Monetary Policy and Defaults in the United States*

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This paper uses a structural VAR model to study the effect of monetary policy on the delinquency rate of business loans and consumer credit. The VAR is identified using, jointly, several external instruments that reflect different approaches from the literature. Delinquency rates, defined as the rate of loans with overdue repayments relative to total loans, are found to decrease in response to an exogenous monetary expansion. The results are consistent with a general equilibrium effect formalized in the paper using a standard model of optimal defaults. According to both the theoretical model and the reported empirical evidence, the decrease in defaults is driven by the fact that monetary expansions increase aggregate demand and push up profits and income, thereby improving the repayment possibility of borrowers.

JEL Codes: E52, E58.

1. Introduction

This paper studies the effect of monetary policy on the delinquency rate of U.S. business loans and consumer credit. Since delinquent loans measure loans whose repayment is overdue for more than thirty days, the ratio of delinquent loans to total loans (the delinquency

*I thank Wouter Den Haan for his priceless guidance. I also thank Saleem Bahaj, Luca Fornaro, Leonardo Gambacorta, Jochen Günter, Ethan Ilzetzki, Michael McMahon, Jean-Stephane Mesonnier, Pascal Paul, José Peydró, Max Podstawski, Malte Rieth, Paolo Surico, and Thijs van Rens for comments and suggestions. The paper benefited from financial support from the Fondazione Eni Enrico Mattei, from the Economic and Social Research Council, and from Banca Popolare Commercio e Industria. Author contact: Queen Mary, University of London, School of Economics and Finance, Mile End Road, London E1 4NS, United Kingdom. E-mail: m.b.piffer@gmail.com. Tel.: +44(0)2078828712. Personal web page: https://sites.google.com/site/michelepiffereconomics/.

rate) is closely monitored by the Federal Reserve as a measure of the quality of loans and as a proxy for the default probability of loans.[1] This paper first studies empirically the effect of monetary policy on delinquencies using a structural vector autoregression (SVAR) model identified with external instruments, employing the methodology of Stock and Watson (2012) and Mertens and Ravn (2013). It then uses comparative statics on the debt contract of Townsend (1979) and Bernanke, Gertler, and Gilchrist (1999) to develop an economic intuition of what might drive the results.

From an empirical point of view, identifying the causal effect of a monetary intervention on the default rate of loans is not straightforward, as one needs to establish whether the federal funds rate is exogenous to delinquency rates. It could be argued that the federal funds rate is exogenous to expected future defaults, given that future defaults are not an explicit target of central banks. However, while not set directly as a function of future defaults, the federal funds rate might respond to expected future defaults indirectly, given that defaults are correlated with economic activity. As such, an impulse response that predicts that a monetary expansion increases delinquency rates might still be driven by the fact that the Federal Reserve expanded monetary policy in anticipation of a downturn in economic activity.[2]

In the empirical part of the paper, I address the above identification challenge using a VAR model for the period between 1979:Q3 and 2008:Q4 identified with external instruments. I use several instruments for monetary policy shocks, combining in a two-stage least-squares estimation the instruments generated by the three most widely used approaches in the literature. In particular, I use the Romer and Romer shocks (developed by Romer and Romer 2004), the shocks estimated by a large recursive VAR model (which

[1]See, for instance, the following speech by former Chairman Ben Bernanke in May 2008, http://www.federalreserve.gov/newsevents/speech/bernanke20080505a.htm.

[2]On the one hand, financial stability concerns rarely appear in the minutes of the Federal Open Market Committee before the 2007 crisis, as documented by Dell'Ariccia, Laeven, and Suarez (2017). On the other hand, financial stability concerns might have always indirectly played a relevant part in the conduct of monetary policy by the Federal Reserve Bank, as argued, for example, by Governor Lael Brainard in a speech on December 3, 2014, http://www.federalreserve.gov/newsevents/speech/brainard20141203a.htm.

I take from Bańbura, Giannone, and Reichlin 2010), and the shocks computed using futures contracts on the federal funds rate (which I take from Gertler and Karadi 2015). This comprehensive approach has the advantage of avoiding selecting and crucially relying on a single identification strategy, a choice which proves hard in light of the limited consensus in the literature on which methodology is the best one. The VAR model used in this paper combines the information content of the Federal Reserve's expectations included in the Greenbook forecasts, the information content of a large data set used in the VAR, and the model-free information content from high-frequency data from financial markets.

The empirical part of the paper finds that an expansionary monetary policy shock decreases the delinquency rate of both business loans and consumer credit. In particular, in response to a one-standard-deviation shock, the federal funds rate decreases on impact by around 80 basis points. This leads to an overall decrease in the delinquency rate on both business loans and consumer credit by around 8 basis points. The decrease in the delinquency rate on business loans is reached eleven quarters after the initial shock and is statistically significant between ten and twelve quarters, while the decrease in the delinquency rate consumer credit occurs around nine quarters after the shock and is statistically significant already after four quarters.

The result that delinquency rates decrease following an exogenous monetary expansion raises the question of what economic forces drive defaults to decrease. From a theoretical point of view, whether a monetary expansion increases or decreases defaults is a priori ambiguous. On the one hand, a monetary expansion is likely to generate general equilibrium effects on borrowers' income and profits in line with the "credit view," as a result of the rightward shift of aggregate demand. These effects decrease defaults, since the wealth of borrowers expands. On the other hand, as discussed below, monetary expansions have been documented to generate risk-taking effects by leading banks to issue loans to more risky borrowers. To the extent that this partial equilibrium effect dominates in equilibrium, ex post defaults increase, rather than decrease, following a monetary expansion. I report empirical evidence supporting the general equilibrium effects just discussed—in particular, the increase in personal income and profits of households and firms. I then use an off-the-shelf model featuring a debt contract and optimal defaults to discuss the interaction of partial and general equilibrium effects of monetary interventions on defaults.

The literature on monetary policy and central banking has dedicated considerable attention to studying the banks' incentives to take on more risk after monetary expansions. This has been done using either microeconomic data (Maddaloni and Peydro 2013, Altunbas, Gambacorta, and Marques-Ibanez 2014, and Jimenez et al. 2014) or aggregate variations in credit standards (Afanasyeva and Güntner 2014 and Buch, Eickmeier, and Prieto 2014a) and leverage (Angeloni, Faia, and Lo Duca 2015). The present paper does not directly inspect the risk-taking channel of monetary policy, which relates to an ex ante incentive by banks to issue new risky loans, a perspective that precedes the possible realization of the risk taken. Analyzing ex ante risk-taking requires a different type of data. The perspective of the paper is, instead, on ex post measures of risk, i.e., after the possible materialization of risk, as in Buch, Eickmeier, and Prieto (2014b).[3]

Buch, Eickmeier, and Prieto (2014b) study whether ex post backward-looking measures of risk signal the additional risk taken by banks. Using a sign-restricted VAR model, they find that the share of non-performing loans held by banks decreases after a monetary expansion, and interpret the result in terms of the positive effect of monetary policy on the interest rate burden on firms. I contribute to the literature by providing further empirical evidence that backward-looking measures of risk tend to decrease after a monetary expansion. I outline how this decrease is consistent with the effect of monetary policy shocks on profits and personal income. I then show that the general equilibrium effect used to interpret the results in this

[3]The Survey of Terms of Business Lending by the Federal Reserve provides data on the average maturity of business loans in the period starting from 1997:Q2. When considering the subperiod that overlaps with the sample used in the baseline analysis, the average maturity of business loans equals 448 days, or approximately five quarters. The relatively short maturity of business loans provides an indirect link between ex ante and ex post measures of risk: an ex ante taking of risk on new loans following the monetary expansion might be reflected in the ex post measure of defaults well before the end of the horizon studied in the impulse responses. Put differently, on average the documented decrease in delinquency rates on business loans following a monetary expansion involves at least to some extent loans issued after the monetary intervention.

paper as well as in Buch, Eickmeier, and Prieto (2014b) is consistent with an off-the-shelf model featuring a credit channel. The empirical results are also consistent with Jimenez et al. (2014), who find that the default probability of existing loans decreases after a monetary expansion, and De Graeve, Kick, and Koetter (2008), who find that banks' probability of distress decreases after a monetary expansion.

The paper is organized as follows. Section 2 develops the empirical analysis and discusses the data, the identification strategy, and the results. Section 3 outlines the key mechanism behind a standard model of defaults and uses comparative statics to interpret the empirical results. Section 4 concludes.

