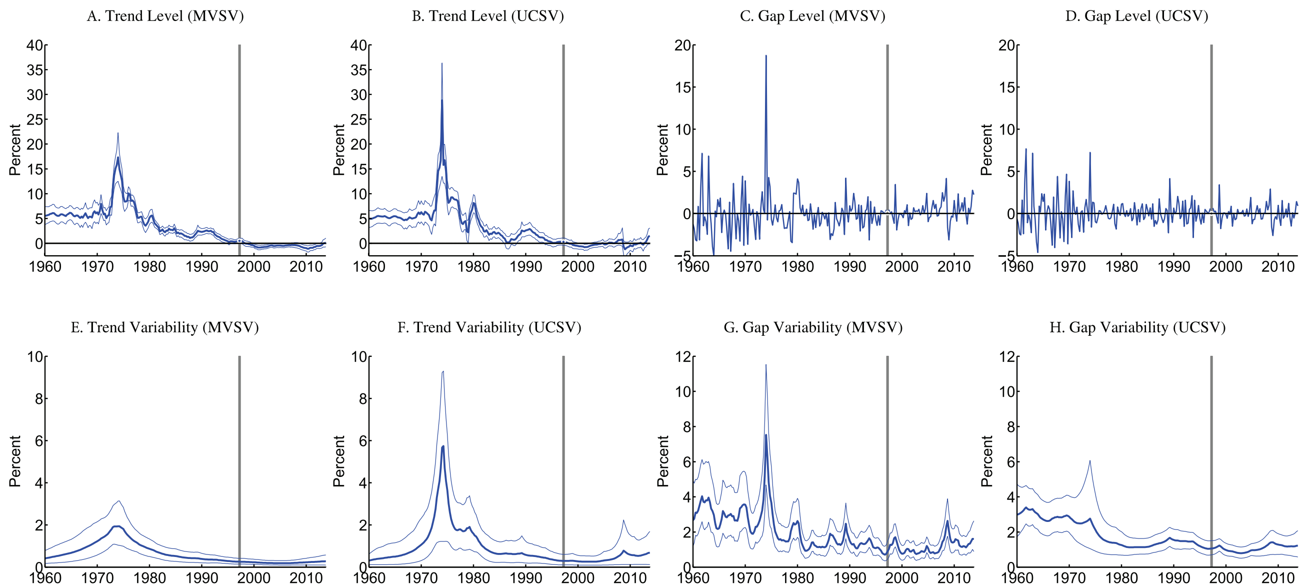
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 7. Italy



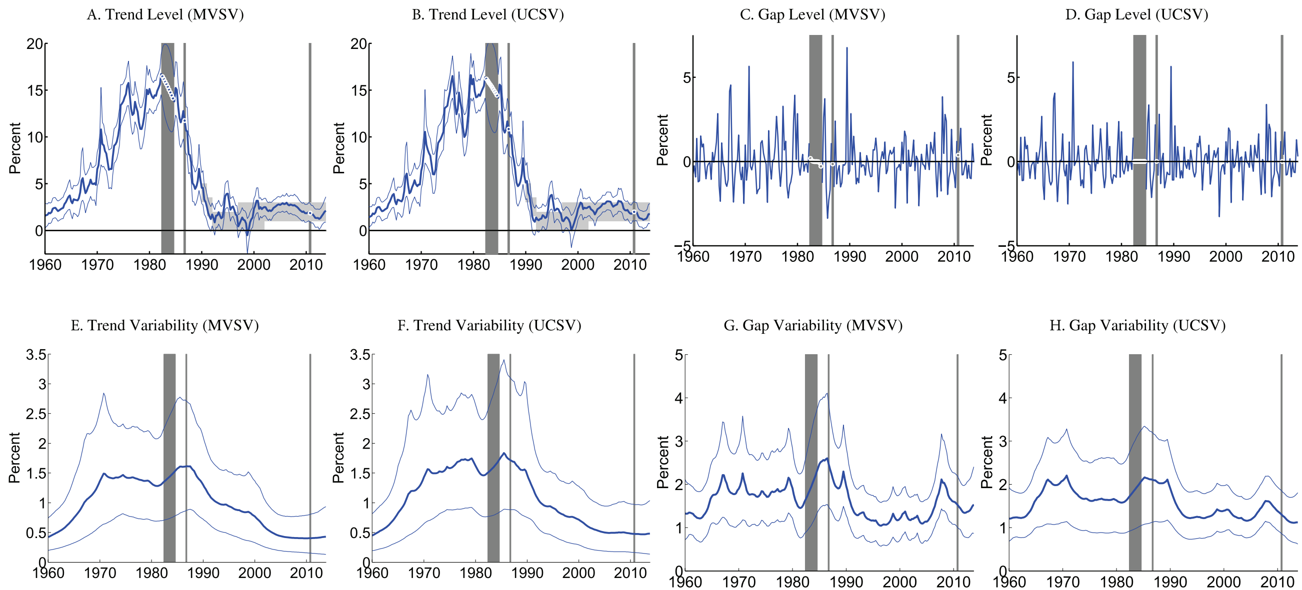
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 8. Japan



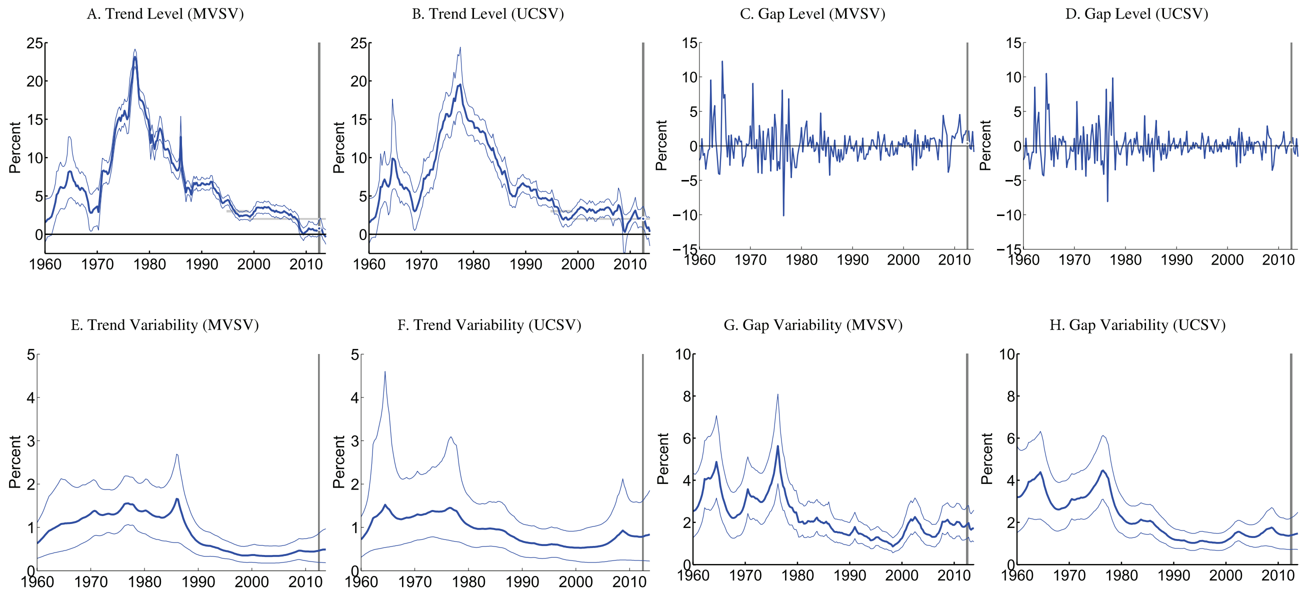
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B.

Figure 9. New Zealand



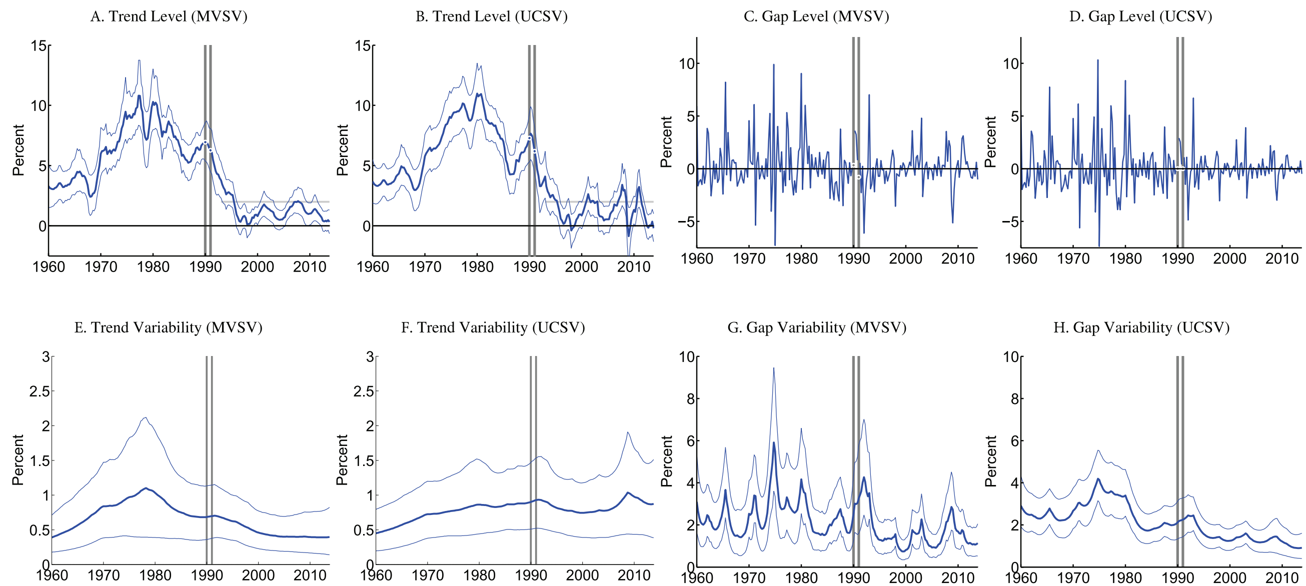
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the light gray area marks the range assigned for an officially stated inflation goal.

Figure 10. Spain



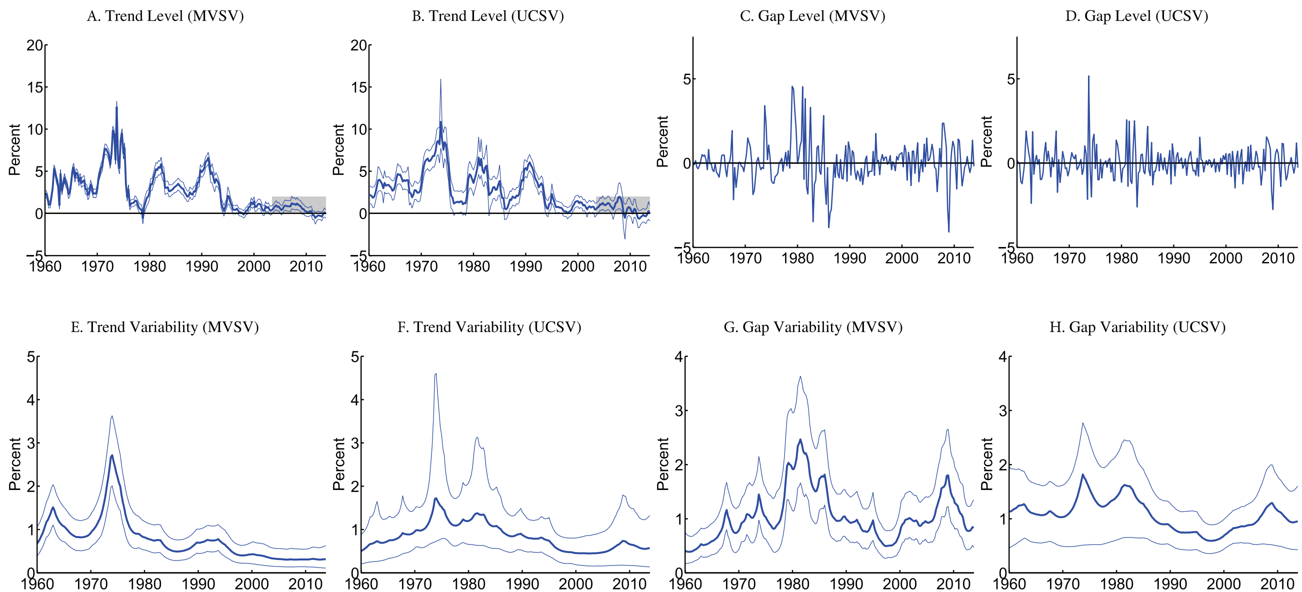
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 11. Sweden



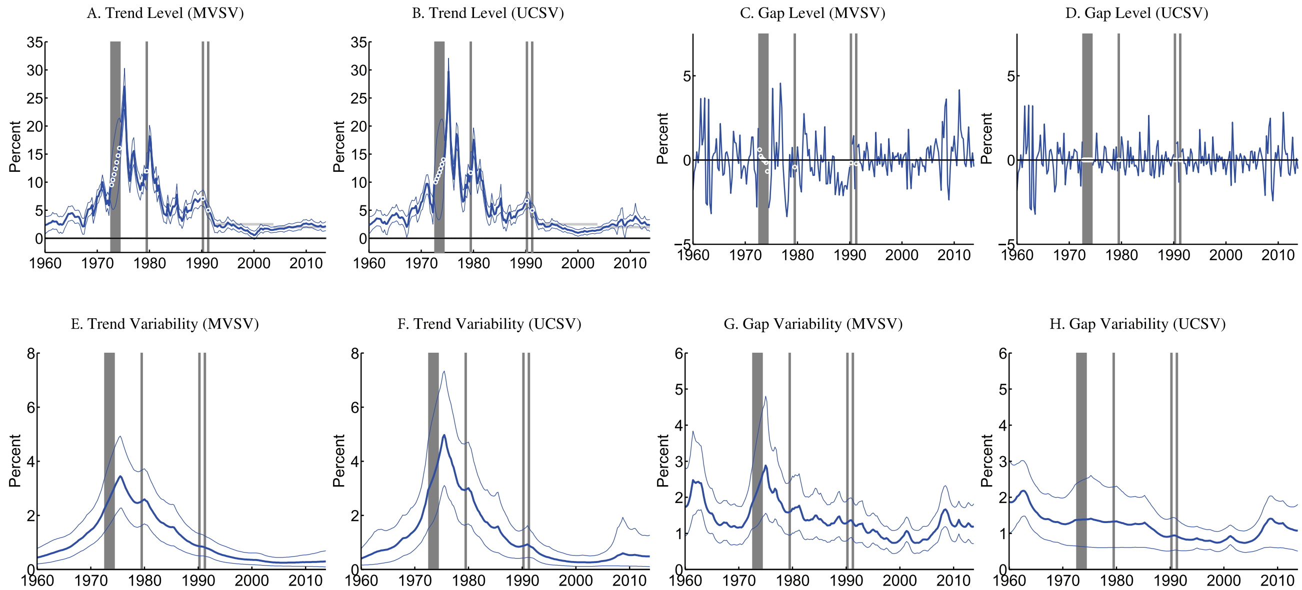
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 12. Switzerland



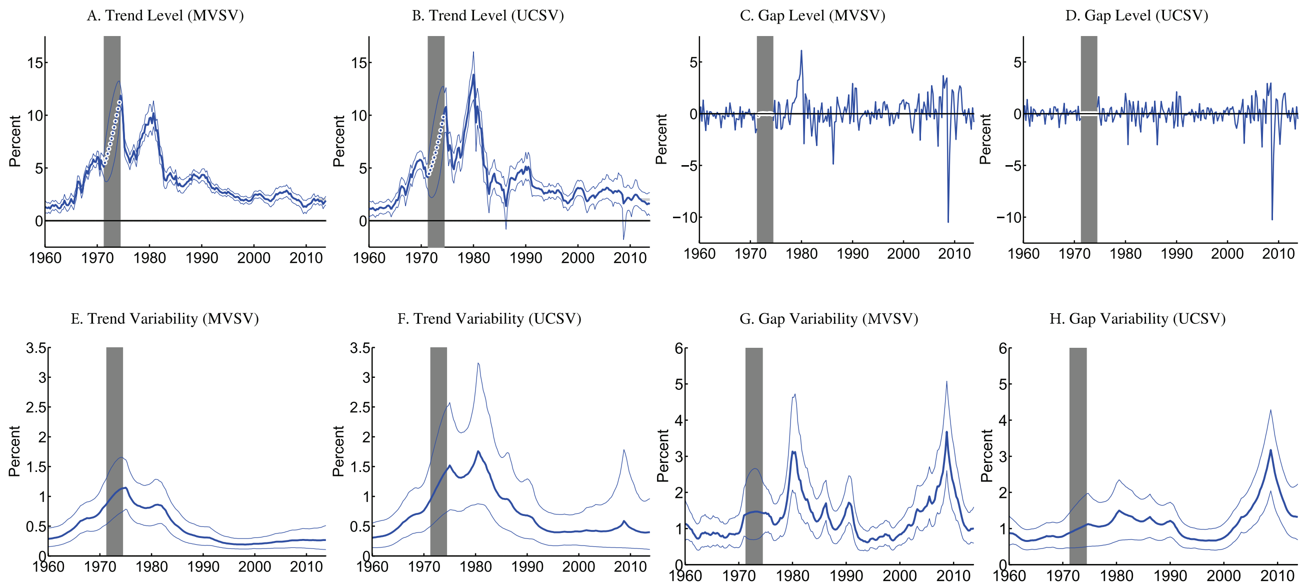
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. In panels A and B, the light gray area marks the range assigned for an officially stated inflation goal.

Figure 13. United Kingdom



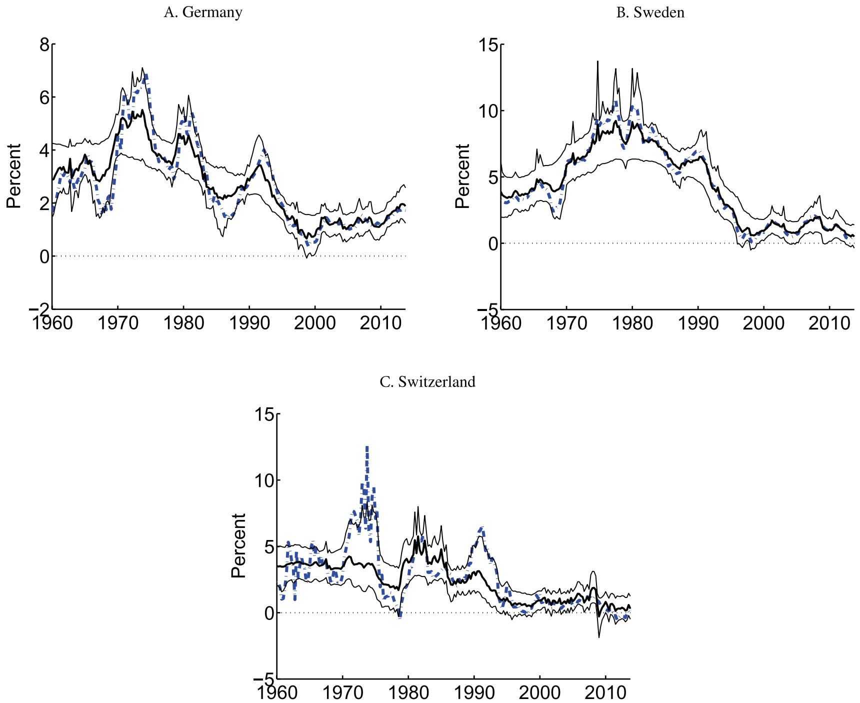
Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B. In panels A and B, the solid, light gray line marks the level assigned for an officially stated inflation goal.

Figure 14. United States



Notes: Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All levels are measured in annualized percentage points. Variability is measured by the standard deviation of a quarterly trend shock. Data sources are as listed in table 1, using all available data since 1960. Dark gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. For those periods, estimated inflation gaps, shown in panels C and D, are marked by white circles. When there are no price-shift dates, the gap estimates are identical to the difference between actual inflation and the trend estimates, shown in panels A and B.

Figure 15. Trend Estimates with Correlation between Shocks to Trend and Gaps



Notes: In each panel, solid lines depict estimates derived from a version of the MVSV model that allows for correlation between the shocks to trend and gap inflation. Dashed lines show the corresponding estimates from a baseline specificton where shocks to trend and gaps are assumed to be uncorrelated. Estimates are obtained from data that treat the price-shift dates listed in table 2 as missing observations. Solid, thick lines show posterior means, and thinner lines depict 90 percent confidence sets derived from the model's posterior distribution conditional on all data. All series are measured in annualized percentage points (as approximated by log-changes).

Figure 16. Gap Persistence

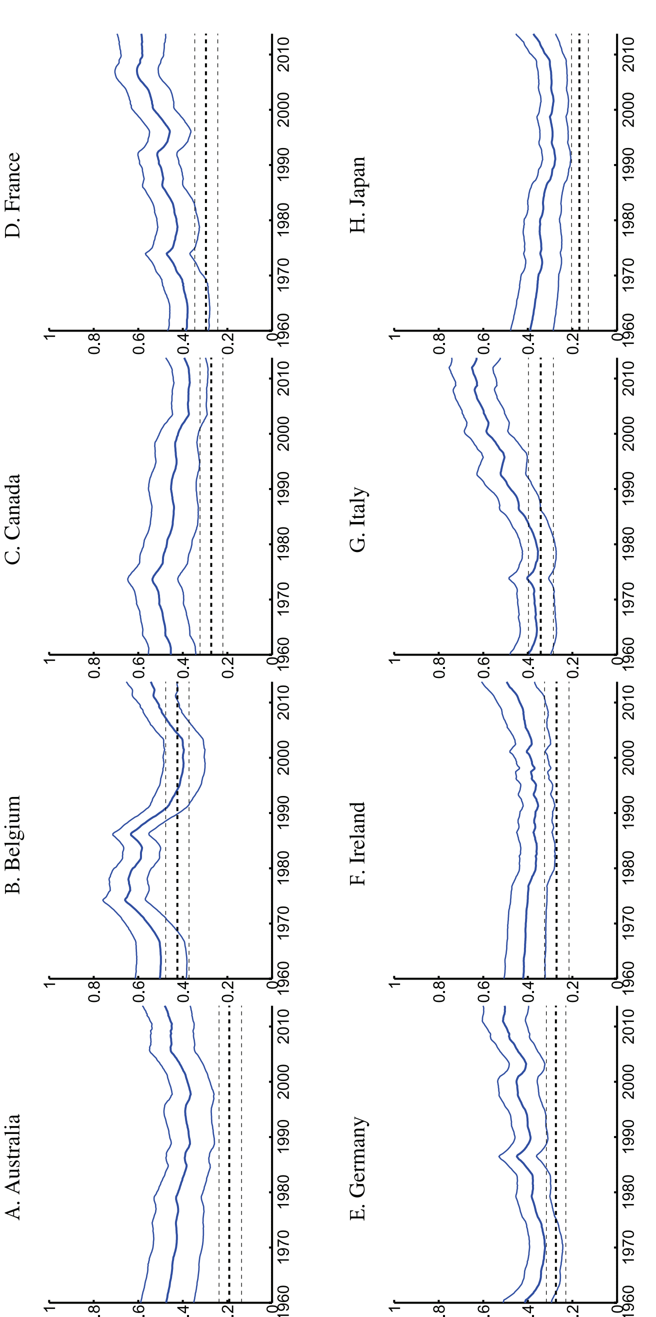


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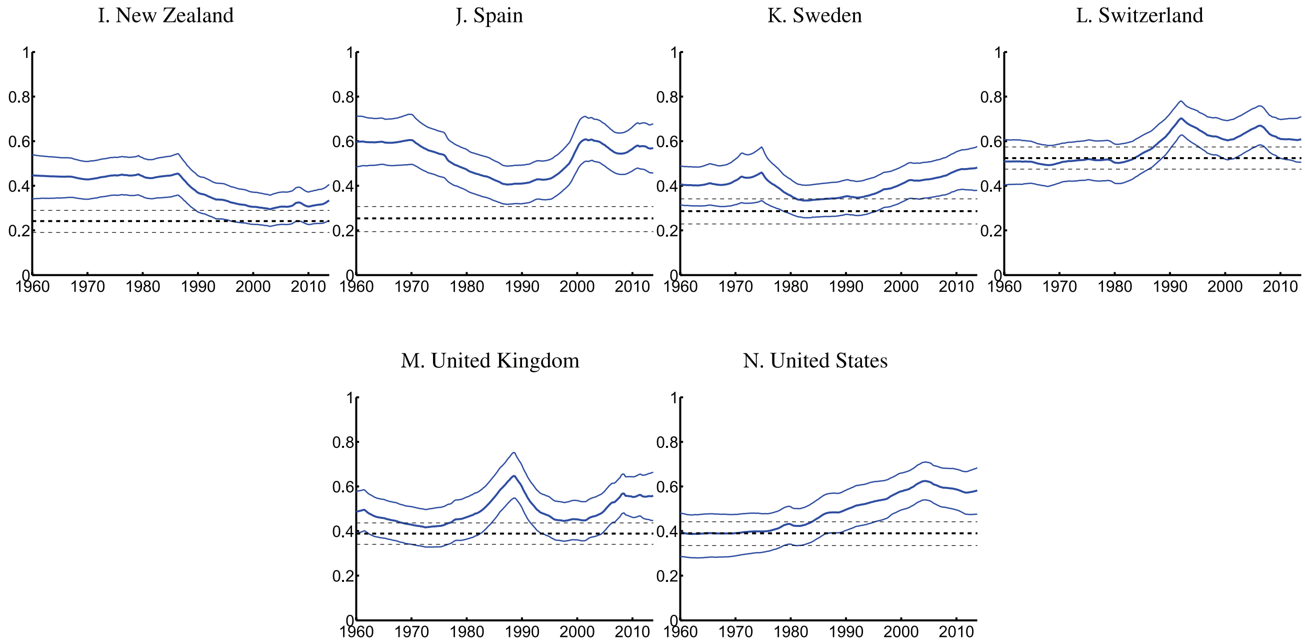
Figure 16. (Continued)



Notes: Thick solid lines depict posterior means of the largest, absolute eigenvalue of the companion matrix associated with the VAR for gap inflation in a version of the MVSV model with time-varying VAR parameters; thin lines depict the interquartile range. Corresponding estimates obtained from our baseline specification with constant VAR parameters are depicted by dashed lines. Estimates are obtained from data that treat the price-shift dates listed in table 2 as missing observations.

missing values in each model's estimation.[23] The relevance of these episodes for our estimates, as brought out by a comparison with estimates conditional on all data, is the subject of this section.

In all, we consider fifteen price-shift episodes affecting seven out of the fourteen countries in our sample; all are listed in table 2. Most episodes are related to increases in taxes on goods and services and similar administrative imposts; in these instances, only a single quarterly observation is omitted from the data. The rationale for excluding inflation observations for these specified dates is that the price level shifted in the period in question not as a reflection of monetary policy or of private-sector-initiated behavior, but because of a non-monetary governmental measure whose effect was essentially to rescale the price level. Only four episodes stretched beyond a year or more: the periods of official price controls in the United States (1971–4), the United Kingdom (1972–4), and New Zealand (1982–4), as well as the transition period in the wake of German reunification (1991).[24] Again, the shift in the price level in these dates corresponded either to a movement away from market determination of prices (in the case of the price-control periods) or a major redefinition of the area covered by the price index (as when the former East Germany was brought into the Federal Republic of Germany).[25]

[23]In the case of price controls, this procedure amounts to interpolating between the final value of inflation recorded *before* the imposition of price controls and the first observation on inflation occurring *after* the period in which controls were lifted. An alternative interpolation procedure would have involved constraining inflation during the omitted quarters to be equal to the average value of inflation observed over those quarters. This alternative procedure would have captured the idea that, when price controls are lifted, the price level catches up to the value it would have reached in the absence of controls. However, following this alternative procedure would have meant treating price controls in a different way from other price shifts that we consider, such as changes in indirect taxes.

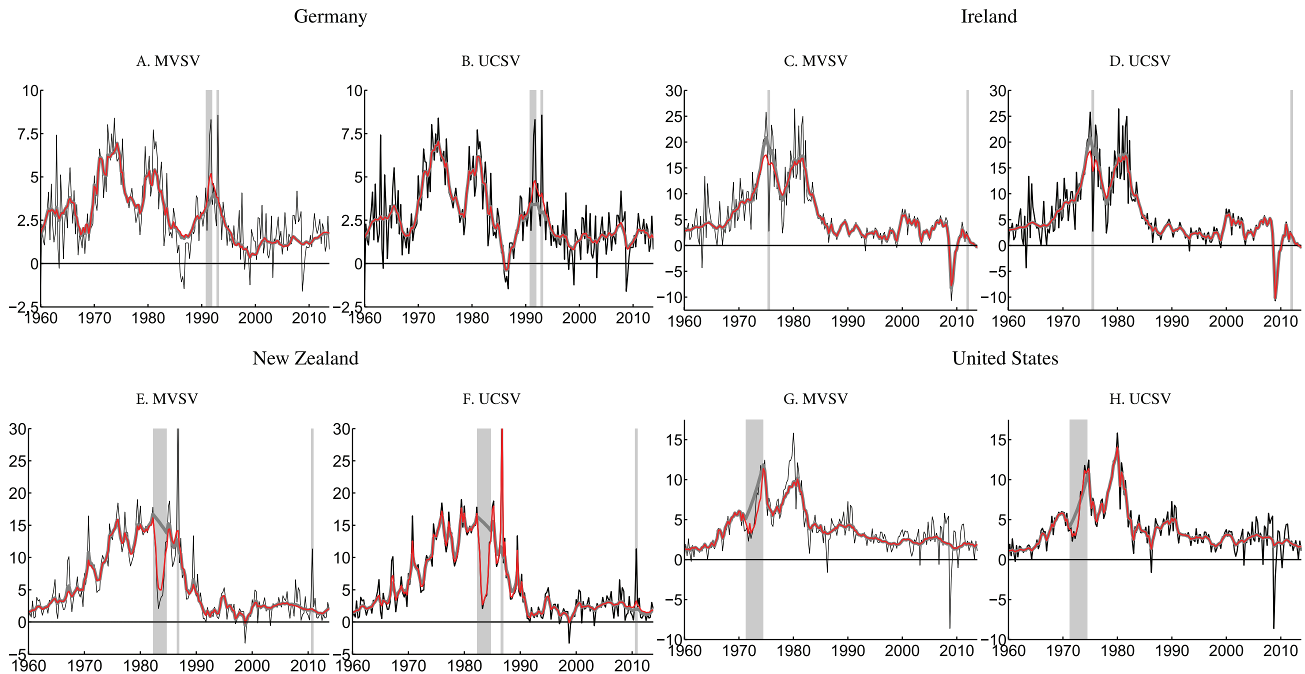
[24]We treat the whole of 1991 as a price shift for Germany, following Levin and Piger (2004).

[25]Gordon (1983) and Staiger, Stock, and Watson (1997) figure among previous studies that allow for the effects of price controls in their study of inflation dynamics, while Levin and Piger's (2004) study of international inflation dynamics allows for major changes in national sales taxes. In addition, the exclusion of control and tax periods from the estimates represents a step in the direction of incorporating historical information about individual countries' experiences into the study of inflation dynamics, as recommended by Cecchetti et al. (2007).

Reflecting their typically short duration, the price-shift dates are not associated with a great impact on trend estimates for many countries. This is not invariably the case, however. Figure 17 presents trend estimates for four countries—Germany, Ireland, New Zealand, and the United States—for which the inclusion of price-shift dates has different effects on trend estimates. The figure presents a comparison of trend estimates discussed in the previous section with estimates that condition on the entire data, including inflation data recorded during the price-shift episodes. For each country, the effects of including price-shift dates on trend estimates from the MVSV model are qualitatively similar to those on the UCSV estimates.

The price-shift episodes of longer duration evidently can have quite sizable effects on trend estimates. For example, estimates of trend inflation in the United States—whether derived from the UCSV or the MVSV model—peak well above 10 percent in the mid-1970s, when conditioned on all observations, whereas for the case in which the price-shift episode is treated as a period of missing data, the estimated inflation trend rises only gradually from about 5 to just below 10 percent. This correction may well, of course, be considered excessive, as it leads to much of the mid-1970s rise in inflation being classed as transitory. The fact that the rise in inflation in the United States in the mid-1970s was preceded by a lengthy and substantial monetary expansion points instead to the possibility that a good deal of the rise in inflation amounted, instead, to an increase in the trend rate of inflation. But even our price-shift-adjusted model estimates largely attribute the mid-1970s peak of inflation to a rise in trend. In particular, and as earlier noted, the MVSV model's characterization of the rise in CPI inflation in the mid-1970s as largely comprising an increase in trend inflation in good part reflects the fact that the increase in GDP deflator inflation over the same period basically confirmed the picture provided by CPI inflation behavior. For both of the U.S. inflation-trend estimates (that is, MVSV and UCSV), the effect of allowing for the 1971–4 price-control episode is not to lower substantially the rise in trend inflation, but instead to remove the decline in trend inflation that is registered in the controls-affected year of 1972—when measured inflation exhibited a decline that was likely spurious.

Figure 17. Trend Estimates and Price-Shift Dates



Notes: In each panel, thick gray lines depict estimates conditioned on data sets, where price-shift dates have been removed, whereas dark solid lines depict estimates conditioned on all inflation data. For each country, separate panels display results from the MVSV model and the UCSV model. Gray shading marks dates in which data were excluded from computation due to shifts in the price index at that time. All country-specific price-shift dates for input measures are listed in table 2. Thin lines denote the actual data for the headline CPI index. All levels are measured in annualized percentage points (as approximated by log-changes).

6. Trend Estimates in Quasi-Real Time

The trend estimates described in the previous two sections have been conditioned on full-sample data—with or without price shifts. Such estimates are typically labeled "smoothed" estimates, as distinct from "quasi-real-time" estimates, to use the terminology familiar from Orphanides and van Norden (2002). These real-time estimates, which we shall also refer to as "filtered" estimates, generate the inflation trend for time t solely on the basis of data observations up to and including time t. We now derive such quasi-real-time estimates by reestimating each for each quarter from 1984:Q4 through 2013:Q4, using all available data from 1960:Q1 onwards. The difference between quasi-real-time and smoothed estimates reflects the effects of reestimating the model's hyperparameters like φ_h, governing the volatility of shocks to the stochastic log-variances, or the coefficients $A(L)$ of the gap-based VAR. Our analysis abstracts from data revisions as a source of difference between real-time estimates of trend inflation and our inflation data. Rather, the data we use throughout are from what is essentially a single vintage that we collected in 2014.[26]

Ahead of our analysis in section 7 of each model's forecast performance based on this quasi-real-time analysis, this section provides a comparison of smoothed and filtered estimates of trend inflation from the MVSV model, as well as the difference between filtered estimates of trend inflation between the UCSV and the MVSV model.

Two results stand out from this comparison. We discuss each in turn.

First, filtered trend estimates from the MVSV model are fairly close to their smoothed counterparts, as can be seen in figure 18. Overall, as is to be expected, the smoothed estimates are a little less variable than their quasi-real-time counterparts. Smoothed estimates are designed to be more precise estimates of the underlying inflation trend, and they benefit from knowledge regarding the subsequent behavior of realized inflation. For this reason, they may not

[26] An alternative notion of "filtered" estimates, not pursued here, would be one in which the model's hyperparameters were taken as given—as would be the case, for example, if values estimated based on the full sample of data were used—so that only the values of the model's latent states (like the level of trend inflation and the stochastic volatility in trend and gaps) needed to be estimated.

Figure 18. Smoothed and Filtered Trend Estimates (MVSV model)

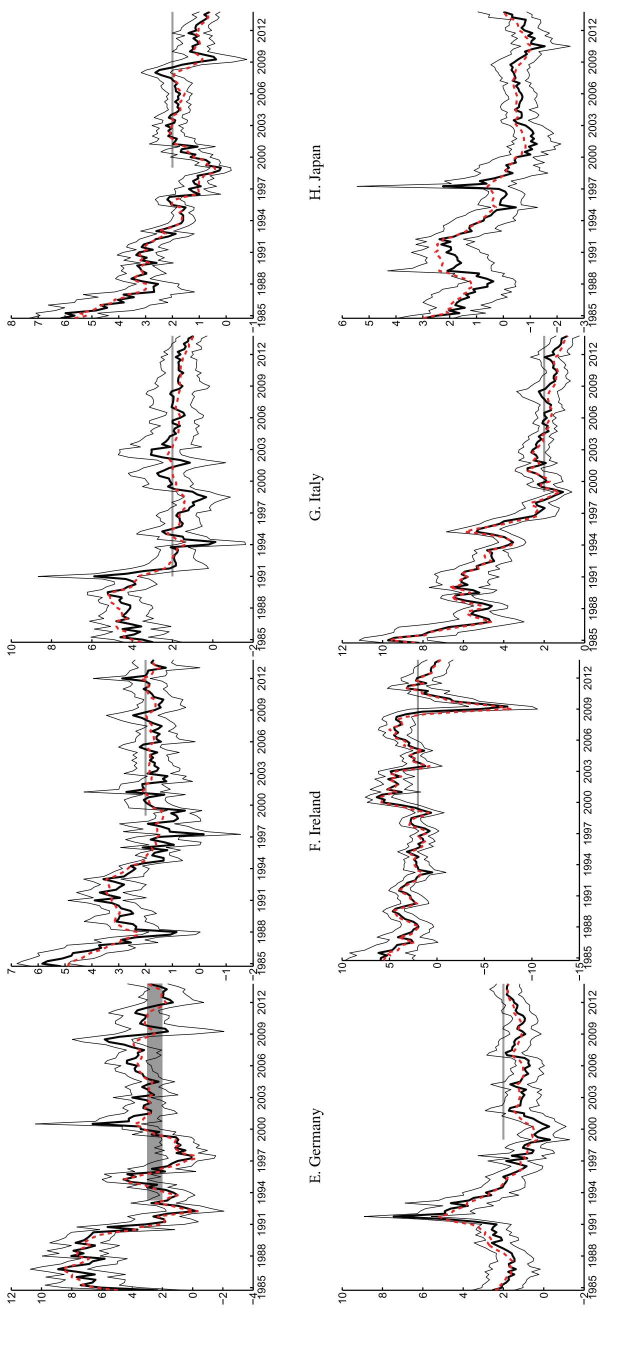


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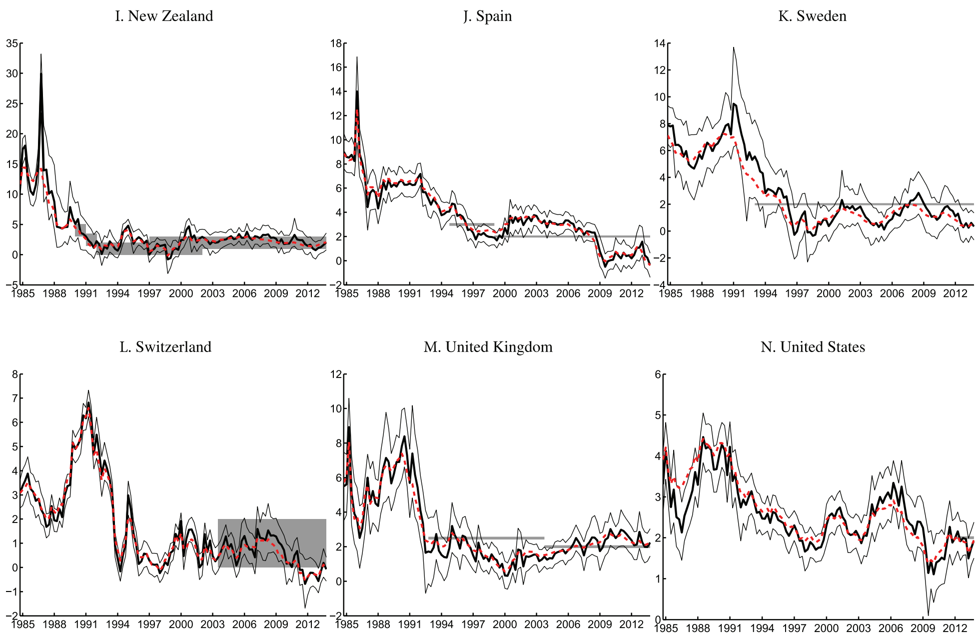
Figure 18. (Continued)



Notes: Each panel depicts quasi-real-time trend estimates (thick solid lines) from the MVSV model and their 90 percent confidence sets (thin solid lines). Each quasi-real-time estimate for a given quarter has been generated by a separate model estimation, using data from 1960:Q1 through the indicated quarter. The dashed line depicts the corresponding smoothed trend estimates, which are conditioned on the entire sample period through 2013:Q4. Gray-shaded areas and solid gray lines mark the range (or levels) assigned for an officially stated inflation goal.

lend themselves to exercises such as determining the exact timing of events, such as the point at which an inflation target became credible. The filtered estimates might thus be more suitable for comparison against other measures of trend inflation derived from financial market indicators. But, at least in the case of the multivariate model, the differences between smoothed and quasi-real-time estimates appear to be fairly small. For example, as can be seen in figure 18, both estimates provide similar signals regarding the extent to which trend inflation is aligned with different countries' official inflation targets.

Second, filtered trend estimates from the UCSV model seem more prone to overreact to transitory changes in inflation than the MVSV model. A similar distinction has been noted previously in the context of smoothed estimates for both models. But the differences are especially striking in the case of the quasi-real-time estimates shown in figure 19. In particular, for the years 2006–12, considerable swings in commodity prices played a major role in observed fluctuations in inflation rates in many countries. And after 2009, persistent signs of disinflationary pressure are far more manifest in the MVSV model's quasi-real-time estimates of the inflation trend in a number of economies—notably the euro area, Japan, Sweden, the United Kingdom, and the United States—than in the UCSV estimates.

7. Forecast Evaluation

Trend inflation is a latent and unobservable variable. Some properties of the MVSV estimates documented in the previous sections might appear more appealing than their UCSV counterparts, but such a conclusion might well rely more on a subjective impression of what constitutes a "reasonable" estimate rather than a direct comparison between estimated and actual values of trend inflation—a comparison that by its very nature is infeasible. In the absence of such a direct comparison, an indirect way of assessing the validity, or usefulness, of different trend estimates is to evaluate inflation forecasts generated by each model at some finite horizons. The idea behind this approach is that, just as the Beveridge-Nelson trend is derived from solving a long-run forecasting problem, a model that allows explicitly for an evolving trend in the inflation rate should generate satisfactory inflation forecasts, and probably

Figure 19. Comparison of Filtered Trend Estimates

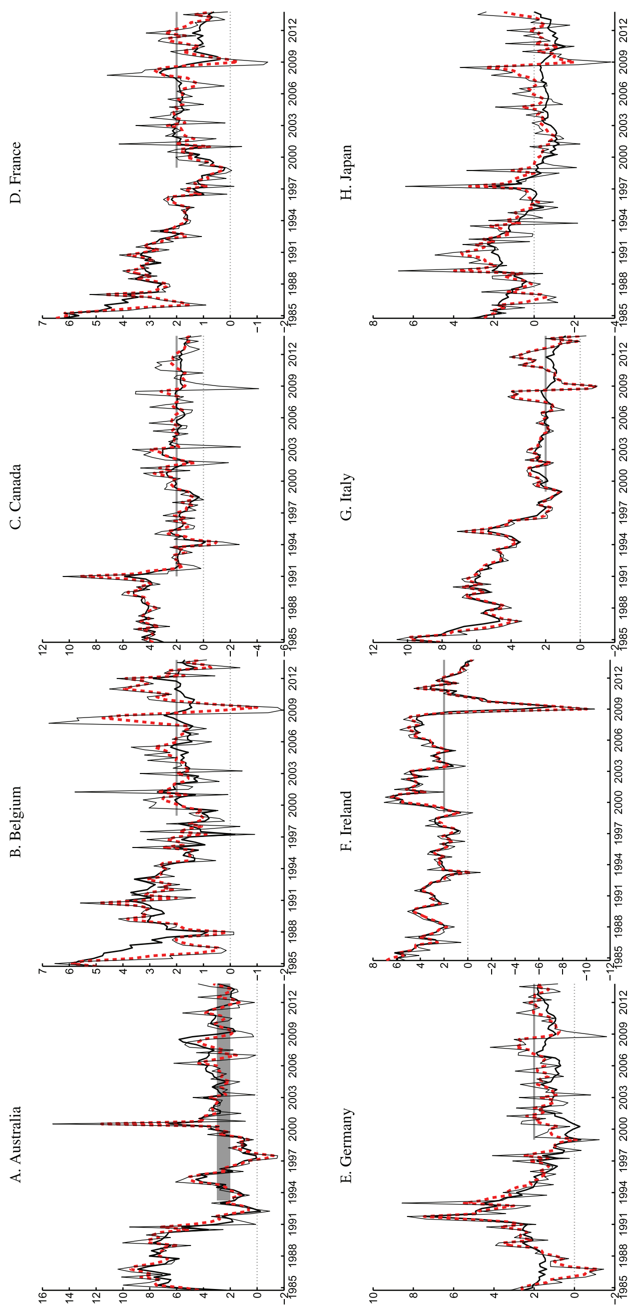


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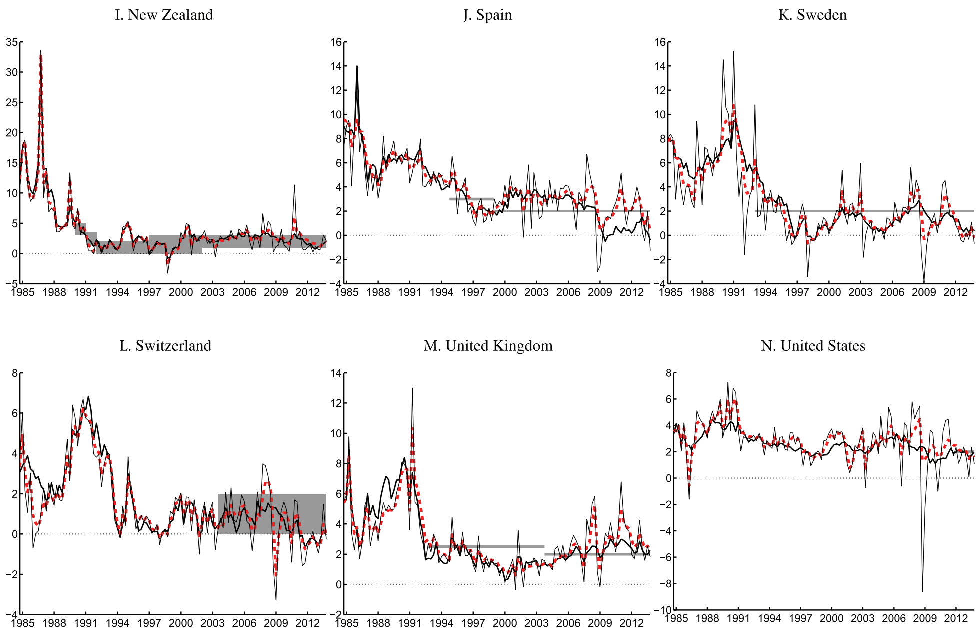
Figure 19. (Continued)



Notes: Each panel shows quasi-real-time trend estimates from the MVSV model (solid) and the UCSV model (dashed). Each quasi-real-time estimate for a given quarter has been generated by a separate model estimation, using data from 1960:Q1 through that quarter. Thin solid lines depict CPI headline inflation data. Gray-shaded areas and solid gray lines mark the range (or levels) assigned for an officially stated inflation goal.

also at horizons shorter than the very long run. Evaluating the forecast performance of different trend-inflation models may be an enlightening basis on which to assess different trend estimates; it should also be relevant for researchers who are especially concerned with generating good inflation forecasts. As argued by Faust and Wright (2013), sound procedures for obtaining inflation forecasts likely include grounding those forecasts on an explicit measure of the trend-inflation rate.

This section evaluates forecasts of CPI headline inflation up to four years ahead derived from the UCSV and MVSV model for each country. In addition, we also consider forecasts motivated by the random-walk benchmark of Atkeson and Ohanian (2001). For this benchmark, inflation forecasts for all horizons are taken as equal to a four-quarter or, alternatively, a twelve-quarter moving average of lagged inflation. Inflation forecasts are generated in quasi-real time from 1985 onwards. The first forecast is therefore conditioned on model estimates obtained for data from 1960:Q1 through 1984:Q4, with an increasing estimation window as the forecast period is shifted forward (that is, as steadily more observations are used in the estimation sample). Every jumping-off date considered is associated with reestimation of each model.[27]

For each quarter considered, we generate inflation forecasts both for annual (that is, four-quarter) inflation rates (computed as the average of expected inflation rates over four consecutive quarters) and for quarterly changes at different horizons.[28] Annual inflation rates are forecast for the upcoming four quarters, one year ahead (quarters 5–8), two years ahead (quarters 9–12), three years ahead (quarters 13–16), and four years ahead (quarters 17–20). Quarterly inflation rates are forecast for the next quarter, then four, eight, twelve, and sixteen quarters ahead. Results are not particularly sensitive to the inclusion of the price-shift dates discussed in section 5—which mostly occurred prior to the 1985–2013 period spanned by our various forecast windows—and all results are

[27]As before, our analysis abstracts from discrepancies between real-time measures of inflation and our inflation data that might have arisen from data revisions.

[28]Stock and Watson (2009) also focus on forecasts of one-year or two-year percentage changes in the price level, whereas Faust and Wright (2013) study forecasts of quarterly inflation rates.

derived from data that include observed inflation for the price-shift dates.

In our application, we measure forecast accuracy using root mean squared errors ("RMSE") and average log-predictive scores, which are reported in table 3 for forecasts of annual inflation and table 4 for quarterly inflation rates. In both cases, inflation rates are expressed in annual percentage units.

Log-predictive scores measure the accuracy of a model's predictive density and are computed here for the UCSV, MVSV, and MVSV-T model.[29] As in Adolfson, Linde, and Villani (2007) and Clark and Ravazzolo (2014), we approximate the predictive density with a normal distribution and compute mean and variance of the predictive density by integrating over the draws generated by the MCMC sampler.[30] Denoting the predictive mean and variance at time t for inflation π_{t+h} by $\mu_{t+h|t}$ and $\sigma^2_{t+h|t}$, respectively, the log-predictive score at t is given by

$$l_{t+h|t} = -0.5 \left(\log(2 \cdot \pi) + \log(\sigma^2_{t+h|t}) + \frac{(\pi_{t+h} - \mu_{t+h|t})^2}{\sigma^2_{t+h|t}} \right)$$

and the average log-predictive score is computed by averaging $l_{t+h|t}$ across all forecasts t for a given forecast horizon h. Whereas the RMSE reflects only the quality of the mean of the predictive density, the normal approximation of the log-density score has the property that it also evaluates the squared errors in relation to forecast uncertainty as measured by the variance of the predictive density.

In tables 3 and 4, forecast performance of alternative models is measured by the ratio of each model's RMSE compared with the MVSV model as well as the difference between the average log-predictive scores (where applicable). A value below unity of the

[29] The moving averages generate only mean predictions without specifying a predictive density.

[30] Conditional on draws of model parameters and levels and volatilities of the inflation trend and gap, it is straightforward to compute the predictive means using standard formulas. Predictive variances can readily be computed by adapting formulas shown in Cogley and Sargent (2015). The laws of iterated expectations and total variances can then be used to compute the predictive mean and variance over all MCMC draws.

Table 3. Forecast Evaluation: Annual Inflation Rates

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Australia	RMSE for MVSV	1.74	2.28	2.56	2.77	2.71
	– Relative to MA(4)	0.89*	0.92	0.93*	0.95	0.95
	– Relative to MA(12)	0.86	0.98	1.04	1.07	0.99
	– Relative to MVSV-Trend	1.00	1.00	1.00	1.00**	1.00**
	– Relative to UCSV	0.90	0.92	0.92	0.94	0.93
	– Relative to MVSV-T	1.15**	1.22***	1.15**	1.13**	1.07*
	Predictive Score vs. UCSV	0.06	0.27***	1.02***	2.38***	4.16***
	– vs. MVSV-T	−0.08	−0.23**	−0.34***	−0.40**	−0.56***
Belgium	RMSE for MVSV	1.43	1.56	1.47	1.35	1.38
	– Relative to MA(4)	0.89	0.90	0.95	0.92	0.88
	– Relative to MA(12)	0.90	0.95	0.94	0.95	1.02
	– Relative to MVSV-Trend	0.98	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.99	0.96	0.96	0.95	0.91
	– Relative to MVSV-T	1.09***	1.07**	1.01	1.03	1.07**
	Predictive Score vs. UCSV	−0.05	0.31***	0.88***	1.82***	3.10***
	– vs. MVSV-T	−0.09	−0.01	−0.02	−0.03	−0.08

(continued)

Table 3. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Canada	RMSE for MVSV	1.18	1.17	1.46	1.57	1.75
	– Relative to MA(4)	0.82**	0.78**	0.86	0.90	0.92
	– Relative to MA(12)	0.91	0.83	0.93	0.95	0.98
	– Relative to MVSV-Trend	1.02***	1.00**	1.00**	1.00	1.00**
	– Relative to UCSV	0.81*	0.80	0.84	0.87	0.90
	– Relative to MVSV-T	1.28**	1.19*	1.21	1.12**	1.12**
	Predictive Score vs. UCSV	0.17***	0.54***	1.32***	2.58***	4.17***
	– vs. MVSV-T	−0.05	−0.19***	−0.31**	−0.44***	−0.50***
France	RMSE for MVSV	0.91	1.03	1.08	1.05	1.15
	– Relative to MA(4)	0.83**	0.92	0.89**	0.94	0.90**
	– Relative to MA(12)	0.69	0.76	0.76	0.75	0.76
	– Relative to MVSV-Trend	0.99	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.90**	0.97	0.93*	0.95	0.94**
	– Relative to MVSV-T	1.05	1.09	1.07	1.05	1.07
	Predictive Score vs. UCSV	0.16***	0.31***	0.75***	1.52***	2.61***
	– vs. MVSV-T	−0.03	0.02	0.03	−0.04	−0.11

(continued)

Table 3. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Germany	RMSE for MVSV	1.15	1.37	1.47	1.62	1.73
	– Relative to MA(4)	0.99	0.90	0.89	0.90	0.84
	– Relative to MA(4)	0.87	0.89	0.88	0.90	0.93
	– Relative to MVSV-Trend	0.99	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.99	0.92	0.91	0.90	0.85
	– Relative to MVSV-T	1.08	1.10*	1.04	1.02	1.04
	Predictive Score vs. UCSV	0.01	0.17*	0.44***	0.90***	1.65***
	– vs. MVSV-T	−0.12	−0.19**	−0.17*	−0.20*	−0.27**
Ireland	RMSE for MVSV	2.18	2.95	3.03	2.84	2.52
	– Relative to MA(4)	0.90*	0.96	0.98	1.02	1.00
	– Relative to MA(4)	0.85**	1.06	1.12	1.12	0.92
	– Relative to MVSV-Trend	1.00	1.00	1.00**	1.00*	1.00**
	– Relative to UCSV	0.97	0.92	0.93	0.93	0.97
	– Relative to MVSV-T	1.03	1.30	1.31*	1.21*	1.08
	Predictive Score vs. UCSV	0.17	0.26***	0.68***	1.56***	2.86***
	– vs. MVSV-T	0.26	0.55	0.49	0.61	0.47

(continued)

Table 3. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Italy	RMSE for MVSV	1.10	1.42	1.45	1.46	1.49
	– Relative to MA(4)	0.88*	0.90**	0.90***	0.94**	0.91***
	– Relative to MA(12)	0.66*	0.73	0.77	0.78	0.74*
	– Relative to MVSV-Trend	0.99	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.93	0.88*	0.87**	0.89***	0.89***
	– Relative to MVSV-T	1.04	1.03	1.01	1.01	1.02
	Predictive Score vs. UCSV	0.09	0.39***	0.99***	1.91***	3.11***
	– vs. MVSV-T	−0.07	0.01	0.00	−0.11	−0.19
Japan	RMSE for MVSV	1.10	1.29	1.30	1.25	1.16
	– Relative to MA(4)	0.93	0.89	0.80***	0.76**	0.73**
	– Relative to MA(12)	0.89	0.91	0.91	0.91	0.90
	– Relative to MVSV-Trend	0.99	1.00	1.00*	1.00*	1.00*
	– Relative to UCSV	0.92	0.91	0.83**	0.79**	0.74**
	Predictive Score vs. UCSV	0.08	0.65***	1.81***	3.48***	5.37***

(continued)

Table 3. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
New Zealand	RMSE for MVSV	3.08	3.51	3.85	4.49	4.87
	– Relative to MA(4)	1.08	1.08	1.10	1.11	1.11
	– Relative to MA(12)	1.06	1.05	1.14	1.14	1.14
	– Relative to MVSV-Trend	1.01	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.92	0.94*	0.96	0.97	0.99
	– Relative to MVSV-T	1.01	1.02	1.03	1.02	1.01
	Predictive Score vs. UCSV	0.14***	0.77***	1.98***	3.63***	5.53***
	– vs. MVSV-T	0.01	−0.28***	−0.46***	−0.63***	−0.78***
Sweden	RMSE for MVSV	2.03	2.37	2.71	2.97	3.13
	– Relative to MA(4)	0.90**	0.87	0.93	0.94	0.96
	– Relative to MA(12)	0.88***	0.90**	0.98	1.02	1.02
	– Relative to MVSV-Trend	0.99**	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.96	0.89	0.96	0.96	0.98
	– Relative to MVSV-T	1.05	1.06	1.10*	1.09	1.08
	Predictive Score vs. UCSV	0.15***	0.27***	0.78***	1.88***	3.37***
	– vs. MVSV-T	−0.06	−0.13	−0.18*	−0.27**	−0.37***

(continued)

Table 3. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Spain	RMSE for MVSV	1.55	1.87	1.89	1.84	1.97
	– Relative to MA(4)	0.99	1.03	1.01	0.99	1.06
	– Relative to MA(12)	0.96	0.98	0.95	0.94	0.93
	– Relative to MVSV-Trend	0.99*	1.00	1.00	1.00	1.00
	– Relative to UCSV	1.06	1.08	1.03	1.01	1.05
	– Relative to MVSV-T	1.08	1.07	1.08	1.06	1.02
	Predictive Score vs. UCSV	0.01	0.26***	1.01***	2.26***	3.60***
	– vs. MVSV-T	0.00	−0.01	−0.13	−0.14**	−0.23***
Switzerland	RMSE for MVSV	1.20	1.59	1.94	2.06	2.14
	– Relative to MA(4)	0.90	0.99	0.99	0.93	0.96
	– Relative to MA(12)	0.84	0.91	1.00	1.01	1.05
	– Relative to MVSV-Trend	0.97	1.00	1.00	1.00	1.00**
	– Relative to UCSV	0.95	1.00	1.01	0.94	0.95
	– Relative to MVSV-T	0.92**	0.90*	0.94	0.94	0.95
	Predictive Score vs. UCSV	0.12*	0.33***	0.98***	2.31***	3.99***
	– vs. MVSV-T	0.15**	0.17*	0.21	0.21	0.26

(continued)

Table 3. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
United Kingdom	RMSE for MVSV	1.21	1.45	1.86	2.15	2.27
	– Relative to MA(4)	0.90	0.85	0.97	1.03	1.07
	– Relative to MA(12)	0.85	0.86	1.02	1.13	1.12
	– Relative to MVSV-Trend	1.02	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.85	0.83*	0.92	0.98	1.03
	– Relative to MVSV-T	0.93*	0.94	0.97	1.00	1.01
	Predictive Score vs. UCSV	0.04	0.53***	1.35***	2.69***	4.27***
	– vs. MVSV-T	0.11	−0.05	−0.16	−0.22*	−0.29**
United States	RMSE for MVSV	1.10	1.22	1.29	1.34	1.30
	– Relative to MA(4)	0.71**	0.75**	0.80***	0.79***	0.83*
	– Relative to MA(12)	0.84**	0.89	0.96	0.98	0.96
	– Relative to MVSV-Trend	1.02	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.77**	0.83**	0.82***	0.81***	0.79**
	– Relative to MVSV-T	1.00	1.00	1.00	1.00	1.00
	Predictive Score vs. UCSV	0.32***	0.63***	1.27***	2.29***	3.57***
	– vs. MVSV-T	−0.00	0.00	−0.00	0.00	−0.00

(continued)

Table 3. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
United States (CPI-U-RS)	RMSE for MVSV	1.14	1.27	1.32	1.38	1.38
	– Relative to MA(4)	0.69**	0.76**	0.80***	0.80**	0.87
	– Relative to MA(12)	0.82**	0.91	0.98	1.02	1.03
	– Relative to MVSV-Trend	0.99***	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.84**	0.93*	0.93*	0.94	0.96
	– Relative to MVSV-T	1.00	1.00	1.00	1.00*	1.00
	Predictive Score vs. UCSV	0.24***	0.31***	0.70***	1.70***	3.08***
	– vs. MVSV-T	−0.00	0.00	−0.00	−0.00**	−0.00

Notes: For each country, root mean squared errors (RMSE) and average log-predictive scores are derived from out-of-sample forecasts that were generated from quasi-real-time estimates of each model from 1985:Q1 onwards; each model estimation is conditioned on data from 1960:Q1 until the beginning of each forecast period. Superscripts *, **, and *** denote statistically significant differences in squared forecast errors and log-predictive scores—as computed from the test by Diebold and Mariano (1995)—at the 10 percent, 5 percent, and 1 percent level, respectively.

Table 4. Forecast Evaluation: Quarterly Inflation Rates

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Australia	RMSE for MVSV	2.32	2.54	3.01	3.24	3.29
	– Relative to MA(4)	0.96	0.92*	0.96	0.98	0.97
	– Relative to MA(12)	0.92	0.92	1.02	1.07	1.04
	– Relative to MVSV-Trend	1.01	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.96	0.92	0.95	0.96	0.96
	– Relative to MVSV-T	1.04	1.09**	1.13***	1.10**	1.07**
	Predictive Score vs. UCSV	0.06	0.03	0.06	0.12**	0.39***
	– vs. MVSV-T	−0.03	−0.06	−0.16***	−0.20***	−0.22**
Belgium	RMSE for MVSV	1.65	1.96	1.92	1.86	1.78
	– Relative to MA(4)	0.95	0.92	0.94	0.99	0.92
	– Relative to MA(12)	0.89*	0.95	0.99	0.96	0.99
	– Relative to MVSV-Trend	0.92*	1.00	1.00	1.00	1.00
	– Relative to UCSV	1.05	0.95	0.97	0.97	0.95
	– Relative to MVSV-T	1.04***	1.06***	1.05**	1.00	1.02
	Predictive Score vs. UCSV	−0.08	0.06	0.16**	0.22**	0.30**
	– vs. MVSV-T	−0.08**	−0.06*	0.00	−0.01	−0.05

(continued)

Table 4. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Canada	RMSE for MVSV	1.71	1.94	1.97	2.15	2.21
	– Relative to MA(4)	0.85***	0.96	0.91*	0.93	0.94
	– Relative to MA(12)	0.91**	0.98	0.95	0.98	0.96
	– Relative to MVSV-Trend	1.00	1.00***	1.00*	1.00***	1.00
	– Relative to UCSV	0.90**	0.91	0.90*	0.89	0.94
	– Relative to MVSV-T	1.04	1.11**	1.08**	1.10	1.05*
	Predictive Score vs. UCSV	0.10*	0.15***	0.24***	0.37***	0.66***
	– vs. MVSV-T	0.03	0.02	−0.07	−0.10	−0.16*
France	RMSE for MVSV	1.07	1.32	1.26	1.31	1.32
	– Relative to MA(4)	0.89**	0.92*	0.92*	0.93**	0.94
	– Relative to MA(12)	0.75*	0.81	0.82	0.81	0.81
	– Relative to MVSV-Trend	0.97	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.99	0.91**	0.95	0.93**	0.97
	– Relative to MVSV-T	1.00	1.05	1.05	1.03	1.03
	Predictive Score vs. UCSV	0.06**	0.15***	0.19***	0.29***	0.49***
	– vs. MVSV-T	0.04	−0.06	−0.03	0.00	−0.06

(continued)

Table 4. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Germany	RMSE for MVSV	1.46	1.66	1.83	1.89	2.00
	– Relative to MA(4)	1.01	0.98	0.96	0.94	0.92
	– Relative to MA(12)	0.92	0.93	0.96	0.93	0.94
	– Relative to MVSV-Trend	0.99	1.00	1.00	1.00	1.00
	– Relative to UCSV	1.01	0.98	0.94	0.93	0.92
	– Relative to MVSV-T	1.02	1.06	1.05*	1.02	1.02
	Predictive Score vs. UCSV	−0.01	0.03	0.07	0.12***	0.15***
	– vs. MVSV-T	−0.03	−0.09**	−0.10**	−0.09*	−0.12*
Ireland	RMSE for MVSV	1.97	3.03	3.33	3.34	3.00
	– Relative to MA(4)	0.87**	0.96	0.98	1.00	1.00
	– Relative to MA(12)	0.73**	0.98	1.09	1.13	1.04
	– Relative to MVSV-Trend	1.00	1.00	1.00	1.00	1.00
	– Relative to UCSV	1.05	0.95	0.92	0.94	0.94
	– Relative to MVSV-T	0.88*	1.13	1.27	1.22*	1.10
	Predictive Score vs. UCSV	0.00	0.24	0.12	0.04	0.04
	– vs. MVSV-T	0.07	−0.14	−0.09	0.04	0.13

(continued)

Table 4. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Italy	RMSE for MVSV	1.06	1.49	1.60	1.64	1.58
	– Relative to MA(4)	0.89*	0.91*	0.90***	0.93***	0.95**
	– Relative to MA(12)	0.67***	0.75	0.78	0.81	0.80
	– Relative to MVSV-Trend	0.96**	1.00	1.00	1.00	1.00
	– Relative to UCSV	1.04	0.90	0.88*	0.89**	0.92***
	– Relative to MVSV-T	1.01	1.03	1.01	1.00	1.01
	Predictive Score vs. UCSV	0.03	0.12*	0.24***	0.39***	0.62***
	– vs. MVSV-T	−0.01	−0.07**	−0.02	0.00	−0.08
Japan	RMSE for MVSV	1.63	1.75	1.88	1.85	1.82
	– Relative to MA(4)	0.97	0.96	0.94	0.90*	0.83***
	– Relative to MA(12)	0.96	0.96	0.97	0.96	0.97
	– Relative to MVSV-Trend	0.99	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.99	0.94	0.95	0.90**	0.86***
	Predictive Score vs. UCSV	−0.02	0.12*	0.30***	0.92***	2.03***

(continued)

Table 4. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
New Zealand	RMSE for MVSV	3.53	4.29	4.60	4.36	4.82
	– Relative to MA(4)	0.96	1.13	1.08	1.06	1.09
	– Relative to MA(12)	0.96	1.08	1.09	1.12	1.11
	– Relative to MVSV-Trend	1.03	1.00*	1.00	1.00	1.00
	– Relative to UCSV	0.94	0.94*	0.97	0.96	0.98
	– Relative to MVSV-T	1.00	1.02**	1.02	1.02	1.02
	Predictive Score vs. UCSV	0.11***	0.11***	0.21***	0.42***	0.95***
	– vs. MVSV-T	0.03	−0.09	−0.24***	−0.37***	−0.43***
Sweden	RMSE for MVSV	2.46	2.87	3.07	3.36	3.50
	– Relative to MA(4)	0.97	0.93	0.93	0.95	0.96
	– Relative to MA(12)	0.90***	0.94*	0.95	1.01	1.02
	– Relative to MVSV-Trend	0.98	1.00	1.00	1.00	1.00
	– Relative to UCSV	1.00	0.95*	0.93	0.97	0.97
	– Relative to MVSV-T	1.03	1.03	1.05	1.07	1.06
	Predictive Score vs. UCSV	0.07	0.12***	0.11***	0.13***	0.18***
	– vs. MVSV-T	−0.00	−0.06	−0.10**	−0.15***	−0.19***

(continued)

Table 4. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
Spain	RMSE for MVSV	1.87	2.17	2.33	2.22	2.21
	– Relative to MA(4)	0.98	1.00	1.02	0.97	1.02
	– Relative to MA(12)	0.94	1.00	0.98	0.96	0.94
	– Relative to MVSV–Trend	0.97***	1.00	1.00	1.00	1.00
	– Relative to UCSV	1.03	1.03	1.03	1.00	1.01
	– Relative to MVSV–T	1.03	1.04	1.04	1.07	1.02
	Predictive Score vs. UCSV	0.01	0.04	0.08*	0.31***	0.67***
	– vs. MVSV–T	0.00	−0.02	−0.04	−0.09*	−0.10***
Switzerland	RMSE for MVSV	1.26	1.71	1.90	2.22	2.29
	– Relative to MA(4)	0.87**	0.98	0.98	0.98	0.94
	– Relative to MA(12)	0.81**	0.94	0.93	1.02	1.02
	– Relative to MVSV–Trend	0.93*	1.00	1.00	1.00	1.00*
	– Relative to UCSV	0.95	0.96	0.98	0.99	0.95
	– Relative to MVSV–T	0.98	0.93*	0.92*	0.95	0.95
	Predictive Score vs. UCSV	0.07***	0.10**	0.18**	0.57***	1.52***
	– vs. MVSV–T	0.04	0.08*	0.12	0.18	0.13

(continued)

Table 4. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
United Kingdom	RMSE for MVSV	1.65	1.75	2.06	2.24	2.53
	– Relative to MA(4)	0.97	0.95	0.93	0.98	1.06
	– Relative to MA(12)	0.92	0.91	0.99	1.03	1.13
	– Relative to MVSV-Trend	1.02	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.96	0.89*	0.90**	0.96	0.99
	– Relative to MVSV-T	0.99	0.94**	0.99	0.98	1.00
	Predictive Score vs. UCSV	0.04	0.09*	0.21***	0.37***	0.72***
	– vs. MVSV-T	0.02	0.04	−0.12	−0.15*	−0.21**
United States	RMSE for MVSV	1.77	1.89	1.88	1.98	2.00
	– Relative to MA(4)	0.85**	0.88*	0.85*	0.91***	0.87**
	– Relative to MA(12)	0.92**	0.95	0.94	1.00	0.99
	– Relative to MVSV-Trend	0.98	1.00	1.00	1.00	1.00
	– Relative to UCSV	0.93*	0.87**	0.90**	0.91**	0.88***
	– Relative to MVSV-T	1.00	1.00	1.00	1.00	1.00
	Predictive Score vs. UCSV	0.13**	0.21***	0.23	0.29	0.37*
	– vs. MVSV-T	0.00	−0.00	−0.00	−0.00	−0.00

(continued)

Table 4. (Continued)

		Years Ahead				
		Next	**1 Year**	**2 Years**	**3 Years**	**4 Years**
United States (CPI-U-RS)	RMSE for MVSV	2.63	2.69	2.72	2.78	2.85
	– Relative to MA(4)	0.87***	0.91**	0.92	0.92***	0.92**
	– Relative to MA(12)	0.93***	0.94***	0.97**	0.98	0.99
	– Relative to MVSV-Trend	0.97	0.98***	0.99***	1.00***	1.00**
	– Relative to UCSV	0.91***	0.97**	0.99	0.99	1.00
	– Relative to MVSV-T	1.00	1.00	1.00	1.00	1.00*
	Predictive Score vs. UCSV	0.15***	0.02	0.04	0.02	0.07
	– vs. MVSV-T	0.00	–0.00	0.00	0.00	0.00

Notes: For each country, root mean squared errors (RMSE) and average log-predictive scores are derived from out-of-sample forecasts that were generated from quasi-real-time estimates of each model from 1985:Q1 onwards; each model estimation is conditioned on data from 1960:Q1 until the beginning of each forecast period. Superscripts *, **, and *** denote statistically significant differences in squared forecast errors and log-predictive scores—as computed from the test by Diebold and Mariano (1995)—at the 10 percent, 5 percent, and 1 percent level, respectively.

RMSE ratio indicates that the MVSV model has a lower RMSE, and conversely for values above unity. A positive value for the difference in the average log-predictive scores indicates a more accurate predictive density of the MVSV value, with the converse holding in the case of a negative value for the difference. The statistical significance of the differences in RMSE and log-predictive scores is assessed with the Diebold-Mariano (1995) test.[31]

Several results recur across both tables. First, with only a couple of exceptions, the MVSV model generates lower RMSE for almost each country and at almost each horizon than a simple random-walk forecast. Second, in most countries, the same is also true, but often to a lesser extent, when the MVSV forecasts are compared with those of the UCSV model. Third, although most of these differences are notable—in the neighborhood of several tenths of the MVSV model's RMSEs—they are often not statistically significant. Primarily in the cases of France, Italy, and the United States, the MVSV model produces forecasts that are significantly better than projections derived from either a random-walk or UCSV model. Strikingly, the MVSV model rarely fares significantly worse than any of the moving averages or the UCSV model. The MVSV model also generates considerably higher log-predictive scores than the UCSV, suggesting a more accurate predictive density, especially over longer forecast horizons. To quite some extent, this reflects the differences in specification of the stochastic volatilities for the inflation gaps. As described in section 3, the UCSV model embeds the assumption that the log of the inflation-gap shock variance follows a random walk whereas the MVSV model uses an AR(1) specification. At longer forecast horizons, the random-walk assumption for the inflation-gap variance seems to lead to undue extrapolation of temporary changes in volatility—a property that has an adverse bearing on the accuracy of the UCSV model's predictive density.

Comparison of the absolute levels of the RMSEs for the MVSV model across both tables shows that RMSE values are somewhat

[31]The Diebold-Mariano (1995) test is designed to ascertain whether the squared losses generated by two different forecasts are, on average, equal. In light of the overlap in the forecast periods, we computed the standard errors using the Newey-West (1997) robust estimator, with a bandwidth set equal to one plus the forecast horizon. The Diebold-Mariano test can also be used to assess differences in log-predictive scores, as recently shown by Clark and Ravazzolo (2014).

larger for cases in which it is the quarterly rather than annual rate of inflation that is being forecast. This pattern is indicative of the considerable amount of highly transitory—and hence harder to forecast—fluctuations found in quarter-to-quarter variations in prices. These variations figure less heavily in the behavior of four-quarter inflation, a series in which the most violent swings in quarterly inflation are averaged out by construction. Correspondingly, the differences in RMSEs across the different models, which are clearly evident in the quarterly inflation results in table 4, are smaller in size and tend to be less statistically significant when forecasts of annual inflation are considered, as in table 3; a similar pattern holds also for differences in log-predictive scores between MVSV and UCSV model.

We also consider the forecasting performance of the MVSV trend alone, neglecting the horizon-specific information resulting from the VAR component of the model's gap equation (for a given trend-inflation estimate). In this case, forecasts for all horizons are set equal to the models' trend estimate, generated in quasi-real time (and shown in figure 18). For projections of both quarterly and annual inflation—reported in tables 3 and 4—there is typically not a great difference between the (average) forecast errors arising from the MVSV model (from which inflation forecasts are derived from summing the inflation-trend forecast and the inflation-gap forecast) and the errors of inflation projections derived from relying solely on the MVSV-generated inflation trend. This finding is consistent with the notion, espoused by Faust and Wright (2013), that improved forecast accuracy stems from the quality of the estimates of the inflation trend. Applied to the MVSV approach, this notion implies that the model's VAR equation for the inflation gap adds little value beyond its role in shaping the trend estimate itself.

For the United States, the MVSV model tends to outperform either a random-walk or the UCSV model, both in terms of RMSE and predictive density score, and significantly so in most cases. Results are fairly similar when using either the regular CPI or the CPI-U-RS measure, as table 3 shows.

As a final comparison, we consider forecasts from the MVSV-T model that sets the inflation trend equal to each country's inflation goal when applicable. In contrast to the baseline MVSV model, the MVSV-T model does not centers its forecasts on an empirical trend estimate. Instead, it takes the trend as corresponding to each country's official inflation goal (when applicable). Furthermore, once an inflation goal has been introduced for a given country, the MVSV-T model treats the inflation trend as deterministic, thus removing uncertainty about future trend shocks from the predictive density.[32] The forecast performance of the MVSV-T model compared with the MVSV model differs for different countries. In several instances, like those of Australia, Canada, and New Zealand, conditioning on a known inflation goal clearly improves forecasts both in terms of RMSE and predictive density, especially for longer forecast horizons. In other cases, like Switzerland and Ireland, the opposite is true, although the differences are not statistically significant. For several countries—including France, Belgium, and the United States—forecasts derived from the MVSV-T model do not differ greatly from those generated by the baseline version of the MVSV model.[33] If anything, the predictive density of longer-horizon forecasts tends to be improved when generated from the MVSV-T model.

8. Conclusion

Our paper has compared estimates of trend inflation in fourteen advanced economies using two different models. Our preferred model is a multivariate extension of Stock and Watson's (2007) unobserved-components model with stochastic volatility (UCSV) that has been applied to the G7 countries by Cecchetti et al. (2007). Like the UCSV model, our multivariate stochastic volatility model (MVSV) tracks time variation in the variability of shocks to trend inflation and the inflation gap. Inflation-gap estimates from our MVSV model allow for inflation-gap persistence—albeit modeled in a more parsimonious fashion than in Cogley, Primiceri, and Sargent (2010)—while the UCSV model embeds the assumption that gaps are serially uncorrelated. We find that, particularly since the 1980s, the MVSV-based

[32]At a given point in time, future adjustments in the inflation goal are, however, not anticipated by the MVSV-T model.

[33]In the case of the United States, forecasts from the MVSV and the MVSV-T model barely differ, on average, from each other in part also because of the limited number of observations for which the Federal Reserve's longer-term inflation objective, officially introduced in 2012, applies in our sample.

inflation trends are smoother and less variable than their UCSV counterparts, as the underlying filtering procedure implies less influence on the trend estimates of persistent variations in inflation that do not prove to be fully permanent.

A key additional property of the MVSV model is that it conditions on multiple inflation series, on the assumption that they share a common trend, as in the model of Mertens (2011). In contrast to Cogley and Sargent (2005), Kang, Kim, and Morley (2009), and Cogley, Primiceri, and Sargent (2010), our model restricts time variation in inflation-gap parameters only to the evolution of stochastic volatility. This variation is in turn limited to only two sources: drift in the log-variances of shocks to the common trend and separate, but cross-correlated, volatility processes for each inflation gap. Placing a limit in this way on the number of time-varying parameters makes the model more tractable, and it also enables us to handle missing data in some of the inflation series for several countries, while still allowing for the possibility of considerable persistence in the inflation-gap series. This restricted approach also holds out the prospect of greater forecast accuracy. Compared with alternative forecasts—generated either from a simple random-walk model or the UCSV model—our MVSV model typically is associated with a lower average size of forecast errors at various horizons and for most countries. In particular, for the exercise of forecasting four-quarter inflation rates (as distinct from quarter-to-quarter rates), the improvements are quite appreciable. However, with the exception of a few countries, it remains hard to generate inflation forecasts that outperform random-walk forecasts of inflation by a statistically significant amount.

Although our estimates of trend inflation display quite some similarities across countries—notably the shared experiences of persistently elevated values during the 1970s and more reliably anchored inflation expectations over the last two decades—there are also clear cross-country differences in the trend estimates. For example, the extent to which trend inflation underwent a rise, and subsequent fall, over the post-war sample differs notably across countries. In addition, for many countries, distinct, country-specific changes in monetary regime, like the adoption of a formal inflation target, are clearly visible in the evolution of our estimates of trend inflation.

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Discussion of "Trend Inflation in Advanced Economies"

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1. Introduction

Garnier, Mertens, and Nelson (this issue, GMN hereafter) conduct model-based trend/cycle decomposition of inflation for fourteen advanced economies since 1960. To do so, they develop a multivariate unobserved components (UC) model of inflation that assumes a common stochastic trend for three different measures of inflation based on headline CPI, core CPI, and the GDP deflator. As in many previous studies, the model also allows for stochastic volatility in the underlying shocks driving inflation. Estimation using Bayesian methods is conducted on a country-by-country basis, with certain historical shifts in each country's price level that are due to non-market factors (e.g., price controls and large changes in indirect taxes) taken into account.

GMN find that the estimates of trend inflation for their multivariate UC model are smoother and more robust to controlling for price shifts than estimates based on a univariate UC model along the lines of what has been previously applied to inflation for G7 countries by Cecchetti et al. (2007). However, despite the relative smoothness of the multivariate estimates, trend inflation is clearly still the primary driving force behind the behavior of inflation over the past fifty years. In particular, mirroring the pattern for measured inflation in all fourteen advanced economies, trend inflation was high and volatile in the 1970s and lower and more stable in recent years.

Reflecting the importance of trend inflation, GMN find that quasi-real-time estimates of trend based on their model provide reasonably good out-of-sample point forecasts of headline CPI inflation, regardless of forecast horizon. Notably, these forecasts are generally more accurate than random-walk benchmarks or forecasts based on the univariate UC model, although not always significantly so according to Diebold-Mariano (1995) tests. Density forecasts are also generally more accurate for the multivariate UC model than for the univariate UC model and often significantly so.

GMN consider the role of formal inflation targets in anchoring trend inflation by also estimating a modified version of their multivariate UC model that sets trend inflation to an explicit objective when one is available (e.g., the midpoint of an official target range for CPI inflation). In several instances—especially for Australia, Canada, Germany, New Zealand, and Sweden—the point and density forecasts are significantly improved by setting the trend in this way.

The main contribution of GMN is to develop a very flexible time-series model of inflation that, based on the forecast evaluation, appears to provide more accurate estimates of trend inflation than other approaches. Notably, the multivariate UC model's flexibility makes it readily applicable to inflation data for many different economies, including in terms of being able to handle missing observations and, as mentioned above, in producing more robust estimates in the presence of discrete price shifts.

The remainder of my discussion focuses on how, in addition to providing more accurate estimates of trend inflation for advanced economies, GMN also shed partial light on two challenging and potentially related questions that are of utmost importance to macroeconomists: Why has trend inflation changed? Why has inflation become less persistent? However, I conclude that these questions remain largely unresolved and suggest possible modifications to GMN's approach that might help address these questions in future research.

2. Why Has Trend Inflation Changed?

Estimates for GMN's main model are consistent with the idea that changes in monetary policy practices are responsible for the big swings in the level and volatility of trend inflation over the past fifty years. However, this is just an ex post interpretation of the results based on the broad timing of the estimates, including a general rise in the level and volatility of trend inflation around the collapse of the Bretton Woods system in the early 1970s and a general fall and stabilization of trend inflation during Paul Volcker's chairmanship of the Federal Reserve in the early 1980s and continuing with the adoption of formal inflation targeting in several countries from the early 1990s and on. As far as the model is concerned, though, the trend is assumed to be exogenous, meaning that the model itself provides no direct insights into the sources of changes in trend inflation.

The modified version of GMN's model that sets trend inflation to an explicit objective when one is available goes some way towards addressing this exogeneity issue, and the strong performance of this modified model in the forecast evaluation provides reasonably compelling support, beyond just a broad sense of timing, for the idea that monetary policy practices have helped determine trend inflation. However, there remains a question, unanswered by the model at least, of what exactly led to the increase in trend inflation in the 1970s. Also, what was it about the specific conduct of monetary policy under inflation targeting that appears to have stabilized trend inflation?

As a robustness check, GMN follow Kang, Kim, and Morley (2009) and allow for correlation between the inflation gap (i.e., the deviation of measured inflation from trend inflation) and changes in trend inflation in another modified version of their model. This alternative specification nests the accelerationist view that shocks to the inflation gap (e.g., aggregate demand and cost-push shocks) can also impact the level of trend inflation—i.e., trend inflation is endogenous with respect to these shocks. However, GMN find that, for most countries at least, estimates of trend inflation are very similar to what they were for their main model, presumably reflecting relatively little correlation between the inflation gap and changes in trend (although these estimates are not reported). Thus, there appears to be empirical support for the assumption in the main model that trend inflation is exogenous with respect to the shocks driving the inflation gap.

But ruling out certain shocks, while better than nothing, does little to answer what other factors might be important in driving trend inflation. One interesting possibility would be to explicitly consider whether changes in the systematic behavior of monetary policy in terms of setting a policy interest rate (e.g., the intercept in a Taylor-rule characterization of policy) can be related to changes in trend inflation. Or, assuming that adjusting money growth is really the only way monetary policy can determine trend inflation when a

Fisher relationship holds for interest rates in the long run (see Nelson 2008 on this point), it would be useful to check whether changes in money growth (somehow correctly measured) can be related to changes in trend inflation.

3. Why Has Inflation Become Less Persistent?

The changes in the relative variances of the underlying shocks driving inflation can explain why inflation in advanced economies appears to be less persistent in recent years (see Cecchetti et al. 2007, and Stock and Watson 2007). In particular, a decrease in the signal-to-noise ratio for inflation (i.e., when trend variability falls by more than inflation-gap variability) implies less visible persistence in inflation or, more formally, less persistence as measured by impulse response functions for forecast errors, as in Kang, Kim, and Morley (2009).

However, because GMN's main model assumes time-invariant VAR dynamics for deviations from trend over the whole sample period, it effectively only allows for this "changing signal-to-noise ratio" explanation for the change in inflation persistence. Fortunately, GMN also consider the robustness of their results using another modified version of their model that allows for time variation in the VAR dynamics. Although they find some changes in the persistence of the deviations from trend, as measured by the largest eigenvalue for the companion matrix of the VAR process, there is little impact on the estimates of trend inflation. Thus, the "changing signal-to-noise ratio" explanation for changing persistence appears to be empirically relevant, rather than just being assumed.

At the same time, according to the estimates for the modified version of the model with time variation in the VAR dynamics, the persistence of the deviations from trend has changed over time, begging the question of why. In Morley, Piger, and Rasche (2015), we consider this question when applying a bivariate UC model of inflation and the unemployment rate to data for G7 countries on a country-by-country basis. We find that the impact of the unemployment gap on the inflation gap has been relatively stable for most of the G7 countries over time, but the variance of the residual component of the inflation gap, which turns out to be highly correlated with the food and energy component of headline CPI inflation, has changed substantially. Because the unemployment gap is more persistent than the residual component, the overall persistence of the inflation gap has correspondingly changed over time. It would be useful to have a version of GMN's model that separated the inflation gap into different components, as in Morley, Piger, and Rasche (2015), in order to get a better sense of why the persistence of the inflation gap and, therefore, inflation itself has changed.

4. Conclusion

Monetary policy appears to have played a role in stabilizing trend inflation in advanced economies over the past fifty years, with the superior forecasting performance of a model that takes formal inflation targets into account providing particularly strong empirical support for this idea. The stabilization of trend inflation also appears to have helped explain changes in the persistence of inflation over time. However, changes in the persistence of the inflation gap may be important too.

When analyzing the role of monetary policy in driving trend inflation, it would be useful to consider a model that allows for multiple discrete regime changes at unknown points of time, including allowing the variance of the change in trend inflation to sometimes be zero in the case of fully anchored expectations, rather than just assuming the only discrete change of this sort was with the formal introduction of inflation targeting. In Kang, Kim, and Morley (2009), we considered a univariate model of U.S. inflation that allowed for discrete regime changes and found that estimates for the timing of changes in trend volatility did, indeed, match with major changes in the practice of U.S. monetary policy. This result provides even more compelling support for the idea that monetary policy drives trend inflation than a result based on imposing a regime change corresponding to a known monetary event like the introduction of an inflation target. Meanwhile, as discussed above, it would also be useful to check whether changes in the level of trend inflation correspond to changes in monetary practices as captured by changes in the parameters of a Taylor rule or in the long-run growth rate of money.

In terms of understanding changes in inflation persistence, it would be useful to consider further multivariate analysis (beyond multiple measures of inflation) that allows for a changing composition of shocks driving the inflation gap, as well as allowing for changes in the dynamic effects of these shocks. GMN argue against the necessity of such multivariate analysis on the basis that Stock and Watson (2009) and others have shown it is difficult to improve inflation forecasts with other information beyond inflation, including from an assumed Phillips-curve relationship. However, Stock and Watson (2010) find that an "unemployment recession gap" (which looks like a mirror image of the highly asymmetric output gap estimated in Morley and Piger 2012) helps generate at least episodic forecasting improvements over univariate forecasts of inflation. Thus, any further multivariate analysis should take non-standard measures of economic slack and/or possibly non-linear specifications for the Phillips curve into account in order to generate an improved forecasting performance.

Because trend inflation is not directly observed, finding a better measure for it is a crucial first step in understanding its role in the overall behavior of inflation. GMN make an important contribution to this effort by developing a flexible model that appears to provide accurate estimates of trend inflation in the sense that they forecast future inflation relatively well. However, more work needs to be done in future research in order to nail down the empirical sources of changes in trend inflation and inflation persistence.

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Inflation Targeting and Economic Reforms in New Zealand*

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We study the consequences of economic reforms in New Zealand since the beginning of the 1990s. Inflation targeting became the monetary policymaking framework of the RBNZ in 1990. In the years that followed, New Zealand implemented labor market reform and became increasingly integrated in world trade. We use a New Keynesian model with rich trade microfoundations and labor market dynamics to study the performance of inflation targeting versus alternative monetary policy rules for New Zealand in relation to these market characteristics and reforms. We show that nominal income targeting would have been a better choice than inflation targeting or price-level targeting prior to market reforms by delivering more stable unemployment dynamics in a distorted economic environment. Nominal income targeting would also have been better than inflation targeting with respect to the transition costs

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of labor market reforms, though inflation targeting allowed for better management of the transition after trade integration. With New Zealand in its new long-run environment of integrated trade and flexible labor markets, the welfare gap between nominal income targeting and price/inflation targeting declines, as market reforms lower unemployment volatility.

JEL Codes: E24, E32, E52, F16, F41, J64.

1. Introduction

After a decade or more of disappointing economic performance, beginning in 1984, with the election of the Labour Party, the New Zealand government embarked upon a major restructuring of the nation's economy. The reforms that were undertaken touched almost all facets of the economy, both public and private, and have on occasion been characterized as being revolutionary; see, e.g., Grafton, Hazledine, and Buchardt (1997).[1]

A crucial element of the reforms was the Reserve Bank of New Zealand (RBNZ) Act passed in late 1989 and taking effect in early 1990. The cornerstone of the Act was that the primary function of the RBNZ was to conduct monetary policy so as to maintain price stability across a broad spectrum of prices. The first Policy Targets Agreement (PTA) published in early 1990 stated that the target for the RBNZ was to maintain CPI inflation within a (0–2 percent) band. This has subsequently been modified in minor ways in a revision to the PTA published in September 2012; see Kendall and Ng (2013).

The objective of this paper is to evaluate the effectiveness of the inflation-targeting policy as it has been implemented in conjunction with other reforms implemented by New Zealand. The model we employ is one developed by Cacciatore and Ghironi (2012), used to analyze the consequences of trade integration for monetary policy in open economies. This model is a New Keynesian extension of Ghironi and Melitz (2005) that incorporates sticky prices and wages, together with search-and-matching frictions in labor markets. By incorporating endogenous costly entry of producers into domestic

[1] For an extensive discussion of the reforms, see Evans et al. (1996) and Silverstone, Bollard, and Lattimore (1996).

and export markets, the model makes it possible to analyze how trade integration impacts micro-level and aggregate dynamics, and how this matters for monetary policy. By incorporating labor market frictions, the model is suited for analyzing labor market reform and its consequences for macro policy.[2]

The small open-economy version of the Cacciatore-Ghironi model that we employ here is particularly well adapted to addressing issues pertaining to the New Zealand experience of liberalization. In this regard, while the reforms in New Zealand have been extremely broad, we focus our attention on two aspects that are particularly relevant and which, as noted, the model is well suited to address. These include (i) trade liberalization, and (ii) labor market liberalization.[3] In assessing the inflation-targeting policy, we also compare it with two natural alternatives that have received attention in recent and ongoing policy discussions in New Zealand and other inflation-targeting countries, namely nominal income targeting and price-level targeting. The main conclusions we obtain include the following:[4]

- Strict nominal income targeting dominates inflation and price-level targeting in the pre-deregulation scenario, as it stabilizes unemployment fluctuations in the presence of distorted product and labor markets. In this environment, inflation targeting performs better than price-level targeting.
- Along the transitional dynamic path triggered by the implementation of reforms, strict inflation targeting performs better than does strict nominal income targeting following trade

[2]Cacciatore, Fiori, and Ghironi (2015) use the model to study the consequences of market reforms in Europe, including product market deregulation, for U.S.-Europe interdependence and monetary coordination.

[3]Labor market liberalization was implemented through the Employment Contracts Act (ECA) enacted in 1991, which substantially changed the way that employers and employees contract with one another. One of its most profound effects was to reduce union membership by almost 50 percent.

[4]A key feature of our analysis is that we focus on the interaction of the inflation-targeting rule with two aspects of the market reforms. An earlier paper by Buckle, Kim, and McLellan (2003) employs a structural VAR model to examine the effects of inflation targeting on the variability of inflation and business cycles, but abstracting from any of the concurrent reforms that were taking place in the New Zealand economy.

liberalization. But strict nominal income targeting is more beneficial in response to labor market deregulation.

- In the new, deregulated, environment, the welfare gap between strict nominal income targeting and price/inflation targeting declines, as market reforms eliminate some key distortions that were responsible for inefficiently high volatility of job creation. Interestingly, post-deregulation, price targeting dominates inflation targeting when the labor market is flexible.

By incorporating producer dynamics and endogenous selection into trade, our paper contributes to a vast literature on monetary policy in New Keynesian small open-economy models where these market characteristics are not incorporated, and only a reduced-form approach to the consequences of trade integration for monetary policy incentives is considered (usually by varying home bias in preferences). This is the approach in many studies that build, for instance, on Galí and Monacelli's (2005) influential small open-economy model. Our approach fully separates policy—a trade policy action—from structural parameters in analyzing the effect of trade on monetary policy incentives, and results. It relies on a model that, as discussed by Cacciatore and Ghironi (2012), more successfully reproduces international business-cycle statistics—especially with respect to the effect of trade on the business cycle—than does the standard New Keynesian framework without producer dynamics and labor market frictions.

We also contribute to the literature on the consequences of market reforms for fluctuations and macroeconomic policy, by focusing on the case of New Zealand for a set of policy regimes not considered in other studies. A recent strand of the literature introduces product and labor market frictions into otherwise-standard real business-cycle models to study the dynamic effects of market deregulation, including transition dynamics and business-cycle implications of reforms (see, for instance, Cacciatore and Fiori 2010 and Veracierto 2008).[5] Another line of research investigates the consequences of labor (and product) market reforms for monetary policy in New Keynesian models where market reforms are modeled as exogenous cuts in wage (and price) markups (see, for instance, Eggertsson, Ferrero,

[5] A more complete list of references is available in Cacciatore and Fiori (2010).

and Raffo 2014, and Fernández-Villaverde, Guerrón-Quintana, and Rubio-Ramírez 2011). Market reforms necessarily have deflationary consequences and exacerbate zero lower bound issues in these exercises. Exogenous markup cuts also improve the external balance by immediately depreciating the terms of trade. The more structural approach to market reforms that we adopt does not necessarily have these implications.[6]

Finally, we contribute to a recent and growing literature that studies macroeconomic dynamics following trade integration. In this vein, our paper is closest to Cacciatore (2014) and Itskhoki and Helpman (2014), who investigate how labor market frictions affect short-run dynamics following trade integration.[7] We contribute to this literature by investigating how monetary policy affects transitional dynamics and the business-cycle implications of stronger trade linkages.

The remainder of the paper is structured as follows. Section 2 describes the model, while section 3 sets out the alternative specifications of monetary policy. Our analysis treats New Zealand (NZ) as a small open economy, which is impacted by certain key variables in the rest of the world but has no impact on the rest of the world. The relevant aspects of foreign aggregates are briefly summarized in section 4. Section 5 calibrates the model, where we base the calibration parameters of the rest of the world on data pertaining to the United States. Section 6 reports the numerical simulations in the pre-deregulation phase, while section 7 discusses the macroeconomic effects of the reform, both during the transition and in the post-deregulation phase. Section 8 summarizes the sensitivity analysis we have conducted, while section 9 concludes. Relevant technical details of the model are summarized in an appendix.

[6]See Cacciatore, Fiori, and Ghironi (2013) for an analysis of these issues and optimal monetary policy in the context of a monetary union. Andrés, Arce, and Thomas (2014) and Krebs and Scheffel (2014) contribute to this literature by studying the consequences of debt overhang for the effects of exogenous markup cuts, and by addressing the role of market incompleteness.

[7]Burstein and Melitz (2011), Costantini and Melitz (2011), and Kambourov (2009) also study the transition dynamics following trade liberalization, abstracting from the role of frictions in the labor market. Albertini, Kamber, and Kirker (2012) estimate a model for New Zealand that incorporates search and frictional unemployment, focusing on the resulting labor market dynamics.

2. The Model

The model we employ is an application of the framework developed by Cacciatore and Ghironi (2012). The difference is that NZ is the prototype small open economy. As is now standard practice in the literature, we model the small open economy as a limiting case of a two-country dynamic general equilibrium model in which one country (the small open economy, also referred to as Home) is of measure zero relative to the rest of the world (Foreign henceforth). As a consequence, the policy decisions and macroeconomic dynamics of the small open economy have no impact on Foreign. Next we describe in detail the problem facing households and firms located in the small open economy.

2.1 Household Preferences

The small open economy is populated by a unit mass of atomistic households, where each household is viewed as an extended family with a continuum of members along the unit interval. In equilibrium, some family members are employed, while others are unemployed. As is common in the literature, we assume that family members insure each other perfectly against variations in labor income due to changes in employment status, so that there is no ex post heterogeneity across individuals in the household (see Andolfatto 1996 and Merz 1995).

The representative household in the Home economy maximizes the expected intertemporal utility function $E_0 \sum_{t=0}^{\infty} \beta^t \left[u(C_t) - l_t v(h_t)\right]$, where $\beta \in (0,1)$ is the discount factor, C_t is a consumption basket that aggregates domestic and imported goods as described below, l_t is the number of employed workers, and h_t denotes hours worked by each employed worker. Period utility from consumption, $u(.)$, and disutility of effort, $v(.)$, satisfy the standard assumptions.

The consumption basket C_t aggregates Home and Foreign sectoral consumption outputs, $C_t(n)$, in Dixit-Stiglitz (1977) form:

$$C_t = \left[\int_0^1 C_t(n)^{\frac{\phi-1}{\phi}} dn\right]^{\frac{\phi}{\phi-1}}, \tag{1}$$

where $\phi > 1$ is the symmetric elasticity of substitution across goods. The corresponding consumption-based price index is given by

$$P_t = \left[\int_0^1 P_t(n)^{1-\phi} dn \right]^{\frac{1}{1-\phi}}, \tag{2}$$

where $P_t(n)$ is the price index for sector n, expressed in Home currency.

2.2 Production

There are two vertically integrated production sectors. In the upstream sector, perfectly competitive firms use labor to produce a non-tradable intermediate input. In the downstream sector, each consumption-producing sector n is populated by a representative monopolistically competitive multi-product firm that purchases the intermediate input and produces differentiated varieties of its sectoral output. In equilibrium, some of these varieties are exported while the others are sold only domestically.[8]

2.2.1 Intermediate Goods Production

There is a unit mass of intermediate producers. Each of them employs a continuum of workers. Labor markets are characterized by search-and-matching frictions as in the Diamond-Mortensen-Pissarides (DMP) framework.[9] To hire new workers, firms need to post vacancies, incurring a cost of κ units of consumption per vacancy posted. The probability of finding a worker depends on a constant-returns-to-scale matching technology, which converts aggregate unemployed workers, U_t, and aggregate vacancies, V_t, into aggregate matches, $M_t = \chi U_t^{1-\varepsilon} V_t^{\varepsilon}$, where $\chi > 0$ and $0 < \varepsilon < 1$. Each firm meets unemployed workers at a rate $q_t \equiv M_t/V_t$. As in Krause and Lubik (2007) and other studies, we assume that newly created matches become productive only in the next period. For

[8] This production structure greatly simplifies the introduction of labor market frictions and sticky prices in the model.

[9] See Diamond (1982a, 1982b) and Mortensen and Pissarides (1994).

an individual firm, the inflow of new hires in period $t+1$ is therefore $q_t v_t$, where v_t is the number of vacancies posted by the firm in period t.[10]

Firms and workers can separate exogenously with probability $\lambda \in (0,1)$. Separation occurs only between firms and workers who were active in production in the previous period. As a result, the law of motion of employment, l_t (those who are working at time t), in a given firm is given by $l_t = (1-\lambda)l_{t-1} + q_{t-1}v_{t-1}$.

The representative intermediate firm produces output $y_t^I = Z_t l_t h_t$, where Z_t is exogenous aggregate productivity.[11] We normalize steady-state productivity, Z, to 1 and assume that Z_t follows an $AR(1)$ process in logarithms, $\log Z_t = \phi_Z \log Z_{t-1} + \boldsymbol{\epsilon}_t$, where $\boldsymbol{\epsilon}_t$ represents i.i.d. draws from a normal distribution with zero mean and standard deviation σ_ϵ.

As in Arseneau and Chugh (2008), firms face a quadratic cost of adjusting the hourly nominal wage rate, w_t. For each worker, the real cost of changing the nominal wage between period $t-1$ and t is $\vartheta \pi_{w,t}^2/2$, where $\vartheta \geq 0$ is in units of consumption and $\pi_{w,t} \equiv (w_t/w_{t-1}) - 1$ is the net wage inflation rate. If $\vartheta = 0$, there is no cost of wage adjustment.

Intermediate goods producers sell their output to final producers at a real price φ_t, expressed in units of consumption. Intermediate producers choose the number of vacancies, v_t, and employment, l_t, to maximize the expected present discounted value of their profit stream:

$$E_0 \sum_{t=0}^{\infty} \beta^t \frac{u_{C,t}}{u_{C,0}} \left(\varphi_t Z_t l_t h_t - \frac{w_t}{P_t} l_t h_t - \frac{\vartheta}{2} \pi_{w,t}^2 l_t - \kappa v \right),$$

subject to the dynamics of employment, where $u_{C,t}$ denotes the marginal utility of consumption in period t. Profit in any period consists of output sales less labor costs inclusive of wage adjustment costs plus vacancy costs. Future profits are discounted at the stochastic discount factor of domestic households, who are assumed to own Home firms.

[10] In equilibrium, $v_t = V_t$.

[11] Note that the assumption of a unit mass of intermediate producers ensures that y_t^I is also the total output of the intermediate sector.

Combining the first-order conditions for vacancies and employment yields the following job-creation equation:

$$\frac{\kappa}{q_t} = E_t \left\{ \beta_{t,t+1} \left[(1-\lambda)\frac{\kappa}{q_{t+1}} + \varphi_{t+1} Z_{t+1} h_{t+1} - \frac{w_{t+1}}{P_{t+1}} h_{t+1} - \frac{\vartheta}{2}\pi_{w,t+1}^2 \right] \right\}, \quad (3)$$

where $\beta_{t,t+1} \equiv \beta u_{C,t+1}/u_{C,t}$ is the one-period-ahead stochastic discount factor. The job-creation condition states that, at the optimum, the vacancy-creation cost incurred by the firm per current match is equal to the expected discounted value of the vacancy-creation cost per future match, further discounted by the probability of current match survival $1-\lambda$, plus the profits from the time-t match. Profits from the match take into account the future marginal revenue product from the match and its wage cost, including future nominal wage adjustment costs.

Wage and Hours. The nominal wage is the solution to an individual Nash bargaining process, and the wage payment divides the match surplus between workers and firms. Due to the presence of nominal rigidities, we depart from the standard Nash bargaining convention by assuming that bargaining occurs over the nominal wage payment rather than the real wage payment.[12] With zero costs of nominal wage adjustment ($\vartheta = 0$), the real wage that emerges would be identical to the one obtained from bargaining directly over the real wage. This is no longer the case in the presence of adjustment costs.

The details of wage determination are set out in the appendix. There we show that the equilibrium sharing rule can be written as $\eta_{w,t} H_t = (1-\eta_{w,t}) J_t$, where $\eta_{w,t}$ is the bargaining share of firms, H_t is worker surplus, and J_t is firm surplus (see the appendix for the expressions). As in Gertler and Trigari (2009), the equilibrium bargaining share is time varying due to the presence of wage adjustment costs. Without these costs, we would have a time-invariant bargaining share $\eta_{w,t} = \eta$, where η is the weight of firm surplus in the Nash bargaining problem. (The steady-state value of $\eta_{w,t}$, η_w,

[12] The same assumption is made by Arseneau and Chugh (2008), Gertler, Sala, and Trigari (2008), and Thomas (2008).

differs from η if wages are sticky and there is non-zero steady-state wage inflation.)

The bargained wage satisfies

$$\frac{w_t}{P_t}h_t = \eta_{w,t}\left(\frac{v(h_t)}{u_{C,t}} + b\right) + (1-\eta_{w,t})\left(\varphi_t Z_t h_t - \frac{\vartheta}{2}\pi_{w,t}^2\right)$$
$$+ E_t\left\{\beta_{t,t+1}J_{t+1}\left[(1-\lambda)(1-\eta_{w,t})\right.\right.$$
$$\left.\left. -(1-\lambda-\iota_t)(1-\eta_{w,t+1})\frac{\eta_{w,t}}{\eta_{w,t+1}}\right]\right\}, \quad (4)$$

where $v(h_t)/u_{C,t} + b$ is the worker's outside option (the utility value of leisure plus an unemployment benefit b), and ι_t is the probability of becoming employed at time t, defined by $\iota_t \equiv M_t/U_t$. With flexible wages, the third term on the right-hand side of this equation reduces to $(1-\eta)\iota_t E_t(\beta_{t,t+1}J_{t+1})$, or, in equilibrium, $\kappa(1-\eta)\iota_t/q_t$. In this case, the real wage bill per worker is a linear combination—determined by the constant bargaining parameter η—of the worker's outside option and the marginal revenue product generated by the worker (net of wage adjustment costs) plus the expected discounted continuation value of the match to the firm (adjusted for the probability of worker's employment). The stronger the bargaining power of firms (the higher η), the smaller the portion of the net marginal revenue product and continuation value to the firm appropriated by workers as wage payments, while the outside option becomes more relevant. When wages are sticky, bargaining shares are endogenous, and so is the distribution of surplus between workers and firms. Moreover, the current wage bill reflects also expected changes in bargaining shares.

As is common practice in the literature, we assume that hours per worker are determined by firms and workers in a privately efficient way, i.e., so as to maximize the joint surplus of their employment relation.[13] The joint surplus is the sum of the firm's surplus and the worker's surplus, i.e., $J_t + H_t$, as defined in (24) and (27). The maximization yields a standard intratemporal optimality condition for hours worked that equates the marginal revenue product of hours

[13] See, among others, Thomas (2008) and Trigari (2009).

per worker to the marginal rate of substitution between consumption and leisure: $v_{h,t}/u_{C,t} = \varphi_t Z_t$, where $v_{h,t}$ is the marginal disutility of effort.

2.2.2 Final Goods Production

A contribution of Cacciatore and Ghironi (2012) is to show how price stickiness can be introduced in a tractable way in the Ghironi-Melitz (2005) model of trade and macroeconomic dynamics, while preserving the aggregation properties of Melitz's (2003) heterogeneous firms model. This is done by introducing price stickiness at the level of sectoral product bundles for domestic sale and export that aggregate individual product varieties produced by plants with heterogeneous productivity. In this subsection we describe final goods creation and production, the export decision, and price setting.

In each consumption sector, n, the representative, monopolistically competitive firm n produces the sectoral output bundle, $Y_t(n)$, sold to consumers in Home and Foreign. Producer n is a multi-product firm that produces a set of differentiated product varieties, indexed by ω and defined over a continuum Ω:

$$Y_t(n) = \left(\int_{\omega \in \Omega}^{\infty} y_t(\omega, n)^{\frac{\theta-1}{\theta}} d\omega \right)^{\frac{\theta}{\theta-1}}, \tag{5}$$

where $\theta > 1$ is the symmetric elasticity of substitution across product varieties.[14]

Each product variety $y(\omega, n)$ is created and developed by the representative final producer n. Since consumption-producing sectors are symmetric in the economy, we omit the index n to simplify notation. The cost of the product bundle Y_t, denoted by P_t^y, is

$$P_t^y = \left(\int_{\omega \in \Omega}^{\infty} p_t^y(\omega)^{1-\theta} d\omega \right)^{\frac{1}{1-\theta}}, \tag{6}$$

where $p_t^y(\omega)$ is the nominal marginal cost of producing variety ω.

[14] Sectors (and sector-representative firms) are of measure zero relative to the aggregate size of the economy. Notice that $Y_t(n)$ can also be interpreted as a bundle of product features characterizing product n.

The number of products created and commercialized by each final producer is endogenously determined. At each point in time, only a subset of varieties $\Omega_t \subset \Omega$ is actually available to consumers. To create a new product, the final producer needs to undertake a sunk investment, $f_{e,t}$, in units of intermediate input. Product creation requires each final producer to create a new plant that will produce the new variety.[15] Plants employ different technologies indexed by relative productivity z. To save notation, we identify a variety with the corresponding plant productivity z, omitting ω. Upon product creation, the productivity level of the new plant z is drawn from a common distribution $G(z)$ defined over $[z_{\min}, \infty)$. This relative productivity level remains fixed thereafter. Each plant uses intermediate input to produce its differentiated product variety, with real marginal cost:

$$\varphi_{z,t} \equiv \frac{p_t^y(z)}{P_t} = \frac{\varphi_t}{z}. \tag{7}$$

At time t, each final Home producer commercializes $N_{d,t}$ varieties and creates $N_{e,t}$ new products that will be available for sale at time $t+1$. New and incumbent plants can be hit by a "death" shock with probability $\delta \in (0,1)$ at the end of each period. The law of motion for the stock of producing plants is

$$N_{d,t+1} = (1-\delta)(N_{d,t} + N_{e,t}).$$

When serving the Foreign market, each final producer faces per-unit iceberg trade costs, $\tau_t > 1$, and fixed export costs, $f_{x,t}$.[16] Fixed export costs are denominated in units of the intermediate input and are paid for each exported product. Thus, the total fixed cost is

[15] Alternatively, we could model product creation by assuming that monopolistically competitive firms produce product varieties (or features) that are sold to final producers, in this case interpreted as retailers. The two models are equivalent. Details are available upon request.

[16] Empirical micro-level studies have documented the relevance of plant-level fixed export costs—see, for instance, Bernard and Jensen (2004). Although a substantial portion of fixed export costs are probably sunk upon market entry, we follow Ghironi and Melitz (2005) and do not model the sunk nature of these costs explicitly. We conjecture that introducing these costs would further enhance the persistence properties of the model. See Alessandria and Choi (2007) for a model with heterogeneous firms, sunk export costs, and Walrasian labor markets.

$F_{x,t} = N_{x,t} f_{x,t}$, where $N_{x,t}$ denotes the number of product varieties (or features) exported to Foreign. Without fixed export costs, each producer would find it optimal to sell all its product varieties in Home and Foreign. Fixed export costs imply that only varieties produced by plants with sufficiently high productivity (above a cut-off level $z_{x,t}$, determined below) are exported.[17]

To proceed further, we define two special average productivity levels (weighted by relative output shares): (i) an average $\tilde{z}_d$ for all producing plants, and (ii) an average $\tilde{z}_{x,t}$ for all plants that export:

$$\tilde{z}_d = \left[\int_{z_{\min}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}},$$

$$\tilde{z}_{x,t} = \left[\frac{1}{1-G(z_{x,t})}\right]\left[\int_{z_{x,t}}^{\infty} z^{\theta-1} dG(z)\right]^{\frac{1}{\theta-1}}.$$

We assume that $G(\cdot)$ is a Pareto distribution with shape parameter, $k_p > \theta - 1$. As a result, $\tilde{z}_d = \alpha^{\frac{1}{\theta-1}} z_{\min}$ and $\tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}} z_{x,t}$, where $a \equiv k_p/[k_p - (\theta - 1)]$. Thus, the share of exporting plants is given by

$$N_{x,t} \equiv [1 - G(z_{x,t})] N_{d,t} = \left(\frac{z_{\min}}{\tilde{z}_{x,t}}\right)^{-k_p} \alpha^{\frac{k_p}{\theta-1}} N_{d,t}. \tag{8}$$

The output bundles for domestic and export sale, and associated unit costs, are defined as follows:

$$Y_{d,t} = \left[\int_{z_{\min}}^{\infty} y_{d,t}(z)^{\frac{\theta-1}{\theta}} dG(z)\right]^{\frac{\theta}{\theta-1}},$$

$$Y_{x,t} = \left[\int_{z_{x,t}}^{\infty} y_{x,t}(z)^{\frac{\theta-1}{\theta}} dG(z)\right]^{\frac{\theta}{\theta-1}}, \tag{9}$$

[17] Notice that $z_{x,t}$ is the lowest level of plant productivity such that the profit from exporting is positive.

$$P^y_{d,t} = \left[\int_{z_{\min}}^{\infty} p^y_t(z)^{1-\theta} dG(z)\right]^{\frac{1}{1-\theta}},$$

$$P^y_{x,t} = \left[\int_{z_{x,t}}^{\infty} p^y_t(z)^{\frac{\theta-1}{\theta}} dG(z)\right]^{\frac{1}{1-\theta}}. \tag{10}$$

Using equations (7) and (10), the real costs of producing the bundles $Y_{d,t}$ and $Y_{x,t}$ can then be expressed as

$$\frac{P^y_{d,t}}{P_t} = N_{d,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_d}, \quad \frac{P^y_{x,t}}{P_t} = N_{x,t}^{\frac{1}{1-\theta}} \frac{\varphi_t}{\tilde{z}_{x,t}}. \tag{11}$$

The present discounted cost facing the final producer in the determination of product creation and the export bundle is thus

$$E_t \left\{ \sum_{s=t}^{\infty} \beta_{t,s} \left[\frac{P^y_{d,s}}{P_s} Y_{d,s} + \tau_s \frac{P^y_{x,s}}{P_s} Y_{x,s} \right.\right.$$
$$\left.\left. + \left(\frac{N_{s+1}}{1-\delta} - N_s\right) f_{e,s}\varphi_s + N_{x,s} f_{x,s}\varphi_s \right] \right\}.$$

The producer chooses $N_{d,t+1}$ and the productivity cutoff $z_{x,t}$ to minimize this expression subject to (8), (11), and $\tilde{z}_{x,t} = \alpha^{\frac{1}{\theta-1}} z_{x,t}$.[18]

The first-order condition with respect to $z_{x,t}$ yields

$$\frac{P^y_{x,t}}{P_t} Y_{x,t}\tau_t = \frac{(\theta-1)k_p}{[k_p - (\theta-1)]} f_{x,t} N_{x,t}\varphi_t. \tag{12}$$

The above condition states that, at the optimum, marginal revenue from adding a variety with productivity $z_{x,t}$ to the export bundle has to be equal to the fixed cost. Thus, varieties produced by plants with productivity below $z_{x,t}$ are distributed only in the domestic market. The composition of the traded bundle is endogenous, and the set of exported products fluctuates over time with changes in the profitability of export.

The first-order condition with respect to $N_{d,t+1}$ determines product creation:

[18] Equation (8) implies that by choosing $z_{x,t}$ the producer also determines $N_{x,t}$.

$$\varphi_t f_{e,t} = (1-\delta)E_t \left\{ \beta_{t,t+1} \left[\varphi_{t+1} \left(f_{e,t+1} - \frac{N_{x,t+1}}{N_{d,t+1}} f_{x,t+1} \right) \right. \right.$$
$$\left. \left. + \frac{1}{\theta - 1} \left(\frac{P^y_{d,t+1} Y_{d,t+1}}{P_{t+1} N_{d,t+1}} + \frac{P^y_{x,t+1} Y_{x,t+1}}{P_{t+1} N_{x,t+1}} \frac{N_{x,t+1}}{N_{d,t+1}} \tau_{t+1} \right) \right] \right\}.$$

In equilibrium, the cost of producing an additional variety, $\varphi_t f_{e,t}$, must equal its expected benefit (expected savings on future sunk investment costs augmented by the marginal revenue from commercializing the variety, net of fixed export costs, if it is exported).

We are now left with the determination of domestic and export prices. We denote by $P_{d,t}$ the price (in Home currency) of the product bundle $Y_{d,t}$ and let $P_{x,t}$ be the price (in Foreign currency) of the exported bundle $Y_{x,t}$. Each final producer faces the following domestic and foreign demand for its product bundles:

$$Y_{d,t} = \left(\frac{P_{d,t}}{P_t} \right)^{-\phi} Y_t^C, \qquad Y_{x,t} = \left(\frac{P_{x,t}}{P_t^*} \right)^{-\phi} Y_t^{C^*},$$

where Y_t^C and $Y_t^{C^*}$ are aggregate demands of the consumption basket in Home and Foreign. Aggregate demand in each country includes sources other than household consumption, but it takes the same form as the consumption basket, with the same elasticity of substitution $\phi > 1$ across sectoral bundles. This ensures that the consumption price index for the consumption aggregator is also the price index for the aggregate demand of the basket.

Prices in the final sector are sticky. We follow Rotemberg (1982) and assume that final producers must pay quadratic price adjustment costs when changing domestic and export bundle prices, which we assume are set in accordance with producer currency pricing (PCP): Each final producer sets $P_{d,t}$ and the domestic currency price of the export bundle, $P^d_{x,t}$, letting the price in the foreign market be $P_{x,t} = \tau_t P^d_{x,t}/S_t$, where S_t is the nominal exchange rate (units of Home currency per unit of Foreign). The nominal costs of adjusting domestic and export price are, respectively, $\Gamma_{d,t} \equiv v\pi^2_{d,t} P_{d,t} Y_{d,t}/2$ and $\Gamma^d_{x,t} \equiv v\pi^{d^2}_{x,t} P^d_{x,t} Y_{x,t}/2$, where $v \geq 0$ determines the size of the adjustment costs (domestic and export prices are flexible if $v = 0$), $\pi_{d,t} \equiv (P_{d,t}/P_{d,t-1}) - 1$, and $\pi^d_{x,t} \equiv (P^d_{x,t}/P^d_{x,t-1}) - 1$.

In the absence of fixed export costs, the producer would set a single price $P_{d,t}$ and the law of one price (adjusted for the presence of trade costs) would determine the export price as $P_{x,t} = \tau_t P_{x,t} = P_{d,t}/S_t$. With fixed export costs, however, the composition of domestic and export bundles is different, and the marginal costs of producing these bundles are not equal. Therefore, final producers choose two different prices for the Home and Foreign markets even under PCP.

We relegate the details of optimal price setting to the appendix. We show there that the (real) price of Home output for domestic sales is given by

$$\frac{P_{d,t}}{P_t} = \frac{\phi}{(\phi - 1)\Xi_{d,t}} \left(\frac{P^y_{d,t}}{P_t} \right), \tag{13}$$

where

$$\Xi_{d,t} \equiv 1 - \frac{\nu}{2}\pi^2_{d,t} + \frac{\nu}{(\phi - 1)} \left\{ \pi_{d,t}(1 + \pi_{d,t}) - E_t \left[\beta_{t,t+1}\pi_{d,t+1} \frac{(1 + \pi_{d,t+1})^2}{1 + \pi^C_{t+1}} \frac{Y_{d,t+1}}{Y_{d,t}} \right] \right\}, \tag{14}$$

and $\pi_{C,t} \equiv (P_t/P_{t-1}) - 1$. As expected, price stickiness introduces endogenous markup variations: The cost of adjusting prices gives firms an incentive to change their markups over time in order to smooth price changes across periods. When prices are flexible ($v = 0$), the markup is constant and equal to $\phi/(\phi - 1)$.

The (real) price of Home output for export sales is equal to

$$\frac{P_{x,t}}{P^*_t} = \frac{\phi}{(\phi - 1)\Xi^d_{x,t}} \left(\frac{\tau_t P^y_{x,t}}{Q_t P_t} \right), \tag{15}$$

where $Q_t \equiv S_t P^*_t / P_t$ is the consumption-based real exchange rate (units of Home consumption per units of Foreign), and

$$\Xi^d_{x,t} \equiv 1 - \frac{\nu}{2}\pi^{d^2}_{x,t} + \frac{\nu}{(\phi - 1)} \left\{ (1 + \pi^d_{x,t})\pi^d_{x,t} - E_t \left[\beta_{t,t+1}\pi^d_{x,t+1} \frac{(1 + \pi^d_{x,t+1})^2}{1 + \pi^C_{t+1}} \frac{Y_{x,t+1}}{Y_{x,t}} \right] \right\}. \tag{16}$$

Absent fixed export costs, $z_{x,t} = z_{\min}$ and $\Xi^d_{x,t} \equiv \Xi_{d,t}$. Plant heterogeneity and fixed export costs, instead, imply that the law of one price does not hold for the exported bundles.

For future purposes, define the average real price of a domestic variety, $\tilde{\rho}_{d,t} \equiv N_{d,t}^{\frac{1}{\theta-1}}(P_{d,t}/P_t)$, and the average real price of an exported variety, $\tilde{\rho}_{x,t} \equiv N_{x,t}^{\frac{1}{\theta-1}}(P_{x,t}/P^*_t)$. Combining equations (11), (13), and (15), we have

$$\tilde{\rho}_{d,t} = \mu_{d,t}\frac{\varphi_t}{\tilde{z}_d}, \qquad \tilde{\rho}_{x,t} = \mu_{x,t}\frac{\tau_t}{Q_t}\frac{\varphi_t}{\tilde{z}_{x,t}}, \tag{17}$$

where $\mu_{d,t} \equiv \phi/[(\phi-1)\Xi_{d,t}]$ and $\mu_{x,t} \equiv \phi/[(\phi-1)\Xi^d_{x,t}]$. Finally, letting $\tilde{y}_{d,t}$ and $\tilde{y}_{x,t}$ denote the average output of, respectively, a domestic and exported variety, we have

$$\tilde{y}_{d,t} \equiv \tilde{\rho}_{d,t}^{-\phi} N_{d,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^C, \qquad \tilde{y}_{x,t} \equiv \tilde{\rho}_{x,t}^{-\phi} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C^*}. \tag{18}$$

2.3 Household Budget Constraint and Intertemporal Decisions

International assets markets are incomplete, as the representative household can invest only in nominal riskless bonds denominated in Home and Foreign currency. Home-currency-denominated bonds are traded only domestically. Let A_{t+1} and $A_{*,t+1}$ denote, respectively, nominal holdings of Home and Foreign bonds at Home.[19] To ensure a determinate steady-state equilibrium and stationary responses to temporary shocks in the model, we follow Turnovsky (1985) and, more recently, Benigno (2009) and assume a quadratic cost of adjusting Foreign bond holding, $\psi(A_{*,t+1}/P^*_t)^2/2$.[20] These costs are paid to financial intermediaries whose only function is to collect these transaction fees and to rebate the revenue to households in lump-sum fashion in equilibrium.

[19] Foreign nominal holdings of Foreign bonds are denoted by $A^*_{*,t}$.

[20] Given that idiosyncratic risk is pooled among domestic households, and foreign households only trade foreign-currency-denominated bonds, domestic-currency-denominated bonds are in zero net supply. That is, in reality only foreign-currency-denominated bonds are traded in equilibrium. As a result, defining the intermediation costs over the foreign currency bond only is sufficient to pin down the overall steady-state net foreign asset position.

The Home household's period budget constraint is

$$A_{t+1} + S_t A_{*,t+1} + \frac{\psi}{2} S_t P_t^* \left(\frac{A_{*,t+1}}{P_t^*} \right)^2 + P_t C_t$$
$$= (1 + i_t) A_t + (1 + i_t^*) A_{*,t} S_t + w_t L_t + P_t b(1 - l_t) + T_t^G$$
$$+ T_t^A + T_t^I + T_t^F,$$

where i_t and i_t^* are, respectively, the nominal interest rates on Home and Foreign bond holdings between $t-1$ and t, known with certainty as of $t-1$. Moreover, T_t^G is a lump-sum transfer (or tax) from the government, T_t^A is a lump-sum rebate of the cost of adjusting bond holdings from the intermediaries to which it is paid, and T_t^I and T_t^F are lump-sum rebates of profits from intermediate and final goods producers.[21]

Let $a_{t+1} \equiv A_{t+1}/P_t$ denote real holdings of Home bonds (in units of Home consumption) and let $a_{*,t+1} \equiv A_{*,t+1}/P_t^*$ denote real holdings of Foreign bonds (in units of Foreign consumption). The Euler equations for bond holdings are

$$1 = (1 + i_{t+1}) E_t \left\{ \frac{\beta_{t,t+1)}}{1 + \pi_{C,t+1}} \right\}, \tag{19}$$

$$1 + \psi a_{*t+1} = (1 + i_{t+1}^*) E_t \left[\beta_{t,t+1} \frac{Q_{t+1)}}{Q_t (1 + \pi_{C,t+1}^*)} \right], \tag{20}$$

where $\pi_{C,t}^* \equiv (P_t^*/P_{t-1}^*) - 1$.

We present below the law of motion for net foreign assets that follows from imposing equilibrium conditions in the household's budget constraint. Other details on the equilibrium can be found in the appendix.

[21] In equilibrium,

$$T_t^G = -P_t b(1 - l_t), \quad T_t^A = S_t P_t (\psi/2)(A_{*,t+1}/P_t^*)^2,$$
$$T_t^I = P_t(\varphi_t Z_t l_t - (w_t/P_t) l_t - (\vartheta/2)\pi_{w,t}^2 l_t - \lambda V_t),$$
$$T_t^F = \left(\frac{\mu_{d,t} - 1}{\mu_{d,t}} - \frac{\nu}{2}(\pi_{d,t})^2 \right) \tilde{\rho}_{d,t} N_{d,t} \tilde{y}_{d,t} + Q_t \left(\frac{\mu_{x,t} - 1}{\mu_{x,t}} - \frac{\nu}{2}(\pi_{x,t})^2 \right) \tilde{\rho}_{x,t} N_{x,t} \tilde{y}_{x,t}$$
$$- \varphi_t (N_{x,t} f_{x,t} + N_{e,t} f_{e,t}).$$

2.4 Net Foreign Assets and the Trade Balance

Bonds are in zero net supply, which implies that the equilibrium for the domestic bonds, being non-traded, is $a_t = 0$ in all periods. Home net foreign assets are determined by

$$Q_t a_{*,t+1} = Q_t \frac{1+i_t^*}{1+\pi_{C,t}^*} a_{*,t} + Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*.$$

Defining $1+r_t^* \equiv (1+i_t^*)/(1+\pi_{C,t}^*)$, the change in net foreign assets between t and $t+1$ is determined by the current account:

$$Q_t(a_{*,t+1} - a_{*,t}) = CA_t \equiv Q_t r_t^* a_{*,t} + TB_t,$$

where TB_t is the trade balance:

$$TB_t \equiv Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*.$$

3. Monetary Policy and Data-Consistent Variables

Before describing the interest rate setting rule, we must address an issue that concerns the data that are actually available to the central bank, i.e., we need to determine the empirically relevant variables that should enter the theoretical representation of historical policy. As pointed out by Ghironi and Melitz (2005), in the presence of endogenous product creation and "love for variety" in the production of final consumption varieties, variables measured in units of consumption do not have a direct counterpart in the data, i.e., they are not data consistent. As the economy experiences entry of Home and Foreign firms, the welfare-consistent aggregate price index P_t can fluctuate even if product prices remain constant. In the data, however, aggregate price indexes do not take these variety effects into account.[22] To resolve this issue, we follow Ghironi and Melitz (2005), and we construct an average price index $\tilde{P}_t \equiv (N_{d,t} + N_{x,t}^*)^{1/(\theta-1)} P_t$. The average price index $\tilde{P}_t$ is closer to the actual CPI data constructed by statistical agencies than is the welfare-based index P_t, and, therefore, it is the data-consistent CPI implied by the model.

[22] There is much empirical evidence that gains from variety are mostly unmeasured in CPI data, as documented most recently by Broda and Weinstein (2010).

In turn, given any variable X_t in units of consumption, its data-consistent counterpart is $X_{R,t} \equiv X_t P_t / \tilde{P}_t$. The data-consistent CPI inflation rate is $\tilde{\pi}_t^C \equiv (\tilde{P}_t / \tilde{P}_{t-1}) - 1$.

We now specify the monetary policy adopted by the small open economy. As Huang, Margaritis, and Mayes (2001) have shown, a standard Taylor (1993) rule describes New Zealand monetary policy quite well. In order to capture the basic policy of inflation targeting, we begin by assuming that the central bank of the small open economy sets the contemporaneous policy interest rate, according to

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left\{ (1 + i) \left[E_t \left(\frac{\hat{P}_{t+k}}{\hat{P}_{t+k-1}} \right) \right]^{\varrho_\pi} \left(\hat{Y}_{R,t}^g \right)^{\varrho_{Y^g}} \right\}^{1-\varrho_i},$$

where $\hat{Y}_{R,t}^g \equiv Y_{R,t} / Y_{R,t}^{flex}$ denotes the output gap—deviations of real output, $Y_{R,t}$, from real output under flexible prices and wages, $Y_{R,t}^{flex}$—and $\hat{P}_t$ denotes deviations of the data-consistent CPI from trend. (Here and for nominal income below, deviations from trend are defined as ratios to trend levels.)

One of our objectives is to compare this with alternative monetary policies and, in this regard, we specify the price-level targeting and nominal income targeting policies as follows:

Price-level targeting:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i) \left(E_t \hat{P}_{t+k} \right)^{\varrho_P} \left(\hat{Y}_{R,t}^g \right)^{\varrho_{Y^g}} \right]^{1-\varrho_i};$$

Nominal income targeting:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left[(1 + i) \left(E_t \hat{Y}_{t+k}^N \right)^{\varrho_{Y^N}} \left(\hat{Y}_{R,t}^g \right)^{\varrho_{Y^g}} \right]^{1-\varrho_i},$$

where $\hat{Y}_t^N$ denotes deviations of nominal income from trend.

The three policy rules above can be written more compactly as

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left\{ (1 + i) \left[E_t \left(\frac{\hat{P}_{t+k}}{\hat{P}_{t+k-1}^{I_P}} \right)^{1-I_{Y^N}} \left(E_t \hat{Y}_{t+k}^N \right)^{I_{Y^N}} \right]^{\varrho} \times \left(\hat{Y}_{R,t}^g \right)^{\varrho_{Y^g}} \right\}^{1-\varrho_i}, \tag{21}$$

where I_P and I_{Y^N} take value zero or one. Inflation targeting implies $I_P = 1$ and $I_{Y^N} = 0$; price-level targeting implies $I_P = I_{Y^N} = 0$; nominal income targeting implies $I_{Y^N} = 1$. Two points regarding the specification of (21) merit comment insofar as the Reserve Bank of New Zealand is concerned. First, it allows for a lagged adjustment, reflecting a policy of interest rate smoothing and cautious adjustment in response to multiplicative uncertainty (Tarkka and Mayes 1999). Second, it allows for a forward-looking policy according to which the interest rate is adjusted to k-period forecasts of inflation, prices, and output; see Huang, Margaritis, and Mayes (2001). In our benchmark specification we set $k = 0$.

Table 1 summarizes the key equilibrium conditions of the model. The table contains thirteen equations that determine thirteen endogenous variables of interest: $C_t, \tilde{\rho}_{d,t}, l_t, h_t, V_t, N_{d,t}, w_t/P_t, \tilde{z}_{x,t}, \pi_{w,t}, \pi_{C,t}, i_{t+1}, a_{*,t+1}$, and Q_t. (Other variables that appear in the table are determined as described above.)

4. Foreign Aggregates

As summarized in table 1, six Foreign variables directly affect the macroeconomic dynamics in the small open economy: $Y_t^{C^*}, i_t^*, \pi_{C,t}^*, N_{x,t}^*, \tilde{y}_{x,t}^*, \tilde{\rho}_{x,t}^*$. Aggregate demand, $Y_t^{C^*}$, the nominal interest rate, i_t^*, and inflation, $\pi_{C,t}^*$, are determined by treating the rest of the world (Foreign) as a closed economy that features the same production structure, technology, and frictions that characterize the small open economy.[23] Here we focus on the determination of the number of Foreign exporters, $N_{x,t}^*$, the average output of Foreign exported varieties, $\tilde{y}_{x,t}^*$, and their average relative price, $\tilde{\rho}_{x,t}^*$. Since the small open economy is infinitesimally small relative to the rest of the world, these variables affect macroeconomic dynamics in the small open economy without having any effect on Y_t^{C*}, i_t^*, and $\pi_{C,t}^*$.

We assume that Foreign producers solve a profit-maximization problem that is equivalent to that faced by Home producers, including the assumption that export prices are denominated in producer currency. The number of Foreign exporters is a time-varying fraction

[23] We do not report the details of the foreign economy. They are discussed in depth by Cacciatore and Ghironi (2012).

Table 1. Model Summary

Equilibrium Price Index: $1 = \tilde{\rho}_{d,t}^{1-\theta} N_{d,t}^{\frac{1-\phi}{1-\theta}} + \tilde{\rho}_{x,t}^{*\,1-\theta} N_{x,t}^{*\,\frac{1-\phi}{1-\theta}}$

Equilibrium Exports: $\tilde{\rho}_{x,t}^{-\theta} N_{x,t}^{\frac{\theta-\phi}{1-\theta}} Y_t^{C*} = \frac{(\theta-1)}{k_p-(\theta-1)} \frac{\tilde{z}_{x,t}}{\tau_t} f_{x,t}$

Labor Market Clearing: $l_t h_t = N_{d,t} \frac{\tilde{y}_{d,t}}{Z_t \tilde{z}_d} + N_{x,t} \frac{\tilde{y}_{x,t}}{Z_t \tilde{z}_{x,t}} \tau_t + N_{e,t} \frac{f_{e,t}}{Z_t} + N_{x,t}$

Employment Dynamics: $l_t = (1-\lambda) l_{t-1} + q_{t-1} V_{t-1}$

Product Creation: $1 = E_t \left\{ \beta_{t,t+1} \frac{\tilde{\rho}_{d,t+1}}{\tilde{\rho}_{d,t}} \left[\begin{array}{c} \frac{\mu_{d,t}}{\mu_{d,t+1}} \left(\frac{f_{e,t+1}}{f_{e,t}} - \frac{N_{x,t+1}}{N_{d,t+1}} \frac{f_{x,t+1}}{f_{e,t}} \right) + \\ \frac{1}{(\theta-1) f_{e,t}} \left(\frac{\mu_{d,t}}{\mu_{d,t+1}} \tilde{y}_{d,t+1} + \frac{N_{x,t+1}}{N_{d,t+1}} \frac{Q_{t+1} \tilde{\rho}_{x,t+1} \tilde{z}_{x,t+1}}{\tilde{\rho}_{d,t+1} \tilde{z}_d} \frac{\mu_{d,t+1}}{\mu_{x,t+1}} \tilde{y}_{x,t+1} \right) \end{array} \right] \right\}$

Job Creation: $1 = E_t \left\{ \beta_{t,t+1} \left[(1-\lambda) \frac{q_t}{q_{t+1}} + \frac{q_t}{\kappa} \left(\varphi_{t+1} Z_{t+1} h_{t+1} - \frac{w_{t+1}}{P_{t+1}} h_{t+1} - \frac{\vartheta}{2} \pi_{w,t+1}^2 \right) \right] \right\}$

Determination of Hours: $v_{h,t} / u_{C,t} = \varphi_t Z_t$

Wage Inflation: $1 + \pi_{w,t} = \frac{w_t / P_t}{w_{t-1} / P_{t-1}} (1 + \pi_{C,t})$

Equilibrium Wage Bargain:

$$\frac{w_t}{P_t} h_t = \eta_{w,t} \left(\frac{v(h_t)}{u_{C,t}} + b \right) + (1 - \eta_{w,t}) \left(\varphi_t Z_t h_t - \frac{\vartheta}{2} \pi_{w,t}^2 \right)$$
$$+ E_t \left\{ \beta_{t,t+1} J_{t+1} \left[(1-\lambda)(1-\eta_{w,t}) - (1-\lambda-\iota_t)(1-\eta_{w,t+1}) \frac{\eta_{w,t}}{\eta_{w,t+1}} \right] \right\}$$

Monetary Policy Rule: $1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left\{ (1+i) \left[E_t \left(\frac{\hat{P}_{t+k}}{\hat{P}_{t+k-1}^{I_P}} \right)^{1-I_{\tilde{Y}}} \left(E_t \hat{Y}_{t+k}^N \right)^{I_{\tilde{Y}}} \right]^{\varrho} \left[\left(\hat{Y}_{R,t}^g \right)^{\varrho_{Y^g}} \right] \right\}^{1-\varrho_i}$

Euler Equation for Domestic Bonds: $1 = (1 + i_{t+1}) E_t \beta_{t,t+1} \left(\frac{1}{1 + \pi_{C,t+1}} \right)$

Euler Equation for Foreign Bonds: $1 + \psi a_{*t+1} = \left(1 + i_{t+1}^* \right) E_t \left\{ \beta_{t,t+1} \frac{Q_{t+1}}{Q_t \left(1 + \pi_{C,t+1}^* \right)} \right\}$

Foreign Asset Accumulation: $Q_t (a_{*,t+1} - a_{*,t}) = Q_t \frac{(1+i_t^*)}{\left(1+\pi_{C,t}^*\right)} a_{*,t} + Q_t N_{x,t} \tilde{\rho}_{x,t} \tilde{y}_{x,t} - N_{x,t}^* \tilde{\rho}_{x,t}^* \tilde{y}_{x,t}^*$

of the number of Foreign producers that serve their domestic market:

$$N^*_{x,t} \equiv \left[1 - G\left(z^*_{x,t}\right)\right] N^*_{d,t} = \left(\frac{z_{\min}}{\tilde{z}^*_{x,t}}\right)^{-k_p} \alpha^{\frac{k_p}{\theta-1}} N^*_{d,t},$$

where $\tilde{z}^*_{x,t}$ is determined by imposing a zero export-profit condition that is the Foreign counterpart to equation (12):

$$\tilde{\rho}^{*-\theta}_{x,t} N^{*\frac{\theta-\phi}{1-\theta}}_{x,t} Y^C_t = \frac{(\theta-1)}{k_p - (\theta-1)} \frac{\tilde{z}^*_{x,t}}{\tau^*_t} f^*_{x,t}.$$

In the above expression, τ^*_t and $f^*_{x,t}$ denote, respectively, iceberg trade costs and fixed export costs for Foreign firms (both costs are exogenous). The average output of a variety exported by Foreign to Home is

$$\tilde{y}^*_{x,t} = \left(\tilde{\rho}^*_{x,t}\right)^{-\phi} \left(N^*_{x,t}\right)^{\frac{\theta-\phi}{1-\theta}} Y^C_t,$$

where the average relative price $\tilde{\rho}^*_{x,t}$ is given by

$$\tilde{\rho}^*_{x,t} = Q_t \mu^*_{x,t} \tau^*_t \frac{\varphi^*_t}{\tilde{z}^*_{x,t}}.$$

In the above expression, φ^*_t denotes the marginal costs of production of an individual variety in the rest of the world; the term $\mu^*_{x,t}$ denotes the export markup:

$$\mu^*_{x,t} \equiv \xi_t \frac{\phi}{(\phi-1)\Xi^{*d}_{x,t}},$$

where

$$\Xi^{*d}_{x,t} \equiv 1 - \frac{\nu}{2}\pi^{*d^2}_{x,t} + \nu(1+\pi^{*d}_{x,t})\pi^{*d}_{x,t} - \frac{\nu}{(\phi-1)} E_t\left[\beta^*_{t,t+1}(1+\pi^{*d}_{x,t+1})\pi^{*d}_{x,t+1}\frac{Y^*_{x,t+1}}{Y^*_{x,t}}\right],$$

$Y^*_{x,t} = (N^*_{x,t})^{\frac{\theta}{\theta-1}} \tilde{y}^*_{x,t}, 1 + \pi^{*d}_{x,t} \equiv (1 + \pi^*_{C,t})(Q_{t-1}/Q_t)(\tilde{\rho}^*_{x,t}/\tilde{\rho}^*_{x,t-1})$ denotes Foreign export price inflation, and ξ_t is a Foreign export markup shock that we will use to introduce shocks to the terms of trade in our sensitivity analysis below.

5. Calibration and Model Properties

5.1 Calibration

We interpret periods as quarters and calibrate the rest-of-the-world parameters to match standard post-war U.S. macroeconomic data. With the exception of the workers' bargaining power, the monetary policy coefficients appearing in the interest rate rule, and the process of exogenous shocks, we assume that the parameters that characterize the small open economy are symmetric to the rest of the world. Given that NZ is an advanced economy, we view this as being a plausible assumption. Table 2 summarizes the calibration. (Variables without time indexes denote steady-state levels; parameters denoted with an asterisk are specific to the rest of the world, i.e., the calibration of those parameters is not symmetric across countries.)

5.1.1 Rest of the World

We set the discount factor β to 0.99, implying an annual real interest rate of 4 percent. The period utility function is given by $u_t = C_t^{1-\gamma_C}/(1-\gamma_C) - l_t h_t^{1+\gamma_h}/(1+\gamma_h)$. The risk aversion coefficient γ_C is equal to 2, while the Frisch elasticity of labor supply $1/\gamma_h$ is set to 0.4, a midpoint between empirical micro and macro estimates.[24] The elasticity of substitution across product varieties, θ, is set to 3.8 following Bernard et al. (2003), who find that this value fits U.S. plant and macro trade data. Following Ghironi and Melitz (2005), we set the elasticity of substitution across Home and Foreign goods, ϕ, equal to θ. Also as in Ghironi and Melitz (2005), we set $k_p = 3.4$ and normalize $z_{\min}$ to 1.

To ensure steady-state determinacy and stationarity of net foreign assets, we set the bond adjustment cost parameter ψ to 0.0025 as in Ghironi and Melitz (2005). The scale parameter for the cost of

[24]The value of this elasticity has been a source of controversy in the literature. Students of the business cycle tend to work with elasticities that are higher than microeconomic estimates, typically unity and above. Most microeconomic studies, however, estimate this elasticity to be much smaller, between 0.1 and 0.6. For a survey of the literature, see Card (1994). Keane and Rogerson (2012) offer a reconciliation that credibly supports the range of estimates typically adopted in macroeconomic simulations. Our results are not affected significantly if we hold hours constant at the optimally determined steady-state level.

Table 2. Calibration

	Parameter
Risk Aversion	$\gamma_C = 2$
Frisch Elasticity	$1/\gamma_h = 0.28$
Discount Factor	$\beta = 0.99$
Elasticity Matching Function	$\varepsilon = 0.4$
Firm Bargaining Power	$\eta = 0.6$
Unemployment Replacement Rate	$b/w = 0.54$
Exogenous Separation	$\lambda = 0.1$
Vacancy Cost	$\kappa = 0.08$
Matching Efficiency	$\chi = 0.73$
Elasticity of Substitution	$\theta = 3.8$
Plant Exit	$\delta = 0.035$
Pareto Shape	$k_p = 3.4$
Pareto Support	$z_{\min} = 1$
Sunk Entry Cost	$f_e = 0.51$
Fixed Export Costs	$f_x = 0.003$
Iceberg Trade Costs	$\tau = 1.52$
Rotemberg Wage Adjustment Cost	$\vartheta = 260$
Rotember Price Adjustment Cost	$\upsilon = 80$
Policy Rule—Interest Rate Smoothing	$\varrho_i = 0$
Policy Rule—Inflation Parameter	$\varrho_\pi = 1.44$
Policy Rule—Output-Gap Parameter	$\varrho_{Y^g} = 0.18$
Bond Adjustment Cost	$\psi = 0.0025$

adjusting prices, υ, is equal to 80, as in Bilbiie, Ghironi, and Melitz (2008). We choose ϑ, the scale parameter of nominal wage adjustment costs, so that the model reproduces the volatility of unemployment relative to GDP observed in the data. This implies $\vartheta = 260$. To calibrate the entry costs, we follow Ebell and Haefke (2009) and set f_e so that regulation costs imply a loss of 5.2 months of per capita output.

Unemployment benefits, b, are equal to 54 percent of the steady-state wage, the average value for the United States reported by OECD (2004). The steady-state bargaining share of workers, $1-\eta^*$, is equal to 0.4, as estimated by Flinn (2006) for the United States. The unemployment elasticity of the matching function, $1-\varepsilon$, is also equal to 0.6, within the range of estimates reported by Petrongolo and Pissarides (2006) and such that the Hosios condition holds in steady state. The exogenous separation rate between firms and workers, λ, is 10 percent, as reported by Shimer (2005). To pin down exogenous plant exit, δ, we target the portion of worker separation due to plant exit equal to 40 percent reported by Haltiwanger, Scarpetta, and Schweiger (2008).

Two labor market parameters are left for calibration: the scale parameter for the cost of vacancy posting, κ, and the matching efficiency parameter, χ. We set these parameters to match the steady-state probability of finding a job and the probability of filling a vacancy. The former is 60 percent, while the latter is 70 percent, in line with Shimer (2005).