2. A Proxy SVAR on Delinquency Rates

This section discusses the data used to measure defaults. It then introduces the different series of monetary shocks employed to identify the structural VAR model, and the reduced-form specification. Last, it discusses the results and their robustness.

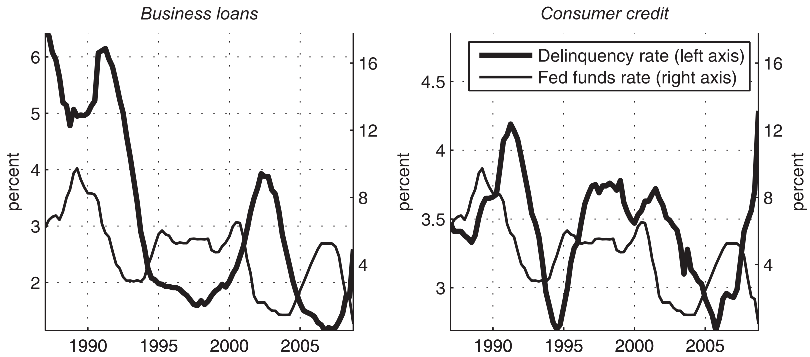
2.1 Data on Delinquency Rates

A borrower is officially considered delinquent on a loan if the loan repayment (interest or principal) is overdue for more than thirty days. The delinquency rate is defined as the ratio of the value of delinquent loans over the value of outstanding loans. The Federal Reserve collects data on delinquency rates from the Call Report, which is filed quarterly on a compulsory basis by all U.S.-chartered commercial banks. For confidentiality reasons, only a limited set of aggregate time series is made publicly available.

I use two aggregate delinquency rates, which are the delinquency rates on business loans and on consumer credit, respectively. Data on delinquency rates are available starting from 1987:Q1. The delinquency rates used refer to loans issued by all commercial banks. According to flow-of-funds data, the correlation of the value of these loans with the monetary aggregate M2 equals 86 percent and 92 percent, respectively. Overall, business loans and consumer credit jointly account for around 25 percent of banks' total assets.[4]

[4]The Federal Reserve also provides data on the delinquency rate of residential mortgages. I do not use this data because it is available only starting from 1991, and because it displays very limited variation before the 2007 crisis.

Figure 1. Aggregate Delinquency Rates



Notes: Deseasonalized delinquency rates and the federal funds rate in the period 1987:Q1–2008:Q4.

Figure 1 shows the evolution of the deseasonalized delinquency rates used in the analysis. The average value of the delinquency rates on business loans and consumer credit equals 3.10 percent and 3.43 percent, respectively, while the standard deviations equal 164 basis points and 37 basis points, respectively. Both series are strongly countercyclical. The period covered includes the buildup of delinquencies during the recession in the early 1990s, the recession that followed the dot-com bubble, and the period of high financial instability that began in summer 2007.

2.2 Monetary Shocks

Identifying the effects of monetary policy on delinquency rates requires isolating fluctuations in the federal funds rate that are exogenous to the Federal Reserve's expectations of future delinquency rates (see also Cochrane 2004 for a comment on this point). The literature has developed several methodologies to estimate monetary shocks. Since it is not clear a priori which of these methodologies is more likely to deliver shocks that are exogenous to the Federal Reserve's forecasts of defaults, I identify the SVAR developed in the next section simultaneously using different candidate available shocks as instruments for the monetary shocks. In particular, I use the time series of candidate monetary shocks representing the three most widely used approaches in the literature.

The first series of monetary shocks is taken from Romer and Romer (2004). These shocks are obtained as the residual when regressing an index of the intended variations of the federal funds rate on the Federal Reserve's Greenbook forecasts of real output growth, the GDP deflator, and the unemployment rate. The second series is taken from a recursively identified large VAR model by Bánbura, Giannone, and Reichlin (2010). I use the medium specification of their model, which includes twenty variables.[5] The third series of monetary shocks is taken from Gertler and Karadi (2015). They build on Kuttner (2001) and approximate the unanticipated policy rate variation with the variation in the three-month-ahead federal funds futures over narrow windows around monetary policy announcements. The baseline specification of the model uses the above three series of shocks as instruments to identify the monetary shock in VAR models.

To assess the robustness of the results to the inclusion of data covering also the period after the 2007 financial crisis, I also use the monetary shocks by Nakamura and Steinsson (forthcoming). Similar to Gertler and Karadi (2015), they compute the shocks on data on futures contracts but cover a more recent period, exploiting more than one interest rate, as in Gürkaynak, Sack, and Swanson (2005). The time availability of each of the four series is shown in table 1. The original series are available on a monthly frequency. In the baseline specification of the analysis, I transform these shocks to a quarterly frequency using the sum within quarter, an aggregation also used in Romer and Romer (2004).

The simultaneous use of several instruments to identify the structural model exploits the information content of several approaches. It is reasonable to expect that the Romer and Romer shocks are at least in part exogenous to the Federal Reserve's forecast of defaults,

[5]The variables included in the replicated medium VAR are personal income, consumption, industrial production index, capital utilization, unemployment rate, number of employees on non-farm sector, housing starts, producer price index, the price index of personal consumption expenditures, the CPI index, the trade-weighted U.S. dollar index, hourly earnings of production, the federal funds rate, M1, M2, total reserves, non-borrowed reserves, the industrial production index, business loans, and loans on residential real estate.

Table 1. Monetary Shocks Used as Instruments

	Methodology	Sample Period
Romer and Romer (2004)	Fed Greenbook Data	1976:M1–2008:M12
Bańbura, Giannone, and Reichlin (2010)	Large Recursive VAR	1976:M1–2008:M12
Gertler and Karadi (2015)	Federal Funds Futures	1990:M1–2012:M6
Nakamura and Steinsson (forthcoming)	Federal Funds Futures	2000:M2–2014:M3

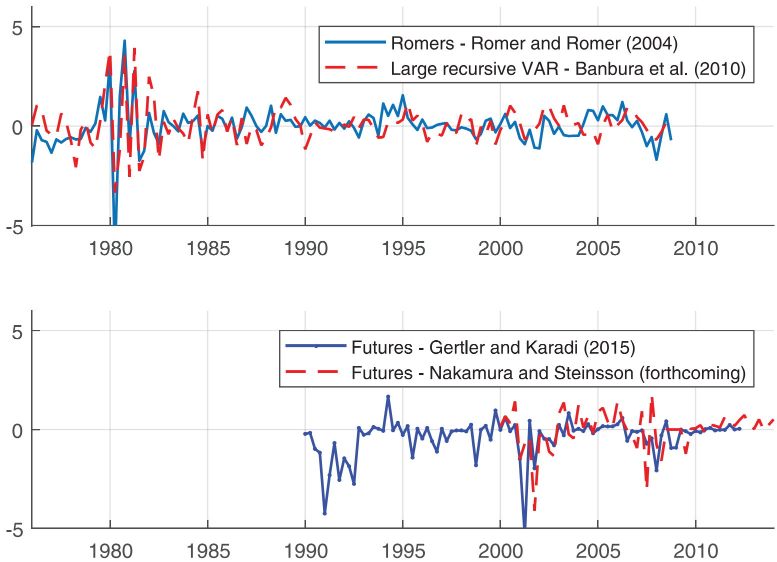
Notes: The Romer and Romer shocks refer to the computation by Coibion et al. (2017), who extend the original estimates to 2008:M12. I am grateful to the authors for having shared their statistics.

since future GDP is realistically correlated with the future financial position of borrowers. At the same time, a large VAR model is likely to include a rich set of information available to the Federal Reserve when making decisions of monetary policy. Last, monetary shocks computed from data on futures contracts are less model dependent. The identification of the VAR using external instruments accounts for noise in the instruments (Mertens and Ravn 2013).

The simultaneous use of several instruments for the identification of a single shock also allows for the test of over-identifying restrictions present in the instruments used. As discussed in section 2.4, the data fail to reject the hypothesis of no over-identification, supporting the hypothesis that the three instruments used in the identification of the monetary shock contain similar information and hence support one another.