For the productivity process, we follow King and Rebelo (1999) and set persistence equal to 0.979 and standard deviation of innovations to 0.0072. In our benchmark scenario, we assume that there are no shocks to the Foreign export markup, i.e., we set $\xi_t = 1$ in all periods. Finally, the parameter values in the policy rule for the Federal Reserve's interest rate setting are those estimated by Clarida, Galí, and Gertler (2000). The inflation and GDP gap weights are 1.65 and 0.34, respectively, while the smoothing parameter is 0.71.

5.1.2 Small Open Economy

As discussed above, parameters are assumed to be symmetric across countries, with the exception of the firm's bargaining power, η, the coefficients appearing in the interest rate rule (21), and the standard deviation of productivity innovations. Moreover, three exogenous variables are specific to the small open economy: the fixed export cost, $f_{x,t}$; iceberg trade costs related to imports, τ_t^*; and iceberg trade costs related to exports, τ_t. We assume that these costs are constant, except for one-time, permanent changes in iceberg costs associated with trade integration. Thus, we drop the time index for simplicity. Moreover, we assume that iceberg trade costs related to imports (exports) are the sum of tariffs, $\tau^{T^*}(\tau^T)$, and non-tariff barriers, $\tau^{NT^*}(\tau^{NT})$, i.e., $\tau^* = 1 + \tau^{T^*} + \tau^{NT^*}(\tau = 1 + \tau^T + \tau^{NT})$. Moreover, we let $\tau = \tau^*$, so that in the benchmark scenario trade costs associated with exports and imports are assumed to be symmetric.

For the parameters that we use to capture market reforms (flexible-wage, worker bargaining power, and tariffs: η, τ^{T^*}, and τ^T), we consider two alternative parameterizations. The first one captures the level of market regulation prior to the introduction of reforms in NZ. In this case, we set $1-\eta = 0.8$, since trade-union density in NZ was approximately twice as large as in the United States, and $\tau^{T^*} = \tau^T = 0.27$.[25] The second parameterization reflects the adoption of market reforms. Consistent with the observed 30 percent reduction in union density, we set $1-\eta = 0.65$, and consistent with the observed tariff reductions, we set $\tau^{T^*} = 0.07$. For Foreign tariffs, we consider two alternative scenarios: In one, we leave $\tau^T = 0.27$; in the other, we consider a symmetric reduction also in τ^T to 0.07. We treat these parameter changes as permanent shocks to NZ and study the response of the economy to these shocks under alternative policy regimes.

We consider different cases for the policy rule (21), depending on the specific monetary policy regime at study—inflation targeting (IT), price-level targeting (PLT), and nominal income targeting (NIT). The benchmark rule is historical NZ's monetary policy post-1990, which corresponds to the inflation-targeting regime. As described above, this implies setting the indicator parameters $I_P = 1$ and $I_{Y_N} = 0$ in the policy rule (21). Consistent with the estimates in Huang, Margaritis, and Mayes (2001), we set $k = 0$, $\varrho_i = 0$, $\varrho = 1.44$, and $\varrho_{Y^g} = 0.18$.[26] When we consider the alternative scenarios of price-level or nominal income targeting, we keep k and the response coefficients ϱ_i, ϱ, and ϱ_{Y^g} at these values, but we change the targets in the policy rule by resetting the indicator parameters in (21) appropriately: $I_P = I_{Y^N} = 0$ for price-level targeting and $I_{Y^N} = 1$ for nominal income targeting. Under all policy scenarios, the data-consistent CPI in the initial steady state is normalized to 1. Under IT, the target inflation rate is 1.5 percent annually as dictated by the RBNZ mandate. Under PLT, the target price-level path is the path implied by 1.5 percent annual inflation starting from the

[25]Data are available at http://www.oecd.org/employment/emp/onlineoecdemploymentdatabase.htm#epl.

[26]The figures refer to table 3, column 3 on page 189 of their article. Notice that the authors show that a Taylor rule with the standard parameters used in the United States also describes NZ monetary policy quite well. However, their estimates point out that the RBNZ has focused more strongly on price stability, as required by its Policy Targets Agreements.

initial data-consistent CPI level of 1. Under NIT, the target nominal income path is the path implied by the steady-state level of data-consistent real GDP times the price level implied by 1.5 percent annual inflation starting from the initial data-consistent CPI level of 1. For illustrative purposes, for all three policy regimes, we also consider scenarios of strict targeting, in which the relevant target variable is fully stabilized at the trend target in all periods.

Finally, we choose f_x so that the share of exporting plants is equal to 30 percent and set non-tariff barriers equal to 0.45, an average of the estimates provided by Winchester (2009) for NZ. We set the persistence of productivity and the volatility of innovations to match the autocorrelation and volatility of NZ's labor productivity over the period 1990–2014. This requires setting $\phi_Z = 0.95$ and $\sigma_\epsilon = 0.095$.

5.2 Model Properties

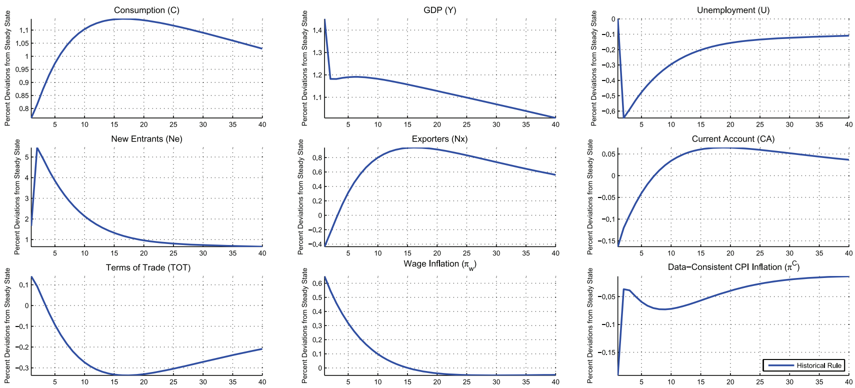
We now discuss the propagation of aggregate shocks in the model and compare business-cycle dynamics under historical monetary policy (inflation targeting) relative to the data.

Figure 1 shows the impulse responses to a 1 percent innovation in Home (NZ) productivity under the historical rule for interest rate setting. Unemployment (U_t) declines in the periods immediately following the shock. On impact, the higher expected return of a match induces domestic intermediate input producers to post more vacancies, which results in higher employment the following period. Firms and workers renegotiate nominal wages because of the higher surpluses generated by existing matches, and wage inflation ($\pi_{w,t}$) increases. Wage adjustment costs make the effective firm's bargaining power procyclical, i.e., $\eta_{w,t}$ rises.[27] Other things equal, the increase in $\eta_{w,t}$ dampens the response of the renegotiated equilibrium wage, amplifying the response of job creation to the shock.

Higher productivity increases producer entry in NZ and reduces the export cutoff, $z_{x,t}$. Accordingly, a larger share of NZ goods are available to domestic and foreign consumers. On impact, Foreign

[27]Intuitively, $\eta_{w,t}$ increases to ensure optimal sharing of the cost of adjusting wages between firms and workers.

Figure 1. Home Productivity Shock, High Market Regulation, Historical Monetary Policy



households shift resources to finance product creation in the more productive economy. As a consequence, NZ runs a current account deficit in response to the productivity increase (CA_t falls). NZ terms of trade (defined as $TOT_t \equiv Q_t\tilde{\rho}_{x,t}/\tilde{\rho}^*_{x,t}$) depreciate, so that NZ goods become relatively cheaper. However, the terms-of-trade depreciation is mild compared with standard international business-cycle models. Producer entry and the countercyclical response of $z_{x,t}$ counteract the effects of higher productivity on marginal costs, and domestic export prices fall by less, as compared with a model that abstracts from plant entry and heterogeneity.

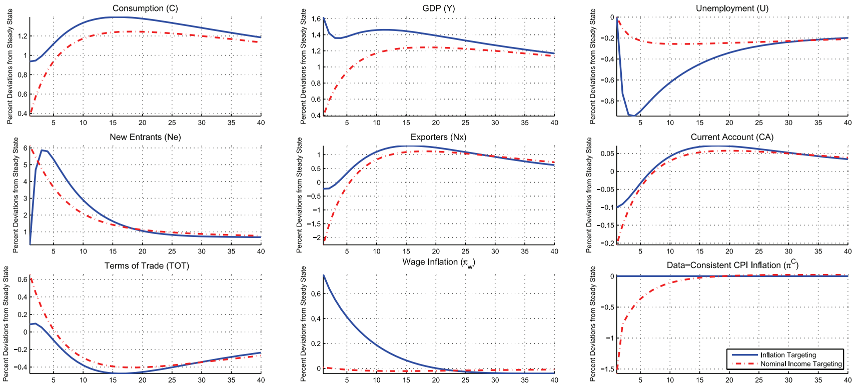
Table 3 presents the implied second moments for key aggregates of the model NZ under historical policy. In the table, model I refers to the benchmark model, where the only stochastic shocks are due to aggregate productivity shocks occurring in the intermediate goods sector. In that case, our parameterization matches the moments for real GDP, investment, employment, and real wages fairly well, but understates the volatility of real consumption, exports, and imports. (Investment in our model is given by investment in new product creation: $I_t \equiv \varphi_t f_{e,t} N_{e,t}$ and $I_{R,t} \equiv P_t I_t/\tilde{P}_t$.) The model is also rather successful in reproducing, at least qualitatively, the observed autocorrelations and the contemporaneous correlation of macroeconomic variables with GDP. Model II augments the productivity shocks with an exogenous stochastic component in terms-of-trade

Table 3. Historical Policy, Business-Cycle Statistics

Variable	σ_X			σ_X/σ_{Y_R}			$corr(X_t, Y_{R,t})$		
	Data	**Model I**	**Model II**	**Data**	**Model I**	**Model II**	**Data**	**Model I**	**Model II**
Y_R	1.50	1.50	1.77	1	1	1	1	1	1
C_R	1.60	0.82	1.48	1.06	0.55	0.83	0.75	0.89	0.85
I_R	8.88	7.60	8.60	5.86	5.06	4.83	0.66	0.63	0.68
L	1.24	1.07	1.10	0.82	0.72	0.62	0.64	0.57	0.48
w_R	0.91	0.59	1.011	0.60	0.40	0.56	−0.02	0.30	0.51
X_R	5.55	1.77	3.76	3.70	1.18	2.11	0.13	0.45	0.34
IM_R	7.10	1.43	8.77	4.72	0.95	4.93	0.35	0.79	0.61
TOT	3.60	0.44	4.23	2.39	0.29	2.39	−0.04	−0.40	0.20
$corr(Y_{R,t}, Y^*_{R,t})$	0.23	0.18	0.18						

Notes: $\sigma_X \equiv$ standard deviation of variable X; $\sigma_{Y_R} \equiv$ standard deviation of data-consistent, real GDP. Model I $\equiv$ TFP shocks; Model II $\equiv$ TFP and terms-of-trade shocks.

Figure 2. Home Productivity Shock, High Market Regulation, Strict Inflation Targeting (solid line) vs. Strict Nominal Income Targeting (dashed line)



dynamics (discussed in more detail in section 8 below), a result of which is that the model matches trade-related moments much more closely.

6. Business Cycles and Alternative Policy Regimes in Pre-Reform New Zealand

To begin our analysis of different monetary policy regimes, we study how alternative monetary policy arrangements—inflation targeting, price-level targeting, and nominal income targeting—affect NZ's business-cycle fluctuations and welfare in the highly regulated economy with high trade protection. That is, we study the performance of alternative monetary policy regimes, assuming that the NZ economy did not adopt market reforms.

Figure 2 compares the impulse responses with a 1 percent innovation in Home productivity under strict nominal income targeting and strict inflation targeting.[28] The figure shows that strict NIT is more

[28]Notice that strict inflation targeting implies $\hat{P}_t = 0$ (assuming a constant inflation target). In turn, zero deviations of the CPI index from trend imply strict price-level targeting.

effective in stabilizing unemployment fluctuations than is strict IT (or PLT). At issue are efficiency trade-offs that exist over the business cycle. These include, first, the tension between the beneficial effects of manipulating inflation and its costs. In addition, there is the trade-off between stabilizing price inflation (which contributes to stabilizing markups) and wage inflation (which stabilizes unemployment). Third, there is the impossibility to stabilize domestic and export markups jointly, due to the presence of firm heterogeneity, as discussed earlier.

These policy trade-offs explain why a policy of price stability can be sub-optimal. Under this policy, wage inflation is too volatile, and markup stabilization correspondingly too strong. Following fluctuations in aggregate productivity, sticky wages (and positive unemployment benefits) generate real wage rigidities, i.e., a positive (negative) productivity shock is not fully absorbed by the rise (fall) of the real wage, affecting job creation over the cycle. Higher NZ productivity pushes the real wage above its steady-state level, as the real value of existing job matches has increased. Under a policy of price stability, the effect of wage stickiness is magnified, since the real wage becomes even more rigid. Firms post too many vacancies and, in equilibrium, nominal wage adjustment costs are too large. In turn, lower unemployment volatility leads to smaller aggregate volatility. Both consumption and investment respond less under NIT.

Table 4 summarizes the welfare effects associated with the reforms we consider, and comprises two panels. Panel A reports the overall benefits resulting from the reforms, including those incurred along the transitional path that we will discuss in section 7 in conjunction with the dynamic adjustments. Panel B presents the welfare costs of business cycles associated with the alternative monetary policy regimes. To determine this we compute the percentage Δ^{BC} of steady-state consumption that would make the households indifferent between living in a world with uncertainty under monetary policy $m (m = IT,\ PLT,\ NIT)$ and living in a deterministic world:

$$E_0 \sum_{t=0}^{\infty} \beta^t u\left(C_t^m, l_t^m, h_t^m\right) = \frac{1}{1-\beta} u\left[\left(1 + \frac{\Delta^{BC}}{100}\right) C, l, h\right]. \qquad (22)$$

First-order approximation methods are inappropriate to compute the welfare associated with each monetary policy arrangement. This

Table 4. Welfare Effects of Reform

	Inflation Targeting ($\tilde{P}_t/\tilde{P}_{t-1}$)			Price-Level Targeting ($\tilde{P}_t$)			Nominal Income Targeting ($\tilde{P}_t Y_{R,t}$)		
	Strict	**Hist.**	**Smoothing**	**Strict**	**Hist.**	**Smoothing**	**Strict**	**Hist.**	**Smoothing**
A. Δ Welfare									
Market Reform									
Bargaining Power (η)	3.95	3.96	3.96	3.95	3.95	3.95	3.98	3.98	3.98
Tariffs (τ^*)	1.61	1.58	1.57	1.61	1.59	1.59	1.58	1.58	1.58
Tariffs (τ^* and τ)	3.16	3.10	3.11	3.16	3.15	3.15	3.10	3.10	3.10
B. Δ^{BC} Welfare									
High Regulation	0.77	0.87	0.63	0.77	0.75	0.72	0.07	0.08	0.08
Market Reform									
Bargaining Power (η)	0.43	0.49	0.40	0.43	0.42	0.41	0.04	0.04	0.04
Tariffs (τ^*)	0.73	0.81	0.60	0.73	0.71	0.69	0.07	0.07	0.07
Tariffs (τ^* and τ)	0.70	0.76	0.57	0.70	0.67	0.66	0.06	0.07	0.06

Notes: $\tilde{P}_t \equiv$ data-consistent CPI; $Y_{R,t} \equiv$ data-consistent GDP; Strict $\equiv$ strict targeting: $\varrho_i = 0$; $\varrho = 1,000$; $\varrho_{Yg} = 0$. Hist $\equiv$ historical rule: $\varrho_i = 0$; $\varrho = 1.44$; $\varrho_{Yg} = 0.18$. Smoothing $\equiv$ historical rule with smoothing: $\varrho_i = 0.71$; $\varrho = 1.44$; $\varrho_{Yg} = 0.18$. Δ Welfare $\equiv$ steady-state welfare change (% of pre-reform steady-state consumption), including transition dynamics. Δ^{BC} Welfare $\equiv$ change in welfare costs of business cycles (% of pre-reform steady-state consumption).

is because the solution of the model implies that the expected value of each variable coincides with its non-stochastic steady state. However, in an economy with a distorted steady state, volatility affects both the first and second moments of the variables that determine welfare. Hence we compute welfare by taking a second-order approximation to the policy functions. Thus, a lower value of Δ^{BC} implies that the welfare costs of business cycles so computed are reduced.

The first line in panel B of table 4 compares the three monetary policies in the pre-deregulation period. There it is seen that strict NIT significantly reduces the welfare costs of business cycles relative to strict IT, reducing the welfare costs from 0.77 percent to 0.07 percent. As discussed above, this is so since NIT stabilizes job creation and thus unemployment fluctuations, whereas IT does not achieve this. That is, NIT better addresses the unemployment-inflation trade-off faced by the RBNZ.

Next, we compare the historical monetary policy of flexible IT with the alternatives of flexible PLT and flexible NIT. As described above, we do so by keeping the estimated coefficients in the interest rate rule fixed and replacing the inflation target with price or nominal income targets. NIT still clearly dominates, reducing welfare costs to 0.08 percent from 0.87 percent. Furthermore, by reducing welfare costs to 0.75 percent, PLT is also superior to IT. This is because PLT results in more volatile inflation, which ultimately dampens unemployment volatility more effectively relative to IT. When we allow for interest rate smoothing ($\varrho_i = 0.71$), the picture remains generally unchanged, although now IT is superior to PLT.

A natural question is whether NIT remains the more desirable regime when monetary policy is chosen optimally. To address this issue, we solve a constrained Ramsey problem in which the monetary authority maximizes the welfare of agents subject to the constraints represented by the competitive economy relations and a given monetary policy rule. We consider the following interest rate reaction function:

$$1 + i_{t+1} = (1 + i_t)^{\varrho_i} \left\{ (1 + i) \left[E_t \left(\frac{\hat{P}_{t+k}}{\hat{P}_{t+k-1}} \right) \right]^{\varrho_\pi} \right.$$
$$\left. \times \left(E_t \hat{P}_{t+k} \right)^{\varrho_P} \left(E_t \hat{Y}^N_{t+k} \right)^{\varrho_{Y^N}} \left(\hat{Y}^g_{R,t} \right)^{\varrho_{Y^g}} \right\}^{1-\varrho_i}$$

and search across the grid of parameters $\{\varrho_i, \varrho_\pi, \varrho_P, \varrho_{Y^N}, \varrho_{Y^g}\}$ for the rule that minimizes the welfare cost of business cycles in (22). We maintain the assumption that $k = 0$ and perform the search over the range [0, 10] for each parameter, with fineness equal to 0.01. We consider only those combinations of policy parameters that deliver a unique rational expectations equilibrium. The maximized rule yields $\varrho_{Y^N} = 10$ and $\varrho_i = \varrho_\pi = \varrho_P = \varrho_{Y^g} = 0$, which virtually mimics the policy of strict NIT described above—the welfare cost of business cycles is 0.07, identical to that obtained above.

7. The Macroeconomic Effects of Market Reforms in New Zealand

We now study the macroeconomic consequences of NZ labor market reform and trade integration under the alternative monetary policy regimes. Starting from an initial steady state featuring a highly regulated labor market and high barriers to trade, we consider the transitional dynamics generated by the reductions in worker bargaining power and tariffs described above. We treat these parameter changes as shocks to the NZ economy—the results of labor market and trade policy changes—and we assume that these changes are permanent and implemented under perfect foresight.[29] We begin by studying the dynamic adjustment to these reforms.

7.1 Transition Dynamics

Given the large size of the reform shocks, transitional dynamics from the initial equilibrium to the final equilibrium are found by solving the model as a non-linear forward-looking deterministic system using a Newton-Raphson method, as described in Laffargue (1990). This method solves simultaneously all equations for each period, without relying on local approximations.

Figure 3 illustrates the dynamic adjustment to labor market deregulation, while figures 4 and 5 refer to asymmetric and symmetric trade liberalization, respectively (i.e., tariff reductions only in NZ or in both NZ and Foreign). In each figure we compare the adjustment under strict IT (solid lines) and strict NIT (dotted lines).

[29] In our analysis, reforms are implemented in just one period.

Figure 3. Labor Market Deregulation, Strict Inflation Targeting (solid line) vs. Strict Nominal Income Targeting (dashed line)

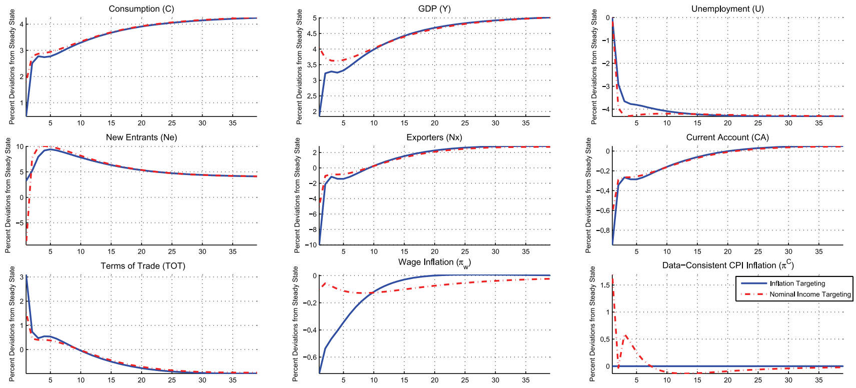
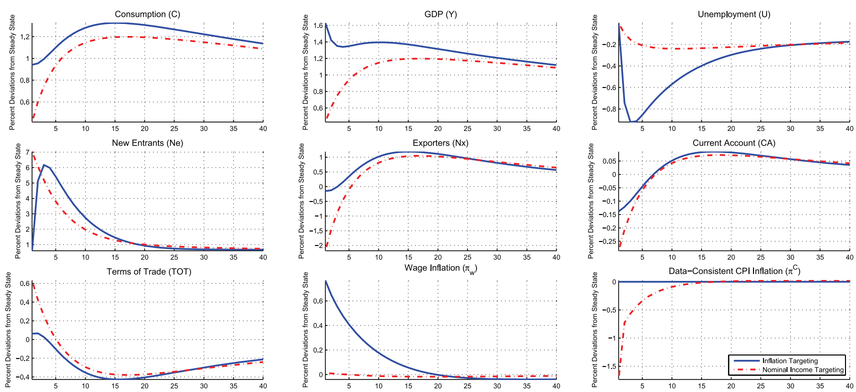
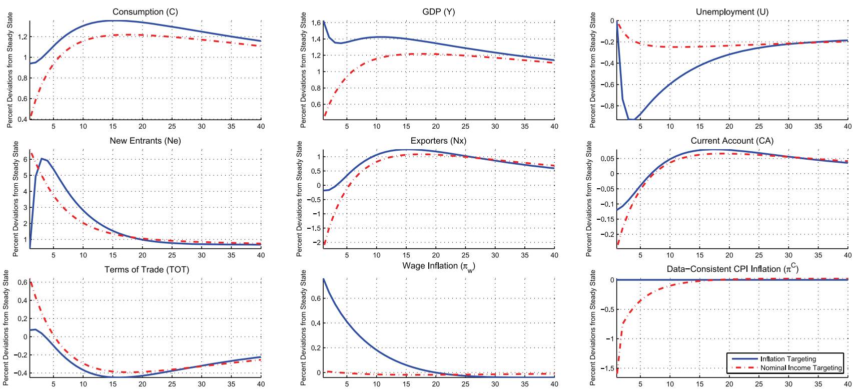


Figure 4. Asymmetric Trade Liberalization, Strict Inflation Targeting (solid line) vs. Strict Nominal Income Targeting (dashed line)



In the long run, market reforms boost aggregate output and reduce unemployment, a result consistent with the observed steady reduction in NZ's unemployment that took place from the early 1990s, when in ten years, the unemployment rate dropped from a peak of 11.4 percent to 5 percent. In the absence of aggregate shocks, monetary policy affects welfare by reducing (or increasing)

Figure 5. Symmetric Trade Liberalization, Strict Inflation Targeting (solid line) vs. Strict Nominal Income Targeting (dashed line)



transition costs. As discussed by Cacciatore and Ghironi (2012), pre-deregulation the economy features a steady state with inefficiently low job creation due to the presence of firm monopoly power, distortionary regulation, and misallocation of resources to change prices and wages (in the presence of positive trend inflation). Since the positive effects of reforms take time to materialize, expansionary monetary policy is beneficial, as it reduces markups and boosts job creation during the transition.

However, which monetary rule is more expansionary depends on the reform considered. In the case of labor market deregulation, strict NIT is superior to strict IT; see table 4. As shown in figure 3, strict NIT results in a larger monetary expansion in the aftermath of the reform, boosting consumption and reducing unemployment, more so than under strict IT. The reason is that reducing worker bargaining power has a milder effect on producer prices on impact: on the one hand, lower η lowers wages (by reducing the workers' outside option at the bargaining stage); on the other hand, as job creation increases, it becomes more costly to recruit new workers, which pushes up equilibrium wages. By contrast, NIT results in a stronger monetary expansion; in the aftermath of the reform the central bank induces inflationary pressure to boost consumption and reduce investment in product creation. As a result, the beneficial effects of deregulation materialize sooner.

In the case of trade liberalization, strict IT induces higher welfare. The key difference is that trade liberalization induces sizable price dynamics, as cheaper foreign imports induce deflation in the aftermath of the reform. The monetary response under strict IT is therefore expansionary. When we allow for endogenous monetary responses to the output gap or interest rate smoothing, the picture is a bit more nuanced, although the general results discussed above continue to hold. It is also interesting to observe the contrast in the current account dynamics implied by the two reforms (regardless of the form of monetary policy in effect).

As noted, panel A of table 4 quantifies the overall benefits of the reforms by computing the changes in steady-state welfare including transition dynamics. Specifically, we compute the percentage increase Δ in steady-state consumption relative to the status quo (no reform) that leaves households indifferent between whether or not the reform is implemented. Thus Δ is obtained by solving

$$\sum_{t=0}^{\infty} \beta^t u\left(C_t^m, l_t^m, h_t^m\right) = \frac{1}{1-\beta} u\left[\left(1 + \frac{\Delta}{100}\right) C^{SQ}, l^{SQ}, h^{SQ}\right], \quad (23)$$

where "SQ" denotes the status quo, and m denotes the monetary regime (m = *IT, PLT, NIT*). A higher value of Δ implies that welfare increases following the reform.

As shown in table 4, during the transition, strict IT performs slightly better than does strict NIT in response to trade liberalization, raising welfare by 1.61 percent versus 1.58 percent in the case of domestic tariff reduction and 3.16 percent versus 3.10 percent in the case of symmetric trade liberalization. However, in the case of labor market reforms, the relative merits are reversed (3.96 percent vs. 3.98 percent).

7.2 Business Cycles in Post-Deregulation New Zealand

The dynamic effects of reforms are not limited to transition dynamics, since the economy may face a different adjustment to aggregate shocks once reforms are completed, with consequences for the welfare cost of business cycles. We now turn to this issue.

Figure 6. Home Productivity Shock, Low Labor Market Regulation, Strict Inflation Targeting (solid line) vs. Strict Nominal Income Targeting (dashed line)

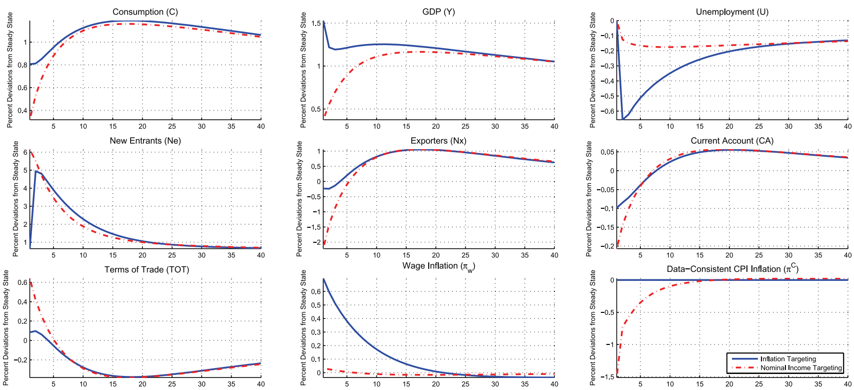


Figure 6 compares the impulse responses with the domestic productivity shock under strict IT and strict NIT following labor market deregulation and yields the following observations. NZ labor market reform affects the propagation of aggregate shocks through the cyclical behavior of the workers' outside option. Increased labor market flexibility makes job creation less responsive to shocks. Reduced worker bargaining power implies that adjustment takes place increasingly through the real wage, reducing job flows over the cycle. Strict NIT remains most effective in stabilizing unemployment. However, differences in unemployment dynamics across the two monetary regimes are reduced. This occurs because the need to stabilize wage inflation is mitigated.

Figures 7 and 8 trace out the impulse responses to the NZ productivity shock following a reduction in domestic tariffs and symmetric trade reforms, respectively. Similar to the labor market reform, there is less need to stabilize wage inflation over the cycle. As a result, the volatility gap between strict NIT and IT is reduced. To understand this result, notice that the reduction of NZ tariffs increases domestic competition, reallocating resources toward relatively more productive firms. In this process, expenditure switching toward cheaper Foreign goods reduces the

Figure 7. Home Productivity Shock, Low Import Tariffs, Strict Inflation Targeting (solid line) vs. Strict Nominal Income Targeting (dashed line)

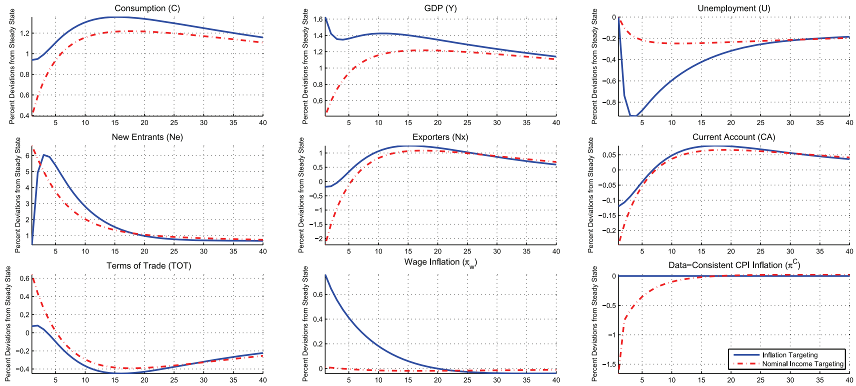
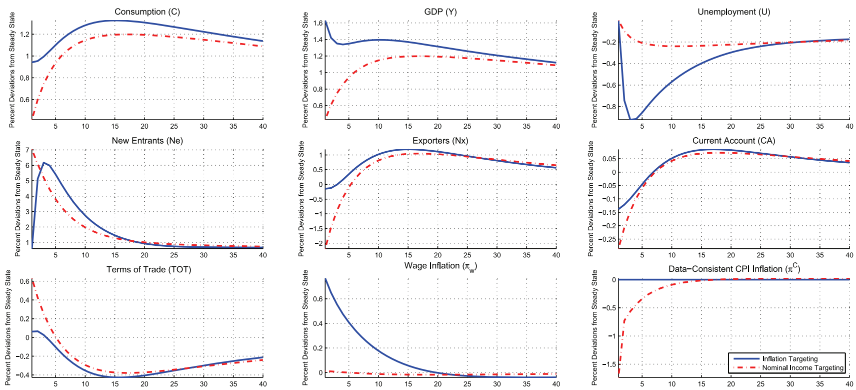


Figure 8. Home Productivity Shock, Low Import and Export Tariffs, Strict Inflation Targeting (solid line) vs. Strict Nominal Income Targeting (dashed line)



market value of NZ firms, which leads to a higher cut-off productivity for export in the new equilibrium. Furthermore, cheaper Foreign goods induce a positive income effect for Home households which, other things equal, increases the demand for NZ goods. In equilibrium, demand for intermediate inputs increases, resulting in higher profits per job match. Accordingly, in the new steady state, vacancy postings increase and unemployment falls. Therefore, unemployment varies by less (as a percentage of steady state) in response to aggregate disturbances, reducing the need to stabilize wage inflation.

This effect is stronger when trade integration is symmetric; see figure 8. In this case exporting becomes less costly for NZ producers and resource allocation toward more productive firms is stronger. Higher average productivity further increases the demand for intermediate inputs and reduces unemployment.

Comparing the measures of Δ^{BC} following the market reforms with the pre-deregulation measures reported in table 4, we see that both labor market and trade reforms reduce the welfare costs of business cycles for any given monetary policy regime. As explained above, reduced worker bargaining power makes real wages more procyclical, dampening the volatility of job creation. Trade liberalization reallocates market shares towards more productive firms, reducing the sensitivity of firm profits to aggregate shocks, which ultimately results in a moderation of aggregate employment volatility.

Thus, reform reduces the need for inflation volatility to stabilize cyclical unemployment. Accordingly, IT and PLT become less costly relative to NIT, which, however, continues to remain the best rule. This is particularly pronounced with labor market reforms. In that case, the welfare costs of business cycles are reduced by 35 percent under IT.

Table 5 reports post-reform business-cycle statistics for several key variables. Comparing these with the corresponding statistics in table 3, it is evident that reform results in less volatility in almost all cases, independent of the form of monetary policy. The one exception appears to be investment, the volatility of which has marginally increased.[30]

To conclude, we investigate whether market reforms change the nature of optimal monetary policy. Toward this end, we repeat the maximization described in the latter part of section 6. The maximized rule continues to prescribe strict NIT.

[30]These moments are generally consistent with the post-deregulation NZ business-cycle statistics reported by Hall, Thompson, and McKelvie (2014) and McKelvie and Hall (2012), although there are inevitable differences.

Table 5. Regulation and Business-Cycle Statistics

Variable	σ_X							
	High Regulation		**Bargaining Power (η)**		**Tariffs (τ*)**		**Tariffs (τ* and τ)**	
	SIT	**SNIT**	**SIT**	**SNIT**	**SIT**	**SNIT**	**SIT**	**SNIT**
Y_R	1.41	0.73	1.27	0.67	1.39	0.72	1.32	0.72
C_R	0.91	0.73	0.75	0.68	0.88	0.71	0.87	0.70
I_R	8.69	8.03	7.18	7.74	8.92	8.50	9.09	8.92
L	1.43	0.52	0.90	0.35	1.41	0.52	1.38	0.51
w_R	0.67	0.84	0.60	0.81	0.67	0.84	0.67	0.84
X_R	2.12	2.75	1.77	2.65	2.02	2.72	1.93	2.69
IM_R	1.69	1.68	1.51	1.61	1.64	1.60	1.60	1.56
$corr(Y_{R,t}, Y^*_{R,t})$	0.058	0.040	0.056	0.050	0.068	0.050	0.069	0.059

Notes: $\sigma_X \equiv$ standard deviation of variable X (percentage points). $SIT \equiv$ strict inflation targeting; $SNIT \equiv$ strict nominal income targeting.

8. Sensitivity Analysis

In the benchmark version of our model, the Home economy's terms of trade fluctuate only endogenously in response to Home and Foreign productivity shocks due to the presence of firm monopoly power in both countries. However, as previously discussed, the benchmark model understates the volatility of TOT_t relative to output, suggesting that unmolded forces affect NZ's terms-of-trade fluctuations. Indeed, existing evidence suggests that terms-of-trade shocks are an important driver of NZ's business cycles (Karagedikli and Price 2012). To address this issue, we introduce exogenous terms-of-trade shocks, in the form of exogenous shocks ξ_t to the Foreign export markup, $\mu^*_{x,t}$.[31] Normalizing the steady-state value of ξ_t to 1, we assume that ξ_t follows an $AR(1)$ process in logarithms, $\log \xi_t = \phi_\xi \log \xi_{t-1} + \overline{\omega}_t$, where $\overline{\omega}_t$ represents i.i.d. draws from a normal distribution with zero mean and standard deviation $\sigma_{\overline{\omega}}$. We calibrate the persistence of the shock ϕ_ξ and the standard deviation of innovations $\sigma_{\overline{\omega}}$ to match the observed autocorrelation and standard deviation of NZ's terms of trade. This requires setting $\phi_\xi = 0.3$ and $\sigma_{\overline{\omega}} = 0.28$.[32] As shown in table 3, when business cycles are driven by both productivity and terms-of-trade shocks, the model reproduces much more closely the observed volatility of imports and exports relative to GDP, as well as their contemporaneous correlation with output. The correlation of TOT_t with output is also in line with the data.

Table 6 compares again the stabilization properties of alternative monetary policy arrangements. Panel A considers only terms-of-trade shocks; panel B considers simultaneously productivity and terms-of-trade shocks. While the presence of terms-of-trade shocks

[31] On the supply side, ξ_t captures international, commodity-market-specific shocks. On the demand side, it can be interpreted as reflecting changes in world demand (preferences). The assumption that shocks to international prices, rather than domestic export price shocks, drive exogenous NZ's terms-of-trade fluctuations is consistent with the evidence in Karagedikli and Price (2012). Nevertheless, we obtain similar results if we model terms-of-trade shocks as exogenous shocks to the time-varying markup of Home exporters.

[32] Notice that this does not imply that terms-of-trade dynamics become fully exogenous in the model. It is only these two moments that are determined fully exogenously by calibration. The exogenous shock ξ_t and the endogenous nature of the terms of trade in our model then jointly affect the equilibrium path of TOT_t.

Table 6. Welfare Effects of Reforms, Sensitivity Analysis

	Inflation Targeting ($\tilde{P}_t/\tilde{P}_{t-1}$)		Price-Level Targeting ($\tilde{P}_t$)		Nominal Income Targeting ($\tilde{P}_t Y_{R,t}$)	
	Strict	**Hist.**	**Strict**	**Hist.**	**Strict**	**Hist.**
A. Δ^{BC} Welfare, Terms-of-Trade Shocks						
High Regulation	0.65	1.00	0.65	0.46	0.43	0.38
Market Reform						
Bargaining Power (η)	0.52	0.87	0.52	0.39	0.38	0.34
Tariffs (τ^* and τ)	1.02	1.71	1.02	0.73	0.66	0.60
B. Δ^{BC} Welfare, Productivity, and Terms-of-Trade Shocks						
High Regulation	1.41	1.87	1.41	1.21	0.45	0.46
Market Reform						
Bargaining Power (η)	0.95	1.37	0.95	0.91	0.38	0.38
Tariffs (τ^* and τ)	1.71	2.46	1.71	1.41	0.65	0.67

Notes: $P_t \equiv$ data-consistent CPI; $Y_{R,t} \equiv$ data-consistent GDP; Strict $\equiv$ strict targeting: $\varrho_i = 0$; $\varrho = 1,000$; $\varrho_{Yg} = 0$. Hist $\equiv$ historical rule: $\varrho_i = 0$; $\varrho = 1.44$; $\varrho_{Yg} = 0.18$. Δ^{BC} Welfare $\equiv$ change in welfare costs of business cycles (% of pre-reform steady-state consumption).

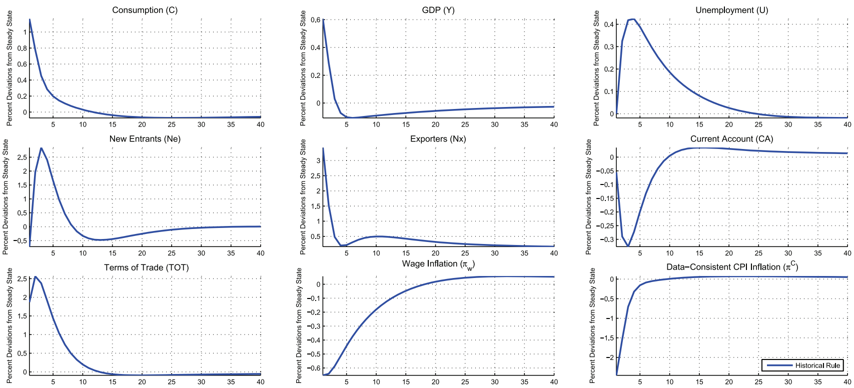
does not change the main message of the paper, two new results emerge. First, inefficient terms-of-trade fluctuations increase the welfare cost of business cycles for a given monetary policy regime and a given level of market regulation. Second, the opening of trade no longer decreases the welfare cost of business cycles. To understand these new results, it is useful to inspect the propagation of terms-of-trade shocks.

Figure 9 shows the impulse responses following a one-standard-deviation decrease in the Foreign export markup under historical monetary policy. The reduction in the Foreign markup appreciates NZ's terms of trade—the relative price of NZ exports in terms of NZ imports increases. In turn, cheaper imports increase demand for Foreign goods. At the same time, the appreciation of the terms of trade generates a positive wealth effect that sustains aggregate demand for domestic output. Thus, expenditure switching toward Foreign goods does not increase unemployment in the aftermath of the shock. NZ consumption increases by 0.9 percent at the peak. During the transition, the number of foreign exporters increases, while the terms of trade revert to their steady-state level. Unemployment temporarily increases, while GDP displays a modest decline below trend.

As shown in table 6, for any level of labor market regulation and trade integration, strict IT is approximately twice as costly relative to the benchmark model. The intuition for this result is that Foreign markup shocks exacerbate the monetary policy trade-offs faced by the model RBNZ. In particular, in order to offset falling CPI inflation, the monetary authority ends up increasing unemployment volatility and thus the welfare cost of business cycles. Thus, as for the case of productivity shocks, NIT reduces sub-optimally unemployment volatility.[33] With the opening of trade, the importance of terms-of-trade shocks increases, since a larger share of NZ demand falls on Foreign goods. As a result, the reduction in real distortions associated with lower trade barriers is no longer sufficient to lower the welfare cost of business cycles. While the overall effect remains modest under NIT, the welfare cost of business cycles increases to

[33]Notice that PLT is more efficient than IT. As explained before, the reason is that PLT results in higher inflation volatility, which ultimately implies more stable unemployment fluctuations.

Figure 9. Terms-of-Trade Shock, Historical Policy



1.7 percent under strict IT. The optimized rule continues to be strict NIT.

To conclude, we perform additional sensitivity analysis along two dimensions. First, we investigate whether our results are robust to the presence of forward-looking targets in the policy rules considered above. Specifically, we run all the simulations setting $k = 1$ in (21). Second, we consider alternative values for the parameters whose calibration is relatively controversial in the literature. For household preferences, we consider a higher Frisch elasticity of labor supply ($1/\gamma_h = 4$, as typically assumed in the business-cycle literature). We evaluate the importance of nominal rigidity by considering smaller values for the scale parameters of price and wage adjustment costs ($\nu = \vartheta = 20$). Finally, we consider an alternative value for the elasticity of the matching function ($\varepsilon = 0.4$, the lower bound of the estimates reported by Petrongolo and Pissarides 2006). We consider the effect of changing one parameter value at a time relative to the benchmark calibration. The main results of the paper are very robust to the alternative parameter values we consider. (Detailed results are available upon request.)

9. Conclusions

Was inflation targeting the best monetary policy regime for New Zealand prior to the increase in its trade integration and labor market flexibility since the early 1990s? Was it the best strategy to manage the transition dynamics generated by these changes in market characteristics? And is it the best option for a now flexible, highly integrated New Zealand? This paper addressed these questions using a New Keynesian model with micro-level producer and trade dynamics and labor market frictions. We found that nominal income targeting would have been preferable to inflation targeting in the distorted environment of a rigid labor market and low trade integration. Nominal income targeting would have also reduced the transition costs of labor market reform, though inflation targeting achieved a better response to trade integration. With New Zealand in its new long-run environment of integrated trade and flexible labor markets, the welfare gap between nominal income targeting and price/inflation targeting is smaller, as market reforms lower unemployment volatility.

As a final caveat, we should note that our analysis has focused on the two aspects of the reforms, labor market and trade, which we feel the model we employ is most appropriate to address. But New Zealand's reforms were very far reaching, including fiscal restructuring, energy policy, agriculture, transportation, privatization, financial liberalization, and liberalization of immigration policy, to name just a subset. Thus, in order to draw any definitive conclusions as to the merits of inflation targeting versus other monetary policies, one needs to address the roles played by these other aspects of the comprehensive reform program.

Appendix

Wage Determination

This appendix summarizes wage determination. Let J_t denote the real value of an existing productive match for the producer; then

$$J_t = \varphi_t Z_t h_t - \frac{w_t}{P_t} h_t - \frac{\vartheta}{2}\pi_{w,t}^2 + E_t \beta_{t,t+1}(1-\lambda)J_{t+1}. \tag{24}$$

That is, J_t equals the current marginal value product of the match, less the wage bill inclusive of wage adjustment costs, plus the expected discounted continuation value of the match next period.

Next, let W_t denote the worker's asset value of being matched, and $U_{u,t}$ the value of being unemployed. The value of being employed at time t equals the real wage the worker receives plus the expected future value of continuing to be matched to the firm. Thus,

$$W_t = \frac{w_t}{P_t} h_t + E_t \left\{ \beta_{t,t+1} \left[(1-\lambda) W_{t+1} + \lambda U_{u,t+1} \right] \right\}. \tag{25}$$

The value of being unemployed is

$$U_{u,t} = \frac{\nu(h_t)}{u_{C,t}} + b + E_t \left\{ \beta_{t,t+1} \left[\iota_t W_{t+1} + (1-\iota_t) U_{u,t+1} \right\} \right., \tag{26}$$

which equals the utility gain from leisure in terms of consumption, plus the unemployment benefit from the government, plus the expected discounted value of gaining reemployment next period (versus remaining unemployed), the probability of which occurring is $\iota_t \equiv M_t/U_t$. Combining (25) and (26), the worker's surplus, $H_t \equiv W_t - U_{u,t}$, is thus

$$H_t = \frac{w_t}{P_t} h_t - \left(\frac{v(h_t)}{u_{C,t}} + b \right) + (1 - \lambda - \iota_t) E_t (\beta_{t,t+1} H_{t+1}). \tag{27}$$

The Nash bargain maximizes the joint surplus $J_t^{\eta} H_t^{1-\eta}$ with respect to w_t. Carrying out the optimization yields

$$\eta H_t \frac{\partial J_t}{\partial w_t} + (1-\eta) J_t \frac{\partial H_t}{\partial w_t} = 0, \tag{28}$$

where

$$\frac{\partial J_t}{\partial w_t} = -\frac{h_t}{P_t} - \vartheta \frac{\pi_{w,t}}{w_{t-1}} + (1-\lambda) \vartheta E_t \left[\beta_{t,t+1} (1 + \pi_{w,t+1}) \frac{\pi_{w,t+1}}{w_t} \right],$$
$$\frac{\partial H_t}{\partial w_t} = \frac{h_t}{P_t}.$$

The sharing rule (28) can thus be written as

$$\eta_{w,t} H_t = (1 - \eta_t) J_{w,t}, \tag{29a}$$

where

$$\eta_{w,t} \equiv \frac{\eta}{\eta - (1-\eta)(\partial H_t / \partial w_t)(\partial J_t / \partial w_t)^{-1}}. \tag{29b}$$

Combining equations (28) and (29) yields equation (4) of the text.

Pricing Decisions

The representative final-sector firm sets the price of the output bundle for domestic sale, $P_{d,t}$, and the domestic currency price of the export bundle, $P^d_{x,t}$, letting the price in the foreign market be determined by $P_{x,t} = \tau_t P^d_{x,t}/S_t$. When choosing $P_{d,t}$ and $P^d_{x,t}$, the firm maximizes

$$E_t \sum_{s=t}^{\infty} \beta_{t,t+s} \left[\left(\frac{P_{d,s}}{P_s} - \frac{P^y_{d,s}}{P_s} \right) Y_{d,s} + \left(\frac{P^d_{x,s}}{P_s} - \frac{P^y_{x,s}}{P_s} \tau_s \right) Y_{x,s} - \frac{\Gamma_{d,s}}{P_s} - \frac{\Gamma^d_{x,s}}{P_s} \right], \tag{30}$$

where $\Gamma_{d,s} \equiv \nu \pi^2_{d,s} P_{d,s} Y_{d,s}/2$, $\Gamma^d_{x,s} \equiv \nu \pi^{d^2}_{x,s} P^d_{x,s} Y_{x,s}/2$, $\pi_{d,s} \equiv (P_{d,s}/P_{d,s-1}) - 1$, $\pi^d_{x,s} \equiv (P^d_{x,s}/P^d_{x,s-1}) - 1$, and output bundle demands are determined by

$$Y_{d,s} = \left(\frac{P_{d,s}}{P_s} \right)^{-\phi} Y^C_t, \qquad Y_{x,s} = \left(\frac{\tau_s P^d_{x,s}}{Q_s P_s} \right)^{-\phi} Y^{C^*}_t.$$

First-order optimality conditions for $P_{d,t}$ and $P^d_{x,t}$ and straightforward, though tedious, algebra yield equations (13)–(16) in the text. (To obtain (15)–(16), recall that $P_{x,t} = \tau_t P^d_{x,t}/S_t$ and $Q_t \equiv S_t P^*_t/P_t$.)

Other Equilibrium Details

The aggregate stock of employed labor in the Home economy is determined by

$$l_t = (1-\lambda) l_{t-1} + q_{t-1} V_{t-1}.$$

Wage inflation and consumer price inflation are tied by

$$1 + \pi_{w,t} = (w_t/P_t)(w_{t-1}/P_{t-1})^{-1}(1 + \pi_{C,t}).$$

The expression for the consumption price index implies

$$1 = \tilde{\rho}^{1-\theta}_{d,t} N^{\frac{1-\phi}{1-\theta}}_{d,t} + \tilde{\rho}^{*1-\theta}_{x,t} N^{\frac{1-\phi}{*1-\theta}}_{x,t}.$$

Finally, labor market clearing requires

$$l_t h_t = N_{d,t} \frac{\tilde{y}_{d,t}}{Z_t \tilde{z}_d} + N_{x,t} \frac{\tilde{y}_{x,t}}{Z_t \tilde{z}_{x,t}} \tau_t + N_{e,t} \frac{f_{e,t}}{Z_t} + N_{x,t} \frac{f_{x,t}}{Z_t}.$$

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Discussion of "Inflation Targeting and Economic Reforms in New Zealand"*

Michael Reddell

Successive New Zealand ministers of finance and central bank governors have chosen inflation targeting, but results in the paper suggest that New Zealand might have been better off with nominal income targeting, both pre-liberalization and after the transition to an economy with much lower trade protection and more flexible labor markets. So did David Caygill—the minister of finance responsible for the framework—and Don Brash (governor at the time) get it right?

I was invited to discuss the paper as someone who was closely involved in New Zealand's monetary policy design and implementation for most of the time since the late 1980s. So these comments are more in the nature of thoughts prompted by the paper than a detailed commentary on the structure of the model. As the paper does, I will try to treat separately the pre-liberalization period, the liberalization transition (which included the adoption of inflation targeting), and finally the post-liberalization period.

1. Pre-liberalization

The authors have tried to calibrate the model to capture features of the New Zealand data for the pre-liberalization period. That is heroic, especially given the quality of much of the earlier New Zealand data. I wonder if it was worth the effort, but also whether they have the model correctly calibrated.

The model looks to have been evaluated using rules that only make sense in a floating exchange rate world. But we had a largely

*At the time these comments were first delivered, the author was employed at the Reserve Bank of New Zealand. Views expressed here are those of the author and should not be attributed to the Reserve Bank of New Zealand. The author is currently blogging at http://www.croakingcassandra.com.

fixed exchange rate. The practical target of policymakers was avoiding too frequent or too severe current account crises, and keeping unemployment (extremely) low. What does it mean, I wonder, to say that nominal GDP (NGDP) targeting would have been the preferable rule in that era?

And I wonder if the model is really capturing key features of the hugely distorted pre-liberalization New Zealand economy. For example, the authors several times note that various results arise because unemployment would become less variable post-liberalization than it was pre-liberalization. But that was not New Zealand's experience. The unemployment rate was incredibly low and stable in the pre-liberalization period (even though we had at least two serious recessions—in 1967 and 1977—as deep as anything in the U.S. data). By contrast, unemployment (and hours) looks more conventionally variable in the post-liberalization era (even as GDP itself has become less variable). Pre-liberalization New Zealand probably had inefficiently low—if socially welcomed—volatility in both job creation and unemployment.

2. The Liberalization Transition

Between 1984 and 1993, New Zealand governments adopted a huge range of liberalization measures.

But that period was as much about macroeconomic stabilization as about microeconomic liberalization. I don't think the paper adequately recognizes or allows for that. By "macroeconomic stabilization" we were not then talking about limiting cycles in unemployment or the output gap, but about getting under control huge fiscal deficits, a large public and foreign debt, and an inflation record that had become one of the worst (highest and most volatile) among the member countries of the OECD.

The paper, and those on which it builds (e.g., Cacciatore, Fiori, and Ghironi 2013), seems to start from an implicit assumption that such macroeconomic stability has already been secured. It looks at the implications of a transition from highly regulated to less regulated external trade and labor markets, but not at the implications of the transition from high to low inflation (or indeed, high to lower nominal income growth). Of course, those transitions are not the focus of the paper, but it struggles to shed light on the actual New Zealand experience, its advertised aim, without doing so. In New Zealand—probably more so than in most of the countries that adopted inflation targeting in the 1990s—the two processes (liberalization and stabilization) went hand in hand.

In our specific context, the inflation target was about two things: getting and keeping inflation down, and providing a basis for formalized accountability. It was *not* primarily about the best ongoing cyclical stabilization properties. Of course, we wanted to avoid a formal accountability process that would "require" us to do stupid things in response to the inevitable shocks, but that was not the focus in choosing to introduce an inflation target.[1]

By the late 1980s New Zealand seemed to have (just recently) put behind it the 15 percent annual inflation rates of the earlier period, but the worry—shared across the Reserve Bank, the Treasury, and the minister of finance—was that firms, households, and markets would expect us to settle for perhaps 5 percent annual inflation. Reform programs burn up political capital. So in shaping and communicating monetary policy, the constant search had been for ways to get inflation down (and keep it down) that reduced the transitional real economic costs[2] and, not incidentally, minimized the risk that the whole reform program would be abandoned or reversed.

So a key goal was to influence expectations and behavior, by persuading wage and price setters to take seriously a regime that was (i) novel, (ii) supported by only bare majorities in both major

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[1]Rereading old files, or examining the early Policy Targets Agreements (discussed in more depth in Reddell 2014), is to be reminded how much analysis and debate went into trying to get these details right. Issues included are as follows:

- The treatment of housing. At the time, the headline CPI included mortgage interest rates and had a large asset price component (including the costs of residential sections and the cost of existing houses).
- Government taxes and charges. Material adjustments here were not seen as matters that the Reserve Bank should attempt to offset (whether in levels or changes).
- Natural disasters (including earthquakes and foot-and-mouth disease outbreaks) were a basis for the inflation targets to be renegotiated.
- Terms-of-trade shocks.

[2]The Bank was conscious of the micro-reform program and regularly championed the case for faster progress in reducing trade protection, liberalizing the labor market, and cutting the fiscal deficit, to ease pressure on monetary policy (minimizing job losses and/or excess pressure on the tradables sector).

political party caucuses, and (iii) one which even the then minister of finance could observe privately (cited in Reddell 1999) on the eve of the Reserve Bank legislation passing that, if it looked likely the target would be missed, it would "simply be abandoned."

By contrast, in the paper, expectations appear to have a very small role. Implicit rational expectations are embedded in the model, which may make sense in stable times with regimes that enjoy widespread technical and political backing. But what was a rational (i.e., reasonable mean) expectation in late 1989, when it was unknowable which wing of the party ("wet" or "dry" in British parlance) would dominate the next National government[3] and whether David Caygill or the leading dissenter on the left, Jim Anderton, would be more important in determining the stance the political left would take after the seemingly inevitable 1990 defeat of the reforming Labour government?

The other thing that shaped the New Zealand outcome was the need for something measurable as part of a formalized accountability structure. I've argued consistently (e.g., Reddell 1999) that the Reserve Bank Act was an outcome of two separate forces: on the one hand, it was the result of the dismal inflation track record and concerns about the past politicization of monetary policy. But on the other, the Reserve Bank was just another government agency, at a time when far-reaching state sector reform was under way. The focus was on principals holding agents accountable for measurable *outputs*.

In the contemporary discussions, officials were not oblivious to options other than inflation for nominal targets. Immediately post-liberalization, the Reserve Bank and the Treasury quickly realized that in the midst of financial deregulation monetary and credit aggregates were going to be impossible to interpret for some years. And some benchmark nominal GDP indicative targets had been announced (to try to shape expectations) by the minister of finance in his 1985 budget (and then never heard of again).[4]

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[3]Indeed, in mid-1991, with the economy deep in recession, fairly senior Treasury officials urged Reserve Bank officials to be more relaxed about inflation and not to be too bothered about 0–2 percent inflation, to help safeguard the political position of the embattled minister of finance (a key advocate of the Reserve Bank Act framework).

[4]And in a recent working paper, Silverstone (2014) documents a survey he ran of Reserve Bank economists while a visiting academic at the Bank in 1987. His

For some in the Treasury, money base or note issue limits seemed ideal for the purpose—something measurable that the central bank could directly control if it chose. And there was some concern that the lags from monetary policy to inflation were simply too long to provide, in isolation, a reliable basis for accountability, or to signal to price and wage setters whether or not policy was "on track." With the focus on output targets, wherever possible, agreement to use an inflation target as a centerpiece for accountability was a fairly major concession. One thing going for the CPI, in this conception, was that it was hardly ever revised—at least in principle it would always be clear whether or not the target had been met.

Probably the only feasible alternative at the time was a fixed exchange rate—recall that this was about the time the United Kingdom joined the Exchange Rate Mechanism. It was measurable, easily understood, and unrevised. But if we had gone that way, the target would not have lasted long, as New Zealand proved to have a much higher neutral real interest rate than other advanced economies.

Nominal GDP was not a serious contender. We barely had the data at all, revised or unrevised. In researching this talk, I unearthed a particularly trenchant piece of Reserve Bank advice to the minister of finance in mid-1989:[5] in response to "some commentators," the Bank noted that New Zealand at the time had no quarterly nominal GDP numbers,[6] and the annual numbers were released with an eight-month lag, concluding that "since nominal GDP is of little use either as an indicator or as an ultimate target, the Bank does not include nominal GDP in its list of indicators and does not intend to formulate any nominal GDP targets."

There is simply no way that the early Policy Targets Agreements could ever have been formulated in terms of nominal GDP targets, even if officials on either side of The Terrace had been more

questions asked them whether the Bank should have an explicitly stated desired time path for (i) inflation and/or (ii) nominal income. More respondents favored an inflation time path than favored a nominal income one, but the difference in numbers wasn't great.

[5]Reserve Bank of New Zealand, Memorandum for the Minister of Finance, "Review of the Monetary Policy Framework," June 15, 1989.

[6]And thus, e.g., quarterly PCE deflator numbers were also not available.

sympathetic to the conceptual arguments.[7] Incomplete data and the prospect of substantial ongoing revisions would have made it useless for the sort of accountability envisaged at the time. And nominal GDP simply had no resonance in the domestic debate, whether academic or political.

Perhaps it is telling that the model in the paper does not, in fact, offer much guidance on what might have been the best monetary policy during the transition period. In panel A of table 4, whether one uses the historical or the smoothing versions, each of the rules emerges as best in one of the reform scenarios. And that is just with three variants of reform. Perhaps the model is going to be most helpful for thinking about reform in a single major sector, but rather less so in thinking about what might be best in the midst of a very wide-ranging reform program of the sort New Zealand undertook. It was very difficult for anyone to keep track of all the reforms and their (transitional or longer-term) implications, let alone model them.

When a great deal of reform is going on all at the same time, when reading the data is even harder than usual, when breaking a pattern of high and variable inflation is also in the mix, perhaps there simply has to be a lot of "playing things by ear." Perhaps "political" dimensions—what helps keep policy moving in broadly the right direction, without doing too much damage in the interim—inevitably play a bigger role than in more settled times. And serendipity can also influence outcomes. If thoroughgoing reform of the governance of core government agencies had not happened to be under way at the same time, it is highly unlikely that the Reserve Bank would have become known as the first adopter of modern inflation targeting (or, hence, that the Bank would be co-hosting this conference).

3. Towards the Present

Beyond the transition, the authors conclude that, on this model and these specifications, in the post-liberalization era nominal GDP

[7] If they had been feasible, they would have faced some similar measurement issues. For example, with lots of taxes and subsidies changing, should a target be expressed in terms of NGDP at market prices or at factor cost? The former would probably have attracted more media attention, prompting the need for discussions around core/trend/underlying growth in NGDP.

targeting still beats inflation targeting and price-level targeting, albeit by a smaller margin.

In one sense, that should not be surprising. In putting together our inflation-targeting framework, we knew of the literature suggesting that nominal GDP targets could be attractive in the presence of supply shocks. And in the paper, the various monetary policy rules are evaluated using a specific type of supply shock—an economy-wide domestic productivity shock.

It was not clear why they chose to evaluate only this shock. Some colleagues suggested that it was a common approach in the literature, and for some purposes that sounds fine. But to evaluate possible alternative monetary policy rules for New Zealand—where economy-wide productivity shocks don't appear to have been particularly important—one would surely need a more extensive assessment of how the model performs in the face of a much wider range of shocks. To reach a robust view on whether, even in concept and within the model, a nominal GDP approach would likely be superior for New Zealand, I would want to understand how the model performs under fiscal shocks, credit availability shocks, exogenous migration shocks, climatic shocks, and export and import price shocks.

Even if the model still suggested that nominal GDP targeting was superior, one would need to look carefully, and critically, at how much difference such a rule—as it would likely have been applied by real-world policymakers—might have made, relative to the real-world benchmark of how inflation targeting has actually been run.

I want to use terms-of-trade fluctuations to illustrate the point. New Zealand's entire post-1840 economic history had been shaped by periodic surges and slumps in the real prices of its agricultural and pastoral exports. As Steenkamp (2014) documents, in recent decades New Zealand's terms of trade have been among the most variable of those of OECD member countries. I welcome the effort to incorporate exogenous terms-of-trade shocks in the revised version of the paper. Such shocks certainly got considerable attention in the design (and ongoing operation) of the New Zealand inflation-targeting regime.

When oil prices rise (fall) sharply, the approach the Reserve Bank is mandated to take is to allow the first-round direct price effects into the CPI and not attempt to offset them. The focus is on having monetary conditions set to ensure that inflation stays consistent with the target over the medium term, avoiding any material displacement of inflation expectations. Headline inflation initially deviates from (headline) target and then gradually returns to it. What would a nominal GDP targeter do? It is plausible that monetary policy might be set a little more loosely in the face of a sharp oil price increase than would be the case under inflation targeting, but (i) surely the difference will typically be small, and (ii) the scope and magnitude of any difference will depend on how wage and price expectations behave. In neither case does one typically tighten monetary policy in the face of a sharp rise in oil prices—as a caricature of strict inflation targeting might suggest—unless expectations appear likely to be displaced.

Import price shocks—which have mostly involved oil prices—have pervasive effects on purchasing power and input costs across the economy. Oil prices also look more like a random walk. And New Zealand's import prices are not unusually volatile by OECD standards.

But our export prices have been among the most volatile in the OECD and, if anything, have been becoming more volatile over the last decade. Unfortunately the Huang, Margaritas, and Mayes (2001) version of the Taylor rule used in the paper was estimated over one of the periods in New Zealand history with the most stable terms of trade. The differences between nominal GDP targeting and inflation targeting in New Zealand might be starker with respect to export prices.

In an NGDP rule of the sort used in the paper, under which policy responds to deviations of nominal GDP growth from target, a lift in the terms of trade, from the export side, would prompt an immediate tightening in policy. NGDP would rise immediately. By contrast, applying something like a Taylor rule under inflation targeting would result in no immediate change in policy—there would be no observed change in the output gap and, if anything, headline CPI inflation might move a little lower (since the exchange rate tends to rise when commodity prices do).

That is a stark difference, and it is somewhat akin to the difference tested in the paper (which doesn't evaluate forward-looking policy). But, of course, no one sets out to run policy using Taylor-type rules. Instead, we try to run forecast-based policies. The Reserve

Bank has often forecast export prices on the basis of mean reversion, reflecting the series of quite marked cycles seen in dairy prices in particular.

Here there looks to be quite a difference between nominal GDP growth and levels targeting. Faced with a positive export price shock, a forecast-based NGDP growth targeter will observe a near-instantaneous lift in NGDP growth, but it is too late to do anything about dampening it. But unless they assume that the terms of trade is a random walk (not the Reserve Bank practice), they will also typically have a forecast in which future NGDP growth might well *undershoot* the medium-term target band. Since NGDP targeting tends to induce a stronger policy reaction to terms-of-trade shocks, there is then a risk of engendering more volatility into policy—easing policy into an export price boom. The paper itself evaluates an NGDP levels target, which appears less prone to that risk, but it would be interesting to see how different the results are between the model's results for NGDP levels and growth rate rules. I suspect the model would struggle to deal with the question of what policy rule would be optimal if the central bank were often to get its export price forecasts wrong.

In thinking about an export price shock, it might also be important to understand the transmission of the shock across the rest of the economy. A highly open economy, in which a generalized export price shock affected firms across an employment-rich wide-ranging export sector, might look considerably different than a sector-specific shock in a moderately open economy where the commodity production sectors employ relatively little labor (the story in New Zealand dairy, and much more so in Australian minerals and gas extraction). If New Zealand experiences a surge in dairy prices, and much of the proceeds are saved by farmers—perhaps because they are very conscious of the volatility of prices—why would one want to tighten monetary policy against that lift, if there was little or no apparent spillover to domestic (wage or price) inflation? Perhaps if the shock destabilized wage expectations there could be a basis, but there has been little sign of that sort of wage-setting behavior in response to recent export price shocks. The issues are even more stark in Australia, where most of the profit variability in the face of export price shocks accrues to non-Australian owners of capital (whose consumption choices are likely to put few pressures on domestic resources in Australia).

I can imagine—but would like to see tested—that if an initial export price shock prefigured a multi-year trend in export prices in the same direction, an NGDP rule would produce superior welfare properties, by easing adjustment in the presence of nominal rigidities. But if the volatility dominates the trend, as I suggest that it has over the time horizons of interest, inflation targeting—especially as practiced, focused on core medium-term trends in inflation—seems likely to be a (much) better option.

But that should not be the end of the story. Much of the academic discussion of inflation targeting focuses on the idea of stabilizing the stickier prices in order to minimize the real costs of adjustment to shocks. Since, as this paper agrees, wages are typically among the stickier prices, perhaps we should be more seriously considering the merits of nominal wage targeting, as Earl Thompson argued decades ago. I have noted elsewhere (Reddell 2014) that such a rule could even have financial stability advantages. Nominal wages are the prime basis for servicing the nominal household debt that dominates the balance sheets of our banks. Faced with adverse shocks, and especially deflationary ones, nominal debt is arguably the biggest rigidity of them all. It would be interesting to see such a rule evaluated in a suitable model.

If productivity shocks were the dominant source of dislocations in New Zealand, such a wage rule could also have considerable appeal—shifting the variability into the price level rather than into (sticky) nominal wage inflation. As it is, over the last twenty years, wage inflation has followed a rather similar path to core CPI inflation—and does not look much like fluctuations in the path of nominal GDP (or in NGDP per capita, or NGDP per hour worked). So perhaps, at least over that period, policy should have looked very little different under a wage rule than under the CPI inflation targets that successive ministers and governors have agreed upon.

A single paper cannot cover all the issues, and a single model cannot capture all important distortions, but in one respect this paper did strike me as having a slightly dated feel to it. A decade ago most of us told ourselves stories in which the zero lower bound was a textbook curiosity, and if the Japanese had got there, that was surely a reflection of some really bad policy choices. But across much of the advanced world, central bankers have spent the last six years or so at, or acting as if they believe they are at, the near-zero lower bound. How well do each of the possible rules do in easing that constraint or mitigating the consequences of hitting it? I suspect that to deal with that challenge one would need to introduce a richer treatment of expectations. The issue is timely: few advanced countries are now far from zero and even New Zealand is much less than a typical easing cycle away.

Some argue that even if an analytical case for change to an NGDP target were to become more persuasive, there has been such a large investment in communicating with the public, markets, etc., about inflation targets, which would all be lost with a shift to an NGDP target, that it is not worth changing. But, in practice, a large amount of central bank communications consists of telling people not to pay much attention to headline inflation but to look at this, that, or the other measure of underlying medium-term or persistent inflation pressure. The lack of revisions to the CPI is often presented as an advantage, but (i) no one has followed New Zealand in making the governor dismissable over monetary policy errors, and even in New Zealand no one can specify what would or should result in such a (recommendation for) dismissal,[8] and (ii) revisions partly reflect genuinely uncertainty about our ability to measure and report accurately on macroeconomically meaningful aggregates (including, of course, the output gap).

A final consideration is that no other country has chosen to adopt NGDP targeting, whether in levels or growth rate form. I have often argued that there must be some wisdom in the revealed choices others have made, especially when the issues have been around for decades. But, in fairness, we also know that countries can settle on choices that quickly look quite bad in hindsight. As just one example, leading up to 1929 more and more countries were getting back onto the gold standard.

[8]By contrast, when the then governor was asked by an interviewer in 1993 what would happen if inflation went above 2 percent (then top of the target range) and whether this would mean he would lose his job, Dr. Brash (1993) responded without qualification, "Exactly right." Actual accountability with respect to monetary policy is much more about process than about outcomes (a point elaborated in Reddell 2006).

4. Conclusion

Formal models such as these can help one think through the issues carefully. If it was disappointing, it was probably not surprising that the paper could not offer much guidance on appropriate policy rules in transitions, perhaps especially not multi-dimensional ones like New Zealand's.

To see whether the case for nominal GDP targeting looks plausible for New Zealand, it would be interesting to see an assessment of how the model performs using a forecast-based approach. This paper probably is not enough to make any central bank converts to NGDP targeting at present, but it is a useful reminder that we need to remain open and that inflation targeting is most unlikely to represent the end of monetary policy history.

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Targeting Inflation from Below: How Do Inflation Expectations Behave?*

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Inflation targeting (IT) had originally been introduced as a device to bring inflation down and stabilize it at low levels. Given the current environment of persistently weak inflation in many advanced economies, IT central banks must now bring inflation up to target. This paper tests to what extent inflation expectations are anchored in such circumstances, by comparing across periods when inflation is around target, (persistently) high, or (persistently) weak. It finds that under persistently low inflation, inflation expectations are not as well anchored as when inflation is around target: inflation expectations are more dependent on lagged inflation; forecasters tend to disagree more; and inflation expectations get revised down in response to lower-than-expected inflation, but do not respond to higher-than-expected inflation. This suggests that central banks should expect inflation expectations to behave differently than was the case previously, when inflation was often remarkably close to target in many advanced economies.

JEL Codes: E52, E58, E31, C53.

1. Introduction

When inflation targeting (IT) was first introduced in New Zealand in 1989, its aim was to reduce and stabilize inflation, and to anchor

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inflation expectations at lower levels, given that inflation had been running at double-digit rates for much of the late 1970s and the 1980s. Subsequent adopters of IT, such as Canada in 1991 or the United Kingdom in 1992, also intended to bring inflation down, to make it less volatile, and to anchor inflation expectations at a lower level.

In contrast, more recently, the Bank of Japan adopted IT following an extended period of subdued inflation, with the declared intention to bring inflation up to target and to boost inflation expectations. In a similar vein, in 2012, the U.S. Federal Reserve announced an inflation objective in a situation where headline inflation stood slightly above the new goal but core inflation had been substantially below for a considerable amount of time. Also, following the global financial crisis, a number of countries that had already adopted IT were (and, at the time of writing, several of them still are) faced with a prolonged period of below-target inflation.

Although designed to *lower* inflation and inflation expectations, IT is now charged with the objective to *raise* them, a challenge that has not yet been studied extensively.[1] Questions that are of particular interest are whether the formation of inflation expectations differs when inflation is (persistently) weak from when inflation is at or above target, and whether there is a risk that inflation expectations become disanchored. Benhabib, Schmitt-Grohé, and Uribe (2002) and more recently Armenter (2014), for instance, show that at the zero lower bound, low-inflation expectations can become self-fulfilling. In a similar vein, Busetti et al. (2014) show how a series of deflationary shocks can unanchor inflation expectations.

Naturally, given the historical background of IT, the existing literature has mostly studied the performance of IT in bringing inflation down, stabilizing it, and anchoring inflation expectations. In contrast, much less is known about how IT performs if inflation is

[1] At the same time, there is an ongoing debate about the optimal level of inflation targets under low inflation. Several authors (Blanchard, Dell'Ariccia, and Mauro 2010; Ball 2014) have proposed raising inflation targets from the currently common level of around 2 percent to a new level of 4 percent, in order to reduce the likelihood of hitting the zero lower bound (ZLB). The question has been discussed critically, for instance, by McCallum (2011), Walsh (2011), and Coibion, Gorodnichenko, and Wieland (2012), but has generally been met with resistance by central bankers (e.g., Bernanke 2010).

below target, and persistently so. Since we have recently seen low inflation for prolonged periods in a number of advanced economies, sufficient amounts of data have accrued that now allow us to provide some empirical evidence that can address these questions. This paper studies to what extent inflation expectations are anchored in different inflation regimes—in normal times, under high (and possibly persistently high) inflation, and if inflation is weak (and persistently so). It employs monthly inflation expectations as provided by Consensus Economics for ten IT countries, covering the time between the adoption of IT and December 2014. Based on these data, the paper tests (i) the extent to which inflation expectations depend on lagged, realized inflation, (ii) the extent to which forecasters disagree, and (iii) how inflation expectations are revised in response to news about inflation.

The key finding of the paper is that under persistently low inflation, some disanchoring of inflation expectations occurs compared to situations where inflation is around target. Evidence for this comes from all three tests: inflation expectations are more dependent on lagged inflation; forecasters tend to disagree more; and inflation expectations get revised down in response to lower-than-expected inflation, but do not respond to higher-than-expected inflation. This evidence suggests that central banks should expect inflation expectations to behave differently than was the case previously, when inflation was often remarkably close to target in many advanced economies. Still, even under persistently low inflation, expectations in the IT countries studied here are generally better anchored than they were in Japan over its period of prolonged weak inflation.

The paper proceeds as follows: section 2 provides an overview of the related literature. The data are explained in section 3. The current environment of weak inflation in advanced economies is discussed in section 4. Section 5 presents the empirical evidence regarding the behavior of inflation expectations, and section 6 concludes.

2. Literature Review

There is a large empirical literature on the effects of IT. Since IT had been designed with a view to taming inflation and inflation expectations, this has been the focus of most previous contributions. The two main aspects of this literature are (i) the effect on inflation and (ii) the effect on inflation expectations. We will briefly review each (for a more detailed summary of the relevant literature and its placement in the broader context of central bank communication, see Blinder et al. 2008).

2.1 The Effect on Inflation

Despite the fact that IT is viewed as a success by IT central banks, and even though inflation has typically been lower and more stable following the adoption of inflation targets, there is still a vigorous debate on the merits of IT. There has been early supportive evidence (King 2002 for the United Kingdom, and Kuttner and Posen 1999 for Canada and the United Kingdom), and Bleich, Fendel, and Rülke (2012) show that the introduction of IT has significantly shifted the reaction functions of central banks toward inflation stabilization. Still, others have questioned whether there is a causal link between IT and inflation developments, pointing to various complications in any empirical analysis of this question.

One complication is a possible endogeneity issue, whereby the decision to adopt IT is not independent of country fundamentals (Mukherjee and Singer 2008; Samarina and De Haan 2014). Ball and Sheridan (2005) pointed out that countries that adopted IT often had above-average inflation prior to adoption. They argue that this affects the empirical evidence, showing that once mean reversion in inflation is allowed for by controlling for the initial level of inflation, the decline in inflation is similar for targeters and non-targeters—a result that is shared by Willard (2012).

Another complication is the identification of a control group. Mishkin and Schmidt-Hebbel (2007), for instance, argue that inflation targeters do not show a performance superior to that of a group of successful non-targeters. Still, even when using advanced econometric methodologies such as propensity score matching to address this issue, the evidence remains inconclusive: Vega and Winkelried (2005) conclude that IT has had the desired effect, whereas Lin and Ye (2007) come to the opposite conclusion.[2]

[2]Other complications arise because the start of IT needs to be defined (for instance, as the announcement date, as in Bernanke et al. 1999, or as the implementation date, as in Ball and Sheridan 2005), and because the classification of inflation targeters is not always clear (Kuttner 2004).

One reason for the inconclusive findings could be that several countries in the usual control group have adopted other forms of quantitative targets. Fatas, Mihov, and Rose (2007) argue that the quantification matters more than the type of the target, since they find that inflation, exchange rate, and monetary targets are all linked to lower inflation. Also, IT might be more successful under some circumstances—Alpanda and Honig (2014) and Samarina, Terpstra, and de Haan (2014) find little evidence for the success of IT overall but identify substantial effects of IT in emerging economies.

2.2 The Effect on Inflation Expectations

Also the evidence regarding the effect of IT on inflation expectations is inconclusive. Johnson (2003) predicts expected inflation in IT countries based on a model of expectation determination prior to the adoption of IT, and finds that actual inflation expectations are substantially lower than their predicted values. Comparing targeting with non-targeting countries, Johnson (2002) provides evidence of a relative reduction in inflation expectations in the IT countries, while Levin, Natalucci, and Piger (2004) show that long-term inflation forecasts depend on past inflation in the control group but not in the IT group. Gürkaynak, Levin, and Swanson (2010) and Davis (2014) find inflation expectations to be less responsive to news in IT countries than in the respective control groups.

While these studies suggest a better anchoring of inflation expectations in IT countries, other evidence does not confirm these findings. Castelnuovo, Nicoletti-Altimari, and Rodriguez-Palenzuela (2003) find that long-term inflation expectations are well anchored in all countries in their sample except Japan, regardless of whether the central bank has an inflation target or not. Also, Pierdzioch and Rülke (2013) show that forecasters in IT countries often scatter their inflation forecasts away from the inflation target.

Another strand of this literature has studied the effects of IT, or central bank transparency more generally, on *disagreement* among inflation forecasters. Capistran and Timmermann (2009) show that disagreement in inflation expectations rises with the level and the variance of the inflation rate, such that we might expect less disagreement under IT (if having an inflation target contributes to reducing and stabilizing inflation). Swanson (2006) finds that with the increased transparency of the U.S. Federal Reserve, the dispersion across private-sector forecasters of U.S. interest rates has declined, a finding that is supported at the international level in Dovern, Fritsche, and Slacalek (2012). Crowe (2010) tests whether IT promotes convergence to lower forecast errors, and points out that convergence occurs in all countries because of mean reversion, but that the adoption of IT leads to greater convergence. Ehrmann, Eijffinger, and Fratzscher (2012) identify IT as one of various transparency measures that effectively reduce disagreement among inflation forecasters.

Other evidence is less conclusive. Cecchetti and Hakkio (2010) report only small effects, and Capistran and Ramos-Francia (2010) detect them only for developing countries. Siklos (2013) studies forecaster disagreement across many different forecast types, including those prepared by central banks and international institutions, as well as survey-based forecasts conducted among households and businesses. He finds that central bank transparency in general is associated with an *increase* in forecast disagreement, but that the adoption of IT has little effect on forecast disagreement.

To summarize, it appears that the case for IT is far from settled. Most longitudinal analyses find that inflation is reduced and more stable, and that inflation expectations fall and are better anchored after the adoption of an inflation target, whereas cross-sectional comparisons often conclude that similar results have also been obtained in other countries. In other words, it appears that while IT has lived up to its promise, it is not unique in delivering low and stable inflation and well-anchored inflation expectations.

This paper adds a new dimension to the analysis by studying the performance of IT in different circumstances, namely when inflation is weak (and persistently so), as opposed to times when inflation is around target, or when inflation is high (and persistently so).

3. Data

For the empirical analysis, we use data on inflation expectations provided by Consensus Economics, which are based on surveys among professional forecasters and are available for a reasonably long history in a comparable fashion across countries. The same database has been used in several related studies, such as Crowe

(2010), Dovern, Fritsche, and Slacalek (2012), Ehrmann, Eijffinger, and Fratzscher (2012), and Davis (2014).

Since the recent episode of weak inflation has been largely an advanced-economy phenomenon, we restrict the analysis to the advanced economies in the data set. Also, since we are, inter alia, interested in studying forecaster disagreement, the set of countries is restricted to those where individual forecaster data are available.

Also, we will only include IT countries, and do therefore need a corresponding classification of countries. Beyond the set of central banks that are officially classified as inflation targeters, we also include the current monetary policy regimes of the Federal Reserve, the Swiss National Bank, and the European Central Bank (ECB) in the IT category. These central banks currently have a quantified inflation objective—while they are not inflation targeters sensu stricto, the quantification of the inflation objective should provide a similar anchor for inflation expectations.

Accordingly, the data set spans the following ten economies: Australia, Canada, the euro area, New Zealand, Norway, Spain (prior to joining the European Monetary Union), Sweden, Switzerland, the United Kingdom, and the United States. We also include Japan, even prior to its adoption of IT, to provide a comparator country, given its long-lasting experience of weak inflation.

The data are monthly, and the mean inflation forecasts are available since January 1990 (with the exception of the euro area, for which forecasts start in December 2002). We use the data as of the month when the quantified inflation objective was adopted (as in Ball and Sheridan 2005), according to the central bank websites. Alternatives would have been the announcement date (as in Bernanke et al. 1999) or a later date to allow for the fact that central banks need to build up credibility for their target (e.g., Goldberg and Klein 2011 for the ECB), or to cater to the fact that the Bank of England gained independence only after introducing its target (Gürkaynak, Levin, and Swanson 2010). Choosing the adoption date places us in the middle of these alternatives.

The sample ends in December 2014. Note, however, that we end the sample for Spain in December 1998, i.e., with the formation of the European Monetary Union. The reason for this is that there are no country-specific inflation targets—the ECB defines price stability for the euro area as a whole, and because of relatively persistent inflation differentials across the euro-area countries (Angeloni and Ehrmann 2007), it is not clear how the euro-area objective would translate into national inflation expectations. This procedure also ensures that the euro area is not double-counted once data for the euro-area aggregate are available.

Table 1 provides information on the data availability by country. On average, the data set comprises seventeen forecasters per country and month, but there is some variation, with a minimum of four and a maximum of thirty-four respondents. Survey participation is relatively smaller in Norway, with nine forecasters on average, whereas the number of forecasters in the euro area, the United Kingdom, and the United States is relatively large, with at least twenty-five on average.

In the Consensus Economics survey, respondents are asked to provide their forecasts for consumer price inflation. For a robustness analysis, we also use the forecasts for real GDP growth. Forecasts are provided for the current and the next calendar year. This implies that the forecast horizon decreases over the course of a given year—while a current-calendar-year forecast in January spans effectively an entire year, the forecasting problem in December is much simpler, since much of the year's data are already realized and released. In the empirical analysis, we will therefore control for the forecast horizon by including month fixed effects where relevant.

It is also important to note that the forecasting horizon of our data is rather short. Mehrotra and Yetman (2014) have shown that longer-term forecasts are better anchored than shorter-term forecasts, which is intuitive because the central bank should be able to bring inflation to target over longer horizons, whereas in the short run, the long lags in the transmission of monetary policy make it more likely that inflation deviates from target. This should be mirrored in the short-term inflation expectations that we study here.

We sourced the actual consumer price inflation rates from the national statistical offices via Haver Analytics.[3] The central bank

[3]We use consumer price index (CPI) inflation rates for all countries, in line with the concept that is forecasted in the Consensus Economics survey, even if the inflation target relates to a different price concept (such as the Harmonised Index of Consumer Prices (HICP) in the euro area). Results are robust to using the alternative inflation concept.

Table 1. Coverage of the Data Set

Country	Sample				No. of Forecasters		
	Start Date: Mean Forecasts	Start Date: Individual Data	End Date	Monthly Obs.	Avg.	Min.	Max.
Australia	1993:M3	1993:M3	2014:M12	262	17	4	21
Canada	1991:M2	1991:M2	2014:M12	287	15	11	19
Euro Area	2002:M12	2002:M12	2014:M12	145	28	22	34
New Zealand	1990:M3	1994:M12	2014:M12	298	13	6	17
Norway	2001:M3	2001:M3	2014:M12	166	9	5	12
Spain	1994:M11	1995:M1	1998:M12	50	12	7	15
Sweden	1993:M1	1995:M1	2014:M12	264	13	6	18
Switzerland	2000:M1	2000:M1	2014:M12	180	13	6	17
United Kingdom	1992:M10	1992:M10	2014:M12	267	25	16	34
United States	2012:M1	2012:M1	2014:M12	36	29	24	33
Japan	1990:M1	1990:M1	2014:M12	300	17	5	25

Notes: The table provides an overview of the coverage of the Consensus Economics forecast data set. The figures for "Monthly Observations" are calculated for the mean forecast.

Table 2. Summary Statistics

	Obs.	Mean	St. Dev.	Min.	Max.
Inflation	1955	1.936	1.306	−1.834	7.669
Current-Calendar-Year Expectations	1955	2.105	1.136	−0.640	5.975
Next-Calendar-Year Expectations	1955	2.183	0.764	−0.061	5.050
Low Inflation	1955	0.248	0.432	0	1
Low Inflation, at Least Six Months	1955	0.199	0.399	0	1
Low Inflation, at Least Nine Months	1955	0.173	0.378	0	1
Low Inflation, at Least Twelve Months	1955	0.158	0.364	0	1

Notes: The table shows summary statistics for CPI inflation, for inflation expectations, and for dummy variables that cover periods of low inflation. Statistics are for the regression sample, i.e., without Japan.

policy rates were taken from central bank websites, as were the levels of the central banks' inflation targets.[4]

Table 2 provides some information on the inflation outcomes of the IT sample (i.e., excluding Japan) and the corresponding inflation expectations. Inflation has been 1.9 percent, which is very closely reflected in inflation expectations—current-calendar-year expectations amount to 2.1 percent, and next-calendar-year expectations to 2.2 percent. Interestingly, inflation expectations are more stable than actual inflation, and expectations for the longer forecast horizon are more stable than the current-calendar-year expectations.

Another type of data is required for testing for the extent to which inflation expectations respond to news about realized inflation. For that purpose, we follow the standard in the announcement literature (e.g., Andersen et al. 2003) and calculate the surprise

[4]Unfortunately, variation in the inflation targets is only very small (they range from 1 percent to 3 percent, with 56 percent of all observations corresponding to a target of 2 percent, and another 30 percent of observations to a target of 2.5 percent), preventing us from testing whether relatively higher targets attenuate the findings that inflation expectations are not anchored as well under low inflation.

component contained in the release of CPI inflation by deducting the expectation of the announcement from the actual announcement value. As is common in this literature, we have obtained data on the expectations of the macroeconomic releases from a survey among financial market participants conducted by Bloomberg, and we use the median response as our measure of expectations. We ensure that the data release is appropriately assigned to the relevant Consensus Economics forecast round; i.e., we test whether the inflation forecasts respond to the data release that occurs just before the survey is conducted.

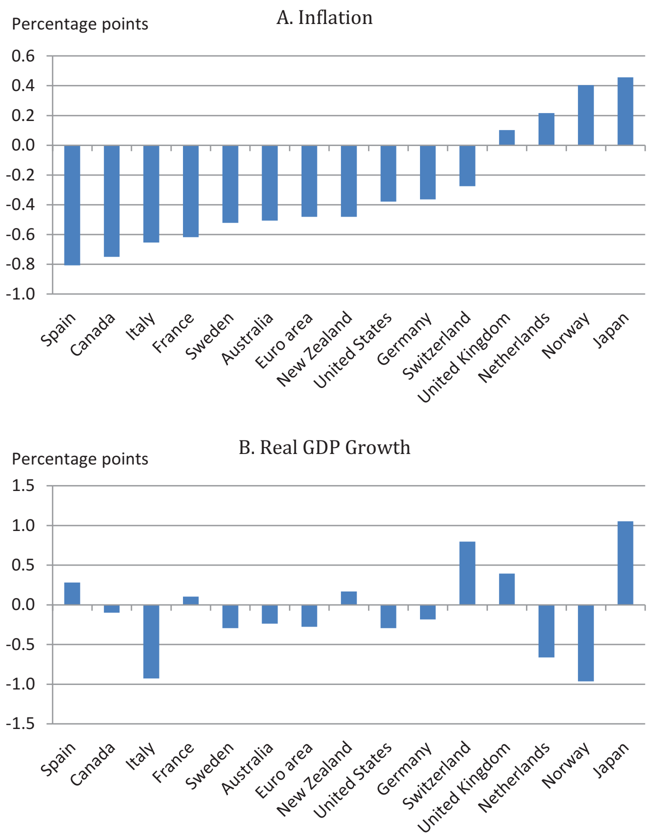
4. The Current Environment of Weak Inflation in Advanced Economies

Following the global financial crisis, inflation developments in advanced economies have surprised many economists, in two different ways. First, as documented by the International Monetary Fund (2013), there has been a period of "missing disinflation": based on previous relationships, given the depth of the recession, inflation should have declined much more strongly than it actually did. This period has been analyzed, inter alia, by Gordon (2013), Murphy (2014), Coibion and Gorodnichenko (2015), and Del Negro, Giannoni, and Schorfheide (2015).

Second, inflation has more recently surprised to the downside. While policymakers have pointed this out (e.g., Macklem 2014), little research has tried to understand the drivers of inflation dynamics in this period, with the notable exceptions of Ferroni and Mojon (2014) and Friedrich (2014).

Figure 1 provides some evidence that the developments in advanced economies' inflation rates in 2013 were indeed surprising to economists. Panel A shows how the 2013 calendar-year forecasts gathered by Consensus Economics were revised over the course of 2013 (by comparing the mean forecasts for a given country c provided in January with those provided in December 2013: $E_{c,December2013}(\pi_{c,2013}) - E_{c,January2013}(\pi_{c,2013})$. In most countries, inflation forecasts were revised downward, and in many cases substantially so. To check this finding, panel B shows the corresponding revisions to GDP growth forecasts (ordered as in panel A, i.e., by the magnitude of the revision in inflation forecasts). While inflation forecasts were consistently revised down over the course

Figure 1. 2013 Forecast Revisions

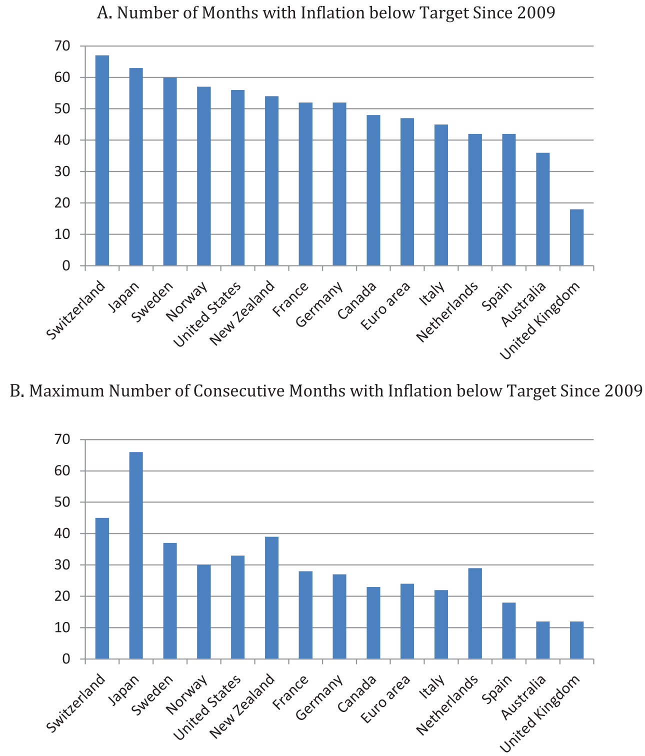


Notes: The figure shows the revisions to the mean Consensus Economics forecasts for 2013 inflation (panel A) and 2013 real GDP growth (panel B) between the forecasts conducted in January 2013 and December 2013. For the euro area, the figure covers the aggregate as well as the five largest euro-area countries.

of the year, this is not true for GDP growth forecasts, confirming that inflation forecasts were not revised down as a consequence of downward revisions to economic activity.[5] Rather, the evolution of inflation itself seems to have surprised forecasters.

[5]Looking at the evolution of oil prices or the Consensus Economics oil price forecasts, it is apparent that the downward revisions to inflation expectations were not driven by oil prices either.

Figure 2. Weak Inflation in Advanced Economies



Notes: The figure shows the number of months with inflation below target since 2009 (panel A) and the maximum number of consecutive months with inflation below target since 2009 (panel B), by country. For the euro area, the figure covers the aggregate as well as the five largest euro-area countries.

Overall, the period following the global financial crisis can be characterized as one of weak inflation. This is illustrated in panel A of figure 2, which shows the number of months that inflation has been below target since 2009 in the various countries. This was the case for 69 percent of all observations (74 percent since 2012). The most extreme cases are Switzerland and Japan, where inflation has been below the definition of price stability in sixty-seven and sixty-three out of the seventy-two months in that period, respectively. On the other side of the spectrum is the United Kingdom, with only eighteen out of seventy-two months with below-target inflation. Furthermore, inflation has been below target by substantial amounts. The average gap between inflation and its target has been –0.4 percentage points since 2009 and –0.7 percentage points since 2012.

Not only has inflation been low on average, it has also been low in a persistent manner. This is illustrated in panel B of figure 2, which shows the maximum number of consecutive months for which inflation has been below target since 2009 in each country. Obviously, the outliers are again Switzerland and Japan, with inflation below the objective in forty-five and sixty-three out of the seventy-two months, respectively, but many other countries have also seen persistently weak inflation, with New Zealand, Norway, Sweden, and the United States all having had thirty or more consecutive months with inflation below target.

At the end of the sample, inflation was below target in fourteen of the fifteen countries considered in the figure, suggesting that the episode of weak inflation is still ongoing at the time of writing this paper.

5. The Anchoring of Inflation Expectations

The hypothesis to be studied in this paper is the extent to which inflation expectations are anchored, comparing across different inflation environments. We will perform three types of tests for the anchoring of expectations. The first examines the extent to which inflation expectations depend on lagged, realized inflation; the second studies disagreement across forecasters; and the third tests the extent to which inflation expectations get revised in response to inflation news.

5.1 Dependence on Realized Inflation

If inflation expectations were perfectly anchored at target, they should not move away from the target, regardless of the current inflation rate that is observed in the economy. Such a degree of anchoring is most likely not observed in the data (especially given that we are studying short-term inflation expectations), but the example clarifies that a valid test for the anchoring of inflation expectations is the degree to which they depend on the inflation rates that are observed in the economy. This type of test has a long tradition in the related literature and has, for instance, been employed in Levin, Natalucci, and Piger (2004). The regression underlying these tests is as follows:

$$E_{c,t}(\pi_{c,t+h}) = \alpha_c + \beta_1 \pi_{c,t-1} + \beta_2 D^l_{c,t} + \beta_3 D^l_{c,t}\pi_{c,t-1} + \beta_4 D^h_{c,t} + \beta_5 D^h_{c,t}\pi_{c,t-1} + \varepsilon_{c,t}, \quad (1)$$

where $E_{c,t}(\pi_{c,t+h})$ denotes the mean inflation expectations for country c over the forecast horizon h (i.e., the next-calendar-year forecasts), collected in the Consensus Economics survey conducted in month t. α_c are country fixed effects.[6] $D^l_{c,t}$ is a dummy variable for times of (persistently) low inflation, and $D^h_{c,t}$ is a dummy variable for periods when inflation is (persistently) high. The models are estimated by ordinary least squares. We calculate Driscoll and Kraay (1998) standard errors, which allow for heteroskedasticity, autocorrelation up to a maximum lag order of 12, and cross-sectional correlation.[7]

The corresponding results are provided in table 3. The first column reports results from a regression that does not differentiate across different inflation episodes, and shows that inflation expectations are somewhat backward looking, which is not surprising, given the short forecasting horizon. In the subsequent estimations, we distinguish different inflation episodes. First, we test periods of low and high inflation. These are defined as times when inflation is more than 1 percentage point below target, and more than 1 percentage point above target, respectively.[8]

Second, to test for different effects if inflation is high or low in a persistent manner, we define various dummy variables that are

[6]These control for possible country-specific differences that can affect inflation expectations, such as the quality of the forecaster pool and the difficulty to make forecasts for a given economy (e.g., because smaller economies are more prone to shocks and, as such, might ceteris paribus be relatively more volatile). Results are robust to the inclusion of month fixed effects.

[7]Results are robust to using panel-corrected standard errors.

[8]All results are robust when we define low and high inflation to be below 1 percent and above 3 percent, respectively.

Table 3. Dependence of Inflation Expectations on Past Inflation

	Overall	**Low/High Inflation**	**Low/High Inflation, at Least 6 Months**	**Low/High Inflation, at Least 9 Months**	**Low/High Inflation, at Least 12 Months**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
A. Benchmark: Full Sample, with Country Fixed Effects					
Lagged Inflation (β_1)	0.241***	0.186***	0.180***	0.154***	0.130***
	(0.031)	(0.040)	(0.036)	(0.034)	(0.031)
Low Inflation (β_2)	–	−0.115	−0.110*	−0.207***	−0.285***
		(0.077)	(0.066)	(0.057)	(0.056)
Interaction Lagged Inflation/ Low Inflation (β_3)	–	0.107	0.102	0.213***	0.184***
		(0.066)	(0.069)	(0.058)	(0.040)
High Inflation (β_4)	–	−0.624**	−0.511	−0.446	−0.395
		(0.290)	(0.330)	(0.360)	(0.361)
Interaction Lagged Inflation/ High Inflation (β_5)	–	0.176**	0.162*	0.170*	0.178*
		(0.083)	(0.086)	(0.091)	(0.093)
p-value ($\beta_1 + \beta_3$)	–	0.000	0.000	0.000	0.000
p-value ($\beta_1 + \beta_5$)	–	0.000	0.000	0.001	0.001
Observations	1,955	1,955	1,955	1,955	1,955
R-squared	0.627	0.633	0.632	0.637	0.641
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	No	No	No	No	No

(continued)

Table 3. (Continued)

	Overall	**Low/High Inflation**	**Low/High Inflation, at Least 6 Months**	**Low/High Inflation, at Least 9 Months**	**Low/High Inflation, at Least 12 Months**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
B. Robustness: Full Sample, with Time Fixed Effects					
Lagged Inflation (β_1)	0.171***	0.183***	0.169***	0.137***	0.122***
	(0.028)	(0.046)	(0.039)	(0.036)	(0.035)
Low Inflation (β_2)	–	−0.025	−0.056	−0.177***	−0.225***
		(0.081)	(0.074)	(0.060)	(0.055)
Interaction Lagged Inflation/	–	0.060	0.054	0.131**	0.145**
Low Inflation (β_3)		(0.067)	(0.065)	(0.057)	(0.062)
High Inflation (β_4)	–	−0.087	−0.052	−0.014	0.042
		(0.341)	(0.388)	(0.432)	(0.442)
Interaction Lagged Inflation/	–	0.000	−0.001	0.009	0.010
High Inflation (β_5)		(0.092)	(0.095)	(0.099)	(0.100)
p-value ($\beta_1 + \beta_3$)	–	0.000	0.000	0.000	0.000
p-value ($\beta_1 + \beta_5$)	–	0.017	0.049	0.113	0.157
Observations	1,955	1,955	1,955	1,955	1,955
R-squared	0.782	0.783	0.783	0.785	0.786
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes

(continued)

Table 3. (Continued)

	Overall	**Low/High Inflation**	**Low/High Inflation, at Least 6 Months**	**Low/High Inflation, at Least 9 Months**	**Low/High Inflation, at Least 12 Months**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
C. Robustness: Sample Prior to 2009					
Lagged Inflation (β_1)	0.251***	0.222***	0.197***	0.161***	0.133***
	(0.041)	(0.061)	(0.052)	(0.046)	(0.042)
Low Inflation (β_2)	–	0.009	−0.023	−0.158*	−0.256***
		(0.134)	(0.105)	(0.094)	(0.091)
Interaction Lagged Inflation/ Low Inflation (β_3)	–	0.026	0.048	0.195*	0.151
		(0.118)	(0.125)	(0.114)	(0.100)
High Inflation (β_4)	–	−0.472	−0.349	−0.255	−0.261
		(0.323)	(0.368)	(0.401)	(0.411)
Interaction Lagged Inflation/ High Inflation (β_5)	–	0.131	0.130	0.140	0.162
		(0.098)	(0.098)	(0.100)	(0.104)
p-value ($\beta_1 + \beta_3$)	–	0.015	0.044	0.001	0.003
p-value ($\beta_1 + \beta_5$)	–	0.000	0.001	0.004	0.005
Observations	1,343	1,343	1,343	1,343	1,343
R-squared	0.558	0.563	0.564	0.571	0.576
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	No	No	No	No	No

(continued)

Table 3. (Continued)

	Overall	Low/High Inflation	Low/High Inflation, at Least 6 Months	Low/High Inflation, at Least 9 Months	Low/High Inflation, at Least 12 Months
	(1)	(2)	(3)	(4)	(5)
D. Robustness: Sample Restricted to July Forecasts					
Lagged Inflation (β_1)	0.236***	0.260***	0.203***	0.172***	0.149***
	(0.040)	(0.024)	(0.037)	(0.038)	(0.027)
Low Inflation (β_2)	–	0.018	−0.092	−0.186***	−0.277***
		(0.092)	(0.063)	(0.041)	(0.051)
Interaction Lagged Inflation/ Low Inflation (β_3)	–	0.085	0.170***	0.305***	0.256***
		(0.071)	(0.041)	(0.040)	(0.036)
High Inflation (β_4)	–	−0.083	0.067	0.316	0.296
		(0.161)	(0.178)	(0.259)	(0.269)
Interaction Lagged Inflation/ High Inflation (β_5)	–	0.002	0.014	−0.007	0.009
		(0.060)	(0.057)	(0.073)	(0.080)
p-value ($\beta_1 + \beta_3$)	–	0.000	0.000	0.000	0.000
p-value ($\beta_1 + \beta_5$)	–	0.000	0.001	0.070	0.072
Observations	163	163	163	163	163
R-squared	0.617	0.620	0.621	0.629	0.630
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	No	No	No	No	No

(continued)

Table 3. (Continued)

	Overall	Low/High Inflation	Low/High Inflation, at Least 6 Months	Low/High Inflation, at Least 9 Months	Low/High Inflation, at Least 12 Months
	(1)	(2)	(3)	(4)	(5)
E. Robustness: Sample without Zero Lower Bound					
Lagged Inflation (β_1)	0.238***	0.185***	0.178***	0.150***	0.122***
	(0.035)	(0.047)	(0.038)	(0.036)	(0.033)
Low Inflation (β_2)	–	−0.059	−0.057	−0.169**	−0.262***
		(0.116)	(0.095)	(0.082)	(0.080)
Interaction Lagged Inflation/ Low Inflation (β_3)	–	0.062	0.062	0.201**	0.169**
		(0.098)	(0.103)	(0.089)	(0.072)
High Inflation (β_4)	–	−0.607**	−0.459	−0.361	−0.314
		(0.300)	(0.346)	(0.381)	(0.383)
Interaction Lagged Inflation/ High Inflation (β_5)	–	0.178**	0.160*	0.163*	0.175*
		(0.088)	(0.089)	(0.093)	(0.096)
p-value ($\beta_1 + \beta_3$)	–	0.005	0.019	0.000	0.000
p-value ($\beta_1 + \beta_5$)	–	0.000	0.000	0.001	0.003
Observations	1,699	1,699	1,699	1,699	1,699
R-squared	0.540	0.547	0.547	0.553	0.559
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	No	No	No	No	No

Notes: The table shows results from the regression $E_{c,t}(\pi_{c,t+h}) = \alpha_c + \beta_1 \pi_{c,t-1} + \beta_2 D^l_{c,t} + \beta_3 D^l_{c,t}\pi_{c,t-1} + \beta_4 D^h_{c,t} + \beta_5 D^h_{c,t}\pi_{c,t-1} + \varepsilon_{c,t}$, where $D^l_{c,t}$ is a dummy variable for times of (persistently) low inflation, and $D^h_{c,t}$ is a dummy variable for periods when inflation is (persistently) high. Panel A reports the benchmark results. Panel B shows results for a model with time fixed effects, panel C for a model that excludes data after 2008. Panel D is restricted to forecasts in July of each year, and panel E drops observations when policy rates are close to the ZLB, defined here as policy rates smaller than or equal to 50 basis points. ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. Numbers in parentheses are standard errors.

equal to one if inflation has been low (or high) according to the above definition for at least six, nine, or twelve consecutive months.

The underlying hypothesis is that the determination of inflation expectations might be affected if inflation is low (high) for long. This notion is consistent with recent work by Bianchi and Melosi (2014), who develop a theoretical framework in which the anti-inflationary determination of monetary policy varies over time. In this context, inflation expectations remain anchored when the central bank deviates from an active monetary policy for a short period of time, but disanchoring occurs and uncertainty rises when the deviation persists over time. Table 2 provides summary statistics for these dummy variables—overall, there are 485/389/338/308 observations where inflation is low for at least one/six/nine/twelve months.

The first row in table 3 shows the dependence on lagged inflation that results in times when inflation is neither (persistently) low nor (persistently) high. The estimated coefficients are similar to those obtained for the full sample (shown in column 1).

Looking at the interaction terms (β_1 and β_5), there is little evidence that the behavior of inflation expectation changes if inflation is *high*, or persistently so. In contrast, the results suggest that if inflation is *low*, and in particular if it is low for long, inflation expectations become more dependent on realized inflation. The magnitudes are substantial—if inflation has been low for at least nine consecutive months, the overall coefficient (given as the sum of $\beta_1 + \beta_5$) is 0.367, compared with a coefficient of 0.154 otherwise. This implies that inflation expectations return to target more slowly than otherwise.[9]

How do these results compare to the behavior of inflation expectations in Japan? For Japan, we estimate a coefficient of 0.575 (significant at the 1 percent level), suggesting that inflation expectations were still relatively more backward looking in Japan than in the IT countries under persistently low inflation.

Panels B–E of table 3 contain the results of several robustness tests. The first two tackle the question to what extent the results

[9]These results do not depend on Switzerland or the euro area (which have an asymmetric definition of price stability), nor on the United States (which enters our data set only very late); dropping these countries from the sample does not affect results—in this case, the estimate of β_1 is 0.143*** and the estimate of β_5 is 0.255***.

depend on the recent period of weak inflation. As many countries simultaneously experienced weak inflation recently, one might wonder to what extent these observations are independent. Even though we allow for cross-sectional correlation of the residuals, two additional tests are performed. First, we include time fixed effects, which control for common developments in inflation expectations across all countries (like the recent weak inflation episode). Second, we only include observations prior to 2009, given that inflation started to weaken across many countries in 2009. For the first of these tests (reported in panel B), all results are robust. In contrast, for the second test (reported in panel C, for which we lose around a third of all observations), results largely lose their statistical significance. This suggests that the observations since 2009 are important for the results, but that these do not depend on inflationary developments that are common across countries.

The third robustness (panel D) deals with the changing forecast horizon of the data over the course of a year. It only includes data from July, i.e., the middle of the year (in order not to change the average forecast horizon), and finds that results are remarkably robust (even though, of course, we are now only using around a twelfth of all observations). Finally, panel E reports results for a robustness test that excludes all observations where policy rates are close to the ZLB. The goal of this test is to see whether the previous result is driven by the ZLB observations—if policy rates get close to zero, the central bank might be perceived as having less-powerful tools to bring inflation back to target, resulting in inflation expectations being relatively more backward looking. While the results are obtained only at somewhat lower levels of statistical significance, they are overall robust.[10]

While these results point to some degree of disanchoring of inflation expectations, a potential alternative explanation for the findings could be that inflation is effectively more persistent if it is low,[11] and

[10]Even when dropping observations at the ZLB, there is a sufficient number of observations to warrant econometric testing—we are left with 384/299/256/226 observations with inflation being low for at least one/six/nine/twelve months.

[11]This, however, does not seem to be the case in our data. When testing for different persistence conditional on the level of inflation, the differences are not statistically significant.

that inflation expectations simply reflect this pattern. This argument is particularly important because the horizon of inflation expectations that we are studying is relatively short. It could well be that, while inflation expectations at shorter horizons become more backward looking, those at longer horizons remain well anchored. Accordingly, it is important to confirm the findings with alternative tests that are less affected by this complication.

5.2 Forecaster Disagreement

Another way to study the anchoring of inflation expectations is through forecaster disagreement. If expectations were perfectly anchored at target, there should be no disagreement. Hence, less disagreement can be taken as a signal indicating better anchoring of inflation expectations. As pointed out in the literature review, this approach has been used in several previous studies.[12]

To study disagreement, we need to define a corresponding metric. Much of the literature (e.g., Mankiw, Reis, and Wolfers 2004 or Dovern, Fritsche, and Slacalek 2012) uses the interquartile range of forecasts in a given country and month. The advantage of this measure over the simple standard deviation is that it is insensitive to outliers, which might be important in the analysis of survey data. In this paper, we use the interdecile range instead, which potentially incorporates a broader range of views while still being robust to outliers (unless one believes that more than 10 percent of the observations on each side of the distribution are outliers). Importantly, results are qualitatively equivalent for the interquartile range and the standard deviation.

The regressions are specified as follows:

$$\Omega_{c,t}(\pi_{c,t+h}) = \alpha_c + \alpha_m + \gamma_1 E_{c,t}(\pi_{c,t+h}) + \gamma_2 D^l_{c,t} + \gamma_3 D^h_{c,t} + \varepsilon_{c,t}, \qquad (2)$$

where $\Omega_{c,t}(\pi_{c,t+h})$ denotes the interdecile range of the inflation expectations for country c over the forecast horizon h (again, the

[12] Capistran and Ramos-Francia (2010); Cecchetti and Hakkio (2010); Crowe (2010); Ehrmann, Eijffinger, and Fratzscher (2012).

next-calendar-year forecasts), collected in the Consensus Economics survey conducted in month t. The model, as before, controls for country fixed effects but now also includes month fixed effects α_m (given that over the course of the year, the forecast horizon shrinks, forecast uncertainty is reduced, and therefore disagreement should also be lower). It also includes the level of inflation expectations, to allow for the fact that higher inflation tends to be more volatile and therefore might be subject to more disagreement. As before, we estimate these regressions using simple ordinary least squares, allowing for Driscoll and Kraay (1998) standard errors.

Table 4 shows the corresponding results. Consistent with the findings of Capistran and Timmermann (2009), the estimate of γ_1 shows that disagreement is larger when inflation expectations are higher. This suggests that higher inflation rates are more difficult to forecast, a point that has been raised in arguments in favor of low inflation targets.

Moving on to the estimates of γ_2 and γ_3, we see how the cross-sectional dispersion increases both when inflation is persistently low and when it is persistently high. Comparing these results with the level of forecaster disagreement in Japan is not straightforward. One way to do this is to add the Japanese data to the regression and to simply test for a Japan-specific intercept shift. If we do this, we get a coefficient of 0.204 (statistically significant at the 1 percent level), which is substantially larger than the coefficients we obtain for γ_2, suggesting that forecaster disagreement in Japan has been larger than what is observed under persistently low inflation in the other economies.

Panels B–D contain the results of several robustness tests. The first one includes time fixed effects, as for table 3. In this case, results are no longer statistically significant (as when restricting the sample to pre-2009 data). The second, in panel C, shows that results are robust to using the standard deviation as a measure of forecaster disagreement. Finally, panel D retains the interdecile range as a measure of cross-sectional dispersion but tests whether similar results can be obtained for forecasts real GDP growth. The results confirm that disagreement increases when inflation is (persistently) low and (persistently) high.

Table 4. Cross-Forecaster Dispersion

	Overall	Low/High Inflation	Low/High Inflation, at Least 6 Mths	Low/High Inflation, at Least 9 Mths	Low/High Inflation, at Least 12 Mths
	(1)	(2)	(3)	(4)	(5)
A. Benchmark: Interdecile Range, Next-Calendar-Year Inflation Expectations					
Inflation Expectations (γ_1)	0.244***	0.226**	0.221**	0.223**	0.229**
	(0.085)	(0.093)	(0.093)	(0.093)	(0.092)
Low Inflation (γ_2)	–	0.039	0.050	0.104**	0.107*
		(0.043)	(0.048)	(0.052)	(0.058)
High Inflation (γ_3)	–	0.146	0.197	0.239*	0.208
		(0.094)	(0.120)	(0.131)	(0.140)
Observations	1,872	1,872	1,872	1,872	1,872
R-squared	0.225	0.237	0.244	0.254	0.248
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes
B. Robustness: Time Fixed Effects					
Inflation Expectations (γ_1)	0.124**	0.103*	0.103*	0.111*	0.112*
	(0.056)	(0.056)	(0.058)	(0.060)	(0.059)
Low Inflation (γ_2)	–	−0.046	−0.048	0.008	0.022
		(0.044)	(0.052)	(0.050)	(0.056)
High Inflation (γ_3)	–	0.215***	0.251***	0.278***	0.238**
		(0.069)	(0.080)	(0.087)	(0.100)
Observations	1,872	1,872	1,872	1,872	1,872
R-squared	0.570	0.588	0.591	0.592	0.586
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes

(continued)

Table 4. (Continued)

	Overall	Low/High Inflation	Low/High Inflation, at Least 6 Mths	Low/High Inflation, at Least 9 Mths	Low/High Inflation, at Least 12 Mths
	(1)	(2)	(3)	(4)	(5)
C. Robustness: Standard Deviation					
Inflation Expectations (γ_1)	0.089*	0.081**	0.081**	0.081**	0.085**
	(0.035)	(0.040)	(0.039)	(0.040)	(0.039)
Low Inflation (γ_2)	–	0.016	0.025	0.044**	0.046**
		(0.017)	(0.020)	(0.021)	(0.023)
High Inflation (γ_3)	–	0.062	0.079	0.095*	0.079
		(0.038)	(0.048)	(0.053)	(0.056)
Observations	1,872	1,872	1,872	1,872	1,872
R-squared	0.227	0.241	0.246	0.257	0.250
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes
D. Robustness: Interdecile Range, Next-Calendar-Year Real GDP Growth Expectations					
GDP Growth Expectations (γ_1)	−0.210***	−0.205***	−0.204***	−0.204***	−0.206***
	(0.066)	(0.067)	(0.065)	(0.066)	(0.068)
Low Inflation (γ_2)	–	0.053	0.103**	0.139**	0.115**
		(0.040)	(0.048)	(0.059)	(0.056)
High Inflation (γ_3)	–	0.071	0.128***	0.152***	0.123**
		(0.046)	(0.049)	(0.055)	(0.058)
Observations	1,872	1,872	1,872	1,872	1,872
R-squared	0.238	0.243	0.253	0.261	0.252
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes
Level of Inflation Expectations	Yes	Yes	Yes	Yes	Yes

Notes: Results from the regression $\Omega_{c,t}(\pi_{c,t+h}) = \alpha_c + \alpha_m + \gamma_1 E_{c,t}(\pi_{c,t+h}) + \gamma_2 D^l_{c,t} + \gamma_3 D^h_{c,t} + \varepsilon_{c,t}$, where $\Omega_{c,t}(\pi_{c,t+h})$ denotes the interdecile range of the inflation expectations for country c over the forecast horizon h, collected in the Consensus Economics survey conducted in month t. All other variables are as defined in the previous tables. Panel A reports the benchmark results. Panel B shows results for a model with time fixed effects, panel C for the standard deviation. Panel D provides results for the interdecile range for forecasts of real GDP growth. ***, **, * denote statistical significance at the 1, 5, and 10 percent level, respectively. Numbers in parentheses are standard errors.

5.3 Responsiveness to the Surprise Component in CPI Releases

A third way to study the anchoring of inflation expectations is to see how responsive they are to the surprise component contained in news releases. Related tests have, for instance, been conducted by Gürkaynak, Levin, and Swanson (2010) and Davis (2014).[13] The idea is that, in the presence of well-anchored inflation expectations, incoming news about the current level of inflation should not be important.

Analogous to the previous tests, we estimate the following relationship:

$$R_{c,t}(\pi_{c,t+h*}) = \alpha_c + \alpha_m + \delta_1 S_{c,t-1} + \delta_2 D^l_{c,t} + \delta_3 D^l_{c,t} S_{c,t-1} + \delta_4 D^h_{c,t} + \delta_5 D^h_{c,t} S_{c,t-1} + \varepsilon_{c,t}, \quad (3)$$

where $S_{c,t-1}$ is the surprise component contained in the CPI release in country c just prior to the survey conducted in month t. The dependent variable is $R_{c,t}(\pi_{c,t+h*})$, which denotes the *revision* in the inflation forecasts compared with the previous month. This test is therefore different from the first set, where we tested whether the *level* of the expectations depends on the level of lagged inflation. In contrast, we are now interested in understanding whether news about actual inflation leads to a revision in forecasts. To construct the revision, we follow the approach proposed by Kilian and Hicks (2013). Revisions for the months of January to September are based on the current-year forecasts ($R_{c,t}(\pi_{c,t+h*}) = E_{c,t}(\pi_{c,t+h0}) - E_{c,t-1}(\pi_{c,t+h0})$), whereas starting in October, the revisions are based on the expectations for the next calendar year ($R_{c,t}(\pi_{c,t+h*}) = E_{c,t}(\pi_{c,t+h1}) - E_{c,t-1}(\pi_{c,t+h1})$).

Note that equation (3) includes month fixed effects α_m, like equation (2), this time because it is likely that there is less need to revise forecasts if the forecast horizon becomes shorter. Since the

[13] Using a related technique, Galati, Poelhekke, and Zhou (2011) find that there was a larger responsiveness in U.S., UK, and euro-area inflation expectations to news during the global financial crisis. Autrup and Grothe (2014) and Nautz and Strohsal (2015) confirm this for the United States. An interesting recent extension to the static modeling approach has been provided by Strohsal and Winkelmann (2015), who allow for exponential smooth transition autoregressive dynamics.

Bloomberg expectations data for the CPI releases are not available for all countries right from the beginning of our sample period, these tests are based on substantially fewer observations than the earlier tests. Table 5 shows the results.

Following the previous results, it is not surprising that δ_1 is positive, i.e., that inflation expectations are responsive to news. What is surprising, however, is that under persistently low inflation, the responsiveness seems to be muted (as can be seen by the negative coefficients for δ_3). This suggests a *better* anchoring of inflation expectations under these circumstances (whereas, so far, we have argued that they are not anchored as well). How can this be reconciled?

Panels B and C split the analysis into cases where the inflation numbers have been surprising to the upside and those where the surprises were negative, i.e., expectations were for a higher number than was actually released. A striking result emerges—under low inflation, inflation expectations stop responding to positive inflation surprises but continue to respond to negative inflation surprises ($\delta_1 + \delta_3$ is statistically significantly positive in panel B, as can be seen by the respective p-values shown in the table, but it is statistically effectively zero in panel C). In other words, if inflation is low and inflation numbers come in *lower* than expected, inflation expectations decrease further. In contrast, if inflation is low and inflation numbers come in *higher* than expected, inflation expectations do not increase. No such asymmetry is observed if inflation is (persistently) high.

Robustness tests (not shown here for brevity) show that these results go through for the pre-2009 sample. In contrast, for the model with time fixed effects, coefficients are statistically insignificant for the negative surprises. It is important to note, though, that the time fixed effects severely limit the degrees of freedom, given the small number of observations for this test.

How do these results compare to what we find for Japan? For Japan, there is no statistically significant response to surprises—not for positive surprises, not for negative surprises, and not for all surprises taken together. However, it is not clear whether this is an economically meaningful result or whether this is simply due to a lack of power—as most Japanese CPI announcements in our data sample were well predicted, there are only fifty-two instances of positive surprises, and there are thirty-five instances of negative surprises.

Table 5. Responsiveness of Inflation Expectations to News Surprises about Inflation

	Overall	**Low/High Inflation**	**Low/High Inflation, at Least 6 Months**	**Low/High Inflation, at Least 9 Months**	**Low/High Inflation, at Least 12 Months**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
A. Benchmark: All News Surprises					
News Surprise (δ_1)	0.280***	0.260***	0.266***	0.271***	0.279***
	(0.028)	(0.038)	(0.033)	(0.031)	(0.031)
Low Inflation (δ_2)	–	−0.072***	−0.067***	−0.068***	−0.066***
		(0.012)	(0.012)	(0.012)	(0.015)
Interaction News Surprise/	–	−0.081*	−0.090*	−0.101*	−0.126**
Low Inflation (δ_3)		(0.045)	(0.053)	(0.052)	(0.057)
High Inflation (δ_4)	–	0.021	0.024	0.019	0.072***
		(0.036)	(0.050)	(0.057)	(0.022)
Interaction News Surprise/	–	0.095	0.188	0.214	0.145
High Inflation (δ_5)		(0.096)	(0.130)	(0.144)	(0.127)
p-value ($\delta_1 + \delta_3$)	–	0.000	0.000	0.000	0.000
p-value ($\delta_1 + \delta_5$)	–	0.000	0.000	0.001	0.001
Observations	1,119	1,119	1,119	1,119	1,119
R-squared	0.208	0.252	0.245	0.242	0.249
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes

(continued)

Table 5. (Continued)

	Overall	Low/High Inflation	Low/High Inflation, at Least 6 Months	Low/High Inflation, at Least 9 Months	Low/High Inflation, at Least 12 Months
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
B. Robustness: Negative News Surprises					
News Surprise (δ_1)	0.368***	0.377***	0.368***	0.368***	0.388***
	(0.080)	(0.103)	(0.083)	(0.085)	(0.095)
Low Inflation (δ_2)	–	−0.080***	−0.069***	−0.073***	−0.065***
		(0.024)	(0.018)	(0.018)	(0.017)
Interaction News Surprise/	–	−0.065	−0.026	−0.046	−0.052
Low Inflation (δ_3)		(0.113)	(0.101)	(0.100)	(0.112)
High Inflation (δ_4)	–	−0.008	0.012	−0.020	0.021
		(0.052)	(0.062)	(0.061)	(0.060)
Interaction News Surprise/	–	0.115	0.160	0.113	−0.164
High Inflation (δ_5)		(0.280)	(0.262)	(0.258)	(0.329)
p-value ($\delta_1 + \delta_3$)	–	0.000	0.000	0.000	0.001
p-value ($\delta_1 + \delta_5$)	–	0.129	0.067	0.095	0.412
Observations	454	454	454	454	454
R-squared	0.187	0.222	0.216	0.213	0.210
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes

(continued)

Table 5. (Continued)

	Overall	Low/High Inflation	Low/High Inflation, at Least 6 Months	Low/High Inflation, at Least 9 Months	Low/High Inflation, at Least 12 Months
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
C. Robustness: Positive News Surprises					
News Surprise (δ_1)	0.294***	0.271***	0.296***	0.309***	0.305***
	(0.079)	(0.125)	(0.077)	(0.071)	(0.076)
Low Inflation (δ_2)	–	−0.062*	−0.026	−0.010	−0.021
		(0.036)	(0.035)	(0.038)	(0.040)
Interaction News Surprise/ Low Inflation (δ_3)	–	−0.174	−0.321*	−0.395**	−0.346*
		(0.185)	(0.169)	(0.193)	(0.192)
High Inflation (δ_4)	–	0.055	0.051	0.079	0.096
		(0.061)	(0.056)	(0.062)	(0.059)
Interaction News Surprise/ High Inflation (δ_5)	–	−0.047	−0.028	−0.153	0.005
		(0.210)	(0.173)	(0.228)	(0.288)
p-value ($\delta_1 + \delta_3$)	–	0.507	0.879	0.664	0.843
p-value ($\delta_1 + \delta_5$)	–	0.055	0.090	0.495	0.255
Observations	361	361	361	361	361
R-squared	0.211	0.273	0.255	0.252	0.270
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes
Month Fixed Effects	Yes	Yes	Yes	Yes	Yes

Notes: The table shows results from the regression $R_{c,t}(\pi_{c,t+h*}) = \alpha_c + \alpha_m + \delta_1 S_{c,t-1} + \delta_2 D^l_{c,t} + \delta_3 D^l_{c,t} S_{c,t-1} + \delta_4 D^h_{c,t} + \delta_5 D^h_{c,t} S_{c,t-1} + \varepsilon_{c,t}$, where $R_{c,t}(\pi_{c,t+h*})$ denotes the revision in the inflation forecasts compared with the previous month. $S_{c,t-1}$ is the surprise component contained in the CPI release in country c just prior to the survey conducted in month t. All other variables are as defined in the previous tables. Panel A reports the benchmark results. Panel B shows results for positive news surprises (i.e., CPI inflation data coming in higher than expected), panel C for negative news surprises (i.e., CPI inflation data coming in lower than expected. ***, **, and * denote statistical significance at the 1 percent, 5 percent, and 10 percent level, respectively. Numbers in parentheses are standard errors.

6. Conclusions

Inflation targeting had originally been introduced to lower and stabilize inflation, and to anchor inflation expectations. Only recently, some central banks have started to target inflation (or provide a quantitative definition of their inflation objective) while in a situation of weak inflation. At the same time, a number of IT central banks have been confronted with an environment where inflation has been below target for considerable amounts of time. Therefore, IT is now charged with targeting inflation from below, as opposed to its traditional focus of targeting inflation from above.

Until recently, there have simply not been sufficient data to provide empirical evidence about the environment that central banks can expect when they are targeting inflation from below. This paper has attempted to provide some initial evidence in this direction, focusing on the behavior of inflation expectations. Using Consensus Economics inflation forecasts for ten IT countries, the paper has demonstrated that under persistently weak inflation, expectations are not as well anchored as otherwise. They tend to become more backward looking; disagreement across forecasters increases; and they get revised down in response to lower-than-expected inflation, but do not respond to higher-than-expected inflation. This evidence suggests that central banks should expect inflation expectations to behave differently than was the case previously, when inflation was often remarkably close to target in many advanced economies. Still, even under persistently low inflation, expectations in the IT countries studied here are generally better anchored than they were in Japan over its period of prolonged weak inflation.

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Discussion of "Targeting Inflation from Below: How Do Inflation Expectations Behave?"

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The adoption of inflation targeting by central banks around the world has been nothing short of spectacular. In the twenty-five years since the Reserve Bank of New Zealand first adopted the inflation-targeting (IT) framework, it has become the de facto standard against which all other monetary policy frameworks are compared. While some countries, such as New Zealand, the United Kingdom, Sweden, and Norway, are very explicit about how their monetary policy is tied to IT, other countries, such as the United States, are not explicit followers of the framework and can only be considered inflation targeters "in spirit," if at all.

Given the widespread success of inflation targeting as an idea, it is perhaps surprising that there is not more empirical evidence documenting its success as a monetary policy framework. In fact, the empirical evidence on this question is decidedly mixed, as can be seen in the nice literature review in Michael Ehrmann's paper. While many studies have found that countries that adopted IT have lower inflation and/or better-anchored inflation expectations than they did before adopting IT, the difficulty lies in showing that those countries have lower inflation and/or better-anchored inflation expectations than a *control group* of countries that did not adopt IT. Ideally, the control group should also control for the initial level of inflation, since IT countries as a whole have tended to start from a higher initial inflation level, which was what drove them to adopt IT in the first place (Ball and Sheridan 2005). This correlation in the data makes it hard to separate the effects of IT from those of potential mean reversion (Ball and Sheridan 2005).

Thus, the difficulties in the empirical literature seem to be not so much documenting an improved performance of IT countries per se, but rather documenting a performance in IT countries that is *significantly better* than in other countries that didn't adopt IT.

In “Targeting Inflation from Below: How Do Inflation Expectations Behave?” Michael Ehrmann looks at a somewhat different question. Rather than ask whether IT has affected the behavior of inflation and inflation expectations relative to a control group of *non*-IT countries, Michael investigates whether the behavior of inflation and inflation expectations differs across IT countries with *low* vs. *average* or *high* inflation. The comparison that’s being studied by Michael in this paper is thus substantially different from the comparisons that have been analyzed before, and may be more cleanly identified in the data.

1. Data and Sample

Of course, for any empirical study, it’s important to have good data. The first point to note about Michael’s analysis is the wealth of data that is brought to bear on the issue. The Consensus Economics data set consists of monthly observations for about ten countries over twenty or more years. Moreover, the Consensus Economics data includes not just the level of inflation but also inflation expectations for the current year, next year, and individual forecasters’ predictions, which allows the researcher to construct measures of cross-sectional forecast dispersion, or disagreement. The richness of the data set gives Michael a reasonable chance of identifying the difference that he is interested in—the differential behavior of inflation and inflation expectations in IT countries with low vs. high inflation.

Although the Consensus Economics inflation and mean inflation expectations data go back to at least the beginning of 1990 for all the countries in the sample, Michael deliberately chooses to focus only on the period during which each listed country was an inflation targeter. Thus, the “start dates” listed in the first column of table 1 of his paper are not due to data availability, but rather correspond to the date that inflation targeting in each country began. The reason for this choice is the paper’s different focus from the previous literature—rather than compare IT vs. non-IT countries, Michael’s paper focuses on the comparison between IT countries with low vs. average or high inflation. This results in a somewhat reduced sample size of about 1,872 country-month observations, relative to the maximum possible sample size of about 3,000 country-month observations that would be available using all of the Consensus Economics data (not to mention the additional non-IT countries of France, Germany, Italy, and the Netherlands, which could be included in the analysis prior to 1999 along with Spain.) The somewhat reduced sample size that results from this choice is made up for by the clearer focus of the regressions on the comparison of interest—the additional observations discussed above would not help to identify the difference between IT countries with low vs. high inflation.

2. Correlation over Time and across Countries

As impressive as the large sample size in the data set is, it's important to bear in mind that those 1,872 (or even 3,000+) observations are not independent. Inflation is a persistent, slow-moving process in every country, so the residuals in each of Michael's regressions are likely to be serially correlated. Although each of those regressions includes country fixed effects, those fixed effects control only for differences in the average *level* of inflation across countries, and do not fully remove the serial correlation that is present within each country. A few of Michael's regressions include time fixed effects as well, but those also will not eliminate the problem—time fixed effects remove the average level of inflation residuals across countries each month but do not correct for the fact that countries with idiosyncratically high inflation one month will also tend to have idiosyncratically high inflation for several subsequent months.

Inflation is also likely to be correlated across countries due to changes in global commodity prices, global business-cycle conditions, and other global factors, but here the time fixed effects that Michael includes in a few of the regressions will typically be sufficient to soak up the correlation. Regressions without those time fixed effects, however, will be subject to this additional source of correlation as well.

A separate, but closely related, issue is that inflation has trended downward over time in virtually every country. After removing country fixed effects, these downward trends will appear as serial correlation in the residuals within each country, independent of whether inflation deviations from trend are serially correlated or not.

For all of these reasons, there are effectively far fewer than 1,872 independent observations in each of Michael's regressions. Ordinary least squares standard errors will be severely downward biased (and

t-statistics upward biased), even when country and/or time fixed effects are included. Thus, the use of the Driscoll-Kraay (1998) panel standard error correction in each regression is crucial for ascertaining the true statistical significance of the results. This correction (or something like it) is not performed nearly as often as it should be in panel studies of inflation targeting. However, as with the standard Newey-West (1987) procedure for a single time series, it is important to specify the number of lags of potential serial correlation in the Driscoll-Kraay (1998) correction. A moderate number of monthly lags, such as twelve, may be sufficient if serially correlated inflation deviations from trend are the only problem, but if the inflation data suffer from downward *trends* over the sample, then twelve lags may not be sufficient, since the residual serial correlation will persist for several years. (Of course, the best correction in case of downward trends would be to explicitly allow for these trends in the regression specification itself, rather than try to control for them in the standard error-correction procedure, but given that Michael's regressions do not include time trends, we should bear in mind the possibility of biased standard errors here.) It would be helpful if Michael offered some guidance as to the appropriate lag length for the standard error correction for the Consensus Economics inflation and inflation forecast data, and considered a specification with time trends as a check on the results.

3. Regression Results

The results in Michael's regressions are quite robust. IT countries with persistently low inflation (below target for nine months or more) seem to have substantially lower inflation expectations than IT countries with average or high inflation (table 3 in his paper), and those expectations are more sensitive to the level of inflation itself (also table 3). IT countries with persistently low inflation also seem to have significantly greater inflation forecast dispersion (table 4 in his paper). The statistical significance of these results holds across a wide variety of specifications in both tables, which is remarkable given the difficulty the literature has had in finding robust differences between IT vs. non-IT countries. Apparently, the difference between low- vs. average- or high-inflation IT countries is easier to identify in the data than the difference between IT vs. non-IT countries.

The results in tables 3 and 4 suggest that inflation expectations in IT countries with persistently low inflation are not as well anchored as in average- or high-inflation IT countries. Inflation expectations are below target, they are more below target for countries with lower inflation, and disagreement across forecasters is greater for countries that are more below target. The effects are not symmetric—they apply only to countries that are running below target, and not above. The regressions do not shed light on *why* inflation expectations seem to become unanchored when inflation is below rather than above target, but they do suggest that there is a cost of inflation running below target. To the extent that the benefits of inflation targeting come from a firmer anchoring of inflation expectations, those benefits seem to decline substantially if inflation remains below target for more than a few months. Of course, this raises the intriguing possibility that the benefits may decline to the point where non-IT countries could actually perform *better* than IT countries in a low-inflation environment, in terms of inflation and inflation expectations being closer to target and better anchored.

4. Interpretation of the Results

Let me now speculate as to *why* Michael finds the results that he does. In other words, why does inflation below target seem to de-anchor inflation expectations in IT countries, while inflation above target does not have the same de-anchoring effect?

A natural explanation seems to be one of perceived impotence of the central bank. When inflation is above target, it's natural for the public and the media to interpret the higher inflation as an optimal choice of the central bank. After all, the central bank's alternative was to raise interest rates further and thereby reduce real economic activity.

However, when inflation is running *below* target, it's more difficult for the public and the media to interpret the outcome as an optimal choice. Presumably, central banks prefer more real economic activity to less, as long as inflation does not rise substantially above target, and yet the central bank did not stimulate the economy. It's hard to imagine why the central bank wouldn't have done so unless it was somehow unable to stimulate the economy. Thus, inflation target misses on the downside naturally seem to suggest an explanation based on central bank impotence rather than optimization. This perception of impotence is probably strengthened by the obvious zero lower bound constraint faced by many central banks in recent years.

It's important to note that Michael's results suggest a problem of *perceptions* of central bank impotence by forecasters, rather than actual impotence. Much theoretical work (e.g., Reifschneider and Williams 2000; Eggertsson and Woodford 2003) and empirical evidence (e.g., Gurkaynak, Sack, and Swanson 2005; Swanson and Williams 2014) suggests that central banks can work around the zero lower bound constraint without too much difficulty as long as they have some ability and willingness to commit to policy actions in the future. Nevertheless, central banks may suffer from a perception of impotence to the extent that these workarounds are not understood by the public and the Consensus Economics forecasters.[1]

However, if Michael's results are driven by the zero lower bound and private-sector perceptions of central bank impotence, then this does call into question whether the inflation-targeting criterion is necessary or even relevant for the analysis. In other words, do we need to restrict attention to inflation-targeting countries to obtain the same results that Michael finds? Or would we find very similar results if we looked at a broader sample of low-inflation vs. high-inflation countries that included both IT and non-IT central banks? Some additional research on this question seems like it would be warranted.

5. Conclusions

In summary, Michael asks a question in this paper that is different from what has typically been considered in the inflation-targeting literature. As a result, he gets stronger and more robust results than is typical for that literature. Apparently, the difference between IT countries with low inflation vs. average or high inflation is better identified in the data than is the difference between IT and non-IT countries themselves.

[1] Of course, it's also possible that central banks do suffer from impotence to some extent at the zero lower bound, which would help to explain why several of them allowed inflation to run below target for several months or even years without doing more to stimulate their economies.

IT countries with persistently low inflation seem to suffer from a "de-anchoring" problem. Their inflation expectations are lower (relative to IT countries with average or high inflation), their inflation expectations are more sensitive to the level of inflation itself, and there is more disagreement across forecasters about the future path of inflation.

A natural explanation for these findings seems to be the zero lower bound and private-sector perceptions of central bank impotence. However, this raises the question whether the restriction to IT countries is necessary to obtain the same result. To the extent that *all* central banks face a problem of impotence (or perceived impotence) at the zero lower bound, then we should expect to see similar results even for non-IT central banks. Future research into this question seems warranted.

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Inflation Targeting: A Victim of Its Own Success*

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Since the introduction of inflation targeting, inflation expectations have become firmly anchored at target and there has been a flattening of the Phillips curve. These changes mean that a "divine coincidence" between headline inflation and output-gap stabilization is less apparent than when inflation targeting was introduced. This has led some to call for a fundamental reengineering of inflation-targeting regimes: either adopting explicit dual mandates or replacing headline inflation with a target inflation measure more closely related to domestic output gaps. We argue instead for an evolution in the practice of CPI inflation targeting. In practice, many central banks have already moved in this direction with the adoption of flexible inflation-targeting frameworks.

JEL Codes: E31, E52, E58.

1. Introduction

Despite one of the largest global recessions in decades during the financial crisis, global inflation barely budged. In some respects, this could be seen as a triumph for inflation targeting—inflation remained close to target despite some of the largest economic shocks in living memory. In the eyes of some, however, the financial crisis has demonstrated the weaknesses of inflation targeting. It has been argued that, in the face of record levels of unemployment in

*The views expressed in this paper are those of the authors and should not be attributed to the Reserve Bank of Australia. We are grateful for comments provided by Alexandra Heath, Chris Kent, Peter Tulip, Alex Wolman (discussant), and participants at the 2014 RBNZ/IJCB conference "Reflections on 25 Years of Inflation Targeting." We would like to thank Emil Stavrev and Troy Matheson for sharing MATLAB code to estimate Phillips curves with time-varying coefficients.

many economies, central banks should weigh unemployment outcomes more heavily in their objectives. There have also been arguments that central banks, in responding to imported inflation shocks while domestic demand remains depressed, or focusing on low headline inflation while asset prices were accelerating, have focused on inappropriate or misleading inflation measures. This paper makes the argument that these two, seemingly contradictory, outcomes are a reflection of the general success of inflation targeting. Like a vaccination program, once the disease is effectively conquered, people begin to question the value of vaccination. This means that the communication challenges for central banks are magnified, but it doesn't necessarily mean that the vaccination program itself, inflation targeting, needs to be fundamentally reengineered.

To reach this conclusion, we first look at the behavior of inflation in Australia over the past twenty-five years or so since inflation targeting was introduced. While we look at data from Australia, reflecting our familiarity with the Australian experience, the findings are illustrative of a broader experience that is common across most inflation-targeting central banks, and our subsequent discussion is not specific to any one country (see International Monetary Fund 2013). We document significant changes in the behavior of inflation over that time period: long-term inflation expectations have become firmly anchored at target inflation rates; the simultaneous flattening of the Phillips curve has contributed to a substantial reduction in the variability of prices directly affected by domestic monetary policy; and imported inflation now accounts for a larger share of the variability in consumer price inflation than in the past, while also having less ongoing influence on inflation.

These changes in the inflation process have made CPI inflation a less reliable guide to the appropriate stance of monetary policy. Changes in CPI inflation are now more likely to reflect imported inflation than changes in domestic economic conditions. Furthermore, the flattening of the Phillips curve, whether caused by or coincident with the adoption of inflation targeting, has complicated the task of identifying deviations in output from potential and, thus, forecasting inflation. Inflationary pressures arising from imbalances between demand and supply are smaller and more difficult to separate from idiosyncratic variation in inflation.

We consider the implications of these changes in the inflation process for the conduct of inflation targeting over the next twenty-five years. We focus our discussion around the central bank objective of maintaining price stability rather than also exploring the other major responsibility of central banks—financial stability. This is not to say that financial stability is not important. Rather, it is a sufficiently large topic that it would be difficult to do it justice within the same paper. Notwithstanding this, we do touch on financial stability considerations to the extent that financial stability can affect price or output stability. Thus, reflecting our focus on the price stability mandate, we discuss two particularly prominent proposals for change: either adopting explicit dual unemployment-inflation mandates or changing the target to a measure more closely related to domestic economic conditions than CPI inflation. Our discussion emphasizes that a breakdown in the correspondence between output and inflation stabilization, caused in part by the success of inflation targeting, motivates these proposals for change and can help us understand the perceived "failings" of inflation targeting during the recent crisis. We conclude by suggesting some particular areas of the practice of central banking that will need to change and improve if inflation targeting is to celebrate its fiftieth anniversary twenty-five years from now. We do not recommend wholesale change, but there may be some scope for enhancements.

2. The Past Twenty-Five Years

When inflation targeting was first introduced in New Zealand twenty-five years ago, the world was a very different place from the one we know today. In New Zealand, inflation was hovering around 7 percent and interest rates, both monetary policy and mortgage, were in the high teens. The high interest rates were a reflection of the fact that, with limited inflation credibility, an aggressive policy response was required to reduce inflation. The situation was not so different in Australia: highly contractionary monetary policy in the early 1990s—mortgage interest rates were around 18 percent—preceded a large disinflation and the adoption of inflation targeting. Previous frameworks, such as fixed exchange rate regimes and money growth targeting, had broken down and the even higher inflation and interest rates experienced in the 1970s were very much an ongoing concern rather than the distant memory they are today.

Since then the practice of inflation targeting has evolved substantially, as has the economic environment. This early evolution occurred in small open economies such as Australia, Canada, and New Zealand, and was driven by the practicalities of making monetary policy decisions in an uncertain world. There were large debates about how to implement inflation targeting, and the questions that were asked then are not so different from the ones being debated today. Policymakers and academics debated: Should the target be aggregate consumer prices or only non-traded consumer prices? Should asset prices be included in the objective function or not? And what was the appropriate horizon for achieving an inflation target?

From these debates, and the experience gained implementing inflation targeting, emerged the inflation-targeting frameworks we have today. These frameworks are commonly described as "flexible inflation targeting," whereby central banks give priority to controlling inflation over the medium run but, where the opportunity exists, stabilize output or employment as well. Furthermore, while targets are invariably stated in terms of headline inflation, underlying inflation measures are routinely used as a guide for policy. These frameworks have proved to be remarkably successful in both reducing inflation and anchoring expectations. As we demonstrate in this section, the successful implementation of inflation targeting has dramatically altered the behavior of inflation.

A direct way of seeing one aspect of this change in behavior is to look at the way long-term inflation expectations respond to inflation surprises. If expectations are well anchored, they should not respond to surprises. On the other hand, if inflation expectations are adaptive or otherwise poorly anchored, one would expect to see revisions to longer-term expectations when a surprise occurs. To assess this we use Consensus Economics forecasts of inflation and look at the way expectations change between the March and September quarters.[1] The change in current-year inflation expectations between these two dates is a good indicator of the inflation surprise between

[1]Official inflation data in Australia are published at a quarterly frequency.

those dates. Reflecting our comparative advantage, we conduct this exercise on Australian expectations—results for other countries are similar.[2]

Formally, for forecast horizons up to six years ahead, we estimate the regression

$$F_t^{Sep}\pi_{t+h} - F_t^{Mar}\pi_{t+h} = \alpha_h + \beta_t(F_t^{Sep}\pi_t - F_t^{Mar}\pi_t) + \varepsilon_{t+h},$$

where $F_t^{Sep}\pi_{t+h}$ is the September-quarter Consensus forecast in year t for inflation in year t + h, and similarly for the other forecast terms in the regression. The coefficient β_h is the estimated revision to inflation expectations at horizon h in response to a surprise in current-year inflation.

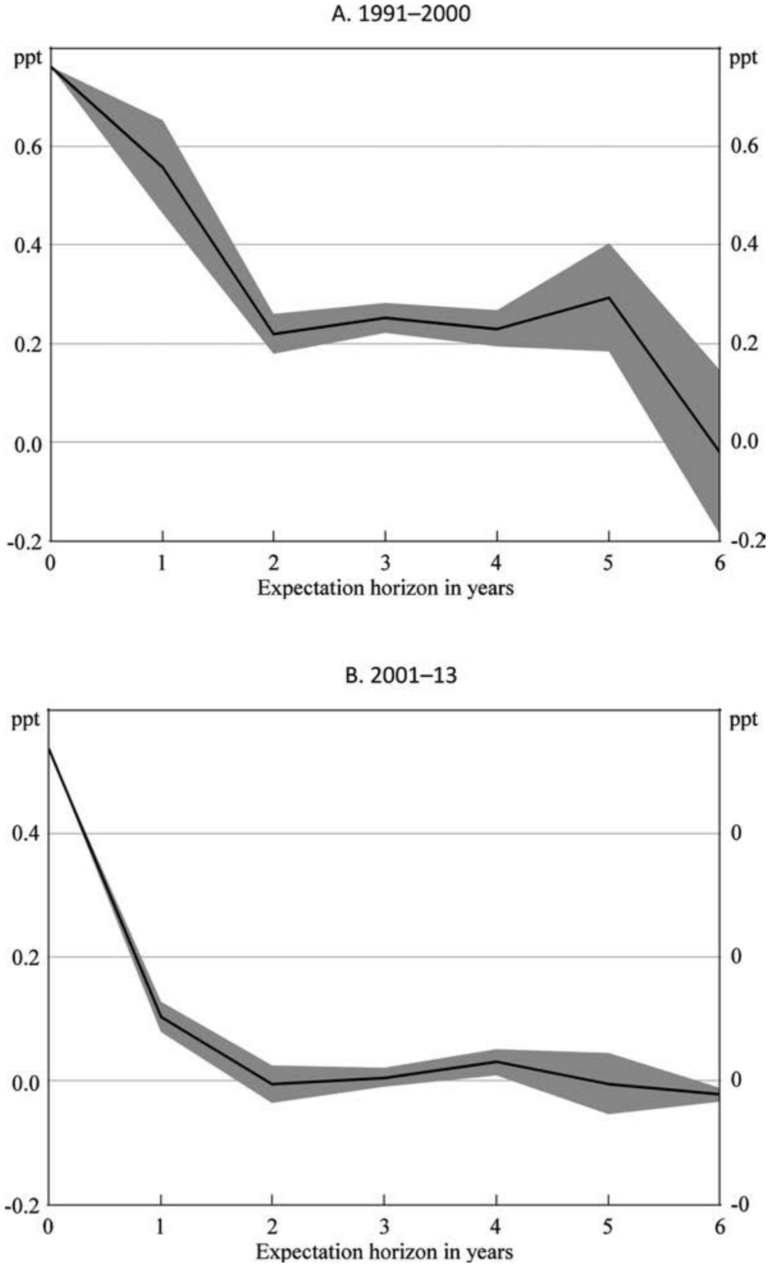
Data are available from 1991, so we split the sample approximately in half, with a sample from 1991 to 2000 that covers the initial years of inflation targeting in Australia and a sample from 2001 to 2013 reflecting more recent experience. We estimate regression coefficients β_h for each sample period, and show in figure 1 the response of inflation expectations to a one-standard-deviation surprise in current-year inflation: $F_t^{Sep}\pi_t - F_t^{Mar}\pi_t$. In the pre-2000 period for Australia, a one-standard-deviation surprise (March to September) in current-year inflation tended to raise professional forecasters' inflation expectations at a five-year horizon, but in the post-2000 period inflation surprises have had a negligible effect on expectations (abstracting from base effects). Inflation expectations are clearly better anchored today than they were when inflation targeting was first being established in Australia.