Figure 2 shows the monetary shocks listed in table 1. To make the comparison clearer, the figure shows the shocks after standardizing their variance to unity. As mentioned above, the baseline specification of the model uses three of these four series of shocks, namely the Romer and Romer shocks, the shocks from the large VAR model, and the shocks from futures contracts by Gertler and Karadi (2015). These three shocks jointly take either positive value or negative value around 35 percent of the time. The correlation between the Romer and Romer shocks and the other two series of shocks is positive and significant. It equals 62 percent with respect to the shocks from the large VAR and 34 percent with respect to the shocks from the

Figure 2. Monetary Shocks Used as Instruments



Notes: The figure plots the shocks used as instruments for the monetary shock in the SVAR. The original shocks are available at a monthly frequency (see table 1). The shocks reported in this figure and used in the baseline specification of the model are aggregated to a quarterly frequency as the sum within quarter. To make the comparison clearer, the figure reports the standardized shocks rather than the original estimates.

futures contracts. The correlation between the shocks from the large VAR and the shocks by Gertler and Karadi (2015) is positive but statistically insignificant, and it equals 15 percent. Overall, the different candidate monetary shocks give a relatively coherent picture, although with some differences. There are two periods in which the three shocks are particularly similar. The first one is soon before year 1995, when all shocks indicate monetary contractions; the second one is in year 2007, around which all shocks moved from being contractionary to being expansionary.

2.3 VAR Model and Identification

The empirical analysis inspects how twenty-one variables respond to an expansionary monetary shock. These variables represent key aggregates of the macroeconomy, selected interest rates, and several financial measures for firms and households, in addition to the delinquency rates discussed above. The data are downloaded from the Federal Reserve Economic Database (FRED) provided by the Federal Reserve Bank of St. Louis. In the baseline specification of the model I estimate the reduced-form model using data for the period 1979:Q3–2008:Q4. The beginning of the sample coincides with the start of Paul Volcker's tenure as Federal Reserve Chairman, as also in Gertler and Karadi (2015), while the end of the sample is suggested by the time at which the U.S. monetary policy hit the zero lower bound. Alternative specifications of the sample period are considered in section 2.5.

Since the data on delinquency rates are available only after 1987:Q1, I follow the approach by Beaudry and Portier (2014) and Gertler and Karadi (2015) and account for the large dimension of the analysis as follows. I first specify a parsimonious VAR model that contains a small selection of variables. This VAR model is referred to as the "initial VAR" and includes three variables: the log of CPI, the log of real GDP, and the federal funds rate. After estimating the initial VAR, I estimate eighteen "additional VARs" that include the three variables from the initial VAR and one additional variable that changes for each model, out of a selection of eighteen variables. The full list of variables is shown in table 2. Variables other than interest rates and delinquency rates enter the models in real terms. Each additional VAR is estimated on the same sample period as the initial VAR, unless dictated otherwise by the availability of the marginal variable.[6]

The VAR models are written as

$$\boldsymbol{y}_t = \boldsymbol{\delta} + A(L)\boldsymbol{y}_{t-1} + \boldsymbol{u}_t, \tag{1}$$

$$\boldsymbol{u}_t = B\boldsymbol{\epsilon}_t, \tag{2}$$

under the additional restriction that $\boldsymbol{\epsilon}_t \sim N(\mathbf{0}, I)$. The dimension of the vector $\boldsymbol{y}_t$ is $k \times 1$, with $k = 3$ in the initial VAR and $k = 4$ in the additional VARs. The $k \times 1$ vector $\boldsymbol{\delta}$ represents the constant terms,

[6] All marginal variables are available in the sample period from the initial VAR, except the delinquency rates, which are available only starting from 1987:Q1, and the LIBOR rates, which are available only starting from 1986:Q1.

Table 2. List of Variables in the VAR Models

Variables in the Initial VAR	Variables Added in the Additional VARs
Log(CPI)	Delinquency Consumer Credit
Log(Real GDP)	Delinquency Business Loans
Federal Funds Rate	One-Month LIBOR
	Three-Month LIBOR
	Rate on Personal Loans
	Rate on Business Loans
	Log(HHs' Total Loans)
	Log(Firms' Total Loans)
	Log(Consumer Credit)
	Log(Total Loans)
	Log(HHs' Total Liabilities)
	Log(Firms' Total Liabilities)
	Log(HHs' Personal Income)
	Log(Firms' Corporate Profits)
	Log(HHs' Net Worth)
	Log (Firms' Net Worth)
	Log(HHs' Leverage)
	Log(Firms' Leverage)

Notes: Data are downloaded from FRED, Federal Reserve Bank of St. Louis, and are downloaded seasonally adjusted when applicable. The "Rate on Personal Loans" measures the average interest rate on personal loans by commercial banks over a twenty-four-month maturity. The "Rate on Business Loans" measures the average interest posted by a majority of top twenty-five commercial banks on business loans. "Total Loans" stands for the unweighted sum of households' and firms' total loans. Leverage ratios are computed as the ratio of total assets and the difference between total assets and total liabilities.

while the $k \times k$ matrix $A(L)$ includes the autoregressive component of the model, with p the number of lags in the model implicit in $A(L)$. I use the Bayesian information criterion to assess the number of lags in each VAR, which is set to 3 for the initial VAR. Alternative lag specifications are discussed in section 2.5.

Rewrite equation (2) as

$$\boldsymbol{u}_t = \boldsymbol{b}\epsilon_t^{mp} + B^* \boldsymbol{\epsilon}_t^*, \tag{3}$$

where ϵ_t^{mp} represents the monetary shock and $\boldsymbol{\epsilon}_t^*$ gathers the remaining $k-1$ structural shocks. The identification of the monetary shock consists of estimating the $k \times 1$ vector $\boldsymbol{b}$ in equation (3).

To outline how the use of external instruments allows for the accomplishment of this step, call m_t a scalar random variable satisfying the following conditions:

$$E(m_t \epsilon_t^{mp}) = 0, \tag{4}$$

$$E(m_t \boldsymbol{\epsilon}_t^*) = \mathbf{0}. \tag{5}$$

The variable m_t is a valid instrument for the identification of ϵ_t^{mp} if it is correlated with the shock of interest (i.e., if it is relevant, equation (4)) and if it is uncorrelated with the other shocks (i.e., if it is exogenous, equation (5)). Under conditions (3) to (5) it holds that $E(\boldsymbol{u}_t m_t) = \boldsymbol{b} \cdot E(m_t \epsilon_t^{mp})$. Accordingly, a method of moments estimator of $E(\boldsymbol{u}_t m_t)$ estimates the impulse vector $\boldsymbol{b}$ up to an unknown scalar $E(m_t \epsilon_t^{mp})$.

Building on the above intuition, call j the equation in which the federal funds rate enters as dependent variable. Define the relative impulse vector $\tilde{\boldsymbol{b}}$ as $\boldsymbol{b}/b_j$, where b_j indicates the j-th element of $\boldsymbol{b}$. $\tilde{\boldsymbol{b}}$ allows for generating impulse responses to a monetary shock that increases the federal funds rate by one unit. From the equality $E(\boldsymbol{u}_t m_t) = \boldsymbol{b} \cdot E(m_t \epsilon_t^{mp})$ one can estimate the relative impulse vector using $\hat{E}(\boldsymbol{u}_t m_t)/\hat{E}(u_{jt} m_t)$, where $\hat{E}(u_{jt} m_t)$ indicates the method of moments estimator of $E(u_{jt} m_t)$. The absolute impulse vector $\boldsymbol{b}$ can then be recovered by combining the information in $\tilde{\boldsymbol{b}}$ with the covariance restrictions $\Sigma = BB'$ with $B = [\boldsymbol{b}, B^*]$, given Σ the covariance structure of the VAR innovations.[7] An estimate of $\boldsymbol{b}$ allows for the computation of impulse responses to a one-standard-deviation shock.