While this evidence is relatively direct and transparent, it is only partial. There are other ways in which inflation targeting may have affected the behavior of inflation. For example, there is ongoing debate about whether the relationship between economic slack and inflation has been changing or, conversely, whether more stable inflation has been a sign of small levels of economic slack despite heightened unemployment.[3] Furthermore, particularly in small open economies, there has been a debate about the changing influence of imported goods and services prices on domestic inflation. To address

[2] See International Monetary Fund (2011).

[3] See Debelle and Vickery (1997) and Kuttner and Robinson (2008).

Figure 1. Response of Inflation Expectations to a Surprise Change in Current-Year Inflation: By Horizon



Notes: The figure shows the change in year-on-year Consensus inflation expectations between the March and September quarters for the current year and each year out to a six-year horizon, in response to a one-standard-deviation surprise change in current-year inflation.

these issues in a more comprehensive way, we estimate a relatively standard New Keynesian Phillips curve. To allow for the fact that the inflation process may have changed over time, we estimate a model with time-varying parameters using a non-linear Kalman filter developed by Matheson and Stavrev (2013). This framework allows us to simultaneously examine changes in the slope of the Phillips curve, the degree of anchoring in inflation expectations, and the natural rate of unemployment.

More technically, in our estimation annualized inflation π_t is described by a Phillips curve that depends on inflation expectations π_t^e, the deviation of unemployment from its natural rate $(u_t - u_t^*)$, and import price inflation $\hat{\pi}_t^{4,m}$:

$$\pi_t = \pi_t^e - \kappa_t(u_t - u_t^*) + \gamma_t \hat{\pi}_t^{4,m} + \varepsilon_t^{\pi}.$$

The import price term $\hat{\pi}_t^{4,m}$ is demeaned tariff-adjusted import price inflation relative to CPI inflation, in year-ended terms. Inflation expectations is a weighted average of a forward-looking measure, long-term Consensus inflation expectations, and a backward-looking measure, lagged year-ended inflation:[4]

$$\pi_t^e = \theta_t \bar{\pi}_t + (1 - \theta_t)\pi_{t-1}^4.$$

The unemployment gap evolves according to the first-order autoregressive process

$$(u_t - u_t^*) = \rho(u_{t-1} - u_{t-1}^*) + \varepsilon_t^{(u-u^*)},$$

with the natural rate of unemployment evolving according to a random-walk process:

$$u_t^* = u_{t-1}^* + \varepsilon_t^{u^*}.$$

[4] After 1991, the long-term inflation expectations series is Consensus forecasts for CPI inflation six to ten years ahead; expectations are surveyed in the June and December quarters, and we linearly interpolate between observations. From 1986 to 1991, we use long-term inflation expectations implied by inflation-indexed bonds, and before 1986 expectations are proxied by the difference between ten-year nominal bonds and an estimate of the world real interest rate (see Debelle and Laxton 1997).

The shock $\varepsilon_t^{(u-u^*)}$ is interpreted to be a demand shock, and $\varepsilon_t^{u^*}$ a shock to the level of the natural rate of unemployment. The slope of the Phillips curve $\kappa_t \geq 0$, the weight on long-term inflation expectations $1 \geq \theta_t \geq 0$, and the coefficient on import prices $\gamma_t \geq 0$ are time varying, each evolving according to a constrained random walk. The coefficient ρ is constant throughout the sample period.

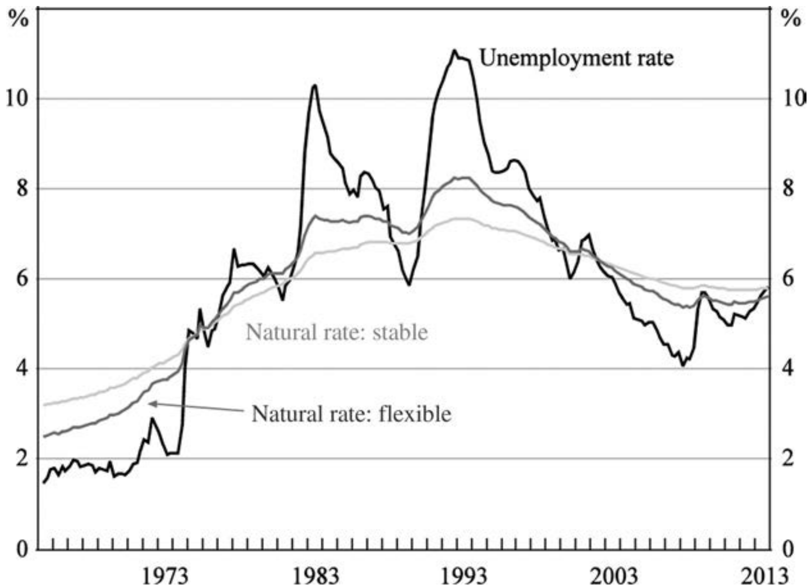
The natural rate of unemployment and time-varying parameters are treated as unobserved states and estimated using a constrained non-linear Kalman filter. A non-linear Kalman filter is required because the measurement equation is multiplicative in unknown state variables: the natural rate of unemployment and the coefficient on the unemployment gap are both allowed to be time varying.

Initial values for the shock variances are calculated using ten-year rolling non-linear least-squares regressions, with the parameters and the natural rate of unemployment assumed to be constant within each ten-year window. Constrained maximum likelihood is used to estimate the parameter ρ and the shock variances, subject to the constraint that the estimated shock variances are no larger than across the ten-year rolling windows. Because there is a potential identification problem for the unemployment-gap demand shock $\varepsilon_t^{(u-u^*)}$ and the natural rate shock $\varepsilon_t^{u^*}$, the relative variance of these two shocks is imposed. We follow Matheson and Stavrev (2013) in choosing $S \equiv var\left(\varepsilon_t^{(u-u^*)}\right)/var\left(\varepsilon_t^{u^*}\right)$ equal to 15, resulting in relatively stable estimates for the natural rate of unemployment; for robustness we also estimate the model assuming $S = 5$, which results in a relatively flexible natural rate of unemployment (shown in figure 2, but the corresponding parameter estimates are omitted in figures 3–5 for clarity—they are qualitatively similar to those shown).[5] We estimate the system at a quarterly frequency for the period 1965–2013, using CPI inflation excluding interest charges and health and tax policy changes.[6]

[5]To avoid convergence on unrealistic variances for the shock processes when $S = 5$, we restrict the estimated variances of the shocks to the parameters κ_t, θ_t, and γ_t to be no less than one-quarter of their estimated magnitude in ten-year rolling regressions; at an optimum, these constraints do not bind.

[6]The official target measure for Australia used Treasury underlying inflation between 1993 and 1998; the econometric results are similar using Treasury underlying inflation in place of CPI inflation for this period.

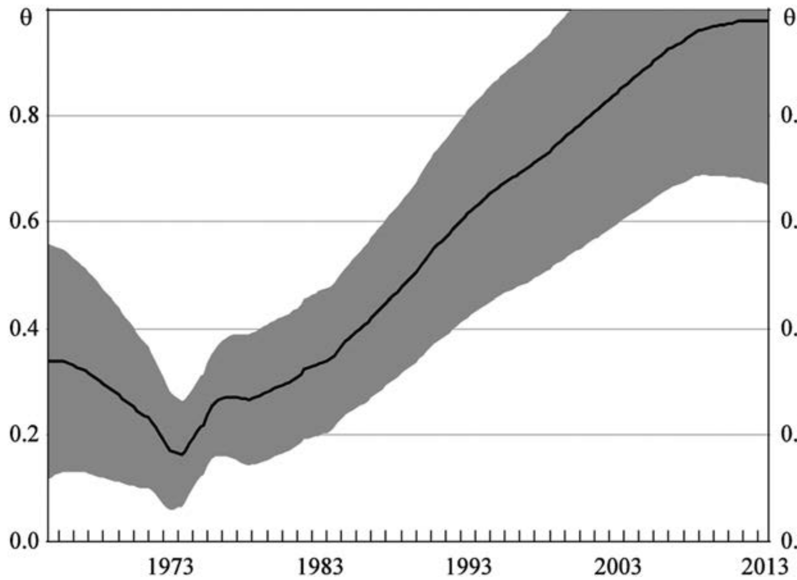
Figure 2. Unemployment and the Natural Rate of Unemployment



Figures 2–5 report the two-sided smoothed estimates of the natural rate of unemployment and the slope parameters. The estimated natural rate of unemployment depends on the imposed degree of stability, and so the size of the unemployment gap at any point in time is quite uncertain, the more so at the endpoints. To give a sense of the uncertainty inherent in these estimates, we present two such estimates in figure 2. Furthermore, as we discuss later, changes in the inflation process have made it more difficult to estimate the natural rate of unemployment precisely. As such, little weight should be placed on the particular estimates of the natural rate of unemployment shown here. For our purposes, the important aspect of these estimates is that we use a natural rate of unemployment that is internally consistent; the estimates of the other parameters are not particularly affected by the degree of smoothness we impose on the natural rate of unemployment.

Turning to the parameters of most interest, we see that, following the introduction of inflation targeting (IT), inflation has become

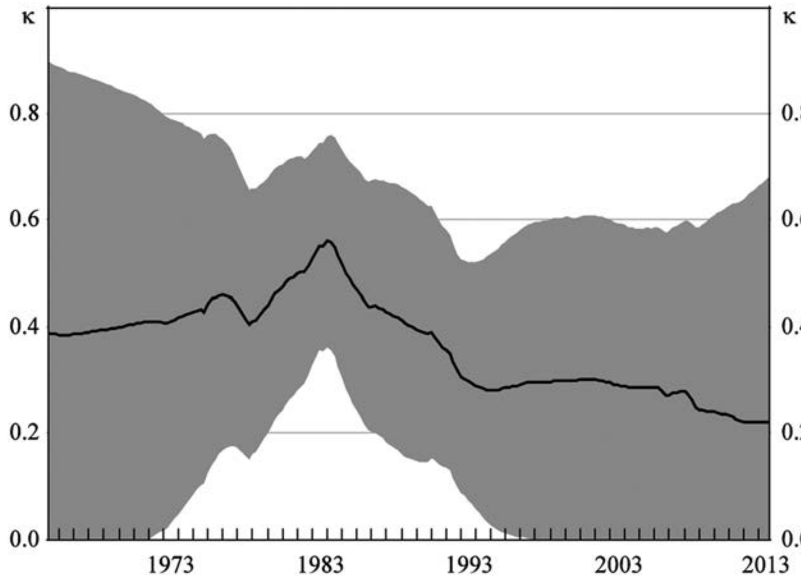
Figure 3. Anchoring of Expectations: Θ



Notes: +/− one-standard-deviation confidence interval is shown.

more firmly anchored on long-term expectations, and less on the previous year's inflation rate: the coefficient θ_t on long-term bond market inflation expectations has risen toward unity over the inflation-targeting period. Furthermore, since the introduction of inflation targeting, long-term inflation expectations have themselves become better anchored: since 1998, long-term inflation expectations have never deviated from the midpoint of the Reserve Bank of Australia's inflation target by more than 0.2 percentage points, unlike in earlier years when co-movement between long-term expectations and current inflation was clearly evident. At the same time, the coefficient k_t on the unemployment gap has become smaller, indicating a flattening of the Phillips curve. The speed with which import price changes pass through to consumer price changes also appears to have slowed. In particular, figure 5 shows that the effect on consumer price inflation of a one-standard-deviation increase in year-ended import price inflation is estimated to have declined over the inflation-targeting period.

Figure 4. Slope of Phillips Curve: κ

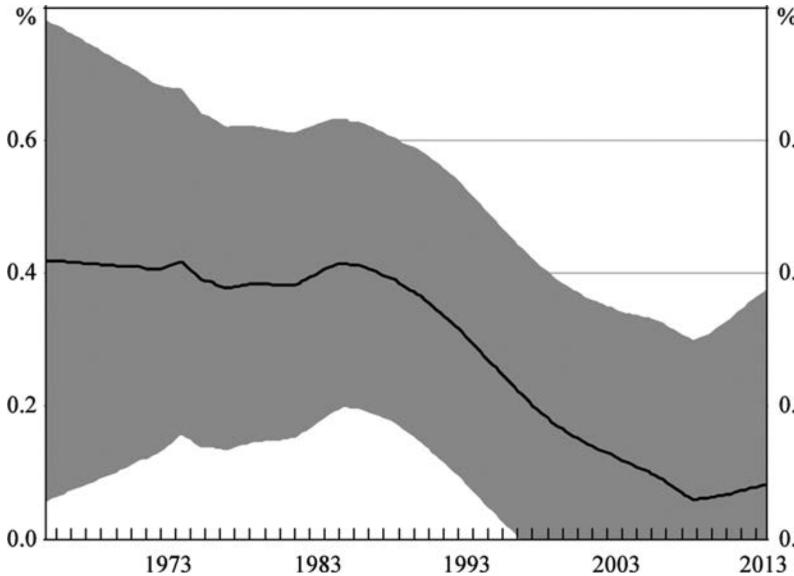


Notes: +/− one-standard-deviation confidence interval is shown.

Our econometric results suggest that shocks have less of an effect on inflation now than prior to the introduction of IT. The wage-price spirals that economists of the 1970s worried about seem to be less of a concern today, reflecting better-anchored inflation expectations but also decentralization of the wage-bargaining process. The transitory nature of inflation surprises in an IT world is confirmed by a trend-cycle decomposition of inflation. For the United States, Stock and Watson (2007) show that the variance of the trend component of inflation declined sharply in the mid-1980s, following the Volcker disinflation, and declined further after 1990, falling to a level of volatility not seen since the mid-1950s. Variability in the transitory component is largely beyond the control of central banks and has remained unchanged. Thus, the share of inflation variability accounted for by transitory shocks has risen sharply.

For Australia, a simple way to see this change in the inflation process is to compare tradable and non-tradable inflation between

Figure 5. Response of CPI Inflation to a One-Standard-Deviation Increase in Real Import Prices



Notes: +/− one-standard-deviation confidence interval is shown. Import prices have been adjusted to include tariff changes.

the 1980s and 1990s, when inflation targeting was in its infancy, and today. Although tradable inflation includes a domestic retailing component, a large portion of the variation in tradable goods and services prices reflects external influences. Consistent with the results of Stock and Watson (2007) for the United States, the first panel in table 1 indicates that there has been a negligible change in the variance of tradable inflation in the pre- and post-IT periods. (We exclude the disinflationary period from these calculations to guard against attributing the mean shift in inflation to variability in the pre-IT period.) In contrast, the variance of non-tradable inflation—the set of prices most influenced by Australian monetary policy—has fallen by more than half. Compounding the increase in the relative importance of imported inflation, the covariance between tradable and non-tradable inflation has declined between the pre- and post-IT periods. The persistence of non-tradable inflation has

Table 1. CPI Inflation Variance Decomposition: Australia

		Pre-Inflation Targeting: 1982:Q2–1990:Q4	**Post-Inflation Targeting: 1993:Q1–2013:Q4**
Original Series	Variance: Non-Tradables	0.90	0.15
	Variance: Tradables	0.60	0.58
	Covariance	0.31	−0.02
AR(p) Model: Non-Tradables	Sum of Coefficients	AR(1): 0.44	AR(4): 0.21
	Variance of Residuals	0.69	0.12
AR(p) Model: Tradables	Sum of Coefficients	AR(0): 0	AR(2): −0.16
	Variance of Residuals	0.60	0.49
	Covariance of Residuals	0.22	−0.03

Notes: Data are in percentage points, at a quarterly frequency, excluding tax changes and interest charges. Lag lengths were selected using the AIC criterion.

fallen together with its variance between the pre- and post-IT periods: the sum of the autoregressive coefficients for non-tradable inflation falls from 0.44 in the pre-IT period to 0.21 in the post-IT period (see the second panel in table 1). Consistent with our earlier results, the variance of shocks to non-tradable inflation, estimated by the residuals of the autoregressive models for the pre- and post-IT periods, has fallen substantially. There is little evidence of persistence in tradable inflation in the pre- or post-IT periods. An implication of the decline in the covariance between tradable and non-tradable inflation is greater relative price variation. As a consequence of more stable non-tradable prices, nominal and real prices of tradable goods now move more closely together.[7]

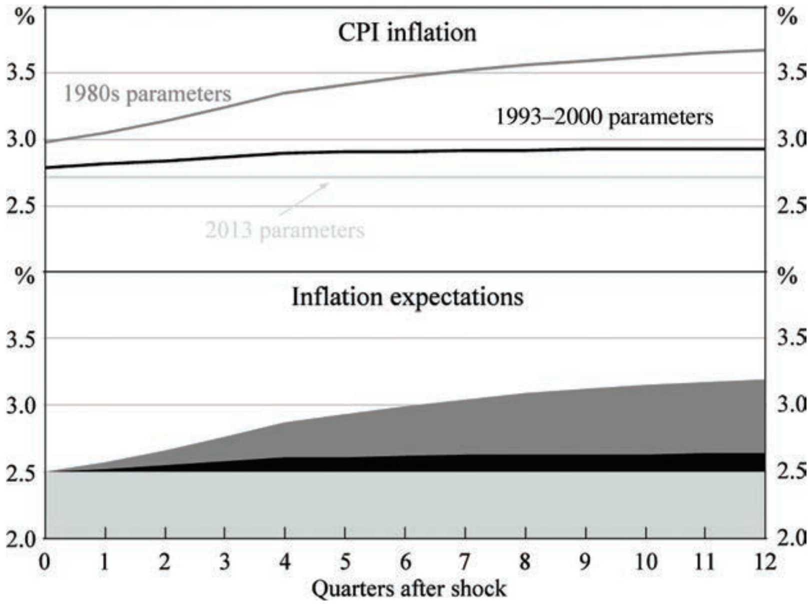
Associated with these changes, the relationship between unemployment and inflation has become substantially weaker. To illustrate the flattening of the Phillips curve, we forecast the response of inflation under old and current parameter values to a sustained 1-percentage-point deviation in unemployment below its natural rate. Figure 6 indicates that the predicted response of inflation to an unemployment gap is now smaller than under parameter values estimated prior to and in the early years of IT. Inflation is less sensitive to an unemployment gap than in the past for two reasons: first, the slope of the Phillips curve has declined, and second, because inflation expectations are now firmly anchored on the inflation target, the increase in inflation caused by the unemployment gap has a negligible effect on inflation expectations.[8] The contribution of inflation expectations to predicted CPI inflation for each scenario is indicated by the area in the lower panel of figure 6. The sensitivity of inflation to import prices is also estimated to have declined, although our scenario assumes unchanged import prices.

With a flatter Phillips curve, a relatively large share of the variability in inflation is now dominated by transitory changes, and deviations in unemployment from its natural rate are more difficult to detect in inflation data than in the past. Excess demand pressures

[7]Thanks to Alex Wolman for bringing this point to our attention.

[8]We assume long-term inflation expectations remain anchored at target for the purposes of this illustration. Given the slow rate at which the degree of anchoring has changed in response to regime changes in the past, this seems reasonable for an illustration of an unchanging regime.

Figure 6. Predicted CPI Inflation



Notes: Inflation is at an annualized rate. Prior to the shock, the unemployment gap is assumed to be equal to zero and inflation expectations to be 2.5 percent per annum. "1980s parameters" uses the average of the estimated model parameters for the 1980s, and analagously for "1993–2000 parameters"; "2013 parameters" uses the estimated model parameter values at end-2013.

are more likely to be swamped by noise than in previous decades. Conversely, changes in unemployment and output are less useful for forecasting inflation than in the past. In a particularly stark demonstration of this point, Atkeson and Ohanian (2001) found NAIRU-based inflation forecasts to now be little better than naive inflation forecasts of U.S. inflation. For Australia, this was demonstrated by Heath, Roberts, and Bullman (2004).

3. The Next Twenty-Five Years

As we have seen, there is evidence that twenty-five years of inflation targeting have delivered inflation processes that are better anchored and less affected by the business cycle than they were before the advent of inflation targeting. Although we focused on Australia above, its experience is illustrative of the experience of many countries around the world.[9] These changes mean that the challenges facing central banks are likely to be of a quite different character than the challenges dealt with over the past twenty-five years. Moreover, the financial crisis has stimulated a renewed debate about whether inflation targeting is the most appropriate way to conduct monetary policy. We suggest that it is—subject to some evolutionary changes. But, before we get there, it is useful to review some of the criticisms that have been directed at inflation targeting since the financial crisis. We discuss the alternative monetary policy frameworks that have been suggested in light of these criticisms and how these criticisms are a natural consequence of the changed behavior of inflation over the past twenty-five years. It is, ultimately, the fact that the changed behavior is a reflection of successful inflation targeting that argues against wholesale change.

3.1 A Flavor of the Debate

The financial crisis has been the catalyst for criticism of inflation targeting. Wren-Lewis (2013) states, "Whatever the causes, there is now a clear conflict between what a sensible UK monetary policy would be doing and what is actually happening. Monetary policy is not providing enough stimulus to the UK economy, because it is focusing on the inflation target, and not the output gap. Inflation targeting in the UK is not working, and something needs to change." Joe Stiglitz (2011) put it thus: "The idea that targeting inflation will lead to financial stability or that focusing on only price and financial stability is sufficient for maintaining a low output gap and stable and robust growth is fundamentally flawed."[10] Jeffrey Frankel (2012b) has already prepared an obituary for IT, writing that "the monetary

[9]See International Monetary Fund (2013).

[10]Notably, however, he acknowledges the following in a parenthetical comment immediately after his criticism: "(In extreme cases, of course, where the issue is not 3, 4, or 5 percent inflation but more like 10 percent inflation, central banks must focus on inflation as well. But in places like the United States and Europe, *where inflation has been controlled*, this is not the issue.)" (emphasis added). We believe this really is the issue and discuss it further below.

regime, known affectionately as 'IT' to its friends, evidently passed away in September 2009."

These criticisms stem from a view that, given depressed economic conditions, central banks should be running very stimulatory monetary policy, pretty much regardless of the rate of headline inflation. While central banks have generally been running stimulatory policy, the criticism is that they have not been aggressive enough because of fears of breaching their inflation targets. For example, it is suggested that the European Central Bank delayed lowering interest rates because it was overly concerned about headline inflation rates that were being boosted by temporary oil and commodity price increases. In the United Kingdom, as alluded to by the quote from Wren-Lewis above, the suggestion is that persistently high inflation outcomes and rising inflation expectations constrained the stimulus that the Bank of England provided.

In short, in the view of many critics, current monetary policy frameworks place too much weight on CPI inflation. The solutions that have been proposed address the perceived shortcomings in two main ways. One strand of suggestions has been to focus on inflation measures other than the consumer price index—in particular, to focus on measures that respond more closely to domestic cyclical conditions. For example, targets could be defined in terms of the rate of increase in labor earnings net of productivity gains (unit labor costs). Another suggestion is to give asset price inflation more prominence in monetary policymaking. Asset price developments may signal changes in financial stability and, thus, inform judgments on the risks to output. While both labor earnings net of productivity gains and asset price changes are still measures of inflationary pressure, the ideas have at their heart the goal of choosing targets that are more in line with output fluctuations. If the economy is booming, it is argued, it is more likely to be showing up in wage measures or asset price rises than in headline inflation.

The other main strand of suggestions is to target output fluctuations more directly. In some, this would be an explicit mandate to stabilize output—similar to the Federal Reserve's so-called dual mandate. In this dual-mandate framework, central banks' decisions would be based not only on their views about inflation but also on direct measures of output and unemployment gaps. Central banks would thus have more discretion to allow inflation fluctuations if addressing them would exacerbate cyclical downturns. Alternative approaches would incorporate output into the framework by making nominal GDP the target of policy.

3.2 The Options

As discussed above, there are two broad suggestions for how to “fix” inflation targeting given the tensions revealed in the aftermath of the financial crisis: (i) modify the particular definition of inflation that is being used or (ii) incorporate output into the target more explicitly. There is, also, a third option to maintain the current framework. We discuss these general suggestions next.

3.2.1 Modify the Target Definition

During the Great Moderation there was an unusual correspondence between stabilization of CPI inflation and output: cost-push shocks were short lived and typically small. But as the Bank of England’s experience illustrates, this correspondence broke down. Confronted with persistent imported inflationary pressures, it has been argued that the CPI inflation target restricted its ability to react to domestic weakness and accommodate non-domestically generated inflation. Similarly, although with the opposite effect, the rise of China and other emerging-market economies as low-cost producers of manufactured goods in the 1990s and early 2000s restrained tradable inflation and led to central banks tolerating relatively high rates of nontradable inflation that became uncomfortable once the effect on tradable inflation waned. Given the way CPI inflation muddied the waters, it seems natural to consider adjusting the target inflation measure to better reflect underlying inflationary forces.

Adopting an inflation measure that corresponds more closely to domestic economic conditions reduces the potential conflict between output and inflation stabilization while maintaining a credible nominal anchor for monetary policy and, given the transitory nature of imported inflation shocks, focusing on a measure that is likely a better indicator of medium-run inflationary trends. A target inflation measure that abstracts from idiosyncratic variation is also attractive because doing so holds the central bank responsible only for the prices under its influence.

Replacing CPI inflation with non-tradable inflation as the target measure, for example, would largely abstract from commodity price and exchange rate movements. As Bharucha and Kent (1998) explain, targeting non-tradable rather than CPI inflation allows the central bank to tolerate relatively large movements in the exchange rate. They consider the exchange rate channel of monetary policy transmission and show that it is optimal for a central bank with a non-tradable inflation target to respond relatively aggressively to supply and demand shocks, at the expense of exchange rate and CPI inflation variability. Furthermore, because tradable prices (e.g., petrol prices) are typically more flexible than non-tradable prices, targeting non-tradable prices puts more weight on sticky-price goods, which is optimal from a welfare perspective in New Keynesian models (Aoki 2001, Eusepi, Hobijn, and Tambalotti 2011). Targeting a non-tradable inflation measure does not hold central banks responsible for cross-country spillover effects of export price inflation, but neither does current practice: IT central banks use consumer rather than producer price target measures.

A complication associated with adopting non-tradable inflation as the target measure is that, reflecting the Balassa-Samuelson effect, non-tradable inflation has consistently exceeded tradable inflation. Because non-tradable inflation is a biased measure of average CPI inflation, consumer inflation expectations might, irrationally, become anchored at this higher level because it was the target of policy. If so, the disconnect between inflation expectations and the inflation target would lead to either a ratcheting up of average inflation, if these higher inflation expectations were allowed to become embedded in prices and wages, or consistently contractionary monetary policy with higher unemployment and output gaps as these pressures were resisted.

As mentioned earlier, another alternative is to adopt a measure of labor earnings net of productivity as the target measure, potentially providing a better indication of the trend pace of inflation than a consumer price measure. A drawback is the notorious difficulty in estimating productivity growth: reliable productivity estimates are only available for the market sector, and the data are often substantially revised. Changes in the composition of employment over the business cycle would also complicate the use of a labor cost target measure to guide monetary policy.[11] Furthermore, such a measure would abstract from the important role that changes in margins play in the inflation process.

3.2.2 Target Output More Explicitly

Rather than change the target inflation measure, central banks could adopt an explicit output stabilization objective, to complement the inflation target. A dual mandate would provide flexibility to accommodate persistent commodity price or exchange rate shocks that push inflation above target during times of economic slack. In contrast, a strict CPI inflation objective requires monetary policy tightening, exacerbating the fall in output. To the extent that there has been a flattening of the structural Phillips curve, a reevaluation of the trade-off between inflation and output would be in order, as offsetting even relatively minor cost-push shocks requires a larger fall in output than in the past.

One mechanism to increase the importance of output relative to inflation is to replace IT with nominal GDP growth targeting, an old idea that has gained prominence since the financial crisis. A nominal GDP growth target implicitly places equal weight on output and inflation stabilization, which to its proponents achieves a better balance of objectives than IT. But targeting nominal GDP growth does more than reweight the inflation and output stabilization objectives: it changes the target inflation measure. The consumer price inflation measure used by IT central banks includes the price of imports and excludes the price of exports, while the GDP price measure does the reverse. Excluding import prices automatically accommodates imported inflation, such as oil price shocks, as would adopting non-tradable inflation as the target inflation measure. However, the desirability of adopting a target measure that includes export prices is less clear. Frankel (2012a) argues that producer price targeting has the beneficial effect of stabilizing export prices in local currency terms. But for a small open economy such as Australia, the inclusion

[11] Notwithstanding this, measurement error in labor earnings and productivity estimates could be offsetting, so the error in the net measure might be smaller.

of export prices in the target inflation measure would expose the non-resources economy to large, and mostly exogenous, monetary policy changes. This is potentially problematic when there are level shifts in the terms of trade that the central bank must seek to identify in real time.

A more radical proposal is the adoption of nominal GDP as a level rather than growth target. Like price-level targeting, a nominal GDP target does not let "bygones be bygones": past deviations from target must be corrected in the future. During his time as Governor of the Bank of Canada, Mark Carney (2012) argued that nominal GDP targeting has particularly attractive properties at the zero lower bound. In an economic slump nominal GDP falls, and inflation expectations must rise for the central bank to maintain its nominal GDP target; any rise in inflation expectations lowers the real interest rate and stimulates demand. In essence, a nominal GDP target might endogenously generate countercyclical inflation expectations. The success of nominal GDP targeting crucially depends on the speed with which consumers' and firms' inflation expectations adjust. Following the adoption of IT, inflation expectations remained substantially above target for several years. Imperfect inflation credibility is likely to have been important, but so was sluggish adjustment of inflation expectations. Supporting this, a growing literature argues that information frictions are an important source of inertia in the monetary policy transmission mechanism (see, for example, Mankiw and Reis 2002). If inflation expectations adjust sluggishly, a nominal GDP target may only raise inflation expectations marginally in an economic slump, undermining one of its key features.

With the exception of the United Kingdom, the potential relevance of a dual-mandate policy is clearest in the lead-up to the crisis, during the sustained rise in oil prices. Jeffrey Frankel (2012b) argues that "it is widely suspected that the reason for the otherwise-puzzling decision of the European Central Bank to raise interest rates in July 2008, as the world was sliding into the worst recession since the 1930s, was that oil prices were just then reaching an all-time high." Regardless of whether Frankel's assessment is correct, it is this type of conflict between output and inflation stabilization that a dual-mandate policy is designed to avoid.

3.2.3 Maintain Current Targets and Lengthen the Target Horizon

As discussed above, alternative proposals are not without their own problems. Thus, one needs to give serious consideration to retaining CPI inflation as the target. CPI inflation is perhaps the simplest and most relevant inflation target to consumers: it measures consumers' average inflation experience, is a key input to wage negotiations, and is used for indexation purposes in contracts. It is used as a target by the vast majority of central banks for a reason. But, importantly, CPI inflation targeting can be implemented in a variety of ways. This can be seen most easily by noting that inflation targeting has evolved since its first implementation and generally takes account of activity in practice. Thus, further evolution of the framework seems feasible. Indeed, given the significant issues identified in some of the critiques, we argue that changes in the practice of inflation targeting may be warranted.

Amending frameworks to lengthen the inflation target horizon provides the most obvious evolution and is a natural middle ground between the wholesale change envisaged by the sharpest critics of IT and no change. Lengthening the target horizon provides central banks with more freedom to practice "flexible inflation targeting." Indeed, this is the direction that IT has been tending since its inception. A long horizon, such as the Reserve Bank of Australia's "over-the-cycle" criterion, maintains CPI inflation as a clear, transparent, medium-term nominal anchor, but minimizes the likelihood of conflict between output and inflation objectives over shorter horizons when transitory influences are more dominant.

A lengthening of the target horizon is also a natural consequence of changes in the inflation process we have documented. Slower pass-through of imported inflation shocks, more anchored expectations, and a flatter Phillips curve mean that inflation is likely to be much slower moving in response to any shocks and policy responses than in the past. Furthermore, with inflation credibility firmly established, there is greater scope than in the early years of inflation targeting to tolerate deviations from target: consumers and firms are less likely to interpret deviations from target as revisions to the implicit inflation target than when inflation targeting was in its infancy. How *much* central banks can leverage their credibility to tolerate persistent deviations in inflation from target is an unknown empirical question. Clearly, there is a limit: expectations adjust, even if only sluggishly. Nevertheless, the potential for inflation expectations to become "unanchored" should not be over-emphasized: a defining feature of the past decade has been the constancy of long-term inflation expectations through large swings in commodity prices and a deep economic slump.

Lengthening of the target horizon provides increased flexibility but also brings new challenges. First, the communication of the central bank may need to become more nuanced. Some inflation shocks, those that reflect fluctuations in domestic economic activity, may have to be addressed aggressively, while it may be better to look through others, such as exchange rate shocks. Of course, not all exchange rate shocks are alike, and the appropriate degree of monetary policy accommodation depends on the source of the shock. The challenge for central banks' communication strategies is to explain why certain shocks are being ignored, while others are being addressed.

Second, central banks' internal analysis may need to improve. While the flattening of the Phillips curve and anchoring of inflation expectations might seem like good news, it has an important drawback. Inference about the state of the economy based upon the behavior of inflation is now more difficult. Previously, capacity constraints would show up in inflation relatively clearly and induce an appropriate tightening of policy. Now, with the effect muted, it can be hard to identify a structural tightness in the economy, which can lead to persistence of that tightness that may have undesired effects. A prime example would be the experience of many euro-area countries that saw property booms in the lead-up to the financial crisis. Contained inflation was taken as evidence that output gaps were smaller than they actually were and allowed stimulatory policy to go on for longer than it otherwise would have. Compounding these analytical challenges are the difficulties of forecasting the highly non-linear effects of financial instability. In short, the flattening of the slope of the Phillips curve and greater anchoring of expectations means that the separation of systematic movements in inflation from random noise is now harder—NAIRU-based forecasts of inflation are now less reliable and new techniques will need to be developed.[12] And changes in the processes governing inflation identified above mean that the Lucas critique applies with great force. Models which fail to take this into account are likely to make systematic errors.

3.3 Discussion of the Options

In thinking through the options, it is worth emphasizing that the effects of inflation targeting evident in the data are twofold. First, there has been a flattening of the Phillips curve, whereby the linkages between current inflation rates and output gaps have weakened. Second, there has been an increase in the anchoring of inflation around long-run expectations, which are invariably the same as the stated targets. These effects, along with slowing pass-through from imported inflation, mean that current inflation is now more affected by shocks where the inflation and output stabilization objectives appear to be in conflict than in the past. But that is mostly because current CPI inflation is now a poor indicator of future inflation. And, in such an environment, a pure CPI inflation target, particularly one focused on shorter-term outcomes, risks destabilizing output to offset idiosyncratic shocks. In this light, all three options discussed above can be seen as ways of reducing the emphasis on current or short-term CPI inflation and increasing that on output—especially to the extent that output is an indicator of future inflation.

The strongest critics of IT argue that wholesale change is required: either adopt explicit dual mandates or change target inflation measures. Both these proposals share the common objective of minimizing the chance of conflict between output and inflation stabilization. But, as we have argued, these arguments for change are, in part, a consequence of the success of IT. With inflation expectations now firmly anchored at target and the Phillips curve flatter, the non-tradable component of inflation has been stabilized, and the relative importance of the idiosyncratic and uncontrollable component of CPI inflation has risen.

The adoption of a dual mandate minimizes the possibility of conflict by permitting inflation to be above target when output is

[12]A corollary is that it is harder to pin down the level of the natural rate of unemployment precisely.

depressed, as does changing the target to an inflation measure more closely associated with economic activity. A difficulty, however, with proposals to down-weight the inflation target is that, even if it does not affect the slope of the Phillips-curve relationship, it risks undermining the anchoring of expectations. And it is only because expectations are now anchored that idiosyncratic shocks appear to be so important.

Additionally, conflict between output and inflation stabilization in the post-financial crisis period should not be over-emphasized. Inflation has remained close to its target for most IT central banks, despite substantial economic slack and highly accommodative monetary policy. The characterization of IT central banks as caring exclusively about CPI inflation is also something of a strawman argument. The practice of inflation targeting has evolved. For example, the Reserve Bank of New Zealand's inflation target band was widened from 0–2 percent to 0–3 percent in December 1996 to provide additional flexibility. More generally, underlying inflation measures are now routinely used as a guide for policy, abstracting from sharp idiosyncratic variation in inflation that is unrelated to domestic economic conditions. Central banks have also become more forward looking, setting monetary policy based on forecasts of inflation, and output and unemployment, rather than contemporaneous estimates. Svensson (1997) argues that making central banks' inflation forecasts an explicit intermediate target simplifies the implementation and monitoring of monetary policy. Because central banks' inflation forecasts are typically guided by a Phillips-curve relationship, and idiosyncratic changes in inflation more than a couple of quarters ahead are essentially unforecastable, inflation forecast targeting implicitly sets monetary policy based on a measure of inflation that reflects domestic economic activity. (Although, as the simulation above showed, if those forecasts are premised on an unchanged Phillips curve, they may prove to be misleading.)

Our suggestion to lengthen the target horizon provides central banks with the flexibility required to tolerate persistent idiosyncratic shocks to inflation, in the same way as the other general proposals do, but without some of the negative consequences for the anchoring of expectations. Notwithstanding this, our recommendation to maintain CPI inflation as the target measure should not be mistaken for complacency. Indeed, we cannot forget that the benign inflationary outcomes during the 2000s masked the buildup of imbalances that contributed to the financial crisis. Rather, central banks must be increasingly vigilant in identifying changes in the trend pace of inflation and, at the same time, willing to tolerate commodity price or exchange rate shocks that push CPI inflation away from target for a time. Clear communication will be required to explain changes in the stance of policy. Policy tightening may be required when the trend pace of inflation is forecast to rise even if CPI inflation remains close to the target. Conversely, in the presence of idiosyncratic shocks, monetary policy may often remain accommodative. Because the appropriate policy response to an inflation surprise crucially depends on its cause, structural models that can identify the source of shocks are needed. Furthermore, the breakdown in the forecasting performance of the Phillips curve suggests that near-term forecasting will need to make use of a broad range of economic indicators.

Thus, we conclude, a lengthened target horizon for CPI inflation targeting provides the necessary additional flexibility to implement "flexible inflation targeting" in a world where ultimately idiosyncratic shocks are more persistent—without some of the downsides more radical proposals suffer from.[13]

4. Conclusion

The practice of inflation targeting over the past twenty-five years has fundamentally changed the character of target inflation measures. Unlike in the early years of inflation targeting, before credibility had been established, long-term inflation expectations are firmly anchored at target, moving little in response to inflation surprises. Variability of the domestic component of inflation has declined substantially, and much of the variation in CPI inflation is now caused by imported shocks, such as commodity price and exchange rate changes. Stabilization of the domestic component of inflation has weakened the relationship between inflation and domestic economic conditions—the Phillips curve has become flatter.

[13]For example, the benefit from adopting a non-tradable inflation target is unclear when monetary policy is guided by inflation forecasts that abstract from exchange rate shocks anyway (Ryan and Thompson 2000).

These changes in the inflation process have resulted in a breakdown in the correspondence between output and inflation stabilization in the short run. Changes in CPI inflation are now more likely to reflect idiosyncratic shocks than signal deviations in output from potential. Some critics argue that this calls for inflation-targeting frameworks to be fundamentally reengineered, placing more weight on output than inflation stabilization. It is argued by some that weighting output more heavily in central banks' objective function would avoid the stability of inflation blinding central banks to spare capacity, and reduce the likelihood of inappropriate monetary policy tightening in response to imported price shocks.

We argue that while the character of target inflation measures has changed, the fundamental relationships are much the same even if the time frames for them to operate have lengthened. Sound monetary policy still requires the stabilization of output about potential, and the accommodation of idiosyncratic inflation shocks. Inflation targeting need not be abandoned or fundamentally reengineered, but its practice must reflect the changing nature of target inflation measures. With inflation credibility now firmly established, central banks can afford to accommodate persistent commodity price and exchange rate swings. Similarly, policymakers need not induce large upfront contractions in activity to avoid any unanchoring of inflation expectations. But stabilization of output about potential is now a more complicated task, as the relationship between domestic output and inflation is weaker and more drawn out than in the past and domestic inflationary pressures are likely to be hidden in noise. Identifying deviations in output from potential is as important as ever, but the task has become harder.

This creates a problem for central bank communications and analysis. First, because the analysis required to differentiate domestically generated demand shocks from imported shocks is tricky, the communication challenges for the central bank are likely to be similarly difficult. While some inflation shocks will be accommodated, others will merit a response. Second, because the potential for shocks to be hidden in noise is magnified now that the effect of any given shock is smaller, there is an increased possibility that mistakes might be made.

Notwithstanding this, the solution is not to declare victory over inflation and switch the primary focus to output. While widespread vaccination has dulled the memory of how dangerous measles and other infectious diseases can be, that does not mean they have become any less dangerous. Both inflation targeting and vaccination programs are victims of their own success. The inflation process has changed over the past twenty-five years, and the practice of IT must evolve accordingly. But the same issues that led to the choice of inflation targeting over the alternatives in the past continue to apply with the same force.

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Discussion of "Inflation Targeting: A Victim of Its Own Success"*

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1. Introduction

Gillitzer and Simon have written a provocative paper on inflation-targeting (IT) experiences in general and specifically in Australia. They see the very success of inflation targeting as opening the door to critics who can point to what IT has *not* done, and of course one thing it did not do was prevent the Great Recession. Focusing on Australia, they illustrate the success of IT in multiple dimensions, which I will summarize as (i) a decreased sensitivity of inflation and inflation expectations to shocks, and (ii) a "de-linking" of traded-goods prices from inflation. They use the successes of inflation targeting to refute critics urging for wholesale changes, instead arguing for changes at the margin.

I will focus my remarks on three areas. First, I will provide a slightly different perspective than the authors on the Australian traded- and non-traded goods inflation decomposition. Second, I will provide some follow-up discussion on the theme of IT as a victim of its own success. Finally, I will ruminate on the question of why it may make sense to put more weight on some price changes than others in determining the optimal volatility of inflation.

2. Pre- and Post-IT Decomposition of Inflation

Table 1 in the paper compares several statistics across the pre- and post-IT regimes in Australia. The variance of non-tradables price

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Table 1. Augmented Statistics

	Pre-Inflation Targeting: 1982:Q2–1990:Q4	**Post-Inflation Targeting: 1993:Q1–2013:Q4**
Variance: Non-Tradables	0.90	0.15
Variance: Tradables	0.60 (0.88)	0.58 (0.77)
Covariance	0.31 (−0.59)	−0.02 (−0.17)
$\text{Cov}(\pi_t^T, \tau_t)$	0.29	0.60

changes fell dramatically, while there was little change in the variance of tradables price changes, and the covariance between tradable and non-tradable price changes vanished. The authors view tradables prices as reflecting external influences to a large extent. Thus, the results indicate IT's success. I have no quarrel with this interpretation. However, I would argue that it is really the relative price change of tradables which we should view as reflecting external influences.

Tradables price changes $\left(\pi_t^T\right)$ are the sum of a relative price change (τ_t), which I will view as exogenous with respect to monetary policy, and the price change of non-tradables (π_t^N), which I will view as endogenous with respect to monetary policy:

$$\pi_t^T = \tau_t^T + \pi_t^N. \tag{1}$$

In table 1, I augment the statistics in Gillitzer and Simon's table 1 with corresponding statistics (in parentheses) that replace the price change for tradables (π_t^T) with the change in the relative tradables price (τ_t^T). The calculations use the following three equations:

$$var\left(\pi_t^T\right) = var\left(\tau_t^T\right) + var\left(\pi_t^N\right) + 2cov\left(\tau_t^T, \pi_t^N\right),$$
$$cov\left(\pi_t^T, \pi_t^N\right) = cov(\tau_t^T, \pi_t^N) + var(\pi_t^N),$$

and

$$cov\left(\pi_t^T, \tau_t\right) = var\left(\pi_t^T\right) - cov\left(\pi_t^T, \pi_t^N\right),$$

which are implied by (1).

Reassuringly, as with nominal tradables prices, there was also a small (though larger) decline in the variance of *relative* tradables price changes, from 0.88 to 0.77. Although this is entirely speculative, perhaps the decline in variance reflects a more stable overall inflationary environment, so that price changes became more effective, in some sense. Also, pre-IT there was a greater degree of monetary policy "offsetting" changes in relative price of tradables: the covariance between non-tradables price changes and the change in relative tradables prices went from −0.59 to −0.17. That is, pre-IT, an increase in the (exogenous) relative price of tradables tended to be accompanied by a decrease in nominal non-traded goods prices, and this effect subsequently fell. It seems that in the credible IT world, monetary policy no longer needs to slam on the brakes in response to relative price shocks to prevent expectations from becoming unanchored. Finally, post-IT, the nominal and relative price changes of traded goods moved more closely together, which is an implication of non-traded goods prices having been stabilized.

3. On IT as Victim of Its Own Success

I agree with the statement in the paper's title. But I cannot resist giving it my own twist. In many countries, IT was introduced in the hope that it would bring about or reinforce a secular decline in inflation. Foreseeing success (as many countries did), we could have also foreseen the inevitable criticism: real fluctuations wouldn't disappear, and at some point would lead naturally to a discussion of whether monetary policy should have done more to dampen them.

Alas, we can't answer the question of what monetary policy should do without knowing—or having a view about—what monetary policy *can* do. So what can monetary policy do? Surprise: we don't know! This is perhaps the biggest question for a monetary economist. Even the sub-question—how much inflation stability can monetary policy achieve?—is unresolved. A theme of the paper is how much inflation variability *should* be tolerated. But I think the prior question—what is the smallest feasible variability in inflation?—deserves much more attention. I can't answer that one either, but by looking at the distributions of realized inflation across countries, we can at least find upper bounds for the smallest feasible variation in inflation. From the U.S. perspective, this question is especially relevant right now: inflation is widely perceived to be "low" over the last three years. But is it meaningfully low given the kind of variation a central bank must accept as inevitable? Again, I do not think we know.

4. Theory and Desirable Inflation Volatility

Data alone can provide some information about the minimum feasible degree of inflation variability, but theory is needed to provide sharp estimates. Since there is no consensus theory, there can be no sharp estimates that are viewed as plausible. Nonetheless, we should use theory to inform our thinking about why certain kinds of inflation might be more tolerable than others. While Gillitzer and Simon argue against changing central banks' targets to something like non-traded goods inflation, their suggestion to lengthen the target horizon has a similar motivation: persistent idiosyncratic shocks to inflation should not require offsetting actions by an inflation-targeting central bank.

Why is it optimal to tolerate inflation if it is associated with idiosyncratic shocks, say to tradables prices or commodity prices? One simple theoretical justification, as mentioned by the authors, is from Aoki (2001): prices are sticky in one sector and flexible in the other sector, and in a Dixit-Stiglitz monopolistic competition model it is optimal to stabilize the sticky prices, which means inflation will fluctuate optimally along with the flexible prices. I like this theory, even if I doubt the realism of the "stickiness + Dixit-Stiglitz" part. Speaking loosely, I think some relative prices are naturally volatile—volatility is the fundamental factor, as opposed to price stickiness or lack thereof. It is optimal for the goods with volatile relative prices to have fluctuating nominal prices, because nominal price changes may be costly: for example, there may be physical costs of nominal price changes, or nominal price changes may sow confusion about relative prices. By pushing nominal price changes toward goods experiencing large relative price changes, it may be possible to limit the physical costs of price changes, and to limit the degree of nominal/real confusion.[1] Note that the Aoki/New Keynesian mechanism—which I have also studied—is not about price *changes* being costly, but about price *level* variation being costly: the model has symmetry

[1] I conjecture that, in general, zero overall inflation may not correspond to the smallest quantity of overall nominal price changes.

of demand and supply fundamentals within a sector, which implies that price *levels* should be equated across goods within a sticky-price sector.

Another reason to tolerate inflation volatility from relative price shocks may have to do with feasibility: monetary policy does not have the ability to offset certain relative price shocks within the period, which may make it optimal not to attempt to offset them at all. This is a story not so much about lags in the effects of monetary policy as about recognition lags for the monetary policymaker—that is, monetary policy reacts to lagged information about the economy. For both of these reasons, it seems optimal for monetary policy not to attempt to offset large relative price shocks. Of course, this prescription requires that large relative price shocks not cause inflation expectations to become unanchored. The authors' results in section 2 are encouraging in this regard.

5. Conclusion

This fine paper stimulated my thinking about several questions: What does it mean for inflation targeting to succeed? What is the nature of the interaction between relative price changes and inflation? Relatedly, what makes some degree of inflation fluctuations unavoidable, as opposed to merely "optimal to allow?" What is the minimum feasible volatility of inflation, and why might it be optimal to tolerate more than this minimum volatility? I look forward to both consuming and producing research on these questions in the years to come.

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Goals and Rules in Central Bank Design*

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Beginning with the Reserve Bank of New Zealand Act of 1989, central banking reforms have focused on assigning clear goals for which monetary policy authorities can be held accountable. Inflation-targeting regimes provide examples of such goal-based policy frameworks. An alternative approach relies on a rule-based framework in which the policy authorities are judged on whether they set their instrument in a manner consistent with a legislated rule. I consider the performance of goal-based and rule-based frameworks. I first show analytically that both goal-based and rule-based systems balance a trade-off between reducing sources of policy distortions and preserving policy flexibility. Then, using an estimated DSGE model, I find the optimal weights to place on goal-based and rule-based performance measures. When the rule is similar to that proposed recently in U.S. H.R. 5108, I find that the optimal weight to assign to the rule-based performance measure is zero. However, when the rule is based on the output efficiency gap, it is generally optimal to make deviations from the rule a part of the central bank's performance measure.

JEL Codes: E52, E61.

1. Introduction

On December 20, 1989, the New Zealand parliament gave unanimous approval to the Reserve Bank of New Zealand Act of 1989 (the Act or the RBNZ Act), thereby formally inaugurating the world's first inflation-targeting regime. The Act was part of a larger reform of

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governmental ministries, a reform designed to boost accountability by establishing clear objectives for government agencies. The assigned objective for the Reserve Bank was set out in clause 8 of the Act:

> The primary function of the Bank is to formulate and implement monetary policy directed to the economic objective of achieving and maintaining stability in the general level of prices.

By establishing a numerical target for inflation, a process for communicating the target to the public through the Policy Target Agreement (PTA) between the government and the central bank, and a mechanism for accountability, the Act and the PTA contained all the key ingredients of inflation targeting.

The Act launched a global wave of central bank reforms that have clarified the policy responsibilities of central banks, increased their independence to implement policies consistent with their responsibilities, and provided clear measures of accountability against which their performance could be judged. These reforms have also promoted a greater level of transparency, transforming the way many central banks communicate their policy decisions and signal their future policy intentions. In general, accountability in inflation-targeting regimes is strengthened by the public nature of the announced target and by the requirement that the central bank produce inflation reports or otherwise explain policy actions and their consistency with the announced target. Achieving the target becomes a measure of the central bank's performance.

Inflation targeting has now spread to almost thirty countries,[1] and many aspects that were pioneered in New Zealand—a public commitment to a target rate of inflation, high levels of transparency, and accountability—are today considered best practice for monetary policy. The impact of New Zealand's reforms goes beyond those central banks labeled as formal inflation targeters, as others—such as the Federal Reserve, which has a dual mandate for price stability and maximum sustainable employment—now quantify the goal of price stability in terms of an announced, numerical goal for inflation. In

[1] Combining the lists of Roger (2010) with that of Rose (2013) yields twenty-eight inflation targeters.

fact, as many as fifty central banks now have quantitative targets or target ranges for inflation.[2] So the twenty-fifth anniversary of the Reserve Bank of New Zealand Act of 1989 marks a landmark event in the history of central banking.

Inflation targeting itself has not remained a static policy framework since its birth. Further reforms in many countries, primarily related to increasing monetary policy transparency, have taken place, and experiences at the zero lower bound and with unconventional policy tools have forced some central banks to reconsider the way their policy decisions, and the information on which they are based, are conveyed to the public. Even away from the zero lower bound, developments in the theory of monetary policy have emphasized the importance of forward guidance (e.g., Woodford 2005, 2013), and some inflation-targeting central banks—here again, the RBNZ has been in the forefront—provide information on the projected future path for the policy interest rate. Others, most notably the Federal Reserve and the Bank of England, have experimented with language designed to convey information about the circumstances that will trigger future increases in interest rates.

While widely adopted, inflation targeting has not won universal acceptance. Some critics have argued that inflation targeting has not mattered—that at least during the Great Moderation period, inflation targeters and non-targeters alike enjoyed similar improvements in macroeconomic performance.[3] Other critics argue it has mattered too much, blaming a focus on inflation for blinding central banks to the dangers of a finance crisis, thereby being part of the policy missteps that led to the global financial crisis of 2008–9.

Proposals to reform inflation targeting or to replace it continue to be debated. Proposed reforms include giving the central bank new goals related to financial stability or replacing inflation as the primary goal with the price level or nominal income. These proposals are consistent with the general approach of inflation targeting in assigning goals to the central bank. They are also consistent with maintaining the central bank's independence to pursue its objectives, while the goals provide natural measures of performance that help ensure the central bank remains accountable.

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[2] See http://www.centralbanknews.info/p/inflation-targets.html.

[3] An early paper to make this argument was Ball and Sheridan (2004).

A central bank's performance measure—the observable variable (or variables) by which the public and elected officials can judge whether the central bank has acted in a manner consistent with its charter—does not need to be based on an ultimate goal of monetary policy such as inflation. A central bank could be assigned and held accountable for achieving targets that are not themselves among the final goals of monetary policy. For example, in the 1970s, the U.S. Congress required the Federal Reserve to establish target growth rates for the money supply. Money growth rates are intermediate targets, neither an ultimate goal of policy nor something directly controlled as an instrument. Another alternative would be to judge the central bank's performance by comparing the central bank's instrument to the value prescribed by a legislated instrument rule. In fact, the U.S. House of Representatives recently held hearings on a bill that would establish an interest rate rule, with the Federal Reserve required to justify any deviations of the federal funds rate from the rule.[4] Taylor (2012) illustrates how an instrument rule can be used to assess ex post the Federal Reserve's policy.

Performance measures can differ, therefore, in terms of whether they focus on ultimate goals of macroeconomic policy while allowing for instrument independence, as is the case with inflation targeting, or whether they limit the instrument independence of the central bank, as would be the case with a legislated instrument rule. Both inflation targeting and other goal-based regimes such as price-level targeting, speed-limit policies, and nominal income targeting frameworks have been extensively analyzed in the literature.[5] However, a similar analysis of regimes that base accountability on adherence to an instrument rule is absent from the literature, a gap the present paper seeks to fill.

[4]Hearings were held in July 2014. According to a *Financial Times* report on Janet Yellen's February 25, 2015 testimony before the U.S. House Banking Committee, "The Fed chair swatted down calls from Republicans for the institution to be subject to mechanical rate-setting rules, saying she did not want its discretion to be 'chained'." See "Janet Yellen Defends US Central Bank Independence," *Financial Times,* February 15, 2015 (available at http://www.ft.com).

[5]For example, Vestin (2006) provides an early analysis of price-level targeting, Walsh (2003b) compares price-level targeting, output-gap growth rate (speed-limit) policies, and nominal income policies, and Billi (2013) studies nominal income policies in the face of the zero lower bound on nominal interest rates.

Of course, there is a huge literature that studies the role of Taylor rules, and variants of Taylor's original rule (usually with the addition of the lagged interest rate) have become the standard method of specifying monetary policy to close general equilibrium models. Simple rules have played a large role in the literature on policy robustness (e.g., Levin and Williams 2003, Taylor and Williams 2010). Ilbas, Roisland, and Sveen (2012) consider model uncertainty and show that including deviations of the policy rate from a simple rule can improve macroeconomic outcomes, allowing the central bank to cross-check its policy against a rule that is potentially robust across a variety of different models.[6] However, they ignore any distortions to the central bank's objectives over inflation and the output gap that might arise from political pressures on monetary policy. These distortions play a central role in my analysis, while I ignore model uncertainty.

Tillmann (2012) is closest to the present paper in that he considers outcomes under discretion when the central bank minimizes a loss function that differs from social loss by the addition of a term reflecting deviations of the policy rate from the rate implied by a simple Taylor-type rule. He finds that some weight should be placed on this new term when inflation shocks are serially correlated, a result similar to that of Clarida, Galí, and Gertler (1999), who found a role for a Rogoff conservative central banker in a New Keynesian model only when inflation shocks were serially correlated. Walsh (2003a) shows that it can be optimal to place additional weight on inflation even when shocks are serially uncorrelated in the face of political distortions that cause the central bank's objectives to differ from those of society. These distortions generate a rationale for performance measures that is absent from the work of Tillmann (2012).

The rest of the paper is organized as follows. Section 2 reviews the objectives that central bank reforms such as the RBNZ Act were designed to achieve. Understanding the reason for reform is critical

[6]The monetary policy loss function incorporated into the Norges Bank's DSGE model (NEMO) actually adds a term of the form $(i_t - i_t^*)^2$. Previous versions of NEMO set i_t^* equal to the value given by a simple instrument rule. Currently i_t^* is equal to the "normal" nominal interest rate, defined as the rate consistent with inflation equal to target and a zero output gap. This term is intended to add an implicity weight on financial imbalances in policy determination. See Evjen and Kloster (2012) and Lund and Robstad (2012).

for evaluating the appropriate nature of any reform. An important distinction that arises is whether central bank reform is designed to constrain the central bank or to constrain the government. I then consider two forms of reform. The first (and standard) type emphasizes the assignment of goals to the central bank. The second approach proposes instrument rules that the central bank should follow. These two alternatives are illustrated using a simple model that allows analytic results to be derived. To evaluate the alternatives in a more realistic setting, a model incorporating sticky wages and sticky prices is employed in section 4. Parameter values and the relative volatility of alternative shocks, which the simple model showed are important for the evaluation, are obtained by estimating the model using Bayesian techniques.

The analytical results suggest that both goal-based and rule-based systems must balance the same trade-off between reducing the impact of distortionary shocks to the central bank's policy objectives (arising, for example, from short-run political pressures) and allowing flexibility to pursue welfare-improving stabilization policies. The findings from the estimated DSGE model highlight the importance of the output measure used in the legislated rule. If the gap between output and its efficient level appears in the rule, judging performance by a comparison of inflation to its assigned target and the policy instrument to the recommendations of the rule both play a role in the optimal policy framework. When the rule takes the form proposed in the recent Congressional hearings, it is never optimal to use the rule to assess the central bank's performance. Conclusions are summarized in section 5.

2. Central Bank Reforms: Goals, Rules, Independence, and Accountability

Central bank reforms over the past twenty-five years have been aimed at removing, or at least reducing, the causes of poor monetary policy outcomes. Understanding the nature of the distortions that have produced poor policy is important for assessing the relative advantages or disadvantages of different types of reforms.

Three types of distortions have loomed large in monetary policy discussions. First, short-term political pressures, often related to a country's election cycle, can distort monetary policy decisions, resulting in an emphasis on near-term economic activity at the cost of longer-term objectives. Given that monetary policy operates with long lags, a central bank buffeted by short-term political pressures might have difficulty in achieving longer-term objectives, including low and stable inflation. And, if monetary policy has its primary effects on inflation through its influence on real economic activity, expansionary policies would first produce an economic boom, with inflation coming only later. This potentially creates an incentive for politicians to pressure central banks for expansionary policies timed to election cycles; a boom leading up to an election would benefit incumbents, while the inflationary costs would only be incurred later.[7] In this case, achieving medium-term inflation objectives would be incompatible with central banking regimes subject to political pressures.

Second, real economic distortions can cause inefficiencies that create a systematic bias towards policies aimed at expanding economic activity. For example, in standard New Keynesian models, monopolistic competition in goods and/or labor markets means the economy's level of economic activity in a zero-inflation environment is too low relative to its efficient level. Real frictions in financial markets or in labor markets characterized by search-and-matching frictions may also generate wedges between the economy's efficient allocation and the allocation arising with flexible prices and wages. While monetary policy can attempt to close these wedges in the short run by deviating from a policy of price stability, it cannot systematically and sustainably close them. Attempts to do so will ultimately fail, leaving the economy with excessively volatile inflation. Distortions arising from real economic inefficiencies and those due to political pressures on central banks may be closely related; the presence of real distortions may explain why politicians seek to influence monetary policy.

And third, even in the absence of political pressures or attempts to use monetary policy to achieve unachievable objectives, policymakers may lack the ability to commit credibly to future policies, leading to inefficient intertemporal policy responses to distortionary

[7] An extensive coverage of political business-cycle models can be found in Drazen (2000).

shocks. That is, even if the first two distortions are prevented from affecting monetary policy, the inability to commit to future actions will result in inefficient stabilization policies. The distortions resulting from discretionary policy played a large role in the academic literature seeking to explain why political pressures or the pursuit of unachievable objectives would lead to undesirably high inflation.[8] In the Barro-Gordon framework, popular at the time of the RBNZ Act in academic work on the inflation bias of discretion, removing short-term political pressures and assigning achievable goals to the central bank also succeeded in eliminating the distortion due to discretion. However, in New Keynesian models, with their emphasis on forward-looking expectations, discretion continues to produce inefficient outcomes even in the absence of political pressures or unsustainable goals.

Given these three potential sources of policy distortions, what types of central banking reforms might lead to improved monetary policy outcomes? I focus on two alternatives, both of which can be viewed as establishing a performance measure for the central bank. Performance measures provide metrics based on observable variables for evaluating the central bank's policy choices.[9] The definition of the performance measure is an important aspect of central bank reform: it affects the central bank's policy actions and is the basis for ensuring accountability in the conduct of policy.

The first type of reform, reforms such as inflation targeting, emphasizes policy goals. An ultimate goal of policy serves as the measure of the central bank's performance. The second type emphasizes rules, with adherence to the rule the basis for assessing the central bank's performance. Using an instrument rule such as the Taylor rule to evaluate the central bank is an example of a rule-based performance measure. In either case, the power of the performance measure indicates how important the measure is in the overall

[8]See chapter 7 of Walsh (2010) for a survey of the literature on the inflation bias resulting from discretionary policies in models based on the time-inconsistency of optimal policy analysis of Kydland and Prescott (1977) as applied to monetary policy in the framework of Barro and Gordon (1983). See also Cukierman (1992).

[9]For the theory of performance measures, see Baker (1992), Baker, Gibbons, and Murphy (1994), and Frankel (2014).

assessment of policy. For example, a strict inflation-targeting regime in which the central bank is instructed to care only about achieving the target is an example of a high-powered regime.

The model of reform provided by the Reserve Bank of New Zealand Act and the Policy Targets Agreement focused on an ultimate goal that could be achieved by monetary policy. It did so by creating a contract between the elected government and the central bank designed to affect the policy choices of the Reserve Bank by altering the incentives of both the government and the central bank.[10] Incentives were affected by publicly establishing a clear policy goal, assigning responsibility for achieving it to the Reserve Bank, and establishing a system of accountability based on the goal. The elected government could alter the Bank's goal by changing the Policy Targets Agreement, but this had to be done in a public manner, and the government could not interfere in the implementation of monetary policy. The Act, together with the Policy Targets Agreement, created a performance measure for the Reserve Bank; it was to be evaluated on the basis of the consistency between its policy actions and the achievement of its inflation target.

A contract of this form could solve two and possibly all three of the distortions that had led to poor monetary policy. First, the public nature of the goal would help insulate the central bank from political pressures to pursue other objectives. By granting the Reserve Bank a high level of instrument independence to implement policy, the Act further limited the scope for short-term political factors to influence policy decisions. In other words, the Act served to constrain elected officials. In fact, in discussing the origins of inflation targeting in New Zealand, Sherwin (1999, p. 1) credits the desire of Roger Douglas to make "monetary policy less susceptible to manipulation for short-term political ends."[11] The view ascribed to Douglas was consistent with empirical evidence pointing to a negative relationship among developed economies between average rates of inflation

[10]Walsh (1995a, 1995b).

[11]"The *process of delegation* through which the government assigns immediate responsibility for the conduct of monetary policy to a central bank is a means of restricting the strategy space available to the *government.*" (Walsh 1995a p. 240, emphasis in original)

and measures of central bank independence.[12] Thus, a key characteristic of the reform was to increase central bank independence to constrain elected governments from influencing the implementation of monetary policy.[13]

While greater independence may shield monetary policy from political influences, it cannot ensure that policy is only directed towards achieving obtainable goals. An independent monetary authority that wishes to promote social welfare may still face a temptation to pursue unsustainable objectives if, for example, real distortions imply that steady-state output is inefficiently low.[14] So the Act assigned a specific goal to the Reserve Bank—price stability—that monetary policy could achieve. Sherwin (1999) quotes the report of the parliamentary Finance and Expenditure Committee as stating, "The Committee . . . is firmly of the view that the primary function of monetary policy should be that set out in clause 8(i) [quoted above]. Members acknowledge that monetary policy should not be made to wear the cost of inappropriate fiscal and micro-economic policies. Monetary policy at the end of the day can only hope to achieve one objective, that is, price stability." Thus, the reforms instituted by the RBNZ Act focused on an achievable *goal* of monetary policy while allowing the central bank the independence to achieve this goal. The Act did not seek to constrain the Reserve Bank in its decisions about the appropriate policy stance required to achieve price stability. It instead removed from the Reserve Bank the authority to set its own goals. In the terminology of Debelle and

[12]Important papers on this relationship include Bade and Parkin (1984), Cukierman, Web, and Neyapti (1992), and Alesina and Summers (1993). See also Cukierman (1992). Criticism of the view that central bank independence is a solution to high inflation is provided by Posen (1993). The negative relationship between indexes of central bank independence and inflation held only for developed economies.

[13]Carlstrom and Fuerst (2009) find that increases in central bank independence can account for two-thirds of the better inflation performance among industrialized economies over the past twenty years.

[14]The academic literature based on the model of Barro and Gordon (1983) generally did not distinguish between politically generated pressures for economic expansions and socially efficient but unsustainable attempts by the central bank to generate expansions. Both were captured by assuming that, even with flexible prices and wages, the economy's output would be below the desired level.

Fischer (1994), the Act established a central bank that lacked goal independence but enjoyed instrument independence.

This type of reform—clear specification of goals together with greater central bank independence—became common during the 1990s.[15] Making the goals public helps to promote accountability, particularly if the central bank is assigned a single policy goal such as price stability or a target for inflation. Independence also has the potential to make the central bank less accountable, so Debelle and Fischer (1994) argued that independence needed to be limited and that independence to set instruments but not to define goals offered the best blueprint for central bank reform.

Neither the assignment of goals nor instrument independence addresses directly the distortions that arise when policymakers are unable to commit to future actions. In the special case of the model of Barro and Gordon (1983), however, all three distortions could be addressed by giving the central bank instrument independence and holding it accountable based on the realized rate of inflation (Walsh 1995b) or, equivalently, by assigning it the right inflation target (Svensson 1997). When private-sector expectations are forward looking, inflation targeting alone does not solve the distortion that arises from discretionary policy. However, as policymakers and academics increasingly understood the important role that expectations of future inflation play in controlling current inflation, and the role the expected future path of the policy interest rate plays in affecting the real economy, central banks placed greater emphasis on being transparent, systematic, and predictable in their actions. Doing so helped them gain greater influence over the private sector's expectations. Thus increases in transparency have been common (Crowe and Meade 2007, Blinder et al. 2008, Cukierman 2008, Geraats 2009, and Dincer and Eichengreen 2014). By being better able to influence future expectations, central banks are also partially able to overcome this third distortion.

To summarize, goal-based regimes are typically associated with instrument independence. Making goals public constrains the

[15]The movement of many central banks towards greater independence and transparency is discussed by Crowe and Meade (2007) and Blinder et al. (2008). See Dincer and Eichengreen (2014) for an updated measure of transparency that illustrates this trend.

government, but if the central bank is judged only on the basis of the goal, as would be the case with strict inflation targeting, it can also restrict the flexibility of the central bank. In the case of New Zealand, it is clear that the RBNZ is to be a flexible inflation targeter. This flexibility is reflected in the addition in 1999 of clause 4(c) to the PTA; this clause states that "in pursuing its price stability objective, the Bank shall implement monetary policy in a sustainable, consistent and transparent manner and shall seek to avoid unnecessary instability in output, interest rates and the exchange rate." A further characteristic of goal-based regimes is that they are likely to be robust, as changes in the economy's structure may affect the monetary transmission process and alter the manner in which policy instruments are adjusted as functions of the state of the economy, but such changes do not alter the ultimate goals of policy.

Central bank reforms emphasizing goals, instrument independence, transparency, and accountability are not the only shape reforms could have taken. An alternative could focus on assigning objectives that, unlike price stability, are not among the ultimate objectives of macroeconomic policy. For example, during the 1970s and 1980s, the role of intermediate targets in monetary policy implementation was widely discussed, and proposals for establishing target growth rates for various monetary aggregates were common. In 1975, a U.S. House of Representatives concurrent resolution called on the Federal Reserve to publicly announce monetary growth targets. The Full Employment Act of 1978 mandated publicly announced, annual growth targets for the money supply, and the Federal Reserve was required to report to Congress on its success in achieving the targets.[16] The Federal Reserve was assigned an objective—monetary growth targets—and in principle was held accountable for achieving these objectives, but the resulting targets were not among the ultimate goals of macroeconomic policy. However, the Federal Reserve was allowed to define its growth rate targets, weakening the target's role in constraining the Federal Reserve and in promoting accountability. Any constraining effect of announced monetary growth targets was further weakened by the Federal Reserve's practice of rebasing the level of the target path for monetary aggregates annually,

[16] See Walsh (1987).

ensuring that past target growth rate misses were compounded into the level of the monetary aggregates.[17]

Intermediate targets generally served as poor performance measures for monetary policy, as the correlation between the targets and the ultimate objectives of monetary policy was often weak. In the United States, rapid monetary growth combined with falling inflation in the early 1980s made the aggregate targets poor guides for policy, and the practice of base drift, while allowing the Federal Reserve greater flexibility in setting policy, weakened the usefulness of monetary growth rate targets as a means of ensuring policy accountability.[18]

Another alternative to making inflation the central bank's performance measure is to assess policy by comparing the central bank's setting of its instrument to a benchmark rule for the policy instrument. Such a rule-based system, in the extreme, eliminates any instrument independence and removes discretion from the policy process, directly solving any problems that arise from allowing policymakers discretion in implementing policy. In fact, Barro and Gordon (1983) and Canzoneri (1985) long ago argued that, absent private central bank information about the state of the economy, the central bank should have no discretion but instead be required to follow a rule that delineates the actions it should take as a function of the state of the economy.[19]

Some rules, such as the gold standard or an exchange rate peg, remove discretion completely from the hands of the central bank. But just as an inflation-targeting regime does not need to be a regime of strict inflation targeting, a rule-based system does not need to be a strict (high-powered) regime in the sense that the central bank is allowed absolutely no discretion. A flexible rule-based regime, much

[17] For an analysis of base drift and the conditions under which it can be appropriate, see Walsh (1986). Inflation targeting leads to a similar situation in that the price level is allowed to be non-stationary. For some evidence that this is the practice in Australia, New Zealand, Sweden, and the United Kingdom but not Canada, see Ruge-Murcia (2014).

[18] In a similar manner, inflation targeting weakens accountability if price stability is the actual goal, as it is in many central bank charters.

[19] Walsh (1995b) showed that aligning the central bank's incentives with observables such as inflation overcame the private information problem highlighted by Canzoneri (1985). Athey, Atkeson, and Kehoe (2005) revisit the rules versus discretion debate in the presence of private information.

like flexible inflation targeting, would establish a rule but allow the central bank to deviate from the rule. Deviations would then need to be explained, or justified, by policymakers, just as a failure to meet an inflation target requires policymakers to explain why the target was missed. With the rule based on observable variables, such a system ensures accountability.[20] The power of the rule as a performance measure would depend on the weight given to such deviations in evaluating and holding accountable the central bank. The advantage of a rule-based system is that it increases the predictability of policy, is transparent, and simplifies the process of ensuring accountability.

Thus, if discretionary decisions by the central bank, and not political pressure from elected officials, are the source of poor monetary policy, reform must differ from the model provided by the RBNZ Act; it must constrain the central bank. As Tirole (1994) notes, rules are imposed when agents cannot be trusted with discretion. Legislating *rules* for the central bank to follow achieves this end by eliminating both goal and instrument independence. In a series of recent papers, John Taylor has argued that a commitment to a rule for monetary policy produces better outcomes than occur in regimes that emphasize central bank independence (Taylor 2011, 2012, 2013). He suggests that overall macroeconomic performance was superior during periods in which the Federal Reserve acted in a systematic, predictable manner, and that forcing the Federal Reserve to adhere more closely to a rule would improve economic outcomes. After reviewing rules versus central bank independence, he concludes that "the policy implication is that we need to focus on ways to 'legislate' a more rule-based policy" (Taylor 2011, p. 16).

Rule-based performance measures suffer from at least three potential problems. First, determining the right rule would be difficult. Even in quite simple theoretical models, the optimal instrument rule can be extremely complex (for example, see Woodford 2010). A complex rule, even if known, might be hard to explain to the public, thereby reducing the ability of a rule-based performance measure to ensure policy transparency and accountability. Second, any optimal rule is optimal only with reference to a specific model, so changes in the economy's structure or our understanding of it will produce

[20]Taylor (2012) provides an example of how the Taylor rule can be used to assess Federal Reserve performance.

changes in the optimal rule. Third, it may not always be possible to characterize policy in terms of a single instrument rule. A rule for a short-term policy interest rate would no longer be meaningful if interest rates were at the zero lower bound, nor would it give guidance for balance sheet policies. Thus, instrument rules are likely to be less robust to structural changes than goal-based systems.[21] However, early work such as Levin, Wieland, and Williams (1999) and Rudebusch (2002) suggested that simple rules may be robust to model uncertainty. These considerations argue for adopting a simple but robust rule such as the Taylor rule but one that also includes escape clauses.[22] Choosing which rule to adopt, and how accountability is to be maintained when the rule might not apply, must involve balancing the gains from limiting discretion against the costs of potentially forcing monetary policy to implement a bad rule.

Given the unprecedented actions by the Federal Reserve and other central banks during the financial crisis, it is not surprising that proposals have emerged for rule-based reforms designed to limit the Federal Reserve's discretion. In July 2014, hearings were held in the United States on H.R. 5018 which would impose several rule-based requirements on the Federal Reserve. First, the Federal Open Market Committee (FOMC) would be required to identify a directive policy rule (DPR). The DPR would identify the policy instrument and "describe the strategy or rule of the Federal Open Market Committee for the systematic quantitative adjustment of the Policy Instrument Target to respond to a change in the Intermediate Policy Inputs" (section 2C(c)(2)). Intermediate Policy Inputs, defined in section 2C(a)(4), include "any variable determined by the Federal Open Market Committee as a necessary input to guide open-market operations" but must include current inflation (together with its definition and method of calculation) and at least one of (i) an estimate of real, nominal, or potential GDP, (ii) an estimate of a monetary aggregate, or (iii) an interactive variable involving the other

[21]But alterations in the economy's structure can also affect policy goals. For example, a change in price indexation would change the definition of inflation volatility that generates inefficiencies and that should appear in the measure of social welfare.

[22]See also Taylor and Williams (2010). Svensson (2003) provides a general critique of relying on Taylor rules, while Benhabib, Schmitt-Grohé, and Uribe (2001) argue that Taylor rules do not rule out zero lower bound equilibria.

listed variables. In addition, the directive policy rule must "include a function that comprehensively models the interactive relationship between the Intermediate Policy Inputs" (section 2C(c)(3)) and "the coefficients of the Directive Policy Rule" (section 2C(c)(4)).

Perhaps more significantly in terms of constraining the Federal Reserve's flexibility, the proposed legislation also defines a reference policy rule (RPR), and section 2C(c)(6) requires that the FOMC must report "whether the Directive Policy Rule substantially conforms to the Reference Policy Rule." If it doesn't, the FOMC will need to provide a "detailed justification" for any deviation of the directive policy rule and the reference policy rule.

The proposed bill is quite specific about the reference policy rule. Section 2C(a)(9) defines the reference policy rule as the federal funds rate given by

$$i_t^{RPR} = \pi_{t-1} + 0.5 \ln\left(\frac{GDP_t}{GDP_t^{potential}}\right) + 0.5(\pi_{t-1} - 2) + 2, \quad (1)$$

where

$$\pi_{t-1} = 100\left(\frac{p_{t-1} - p_{t-5}}{p_{t-5}}\right)$$

is the inflation rate over the previous four quarters. This rule can be rewritten as

$$i_t^{RPR} = 4 + 1.5\,(\pi_{t-1} - 2) + 0.5 \ln\left(\frac{GDP_t}{GDP_t^{potential}}\right).$$

Written in this form, it is clear that it is the Taylor rule (Taylor 1993). If average inflation is equal to 2 percent and the gap between GDP and potential is zero, then the policy rate will equal 4 percent. Thus, the rule assumes an inflation target of 2 percent and an average real interest rate of 2 percent.

Federal Reserve Chairwoman Janet Yellen said, in testimony before the House Financial Services Committee (July 16, 2014), that "it would be a grave mistake for the Fed to commit to conduct monetary policy according to a mathematical rule." In contrast, John Taylor in a *Wall Street Journal* opinion piece (July 9, 2014) argued in favor of the bill. Section 2C(e)(1) does allow that the Act is not meant to require the FOMC to implement the strategy set out in the legislation if the "Committee determines that such plans cannot or should not be achieved due to changing market conditions." If such a situation occurs, the FOMC would have forty-eight hours to provide the U.S. comptroller general and Congress with an explanation and an updated directive policy rule. In turn, the comptroller general would then have forty-eight hours to conduct an audit and issue a report to determine whether the FOMC's updated directive policy rule is in compliance with the bill.

The type of rule-based accountability in the proposal contrasts sharply with goal-based accountability and central bank independence that has characterized most central bank reforms since the 1989 Reserve Bank of New Zealand Act. Under rule-based accountability, the central bank is required to specify clearly its instrument and the rule it uses to determine the setting of that instrument. Deviations from the rule are allowed, but the central bank is required to explain the rationale for any such deviations. Under goal-based accountability, the objectives of the central bank are made clear—if these are set by the government, the central bank lacks goal independence—but in the pursuit of these goals, the central bank enjoys instrument independence. In this case, the central bank is required to explain how its actions are consistent with achieving the goals.

Table 1 summarizes the general characteristics of goal-based and rule-based reforms. I exclude examples of reforms based on intermediate targets such as money growth rates, as they are inefficient systems both for achieving ultimate goals and for restricting the central bank's instrument setting. Goal-based and rule-based reforms have different implications for a central bank and for macroeconomic outcomes. They differ in terms of the type of independence the central bank enjoys, and they differ in terms of who they are designed to constrain. Both can allow for flexibility and both provide the public with the ability to assess policy and, in principle, hold the central bank accountable.

Table 1. Types of Central Bank Reforms

	Goals Based	**Rules Based**
Examples	Inflation Targeting Price-Level Targeting	Exchange Rate Pegs Gold Standard Instrument Rules (H.R. 5018)
CB Independence		
Goal	Varied	Low
Instrument	High	Low
Constrains	Central Bank Government	Central Bank
Flexibility	Varied	Varied
Transparency	Varied	High
Accountability	High	High
Robustness	High	Low

3. The Performance of Goal-Based and Rule-Based Regimes

In this section, a simple model is used to highlight the tensions that arise between accountability and flexibility under different performance measures and to explore how these tensions are addressed by goal-based and rule-based accountability. While the model used is quite simple, it helps to illustrate the effects of different policy regimes, leaving to the following section the use of an estimated model to evaluate goal-based and rule-based systems.

Let π^* be the socially optimal steady-state inflation rate, taken as exogenous and constant for simplicity, and define $\hat{\pi}_t \equiv \pi_t - \pi^*$ as actual inflation relative to the optimal rate. Assume social loss is given by

$$L_t^s = \frac{1}{2}\mathrm{E}_0 \sum \beta^i \left(\hat{\pi}_{t+i}^2 + \lambda x_{t+i}^2\right), \tag{2}$$

where $x_t \equiv x_t - x^*$ is the (log) gap between output and the socially efficient output level. Policy is delegated to a central bank with instrument independence but subject to possible political pressures that affect the goals the central bank pursues. Specifically, assume that absent any assignment of a performance measure, the central bank acts to minimize

$$L_t^{cb} = \frac{1}{2}\mathrm{E}_t^{cb} \sum \beta^i \left[\left(\hat{\pi}_{t+i} - \varphi_{t+i}\right)^2 + \lambda \left(x_{t+i} - u_{t+i}\right)^2 \right], \qquad (3)$$

where φ and u are mean-zero stochastic shocks that represent deviations of the central bank's objectives from their socially optimal values. These can be thought of as representing unmodeled political pressures affecting the policy choices of the central bank or simply as distortions introduced by the preferences of the central bank policy authorities. In keeping with the now common practice in the analysis of monetary policy, I assume a fiscal tax/subsidy policy is in place that eliminates any steady-state inefficiencies. Thus, I ignore distortions arising from attempts to systematically affect the level of steady-state output.

The economy is characterized very simply by a New Keynesian Phillips curve given by

$$\hat{\pi}_t = \beta \mathrm{E}_t \hat{\pi}_{t+1} + \kappa x_t + e_t, \qquad (4)$$

and an expectational Euler equation given by

$$x_t = \mathrm{E}_t x_{t+1} - \left(\frac{1}{\sigma}\right) \left(i_t - \mathrm{E}_t \hat{\pi}_{t+1} - \phi_t\right), \qquad (5)$$

where ϕ_t and e_t are taken to be exogenous stochastic processes. Equation (4) is consistent with the standard Calvo model if firms that do not optimally choose their price instead index their price to π^*. Under optimal discretionary policy with i.i.d. shocks, the appendix shows that the unconditional expected social loss is

$$L_t^s = \frac{1}{2}\left(\frac{1}{1-\beta}\right) \times \left[\left(\frac{\lambda}{\lambda+\kappa^2}\right) \sigma_e^2 + \left(\lambda^3 + \kappa^2\right) \left(\frac{1}{\lambda+\kappa^2}\right)^2 \left(\lambda^2 \sigma_u^2 + \kappa^2 \sigma_\varphi^2\right) \right]. \qquad (6)$$

In the absence of political distortions represented by u and φ (and maintaining the assumption of i.i.d. shocks), social loss would be

$$\frac{1}{2}\left(\frac{1}{1-\beta}\right)\left(\frac{\lambda}{\lambda+\kappa^2}\right)\sigma_e^2 \leq L_t^s.$$

I next investigate whether holding the central bank accountable for achieving a goal such as the inflation rate or for adhering to a rule for setting the instrument can help lower social loss.

3.1 Delegation

Government in a pre-game stage defines a performance measure for the central bank. A goal-based regime specifies the central bank's objectives in terms of π and/or x, the two ultimate objectives on which social welfare depends. A rule-based regime specifies that assessment of the central bank's performance is based on a comparison of the policy instrument and the value implied by a simple instrument rule. I represent each type of regime by assuming the central bank continues to have preferences over actual outcomes given by (3) but is also concerned with minimizing deviations of outcomes from the bank's assigned performance measures. The weights attached to these additional performance measures represent the power of the respective measure. Nesting both regimes, the central bank is assumed to set policy under discretion to minimize

$$L_t^{cb} = \frac{1}{2}\mathrm{E}_t^{cb}\sum \beta^i \Big[\left(\hat{\pi}_{t+i}-\varphi_{t+i}\right)^2 + \lambda\left(x_{t+i}-x_{t+i}^*\right)^2 + \tau\hat{\pi}_{t+i}^2 + \delta\left(i_{t+i}-i_{t+i}^r\right)^2\Big], \tag{7}$$

where τ is the implicit weight placed on achieving the inflation target (equivalently, the degree of central bank conservatism in the terminology of Rogoff 1985) and δ is the weight placed on setting the interest rate equal to i^r, the rate implied by the rule.[23] We can rewrite L_t^{cb} as

[23] For simplicity, I only consider goal-based regimes defined in terms of inflation and not the output gap.

$$L_t^{cb} = \frac{1}{2}\mathrm{E}_t^{cb}\sum\beta^i\left[(1+\tau)\,\hat{\pi}_{t+i}^2 - 2\varphi_{t+i}\hat{\pi}_{t+i} + \lambda x_{t+i}^2 - 2\lambda u_{t+i}x_{t+i} + \delta\left(i_{t+i} - i_{t+i}^r\right)^2\right],$$

where terms independent of policy have been dropped.[24]

Since private agents are forward looking in making decisions, optimal policy under discretion will result in lower social welfare than would the fully optimal commitment policy. The distortionary shocks φ_{t+i} and u_{t+i} also reduce welfare. The question for central bank design is whether a goal-based system with $\tau > 0$ or a rule-based system with $\delta > 0$ can, in an environment of discretionary decision making, improve welfare. In other words, in a pre-game stage, would the government choose non-zero values of τ and/or δ if it wished to minimize (2)?

I first consider the case of a goal-based regime in which $\delta = 0$ but τ is chosen optimally. Then the case of a rule-based regime with $\tau = 0$ and δ chosen optimally is analyzed. Finally, the case in which both τ and δ are jointly chosen is considered.

3.2 The Assignment of Goals

When the government assigns objectives to the central bank based on realized inflation, we have the case studied in Walsh (2003a). The analysis in that paper only considered distortionary shocks affecting the output objective of policy (i.e., $u \neq 0$ but $\varphi \equiv 0$) and also assumed the central bank had imperfect information about cost shocks, an extension I ignore here.

With $\delta = 0$, the central bank's problem under discretion can be written as

$$\min_{\hat{\pi}_t, x_t, i_t} \frac{1}{2}(1+\tau)\,\hat{\pi}_t^2 - \varphi_t\hat{\pi}_t + \frac{1}{2}\lambda x_t^2 - \lambda u_t x_t$$

subject to (4) and (5). The nominal interest rate i is the instrument of monetary policy. Shocks are assumed to be i.i.d.[25] It is

[24] For evidence that the Federal Reserve has implicitly placed some weight on the Taylor rule, see Kahn (2012) and Ilbas, Roisland, and Sveen (2013).

[25] The case of serially correlated shocks is dealt with in the numerical analysis of section 4 based on an estimated model.

straightforward to show that equilibrium inflation and the output gap are given by[26]

$$\hat{\pi}_t = \left[\frac{\kappa\lambda u_t + \kappa^2\varphi_t + \lambda e_t}{\lambda + \kappa^2(1+\tau)}\right]$$
$$x_t = \left[\frac{\lambda u_t + \kappa\varphi_t - \kappa(1+\tau)e_t}{\lambda + \kappa^2(1+\tau)}\right].$$

The central-bank-design problem is to pick τ to minimize the unconditional expectation of social loss. The appendix shows that the optimal value of τ is given by

$$\tau^* = \left(\frac{\lambda + \kappa^2}{\lambda^2}\right)\left(\frac{\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2}{\sigma_e^2}\right) \geq 0. \tag{8}$$

If $\varphi_t \equiv 0$, (8) reduces to the case considered in Walsh (2003a). In this case, $\tau^* = (\lambda + \kappa^2)(\sigma_u^2/\sigma_e^2)$ increases linearly in λ and in the volatility of the distortionary shock to policymakers' goals (σ_u^2) relative to the volatility of cost shocks (σ_e^2). In the absence of both distortionary shocks u and φ, $\tau^* = 0$, consistent with the findings of Clarida, Galí, and Gertler (1999), who showed there is no gain from appointing a Rogoff conservative central banker when the cost shock is serially uncorrelated. When distortionary shocks are present, τ^* is positive even when shocks are serially uncorrelated. The greater the variability of the political distortions represented by u and φ, the larger is the optimal τ and the more the central bank needs to be made accountable based on $\hat{\pi}_t$. Equivalently expressed, the more variable the wedge between social objectives and goals pursued by the central bank, the more high powered (or the stricter) the inflation-targeting regime needs to be.

A rise in the volatility of cost shocks increases the potential value of stabilization policy and so τ^* falls, as a more flexible inflation-targeting regime is desirable. With more potential gain from flexibility, the optimal regime assigns less weight to achieving the inflation target. Importantly, τ^* is independent of aggregate demand shocks operating through the expectational IS relationship, as the central

[26]See the appendix for details.

bank always has an incentive to neutralize the impact of such shocks on inflation and the output gap.

3.3 The Assignment of Rules

Now suppose a legislated instrument rule is used to access the central bank's performance. In contrast to objectives based on an ultimate goal such as inflation, the central bank's objectives are distorted based on how it sets its actual policy instrument. In terms of (7), $\tau = 0$ but δ may be non-zero. The central bank's problem takes the form

$$\min_{\hat{\pi},x,i}\left[\frac{1}{2}\hat{\pi}_t^2 - \varphi_t\hat{\pi}_t + \frac{1}{2}\lambda x_t^2 - \lambda u_t x_t + \frac{1}{2}\delta\left(i_t - i_t^r\right)^2\right]$$

subject to (4) and (5). Because the central bank is judged in part on how it sets its instrument, the expectational IS equation becomes relevant for its policy choice. Assume that the reference rule is defined by

$$i_t^r = \psi_\pi\hat{\pi}_t + \psi_x x_t.$$

The appendix shows that the first-order conditions for the central bank's problem imply

$$i_t = i_t^r + \frac{1}{a\delta}\left[\kappa\left(\hat{\pi}_t - \varphi_t\right) + \lambda\left(x_t - u_t\right)\right],$$

where

$$a \equiv \sigma + \psi_x + \kappa\psi_\pi.$$

In the absence of the rule-based performance measure, the central bank would set the term in brackets equal to zero. The greater the value of δ—that is, the more costly it becomes for the central bank to deviate from the reference policy rule—the smaller the role this unconstrained optimality condition plays in the setting of i_t and the closer i_t comes to equaling the benchmark rule value.

For the case of serially uncorrelated shocks, equilibrium inflation and the output gap are equal to

$$\hat{\pi}_t = \left[\frac{\kappa\alpha\delta\phi_t + \kappa\lambda u_t + \kappa^2\varphi_t}{\lambda + \kappa^2 + a^2\delta}\right] + \left[\frac{\lambda + a\delta\left(\sigma + \psi_x\right)}{\lambda + \kappa^2 + a^2\delta}\right] e_t$$

$$x_t = \frac{\alpha\delta\phi_t + \lambda u_t + \kappa\varphi_t - \left(\kappa + a\delta\psi_\pi\right) e_t}{\lambda + \kappa^2 + a^2\delta},$$

and social loss is

$$\mathcal{L} = \frac{1}{2}a^2\left(\lambda + \kappa^2\right)\left[\frac{\delta}{\lambda + \kappa^2 + a^2\delta}\right]^2 \sigma_\phi^2$$

$$+ \frac{1}{2}\lambda^2\left(\lambda + \kappa^2\right)\left[\frac{1}{\lambda + \kappa^2 + a^2\delta}\right]^2 \sigma_u^2$$

$$+ \frac{1}{2}\kappa^2\left(\lambda + \kappa^2\right)\left[\frac{1}{\lambda + \kappa^2 + a^2\delta}\right]^2 \sigma_\varphi^2$$

$$+ \frac{1}{2}\left\{\frac{\left[\lambda + a\delta\left(\sigma + \psi_x\right)\right]^2 + \lambda\left[\kappa + a\delta\psi_x\right]^2}{\left[\lambda + \kappa^2 + a^2\delta\right]^2}\right\}\sigma_e^2.$$

Minimizing $\mathcal{L}$ with respect to δ implies the optimal weight on the rule-based objective is (see the appendix)

$$\delta^* = \frac{\left(\lambda + \kappa^2\right)\left(\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2\right)}{\left(\lambda + \kappa^2\right)^2\sigma_\phi^2 + \Lambda\sigma_e^2}, \tag{9}$$

where

$$\Lambda \equiv \left[\left(\sigma + \psi_x\right)\kappa - \lambda\psi_\pi\right]^2. \tag{10}$$

To help interpret the expression for δ^*, assume initially that there are no aggregate demand shocks ($\phi \equiv 0$). In this special case,

$$\delta^* = \left(\frac{\lambda + \kappa^2}{\Lambda}\right)\left(\frac{\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2}{\sigma_e^2}\right). \tag{11}$$

Comparing (11) to (8) shows that both depend on $\left(\lambda + \kappa^2\right)\left(\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2\right)/\sigma_e^2$; as the variability of distortionary shocks u and φ increases relative to the variability of cost shocks e, the optimal τ^* and the optimal δ^* both increase. They do so for the same reason: allowing the central bank less flexibility becomes desirable when distortionary shifts in goals are more variable. The optimal τ^* and δ^* are both decreasing in the volatility of inflation shocks; as the scope for welfare-improving stabilization policy increases, the cost of distorting the central bank's objectives either by requiring it to place more weight on inflation variability or on matching the benchmark instrument rule becomes more costly.

The expression for δ^* given in (11) was derived for arbitrary policy response coefficients ψ_x and ψ_π. Suppose instead that these were optimally chosen. For example, continuing with the special case of no demand shocks and serially uncorrelated cost and distortionary shocks, the optimal interest rate rule can be expressed in terms of a reaction to either the output gap or to inflation, that is, only one response coefficient is needed. Let $\psi_x = 0$; the optimal response to inflation is then equal to $\psi_\pi^* = \sigma\kappa/\lambda$. One can show that

$$\lim_{\psi_\pi \to \psi_\pi^*} \delta^* \to \infty.$$

When the benchmark rule is equal to the optimal rule and there are no aggregate demand shocks, the central bank should not be allowed any flexibility.

Equation (11) applied when there were no shocks to the Euler equation, corresponding to the case of a constant equilibrium real interest rate. In the presence of shocks to the equilibrium real interest rate (i.e., $\phi \neq 0$), the optimal penalty on deviations from the rule can be written as

$$\delta^* = \left(\frac{\lambda + \kappa^2}{\Delta}\right)\left(\frac{\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2}{\sigma_e^2}\right) = \left(\frac{\lambda^2}{\Delta}\right)\tau^*,$$

where

$$\Delta \equiv \Lambda + \left(\lambda + \kappa^2\right)^2\left(\frac{\sigma_\phi^2}{\sigma_e^2}\right) \geq \Lambda.$$

Thus, demand shocks ($\sigma_\phi^2 > 0$) call for putting less weight on deviations from the rule. This result is very intuitive—the specified rule does not allow for interest rate movements directly in response to demand shocks; an optimal policy would. Therefore, as demand shocks become a larger source of volatility, the optimal δ falls. If $\psi_x = 0$ and $\psi_\pi = \psi_\pi^*$ so that the assigned rule is consistent with the optimal response to inflation shocks, $\Lambda = 0$ and

$$\delta^* = \left(\frac{1}{\lambda + \kappa^2}\right)\left(\frac{\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2}{\sigma_\phi^2}\right) \geq 0.$$

In this case, the optimal value of δ is non-negative, independent of inflation shocks, but decreasing in the variance of demand shocks.

3.4 Jointly Optimal Goal- and Rule-Based Regimes

The special cases just considered showed how setting τ and δ both involve a similar trade-off between the benefits of reducing flexibility to limit distortions and the costs of reducing the ability of the central bank to pursue socially desirable stabilization policies. The dependence of the power of goal-based and rule-based measures on the relative volatility of underlying shocks is reminiscent of the classic Poole results on instrument choice (Poole 1970). Poole showed that an interest rate instrument performed better than a monetary aggregate instrument in the face of financial market shocks, while the reverse was true in the face of aggregate demand disturbances. In a similar manner, equations (8) and (9) suggest that a goal-based performance measure may be best if shocks to aggregate demand dominate, while a rule-based measure may have advantages if shocks to inflation dominate. In general, Poole's analysis implies that optimal simple rules will depend on the relative variances of the model's underlying shocks.[27] Similarly, one might expect that the weight to give to a goal-based performance measure relative to a rule-based measure may depend on the relative volatility of the model's shocks. The fact that, as shown by (8) and (9), the optimal τ is independent of demand-shock volatility but decreasing in cost-shock volatility while δ is decreasing in the volatility of demand shocks suggests there might be potential gains from using both forms of performance measures.

[27] See Walsh (2010, pp. 513–21).

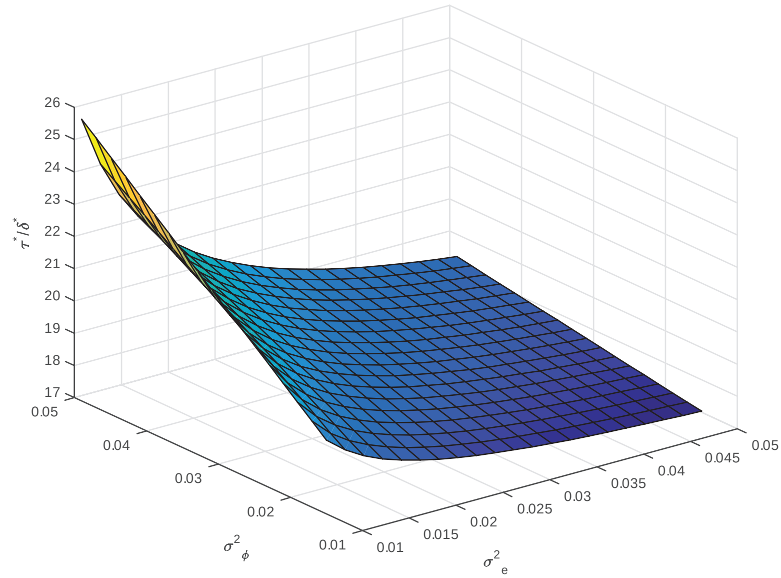
To assess the joint determination of the optimal values of τ and δ, I set $\kappa = 0.172$, consistent with a Calvo model of price adjustment with the fraction of non-optimally adjusting firms equal to 75 percent per quarter combined with log-utility ($\sigma = 1$) and a Frisch elasticity of labor supply of 1. For the baseline, I set the standard deviations of all the shocks equal to 0.025. The parameters of the rule are set equal to their Taylor values of $\psi_\pi = 1.5$ and $\psi_x = 0.125$. I then solve numerically for the values of τ^* and δ^* that minimize the unconditional expectation of social loss, given by (2). I set λ equal to the value appropriate if (2) is interpreted as a second-order approximation to the welfare of the representative household.[28] The analytic results for the optimal values of τ and δ taken individually showed that the variances of demand and cost shocks played a key role, so I investigate how variations in these variances affect the optimal power of the goal-based versus rule-based regimes.

To assess the relative roles of τ and δ when both are chosen optimally, I report the ratio of their optimal values, as the variances of the disturbances vary. Figure 1 plots τ^*/δ^* as a function of the variances of the fundamental demand and cost shocks σ_ϕ^2 and σ_e^2. Both τ^* and δ^* are positive, indicating a role for goals and rules, but as suggested by (8) and (9), the relative weight on goals as measured by τ rises as demand shocks increase in volatility, while the weight on rules as measured by δ rises as cost shocks become more volatile. For the parameters considered here, however, the weight given to deviations from the inflation target in assessing the central bank's performance is much larger than the optimal weight placed on deviations from the Taylor rule.

According to (8) and (9), an increase in $\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2$—that is, an increase in the volatility of the distortionary shifts in objectives—would increase τ^* when $\delta = 0$ and δ^* when $\tau = 0$. In fact, these two equations imply that the ratio between τ^* and δ^* is independent of

[28]This implies a value of λ equal to $(\kappa/\theta^p)(1+\eta)/(1-a)$, where θ^p is the price elasticity of demand faced by firms, η is the inverse wage elasticity of labor supply, and $1-a$ is the elasticity of output with respect to labor. For $\theta^p = 9$, $\eta = 1$, and $a = 0.3$, this implies $\lambda = 0.0545$. See (21).

Figure 1. Ratio of Optimal τ to Optimal δ when Jointly Optimized as Function of the Variances of Demand (σ_ϕ^2) and Cost (σ_e^2) Shocks



the volatility of the distortionary shocks u and φ but depends on the relative variances of demand and cost shocks:

$$\frac{\tau^*}{\delta^*} = \left(\frac{\lambda + \kappa^2}{\lambda^2}\right)\left(\frac{\sigma_\phi^2}{\sigma_e^2}\right) + \frac{\Lambda}{\lambda^2}.$$

This continues to be true when τ and δ are optimally chosen jointly; they both increase with the volatility of the distortionary shocks u and φ, rising proportionately so that their ratio remains constant as $\lambda^2\sigma_u^2 + \kappa^2\sigma_\varphi^2$ increases. Thus, figure 1 is independent of $\lambda^2\sigma_u^2+\kappa^2\sigma_\varphi^2$. While the optimal measure of performance places some weight on deviations from the inflation goal and deviations from the interest rate rule, the fundamental choice between a goal-based and a rule-based performance measure depends on the relative importance of the underlying shocks to private-sector consumption and price-setting behavior.

3.5 Conclusions from the Simple Model

The simple model utilized in this section suggests that when political (or other) pressures cause transitory distortions to the objectives the central bank pursues relative to society's goals, there can be a role for both goal-based reforms and rule-based reforms. Both establish performance measures that affect the central bank's incentives and therefore affect policy choices. When each type of reform is considered in isolation, analytical expressions could be obtained for the optimal weight to place on achieving stable inflation and for punishing deviations from the Taylor rule. These expressions for τ^* and δ^* showed that increases in the variance of shocks that distorted the central bank's objectives called for increasing the power of both types of accountability measures. Increased volatility of cost shocks reduces the weight that should be placed on inflation goals, as limiting the flexibility to respond to these shocks becomes more costly. Under goal-based accountability, demand shocks do not affect the optimal power, as the central bank already has an incentive to neutralize demand shocks. In contrast, demand shocks reduce the optimal power of the rule-based system since the Taylor rule does not allow for shifts in the equilibrium real rate of interest.

4. Goals and Rules in an Estimated Model with Sticky Prices and Wages

The previous section considered the use of goal-based and rule-based policy regimes using a very simple model in which some analytical results could be obtained and some results required a calibrated version of the model. In this section I consider the effects of τ and δ in an estimated New Keynesian model of sticky prices and wages based on Erceg, Henderson, and Levin (2000) (henceforth, EHL). As was clear from the expressions for τ^* and δ^* obtained in the previous section, their values will depend importantly on the relative volatility of different shocks. Thus, obtaining these values from an estimated model will provide a more realistic assessment of the performance of goal- versus rule-based incentive systems.

The basic model is standard and details of its derivation can be found in Erceg, Henderson, and Levin (2000) or chapter 6 of Galí (2008). The model takes the following form:

$$y_t = \mathrm{E}_t y_{t+1} - [i_t - \mathrm{E}_t \pi_{t+1} - (1 - \rho_\chi)\, \chi_t] \tag{12}$$

$$(1 + \beta\delta_p)\, \pi_t = \beta \mathrm{E}_t \pi_{t+1} + \delta_p \pi_{t-1} + \kappa_p\, (\omega_t - mpl_t + \mu_t^p) \tag{13}$$

$$(1 + \beta\delta_w)\, \pi_t^w = \beta \mathrm{E}_t \pi_{t+1}^w + \delta_w \pi_{t-1}^w + \kappa_w\, (mrs_t + \mu_t^w - \omega_t) \tag{14}$$

$$\omega_t = \omega_{t-1} + \pi_t^w - \pi_t + e_{z,t} \tag{15}$$

$$mpl_t = -a h_t \tag{16}$$

$$mrs_t = y_t + \eta h_t - \chi_t \tag{17}$$

$$y_t = (1 - a)\, h_t \tag{18}$$

$$g_t = y_t - y_{t-1} + e_{z,t}, \tag{19}$$

where y is output, ω the real wage, π inflation, π^w wage inflation, mpl the marginal product of labor, mrs the marginal rate of substitution between leisure and consumption, h hours, and g the growth rate of output. Aggregate productivity is assumed subject to a random-walk process with innovation $e_{z,t}$, so output, the real wage, the marginal product of labor, and the marginal rate of substitution between leisure and consumption are all defined as log-deviations from the permanent component of productivity. Other variables are expressed as log-deviations from their steady-state values (including zero steady-state rates of price and wage inflation). χ, μ^p, and μ^w are stochastic shocks to the marginal utility of consumption, price markups, and wage markups, all assumed to follow AR(1) processes with, for example, ρ_χ denoting the AR(1) coefficient for χ and $e_{\chi,t}$ denoting its innovation. The first equation is a standard Euler condition linking the marginal utility of consumption in periods t and $t+1$. The next two equations are reduced-form expressions for price and wage inflation, where δ_p and δ_w are the degrees of indexation in price and wage setting. The parameter η is the inverse wage elasticity of labor supply; $1 - a$ is the elasticity of output with respect to hours, the only variable input to production. To be consistent with the assumed unit-root process in productivity, the elasticity of intertemporal substitution in consumption is set equal to 1.

The elasticity of inflation with respect to real marginal cost is equal to

$$\kappa_p = \frac{(1-\varphi^p)(1-\beta\varphi^p)}{\varphi^p}\frac{1-a}{1-a+a\theta^p},$$

where $1-\varphi^p$ is the fraction of firms optimally adjusting price each period and θ^p is the price elasticity of demand facing individual firms. Similarly, the elasticity of wage inflation with respect to the gap between the marginal rate of substitution between leisure and consumption and the real wage is

$$\kappa_w = \frac{(1-\varphi^w)(1-\beta\varphi^w)}{\varphi^w}\frac{1}{1+\eta\theta^w},$$

where $1-\varphi^p$ is the fraction of wages optimally adjusting each period and θ^w is the wage elasticity of demand for individual labor types.

For estimation purposes, the model is closed with a specification of monetary policy, where the nominal interest rate i is treated as the policy instrument. I assume a standard Taylor rule with inertia of the form

$$i_t = \rho_i i_{t-1} + (1-\rho_i)(\phi_\pi \pi_t + \phi_g y_t) + v_t,$$

where v is an exogenous policy shock.

4.1 Estimation

The model is estimated by Bayesian methods over the period 1984:Q1–2007:Q4, corresponding to the Great Moderation. A similar version of the EHL model has been estimated over 1984:Q1–2008:Q2 by Casares, Moreno, and Vázquez (2011). I base my priors partially on their results, but I follow Chen, Curdia, and Ferrero (2012) in choosing prior distributions of beta for parameters constrained to be between 0 and 1 and gamma for parameters that should be positive. Output growth, inflation, wage inflation, and the nominal interest rate are treated as observables. Output is measured by chained real GDP deflated by the civilian population aged sixteen and over. Inflation is measured by the log-change in the GDP deflator, while wage inflation is the log-change in hourly compensation in the non-farm business sector. The interest rate is the effective federal funds rate.

Table 2. Prior and Posterior Distributions: Structural Parameters

	Priors			Posterior		
	Prior Dist.	**Mean**	**S.D.**	**Mean**	**5%**	**95%**
Structural Parameters						
η	Gamma	4.34	0.25	3.7812	2.6792	4.6645
δ_p	Beta	0.50	0.15	0.3690	0.3090	0.4410
δ_w	Beta	0.50	0.15	0.2325	0.2000	0.2606
φ_p	Beta	0.75	0.10	0.2081	0.0914	0.3218
φ_w	Beta	0.75	0.10	0.1891	0.0703	0.2946
Monetary Policy						
ρ_i	Beta	0.83	0.10	0.5144	0.5000	0.5329
ϕ_π	Gamma	2.00	0.25	2.7303	2.4659	2.9993
ϕ_g	Gamma	0.35	0.05	0.4404	0.3822	0.5000
Disturbances						
ρ_χ	Beta	0.9	0.2	0.9015	0.8692	0.9350
ρ_{μ^p}	Beta	0.9	0.2	0.9886	0.9646	0.9999
ρ_{μ^w}	Beta	0.9	0.2	0.1421	0.0100	0.2937
ρ_υ	Beta	0.3	0.2	0.4634	0.3611	0.5595
σ_z	Invg	1.0	0.2	0.6567	0.5766	0.7324
σ_χ	Invg	1.0	0.2	1.1921	0.9488	1.3864
σ_υ	Invg	1.0	0.2	0.4412	0.4109	0.4705
σ_{μ^p}	Invg	1.0	3.0	1.2011	1.0027	1.3801
σ_{μ^w}	Invg	1.0	3.0	4.9443	3.9333	5.9998

All four observables are measured at quarterly rates. The values $\sigma = 1, \beta = 0.99, a = 0.36, \theta^p = 9$, and $\theta^w = 4.5$ were fixed, where the latter two values follow Galí (2013). Table 2 reports the prior distribution, means, and standard deviations, together with the posterior means and confidence intervals of the estimated parameters.[29]

[29]The estimation period is chosen to exclude the post-2008 period during which the federal funds rate was effectively at zero. The implications of the zero lower bound for goal-based and rule-based performance masures are discussed in the concluding section.

4.2 Welfare Measures

In viewing central bank design as an issue of delegation, the objectives pursued by the central bank may differ from those of society, either because the central bank's evaluation of economic outcomes differs inherently from society's or because the central bank has been assigned objectives that differ from those of society. The former case corresponds to Rogoff's conservative central banker, a policymaker whose preference for low and stable inflation is greater than that of the public. The latter is the case considered in this paper in which policymakers share society's preferences but have been assigned objectives that may differ from those of society. In either case, it is necessary to specify two sets of preferences—those taken to represent society's and those that underlie the central bank's policy choices.

In specifying these preferences, much of the monetary policy literature, including work on inflation targeting, takes the objectives of the central bank to be represented by a quadratic loss function in inflation squared (or squared deviations of inflation from target) and an output gap squared. These objectives are then also implicitly identified with those of society. Under a delegation scheme, society's and the central bank's objectives could each be represented by ad hoc quadratic loss functions, but the two loss functions may differ. Alternatively, in models based on the preferences of the individual agents populating the economy, outcomes can be evaluated in terms of their implications for the welfare of the representative household. If a welfare-based measure is used to represent society's preferences, the objectives of the central bank could take one of two basic forms. One could still represent the central bank's objectives by a standard quadratic loss function augmented by the performance measures assigned to the bank. Or one could assume the policymaker cares about the welfare of the representative household, in addition to the performance measures they have been assigned. Each of these alternatives could then allow for distortionary shocks to the policymaker's output objective. Table 3 summarizes the combinations of objective functions that could be used to measure society's welfare and to represent the central bank's objectives. In the analysis of this section, six of the eight possible combinations of objectives will be considered; these combinations are indicated in the table. I have

Table 3. Alternative Welfare Measures

		Society	
		Ad Hoc	**Welfare Based**
Central Bank	Ad Hoc	X	X
	Ad Hoc with Distorted Output Gap	X	X
	Welfare Based		X
	Welfare Based with Distorted Output Gap		X

excluded the cases in which society's preferences are given by an ad hoc loss function while the central bank uses the welfare of the representative household to evaluate outcomes, as these combinations of preferences seem of limited relevance.

The ad hoc measure used to evaluate outcomes from society's perspective is taken to be

$$L_t^{s,adhoc} = \frac{1}{2}\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \left(\hat{\pi}_{t+i}^2 + \lambda_x x_{t+i}^2\right), \tag{20}$$

while the welfare-based measure is taken to be a second-order approximation to the welfare of the representative household, where the approximation is taken around the economy's zero-inflation efficient equilibrium.[30] In the context of the sticky-price, sticky-wage model, this is given by (see Erceg, Henderson, and Levin 2000)

$$L_t^{s,welf} = \frac{1}{2}\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \Big[\left(\hat{\pi}_{t+i} - \delta_p \hat{\pi}_{t+i-1}\right)^2 + \lambda_x x_{t+i}^2 + \lambda_w \left(\hat{\pi}_{t+i}^w - \delta_w \hat{\pi}_{t+i-1}^w\right)^2\Big], \tag{21}$$

where

$$\lambda_x = \left(\frac{\kappa_p}{\theta^p}\right)\left(\frac{1+\eta}{1-a}\right)$$

[30] I assume that fiscal taxes and/or subsidies are in place to ensure the steady-state allocation is efficient.

$$\lambda_w = (1-a)\left(\frac{\kappa_p}{\kappa_w}\right)\left(\frac{\theta^w}{\theta^p}\right).$$

Since the weight on output-gap volatility in $L_t^{s,adhoc}$ is ad hoc, I employ the same value for λ_x in (20) as for λ_x in (21). Based on the estimated parameters reported in table 1, $\lambda_x = 0.1486$ and $\lambda_w = 0.4061$.

The central bank is assumed to minimize a loss function that is augmented by the performance measures which place additional weight on inflation volatility and deviations from an instrument rule:

$$L_t = L_t^{cb} + \frac{1}{2}\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \left[\tau \hat{\pi}_{t+i}^2 + \delta \left(i_{t+i} - i_{t+i}^r\right)^2\right],$$

where L_t^{cb} is the central bank's loss function in the absence of performance measures. Four alternative specifications for L_t^{cb} are used. These differ according to whether an ad hoc quadratic loss function or the welfare approximation is used and whether, for each of these loss functions, the central bank is concerned with x_{t+i}^2 or with the distorted gap $(x_{t+i} - u_{t+i})^2$. For example, if $u_t \equiv 0$ and the central bank employs an ad hoc quadratic loss function, policy will aim to minimize

$$\frac{1}{2}\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \left[\hat{\pi}_{t+i}^2 + \lambda_x x_{t+i}^2 + \tau \hat{\pi}_{t+i}^2 + \delta \left(i_{t+i} - i_{t+i}^r\right)^2\right]. \tag{22}$$

If the central bank's gap objective is distorted, policy will minimize

$$\frac{1}{2}\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \left[\hat{\pi}_{t+i}^2 + \lambda_x \left(x_{t+i} - u_{t+i}\right)^2 + \tau \hat{\pi}_{t+i}^2 + \delta \left(i_{t+i} - i_{t+i}^r\right)^2\right]. \tag{23}$$

A similar distinction will arise if the central bank is concerned with minimizing (21) or (21) with x_t^2 replaced by $(x_t - u_t)^2$.

Finally, the reference policy rule defining i_t^r is given by

$$i_t^r = 1.5\pi_t + 0.125 z_t, \tag{24}$$

Table 4. Optimal τ and δ, Taylor Rule in π and y

	Social Loss			
	(1) Ad Hoc (eq. 20)		(2) Welfare (eq. 21)	
Central Bank Loss	τ*	δ*	τ*	δ*
(1) Ad Hoc: π, x	4.04	0	1.37	0
(2) Ad Hoc: $\pi, x - u$	12.95	0	6.15	0
(3) Welfare			0.33	0
(4) Welfare in $x - u$			1.54	0

where z_t is a measure of real activity. Two alternatives for z_t will be considered: x_t, the gap between output and the efficient level of output, and y_t, output relative to the permanent component of output, interpreted as corresponding to output relative to trend.

4.3 Results

As a starting point, consider the case in which social loss is measured by the standard quadratic loss function given by (20), and the central bank's objective is (22). Assume $z_t = y_t$ in (24) so the reference policy rule includes inflation and the gap between output and potential as in the reference policy rule proposed in H.R. 5018. The model given by (12)–(19) is solved over a grid of values for τ and δ under the optimal discretionary policy designed to minimize (22). For each combination, social loss measured by (20) is evaluated to obtain the values τ^* and δ^* that minimize social loss.

Row 1, column 1 of table 4 shows that $\tau^* > 0$ but $\delta^* = 0$ when a standard quadratic loss function in inflation and the efficiency output gap is used to represent both social loss and the central bank's preferences. Because there is no distortion appearing directly in the central bank's loss function, i.e., $u_t \equiv 0$ and the central bank cares about $\hat{\pi}_t^2$ and x_t^2, the only role for the performance measures is to address the dynamic inefficiency of discretionary policy. Recall that Clarida, Galí, and Gertler (1999) showed that in the presence of serially correlated cost shocks, as is the case here, having the central bank place more weight on its inflation goal (relative to the true social loss function) would lead to improved outcomes.[31] In contrast, the rule-based performance measure receives zero weight.

Now suppose the distortionary shock u_t that affects the output goal pursued by the central bank is added, so that the central bank seeks to minimize (23). Since shocks to the central bank's preferences were not incorporated into the estimated model, I arbitrarily set $\sigma_u = 1.0$ (1 percent). Going from row 1, column 1 of table 4 to row 1, column 2 shows that the optimal value of τ^* increases. As discretionary policy now suffers from the distortions in the central bank's output goal and those arising from discretion, the optimal power of the goal-based performance measure rises. As expected from the results of section 3, adding this distortion significantly increases τ^* (from 4.04 to 12.95). The optimal δ^* is still equal to zero.

Results are similar when the welfare loss (21) is used to evaluation outcomes. Whether the central bank's objectives are based on the ad hoc loss function (22) (row 1, column 2) or (23) that includes a distorted output-gap objective (row 2, column 2), it is optimal to rely solely on the goal-based performance measure ($\tau^* > 0$, $\delta^* = 0$).

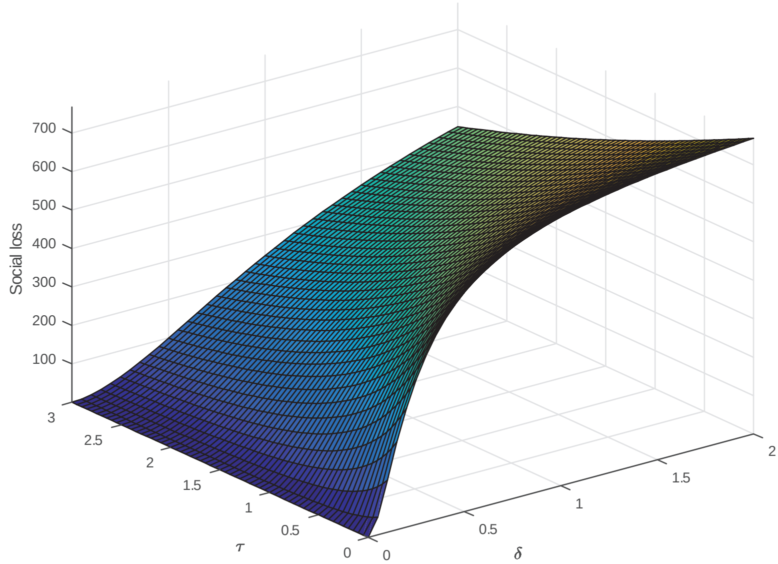
Now suppose the central bank cares about social welfare as well as its assigned performance measures. That is, the central bank attempts to minimize

$$\frac{1}{2}\mathrm{E}_t \sum_{i=0}^{\infty} \beta^i \Big[\left(\hat{\pi}_{t+i} - \delta_p \hat{\pi}_{t+i-1}\right)^2 + \lambda_x x_{t+i}^2 + \lambda_w \left(\hat{\pi}_{t+i}^w - \delta_w \hat{\pi}_{t+i-1}^w\right)^2 + \tau \hat{\pi}_{t+i}^2 + \delta \left(i_{t+i} - i_{t+i}^r\right)^2 \Big]. \quad (25)$$

When the central bank cares about the welfare-based measure of loss, whether distorted by shocks to its output objective or not (rows 3 and 4, column 2), $\tau^* > 0$ and $\delta^* = 0$. Notice that the optimal power of the performance measure (τ^*) falls when the central bank cares about the welfare-based loss (compare row 1 and 2 with rows 3 and 4). Figure 2 shows how τ and δ affect welfare-based social loss when the central bank also cares about the welfare-based loss function but with distortions to its output objective (corresponding to row 4, column 2 of table 5). Loss quickly becomes extremely large as δ increases above zero. It increases so quickly that the

[31]See also Tillmann (2012).

Figure 2. Loss Rises Quickly with δ when the Reference Policy Rule Depends on y



Notes: Social loss is given by (21) and central bank loss by (25), distorted by the presence of u shocks to the output-gap objective.

Table 5. Optimal τ and δ, Taylor Rule in π and x

	Social Loss			
	(1) Ad Hoc (eq. 20)		**(2) Welfare (eq. 21)**	
Central Bank Loss	τ^*	δ^*	τ^*	δ^*
(1) Ad Hoc: π, x	6.44	1.19	0.24	0.70
(2) Ad Hoc: $\pi, x - u$	11.26	2.38	0.00	1.50
(3) Welfare			26.21	11.36
(4) Welfare in $x - u$			36.05	12.22

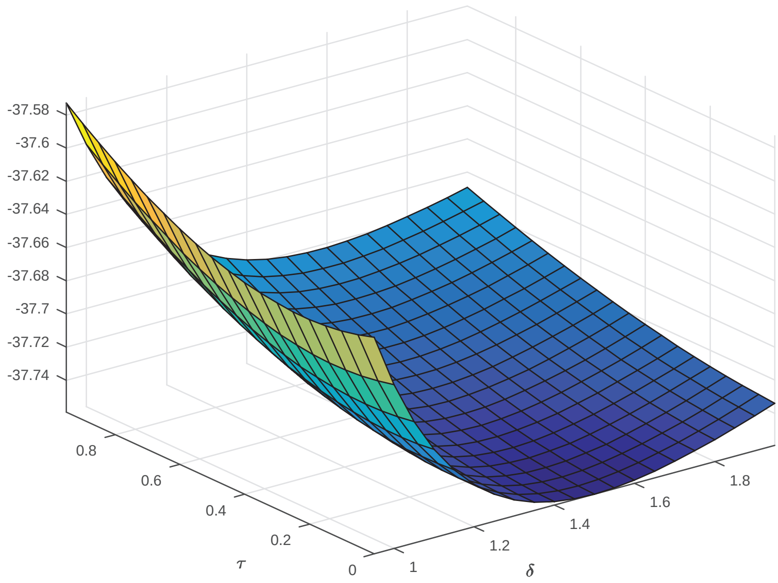
scale of the figure obscures the way loss varies with τ when δ is fixed at its optimal value of zero, making it hard to discern that $\tau^* = 1.54$. While setting τ equal to its optimal value reduces loss by 16 percent relative to the $\tau^* = \delta^* = 0$ case, increasing δ from 0 to just 0.05 when $\tau = 0$ leads to an increase in social loss by a factor of almost 50.

The results reported in table 4 can be summarized briefly; for all combinations of loss functions for the central bank and the measure of social loss, whether the central bank's output target is distorted or not, the optimal weight to place on the goal-based performance measure (τ) is positive while the optimal weight to place on the rule-based performance measure (δ) is zero.

Now assume $z_t = x_t$ in (24) so that the reference policy rule includes inflation and the gap between output and its efficient level. In this case, the reference rule is defined in a manner that is more consistent with the underlying model. Results are shown in table 5. Now, $\delta^* > 0$ for all six different combinations considered. Row 1, column 1 of table 5 shows that when a standard quadratic loss function in inflation and the efficiency output gap is used to represent social loss and the central bank's preferences, it is optimal to employ both a goal-based system (i.e., $\tau^* > 0$) and a rule-based system ($\delta^* > 0$). Both performance measures are used in this case to address the dynamic inefficiency of discretionary policy. Adding the distortion to the central bank's output goal (row 2, column 1) increases the power of both performance measures. For this case with two distortions, the two performance measures serve to some degree as substitutes. For example, if either τ or δ are set to zero, there is a large reduction in social loss as the other increases from zero. The gain from setting τ optimally when $\delta = 0$ is approximately the same as that obtained by setting δ optimally when $\tau = 0$. However, if either is set at their optimal value, the further gain from employing the other performance measure is relatively small.

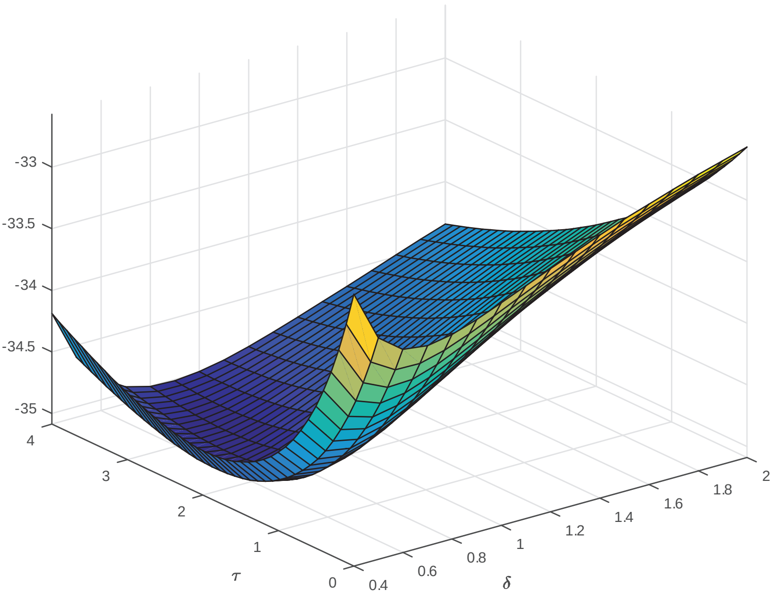
Rather than using an ad hoc loss function to assess outcomes as τ and δ vary, suppose the welfare-based loss function (21) is used to evaluate social loss. Assume policy is still determined by the central bank to minimize the ad hoc quadratic loss function (22) in $\hat{\pi}_t^2$ and x_t^2. Optimal values of τ and δ for this case are shown in rows 1 and 2, column 2 of table 5. The weights on both the goal-based and the rule-based performance measures fall relative to the case when the ad hoc loss function was used to measure social loss. The reduction in τ^* when welfare is measured by (21) rather than the ad hoc (20) is large, from 6.44 to 0.24 when $u_t \equiv 0$, while δ^* falls by over 40 percent. But perhaps more interesting is the result in row 2, column

Figure 3. When the Reference Policy Rule Is Based on $\hat{\pi}$ and x, Social Loss Is Given by (21), and the Central Bank's Loss Is (23), $\tau^* = 0$, and $\delta^* > 0$ (compare with figure 2)



2. If the central bank's output-gap target is subject to stochastic distortion as in (23), the optimal scheme involves only the rule-based performance measure ($\tau^* = 0$). This result is consistent with the idea that a rule-based performance measure is a means of restricting central bank discretion. Figure 3 shows the percent reduction in social loss as a function of τ and δ. Loss clearly declines as δ rises from zero; in contrast, the reduction in loss is relatively flat as τ varies for a fixed δ. In any case, the effects on loss as τ and δ vary is small. The results from section 3.4 indicated τ^* and δ^* would depend on the relative volatilities of the underlying shocks. Redoing the case corresponding to row 2, column 2 of table 5 with the standard deviation of aggregate demand shocks doubled causes τ^* to rise from 0 to 2.70 while δ^* falls to 0.70. The percent reduction in social loss as τ and δ vary for the case of more volatile demand shocks is shown in figure 4. Now, it is optimal to rely on both the goal-based

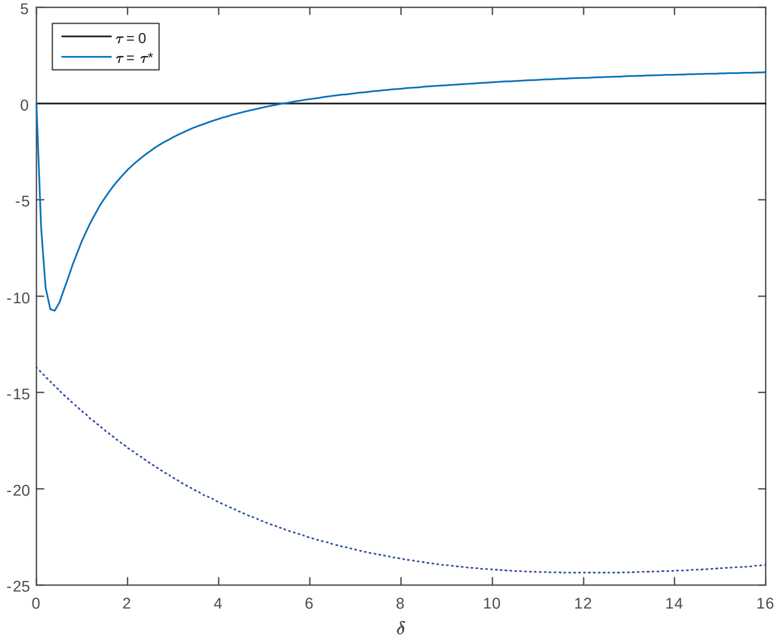
Figure 4. When the Reference Policy Rule Is Based on $\hat{\pi}$ and x, Social Loss Is Given by (21), and the Central Bank's Loss Is (23), an Increase in the Volatility of Aggregate Demand Shocks Increases τ^* and Reduces δ^* (compare with figure 3)



measure and the rule-based measure of performance. This suggests that the optimal performance measure may be highly dependent on the properties of the model's stochastic disturbances.

Rows 3 and 4 report results when the central bank cares about the welfare-based loss function (25). In the absence of a distorted output-gap objective, both τ^* and δ^* are positive (table 5, row 3, column 2), and both are large. If the output-gap target the central bank focuses on is distorted by u shocks so that $x_t - u_t$ rather than just x_t appears in the central bank's loss function, the optimal values of τ^* and δ^* both increase (see row 4, column 2), and in the case of τ^*, it increases quite significantly. Interestingly, when each performance measure is considered in isolation, the optimal weights are relatively small. For example, if $\delta = 0$ so that only the inflation measure is employed, the optimal weight to place on the goal-based

Figure 5. Percent Change in Social Loss Defined by (21) as a Function of δ for $\tau = 0$ and for $\tau = \tau^* = 36.05$



Notes: The central bank's objective given by (25) is distorted by the presence of u shocks to the output-gap objective. The output measure in the instrument rule is x.

measure is 1.45; when δ is also set optimally, $\tau^* = 36.05$. Similarly, if $\tau = 0$, the optimal value of δ is only 0.40; it increases to 12.22 when τ is set optimally. This is shown for δ in figure 5, which plots the change in social welfare as a function of δ for $\tau = 0$ and $\tau = \tau^*$. Notice that if only the rule-based performance measure is employed (i.e., $\tau = 0$), social loss is higher than would occur with no performance measure ($\tau = \delta = 0$) for all $\delta > 5.4$.

In general, the findings in table 5 suggest a role for both types of performance measures. However, in evaluating these results, an important consideration to bear in mind is that the rule-based performance measure analyzed here was taken to be the basic Taylor rule, with the coefficients on inflation and the output measure set equal to Taylor's original values. If these coefficients were optimized for the specific model used, it is likely that the optimal weight to put on the rule-based performance measure would rise.

5. Extensions and Conclusions

The central banking reforms initiated by the RBNZ Act of 1989 emphasized the importance of defining clear and sustainable goals for the central bank, combined with instrument independence in the conduct of policy. Such a system promotes accountability by establishing goals that are clearly defined and by giving the central bank the responsibility and ability to achieve these goals. Accountability has been further enhanced by trends towards greater transparency as central banks have concluded that policy is more effective when it is clearly understood by the public. Goal-based systems were motivated, in part, by a desire to constrain governments in their ability to influence monetary policy while allowing flexibility in the actual implementation of policy.

Reforms based on goals are not the only possibility for central banks. An alternative approach focuses on constraining the central bank by establishing instrument rules as the means of measuring the central bank's performance. Requiring a central bank to justify its policy actions with reference to a specific instrument rule is a means of strengthening accountability by limiting the central bank's flexibility.

In a simple analytical exercise, I showed that stochastic distortions to the central bank's goals, which could arise either from pressures external to the central bank or from the pursuit by the central bank of goals that differ from society's, justify a role for goal-based *and* rule-based performance measures. In using either performance measure, the need to limit distortionary shifts in objectives from affecting output and inflation must be balanced against the cost of reducing the bank's ability to engage in stabilization policies. Using a calibrated version of the simple model, I showed that an increase in the volatility of demand shocks relative to cost shocks increased the optimal weight to place on the goal-based performance measure relative to the rule-based measure.

The two approaches to central bank design were then evaluated using an estimated DSGE model with sticky prices and wages. Using the basic Taylor rule as the reference policy rule in the rule-based performance measure, along with Taylor's original coefficients on inflation and the measure of real economic activity, I find that the definition of real activity used in the rule is crucial. When the rule is based on output deviations from potential, as in the recent proposal in the U.S. House of Representatives, the optimal weight to place on deviations from the rule-based performance measure was always zero. In contrast, it was always optimal to employ a goal-based inflation performance measure. When the measure of real activity in the reference policy rule was the gap between output and its efficient level, it was generally optimal to place weight on both the goal-based and the rule-based measures of performance.

An important consideration in establishing any performance measure is its robustness. A reference policy rule, such as the one analyzed in this paper, that does not allow for shifts in the equilibrium real rate of interest is likely to produce poor outcomes if such shifts are an important source of macroeconomic volatility. An optimal rule would overcome this particular problem, but operational rules must be based on observable variables if they are to be of practical relevance, and the equilibrium real interest rate consistent with efficient production is unobservable. Optimal rules are also unlikely to be robust to model misspecification, an issue not addressed here. A reference policy rule that is optimal for a given model will presumably serve as a good performance measure within that model but may lead to poor results if the model is wrong or if the economic structure changes over time. Rule-based performance measures based on a rule optimized for a specific model would need, therefore, to be of low power. Of course, a simple rule, such as the Taylor rule, may be more robust across models and in the face of structure change than rules optimized for a specific model, and so a simple rule may serve as a useful, robust reference rule.

To simplify the analysis of the paper, I have ignored the constraint imposed by the zero lower bound (ZLB) on nominal interest rates.[32] The presence of the ZLB poses difficulties for both the goal-based and the rule-based performance measures. Neither provides a

[32] I adopt the standard practice of referring to a zero lower bound for nominal interest rates, but the recent experience with negative nominal interest rates in Denmark, Sweden, and the euro zone suggests that the effective lower bound may be below zero.

clear metric for what the central bank should do doing, or for how its performance should be judged, when the policy rate is at zero. This difficulty may, however, be less significant for the goal-based measure. A goal-based regime such as inflation targeting establishes a goal for the central bank but does not tie the hands of policymakers in terms of how policy is implemented to achieve the goal. For example, if the policy rate were at its lower bound and inflation below target, then a goal-based performance measure creates an incentive for the central bank to seek out new policy instruments in an effort to achieve its goal. A rule-based system may not be as effective in creating such incentives. A reference rule defined in terms of a single instrument may be of limited value during extended periods at the ZLB, as it does not provide any guidance to policymakers when the instrument value implied by the rule is unachievable. If the reference rule called for a negative interest rate, the central bank might seek to close the gap between i_t and i_t^r by directly focusing on the variables that affect i_t^r in an attempt to raise i_t^r above zero. In this case, either type of performance measure could promote policy innovations. However, because the rule-based measure is defined in terms of a specific policy instrument, and because it offers no guidance for how performance should be measured if that instrument is constrained, it may prove less likely to lead to the types of unconventional policies implemented by the Federal Reserve, the Bank of England, the Bank of Japan, and the European Central Bank during the past several years.

The focus in this paper has been on assessing policy performance in the presence of inefficient shifts in the central bank's objectives that potentially distort policy. Deviations of inflation from target or the policy interest rate from the recommendation of a Taylor rule were used as performance measures, creating incentives for the central bank to trade off minimizing these deviations against achieving other objectives. This is not the only role deviations from the Taylor rule can play. In the face of model uncertainty, Ilbas, Roisland, and Sveen (2012) show how appending deviations from the Taylor rule to the central bank's (non-distorted) loss function can contribute to policy robustness. In addition, the distortions considered in the present analysis do not affect the economy's steady-state equilibrium. Thus, policy objectives that create steady-state inefficiencies are ignored. Rogoff (1985) showed how placing additional weight on an inflation target could help overcome a systematic inflation bias under discretionary policy; a rule-based performance measure might play a similar role in addressing any systematic policy bias that affects steady-state inflation.

Finally, I have only considered traditional monetary policy objectives associated with controlling inflation and stabilizing an appropriate measure of real economic activity. As a consequence of the global financial crisis, central banks are now frequently tasked with responsibilities for macroprudential policies. An interesting question is whether a goal-based performance measure or a rule-based measure would best serve to promote accountability and good macroprudential outcomes. One significant difficulty in designing a goal-based performance measure in the case of macroprudential policies is the absence of a clear measure of the ultimate goal of policy. Inflation is both an ultimate goal of macroeconomic policy and an indicator that can be measured frequently to provide an ongoing assessment of policy. Achieving financial stability may also be an ultimate goal of policy, but there is no agreed-upon way to measure it. An index such as the ratio of credit to GDP may be a useful measure in this context, but it corresponds to an intermediate target. Assessing policy on the basis of movements in the credit-to-GDP ratio is much like using a monetary growth rate to assess the central bank's inflation performance. The usefulness of intermediate targets suffers if the link between the intermediate variable and the ultimate objective of policy is either uncertain or not well understood. While it may be difficult to develop a goal-based performance measure for macroprudential policy, difficulties also arise in defining a rule-based measure. Macroprudential policies may involve the use of multiple instruments. In this case, basing accountability on how one particular instrument is used can easily distort policy by causing undue attention to that one instrument at the neglect of others. And even when attention is restricted to a single instrument—the setting of capital buffer requirements, for example—the state of research is that there is no benchmark rule that has been extensively studied, is well understood, and could serve as a reference policy rule. The lack of the equivalent to a Taylor rule for macroprudential policy instruments is a severe limitation on the usefulness of a rule-based performance measure in the context of macroprudential policies.

Appendix

Equilibrium in the Simple Model

The first-order conditions for the central bank maximizing the loss function (3) leads to the following standard targeting criterion:

$$\kappa\left(\hat{\pi}_t - \phi_t\right) + \lambda\left(x_t - u_t\right) = 0. \tag{26}$$

Substituting (26) into (4) yields

$$\hat{\pi}_t = \beta \mathrm{E}_t \hat{\pi}_{t+1} + \kappa\left[u_t - \frac{\kappa}{\lambda}\left(\hat{\pi}_t - \phi_t\right)\right] + e_t.$$

When the shocks are i.i.d., $\mathrm{E}_t\hat{\pi}_{t+1} = 0$. Hence,

$$\hat{\pi}_t = \kappa\left[u_t - \frac{\kappa}{\lambda}\left(\hat{\pi}_t - \phi_t\right)\right] + e_t = \left(\frac{1}{\lambda + \kappa^2}\right)\left(\lambda\kappa u_t + \kappa^2\phi_t + \lambda e_t\right).$$

From (26),

$$x_t = u_t - \left(\frac{\kappa}{\lambda}\right)\left(\hat{\pi}_t - \phi_t\right),$$

or

$$x_t = -\left(\frac{1}{\lambda + \kappa^2}\right)\left(\kappa e_t + \lambda\kappa u_t + \lambda\kappa^2\phi_t\right).$$

Social loss in this equilibrium is

$$L_t^s = \frac{1}{2}\mathrm{E}_0 \sum \beta^i \left(\hat{\pi}_{t+i}^2 + \lambda x_{t+i}^2\right) = \frac{1}{2}\left(\frac{1}{1-\beta}\right)\left(\sigma_\pi^2 + \lambda\sigma_x^2\right).$$

Using the results for equilibrium inflation and the output gap,

$$\begin{aligned} L_t^s &= \frac{1}{2}\left(\frac{1}{1-\beta}\right)\left[\left(\frac{\lambda}{\lambda+\kappa^2}\right)^2 \sigma_e^2 + \left(\frac{\kappa}{\lambda+\kappa^2}\right)^2 \sigma_v^2\right] \\ &\quad + \frac{1}{2}\left(\frac{1}{1-\beta}\right)\lambda\left[\left(\frac{\kappa}{\lambda+\kappa^2}\right)^2 \sigma_e^2 + \left(\frac{\lambda}{\lambda+\kappa^2}\right)^2 \sigma_v^2\right] \\ &= \frac{1}{2}\left(\frac{1}{1-\beta}\right)\left[\begin{array}{c} \left(\frac{\lambda}{\lambda+\kappa^2}\right)\sigma_e^2 \\ +\left(\kappa^2+\lambda^3\right)\left(\frac{1}{\lambda+\kappa^2}\right)^2\sigma_v^2 \end{array}\right], \end{aligned}$$

where $\sigma_v^2 \equiv \lambda^2\sigma_u^2 + \kappa^2\sigma_\phi^2$.

In the absence of political distortions ($\sigma_v^2 \equiv 0$), social loss is

$$\frac{1}{2}\left(\frac{1}{1-\beta}\right)\left(\frac{\lambda}{\lambda+\kappa^2}\right)\sigma_e^2 \leq L_t^s.$$

Delegation

Suppose the central bank's objective is modified by the assignment of additional weight on achieving inflation stability and on not deviating from an instrument rule. In this case, the central bank aims to minimize

$$L_t^{pol} = \frac{1}{2}\mathrm{E}_t^{cb}\sum \beta^i \left[\left(\hat{\pi}_{t+i} - \phi_{t+i}\right)^2 + \tau\hat{\pi}_{t+i}^2 + \lambda\left(x_{t+i} - x_{t+i}^*\right)^2 + \delta\left(i_{t+i} - i_{t+i}^r\right)^2\right].$$

Policy continues to be set under discretion.

Goal Based

With $\delta = 0$ but τ potentially non-zero, the central bank's problem under discretion is

$$\min_{\hat{\pi}_t, x_t, i_t} \frac{1}{2}(1+\tau)\hat{\pi}_t^2 - \phi_t\pi_t + \frac{1}{2}\lambda x_t^2 - \lambda u_t x_t$$

subject to

$$\hat{\pi}_t = \beta\mathrm{E}_t\hat{\pi}_{t+1} + \kappa x_t + e_t$$

and

$$x_t = \mathrm{E}_t x_{t+1} - \left(\frac{1}{\sigma}\right)\left(i_t - \mathrm{E}_t\hat{\pi}_{t+1} - \varphi_t\right).$$

Actual inflation and the output gap are given by

$$\hat{\pi}_t = \left[\frac{\kappa}{\lambda+\kappa^2(1+\tau)}\right]\left(\lambda u_t + \kappa\phi_t\right) + \left[\frac{\lambda}{\lambda+\kappa^2(1+\tau)}\right]e_t$$

$$x_t = \left[\frac{\lambda}{\lambda + \kappa^2 (1+\tau)}\right] u_t + \left[\frac{\kappa}{\lambda + \kappa^2 (1+\tau)}\right] \phi_t - \left[\frac{\kappa (1+\tau)}{\lambda + \kappa^2 (1+\tau)}\right] e_t,$$

where each shock is assumed to be i.i.d.

The central-bank-design problem is to pick τ to minimize the unconditional expectation of social loss. That is, τ minimizes

$$\mathcal{L} = \frac{1}{2}\frac{1}{1-\beta}\left(\sigma_{\hat{\pi}}^2 + \lambda \sigma_x^2\right).$$

Using the equilibrium solutions for inflation and the output gap,

$$\begin{aligned}\mathcal{L} = \frac{1}{2}\Bigg\{ &\left[\frac{\lambda\kappa}{\lambda(1-\rho_u\beta) + \kappa^2(1+\tau)}\right]^2 \sigma_u^2 \\ &+ \left[\frac{\kappa^2}{\lambda(1-\rho_\phi\beta) + \kappa^2(1+\tau)}\right]^2 \sigma_\phi^2 \\ &+ \left[\frac{\lambda}{\lambda(1-\rho_e\beta) + \kappa^2(1+\tau)}\right]^2 \sigma_e^2 \\ &+ \lambda\left[\frac{\kappa(1+\tau)}{\lambda(1-\rho_e\beta) + \kappa^2(1+\tau)}\right]^2 \sigma_e^2 \\ &+ \lambda\left[\frac{\lambda(1-\rho_u\beta)}{\lambda(1-\rho_u\beta) + \kappa^2(1+\tau)}\right]^2 \sigma_u^2 \\ &+\lambda\left[\frac{\kappa(1-\rho_\phi\beta)}{\lambda(1-\rho_\phi\beta) + \kappa^2(1+\tau)}\right]^2 \sigma_\phi^2 \Bigg\}.\end{aligned}$$

The first-order condition for the value of τ that minimizes $\mathcal{L}$ implies

$$\frac{\partial \mathcal{L}}{\partial \tau} = -\kappa^2\left(\lambda + \kappa^2\right)\left[\frac{1}{\lambda + \kappa^2(1+\tau)}\right]^3 \left(\lambda^2 \sigma_u^2 + \kappa^2 \sigma_\phi^2\right)$$

$$+ \tau\lambda^2\kappa^2 \left[\frac{1}{\lambda + \kappa^2(1+\tau)}\right]^3 \sigma_e^2$$
$$= 0.$$

Solving for τ, one obtains

$$\tau^* = \left(\frac{\lambda + \kappa^2}{\lambda^2}\right)\left(\frac{\lambda^2\sigma_u^2 + \kappa^2\sigma_\phi^2}{\sigma_e^2}\right) \geq 0,$$

which is equation (8).