As discussed in Stock and Watson (2012), Mertens and Ravn (2013), and Gertler and Karadi (2015), the estimation of the relative impulse vector $\tilde{\boldsymbol{b}}$ can be equivalently achieved by estimating the auxiliary $k-1$ regressions

$$u_{it} = \gamma_i u_{jt} + \nu_{it}, \quad \forall i, i \neq j, \tag{6}$$

[7]For this step, see Mertens and Ravn (2013) and the material available on https://sites.google.com/site/michelepiffereconomics/other.

and instrumenting u_{jt} with m_t. $\tilde{\boldsymbol{b}}$ is then estimated by stacking the coefficients γ_i and setting the j-th entry of $\tilde{\boldsymbol{b}}$ equal to unity, i.e., $\tilde{\boldsymbol{b}} = (\gamma_1, ..., \gamma_{j-1}, 1, \gamma_{j+1}, ...\gamma_k)'$. When a single instrument is used, the estimate of $\tilde{\boldsymbol{b}}$ is the same irrespective of whether one uses the method of moments estimator of $E(\boldsymbol{u}_t m_t)$ discussed above or the instrumental-variable approach from equation (6). When more than one instrument is used, the two-stage least-squares approach allows for the simultaneous use of more than one instrument to compute the relative impulse vector. This is achieved by instrumenting u_{jt} from (6) with more than one instrument. Over-identifying restrictions can be tested using a Sargan-Hansen statistic for each of the $k-1$ equations estimated from model (6).[8]

It is fundamentally not possible to test for the validity and exogeneity conditions of the instruments. However, one can assess whether the instruments are strong by studying the relationship between the instruments and the VAR innovations. The rationale behind the test is that if equation (2) is correct and if the model is well specified, the instruments and the VAR innovations should display a statistically significant correlation. Building on Gertler and Karadi (2015), I test the strength of the instruments by estimating the models

$$u_{it} = \alpha_0 + \beta_1 m_{1t} + \beta_2 m_{2t} + \beta_3 m_{3t} + v_{it}, \quad \forall i, \tag{7}$$

testing the null hypothesis $\beta_1 = \beta_2 = \beta_3 = 0$ using an F test. I take the conventional value of 10 as the threshold value below which the instrument is considered weak (Stock and Yogo 2005).

Mertens and Ravn (2013) compute confidence intervals using a Wild bootstrap. As discussed in section 2.5, in the application of

[8]The over-identification test used in this paper aims to test for over-identification in the two-stage least-squares approach in equation (6) for each equation $i \neq j$, with j the equation where the federal funds rate enters as the dependent variable. The rationale of the test is that the estimation of the relative impulse vector $\tilde{\boldsymbol{b}}$ potentially becomes more precise with the use of more than one instrument. Yet, given a better estimate of $\tilde{\boldsymbol{b}}$, the rest of the structural model remains unidentified, as no claim is made about the remaining shocks in $\boldsymbol{\epsilon}_t^*$ from equation (3). Cesa-Bianchi, Thwaites, and Vicondoa (2016) follow a different approach and test whether the presence of two instruments for a single shock of interest over-identifies the entire system of covariance restrictions $\Sigma = BB'$. See also Olea, Stock, and Watson (2012), who provide the theoretical foundations for the use of more than one instrument for the identification of a single shock.

this paper such procedure yields extremely wide confidence intervals, probably due to the limited availability of the data. For this reason, I compute confidence bands using a standard bootstrap that accounts for estimation uncertainty of the reduced-form VAR and partly for identification uncertainty.[9]

2.4 Results

The first set of results refers to the strength of the instruments from equation (7). The results for the baseline specification of the model are shown in panel A of table 3 and refer to the joint use of three instruments: the Romer and Romer shocks, the shocks from the large recursive VAR model, and the shocks from futures contracts computed by Gertler and Karadi (2015). While the reduced-form model is estimated in the period 1979:Q3–2008:Q4, the availability of the shocks by Gertler and Karadi (2015) allows for the identification of the model only in the period 1990:Q1–2008:Q4. As shown in the table, the F statistic in the equation of the model featuring the federal funds rate as the dependent variable equals 10.65. This suggests that the three instruments used in the baseline specification of the analysis are jointly sufficiently strong. The results of the Sargan-Hansen tests on over-identification show that we cannot reject the null hypothesis of no over-identification. Hence, the instruments contain consistent information regarding the underlying structural shock. Further support to this hypothesis is shown in section 2.5, which documents that the results are robust to the identification of the model using one instrument at a time.

[9] The Wild bootstrap procedure consists of three steps. First, generate pseudo-VAR innovations by changing sign of the vectors of the estimated VAR innovations at randomly selected periods, keeping the ordering across time unchanged. Second, generate pseudo-data recursively from the pseudo-residuals and use the pseudo-data to estimate the reduced-form model. Third, generate pseudo-instruments by changing the sign of the instrument in all periods in which the sign of the reduced-form innovations were changed, and use the pseudo-instruments to identify the model. In this paper I first generate pseudo-data from a bootstrap that randomly selects for each period t a vector of estimated innovations out of the entire set of vectors from $t = 1, 2, ..., T$. I estimate the model and obtain $\hat{A}(L)$ and $\hat{\Sigma}$. I then identify the model using the generated $\hat{\Sigma}$ and the original (rather than the bootstrapped) instruments. The procedure is repeated 1,000 times. Section 2.5 also reports the result when using the bootstrap procedure by Kilian (1998).

Table 3. Tests on the Strength of the Instruments

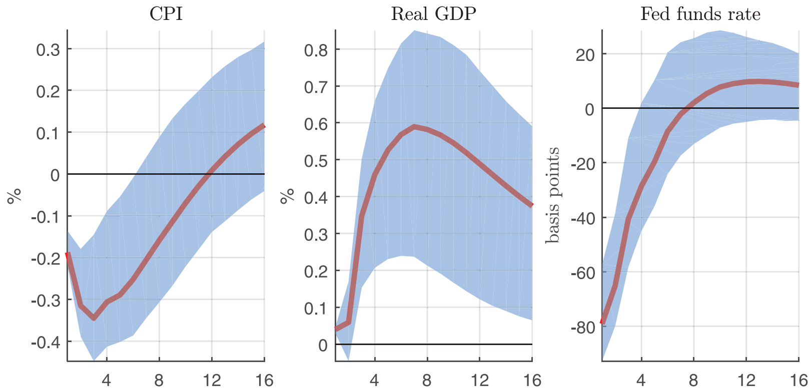
	CPI	Real GDP	Fed. Funds Rate
A. Instruments: Romer and Romer, Large Recursive VAR, and Futures Contracts			
F Statistic	1.72	1.70	10.65
p-Value	0.1697	0.1734	0.0000
R^2	0.07	0.07	0.30
No. of Observations	76	76	76
Sargan-Hansen Statistic	0.9868	0.9868	—
Sargan-Hansen p-Value	(0.6106)	(0.6105)	—
B. Instrument: Romer and Romer			
F Statistic	0.48	7.74	55.20
C. Instrument: Large Recursive VAR			
F Statistic	0.23	0.02	78.64
D. Instrument: Futures Contracts			
F Statistic	0.08	1.20	9.23

Notes: For each column in panel A, the equation estimated is $u_{it} = \alpha + \beta_1 m_{1t} + \beta_2 m_{2t} + \beta_3 m_{3t} + \mu_{it}$, where u_{it} is the VAR innovation on equation i, indicated in the column of this table, and m_{it}, $i = 1, 2, 3$ are the instruments used. The F statistics reported in panel A and the corresponding p-values refer to the null hypothesis $\beta_1 = \beta_2 = \beta_3 = 0$. The F statistics in the remaining panels refer to the null hypothesis $\beta = 0$, having rewritten the equation for the test as $u_{it} = \alpha + \beta m_t + \mu_{it}$.

Having documented that the three instruments used in the analysis are jointly strong, the same table reports the F statistics when testing the strength of each instrument one at a time after specifying equation (7) as $u_{it} = \alpha_0 + \beta_1 m_{1t} + v_{it}$. The results show that the shocks from the large recursive VAR and the Romer and Romer shocks are very strong instruments, with an F statistic as high as 78.64 and 55.20, respectively. The strength of the remaining instrument is less high, with an F statistic equal to 9.23.

I now discuss the impulse response of the variables to a monetary expansion. The shock considered equals a one-standard-deviation expansionary monetary shock. I report impulse responses showing the point estimates and the 95 percent confidence bands computed

Figure 3. Impulse Responses of the Variables in the Initial VAR

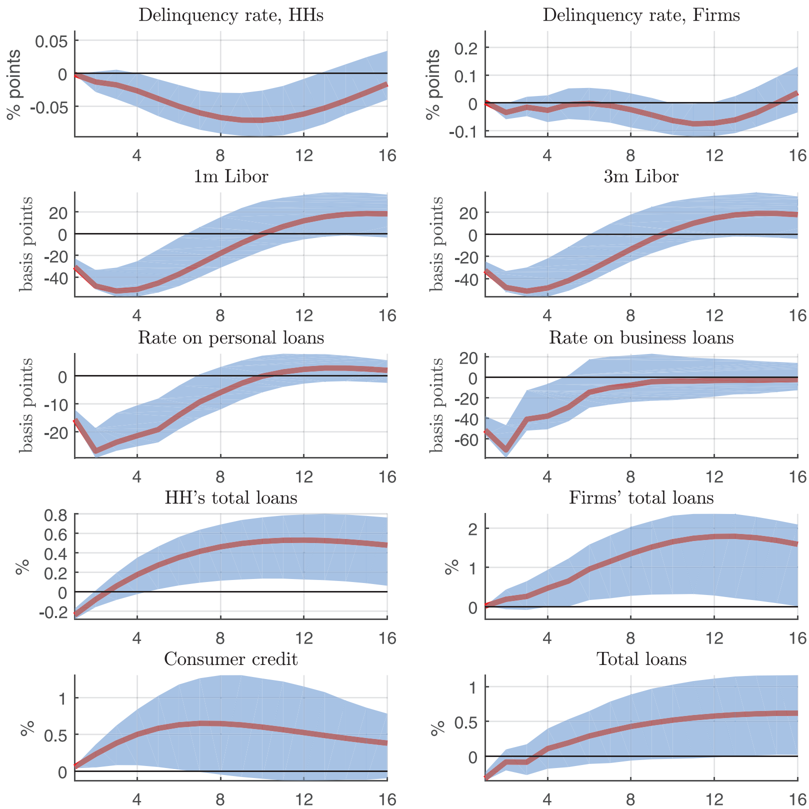


Notes: Expansionary monetary shock of one standard deviation. Pointwise 95 percent confidence bands reported based on 1,000 bootstrap replications.

from 1,000 bootstrap repetitions following the procedure discussed in footnote 9. Figure 3 shows the impulse responses for the variables in the initial VAR, while figures 4 and 5 show the responses of the eighteen marginal variables from the additional VARs.

Figure 3 shows that a one-standard-deviation shock decreases the federal funds rate by approximately 80 basis points. Real GDP increases already on impact, although the peak of the effect materializes around seven quarters after the shock. The effect is very persistent, consistent with Romer and Romer (2004). CPI initially decreases, showing a marked price puzzle, and then increases in a statistically significant way after eighteen quarters. The price puzzle lasts longer than in the work by Romer and Romer (2004) and is closer to the one documented by Coibion (2012). As discussed in section 2.5, the price puzzle is mainly driven by the Romer and Romer shocks and is considerably reduced when identifying the model using the remaining shocks. The federal funds rate responds to the expansionary dynamics of output by overshooting and by generating a subsequent tightening in monetary policy, following a timing that is consistent with the increase in output. The overshooting of the federal funds rate contributes to the slowdown in economic activity after the initial increase. Following the shock, the impulse

Figure 4. Impulse Responses of the First Set of Additional Variables



Notes: Expansionary monetary shock of one standard deviation. Pointwise 95 percent confidence bands reported based on 1,000 bootstrap replications.

responses then return to zero fairly rapidly for the federal funds rate and less rapidly for the CPI and real GDP.

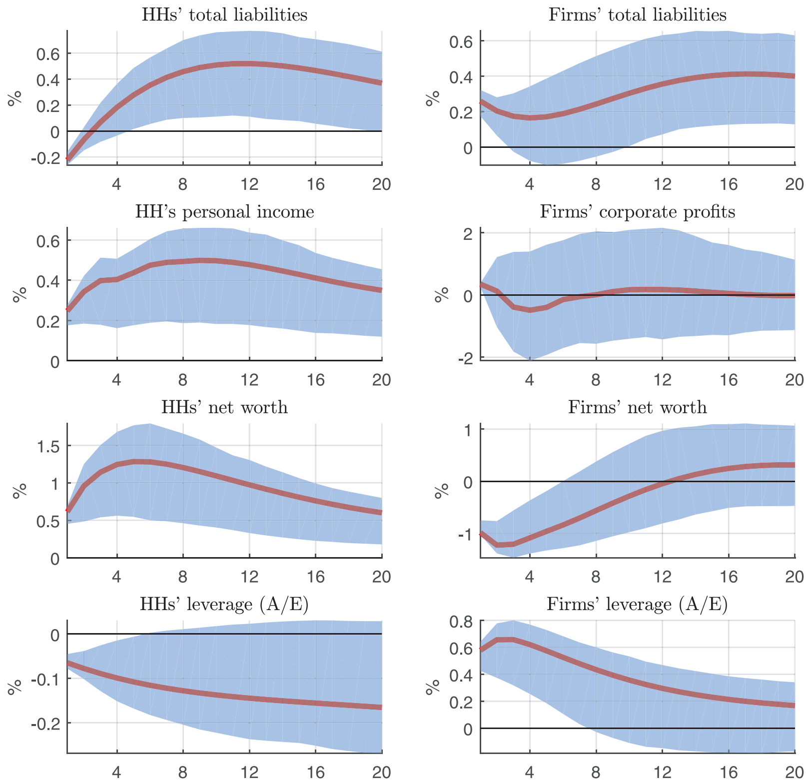
Figures 4 and 5 document how the expansionary monetary shock affects the remaining variables. Figure 4 shows that both the delinquency rate on business loans and the delinquency rate on consumer credit decrease following the exogenous monetary expansion. While the initial effect is quite muted, both delinquency rates decrease in a statistically significant way—in particular, for consumer credit—and reach a trough around ten quarters from the shock. At the trough, the delinquency rate of business loans and on consumer credit decrease by around 8 basis points. This equals around 5 percent and 21 percent of the corresponding standard deviations, suggesting that the results are economically meaningful, although not large.[10]

Consistent with economic theory, short-term borrowing costs, as measured by the one-month and the three-month LIBOR, display similar dynamics to the federal funds rate, with an initial decrease and a subsequent overshooting. The prime interest rate charged by banks on business loans responds very quickly, decreasing by a similar amount as the federal funds interest rate. The average interest rate charged by commercial banks on personal loans, instead, decreases by less, although still in a statistically significant way and still on impact. These results jointly suggest that an interest rate channel is in place in response to the monetary expansion, in line also with the work by Buch, Eickmeier, and Prieto (2014b). As a result of the decrease in the interest rates, overall borrowing by both households and firms increases. The strongest increase in loans by firms relative to households is consistent with the stronger drop in the interest rate on business loans compared to personal loans.

Figure 5 documents that the above dynamics in interest rates and borrowing take place in parallel with a general improvement in the financial condition of firms and households. While total liabilities of both firms and households increase in response to the decrease in the cost of borrowing, personal income and corporate profits increase, likely reflecting the rightward shift in aggregate demand generated by the monetary expansion. The increase in firms' corporate profits is statistically significant only on impact, although several robustness checks in section 2.5 suggest that the increase might be significant also at later horizons. The increase in personal income and profits likely contributes to the overall decrease in delinquency rates. In addition, the finding that the decrease in the delinquency rate on consumer credit is more statistically significant

[10]The delinquency rate on business loans displays a temporarily statistically significant increase around twenty-one quarters from the shock. This increase is harder to interpret, given the long distance from the initial shock. Both delinquency rates then return to zero.

Figure 5. Impulse Responses of the Second Set of Additional Variables



Notes: Expansionary monetary shock of one standard deviation. Pointwise 95 percent confidence bands reported based on 1,000 bootstrap replications.

than the delinquency rate on business loans is consistent with the stronger statistical support for an increase in households' personal income, compared to corporate profits, and with the fact that households' net worth increases, while firms' net worth decreases. Last, while the leverage ratio of households decreases already on impact, reflecting the increase in households' net worth, the leverage ratio of firms increases, consistent with the response of firms' net worth. All impulse responses then return to zero, except for the leverage ratio of households, for which the result should be taken with caution.

2.5 Robustness Checks

I address the robustness of the results along five dimensions. First, I study how the behavior of the variables in the initial VAR changes when adding the marginal variables. Second, I use alternative time aggregation of the instruments used, and use the instruments one at the time. Third, I consider alternative bootstrap procedures to construct confidence bands. Fourth, I address possible non-stationarity in the data using specifications with different lag length and with first differences. Fifth, I extend the sample size to the more recent period and assess how the 2007 crisis changed the dynamics discussed so far. For each alternative specification, I report one figure for the variables in the initial VAR and one figure with all the marginal variables. When possible, I report the confidence bands under the baseline specification as well as the confidence bands under the alternative specification in order to make the figures clearer, and omit point estimates. The figures and tables discussed in this section are reported in the online appendix, available at http://www.ijcb.org.