Rule Based

Now suppose $\tau = 0$ but δ may be non-zero. The central bank's problem takes the form

$$\min_{\hat{\pi},x,i}\left[\frac{1}{2}\hat{\pi}_t^2 - \phi_t\pi_t + \frac{1}{2}\lambda x_t^2 - \lambda u_t x_t + \frac{1}{2}\delta\left(i_t - \psi_\pi\pi_t - \psi_x x_t\right)^2\right]$$

subject to

$$\hat{\pi}_t = \beta\hat{\pi}_{t+1} + \kappa x_t + e_t$$
$$x_t = x_{t+1} - \left(\frac{1}{\sigma}\right)\left(i_t - \mathrm{E}_t\hat{\pi}_{t+1} - \varphi_t\right).$$

Because the central bank is judged in part on how it sets its instrument, the expectational IS equation becomes relevant.

Let the Lagrangian multipliers on the two constraints be θ and χ, respectively. The first-order conditions are

$$\hat{\pi}_t - \phi_t - \psi_\pi\delta\left(i_t - \psi_\pi\pi_t - \psi_x x_t\right) + \theta_t = 0$$
$$\lambda x_t - \lambda u_t - \psi_x\delta\left(i_t - \psi_\pi\pi_t - \psi_x x_t\right) - \kappa\theta_t + \chi_t = 0$$
$$\delta\left(i_t - \psi_\pi\pi_t - \psi_x x_t\right) + \chi_t\left(\frac{1}{\sigma}\right) = 0.$$

Eliminating the Lagrangian multipliers yields a relationship between the variables appearing in the central bank's loss function that can be written as

$$i_t = \frac{1}{a\delta}\left[\left(\kappa + a\delta\psi_\pi\right)\hat{\pi}_t + \left(\lambda + a\delta\psi_x\right)x_t - \kappa\phi_t - \lambda u_t\right],$$

where $a \equiv \sigma + \psi_x + \kappa\psi_\pi$.

With i.i.d. shocks, equilibrium is obtained by jointly solving

$$\hat{\pi}_t = \kappa x_t + e_t$$

$$x_t = \left(\frac{1}{\sigma}\right)\varphi_t - \left(\frac{1}{\sigma}\right)i_t$$

$$\alpha\delta i_t = \left(\kappa + a\delta\psi_\pi\right)\hat{\pi}_t + \left(\lambda + a\delta\psi_x\right)x_t - \kappa\phi_t - \lambda u_t.$$

Doing so yields

$$\hat{\pi}_t = \left[\frac{\kappa\alpha\delta\varphi_t + \kappa\lambda u_t + \kappa^2\phi_t}{\lambda + \kappa^2 + a^2\delta}\right] + \left[\frac{\lambda + a\delta\left(\sigma + \psi_x\right)}{\lambda + \kappa^2 + a^2\delta}\right]e_t$$

$$x_t = \frac{\alpha\delta\varphi_t + \lambda u_t + \kappa\phi_t - \left(\kappa + a\delta\psi_\pi\right)e_t}{\lambda + \kappa^2 + a^2\delta}.$$

Using these expressions, social loss is

$$\begin{aligned}\mathcal{L} = {} & \frac{1}{2}a^2\left(\lambda + \kappa^2\right)\left[\frac{\delta}{\lambda + \kappa^2 + a^2\delta}\right]^2\sigma_\varphi^2 \\ & + \frac{1}{2}\lambda^2\left(\lambda + \kappa^2\right)\left[\frac{1}{\lambda + \kappa^2 + a^2\delta}\right]^2\sigma_u^2 \\ & + \frac{1}{2}\kappa^2\left(\lambda + \kappa^2\right)\left[\frac{1}{\lambda + \kappa^2 + a^2\delta}\right]^2\sigma_\phi^2 \\ & + \frac{1}{2}\left[\frac{\lambda + a\delta\left(\sigma + \psi_x\right)}{\lambda + \kappa^2 + a^2\delta}\right]^2\sigma_e^2 + \frac{1}{2}\lambda\left[\frac{\kappa + a\delta\psi_\pi}{\lambda + \kappa^2 + a^2\delta}\right]^2\sigma_e^2,\end{aligned}$$

and the first-order condition for the optimal δ is

$$\begin{aligned}\frac{\partial\mathcal{L}}{\partial\delta} = {} & a^2\delta\left(\lambda + \kappa^2\right)^2\left[\frac{1}{\lambda + \kappa^2 + a^2\delta}\right]^3\sigma_\varphi^2 \\ & - a^2\lambda^2\left(\lambda + \kappa^2\right)\left[\frac{1}{\lambda + \kappa^2 + a^2\delta}\right]^3\sigma_u^2 \\ & - a^2\kappa^2\left(\lambda + \kappa^2\right)\left[\frac{1}{\lambda + \kappa^2 + a^2\delta}\right]^3\sigma_\phi^2\end{aligned}$$

$$+ a\left[\frac{1}{\lambda+\kappa^2+a^2\delta}\right]^3$$
$$\times\left\{\begin{array}{c}[\lambda+a\delta(\sigma+\psi_x)]\left[(\sigma+\psi_x)\left(\lambda+\kappa^2\right)-a\lambda\right]\\ +\lambda(\kappa+a\delta\psi_\pi)\left[\psi_x\left(\lambda+\kappa^2\right)-a\kappa\right]\end{array}\right\}\sigma_e^2=0.$$

Solving for δ, noting that $a\equiv\sigma+\psi_x+\kappa\psi_\pi$,

$$\delta^*=\frac{\left(\lambda+\kappa^2\right)\left(\lambda^2\sigma_u^2+\kappa^2\sigma_\phi^2\right)}{\left(\lambda+\kappa^2\right)^2\sigma_\varphi^2+\left[(\sigma+\psi_x)\kappa-\lambda\psi_\pi\right]^2\sigma_e^2}.$$

which is equation (9).

Optimal Policy in the Estimated Model

The results reported in section 4 were obtained using the solution method for optimal discretionary policy of Dennis (2007). The equilibrium depends on the form of the loss function assigned to the central bank. Dennis (2007) does not allow for interaction terms in the loss function of the policymaker between endogenous variables and policy instruments. Such terms arise in the rule-based regimes because the squared deviation from the instrument rule, $\left(i_t-i_t^{tr}\right)^2=i_t^2-2i_ti_t^{tr}+\left(i_t^{tr}\right)^2$, involves $i_ti_t^{tr}$ and so includes such interaction terms. Given a specification of social loss an the central bank's objective function, the model is solved over a grid of values for τ and δ; τ^* and δ^* are the values that result in the smallest value of social loss.

Dennis's method involves writing the model in the form

$$A_0y_t=A_1y_{t-1}+A_2\mathrm{E}_ty_{t+1}+A_3x_t+A_4\mathrm{E}_tx_{t+1}+A_5v_t, \qquad (27)$$

where y is a vector of endogenous variables, x is a vector of controls, and

$$v_t=i.i.d.\left[0,\Sigma\right].$$

The policymaker is assumed to minimizes a loss function given by

$$Loss\left(0,\infty\right)=\mathrm{E}_0\sum_{t=0}^{\infty}\beta^t\left[y_t'Wy_t+2y_t'Us_t+x_t'Qx_t\right].$$

This differs from Dennis (2007), who assumes $U = 0$. The solutions for y_t and x_t will be of the form

$$y_t = H_1 y_{t-1} + H_2 v_t$$

$$x_t = F_1 y_{t-1} + F_2 v_t.$$

Using these to form expectations of $t+1$ variables and substituting the results into (27) yields

$$y_t = (A_0 - A_2 H_1 - A_4 F_1)^{-1} (A_1 y_{t-1} + A_3 x_t + A_5 v_t)$$

or

$$y_t = D^{-1} (A_1 y_{t-1} + A_3 x_t + A_5 v_t). \tag{28}$$

Dennis provides the first-order conditions for x_t under discretion when $U = 0$. When $U \neq 0$,

$$x_t = -\Phi^{-1} \left(A_3' D'^{-1} P D^{-1} + U' D^{-1} \right) [A_1 y_{t-1} + A_5 v_t],$$

where

$$\Phi \equiv \left[Q + A_3' D'^{-1} P D^{-1} A_3 + A_3' D'^{-1} U + U' D^{-1} A_3 \right],$$

which reduces to Dennis's equation (24), (p. 38), when $U = 0$. This implies

$$F_1 = -\Phi^{-1} \left(A_3' D'^{-1} P D^{-1} + U' D^{-1} \right) A_1 \tag{29}$$

$$F_2 = -\Phi^{-1} \left(A_3' D'^{-1} P D^{-1} + U' D^{-1} \right) A_5 \tag{30}$$

$$H_1 = D^{-1} (A_1 + A_3 F_1) \tag{31}$$

$$H_2 = D^{-1} (A_5 + A_3 F_2). \tag{32}$$

The matrix P is defined by

$$P = W + \beta F_1' Q F_1 + \beta H_1' U F_1 + \beta H_1' P H_1.$$

The solution algorithm starts with initial values for H_1, H_2, F_1, and F_2. These are used to solve for D and P. These are then used in (29)–(32) to obtain updated values for H_1, H_2, F_1, and F_2. The process is repeated until convergence.

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Is Optimal Monetary Policy Always Optimal?*

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In a world with multiple inefficiencies, the single policy tool the central bank has control over will not undo all inefficiencies; this is well established. We argue that the world is better characterized by multiple inefficiencies and multiple policymakers with various objectives. Asking the policy question only in terms of optimal monetary policy effectively turns the central bank into the residual claimant of all policy and gives the other policymakers a free hand in pursuing their own goals. This further worsens the trade-offs faced by the central bank. The optimal monetary policy literature and the optimal simple rules often labeled flexible inflation targeting assign all of the cyclical policymaking duties to central banks. This distorts the policy discussion and narrows the policy choices to a sub-optimal set. We highlight this issue and call for a broader thinking of optimal policies.

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1. Introduction

The debate on optimal policy mix is old and the current literature on welfare-based optimal monetary policy is extensive. But these two literatures are fundamentally different in that optimal monetary

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policy, as the name suggests, is an exclusively monetary policy question, leaving no room for a policy mix. Sometime between the 1960s and the period's Mundell-Fleming model that allows asking fiscal and monetary policy questions, to the 1990s and the current optimal monetary policy questions, many academic economists and policymakers coalesced around the view that monetary policy is more nimble and hence better suited to address cyclical issues.

The focus on monetary policy has had the unintended consequence of justifying the treatment of central banks as residual claimants of policy. That is, on top of their usual mandate of controlling inflation, central banks are charged with all types of cyclical policy duties not completely addressed by other policymakers. These range from unemployment and financial stability to exchange rates and current account deficits, even to economic inequality. The literature by and large views this favorably, as central banks take the actions of other policymakers as given and internalize social welfare. In this approach to optimal monetary policy, any economic variable that enters the welfare function and is affected by interest rates receives a non-zero weight in the optimal policy rule. This, in turn, justifies using monetary policy to address that variable in practice.

Monetary policy trying to address too many objectives is hampered by two types of problems in replicating the efficient allocation. The first one is well known: a single policy instrument cannot be used to achieve multiple independent objectives. This static concern is of course valid. But we also highlight a second, strategic problem that arises in the presence of multiple policymakers.

To the extent that other policymakers have competing objectives, such as the fiscal policymaker having a bias for increasing (or reducing) spending or the financial regulator having a preferred level of regulation, they will engage in policies that worsen the policy tradeoffs for the central bank if they do not have to internalize outcomes. Asking only the optimal monetary policy question assigns the full burden of welfare-maximizing policy to the central bank and effectively absolves the other policymakers of the consequences of their actions. In that case, they will engage in behavior that will be welfare reducing and cannot be undone by monetary policy.

Our concern is that, especially in the last few years, central banks have become policymakers of last resort. Many central banks around the world try to control inflation while also behaving as residual claimants of all macroeconomic policies. Unemployment or capital flow problems not addressed by fiscal policymakers, macroprudential concerns not addressed by bank regulators (when the regulator is not the central bank), and many other important policy issues have become issues that central bankers talk about and act on. These issues are certainly important, but central banks that effectively take them on as additional mandates may not be socially optimal, as the policymakers better suited to address various issues may be even less likely to act when the central bank is seen as the agent responsible for the outcome.

This paper will therefore highlight the inefficiencies inherent in treating central banks as policymakers of last resort, drawing attention to the fact that central banks cannot effectively address all inefficiencies and also that there will be more inefficiencies if other policymakers do not have to internalize the consequences of their actions.

2. The Only Game in Town

The literature on model-consistent welfare functions and optimal policy that maximizes welfare begins with the seminal work of Rotemberg and Woodford (1997). In almost all of this literature, the policymaker is the central bank that sets the interest rate to maximize welfare. Fiscal policy enters the picture only to the extent that the steady-state inefficiency due to monopoly power is corrected by a lump-sum tax and a subsidy so that welfare is analyzed around an efficient steady state. Thus, fiscal policy is absent from cyclical policy analysis.

Unsurprisingly, in optimal monetary policy problems the interest rate responds to all welfare-relevant variables in the model. Hence, the literature finds that optimal policy is to set interest rates to control a combination of inflation and the output gap (Rotemberg and Woodford 1997, Giannoni and Woodford 2002) as well as exchange rates (Corsetti, Dedola, and Leduc 2010), house prices (Adam and Woodford 2013), macroprudential concerns (Smets 2014), asset prices (Gali 2014), and so on. If the only available policy tool is the interest rate, these conclusions are correct. The policy rate should be set to maximize social welfare and will therefore respond to all distortions that are affected by monetary policy.

This result is implicit in the modeling choice that asks the optimal monetary policy question, rather than the optimal policy question. In actual policy analysis, this corresponds to the answer of the question "how should monetary policy behave if no other policymaker is doing anything?" and indeed, there are times when this is the relevant question. In the recent Global Financial Crisis and subsequent Great Recession, many fiscal authorities that had sufficient budgetary slack and borrowing ability either did not provide much stimulus or pursued contractionary policies due to factors such as political paralysis or policymaker preferences for small governments and low-debt stocks. In these cases, central banks began to put more emphasis on output gap or employment to pick up the policy slack and were subsequently criticized for not doing enough.

A particularly striking example of a central bank minding many competing objectives is Sweden, where monetary policy was used to counter household leveraging, which required raising interest rates at a time of inflation below target and unemployment above NAIRU (Svensson 2014). The question is not whether fast leveraging is a policy concern—it may well be—but rather whether it should be a monetary policy concern. To the extent that higher interest rates lower debt-to-income ratios, which Svensson argues is not the case in Sweden, monetary policy can be used to lower leverage but is a roundabout way that creates steep trade-offs. It may be more efficient to use financial regulation to impose lower loan-to-value rates, for example. But if such regulation is slow to be enacted, central banks often rise to the occasion and use interest rates, perhaps because they are used to doing cyclical policy and can act fast.

The Central Bank of Turkey (CBRT) similarly took on additional mandates in multiple instances in the past few years (Akkaya and Gürkaynak 2012). An inflation targeter with lexicographic mandates that requires the inflation target to be met before it can aid the government in other policy pursuits, the CBRT lowered policy rates to discourage short-term currency flows and help promote exports to aid in closing the large current account deficit, at a time when inflation was above the target. CBRT now mentions financial stability, growth, and exchange rates as well as inflation when talking about policy objectives. Gürkaynak et al. (2015) show that at least partly as a result, the central bank's reaction function has changed and it is not the inflation fighter it used to be. Currency flows, exports, and the current account deficit are of course all important policy objectives that affect social welfare. But have these become relevant for monetary policy because other policymakers are slow or hesitant to do their jobs or have competing objectives, or are other policymakers pursuing competing objectives precisely because CBRT is taking the blame for the undesirable outcomes?

The fact that central banks often have to sacrifice their inflation goals to pursue other objectives is well known. Indeed, a substantial chorus of central bankers point to the limits and challenges that arise when monetary policy takes on the role of the residual claimant of macropolicy. Orphanides (2013) discusses the burdens on monetary policy as central banks expand their focus and objectives to include employment, public-sector balance sheet support, and financial stability. While monetary policy can make attempts to address such issues, other tools are often more appropriate. Inflation-targeting frameworks, instead, may prove effective at limiting central bank excursions into areas where the efficacy of interest rate policy is quite limited, particularly when compared with instruments available to other policy authorities. Although a primary motivation of the inflation-targeting framework was adoption of a nominal anchor, Bernanke and Mishkin (1997) describe the benefits more precisely as bringing coherence, transparency, and discipline to monetary policy. Disciplining the central bank to focus on its narrow mandate is indeed important.

The main point we are making in this paper is that monetary policy is not the only game in town, and behaving as if it is creates more costs than may be commonly perceived. When the central banks take on more policy mandates either explicitly and willingly or implicitly and out of necessity, they are the ones to be criticized when those objectives are unmet. In that case, other policymakers who wield instruments that can more effectively address those objectives have less incentive to actively use these instruments—they no longer internalize the cost of missing targets. This makes the trade-off for central banks even worse.

One way to rethink the examples presented above is through policymaker incentives. As long as the European Central Bank is seen as the only policymaker in the euro area and is blamed for its ills, fiscal authorities in member countries do not have the right incentive to pursue coordinated fiscal policies that will help prop up demand, or to engage in structural reforms that are costly in the short run. Or in Turkey, the government can continue to pursue expansionary policies, stoking currency inflows and boosting imports, while blaming the central bank for not doing enough to counter these as well as for missing the inflation target (Gürkaynak 2015).

While the literature on optimal monetary policy has been instrumental in analyzing normative questions, it also gave theoretical credence to the idea that central banks are default cyclical policymakers and would pick up any policy slack. In a vicious cycle, policymakers' belief that "monetary policy is more nimble and is therefore more appropriate for cyclical policy" and the literature's theoretical finding that "optimal monetary policy should address all cyclical concerns" have fed off each other, turning monetary policy into the residual claimant of all macroeconomic policy.

It is, however, important to remember that we observe equilibrium outcomes. Monetary policy has to be more nimble because it is used for cyclical dampening purposes while fiscal (or other) policies can be slow because no one questions why they are not designed and implemented faster. This is an artifact of the current policy landscape and is a consequence of the implicit distribution of social loss among various policymakers.

Clearly, it matters how the social welfare function is translated into mandates for multiple policymakers. With a single policymaker, assuming away time-inconsistency problems, giving that policymaker maximization of social welfare as the mandate will be optimal. However, with multiple policymakers, if one is maximizing social welfare and others have free hands in pursuing their alternative goals, what will be the welfare consequences? This question does not explicitly arise in the literature, although it is of first-order importance. Below we present a simple model to answer it and highlight our concern about treating central banks as the default cyclical macroeconomic policymakers.

3. General Framework

A few modifications to the benchmark New Keynesian model can highlight the tension between policymakers and the temptation for monetary policy to assume primary responsibility for mitigating the cycle. First, the framework requires a policy instrument that is under the control of a non-monetary authority and enters the forward-looking Phillips curve as follows:

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + \psi z_t + \varepsilon_t, \tag{1}$$

where π_t represents the log-deviation of inflation from its target, x_t is the log-deviation of output from its level under flexible prices, and ε_t is a markup shock. The novel aspect of the setup is z_t, which represents a policy instrument outside of the control of the central bank. As an example, the following section incorporates a value-added tax applied to the monopolistically competitive goods producers within an otherwise standard New Keynesian framework.[1]

The second modification includes an assumption that a monetary and a non-monetary authority set their policy instruments independently. The following section uses the example of a monetary and fiscal authority, exploring cases when each is assigned objectives that maximize social welfare, as well as cases when each pursues different objectives. The example assumes the fiscal authority takes the monetary policy reaction function as given and sets the tax rate in a strategic manner. That is, when setting the tax rate, the fiscal policymaker incorporates, or exploits, the systematic response of monetary policy in a way that aids in achieving its objectives. In contrast, the central bank takes the tax rate as a given exogenous factor and therefore does not incorporate into its optimization problem how tax rates adjust to monetary policy.

In this small model, households' behavior follows the standard New Keynesian formulation given by the linearized consumption Euler equation

$$x_t = E_t x_{t+1} - \sigma^{-1} \left(i_t - E_t \pi_{t+1} \right) + u_t, \tag{2}$$

where i_t is the nominal interest rate and $u_t \sim N\left(0, \sigma_u^2\right)$ can represent, for example, government purchases or the household's discount rate.

[1] See Krause and Lemke (2005) for a similar interpretation regarding the value-added tax.

4. Achieving the Social Optimum via "Correct" Policy Mandates

To illustrate these issues in the context of separate monetary and fiscal authorities, consider a setting with the social loss function given by

$$L_t^S = E_t \sum_{i=0}^{\infty} \beta^i \left(\pi_{t+i}^2 + \lambda^S x_{t+i}^2\right). \tag{3}$$

In terms of the pricing behavior, the framework resembles a standard New Keynesian model, except a value-added tax imposed on producers introduces an additional term into the Phillips curve,

$$\pi_t = \beta E_t \pi_{t+1} + \kappa x_t + \psi \tau_t + \varepsilon_t, \tag{4}$$

where τ_t is the instrument of the fiscal authority and $\varepsilon_t \sim N\left(0, \sigma_\varepsilon^2\right)$ reflects a shock to the monopolistically competitive firms' markup.[2] Household consumption follows (2).

We can now think about welfare under two different policy mandates for the central bank. The first requires exclusive focus on inflation, so the loss specific to the central bank becomes

$$L_t^{CB} = E_t \sum_{i=0}^{\infty} \beta^i \left(\pi_{t+i}^2\right). \tag{5}$$

In this case, monetary policy can offset any demand-side disturbance and adjust the output gap in a manner that perfectly aligns inflation with its target. The solution yields the following instrument rule:

$$i_t = \frac{\sigma}{\kappa}\left(\varepsilon_t + \psi \tau_t\right) + \sigma u_t \tag{6}$$

and results in the central bank meeting its mandate exactly by adjusting the output gap according to $x_t = -\frac{1}{\kappa}\left(\psi \tau_t + \varepsilon_t\right)$. This approach, however, is not the social optimum, since welfare may be improved if the central bank is given the social loss function (3) as

[2] Details concerning equation (4) and derivations of all further results discussed in the main text are relegated to the appendix.

the mandate. In this case, adopting the social loss yields the following rule:

$$i_t = \frac{\kappa\sigma}{\kappa^2 + \lambda^S}(\varepsilon_t + \psi\tau_t) + \sigma u_t,$$

highlighting how the response to the supply-side disturbances declines as weight on output-gap stabilization, λ^S, increases.

When monetary policy aligns its objectives with society, neither objective is exactly met, but social welfare is maximized. This is a manifestation of the general critique of giving too many jobs to central banks. With a single policy tool, the central bank cannot completely address multiple objectives. This standard dictum of optimal control theory appears in the central banking literature repeatedly.

It is, however, the case that the central bank has indeed maximized social welfare subject to its available policy tool and economic environment. This too is a standard finding in the optimal policy literature. As in the case above, where the divine coincidence does not hold in a world with cost-push shocks, the central bank faces a trade-off between various objectives. The received wisdom is that confronting this trade-off is still the optimal policy. We disagree with this view.

Our disagreement is primarily because there exist first-best tools for addressing various inefficiencies in the economy, and the interest rate is rarely, if ever, that tool for inefficiencies other than welfare losses from inflation. Monetary policy can certainly support demand and thereby aid in moving economies towards full employment. Such efforts, however, often lead other policy authorities to neglect implementing policies using more appropriate instruments. Efforts by monetary policy to compensate for the lack of urgency on the part of other policymakers may even create vulnerabilities, such as in the financial system, that ultimately prove counterproductive to achieving the social optimum.

To illustrate how a central bank's focus on objectives other than price stability can distort the incentives of other policymakers, consider the choice of τ_t under the control of a fiscal authority. Label the loss function for this authority F and assume it takes the central bank's reaction function as given. If the central bank follows a strict inflation-targeting regime, as in (5), with the fiscal authority minimizing the loss due to output-gap fluctuations

$$L_t^F = E_t \sum_{i=0}^{\infty} \beta^i \left(x_{t+i}^2 \right),$$

then the tax rate is set according to

$$\tau_t = -\frac{\varepsilon_t}{\psi}, \tag{7}$$

directing it to use the instrument to fully offset the supply-side disturbance. This result follows Benigno and Woodford (2003), where the optimal distorting tax rate in a New Keynesian setting adjusts to perfectly offset the supply-side shock. The central bank can then focus on offsetting demand-side disturbances in a manner that completely stabilizes inflation.

This is the global minimum of the social loss and represents the case where two separate policymakers are given "correct" mandates. That is, there exist two appropriate policy control variables for two distortions. When these tools are optimally employed, social loss is minimized at zero. Notice that in this case, neither policymaker had minimizing the social loss function as their mandates, but they jointly achieve the global minimum of the social loss criterion.

5. Idiosyncratic Policy Objectives

The fact that giving a policymaker the maximization of social welfare may not be optimal has been known since the work of Kydland and Prescott (1977) on time inconsistency, but the mechanism we highlight is fundamentally different. Here the problem is not that the central bank cannot commit to pursuing the policy it promises today. In fact, the problem is that because the central bank will pursue the objective in a time-consistent manner, other policymakers are freed to pursue their own, possibly more narrow, objectives. This is the key concern of this paper.

The issue arises when policymakers have terms in their loss function not contained in the social objective function. Policy preferences unique to a particular policymaking body could reflect an array of factors outside social welfare. For example, desire for fiscal expansion or austerity and "inside" lags associated with challenges in adjusting tax rates are factors that pertain to fiscal policy.[3] If the central bank's loss function remains (5)—a pure inflation targeter—then these other concerns manifest themselves by diminishing the extent to which the tax rate adjusts to offset the supply-side shock.

To illustrate our case, modify the fiscal authority's loss function to include other terms that do not appear in the social loss function as follows:

$$L_t^F = E_t \sum_{i=0}^{\infty} \beta^i \left(x_{t+i}^2 + \lambda^F \tau_{t+i}^2 \right), \tag{8}$$

which reflects a desire to keep the tax rate close to a target rate that the fiscal authority has in mind. The resulting rule for the optimal tax rate is as follows:

$$\tau_t = \frac{\psi}{\kappa \lambda^F} x_t, \tag{9}$$

reflecting how a fiscal authority placing relatively high weight on being close to the target tax rate (i.e., relatively high λ^F) makes only modest adjustments to the tax rate in response to variations in the output gap. The rule can also be expressed in terms of shocks,

$$\tau_t = -\frac{\psi}{\kappa^2 \lambda^F + \psi^2} \varepsilon_t.$$

If $\lambda^F > 0$, then the fiscal authority's concern for some target level of tax rates results in moving the equilibrium away from the social optimum. The stronger this concern, the further the policy pulls the equilibrium away from the social optimum.

Instead of strict inflation targeting, if the central bank includes the output gap in its objective with weight λ^{CB}, then the fiscal authority optimally sets its instrument according to

$$\tau_t = \frac{\kappa \psi}{\lambda^F \left(\kappa^2 + \lambda^{CB} \right)} x_t, \tag{10}$$

[3]These inside lags can also be thought of as equilibrium outcomes resulting from a game played between policymakers rather than being purely exogenous. That is, if fiscal policy does not have to be used for cyclical stabilization, it can afford to have inside lags.

illustrating that if the central bank attaches weight to output fluctuations ($\lambda^{CB} > 0$), even in a way that aligns its loss function with society ($\lambda^{CB} = \lambda^{S}$), the optimal fiscal policy action is to reduce the sensitivity of its instrument to output fluctuations. In other words, the fiscal authority lets the central bank worry about output, as it turns its focus to its other objective that is not included in social welfare. This dynamic is a fundamental reason why optimal monetary policy may not entail directly confronting the trade-off between the output gap and inflation.

In this setting, a key issue is whether given the social loss function (3), the central bank moves outcomes closer to minimizing the social loss by following strict inflation targeting, as in (5), or by adopting the social loss function, even though it may provide an incentive to the fiscal authority to stay away from an active role in output stabilization. Pure inflation targeting delivers perfectly stable inflation, with output following

$$x_t^{IT} = -\frac{\kappa\lambda^F}{\kappa^2\lambda^F + \psi^2}\varepsilon_t.$$

When the central bank adopts the social welfare function, output and inflation follow

$$x_t^S = -\frac{\kappa\lambda^F\left(\kappa^2 + \lambda^S\right)}{\left(\kappa^2\psi + \lambda^F\left(\kappa^2 + \lambda^S\right)^2\right)}\varepsilon_t,$$

$$\pi_t^S = \frac{\lambda^S\lambda^F\left(\kappa^2 + \lambda^S\right)}{\left(\kappa^2\psi + \lambda^F\left(\kappa^2 + \lambda^S\right)^2\right)}\varepsilon_t.$$

The following show how output and inflation move when the fiscal authority places all the weight on hitting the target tax rate, with the central bank minimizing the social loss function,

$$\lim_{\lambda^F\to\infty} x_t^S = -\frac{\kappa}{\left(\kappa^2 + \lambda^S\right)}\varepsilon_t$$

$$\lim_{\lambda^F\to\infty} \pi_t^S = \frac{\lambda^S}{\left(\kappa^2 + \lambda^S\right)}\varepsilon_t,$$

which would be the results in a basic New Keynesian model without the distorting tax. This is the case where $\tau = 0$ at all times and cyclical policy is carried out by the central bank exclusively. This limiting case highlights how a monetary authority willing to confront the trade-offs inherent in attempting to maximize social welfare absolves the fiscal authority from stabilizing output fluctuations (or more broadly, absolves other policymakers from addressing inefficiencies) that they can control.

Still, the question remains under what conditions the monetary authority maximizes social welfare by pursuing pure inflation targeting, as opposed to adopting the social loss function. To address this issue, we apply some conventional parameter values to the model and evaluate whether the following criteria,

$$\text{var}\left(\pi^{IT}\right) + \lambda^S \text{var}(x^{IT}) < \text{var}\left(\pi^S\right) + \lambda^S \text{var}\left(x^S\right),$$

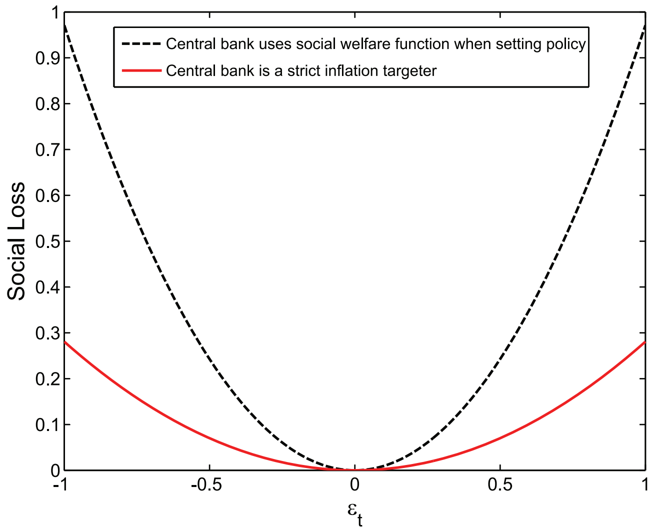
holds for various combinations of λ^S and λ^F.[4] The right-hand side of the inequality corresponds to the unconditional loss when the central bank uses the social welfare function. The left-hand side also is the unconditional loss evaluated using social welfare, but under strict inflation targeting. In the latter case $\text{var}\left(\pi^{IT}\right) = 0$, hence the condition we check is

$$\lambda^S \text{var}(x^{IT}) < \text{var}\left(\pi^S\right) + \lambda^S \text{var}\left(x^S\right).$$

Consider first the case when the fiscal authority places relatively low weight on the target tax rate, using its instrument relatively aggressively to offset supply-side shocks. In this case, as is shown in figure 1, the monetary authority can reinforce this behavior by adopting pure inflation targeting, resulting in overall lower social loss than if it were to adopt the social loss function. The intuition for this result rests with equation (10), as it shows the fiscal authority will adjust the tax rate more aggressively in response to output fluctuations if the central bank is primarily focused on inflation. That is, the fiscal authority takes more ownership for output stabilization and behaves accordingly. This results in a modest cost for the fiscal authority, but inflicts no costs in the context of the social welfare

[4]Parameter values are set so the steady-state markup is 20 percent above marginal cost, the steady-state tax rate is $\tau = .1$, $\sigma = 1$, and the cost of price adjustment is set so that $\kappa = .1$ in the scenario with the relatively steep Phillips curve and $\kappa = .05$ in the case when it's relatively flat.

Figure 1. Social Loss under a Fiscal Authority that Places Relatively Low Weight on a Target Tax Rate ($\lambda^{CB} = .5, \lambda^{F} = .001$)

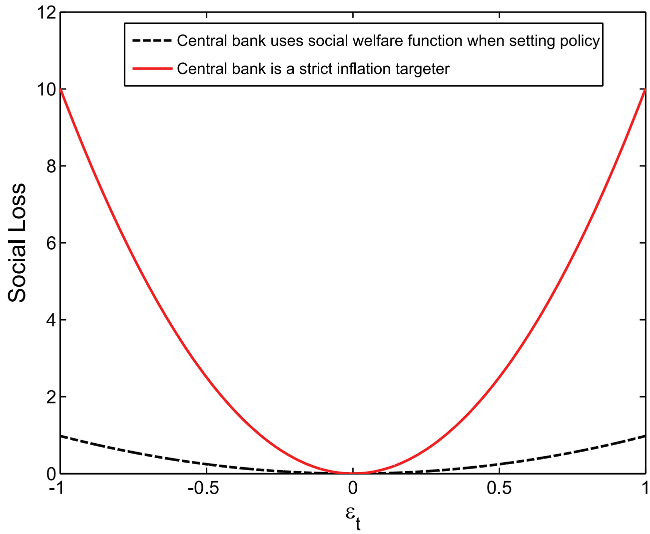


objective. As a result, an inflation-targeting central bank shifts the burden of output stabilization towards the fiscal authority, which has an effective instrument to stabilize output. The combination under inflation targeting is overall welfare improving.

Alternatively, figure 2 shows a case when the fiscal authority places more weight on its tax-smoothing objective. In this case, the fiscal authority is already too focused on its own objective, so the central bank increases overall social loss by focusing narrowly on strict inflation targeting. The fiscal authority is relatively too insensitive to output loss, so the central bank cannot provide a sufficient incentive to induce fiscal policy to do what is socially desirable. By focusing heavily (or only) on inflation, the central bank can again shift some of the burden of output stabilization to the fiscal authority. But the action taken by the fiscal authority is not enough, from a social welfare perspective, to justify the central bank not addressing the output gap itself.

To more broadly illustrate situations when pure inflation targeting is optimal, figure 3 shows the trade-offs in optimal policy design.

Figure 2. Social Loss under a Fiscal Authority that Places Relatively High Weight on a Target Tax Rate ($\lambda^{CB} = .5, \lambda^{F} = .01$)

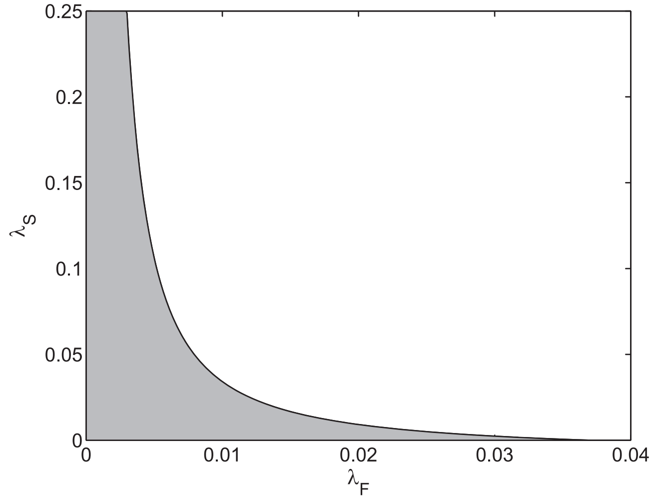


In cases where the fiscal authority places relatively low weight on fiscal objectives outside of output stabilization (i.e., λ^F is near zero), the central bank may raise social welfare via pure inflation targeting. When the fiscal authority puts too little relative weight on output stabilization, she cannot be incentivized enough to act to close the output gap, hence it is socially desirable to have the central bank address both output gap and inflation.[5]

The desirability of strict inflation targeting also hinges on the structure of the economy. Figure 4 shows conditions when strict inflation targeting is socially optimal under a relatively flat Phillips curve. In this case, monetary policy needs to adjust the output gap more forcefully to stabilize inflation. The additional volatility in output induces welfare losses that, relative to economies with a steeper

[5]This of course assumes that the relative weights of output gap and tax smoothing in the fiscal policymaker's loss function are exogenous. Below we discuss the case where the central bank and the fiscal authority share the loss from the output gap so that when the central bank assumes less of the output-gap mandate, the fiscal policymaker assigns proportionately more weight to it.

Figure 3. Monetary-Fiscal Trade-offs under Relatively Steep Phillips Curve ($\kappa = .1$)



Notes: The shaded area represents conditions when social welfare is higher under a pure inflation-targeting regime.

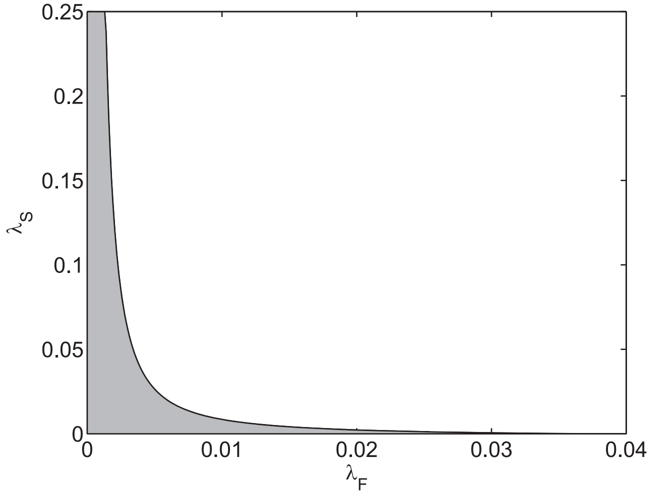
Phillips curve, often makes strict inflation target welfare reducing. The exception, however, is when the fiscal authority attaches little weight to its idiosyncratic objective, which then allows for the clean separation of objectives and instruments.

While these examples take the objective functions of the two policymakers as independent of each other, an alternative way of highlighting our concern is to think of the social loss being shared by the two policymakers. For example, assume the social loss function is as in (3), but that the loss functions of the two policymakers are

$$L_t^{CB} = E_t \sum_{i=0}^{\infty} \beta^i \left(\pi_{t+i}^2 + \lambda^{CB} x_{t+i}^2\right),$$

$$L_t^F = E_t \sum_{i=0}^{\infty} \beta^i \left(\left(\frac{\lambda^S - \lambda^{CB}}{\lambda^S}\right) x_{t+i}^2 + \left(1 - \left(\frac{\lambda^S - \lambda^{CB}}{\lambda^S}\right)\right) \tau_{t+i}^2\right).$$

Figure 4. Monetary-Fiscal Trade-offs under Relatively Flat Phillips Curve ($\boldsymbol{\kappa} = .05$)



Notes: The shaded area represents conditions when social welfare is higher under a pure inflation-targeting regime.

This approach explicitly builds in an understanding on the part of the fiscal authority that the greater the focus on the output mandate from the central bank (i.e., higher settings for λ^{CB}) relative to society's preference, the more the fiscal authority can focus on its competing objective. In this formulation, the central bank adopting the social loss function ($\lambda^{CB} = \lambda^{S}$) is clearly not in society's best interest, as the fiscal authority will then only care about its private objectives. On the other hand, if the central bank does not volunteer for any output-related mandates ($\lambda^{CB} = 0$), then the entire loss due to output-gap fluctuations is born by the fiscal authority, who in this case follows socially optimal policies, and unconditional welfare reaches its global maximum.

Another implication of the above formulation is that the more weight society places on output-gap fluctuations, the more is to be gained if the monetary authority adopts strict inflation targeting. Strict targeting would lead to a clean separation between objectives and instruments of the two policymakers, since the fiscal authority would focus on perfectly offsetting the disturbance to the Phillips curve, while monetary policy can perfectly offset shocks impinging on the Euler equation. This separation returns us to the initial arrangement where each policy authority is given "correct" mandates.

In these examples, where a fiscal policymaker has private objectives but also cares sufficiently about social welfare, pure inflation targeting by the central bank helps align the behavior of the fiscal authority with social preferences. Of course, as we have seen, inflation targeting may not always be optimal. If the fiscal authority places a substantial amount of weight on its own objectives, monetary policy simply cannot get it to pay enough attention to relevant objects in the social welfare function, such as output-gap stabilization.

From this perspective, a fiscal policy that places high weight on factors not included in the social loss function may reflect substantial "inside" lags. In practice, Blinder (2006) discusses how such lags reflect the time between when fiscal policymakers acknowledge the need for some action and the time it takes for policies to be implemented. In terms of the model, inside lags may appear to reflect a preferred tax rate, but in practice may capture the challenges associated with implementing fiscal reforms due to political considerations, or administrative time required to disburse funds and change tax withholding schedules. Interpreted this way, preferred tax rates would reflect exogenous constraints on the fiscal authority and not socially undesirable private concerns.

Whether such lags, or other ancillary policymaker concerns, are exogenous or endogenous matters. We are used to thinking of central banks as the cyclical policymakers because of the slowness in implementing fiscal policy changes. However, this may be the observed result of the game between policymakers, rather than a constraint imposed by nature. One can imagine an alternative environment where the central bank moves slowly due to the long and variable lags of monetary policy effectiveness, and fiscal policy is nimble because someone has to address the cyclical policy needs.

While large inside lags for fiscal policy may call for a monetary policy that does adopt the social welfare loss, clearly an endogeneity issue arises. If the lags are endogenous, monetary policy attempting to address all cyclical concerns may not motivate other policymakers to address the roadblocks that generate such inside lags. As a result, the fiscal authority's first-mover advantage is strengthened from the standpoint of being able to pay less attention to shocks, since they will be addressed by monetary policy, and allow it to shift weight towards its own particular objectives.[6]

While we make our point in a simple, stylized model, the point is very general. The world is a multiple-objective, multiple-policymaker world. Policymakers have their own objectives and behave strategically. If one policymaker volunteers for the responsibility for multiple objectives, either due to the desire to be more important or due to lack of appropriate policies from other policymakers, the equilibrium outcomes may be sub-optimal by the social welfare metric.

6. Discussion

The argument in this paper is motivated by a macroeconomic policy concern. If policymakers do not sufficiently internalize the welfare effects of their actions—in particular, if another policymaker is seen as responsible for those welfare outcomes—then they may choose socially sub-optimal policies.

As a recent example from the United States, aggressive monetary actions from the Federal Reserve, both in terms of balance sheet policies and forward guidance, were tailored toward concerns about improving labor market conditions, though within a context of price stability. During such actions, however, fiscal policy underwent a significant tightening. For example, an estimate from the Brookings Institute suggested that fiscal policy restrained real GDP growth by about 1 percentage point from 2011 through 2014.[7] While it is difficult to determine whether fiscal policies would have been different if U.S. monetary policy had been less accommodative, monetary policy actions certainly incorporated the weight that tighter fiscal policy was exerting on the outlook. The Federal Open Market Committee statement from June 2013, for example, explicitly states that

[6] "First-mover advantage" and "leader/follower" are terminology of sequential games. While the model we present is technically not sequential, the analogy is apt. We will turn to the sequential-game analogy again in the general discussion below.

[7] See http://www.brookings.edu/research/interactives/2014/fiscal-barometer.

"fiscal policy is restraining growth." A monetary policy mandated to pursue both price stability and full employment, as is that of the Federal Reserve, may not have many alternatives in the face of such fiscal restraint. The question posed in this paper is whether such fiscal restraint would arise under the understanding by fiscal authorities that the central bank would not undertake easier policy to compensate.

We think of this as a general policy concern of increasing importance, as central banks are trying to address ever-increasing loads of policy burdens. The model we presented above suggests that assigning the social welfare as the mandate to the central bank may not be optimal, as it may distort the incentives of other policymakers. There are several ways to interpret our argument and tie it to the literature.

An obvious starting point is time inconsistency (Kydland and Prescott 1977). While time inconsistency is effectively a game the central bank plays with the public (and its future self) over time, here we have a game between multiple policymakers within a single period. In this sense our work is closer to that of Dixit and Lambertini (2003), who study monetary and fiscal policy interactions in a time-inconsistency setting. Although the mechanisms are different, the understanding is similar: the game entails strategic behavior of policymakers and, given strategic behavior, it may be optimal not to give the central bank social welfare as the objective. In fact, Rogoff (1985) had shown that a central banker who puts more weight (than social welfare does) on inflation maximizes welfare. Here we show that a central banker who puts similarly high weight on inflation again maximizes welfare, not by making the public take the socially desirable decision, but by making the other policymakers take socially desirable actions.

Another way of thinking of our argument is in terms of a sequential game. This is technically not correct in the context of the model we presented (the model is simultaneous), but the analogy is helpful. One may as well think of the setting where a policymaker moves first and a second policymaker moves next, trying to maximize its objective. If one of these policymakers has distortionary terms in her objective function, it may be preferable to shift the social welfare burden to that policymaker (make that policymaker move last) so that the relative weight of the distortion in her decision making is minimized. Whether this would improve welfare depends on how sensitive the other policymaker will be to this incentive, as discussed in section 5. In our monetary and fiscal policy example, given the nature of the game, having the central bank do inflation targeting is the preferable approach either when society places relatively high weight on price stability or the non-monetary policy agency places sufficiently high weight on output stabilization.

In this sense, our results are bolstered by those of Walsh (this issue), who considers the optimality of flexible inflation targeting when a central bank is pursuing multiple objectives. His concern is not interactions among multiple policymakers; nonetheless, in many circumstances, he shows that strict inflation targeting comes remarkably close to maximizing social welfare. This result may be due to small welfare costs that arise from non-inflation objectives, such as exchange rate volatility or fluctuations in unemployment; or, fluctuations in non-inflation objectives may create welfare costs, but monetary policy is not the most effective instrument to address the distortions. Similarly, in Ravenna and Walsh (2012), a steady-state inefficiency exists in the labor market that requires a relatively large tax to correct, hence is not something monetary policy can effectively address. Any attempt to use monetary policy to offset this inefficiency creates an unfavorable trade-off for monetary policy that generates welfare losses relative to strict inflation targeting. We have a fundamentally different policy focus and mechanism in mind, but see these results as supporting our view that, in many circumstances, giving the central bank too broad a mandate may be sub-optimal.

The example we worked with in this paper is a game between the monetary and fiscal policymakers. This can be thought of as a fiscal dominance story. Although more prevalent in the emerging-markets literature, fiscal dominance has a long history in the analysis of advanced economies as well, leading to the fiscal theory of the price level. In work most relevant for our argument, building on the framework of Leeper (1991), Davig and Leeper (2011) illustrate that competing policy choices can be forced to a head if an economy reaches its fiscal limit, which is the point where tax rates can no longer rise and government purchases can no longer be reduced to stabilize debt dynamics. At this point, either transfer payments to households must be cut, the fiscal authority defaults on its outstanding debt, or monetary policy capitulates by doing whatever it takes to stabilize debt dynamics, which is to allow higher inflation.

Thus, the scenario applies to debt-laden countries that have hit the limit of their borrowing capacity and are faced with difficult choices. A credible inflation-targeting regime can take the monetary policy solution off the table, forcing the fiscal authority's hand to make adjustments that result in stabilizing debt prior to facing the immediate and painful policy choices that remain at the fiscal limit. Opening the door to a monetary solution, however, can incentivize the fiscal authority to make choices that result in rising debt levels, leading to socially sub-optimal equilibria, similar to what we observe in our model.

The examples have all been couched in terms of competing domestic policy authorities, though they also pertain to international monetary policy coordination. Consider a two-country model where one policymaker cares about global welfare and the other cares only about national welfare. The second policymaker may feel compelled to undertake beggar-thy-neighbor policies that cannot be undone by the first policymaker. Of course, not all international policy games are examples for our argument—it is not surprising that countries may strategically engage in competitive devaluations which reduce global welfare, for example. A good open-economy example for our case is the lender-of-last-resort function of the International Monetary Fund (IMF), which is presumably trying to maximize global welfare but may also be setting the stage for a moral hazard problem for the policymakers of the countries that can count on IMF loans when things go badly (Bulow and Rogoff 1988).

While we focus on an issue with clear policy relevance, the policy advice arising from our argument is not obvious. The examples in the paper suggest that a natural division of policy labor is for the central bank to care about inflation, leaving the other policy authorities to focus on objectives well suited to their instruments. Key to our argument is that if the central bank takes on additional mandates, other policymakers may face incentives not in line with social welfare, hence central bank mandate creep may be welfare detrimental. However, this does not answer the question of how to move to the good equilibrium if a country is stuck in the bad one.

If other policymakers are behaving socially sub-optimally, it would entail a very large welfare cost if the central bank does not try to maximize social welfare to induce those policymakers to move to the good policy equilibrium. This is a general problem in too-big-to-fail situations, where the problem is best solved before it arises and the policy options are limited once the choice is between allowing catastrophe now and providing bad incentives for the future.

7. Conclusions

The optimal macroeconomic policy literature focuses on monetary policy, and especially during the recent crisis monetary policy became the policy tool to address all economic ailments. While it is clearly optimal for monetary policy to pick up policy slack if other policymakers are not doing their jobs for various reasons, we highlight the problem that this makes it easier and more likely for those other policymakers not to do their jobs. We should be cognizant of this cost of equating optimal policy with optimal monetary policy.

While we point out the problem, we are short of offering a solution. Monetary policy not behaving as the policymaker of last resort and allowing a sizable welfare loss to incentivize other policymakers to do their jobs is a very costly way of realigning policymaker mandates. We see highlighting the problem as the first step. Hopefully, thinking about ways to alleviate it will follow.

Appendix

Households and Monopolistically Competitive Firms under a Value-Added Tax

Households choose sequences of C_t, N_t, and B_t to maximize utility given by

$$E_t \sum_{t=0}^{\infty} \beta^t \left[\frac{C_t^{1-\sigma}}{1-\sigma} - \frac{N_t^{1+\mu}}{1+\mu} \right], \tag{11}$$

subject to

$$C_t + \frac{B_t}{P_t} = T_t + \frac{W_t}{P_t} N_t + (1 + i_{t-1}) \frac{B_{t-1}}{P_t} + \frac{D_t}{P_t}, \tag{12}$$

where C_t denotes real consumption; B_t nominal bonds; P_t the price level; T_t lump-sum taxes, or rebate; W_t nominal wages; N_t labor supply; i_t the nominal interest rate; and D_t nominal dividends. The consumption bundle is a CES aggregate given by

$$C_t = \left[\int_0^1 c_t(i)^{(\epsilon-1)/\epsilon} di \right]^{\epsilon/(\epsilon-1)}.$$

Linearization of the households' optimality condition for consumption yields (2).

A monopolistically competitive firm i maximizes the present value of real dividends

$$\Pi_{it} = E_t \sum_{j=0}^{\infty} \beta^j \lambda_{t+j} \frac{D_{it+j}}{P_{t+j}}, \tag{13}$$

subject to the following demand curve

$$Y_{it} = \left(\frac{P_{it}}{P_t} \right)^{-\epsilon} Y_t \tag{14}$$

and production function

$$Y_{it} = A_t N_{it}, \tag{15}$$

where A_t represents economy-wide total factory productivity and $\frac{\psi}{2} \left(\frac{P_{it}}{P_{it-1}} - \pi \right)^2 Y_t$ is the quadratic cost of price adjustment. The government runs a period-by-period balanced budget and therefore rebates all proceeds from the tax back to households via a lump-sum transfer. After taking into account a value-added tax, period profits are defined as

$$\frac{D_{it}}{P_t} = \frac{P_{it}}{P_t} Y_{it} (1 - \tau_t) - \Phi_t Y_{it} - \frac{\nu}{2} \left(\frac{P_{it}}{\Pi P_{it-1}} - 1 \right)^2 Y_t, \tag{16}$$

where Π is the steady-state inflation rate and Φ_t is real marginal cost. The firm's first-order condition is given by

$$0 = (1-\epsilon)\lambda_t \left(\frac{P_{it}}{P_t}\right)^{-\epsilon} \left(\frac{Y_t}{P_t}\right)(1-\tau_t) + \epsilon\lambda_t\Phi_t \left(\frac{P_{it}}{P_t}\right)^{-1-\epsilon} \left(\frac{Y_t}{P_t}\right)$$
$$- \nu\lambda_t \left(\frac{P_{it}}{\Pi P_{it-1}} - 1\right)\left(\frac{Y_t}{\Pi P_{it-1}}\right)$$
$$+ \beta E_t \left[\psi\lambda_{t+1}\left(\frac{P_{it+1}}{\Pi P_{it}} - 1\right)\left(\frac{P_{it+1}Y_{t+1}}{\Pi P_{it}^2}\right)\right],$$

which after imposing a symmetric equilibrium, so $P_{it} = P_t$, can be rewritten as follows:

$$0 = (1-\epsilon)\lambda_t(1-\tau_t) + \epsilon\lambda_t\Phi_t$$
$$- \nu\lambda_t\left(\frac{\Pi_t}{\Pi} - 1\right)\left(\frac{\Pi_t}{\Pi}\right)$$
$$+ \beta E_t\left[\psi\lambda_{t+1}\left(\frac{\Pi_{t+1}}{\Pi} - 1\right)\left(\frac{\Pi_{t+1}Y_{t+1}}{\Pi Y_t}\right)\right],$$

where $\Pi_t = P_t/P_{t-1}$. Steady-state marginal costs are given by

$$\Phi = \frac{(\epsilon-1)(1-\tau_t)}{\epsilon}$$

and the linearized Phillips curve is

$$\widehat{\pi}_t = \beta E_t\widehat{\pi}_{t+1} + \frac{(\epsilon-1)(1-\tau)}{\nu}\widehat{\phi}_t + \frac{\tau(\epsilon-1)}{\nu}\widehat{\tau}_t, \qquad (17)$$

where $\widehat{\phi}_t \equiv \log\Phi_t - \log\Phi$, $\widehat{\pi}_t \equiv \log\Pi_t - \log\Pi$, and $\widehat{\tau}_t \equiv \log\tau_t - \log\tau$. Variables without time subscripts denote steady-state values.

Flexible-Price Equilibrium

If prices are fully flexible, the desired price would be a constant markup, θ, over real marginal cost after adjusting for the time-varying tax rate,

$$\left(\frac{P_{it}}{P_t}\right) = \frac{\theta}{(1-\tau_t)}\Phi_t. \qquad (18)$$

In equilibrium, $P_{it} = P_t$, and real marginal cost then varies with the tax rate as follows:

$$\Phi_t = \frac{(1-\tau_t)}{\theta}.$$

From the firm's cost-minimization problem, real marginal costs can also be expressed as

$$\Phi_t = \frac{(W_t/P_t)}{A_t}, \tag{19}$$

which implies

$$\frac{W_t}{P_t} = \frac{(1-\tau_t)\,A_t}{\theta}. \tag{20}$$

To then express the linearized Phillips curve (17) in terms of an output gap, first take the household's optimality condition governing labor supply:

$$\frac{W_t}{P_t} = C_t^{\sigma} N_t^{\mu},$$

then equate expressions for real wages,

$$\frac{(1-\tau_t)\,A_t}{\theta} = C_t^{\sigma} N_t^{\mu},$$

and write in log-deviations from its steady state,

$$\widehat{a}_t = \sigma \widehat{c}_t + \frac{\tau}{1-\tau}\widehat{\tau}_t + \mu \widehat{n}_t,$$

where $\widehat{x}_t \equiv \log X_t - \log X$. Using this relation with the linearized production function and imposing $\widehat{y}_t = \widehat{c}_t$ yields

$$\widehat{y}_t^f = \frac{(1+\mu)}{(\sigma+\mu)}\widehat{a}_t - \frac{\tau}{(1-\tau)\,(\sigma+\mu)}\widehat{\tau}_t, \tag{21}$$

where $\widehat{y}_t^f$ is the log-deviation of output under fully flexible prices. Rewriting (20) allowing for time-varying markups yields

$$\begin{aligned}
\widehat{\phi}_t &= (\widehat{w}_t - \widehat{p}_t) - (\widehat{y}_t - \widehat{n}_t) + \frac{\tau}{1-\tau}\widehat{\tau}_t \\
&= \sigma\widehat{y}_t + \mu\left(\widehat{y}_t - \widehat{a}_t\right) - \widehat{a}_t + \frac{\tau}{1-\tau}\widehat{\tau}_t \\
&= (\sigma+\mu)\,\widehat{y}_t - (1+\mu)\,\widehat{a}_t \\
&= (\sigma+\mu)\left[\widehat{y}_t - \frac{(1+\mu)}{(\sigma+\mu)}\widehat{a}_t + \frac{\tau}{(1-\tau)(\sigma+\mu)}\widehat{\tau}_t\right] \\
&= (\sigma+\mu)\left[\widehat{y}_t - \widehat{y}_t^f\right],
\end{aligned}$$

which allows the Phillips-curve relation to be rewritten in terms of a flexible-price output gap,

$$\widehat{\pi}_t = \beta E_t\widehat{\pi}_{t+1} + \frac{(\epsilon-1)(1-\tau)}{\nu}(\sigma+\mu)\,x_t + \frac{\tau(\epsilon-1)}{\nu}\widehat{\tau}_t, \qquad (22)$$

where $x_t \equiv \left[\widehat{y}_t - \widehat{y}_t^f\right]$.

Optimal Policy under "Correct" Objectives

When the monetary authority is a pure inflation targeter, the optimal interest rate rule is derived by solving the following:

$$\min_{x_t} \; \pi_t^2$$

subject to

$$\pi_t = \beta E_t\pi_{t+1} + \kappa x_t + \psi\tau_t + \varepsilon_t,$$

where expectations are taken as given, so the policy reflects discretion in the sense that the central bank is not committing to a future course of action (but note that neither the social loss function nor any central bank loss function in our model will lead to time inconsistency under discretion). The problem provides a standard reaction function, derived by substituting the first-order condition $\pi_t = 0$ back into the Phillips curve

$$x_t = -\frac{\psi\tau_t + \varepsilon_t}{\kappa}.$$

To express this rule in terms of the interest rate, substitute back into the consumption Euler equation to yield

$$i_t = \frac{\sigma}{\kappa}\left(\varepsilon_t + \psi\tau_t\right) + \sigma u_t, \tag{23}$$

where the central bank takes the tax rate as given when setting policy.

To derive (7), the fiscal authority solves

$$\min_{\tau_t} \; x_t^2$$

subject to

$$x_t = E_t x_{t+1} - \sigma^{-1}\left(i_t - E_t \pi_{t+1}\right) + u_t, \tag{24}$$

and (23), which can be expressed as

$$\min_{\tau_t} \left(-\sigma^{-1}\left(\frac{\sigma}{\kappa}\left(\varepsilon_t + \psi\tau_t\right) + \sigma u_t\right) + u_t\right)^2,$$

yielding the optimal rule (7),

$$\tau_t = -\frac{1}{\psi}\varepsilon_t. \tag{25}$$

The important difference between the monetary and fiscal authorities' problems is that monetary policy takes τ_t as given, whereas the fiscal authority incorporates the interest rate response into how it sets τ_t.

Optimal Policy under Idiosyncratic Objectives

When the fiscal authority adopts a preference for tax smoothing, the loss function becomes

$$\min_{\tau_t} \; x_t^2 + \lambda^F \tau_t^2.$$

After substituting in the consumption Euler equation and the central bank's optimal rule under strict inflation targeting, the problem is recast as follows:

$$\min_{\tau_t} \left(-\sigma^{-1}\left(\frac{\sigma}{\kappa}\left(\varepsilon_t + \psi\tau_t\right) + \sigma u_t\right) + u_t\right)^2 + \lambda^F \tau_t^2,$$

with the first-order condition given by

$$\tau_t = \frac{\psi}{\kappa\lambda^F} x_t.$$

If the monetary authority adopts the social loss function, then the fiscal authority's problem becomes

$$\min_{\tau_t} \left(-\sigma^{-1}\left(\frac{\kappa\sigma}{\kappa^2+\lambda^S}\left(\varepsilon_t+\psi\tau_t\right)+\sigma u_t\right)+u_t\right)^2+\lambda^F\tau_t^2,$$

so the first-condition is then

$$\tau_t = \frac{\kappa\psi}{\lambda^F\left(\kappa^2+\lambda^S\right)} x_t. \tag{26}$$

Equilibrium under Strict Inflation Targeting

When the central bank follows a strict inflation target and the fiscal authority has some preference for a target tax rate, the complete setting is given by

$$\begin{aligned}
x_t &= E_t x_{t+1} - \sigma^{-1}\left(i_t - E_t\pi_{t+1}\right)\\
\pi_t &= \beta E_t\pi_{t+1} + \kappa x_t + \psi\tau_t + \varepsilon_t\\
\tau_t &= \frac{\psi}{\kappa\lambda^F} x_t\\
i_t &= \frac{\sigma}{\kappa}\left(\varepsilon_t + \psi\tau_t\right) + \sigma u_t.
\end{aligned}$$

To compute the solution, guess it takes the following form:

$$x_t = c_x\varepsilon_t, \pi_t = c_\pi\varepsilon_t, \tau_t = c_\tau\varepsilon_t, i_t = c_i\varepsilon_t.$$

Substituting back into the original system and collecting coefficients as follows yields the solution

$$\begin{bmatrix} c_x \\ c_\pi \\ c_\tau \\ c_i \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & \frac{1}{\sigma} \\ -\kappa & 1 & -\psi & 0 \\ -\frac{\psi}{\kappa\lambda^F} & 0 & 1 & 0 \\ 0 & 0 & -\psi & \frac{\kappa}{\sigma} \end{bmatrix}^{-1} \begin{bmatrix} 0 \\ 1 \\ 0 \\ 1 \end{bmatrix} = \begin{bmatrix} -\kappa\frac{\lambda^F}{\psi^2+\kappa^2\lambda^F} \\ 0 \\ -\frac{\psi}{\psi^2+\kappa^2\lambda^F} \\ \kappa\sigma\frac{\lambda^F}{\psi^2+\kappa^2\lambda^F} \end{bmatrix}.$$

Equilibrium when the Central Bank Adopts the Social Welfare Function as Its Objective

When the central bank minimizes social loss and the fiscal authority has some preference for a target tax rate, the complete setting is given by

$$
\begin{aligned}
x_t &= E_t x_{t+1} - \sigma^{-1}\left(i_t - E_t \pi_{t+1}\right) \\
\pi_t &= \beta E_t \pi_{t+1} + \kappa x_t + \psi \tau_t + \varepsilon_t \\
\tau_t &= \frac{\kappa\psi}{\lambda^F\left(\kappa^2 + \lambda^S\right)} x_t \\
i_t &= \frac{\kappa\sigma}{\kappa^2 + \lambda^S}\left(\varepsilon_t + \psi\tau_t\right).
\end{aligned}
$$

To compute the solution, guess it takes the following form:

$$x_t = c_x \varepsilon_t, \pi_t = c_\pi \varepsilon_t, \tau_t = c_\tau \varepsilon_t, i_t = c_i \varepsilon_t.$$

Substituting back into the original system and collecting coefficients as follows yields the solution

$$
\begin{bmatrix} c_x \\ c_\pi \\ c_\tau \\ c_i \end{bmatrix}
= \begin{bmatrix}
1 & 0 & 0 & \frac{1}{\sigma} \\
-\kappa & 1 & -\psi & 0 \\
-\frac{\kappa\psi}{\lambda^F(\kappa^2+\lambda^S)} & 0 & 1 & 0 \\
0 & 0 & -\frac{\kappa\sigma\psi}{\kappa^2+\lambda^S} & 1
\end{bmatrix}^{-1}
\begin{bmatrix} 0 \\ 1 \\ 0 \\ \frac{\kappa\sigma}{\kappa^2+\lambda^S} \end{bmatrix}
$$

$$
= \begin{bmatrix}
-\frac{\kappa\lambda^F\left(\kappa^2+\lambda^S\right)}{\left(\kappa^2\psi^2+\lambda^F(\kappa^2+\lambda^S)^2\right)} \\
\frac{\lambda^S\lambda^F\left(\kappa^2+\lambda^S\right)}{\left(\kappa^2\psi^2+\lambda^F(\kappa^2+\lambda^S)^2\right)} \\
-\frac{\psi\kappa^2}{\left(\kappa^2\psi^2+\lambda^F(\kappa^2+\lambda^S)^2\right)} \\
\frac{\sigma\kappa\lambda^F\left(\kappa^2+\lambda^S\right)}{\left(\kappa^2\psi^2+\lambda^F(\kappa^2+\lambda^S)^2\right)}
\end{bmatrix}.
$$

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Discussion of "Is Optimal Monetary Policy Always Optimal?"*

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A burgeoning part of the monetary policy design literature posits that optimal monetary policy is the solution to a constrained optimization problem where the monetary authority has the discretion to minimize a social welfare function, taking the economy and other policies as given. In their paper "Is Optimal Monetary Policy Always Optimal?" Troy Davig and Refet Gurkaynak (henceforth, DG) argue convincingly that the solution thus attained may fail to deliver the desired outcome.

The key insight is that any economy is characterized by multiple inefficiencies and multiple policymakers with possibly conflicting objectives, not necessarily coinciding with the social welfare function. As a result, designing policy under the false assumption that the central bank is the "only game in town" has undesirable side effects that induce inefficiencies. For example, political considerations may introduce elements other than the social welfare function to the objectives of fiscal policy. In this environment, optimality cannot be attained unless the different policies in question are jointly examined and formulated. Designing "optimal policy" is a question of the optimal mix of various policies (e.g., monetary, fiscal, regulatory, structural) for which different policymakers are responsible. The problem of "optimal policy" is not the same as the problem of "optimal monetary policy," and equating the two yields flawed conclusions both for what monetary policy *can* do and for what it *should* do.

*This note is based on the discussion of the paper by Troy Davig and Refet Gurkaynak, "Is Optimal Monetary Policy Always Optimal?" which was presented at the IJCB and RBNZ conference "Reflections on 25 Years of Inflation Targeting," Wellington, New Zealand, December 1–2, 2014.

In game-theoretic terms, monetary policy that optimizes social welfare taking the policies of all other policymakers as given converts the central bank to a follower in a Stackelberg equilibrium. This overburdens the central bank and, according to DG, treats monetary policy as the "residual claimant of all policy" which changes the incentives and behavior of other policymakers. Social welfare suffers, and indeed outcomes are potentially worse than might be possible to attain with monetary policy formulated in a different fashion than by optimizing social welfare taking other policies as given.

Questioning the foundations of the so-called optimal monetary policy literature brings to the foreground some questions of importance on the twenty-fifth anniversary of inflation targeting: What tasks should be delegated to an independent monetary authority and how narrow or broad should the mandate of monetary policy be? Should price stability be the primary mandate of monetary policy or should multiple goals be assigned to the central bank? Does this assignment achieve good results for overall social welfare in a democratic society? Should a central bank be expected to do more than simply focus on its legal mandate?

The paper makes such a convincing case that one could take issue with the title. Arguably, the question should be: "Is 'Optimal' Monetary Policy *Ever* Optimal?" to which the answer is obviously "No!" There are, of course, numerous reasons why the so-called optimal monetary policy literature fails to deliver on its promise and risks offering false policy advice. Indeed, we have little of the knowledge required to even properly discuss and evaluate what is optimal. Optimality is most often discussed in highly abstract mathematical models that we know with certainty fail to capture reality. Ignorance of the structure of the economy is tackled with inadequate approximating models, and yet questions of the robustness of the approximation are infrequently acknowledged. In addition, we are ignorant of the relevant preferences whose knowledge is pre-supposed for formulating a social welfare function that is meant to be optimized. In a finite lifetime, an individual generally has limited knowledge even of his or her own preferences, and the uncertainty is not necessarily resolved over one's lifetime. And potentially conflicting interests among individuals and among policymakers suggest pervasive non-cooperative behavior at many levels.

The discussion raises a number of broader institutional design problems that are useful to acknowledge in evaluating policy: How should tasks be delegated to different policy institutions in a democracy? How can a central bank best contribute to society? Should objectives be limited to what is feasible to achieve and what a policymaker can be held accountable to? How much discretion should be encouraged or tolerated? Is it sufficient to delegate the task to "independent" authorities with "good intentions"? How can adherence to the institution's mandate be enforced?

More fundamentally, the discussion takes us back to questions pertaining to the classic debate on rules vs. discretion: Should a central bank be allowed to pursue what the policymaker thinks is "best" based on his or her understanding of social welfare in a discretionary manner? How do we limit harmful discretion if the policymaker is allowed to do what appears to be "best"? How do we solve the basic problems of dynamic inconsistency and moral hazard that can result from harmful application of a central bank's discretionary powers? If a "central planner" or a "benevolent dictator" is the solution to organizing society, where are they to be found among humans?

One reason these questions arise is due to the multiplicity of goals that a central bank could contribute to attain, at least in principle. If we were to draw a list of declining importance on various goals, we would likely have a consensus that price stability should be first. Price stability ought to be the central bank's primary task, an objective that should be in its purview to attain with reasonable success with monetary policy. Financial stability could be seen as a second important task, but one for which the central bank would need to coordinate monetary policy with regulatory policy and fiscal policy. Beyond these two objectives, the goals become increasingly more tenuous as monetary policy becomes less and less important relative to other policies such as fiscal, structural, growth, and social policies. Should "economic stability" be a key objective of monetary policy? How about "maximum employment," which is presently one of the Federal Reserve's statutory mandates? How about "widely diffused well-being"? If we are willing to entertain pretty much anything on such a list, we could include fiscal transfers to failed institutions in the mix, a goal that could be particularly appreciated by politicians during a crisis.

Accounting for these broader issues, it may be fruitful to reformulate the question posed by DG as follows: From an institutional design perspective, can we expect good outcomes if the central bank acts as the "residual claimant of all policy"? That is to say, when it comes to monetary policy, are good intentions enough? Intentions at a central bank may be good—to achieve what is "optimal" for society where all other institutions and policymakers may prove inadequate. This bears some resemblance to the question regarding central planning. In theory, central planning works. But the real question is whether it works in practice. Two examples of practical experience relating to monetary policy are instructive—the United States in the 1930s and New Zealand in the 1980s.

Consider first the following description of the objectives of the Federal Reserve, as described by the Board of Governors in 1939:

> The purpose of Federal Reserve functions, like that of Governmental functions in general, is the public good. Federal Reserve policy can not be adequately understood, therefore, merely in terms of how much the Federal Reserve authorities have the power to do and how much they have not the power to do. It must be understood in the light of its objective—which is to maintain monetary conditions favorable for an active and sound use of the country's productive facilities, full employment, and a rate of consumption reflecting widely diffused well-being. (Federal Reserve Board 1939)

The intentions to achieve "widely diffused well-being" may have been noble and the Federal Reserve Board had considerable discretionary power with which to set policy. Did the Federal Reserve manage to come close to maximizing social welfare during the 1930s? Hardly! The 1930s marks the worst decade in the performance of the institution.

Consider next the 1980s in New Zealand. Reflecting on the decade, prior to the introduction of inflation targeting in New Zealand, former Governor Don Brash noted: "The legislation under which we operated required us, in formulating our advice, to have regard for the inflation rate, employment, growth, motherhood, and a range of other good things" (Brash 1999). Intentions may have been good. The Reserve Bank had wide discretionary powers at its disposal. Did good intentions and the discretion to do the right thing deliver good outcomes? Hardly! Indeed, discretionary actions attempting to deliver "optimal" policy failed in New Zealand during the 1980s, the very failure that gave rise to the inflation-targeting framework as an alternative.