Figure A1 shows the response of the variables in the initial VAR comparing the baseline response with the response generated for the same variables by the additional VARs. To improve readability, the figure compares the confidence bands from the baseline specification with the eighteen point estimates from the additional VARs. As shown in the figure, the results are robust to the inclusion the additional variables. The price puzzle tends to remain for all the models considered, although it occasionally becomes statistically insignificant.

The baseline specification of the model uses three instruments aggregated from monthly to quarterly frequency as the sum within quarter. Figures A2 and A3 show that the results are very similar when aggregating the shocks using the aggregation by Gertler and Karadi (2015). One difference from the baseline specification is that the price puzzle is considerably reduced. Figures A4–A9 show that the results also hold when identifying the model using the instruments one at a time. In particular, the comparison of figures A4, A6, and A8 shows that the Romer and Romer shocks drive the price puzzle in the baseline specification. Regarding the dynamics of output, the same comparison shows that the response of real

GDP is more modest when identifying the monetary shock using the instruments one at a time, with a negative impact response when using the Romer and Romer shocks and the shocks by Gertler and Karadi (2015). The subsequent response is qualitatively similar to the baseline specification.

The impulse responses in the baseline specification of the analysis occasionally displayed an asymmetry in the confidence bands relative to the point estimates—for example, for real GDP and the leverage ratios—possibly reflecting short-sample bias in the estimates of the reduced-form VARs. To address this, figures A10 and A11 report impulse responses with confidence bands computed using the bootstrap-after-bootstrap procedure by Kilian (1998), together with point estimates. The results do not change particularly with regard to their statistical significance. While the strongest asymmetry was documented with regard to the response of the leverage ratio of households, this asymmetry holds also under the alternative bootstrap procedure, suggesting that small-sample bias is only partly accounted for. Figures A12 and A13 show the results when bootstrapping using the Wild bootstrap used by Mertens and Ravn (2013). As anticipated in section 2.3 and in footnote 9, this procedure delivers very wide confidence bands.

Figures A14–A17 show that the results hold when including two and four additional lags in each VAR model estimated. The inclusion of two additional lags only occasionally widens the confidence bands but does not change the qualitative features of the results nor their statistical significance. Adding four lags, instead, tends to delay the response of the delinquency rates and of several financial variables.

The top part of table A1 documents non-stationarity in the variables added to the initial VAR. It is unclear whether a VAR model with a limited number of lags can effectively account for the implicit cointegration structure in the data.[11] For this reason, I reestimate the model after specifying all variables in first differences. This transformation eliminates the original non-stationarity, as documented in the lower part of table A1. Figures A18 and A19 show that some variables display counterintuitive dynamics. However, the results that delinquency rates decrease following the monetary expansion

[11] Within the baseline application, this concern is partly reduced by the fact that the estimated VAR innovations were found to be stationary.

remains statistically significant for households, and close to significant and qualitatively present for firms.

Last, I study to what extent the results change when changing the ending period of the sample. The baseline specification uses data for the period 1979:Q3–2008:Q4. Figures A20 and A21 show that the responses are only mildly affected when estimating and identifying the model in the period until 2006:Q4, hence fully excluding financial crisis from the sample. The delinquency rates were found to decrease also when including data until 2016:Q1, hence including the financial crisis. The analysis was carried out after replacing the federal funds rate with the two-year government bond as a policy rate, as in Gertler and Karadi (2015), as the latter is not constrained by the zero lower bound. Figures A22 and A23 report the results for the new specification when using the baseline shocks for the identification. Given the availability of the Romer shocks and the shocks by the large VAR, the identification behind these figures exploits data only until 2008:Q4. Figures A24 and A25, instead, identify the model jointly using the shocks by Gertler and Karadi (2015) and by Nakamura and Steinsson (forthcoming), hence achieving identification using data until 2012:Q2. When including the financial crisis, the positive effect exerted by the monetary expansion on several variables is reduced—for example, on loans. The delinquency rate on business loans initially increases and then decreases, while the delinquency rate on consumer credit still decreases.

3. A Simple Model of Defaults

The empirical analysis in the previous section finds that delinquency rates decrease in response to an exogenous monetary expansion. This section uses a standard debt contract to interpret this empirical result. The model, which consists of the debt contract by Townsend (1979) used in Bernanke, Gertler, and Gilchrist (1999), is not used to replicate quantitatively the responses from section 2.4 but to develop intuition of the forces that might drive the documented response of delinquency rates. The intuition suggested by the model is that, other things equal, a monetary expansion increases probabilities of default because borrowers leverage up their net worth. However, in general equilibrium this effect does not materialize, because the monetary expansion stimulates aggregate demand and increases profits and income, an increase that improves repayment possibilities.

3.1 Environment

A risk-neutral borrower has limited net worth N. At the beginning of the period he borrows $K - N$ from a risk-neutral lender, where K stands for the level of investment. The borrower has access to the following production function:

$$y = \omega R_K K.$$

The shock ω represents an idiosyncratic productivity shock with support $[0, \infty)$, expected value of 1 and cumulative distribution function $\Psi(\omega)$. R_k stands for the aggregate return on the risky technology.

In a general equilibrium environment R_k is stochastic and is unexpectedly pushed up by the monetary expansion due to an outward shift of the aggregate demand curve. This is, for instance, the case in the Bernanke, Gertler, and Gilchrist (1999) application of the model. I simplify the analysis by treating R_k as deterministic and by using comparative statics. The contract is signed at the beginning of the period. The shock ω is realized at the end of the period. ω is costlessly observed by the borrower, but it is not observed by the lender unless she pays a fraction $\mu < 1$ of ex post revenues $\omega R_k K$. The borrower obtains credit from a lender in competitive markets. The contract maximizes the expected profits of the borrower under the condition that the expected return on lending equals the gross opportunity cost of lending R.[12]

3.2 Debt Contract

Townsend (1979) shows that, in this setting, the optimal contract is a simple debt contract, i.e., the borrower either repays a fixed

[12] Note that, in this model, the risk-taking incentive of the lender takes the form of accepting that the borrower leverages up his net worth and runs a higher default probability, because the lender is appropriately compensated for it. This mechanism is not the only plausible one. An additional, complementary mechanism is that lenders find it profitable to shift towards borrowers who finance more risky projects. Modeling the interaction of both forces goes beyond the purpose of the paper, which is to discuss the plausibility of a general equilibrium effect.

amount independently on the realization of the shock or defaults.[13] Let R_b stand for the gross borrowing rate. When the borrower and the lender agree on $K - N$ and R_b, they indirectly agree on an endogenous threshold value $\bar{\omega}$ below which the borrower's revenues are insufficient to cover the debt repayment obligation. This threshold value is pinned down by $\bar{\omega} R_k K = R_b(K - N)$. If $\omega > \bar{\omega}$, then the borrower pays back $R_b(K - N)$ and keeps profits $\omega R_k K - R_b(K - N)$. If $\omega < \bar{\omega}$, then the borrower defaults and the lender recovers $(1 - \mu)\omega R_k K$.

The maximization problem is solved in $\bar{\omega}, R_b, K$ and is written as

$$\max_{\{\bar{\omega}, R_b, K\}} \int_{\bar{\omega}}^{\infty} \omega R_k K - R_b(K - N) d\Psi(\omega), \quad \text{subject to}$$

$$\bar{\omega} R_k K = R_b(K - N), \tag{8}$$

$$[1 - \Psi(\bar{\omega})] R_b + \Psi(\bar{\omega})(1 - \mu) \frac{E(\omega \mid \omega < \bar{\omega}) R_k K}{K - N} \geq R. \tag{9}$$

Equation (8) defines the threshold value $\bar{\omega}$ as a function of R_b and K. Equation (9) gives the participation constraint of the lender. This constraint imposes that the expected return on lending is not lower than the opportunity cost of lending. Ex post variations of R_k move $\bar{\omega}$ in the opposite direction, given that the remaining variables in equation (8) are determined at the beginning of the period.

Substitute R_b from equation (8) into equation (9) and into the objective function in order to simplify the maximization problem to

$$\max_{\bar{\omega}, K} \ F(\bar{\omega}) R_k K, \quad \text{subject to } \ \frac{K}{N} \leq \frac{1}{Q - \frac{R_k}{R} G(\bar{\omega})},$$

with $F(\bar{\omega}) = \int_{\bar{\omega}}^{\infty} \omega d\Psi(\omega) - [1 - \Psi(\bar{\omega})]\bar{\omega}$, $G(\bar{\omega}) = 1 - F(\bar{\omega}) - \mu \int_0^{\bar{\omega}} \omega d\Psi(\omega)$. To develop intuition behind the notation, use $F(\bar{\omega})$ and $G(\bar{\omega})$ and the assumption $E(\omega) = 1$ to derive the following equality:

[13] The intuition behind the optimality of the debt contract is that it is optimal to limit the probability that the deadweight observation cost is incurred. To do so, the lender leaves no revenue to the borrower in case of default in order to reduce the borrowing rate to be paid in case of no default.

$$\left[1 - \mu \int_0^{\bar{\omega}} \omega d\Psi(\omega)\right] R_k K = R_k K \left[F(\bar{\omega}) + G(\bar{\omega})\right]. \tag{10}$$

Equation (10) shows that $F(\bar{\omega})$ and $G(\bar{\omega})$ determine the shares of expected output $R_k K$ net of expected monitoring costs $\mu \int_0^{\bar{\omega}} \omega R_k K d\Psi(\omega)$ allocated to the borrower and the lender, respectively.[14] These shares are implicitly pinned down by the debt contract. It can be shown that, in the relevant support of ω, $F'(\bar{\omega}) < 0$ and $G'(\bar{\omega}) > 0$. Borrowing conditions that indirectly imply a higher share of expected revenues to the borrower imply a lower share of expected revenues to the lender. An increase in the share of expected revenues promised to the lender $G(\bar{\omega})$ is associated with an increase in the default threshold $\bar{\omega}$, because it is harder for the borrower to meet the higher repayment obligation to the lender. Nevertheless, it has the benefit of relaxing the participation constraint of the lender. The equilibrium of the model is pinned down by this tradeoff. To solve the maximization problem, substitute out K from the objective function and derive the optimality condition with respect to $\bar{\omega}$:

$$-F'(\bar{\omega}^*) = F(\bar{\omega}^*) \frac{G'(\bar{\omega}^*)}{\left(\frac{R_k}{R}\right)^{-1} - G(\bar{\omega}^*)}. \tag{11}$$

3.3 Discussion of the Equilibrium

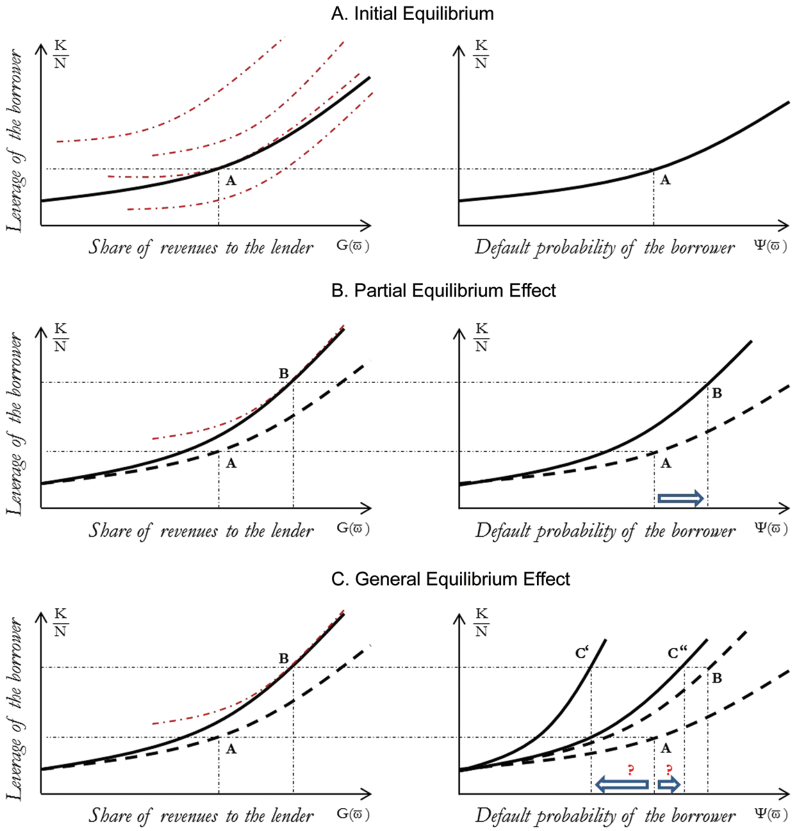
The threshold value $\bar{\omega}^*$ pinned down by equation (11) is a decreasing function of R for any parametrization of the model (see Covas and Den Haan 2012, appendix C).[15] This means that, given R_k, a decrease in the opportunity cost of lending, which proxies the policy rate changed by the central bank, increases the equilibrium default probability of the borrower. Nevertheless, in general equilibrium, this effect could be dominated by other effects. To develop the economic intuition that explains this difference, I use a simple graphical representation.

The graphs on the left in figure 6 show combinations of leverage K/N and $G(\bar{\omega})$ that satisfy the participation constraint of the

[14]The latter is best seen by rewriting the participation constraint as $G(\bar{\omega}) R_k K \geq R(K - N)$.

[15]Covas and Den Haan (2012) study the relationship between $\bar{\omega}^*$ and R_k. Their proof extends to the relationship between $\bar{\omega}^*$ and R.

Figure 6. Effects of Defaults of a Decrease in the Opportunity Cost of Lending



Notes: A decrease in the opportunity cost of lending relaxes the participation constraint of the lender and reduces the cost of borrowing. The borrower reacts to the lower cost of borrowing by leveraging up his net worth in order to invest more, and this increases the default probability (point B). In general equilibrium, the return to capital increases unexpectedly, exerting downward pressure on defaults (points C' and C''). If this effect is strong enough, equilibrium defaults decrease.

lender. An increase in lending increases the borrower's leverage ratio, which reduces the relative buffer that the constant net worth provides to the risky loan. To compensate the lender for this leverage effect, the borrower must pay a leverage premium that takes the form of a higher $G(\bar{\omega})$, i.e., a higher share of expected revenues to the lender. All combinations of $\{(K, G(\bar{\omega})\}$ below the solid line in the left graph satisfy the participation constraint of the lender. The dash-dotted lines represent iso-profit curves of the borrower. The right graph shows the corresponding default probability. Given R_b and R_k, a higher leverage ratio implies a higher default rate.[16]

The initial equilibrium is shown in panel A, point A. A decrease in the opportunity cost of lending R, panel B, rotates the constraint upwards and expands the set of combinations compatible with the participation constraint of the lender. This occurs because perfect competition pushes down the return on lending, implying now a lower borrowing rate for any given level of lending. If K remains constant, the borrower borrows the same amount and pays a lower borrowing rate due to perfect competition. This would decrease the default probability. Nevertheless, borrowing the same amount is not optimal, since the discounted return to capital R_k/R has increased, making each unit of investment more productive in discounted terms. Investing more requires moving along the new participation constraint of the lender and paying the lender a higher expected share of revenues $G(\bar{\omega})$, due to the leverage effect discussed above. In the partial equilibrium model, this leverage effect always dominates, taking the new equilibrium to point B. The new partial equilibrium features a higher default probability. Put simply, debt becomes cheaper, the borrower demands more credit, and since his leverage ratio increases, his default probability increases.

Consider now the general equilibrium effect. In Bernanke, Gertler, and Gilchrist (1999), the borrower is an entrepreneur who rents capital to intermediate good producers. The return to capital R_k equals the rental rate on capital plus the capital gain on undepreciated capital. In their general equilibrium framework, the unexpected monetary expansion increases investments. This pushes up the price of capital, which in turn generates a positive capital gain and increases the return to capital, increasing the borrower's revenues and his future net worth. In the model, it is this increase in aggregate demand, through the increase in investments, that pushes up the borrower's income. This mechanism can be captured in a

[16]To see this, substitute equation (8) in the cumulative distribution function of ω, obtaining $Prob(\omega < \bar{\omega}) = \Psi\left(\frac{R_b}{R_k}\left(1 - \frac{1}{K/N}\right)\right)$.

stylized way by assuming that the decrease in the opportunity cost of lending pushes up the value of R_k at the end of the period, i.e., the value that enters equation (8). The effect on defaults can be seen from panel C of figure 6. Since leverage K/N and the borrowing rate R_b are determined at the beginning of the period, an increase in R_k unexpectedly increases the borrower's income. This pushes up the curve in the right graph. If this effect is relatively weak, then aggregate defaults still increase, although by less than in partial equilibrium (point C'). If, instead, the elasticity of R_k to R is high enough in absolute value, the curve on the right graph shifts by enough that defaults ultimately decrease (point C''). Put simply, in general equilibrium the increase in income exerts the opposite effect on defaults when compared to risk-taking incentives, and potentially prevents risk-taking behavior from materializing into higher defaults.[17]

3.4 A Comparison to the Empirical Results

While the theoretical model just discussed is too stylized to replicate the empirical evidence from section 2.4, several features outlined in the comparative statics of the model are consistent with the empirical results.