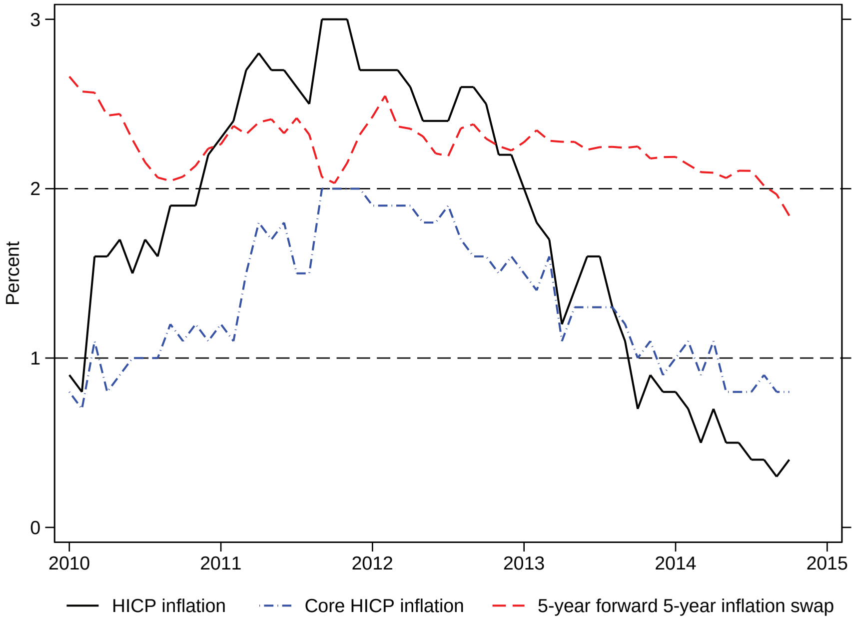
The inflation-targeting framework, as pioneered in New Zealand, has been a success precisely because it liberated monetary policy from the mentality that it should be "optimal." Inflation targeting refocused policy to a single primary objective that is feasible for monetary policy to attain—price stability. Some may consider this goal too modest for a central bank, but the performance of New Zealand as well as other countries that adopted inflation targeting generally suggests that this modest approach can be more successful for delivering what matters for economic welfare than alternative approaches.

The very success of inflation targeting creates the temptation to reinterpret the inflation-targeting framework as "multiple goal targeting" aiming to be "optimal." Indeed, some academic researchers use the qualifier "flexible" to describe what they consider to be a variation of inflation targeting that delivers "optimal" policy. But this is a false promise. The risk is that the very success of inflation targeting may once again make the central bank responsible to support "employment, growth, motherhood, and a range of other good things."

More generally, one solution to the problem highlighted by DG is the adoption of narrow mandates and strict rules. Narrow mandates and rules are essential for successful institutional design in democracies. In assigning tasks to an independent agency, society tries to solve problems of human nature: dynamic inconsistency and moral hazard. As long as discretion is encouraged, with multiple conflicting objectives, the problems remain. Narrow mandates and rules are needed to protect society from harmful discretion. In a democracy, no unelected and unaccountable policymaker should be or act as the residual claimant of all policy.

The tendency to improve upon the achievable outcomes that result with narrow mandates must be checked. Current policy debates around the world highlight some risks of the temptation to overreach. Consider the Federal Reserve. Dissatisfaction with the pace of improvement in labor markets in the aftermath of the Great Recession has apparently led to new guideposts, including discretionary assessments on concepts such as labor force participation. Does the Federal Reserve have the legitimacy to define and try to attain what it believes is the "optimal" level of employment or labor force participation? Does the Federal Reserve advance "social

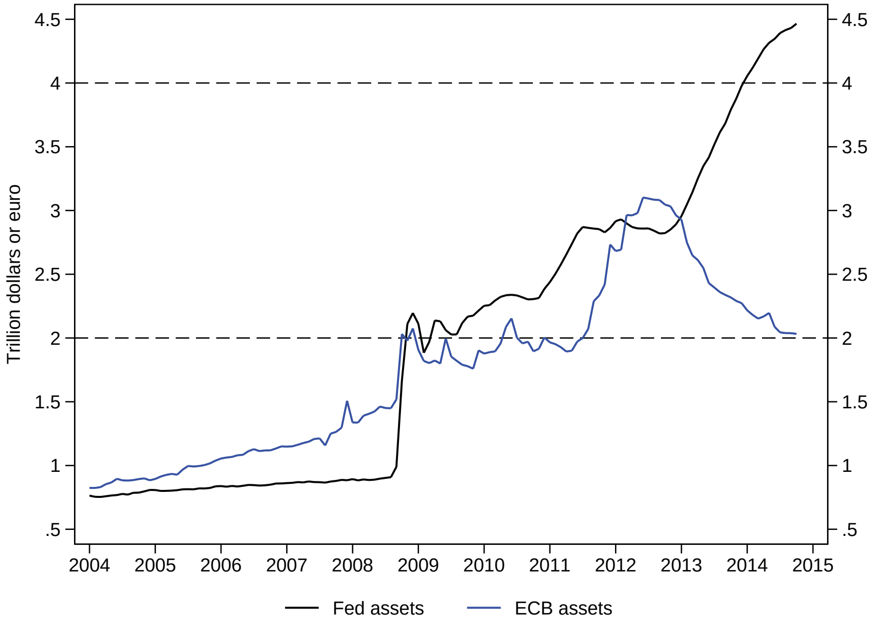
Figure 1. Inflation and Inflation Expectation Measures for the Euro Area



welfare" by taking on these tasks? The Federal Reserve may feel obliged to undertake such tasks in the absence of more forceful structural policies by the government. Then again, the expectation that the Federal Reserve might attempt to improve labor market inefficiencies, albeit not necessarily with positive results, may be exactly what induces government inaction.

A more peculiar but also potentially objectionable situation is currently observed in the case of the European Central Bank (ECB), the central bank of the member states of the euro area. The ECB has found itself in an impossible position due to the mismanagement of the euro-area crisis by euro-area governments, leading to policy decisions that are incredibly difficult to justify in terms of its narrowly defined mandate of price stability (Orphanides 2013, 2014a, 2014b). As of December 2014, the ECB has let inflation and inflation expectation drift significantly below its price stability for some time (figure 1). Resistance to the indicated monetary policy

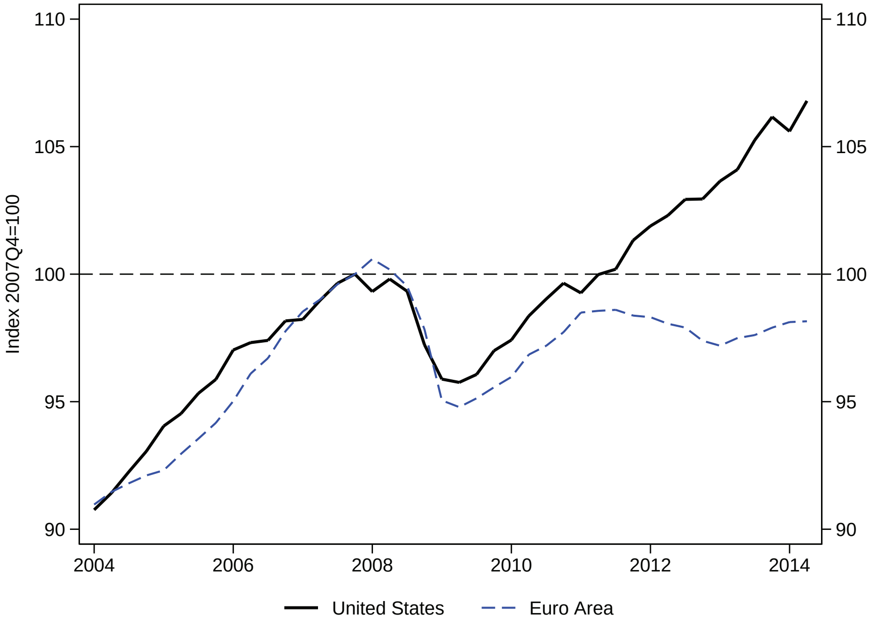
Figure 2. Central Bank Balance Sheets for the United States and the Euro Area



has appeared with numerous justifications. On December 4, 2015, a member of the Governing Council was quoted by Reuters as arguing: "Extremely low interest rates caused countries' willingness to implement structural reforms to tail off."

A question on this occasion is whether the ECB has the democratic legitimacy to let harmfully low inflation persist, as a means to encourage governments to adopt policies that might (in the ECB's judgment) ultimately benefit the euro area. This is highly dubious. And yet this is an argument that has been advanced as a justification for the continuation of tight policy by the ECB, as can be gauged by a comparison with the Federal Reserve. With policy interest rates effectively at the lower bound for both the Federal Reserve and the ECB, the size of the balance sheet has been a useful indicator of policy action. The comparison of the two balance sheets, figure 2, shows that by this measure the ECB has been tightening policy from

Figure 3. Real GDP in the United States and the Euro Area



Notes: Index: 2007:Q4 = 100.

mid-2012 to the end of 2014, while the Federal Reserve kept drastically easing. To be sure, it is not entirely clear if this difference can be attributed to the effort by the ECB to create incentives for the governments to take actions towards resolving the euro-area crisis. And whatever the discretionary policy being followed, the intentions may have been good. Nonetheless, easier monetary policy would have certainly contributed positively to higher real GDP in the euro area. Judging from the comparison with the United States shown in figure 3, the indicated monetary policy easing alone might have been a more certain positive contribution to the euro area than any discretionary deviation meant to provide incentives to governments to do structural reforms.

Returning to the question of whether any institution should take the role of a central planner, it is instructive to recall that there is a reason communism failed. In theory, central planning can work.

In a complex society populated with humans, with all their biases and flaws, the notion of an "optimal" equilibrium that would be supported by a benevolent dictator or central planner is unattainable. Conflicting and competing interests dominate the landscape of human interactions. Institutions bound by rules are needed to protect against losses from the resulting non-cooperative game. We cannot expect the central bank or any other institution to "solve" all of the associated problems. Central banks with a broad mandate to "do good" never deliver optimal outcomes but bring about the undesirable consequences of discretion. A solution is to insist that central banks have narrow mandates and are bound by clear rules that strengthen transparency and accountability. Ultimately, such an institutional structure may be second best but may well represent the feasible optimal point for social welfare.

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Applying an Inflation-Targeting Lens to Macroprudential Policy "Institutions"*

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We describe the origins of inflation targeting in New Zealand, and then use the four key attributes of inflation targeting—independence, the inflation target, transparency, and accountability—as an organizing device to analyze macroprudential policy "institutions"—the rules, regulations, and governance frameworks that implement macroprudential policies.

JEL Codes: E52, E58, E61.

"Economic policy, like any real activity, has to reckon with many aspects originating from very different realms of life, and hence certainly not only economic view-points: institutional, juridical, technical in the widest sense of the word, and psychological."
Tinbergen (1952, p. 74)

1. Introduction

Inflation targeting has been an influential and durable monetary policy framework. It has been widely adopted, and the attributes of inflation targeting have been widely lauded for their contribution to price stability. Yet in recent years the global financial crisis

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and the sovereign debt crisis have challenged macroeconomic frameworks, providing substantial impetus to concerns about financial stability. In this paper we examine macroprudential policy frameworks through an inflation-targeting lens, to understand whether the positive attributes of inflation targeting can and should inform macroprudential frameworks.

Despite an explosion of academic and policy research, macroprudential policies and the frameworks that govern their use are still in their infancy. In many respects, the current state of the art for macroprudential policy is similar to that which prevailed for monetary policy frameworks in the 1970s and early 1980s. There is considerable uncertainty about the objectives that should be pursued, about the intermediate targets that should guide policy, and about the instruments that should be used to realize those objectives.

This paper has been prepared for the twenty-fifth anniversary of the Reserve Bank of New Zealand Act of 1989. This Act was a seminal milestone for inflation targeting as a monetary policy regime. We sketch the origins of inflation targeting in New Zealand and its four attributes: the explicit inflation objective; the independence of the monetary authority; the role of transparency to shape expectations; and the role of communication to ensure accountability.[1] These four attributes are important building blocks for monetary policy governance.

We then use these attributes as a device for thinking about the institutions that govern macroprudential policies. We do not explicitly focus on the development of macroprudential policies in New Zealand (details of which can be found in Rogers 2013 and Dunstan 2014). However, we do use elements of the institutional framework in New Zealand to motivate our more general observations about monetary and macroprudential frameworks. Our observations are inevitably influenced by the policy framework in New Zealand, but we expect that they will be more broadly applicable.

[1]See Bernanke and Mishkin (1997) and Bernanke et al. (1999) for a general overview of inflation targeting.

2. The Historical Backdrop

2.1 Origins of Inflation Targeting

The Reserve Bank of New Zealand (RBNZ) implemented a fixed exchange rate system for around four decades from its inception in 1934. This regime began to break down in the 1970s in light of four developments: the collapse of the Bretton Woods system; the United Kingdom's entry into the European Economic Community (EEC);[2] large terms-of-trade movements;[3] and high domestic inflation, which eroded export competitiveness. The New Zealand dollar was revalued several times in the 1970s, fixed against the U.S. dollar and then against a basket of currencies, and then a crawling peg exchange rate regime was adopted to offset inflation differentials between New Zealand and foreign countries. Finally, the exchange rate was floated in 1985.

During this period, monetary policy supported wider government objectives. Section 8(2) of the 1973 Amendment to the Reserve Bank of New Zealand Act stated the following: "The monetary policy of the Government . . . shall be directed to the maintenance and promotion of economic and social welfare in New Zealand, having regard to the desirability of promoting the highest level of production and trade and full employment, and of maintaining a stable internal price level." Inflation's low priority in this Act contrasts with an earlier statement made by Governor Low (1968) that "there must be one over-riding consideration, namely keeping monetary policy still effective and avoiding any resurgence of inflation."[4]

Reserve Bank independence was non-existent. The Bank was "within the limits of its powers, to give effect to the monetary policy of the Government as communicated in writing to the Bank." Section 5 of the RBNZ Amendment Act of 1973 required the Reserve Bank to "ensure that the availability and conditions of credit provided by financial institutions are not inconsistent with the sovereign right of

[2]The United Kingdom became subject to the EEC's Common Agricultural Policy, which constrained New Zealand's export access.

[3]Increases in New Zealand's commodity prices were subsequently followed by the OPEC oil price shocks.

[4]Inflation in 1967, just prior to Low's article, had peaked at just under 7 percent, increasing from around $\frac{1}{4}$ percent at the beginning of the 1960s.

the Crown to control money and credit in the public interest" and to "advise the government on monetary policy, banking, credit and overseas exchange."

Post-war monetary policy in New Zealand cycled through sectoral constraints on credit allocation, constraints on credit growth, and various controls on interest rates (Quigley 1992). Little use was made of interest rates to allocate resources (Low 1968). Indeed, low interest rates were seen as beneficial for government borrowing and hence fiscal policy. Controls on trading banks led to disintermediation in favor of less regulated financial markets and intermediaries (Bayliss 1968). Private and trustee savings banks and finance companies began to erode the importance of the trading banks, and even lawyers began to intermediate housing finance.[5]

The macroeconomic policies deployed by New Zealand during the 1970s—including exchange rate adjustments, capital controls, and incomes policies—failed to ensure domestic price stability.[6] Administrative control of wages was in place for nearly nine years between 1971 and 1984 (Boston 1984, p. 8), and controls on *prices* were also deployed on various occasions. Despite these controls, headline inflation peaked in 1976, and again in 1980, at around 18 percent (see figure 1). Unemployment remained low, at less than 2 percent up until 1980,[7] but inflation and slow income growth remained major public issues.

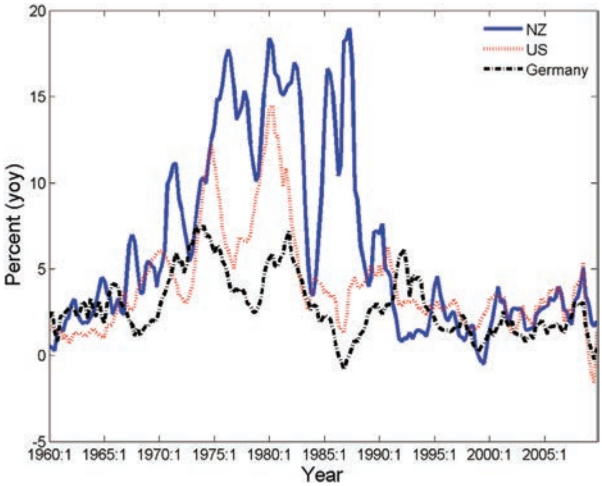
Political discontent grew. In 1984 the ruling National government called a snap election several months early, which they subsequently lost to the opposition Labour Party. During the election there was considerable media speculation that an incoming Labour government would devalue the New Zealand dollar. Despite capital controls, the inflow of currency into foreign reserves dwindled

[5]Solicitors' trust loans peaked at 18 percent of total household liabilities; see table C18 at http://www.rbnz.govt.nz/statistics/discontinued/c18discontinued.xls.

[6]A 1974 Article XIV consultation by the International Monetary Fund noted that "incomes policy remains the main instrument for dealing with inflation." Nelson (2005) argues that Canada, Australia, and New Zealand continued to suffer high inflation into the 1980s because of non-monetary views of inflation.

[7]New Zealand unemployment in the 1970s was low by modern standards, but it was high relative to the average rate of 0.64 percent that prevailed in the 1960s. Contemporary estimates suggested that the unemployment rate in 1979 and 1980 was 3.9–4.1 percent (Deane 1981).

Figure 1. Headline Inflation (YoY)



as importers advanced foreign-currency purchases and as exporters delayed the repatriation of foreign currency. In a messy transition from one government to the next, the Reserve Bank had to close the foreign exchange market, as it effectively exhausted its stock of foreign reserves. The market closure was announced on Sunday, July 15, 1984; a 20 percent devaluation was announced on July 18; and the market reopened on July 19 (Reserve Bank of New Zealand 1986, pp. 199–200).

The election and subsequent foreign exchange crisis were a watershed event for monetary policy in New Zealand. The exchange rate crisis illustrated the operational vulnerability of a fixed exchange rate regime when a government or central bank has limited foreign reserves, even in the presence of capital controls. The variations in foreign exchange rate parities, swings in the terms of trade, and increasingly diverse trade relationships in the 1970s and 1980s also illustrated how difficult it could be to implement a "fixed" exchange rate. Conversely, overseas experience suggested that price stability could be sustained by using monetary policy tools. The inflation outcomes in Germany and Switzerland showed that it was possible to maintain inflation at relatively low levels, while the Volcker disinflation in the United States and the Japanese disinflation of the

1970s also demonstrated that price stability could be restored by the use of conventional monetary policy instruments. (See Nelson 2007 for a discussion of disinflation in Japan.) Furthermore, Australia floated its dollar in December 1983, demonstrating that a small open economy could successfully implement a floating exchange rate regime.

After the July 1984 election, the Labour government committed to fund the fiscal deficit by issuing public debt to the private sector (Deane 1986). Once the New Zealand dollar was floated in March 1985, the Reserve Bank finally gained control over its liabilities, enabling it to pursue domestic monetary policy objectives. Financial markets were substantially deregulated in 1984, with controls on interest rates and capital flows being removed (Evans et al. 1996). In the wake of the devaluation of the New Zealand dollar and the removal of a wage and price freeze, inflation jumped up once again, reaching 15 percent in 1985.[8] Restoring price stability became the preeminent policy objective assigned to monetary policy.[9]

2.2 Inflation Targeting

In 1989 the Reserve Bank of New Zealand Act was passed by parliament, coming into force on February 1, 1990.[10] Sections 8, 9, 13, and 15 of the Act provide the four key inflation-targeting properties that have come to be synonymous with an inflation-targeting regime—the explicit price stability objective, independence, transparency, and accountability.

Section 8 of the Act states that the primary function of the Bank is to "formulate and implement monetary policy directed to the economic objective of achieving and maintaining stability in the general level of prices." Section 9 provides for Policy Targets Agreements (PTAs), which have been used to articulate explicit inflation targets. Section 13 provides for the Bank's independence in meeting these objectives, except as otherwise provided for in the Act.

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[8]A 10 percent value-added tax (GST) was introduced in 1986, further worsening the measured level of inflation.

[9]New Zealand's reform period is described in some detail by Evans et al. (1996) and Silverstone, Bollard, and Lattimore (1996). Singleton et al. (2006) provide a history of the Reserve Bank of New Zealand from 1973 onwards.

[10]The material in this section is based on the Act as originally passed into law.

The announced objective was intended to influence private-sector expectations. As Buiter and Miller (1983) discuss, monetarists in the 1980s suggested that the real consequences of disinflation could be modest if the disinflation was well understood and incorporated into expectations. In practice, disinflations in the United States and United Kingdom in the early 1980s were accompanied by large recessions. New Zealand surveys of business inflation expectations in March 1987 and 1988 were in double digits while inflation outcomes were 7.4 and 4.1 percent, respectively (Evans et al. 1996, p. 1864). With this backdrop it became obvious to New Zealand policymakers that it was important to correct the disconnect between expected and actual inflation. In the late 1980s the Bank published a series of indicative inflation ranges to facilitate the transition towards the 0–2 percent range that had been announced in the first PTA.[11]

Section 15 of the 1989 Act ensures transparency by requiring the Bank to provide policy statements that specify the policies that are being implemented, outline how policies might be formulated and implemented over the next five years, and review policies implemented in previous periods. These monetary policy statements need to be tabled at the next Reserve Bank Board meeting, published in the *Gazette,* and laid before the House of Representatives, providing a key accountability mechanism for the Reserve Bank.

The transparency embedded in the Reserve Bank Act was intended to "future-proof" the monetary policy framework against misuse by political representatives (Singleton et al. 2006). In the 1970s and early 1980s, Reserve Bank governors and Treasury officials provided advice to Minister of Finance Muldoon that was often ignored, yet the advice (and its rejection) did not necessarily enter the public domain. Under the Official Secrets Act of 1951, which prevailed until 1982, releasing official information without authorization was a criminal offense.

The transparency of the Reserve Bank Act was part of a broad change in the philosophy pertaining to public information. The Official Information Act of 1982 enshrined in law "the principle that [official] information shall be made available unless there is good

[11] See http://www.rbnz.govt.nz/monetary_policy/about_monetary_policy/0096846.html.

reason for withholding it."[12] In part, the Official Information Act was intended to promote the accountability of ministers and public officials. This attitudinal shift with respect to official information was also mirrored in other pieces of legislation, such as the Public Finance Act of 1989, which provides parliamentary scrutiny of government expenditure and the management of public assets and liabilities.

2.3 Observations

As we conclude this brief description of inflation targeting in New Zealand, we highlight some key points from this historical experience. First, the Reserve Bank of New Zealand was made independent because there was genuine concern that monetary policy implemented by self-interested *politicians* would lead to poor macroeconomic outcomes. Second, the focus on inflation in New Zealand reflected theoretical developments, foreign monetary policy experience, and the elevated levels of inflation that occurred in New Zealand in the 1970s and 1980s. Double-digit levels of inflation were not satisfactory for the efficient functioning of markets, and they had distributional consequences that were politically unpopular. It was also hoped that a specific target would directly influence inflation expectations and price-setting behavior.

Third, much greater transparency was required of the Bank in accordance with the philosophy underlying the Official Information Act. Accountability was not simply to be addressed with respect to the Board of the Reserve Bank or the minister of finance but also with financial market participants, academics, the media, and the general public.

Fourth, as the single decision maker, the governor had, and continues to have, considerable latitude to use policies to achieve the objectives set down in the Act and in the Policy Targets Agreement. In the 1970s and 1980s, there was considerable *uncertainty* as to what those objectives should be and what instruments should be used to pursue objectives. A policy rule was not delegated to

[12]In the United States the Freedom of Information Act was signed into law in 1966. Australia introduced a Freedom of Information Act in 1982 applying to institutions at the federal level. The United Kingdom introduced a Freedom of Information Act in 2000.

the governor or Reserve Bank because it was not known what rule should best be applied.

We now turn to macroprudential policy, discussing in turn independence, objectives, transparency, and accountability.

3. Macroprudential Policies

In the wake of the Great Recession and the Global Financial Crisis, central bankers have become less complacent about the resilience of their financial systems. As a result, new institutions and policies have been developed in an effort to reduce the frequency and severity of financial crises. Renewed concerns for financial stability have prompted a number of countries to deploy "macroprudential" policies to foster macroeconomic and financial stability.

In New Zealand's case, the legislation underpinning recent macroprudential policies has the same pedigree as inflation targeting. Section 10 of the Reserve Bank Act of 1989 requires the Bank to "have regard to the soundness and efficiency of the financial system" in formulating monetary policy.[13] Section 68 of the Act provides the same soundness and efficiency motivation for the deployment of prudential policies.[14] This soundness and efficiency mandate has always been interpreted in a macroprudential vein given its "systemic" focus.[15]

In the remainder of this article we examine the institutional arrangements that govern macroprudential policies in light of the four inflation-targeting attributes identified earlier. Our discussion focuses on "macroprudential" policies, but our remarks could equally be applied to prudential policies. As noted in the Introduction, the focus is not on the specifics of particular instruments or policies;

[13]The style of the Reserve Bank of New Zealand Act of 1964, which underpinned the 1973 Amendment, was rather different. Section 34 of the 1964 Act gave the Reserve Bank a wide degree of latitude to direct trading banks in relation to advances, discounts, investments, and interest rates. The Reserve Bank could also inspect the books and accounts of the trading banks if, among other reasons, it was "desirable in the public interest that an inspection be made."

[14]The 1989 version of the Act oriented New Zealand's prudential supervision towards registered banks.

[15]The Act simultaneously introduced "statutory management," providing the Bank with substantial powers to resolve bank failures.

rather, the aim is to provide a fairly high-level perspective relating macroprudential policy frameworks to the four inflation-targeting attributes. We begin by discussing independence.

3.1 Macroprudential Independence

A large number of studies have examined the effect of central bank independence, resulting in a fairly positive consensus. Most studies find that central bank independence is unrelated to output or employment volatility, but that it is negatively correlated with average levels of inflation.[16]

Given that independence is favorably regarded for monetary policy, it is natural to consider whether "independence" would also be desirable for macroprudential policy. One of the foremost questions is whether a single authority should govern both macroprudential and monetary policies, or whether two separate organizations should be tasked with the two branches of policy. In principle, macroprudential policy decisions could be determined by the central bank, by some other independent authority, or by political authorities. Here we focus on the "institutional location" of macroprudential decision making and the independence of the decision maker. We take for granted that political authorities will determine the objectives assigned to macroprudential policymakers. As Reis (2013) notes for central banks, "basic democratic principles suggest that society should give it a clear set of goals."

A number of authors have suggested that macroprudential policymaking should reside in central banks. For example, Nier et al. (2011b) argue that it is beneficial to take advantage of the expertise of the central bank, and Lim et al. (2013) suggest that central bank involvement improves the timeliness of macroprudential policy responses. Blinder (2010) and Duff (2014) note that financial stability and price stability objectives are closely interlinked, and therefore that the central bank will be highly motivated to ensure financial stability. Conversely, Willem Buiter notes that monetary and macroprudential objectives may diverge and that concerns about price

[16]See Bade and Parkin (1988), Cukierman (1992), Cukierman, Webb, and Neyapti (1992), Alesina and Summers (1993), Eijffinger and de Haan (1996), Berger, de Haan, and Eijffinger (2000), Crowe and Meade (2008), Klomp and de Haan (2010), Arnone and Romelli (2013), and Parkin (2013), among others.

stability may contaminate macroprudential policy, and vice-versa.[17] Svensson (this issue) provides an example of this problem, arguing that macroprudential concerns adversely affected monetary policy decision making in Sweden. Relatedly, there are concerns that poor macroprudential policy performance might damage a central bank's reputation, tainting its monetary policy independence (Čihák 2010, Smets 2014). Blinder (2010), on the other hand, advances the contra possibility that handling a financial crisis effectively may enhance a central bank's reputation.

Berger and Kißmer (2013) argue that an independent central bank tasked with an inflation objective may pay too little attention to financial stability concerns. Another problem with embedding macroprudential policies in central banks is that it increase the influence and power of central bank officials in determining macroeconomic outcomes; we discuss this further in section 3.4. A further tension associated with the consolidation of power in a single institution is that it increases the possibility of groupthink. Spreading policymaking power across institutions may complicate coordination and communication, but it may also foster greater diversity in views, providing healthy checks and balances on the implementation of policy.

Naturally, agency relationships with an independent policymaker also have potential costs. If it is difficult to distinguish experts, one may inadvertently get stuck with an inexpert decision maker, resulting in poor outcomes for a period of time. On the negative side, appointing an independent agent also exposes one to the possibility of moral hazard. The agent may pursue policies that advance their own conception of welfare, which may differ from that of the general public or the appointment board.

Since macroprudential policies are designed to reduce the frequency of crises or their negative consequences, such policies may also have implications for the fiscal costs of resolving such crises. Consequently, treasuries and finance ministries have a legitimate interest in the deployment of these policies. Of course, assigning responsibility for macroprudential policies to political authorities may induce "political business cycles." Furthermore, like monetary

[17] See http://blogs.ft.com/maverecon/2009/10/the-proposed-european-systemic-risk-board-is-overweight-central-bankers/.

policy, it is possible for macroprudential policies (such as liquidity requirements) to be misused by political authorities to solve traditional financing problems.

In principle, a minister of finance could use monetary or macroprudential authorities as expert advisers, while retaining decision-making powers, as per fiscal policy. Such a framework deals with the expertness advantage of agency noted above, with macro-policy coordination issues, and provides a decision maker with a clear mandate to resolve unforeseen contingencies. Yet having one agent (the policymaker) advise another agent (the minister) may still be problematic for the ultimate principal (the general public). As noted in section 2.1, an "expert-adviser" framework prevailed under the Reserve Bank of New Zealand Amendment Act of 1973. That experience illustrates that an expert-adviser framework can still result in poor decisions.

As the discussion above makes clear, monetary policy, macroprudential policies, and fiscal policies form an interlocking whole, and—given the interdependence of these policies—some degree of coordination is required. Tinbergen (1952) is often invoked to suggest that we need as many "instruments" as we have "target variables," and there is often a presumption that individual instruments can be assigned to specific objectives (see for example Smets 2014). Yet Tinbergen (p. 29) actually argues that one can only assign a single specific instrument to a single specific target in special circumstances: "The values of the instrument variables are dependent, generally speaking, on all the targets set and cannot be considered in isolation." Tinbergen (p. 29) goes on to describe a situation where the structure of the economy is "consecutive," which we might now term recursive. Then, a single instrument may be directed to a single target, taking into account other instruments that are higher up the recursive ordering. In general, however, the structure of the economy need not necessarily support such an ordering. These interdependency issues relate to non-separabilities in the objective, which arise in many economic contexts.

Meade (1984) makes the point that fiscal and monetary policies should be coordinated, and Smets (2014, pp. 265–6) notes that macroprudential and monetary policies should be coordinated because of their interdependencies. From a game-theoretic perspective, policies could be decentralized, but a non-cooperative solution will generally be inferior to one that involves cooperation, since a cooperative solution could always choose the same mix of strategies as a non-cooperative equilibrium.

The extent to which coordination is important depends on the magnitude of the externality effects that one branch of policy has on the other. At the moment, the materiality of these effects is not well understood. There is, however, some indication that they may be substantial. For example, there is an ongoing debate about the risk-taking channel of monetary policy and the impact that stimulatory monetary policy has had on the riskiness of private portfolios. Housing prices, construction activity, and consumption positively co-vary, and macroeconomic activity and inflationary pressures may be materially affected by macroprudential policies if such policies can indeed affect asset prices and credit growth.

Although policies may be interdependent, the institutions that govern them may still have a semblance of independence. For example, fiscal and monetary authorities in inflation-targeting countries generally have independent lines of accountability and ostensibly separate objectives. Yet, in practice, monetary authorities take into account fiscal plans, and fiscal authorities understand and internalize the interest rate consequences of fiscal plans, sometimes asking monetary authorities for explicit information about those consequences. Likewise, macroprudential plans have implications for business cycles and hence monetary policy, and these consequences should be internalized in setting policy.

While it is clear from an abstract perspective that coordination between different policy branches is generally required, other considerations may also be important. Currie and Levine (1985, ch. 6) discuss a situation in which simple policy rules assigned to specific targets may be beneficial if private individuals need to infer public policies using least-squares learning. The complexity of policy rules, and their susceptibility to model misspecification, may thus provide sufficient grounds for considering simple, assigned rules. Nevertheless, it is not obvious why an information asymmetry would persist with respect to the policy rule, and why the asymmetry could not be resolved through central bank communication. One possibility is that there is some essential uncertainty about the rule that should be followed—uncertainty shared by everyone—rather than an information asymmetry about the rule.

Kydland and Prescott (1977) famously explore what happens when policymaker incentives are not aligned with private individuals' incentives. The root of the problem in Kydland and Prescott's paper is an imperfection that causes the socially optimal outcome to diverge from the "natural" outcome that is arrived at under flexible prices. Because policymaker and private incentives diverge, they face inherent incentives to behave non-cooperatively. Assigning policy to an independent policymaker—choosing a conservative agent or assigning a different objective to the policymaking agent—is one way of offsetting the market imperfection.

Macroprudential policies may suffer from the same misalignment of policymaker and private-agent incentives. Definitions of financial instability routinely reference situations where market failures or externalities distort financial intermediation (see, for example, Ferguson 2003), implying the same discord between altruistic policymaker and private-sector objectives, which may prove problematic if policymakers cannot pre-commit to a given policy.

If one is concerned about the ill effects of discretionary policy—i.e., the incentive to surprise private-sector agents, taking advantage of predetermined expectations—it is natural to want to specify a policy rule. In the absence of bounded rationality, contracting parties can establish rules or contracts that deal with every feasible contingency. In practice it may be extremely difficult to identify reasonable state-contingent policies. Specifying state-contingent rules or contracts for macroprudential policy appears to be especially problematic. For example, Taylor (2013) suggests that temporary countercyclical capital buffers should be set aside in favor of "permanent and appropriate capital and subordinated debt ratios." Likewise, Stefan Gerlach, deputy governor of the Central Bank of Ireland, questions the feasibility of employing macroprudential instruments in a time-varying manner.[18]

Before we conclude this independence section, we briefly describe the New Zealand situation with respect to macroprudential independence. On May 13, 2013 the minister of finance and the governor of the Reserve Bank of New Zealand signed a memorandum of understanding (MoU) outlining macroprudential policy and operating

[18]See http://www.bis.org/review/r130920d.pdf.

guidelines.[19] The MoU specifies the objectives, the instruments, and certain consultation expectations between the Bank and the minister of finance. The inclusion of the latter two elements differentiates it from the Policy Targets Agreement for monetary policy, since the PTA only specifies the targets or objectives of policy, not the instruments.

The objective outlined in the MoU for macroprudential policy is motivated by the soundness objective in the Reserve Bank Act, described above in section 2.2. This objective is finessed to say that the aim of the policy "is to increase resilience of the domestic financial system and counter instability in the domestic financial system arising from credit, asset price or liquidity shocks."

The MoU lists four instruments that the Reserve Bank has access to, and notes that development of additional macroprudential instruments is to be undertaken in consultation with the New Zealand Treasury, reflecting the Treasury's role in advising the government on risks to the Crown's balance sheet. The instruments are intended to apply to registered banks, and the Bank is to advise the minister of any expansion of these powers to non-banks (e.g., to non-bank deposit takers, which are now also regulated by the Reserve Bank). The memorandum does not prescribe how macroprudential policy instruments may be used.

In statute, the Reserve Bank retains instrument independence with respect to macroprudential policies, and the memorandum also clearly states that decisions on macroprudential interventions will be made by the governor. However, as stated in the memorandum, the governor has agreed to consult with the minister of finance and the Treasury when a macroprudential intervention is under consideration, and must inform these two parties prior to making a decision or deploying a macroprudential instrument. The "independence" of macroprudential decision making in New Zealand is thus different than that of monetary policy, given that prior consultation could modify or influence decisions.

Ultimately, the New Zealand minister of finance has access to provisions within the Reserve Bank Act that enable him or her to direct the Bank. Section 68B of the current version of the Act

[19] MoUs are relationship documents that typically fall short of having the legal status of binding contracts.

requires the Bank to "have regard" to directions about government policy in relation to the Bank's prudential powers.[20] The New Zealand minister of finance's ability to direct the Reserve Bank contrasts with the situation in Sweden, where no public authority may determine how the Riksbank shall decide matters of monetary policy.[21]

We believe that many institutional arrangements can be devised to successfully deploy macroprudential policies. For small countries like New Zealand, incorporating macroprudential policy decision making within the central bank seems a reasonable approach, given pre-existing expertise and the overlap in responsibilities. Here we have also highlighted that macroprudential policy has spillovers for both monetary and fiscal policy, and it therefore makes sense to coordinate macroprudential policies with monetary and fiscal policies.

3.2 Macroprudential Objectives

Almost by definition, inflation-targeting central banks specify explicit numerical targets for inflation. Such targets could be considered "cheap talk" designed to influence private-sector price setting (see Farrell and Rabin 1996 for a discussion of cheap talk). Announcing an inflation target may help reveal information about the choices that policymakers will make and thus influence the strategic choices of private agents. For example, an inflation target, if believed, may facilitate a less costly transition towards an equilibrium (though targets do not seem to make much difference to the costs of disinflation in practice).

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[20] Section 12 of the Reserve Bank Act provides the governor-general with wide powers to direct the Reserve Bank to formulate *monetary policy* for different economic objectives. Such directions must be made on the advice of the minister of finance. (As the Queen's representative, the governor-general has largely a ceremonial role and is expected to follow the advice of elected ministers.) These powers must be implemented through an Order in Council, which has to be published in the New Zealand *Gazette* and presented to the House of Representatives.

[21] See the English translation of an op-ed article by Lars E.O. Svensson published in *Dagens Nyheter,* May 28, 2014, available at http://larseosvensson.se/2014/05/28/improve-the-democratic-control-of-the-riksbank/#more-2095.

There is widespread agreement that macroprudential authorities should also have a clear mandate,[22] yet for macroprudential policy there is no measurable counterpart to the inflation target. Given the lack of accepted norms about how to use macroprudential policies, broad macroprudential objectives provide little guidance as to what policies will be implemented, when, and in response to what. “Talk” about macroprudential objectives lacks specificity and is generally uninformative about chosen macroprudential policies. The missing detail about policies and objectives needs to be filled in with other forms of communication—speeches, financial stability reports, and so forth.

Although having a clear macroprudential mandate remains important for accountability purposes, there continues to be a lack of unanimity about how to specify that mandate. Perhaps most importantly, the “financial stability objective” of macroprudential policy is not directly observable.

We do not wish to exaggerate the clarity of the inflation targets provided for monetary policy. There has of course been ongoing debate about the price index that should be used to measure inflation, the horizon, and the appropriateness of “caveats” and exclusions, not to mention sectoral issues relate to price stickiness. (On the latter issue see Mahadeva and Sterne 2000, Aoki 2001, Mankiw and Reis 2003, and Woodford 2003).

Conceptually, financial stability and inflation targets are both intermediate objectives. While inflation is often treated as a macro objective in its own right, Woodford (2003) makes clear that it is a metric for measuring distortions that arise in response to sticky prices, and thus a metric for evaluating the extent to which resources are misallocated across firms that have adjusted their prices recently and those firms that have not. Identifying a financial stability metric that approximates distortions in financial intermediation would be desirable, but no single metric has yet been identified.

[22]For example, the European Systemic Risk Board notes, “The tasks and powers of the macro-prudential authority should be clearly defined.” See (10), page 2 at http://www.esrb.europa.eu/pub/pdf/ESRB_Recommendation_on_National_Macroprudential_Mandates.pdf?87d545ebc9fe76b76b6c545b6bad218c. Similarly, the International Monetary Fund suggests that explicit objectives help to “guide decision-making and enhance accountability.” See http://www.imf.org/external/np/pp/eng/2013/061713.pdf.

Theoretical research has endeavored to be more specific about the measurement of distortions that affect welfare. For example, Carlstrom, Fuerst, and Paustian (2010) introduce agency costs into a dynamic stochastic general equilibrium model, and derive a welfare function that contains a "risk premium" in addition to the more standard output and inflation arguments (see also De Paoli and Paustian 2013). Such metrics have not yet been adopted explicitly by policymakers. While there are a number of observed variables that are related to financial stability—asset prices, leverage, credit spreads—there is no consensus about which variable should be of primary interest. The lack of primacy perhaps reflects the fact that there are multiple distortions that may affect financial stability, from agent myopia to information asymmetries to moral hazard, and there is no consensus as to which distortions are most costly.

To sum up, we do not yet have a single numeric objective for macroprudential policy. We do not know which distortions are most important and we do not have a single observed variable to represent those distortions. Research is ongoing to understand how policies affect policymakers' feasible choice sets, but this research is still at an early stage. The objectives as currently expressed for policy purposes provide little guidance as to how macroprudential policies will ultimately be implemented.

3.3 Transparency

In this section we focus on macroprudential policy efforts to strategically influence private agents, first arcing back to discuss the monetary transparency literature. Central bank transparency is intended to shape private expectations, contributing to the transmission of policies to the interest rates and asset prices that influence private behavior.

Inflation reports or monetary policy statements have become one of the most important vehicles of central bank communication. These reports discuss the current state of the economy and current policies. Many inflation reports or monetary policy statements also contain a great deal of information about the future evolution of the economy and future monetary policy actions. For example, the Riksbank, Norges Bank, and the Reserve Bank of New Zealand all report their expected future interest rate paths, and the former two central banks routinely report fan charts to illustrate uncertainty about future outcomes.

Central bank transparency has come under increasing academic scrutiny—influenced at least in part by the development of inflation targeting. A substantial literature quantifies transparency and evaluates its impact on macroeconomic outcomes.[23] The literature on transparency has tended to focus on the impact of informational asymmetries between the central bank and private agents. Models of transparency then need to distinguish the source of private central bank information (whether it is about the state of the economy or the preferences of the central bank); the distribution of private information about the state of the economy; and the quality of the "signal" from the central bank to private agents.

There is an extensive literature that supports increased central bank transparency. However, the *optimal* level of transparency is determined as the outcome of two competing considerations. On the one hand, providing clear and timely information may help central banks achieve their objectives, by making it less costly to disinflate. Yet on the other hand, increased transparency may increase economic volatility if public pronouncements displace private information. Economic agents' decisions may then be contaminated by noise in public communication.[24] In a similar vein, Walsh (2007) develops a theoretical model that shows transparency may help to augment diverse private information sets, but that the desirability of transparency depends on whether supply or demand shocks predominate.

The empirical evidence in favor of transparency is supportive, though not unambiguously compelling. Using cross-country evidence, Demertzis and Hughes Hallett (2007) suggest that greater transparency reduces inflation volatility but increases output volatility. Ehrmann, Eijffinger, and Fratzcher (2012) find that central bank transparency reduces costly forecast disagreement amongst private-sector forecasters. In their review of the literature on central bank communication, Blinder et al. (2008) conclude that communication can be a powerful tool to help monetary authorities

[23] See Geraats (2002), Eijffinger and Geraats (2006), Demertzis and Hughes Hallett (2007), Dincer and Eichengreen (2007, 2014), and Siklos (2011).

[24] See Morris and Shin (2002), Svensson (2006), and Geraats (2007).

achieve their objectives. For New Zealand, Moessner and Nelson (2008) find evidence that the Reserve Bank's forecasts of its policy rate influence market prices.[25] Moreover, they find no evidence that market participants place undue weight on policy rate guidance, and they suggest that market participants understand the uncertainty and conditionality of these forecasts. Looking at New Zealand and Norway, Rudebusch and Williams (2008) reach the same conclusion.

Communication about macroprudential policies has become increasingly important as financial stability concerns have increased in prominence. Macroprudential policy frameworks have appropriated the same transparency mechanisms underlying monetary policy. Financial stability reports (FSRs) report on the risks that might perturb the stability of the financial system, report on the state of the economy (broadly defined), and discuss the use of macroprudential policies to support stability. The discussion of policy may contain ex post evaluations of policies that have been implemented and ex ante descriptions of policies that may be deployed in future. Born, Ehrmann, and Fratzscher (2014) show that FSRs do indeed have a material impact. They investigate a data set of more than 1,000 financial stability reports and speeches for the period 1996–2009 and find that FSRs affect stock market returns and reduce market volatility.

Transparency about macroprudential policies may have important payoffs by moderating the risk-taking behavior of private individuals. Yet being transparent about the tactics of macroprudential policymaking can be difficult, as there is not necessarily a clear mapping from the state of the economy through to actual policy choices. These challenges exist for monetary policy but seem even more acute for macroprudential policies. The difficulties arise because of the proliferation of macroprudential instruments and the lack of well-accepted rules governing their behavior.

Macroprudential policies also impact the propagation of the monetary transmission mechanism (Claessens et al. 2013, Agénor and da Silva 2014). If private agents are to develop a clear idea of how macroprudential (and monetary) policies will be implemented, then

[25]Similar evidence is found by Ferrero and Secchi (2009).

they must learn about policymakers' preferences and about policymakers' understanding of the trade-offs involved, which will be governed by the underlying constraints imposed by policy transmission mechanisms.

Monetary policy communication is very clear about the timing and likely menu of policy actions.[26] Interest rate decisions are generally made at regular intervals, and movements are typically made in 25- or 50-basis-point increments or decrements. At this point, there is much greater ambiguity about how and when macroprudential policies might be implemented and adjusted. There is of course variation across countries. For example, the Reserve Bank of New Zealand does not have a pre-announced schedule for macroprudential policy announcements, though FSRs are biannual. Elsewhere, the Financial Policy Committee of the Bank of England meets roughly quarterly at pre-announced dates, and Norges Bank provides advice on countercyclical capital buffers in conjunction with the Executive Board meetings that determine interest rates.

FSRs are heavily based on intermediate targets such as asset prices, measures of credit, or measures of the price of risk, and these quantities are associated with capital or asset portfolio decisions, which are inherently forward looking. However, Čihák et al. (2012) find that FSRs tend to focus on the current levels of financial stability indicators and the current state of the economy, with relatively less forward-looking information. If policymakers wish to use macroprudential policies to influence asset prices, and if macroprudential policies have some effect on asset prices, then macroprudential policymakers should also look to forecast and reveal future macroprudential policies, since even future policy actions are relevant to current asset prices. Helping private agents to understand the evolution of future policy and future macroeconomic developments should be a central feature of macroprudential communication.

3.4 Accountability

In this section we discuss accountability, with reference to both monetary and macroprudential policies. Accountability has been a

[26] Unconventional policy actions may be considered an exception to this statement.

central element of inflation-targeting regimes, in part reflecting the growing independence of central banks (Cukierman 2008). To be held accountable, policymakers must have clear objectives and a clear delineation of their policymaking powers.

With respect to monetary policy, different inflation-targeting countries have adopted different accountability mechanisms to explain and assess policy actions. These accountability mechanisms are typically multi-layered. Central banks' primary accountability relationships are with independent boards and with governments, but they may also be required to consult with or inform political authorities more broadly. As public institutions, all central banks are subject to the legislated preferences of the government (Goodhart 1994), and administrative law considerations may subject central banks to judicial review. Therefore all central banks are ultimately subject to mechanisms that ensure democratic accountability.

Accountability mechanisms include the provision of information and the incentives provided for performance of duties. When duties are not performed satisfactorily, sanctions may be applied to the monetary authority—perhaps as embodied by the governor. These sanctions vary from country to country, with some jurisdictions sacrificing de jure accountability in favor of greater decision-making independence.

Using theoretical models, Persson and Tabellini (1993) and Walsh (1995) examine the incentives that can be provided to individual central bankers to ensure optimal monetary behavior. Walsh, for example, finds that if the monetary policy agent only cares about their own pecuniary incentives, then the optimal contract may be some kind of inflation rule contingent on supply shocks.[27] Further, Walsh (1995) establishes that the optimal commitment policy can be sustained by a dismissal policy based on the measured rate of inflation, with the central bank governor being fired if inflation exceeds a critical inflation rate determined by the government. In principle, the Reserve Bank of New Zealand Act of 1989 provides mechanisms

[27]In the initial stages of inflation targeting in New Zealand, it was suggested that the governor of the time, Don Brash, had explicit pecuniary incentives to achieve good inflation outcomes. Nowadays, explicit pecuniary incentives receive little attention. In countries with decision-making committees, it may be hard to devise pecuniary incentives to maximize performance.

and a number of grounds for the governor's dismissal,[28] but in practice these provisions have never been deployed. Most central bank legislation allows for the dismissal of officials only in cases of serious misconduct or incapacity, and rarely because of poor performance (Bank for International Settlements 2009).

Much of the incentive for good performance by central bank policymakers come from the reputational costs that ensue if the central bank fails to meet its obligations. These informal accountability mechanisms complement de jure accountability. Robert Reynders, formerly a director of the National Bank of Belgium, has suggested that de facto accountability can exert a much sharper constraint than de jure accountability.[29] Since outcomes depend on both policy actions and other shocks, accountability mechanisms tend to evaluate decision making based on the information and advice that was available ex ante. De jure sanctions may then be difficult to enforce, given that many plausible policy actions can be justified ex ante, particularly since policies must take into account tail risks that may not even arise ex post.

One dimension of accountability that has changed substantially in the last thirty years is the provision of information to the general public. This transparency has increased the accountability of central banks by providing the press, academic experts, financial markets, and a wider spectrum of parliamentary representatives with information that can be used to assess the quality of monetary policy decision making. While it is widely accepted that monetary policy is best placed in the hands of expert central bankers rather than in the hands of politicians,[30] ensuring accountability to the general public remains important to legitimize the decision making undertaken by central bank policymakers.

[28]As Reddell (2006) notes, the Act does not allow the governor to be dismissed simply for failing to meet the policy targets. The criteria in the Act refer explicitly to the performance of the Bank and the governor in pursuit of those targets.

[29]See Reynders' comment on Briault, Haldane, and King (1997).

[30]See Donald Kohn's testimony before the House Committee on Financial Services, February 11, 2014 (available at http://www.brookings.edu/research/testimony/2014/02/11-monetary-policy-state-of-the-economy-kohn) and Romer and Romer (1997).

There is as yet no single "best practice" institutional framework to ensure macroprudential accountability.[31] To a large extent, the accountability mechanisms first instituted for monetary policy have been copied and applied to macroprudential policy. In the New Zealand case, for example, the Reserve Bank Board and the minister of finance oversee both monetary and macroprudential decision making.[32] Biannual financial stability reports have also been instituted to complement quarterly monetary policy statements.

There are, however, several reasons why even stricter accountability mechanisms might be needed for macroprudential policies. First, as a general principle, more extensive powers require greater effort to ensure accountability. Central banks that have been assigned additional responsibility for macroprudential policies should therefore be subject to stronger accountability mechanisms to discipline the implementation of these policies. Second, macroprudential policymakers may be susceptible to regulatory capture, since their policies are likely to affect financial institutions—a well-resourced special interest group. Barth, Caprio, and Levine (2012) suggest that regulatory capture is of substantive importance in the sphere of finance. Third, although even monetary policy has distributional effects (Fischer 2014), the redistributive consequences of macroprudential policies may be even more substantial or more self-evident (Haldane 2013). These policies can directly constrain private behavior and may dictate the allocation of resources within society. Moreover, as noted earlier, macroprudential policies may also have public finance consequences (Goodfriend 2012). Arguably, unelected officials should not determine such redistribution alone.

Baxter (2011) suggests a variety of mechanisms to try to ameliorate the negative consequence of regulatory capture. One suggestion is to foster "creative turbulence," to challenge the frameworks and policies that are being deployed. The high degree of transparency that is a hallmark of inflation-targeting regimes should help to

[31] See Nier et al. (2011a) for a discussion of the institutional arrangements for macroprudential policy deployed by different countries.

[32] The New Zealand Treasury provides additional scrutiny.

scrutinize and challenge the frameworks put in place for macroprudential policies.[33]

Another approach to moderate regulatory capture is to accept that vested interests will be promoted, but to seek to achieve balance between competing interests, ensuring that no single group has a disproportionate impact on outcomes. One suggestion to balance competing interests is to promote public-interest groups to advocate in favor of underrepresented constituencies. In the United States the Consumer Financial Protection Bureau, established under the Dodd-Frank Act in 2010, might be regarded as one such entity. In a related vein, Barth, Caprio, and Levine (2012) suggest that "sentinels" should be created to provide oversight of financial regulators. Arguably, the Board of the Reserve Bank of New Zealand and the "independent evaluation unit" recently established at the Bank of England are examples of such.

In New Zealand, substantial effort has been made to break the monopoly of information—if not the monopoly on expertise. Both monetary policy statements and financial stability reports are referred to the House of Representatives, and the governor testifies to, and answers questions from, the Finance and Expenditure Committee (FEC), a subcommittee of parliament. The FEC may obtain third-party advice to examine these policy documents, in addition to the oversight provided by the Reserve Bank's Board. Bean (1999) argues that to be effective, parliamentary committees need to be well resourced to perform these supervisory functions effectively.[34]

The likelihood of regulatory capture may also be ameliorated in other ways. In New Zealand, for example, the Reserve Bank must consult with persons or the representatives of persons affected by regulations imposed on deposit takers (under section 157E of the Reserve Bank Act). This consultation is open to the general public as a whole. Such consultation broadens the realm of viewpoints to

[33]Multi-agency frameworks that seek to maintain financial stability and committee structures may also contribute diverse points of view. Naturally there is a delicate balancing act between diverse and robust debate and obstructive practices that thwart the effective implementation of policy. It seems likely that all institutional frameworks may successfully negotiate this balance or, conversely, fail to do so.

[34]Similar arguments are also made in Barth, Caprio, and Levine (2012).

which the Reserve Bank is subject.[35] It is interesting to note that there is no counterpart to this consultation in the implementation of monetary policy. While consultation about macroprudential policy is advantageous on accountability grounds, it impedes very rapid changes to policy.

In principle, much of the decision making in macroprudential policy could be devolved back to political authorities. Such a move could be justified by the fact that prudential (and implicitly macroprudential) decisions may have substantial fiscal implications if a large financial institution is provided liquidity support or, in a worst-case scenario, bailed out. Reallocating macroprudential policy to political authorities would then subject it to accountability through the electoral cycle. However, devolving macroprudential decisions to political authorities makes them both "worker and overseer," yielding a potentially contradictory mix of incentives for transparency to the general public. An alternative approach to foster democratic accountability would be to elect either the central bank governor or decision-making committee members possibly to long and/or staggered terms. This approach could be used to "extract" monetary/macroprudential issues from the bundled good that individual political parties "sell" in parliamentary elections (see Besley and Coate 2003 for a related discussion). Parliamentary authorities and/or a separate board could then be used to provide oversight of these elected officials.

The extension of accountability mechanisms to macroprudential policies seems entirely desirable on generic grounds, but it is hard to discount the difficulty of holding macroprudential policymakers to account. There is not so much an information asymmetry between policymakers and the general public as an information deficit. Policymakers and public alike do not know exactly how these policies translate into macroeconomic and macroprudential outcomes. There is uncertainty about the objectives of macroprudential policies, and there is uncertainty about the effects of such policies. Ingves (2011) suggests that accountability must then focus on the correct application of processes rather than outcomes, though this conclusion is dissatisfying and rather at odds with the outcome focus of

[35] It is worth noting that while the Reserve Bank must consult, failure to do so does not affect the validity of regulations made under section 157E.

inflation targeting. These accountability problems exist irrespective of whether macroprudential policy is implemented by a central bank, a financial stability authority, or indeed a political authority.

Uncertainty about macroprudential policies mirrors the monetary policy uncertainty that existed following the breakdown of the Bretton Woods system of fixed exchange rates. As then, the implementation of policy is likely to evolve through time as policymakers develop practical experience using new instruments. We remain convinced that transparent communication to the general public remains a significant element in ensuring accountability.

4. Conclusion

In this article we use the four attributes of inflation targeting—independence, transparency, accountability, and the explicit inflation objective—to help frame debate about the institutions used to govern macroprudential policies. Overall, we argue that these attributes are important for effective macroprudential frameworks. There are, however, some points of difference.

First, the merits of independence are not as clear for macroprudential policy. One reason to appoint an independent policymaker is to take advantage of "expertness." However, this advantage must be balanced against the possibility that the policymaker may pursue trade-offs at odds with the mandate provided by government and the public at large. The scope for such trade-offs is exacerbated if outcomes are not directly observable or if outcomes are not self-evidently related to the policies that have been implemented. These problems seem more substantial for macroprudential policy than for monetary policy.

We have also argued that macroprudential policies are interdependent and cannot be pursued entirely "independently." Monetary and macroprudential policies are unified by their connection to social welfare, and policies should be implemented to optimize their marginal contribution to this overarching notion of welfare. In principle, policies must be coordinated if they are to be set optimally, but whether the interdependencies are material remains uncertain. Of course, macroprudential and monetary policy could be coordinated even if they were housed in separate institutions.

There is a strong case for monetary authorities to be independent and/or for other constraints that prevent political authorities from monetizing budget deficits (since political authorities may have little regard for the inflationary consequences of doing so). While political authorities could use macroprudential policies indirectly to stimulate the economy and therefore increase tax revenue, it may be more difficult to use macroprudential policies to deal with such funding issues. Thus, the case for appointing an agent to run macroprudential policy independently of political authorities is arguably somewhat weaker.

The second observation we make is that financial stability objectives and intermediate targets should be made more explicit. Policymaking involves strategic interaction between policymakers and private agents, and is an exercise in influencing the behavior and expectations of private agents. While announcing objectives can foster coordination in strategic games, we do not see that financial stability objectives, as commonly expressed, provide enough guidance about the macroprudential policies that will be implemented in the future.

Our third observation is that macroprudential policymakers need to consciously address their communication of future policy actions. As advocates for transparency, we suggest that the institutions of policymaking should explicitly address when policy decisions will be announced and/or implemented, and greater attention should be paid to the menu of macroprudential policies. Macroprudential policies governed by principled rules-based behavior would make clear what policies will be pursued and how they will be adjusted through time, but much work needs to be done before operational, state-contingent macroprudential rules can be identified.

Our fourth observation is that applying the accountability mechanisms of inflation targeting to macroprudential policies has been a desirable development, though these mechanisms should be strengthened further. We remain convinced that transparent communication to the general public remains a significant element in ensuring accountability.

Lastly, while the accountability institutions for macroprudential and monetary policies are well developed, oversight and accountability are materially constrained by the quality of current analytical frameworks. Such uncertainty makes it difficult to provide objective assessments of macroprudential policies. Looking forward, we must fully expect that macroprudential policies will evolve as views solidify about the most important distortions and the most important macroprudential mechanisms. Institutional frameworks should be flexible enough to accommodate such changes.

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Discussion of "Applying an Inflation Targeting Lens to Macroprudential Policy 'Institutions'"

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Macroprudential policy has been very much the flavor of the month ever since the 2007–8 global financial crisis, as central banks seek to reconcile their mandate to maintain monetary (price) stability with the objective of maintaining systemic financial stability. Before the crisis, these were seen as largely complementary goals. But, with hindsight, we can see there may be occasions when they are in conflict.

Since Tinbergen, we have known that achieving n objectives requires n (independent) instruments. Monetary policy alone cannot guarantee both monetary and financial stability. We need another instrument, effective at mitigating the risks to financial stability. Macroprudential policy is supposed to provide that additional instrument, leaving monetary policy free to maintain price stability. Unlike monetary policy, however, policymakers have little experience in the application of macroprudential policy tools, and even less in designing an appropriate institutional framework within which to operate them.

In their interesting and novel paper, Güneş Kamber, Özer Karagedikli, and Christie Smith view the issue of institution design through the lens of what they identify as the four key attributes of inflation targeting, namely objective(s), independence, transparency, and accountability.

This certainly provides a useful organizing framework, but the first thing to note is that these attributes themselves derive from what we might think of as just two *meta-objectives*: policy effectiveness and political legitimacy. Not surprisingly, the small—but rapidly growing—economic literature on macroprudential policy focuses on policy effectiveness. It has much less to say about political legitimacy, though I think this is where some of the trickiest issues emerge.

Let me begin, though, by recalling how the authors' four key attributes play a role in achieving price stability. First, expectations of future interest rates, inflation, and output play a central role in determining the level of activity and prices today. And having a clear objective for inflation (and for subsidiary concerns, such as output and employment) together with transparency on how the central bank intends to go about achieving its objective(s) helps to shape those expectations of the future.

The delegation of the instruments of monetary policy to an independent agency is potentially helpful because it can eliminate (or at least mitigate) the time-inconsistency problem and reduce the scope for policy being misdirected for short-term political ends. It is not, however, a *necessary* feature of inflation targeting. For instance, the UK government first adopted an inflation target in 1992 after sterling's ignominious exit from the EU Exchange Rate Mechanism, but the Bank of England was not given full operational responsibility for monetary policy until 1997. Between 1992 and 1997, the Chancellor of the Exchequer still made the decisions on interest rates, but he did so in a regular and open process in which the Bank of England was an equal partner, thus providing a brake on any tendency to misuse policy.

If policy is delegated to the central bank, however, democratic legitimacy necessitates public accountability in return. And effective accountability is enhanced by having a clear objective against which the central bank's performance can be evaluated, as well as transparency over the rationale for its decisions. Trust *can* replace active accountability—for instance, the Bundesbank in the era before monetary union—but it somehow needs to be earned first.

In light of these comments, let me turn to macroprudential policy, starting with the objective. The first thing to be said is that the financial stability objective is intrinsically different from that of price stability. We can easily define an aggregate measure of prices and can observe, more or less continuously, whether price stability according to that measure is achieved, and at what cost to output and employment. In assessing policy, the material issue is then whether the central bank has used its "constrained discretion" effectively and appropriately. To be sure, judgment is necessary, but the room for debate is reasonably well circumscribed.

Maintaining financial stability is completely different, since it hangs on *avoiding* something—financial *in*stability, resulting in a significant impairment to the process of financial intermediation—rather than achieving something. And the mere absence of financial instability does not indicate that everything is well. A prime example here is the buildup of risk ahead of the global financial crisis.

Moreover, we presently lack reliable and agreed indicators of the risks to financial stability. Certainly leverage ratios, bank capital ratios, and risk spreads are sensible things to look at. But leverage ratios do not take into account the riskiness of different assets. Bank capital ratios avoid that problem, but at the cost of introducing another problem in the form of risk weights that are open to manipulation. And spreads often provide a misleadingly comforting picture just before a financial crisis breaks, blowing out only in the subsequent bust.

Now it might be tempting to think that, with research, we might be able to develop reliable statistical indicators of the probability of a financial stability event. I think this is fool's gold. The threats to financial stability tend to shift both form and location over time. Risks can be disguised—for instance, by shifting them off balance sheets, as happened in the run-up to 2007–8. And it is easy for people to think that they are smarter than their predecessors and to believe that "this time is different." All of this means that we should not expect to be able to quantify the likelihood of a financial stability event with precision—the present is just not enough like the past to regard it as a draw from a stable statistical distribution. The problem is more akin to dealing with Knightian uncertainty.

The bottom line from all this is that it is far more difficult to track progress and for people to agree whether actions taken to mitigate financial stability risks were prudent and justified or just a case of tilting at windmills. That in turn makes effective accountability much harder to achieve than in the monetary policy sphere.

That does not mean all is lost. But rather than prioritizing the fine-tuning of the credit cycle, we are better off focusing first on improving systemic resilience: in other words, protecting the banks from the financial cycle. This means ensuring that banks (and other financial institutions) have sufficient loss-absorbing capacity, together with enough debt that can be bailed in; that resolution regimes are fit for purpose; and that the more essential parts of the financial system are suitably ring-fenced. And indeed such issues have rightly been at the top of the G20/Financial Stability Board/Basel Committee on Banking Supervision (BCBS) agenda in the aftermath of the crisis.

Macroprudential policies to address time-varying risks such as a buildup of credit—protecting the economy from the banks, in other words—then becomes more of a supplementary weapon: it is potentially useful, but we should not expect too much. The authors dangle the carrot that eventually such policies might be set according to some simple state-contingent rule, but I think this is really pretty unlikely. Macroprudential state-contingent rules are certainly feasible—for instance, the BCBS "buffer guide" links the countercyclical bank capital buffer to the behavior of the credit-GDP ratio—but are unlikely to have satisfactory operating properties for the reasons already discussed. I think the application of discretion is simply unavoidable in this area.

Let me now turn to the question of whether macroprudential policy is best delegated to an independent agency (which may or may not be the central bank). Even more than with monetary policy, a long time horizon is needed to take financial stability considerations on board. By itself, that provides a strong argument for delegation to a technocratic body charged with taking such a long view. But the distributional consequences, particularly of interventions such as caps on loan-to-income or loan-to-value ratios, are more obvious and concentrated than is the case with monetary policy. You can be sure that when such constraints are applied during the upswing of the credit cycle, there will be no end of pushback from lenders, people denied mortgages, and politicians—all of whom will be claiming that the macroprudential authority is curbing borrowing needlessly. So democratic legitimacy for delegation first requires establishing a broad constituency for financial stability akin to that which now exists for price stability. Despite the financial crisis, I am not sure that constituency is properly established yet.

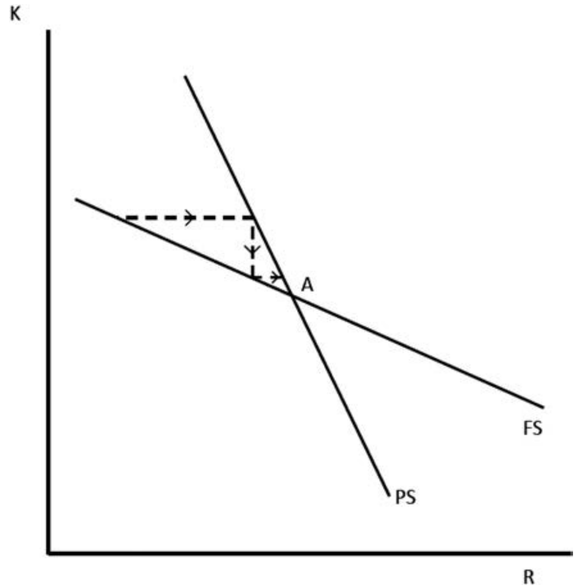
If macroprudential policy is to be delegated, to whom should it go? The obvious choices are either the banking supervisor or the central bank (sometimes, of course, they are the same). The case for the latter is that it already adopts a macroeconomic perspective and also has day-to-day dealings with the banking system. But if banking supervision is not in-house, then it is absolutely essential that central bank and bank supervisor work closely together. Certainly, it is my perception that the Financial Policy Committee, the body charged with operating macroprudential policy in the United Kingdom, has worked more effectively since supervision came back to the Bank of England in 2013.

Should macroprudential policy just be delegated to whatever body already determines monetary policy? This might seem the natural choice, which also internalizes any coordination issues if they are set by separate bodies. However, this ignores the fact that special expertise is useful for both monetary policy (macroeconomics, monetary economics, etc.) and macroprudential policy (finance, knowledge of banking, etc.) and separate committees allow such specializations to be represented.

Of course, if there are two committees, some overlap in membership is probably desirable, as is the case in the new arrangements in the United Kingdom. But does one need to go further and establish formal mechanisms to ensure coordination? I believe the answer to this is no, at least in principle.

Without going through the details, the way I think about the issue is captured in figure 1. Suppose we have two objectives: price stability and financial stability. We also have two instruments: a monetary policy instrument, R; and a macroprudential instrument, K. Raising either R or K reduces aggregate demand and reduces the risk of financial instability. A good macroprudential instrument is one that has a big effect on the risk of financial instability without damaging aggregate demand too much (i.e., it is well targeted). The pairs of R and K consistent with achieving price stability thus lie on a downward-sloping locus (PS in the figure). And the pairs of R and K consistent with a given risk of financial instability will also lie on a downward-sloping locus (FS in the figure). However, if the macroprudential instrument has a comparative advantage in maintaining financial stability, then FS will be flatter than PS. In that case, provided the monetary and macroprudential policy committees share the same *overall* objective (i.e., welfare function), the principal can just assign price stability to the former and financial stability to the latter and leave them to get on with it: the economy will converge to a Nash equilibrium where the two stability loci intersect. That

Figure 1. Assigning Monetary and Macroprudential Policies



said, it seems to me quite natural that the two committees should talk to each other. And, indeed, at the Bank of England, not only do the Monetary Policy Committee and Financial Policy Committee have several members in common, but they have also met together on several occasions.

Having introduced this apparatus, it is also useful for illustrating the point that sometimes monetary and macroprudential policy settings may appear to be in conflict. Figure 2 illustrates a case when they are not: "irrational exuberance" associated with excessive optimism about future prospects. In such a case, both borrowing and aggregate demand are likely to rise, shifting both PS and FS out. As drawn, it is appropriate to raise both R and K.

In contrast, figure 3 shows what happens in the face of a beneficial supply shock. In this case, the increase in supply shifts the PS locus inwards (policy needs to loosen to boost aggregate demand to match supply) but it may also be prone to set in motion a speculative credit boom, shifting the FS locus out. Now we need a loosening in monetary policy (R falls) accompanied by a tightening in

Figure 2. Irrational Exuberance

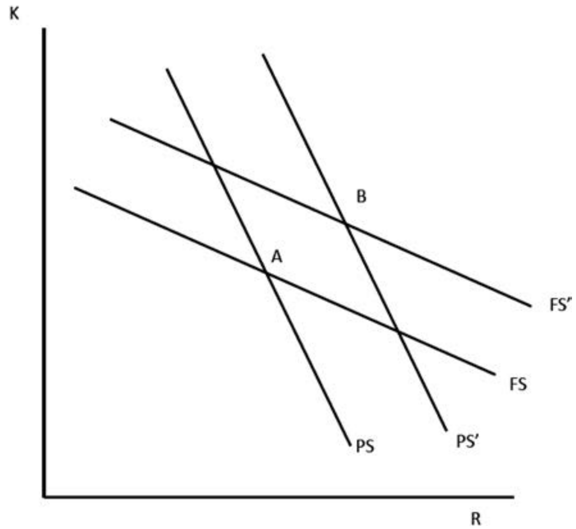
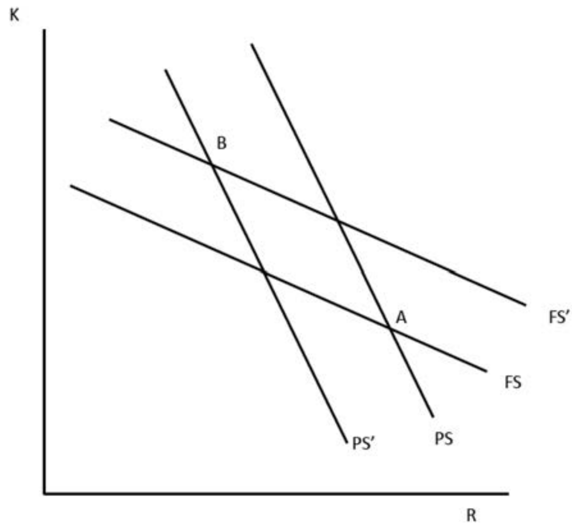


Figure 3. Beneficial Supply Shock



macroprudential policy (K rises). It is therefore perfectly reasonable for the instruments to move in opposite directions.[1]

Let me turn next to transparency. Transparency certainly improves the effectiveness of monetary policy. Can the same be said for macroprudential policy? I think the answer is less clear. Certainly, warnings promulgated through Financial Stability Reports and other communications may change behavior in a beneficial direction—though the warnings contained in the Bank of England's Financial Stability Reports in 2005–6 regarding the underpricing of risk and the problems that could arise from off-balance-sheet vehicles seem to have had negligible effect! And advance warning that, for instance, the macroprudential authorities were contemplating raising the countercyclical capital buffer could both encourage banks to raise capital in advance and discourage them from lending so much now. However, such transparency also gives financial institutions more time to work out ways to arbitrage possible future interventions designed to curb their behavior.

Of course, transparency is not just about increasing policy effectiveness. It is also potentially helpful for improving accountability. Here I think one must acknowledge that finance is a technical and jargon-ridden world that parliamentarians and the public can struggle to understand. Transparency in the macroprudential authorities' communications can also be most helpful in building the constituency for financial stability.

Finally, what about accountability itself? Holding a macroprudential authority accountable is intrinsically harder than holding a monetary policy authority accountable because of the fuzziness of the macroprudential objective and the difficulty of knowing whether policy interventions were justified or were just tilting at windmills. Specialist knowledge is needed, and parliamentarians really need expert support if they are to do an effective job. Alternatively, the oversight function normally carried out by parliamentarians can also be delegated to a group of independent experts, though this runs the risk of creating a world where one lot of experts/technocrats criticize another lot of experts/technocrats. It is not clear why the view of one group should be regarded as preferable to that of the other.

[1]This is a direct analogue of a rebalancing in the composition of aggregate achieved through a combination of fiscal tightening and monetary loosening.