In the theoretical model, the monetary expansion is triggered by a decrease in the opportunity cost of lending R, which in turn endogenously reduces the cost of borrowing. Section 2.4 documents that borrowing rates do decrease following an expansionary monetary shock, in line with the interest rate channel of monetary policy. In addition, an expansion in borrowing was documented in figure 4, as well as in Buch, Eickmeier, and Prieto (2014b). While the general equilibrium positive effects on income and profits are featured by the model only through a comparative static exercise that exogenously increases R_k, there is empirical evidence that income and profits increase following a monetary expansion, in line with the view that monetary policy is effective in stimulating aggregate demand.

[17] In the model, whether the general equilibrium effect prevails or not depends on the exact general equilibrium framework used. Compare, for instance, Hafstead and Smith (2012) and Afanasyeva and Güntner (2014).

A link between the theoretical model and the empirical results is, instead, harder to outline with regard to the leverage ratio. In the model, the leverage ratio is predetermined at the moment in which general equilibrium effects unexpectedly increase R_k. In a more developed general equilibrium model, the leverage ratio would reflect the endogenous response of both the balance sheet expansion through an increase in both borrowing and net worth. Since these two effects can generate opposite forces on the leverage ratio, the ultimate response of leverage ratios to the monetary expansion remains an empirical question. The results in section 2.3 suggest that the net worth effect is stronger for households.

4. Conclusions

This paper studied the effect of an exogenous monetary policy expansion on the delinquency rate of U.S. business loans and consumer credit. The risk-taking channel of monetary policy, widely documented in the literature, suggests that delinquency rates could increase after a monetary expansion. While this literature mainly discussed an ex ante incentive by banks, it is less clear whether ex post and backward-looking measures of defaults can display such additional risk.

Buch, Eickmeier, and Prieto (2014b) find that an exogenous monetary expansion tends to decrease (rather than increase) nonperforming loans. They interpret this result as the effect of the decreased interest rate burden for firms that follows the monetary expansion. In this paper I provide further evidence for their result, and then use a standard model of a debt contract featuring equilibrium defaults to interpret the results. In particular, I show that the delinquency rate of U.S. business loans and consumer credit decreases in response to a monetary expansion. I then argue that the "credit view" of monetary policy formalized in the model by Bernanke, Gertler, and Gilchrist (1999) provides intuition for a general equilibrium effect consistent with the empirical result. The intuition is that a monetary expansion increases income and profits, and hence improves the repayment possibility of borrowers. The empirical findings of the paper support this hypothesis.

References

Afanasyeva, E., and J. Güntner. 2014. "Lending Standards, Credit Booms and Monetary Policy." IMFS Working Paper No. 85.

Altunbas, Y., L. Gambacorta, and D. Marques-Ibanez. 2014. "Does Monetary Policy Affect Bank Risk?" *International Journal of Central Banking* 10 (1): 95–135.

Angeloni, I., E. Faia, and M. Lo Duca. 2015. "Monetary Policy and Risk Taking." *Journal of Economic Dynamics and Control* 52 (March): 285–307.

Bańbura, M., D. Giannone, and L. Reichlin. 2010. "Large Bayesian Vector Auto Regressions." *Journal of Applied Econometrics* 25 (1): 71–92.

Beaudry, P., and F. Portier. 2014. "News-Driven Business Cycles: Insights and Challenges." *Journal of Economic Literature* 52 (4): 993–1074.

Bernanke, B. S., M. Gertler, and S. Gilchrist. 1999. "The Financial Accelerator in a Quantitative Business Cycle Framework." *Handbook of Macroeconomics,* Vol. 1C, ed. J. B. Taylor and M. Woodford, 1341–93 (chapter 21). Elsevier.

Buch, C. M., S. Eickmeier, and E. Prieto. 2014a. "In Search for Yield? Survey-based Evidence on Bank Risk Taking." *Journal of Economic Dynamics and Control* 43 (June): 12–30.

———. 2014b. "Macroeconomic Factors and Microlevel Bank Behavior." *Journal of Money, Credit and Banking* 46 (4): 715–51.

Cesa-Bianchi, A., G. Thwaites, and A. Vicondoa. 2016. "Monetary Policy Transmission in an Open Economy: New Data and Evidence from the United Kingdom." Discussion Paper No. 1612, Centre for Macroeconomics.

Cochrane, J. H. 2004. "Comments on a New Measure of Monetary Shocks: Derivation and Implications by Christina Romer and David Romer." Available at https://faculty.chicagobooth.edu/john.cochrane/research/papers/talk_notes_new_measure_2.pdf.

Coibion, O. 2012. "Are the Effects of Monetary Policy Shocks Big or Small?" *American Economic Journal: Macroeconomics* 4 (2): 1–32.

Coibion, O., Y. Gorodnichenko, L. Kueng, and J. Silvia. 2017. "Innocent Bystanders? Monetary Policy and Inequality." *Journal of Monetary Economics* 88 (June): 70–89.

Covas, F., and W. J. Den Haan. 2012. "The Role of Debt and Equity Finance over the Business Cycle." *Economic Journal* 122 (565): 1262–86.

De Graeve, F., T. Kick, and M. Koetter. 2008. "Monetary Policy and Financial (In)Stability: An Integrated Micro–Macro Approach." *Journal of Financial Stability* 4 (3): 205–31.

Dell'Ariccia, G., L. Laeven, and G. A. Suarez. 2017. "Bank Leverage and Monetary Policy's Risk-Taking Channel: Evidence from the United States." *Journal of Finance* 72 (2): 613–54.

Gertler, M., and P. Karadi. 2015. "Monetary Policy Surprises, Credit Costs, and Economic Activity." *American Economic Journal: Macroeconomics* 7 (1): 44–76.

Gürkaynak, R. S., B. P. Sack, and E. T. Swanson. 2005. "Do Actions Speak Louder than Words? The Response of Asset Prices to Monetary Policy Actions and Statements." *International Journal of Central Banking* 1 (1): 55–93.

Hafstead, M., and J. Smith. 2012. "Financial Shocks, Bank Intermediation, and Monetary Policy in a DSGE Model." Unpublished Manuscript.

Jimenez, G., S. Ongena, J. L. Peydro, and J. Saurina. 2014. "Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say about the Effects of Monetary Policy on Credit Risk-taking?" *Econometrica* 82 (2): 463–505.

Kilian, L. 1998. "Small-sample Confidence Intervals for Impulse Response Functions." *Review of Economics and Statistics* 80 (2): 218–30.

Kuttner, K. N. 2001. "Monetary Policy Surprises and Interest Rates: Evidence from the Fed Funds Futures Market." *Journal of Monetary Economics* 47 (3): 523–44.

Maddaloni, A., and J. L. Peydro. 2013. "Monetary Policy, Macroprudential Policy, and Banking Stability: Evidence from the Euro Area." *International Journal of Central Banking* 9 (1): 121–69.

Mertens, K., and M. O. Ravn. 2013. "The Dynamic Effects of Personal and Corporate Income Tax Changes in the United States." *American Economic Review* 103 (4): 1212–47.

Nakamura, E., and J. Steinsson. Forthcoming. "High-Frequency Identification of Monetary Non-neutrality: The Information Effect." *Quarterly Journal of Economics.*

Olea, J. L. M., J. H. Stock, and M. W. Watson. 2012. "Inference in Structural VARs with External Instruments." Unpublished Manuscript.

Romer, C. D., and D. H. Romer. 2004. "A New Measure of Monetary Shocks: Derivation and Implications." *American Economic Review* 94 (4): 1055–84.

Stock, J. H., and M. W. Watson. 2012. "Disentangling the Channels of the 2007–2009 Recession." *Brookings Papers on Economic Activity* (Spring): 81–156.

Stock, J. H., and M. Yogo. 2005. "Testing for Weak Instruments in Linear IV Regression." In *Identification and Inference for Econometric Models*, ed. D. W. K. Andrews and J. H. Stock, 80–108. New York: Cambridge University Press.

Townsend, R. M. 1979. "Optimal Contracts and Competitive Markets with Costly State Verification." *Journal of Economic Theory* 21 (2): 265–93.