Residential Investment and Economic Activity: Evidence from the Past Five Decades*

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We analyze the evolution and main drivers of residential investment in 15 advanced economies using a large panel with quarterly data since the 1970s. Residential investment is a notably volatile component of real GDP in all countries in the sample. Real house price growth, net migration inflows, household size, and the existing housing stock are significant drivers of residential investment across various model specifications. We detect important asymmetries: interest rate increases affect residential investment more than interest rate declines, and interest rate changes have larger effects on residential investment when its share in GDP is rising. We also show that information on residential investment significantly improves the performance of standard recession-prediction models.

JEL Codes: E22, E32, E37, E43, E52, F44.

1. Introduction

Most research on residential investment focuses on how booms and busts in house prices and housing credit affect macroeconomic and financial outcomes. For example, Jordà, Schularick, and

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Taylor (2016) documented how mortgage credit booms in advanced economies since the Second World War were increasingly associated with deeper recessions and slower recoveries. The co-movement of property prices and credit also features prominently in financial cycle models, whose peaks are closely associated with financial crises (Claessens, Kose, and Terrones 2012; Borio 2014).

Research on the macroeconomic implications of residential investment in terms of volumes—housing output produced for the market—is much scarcer. This is surprising given that residential investment is one of the most volatile components of gross domestic product (GDP), and given the housing booms and busts in countries such as the United States, Ireland, and Spain in the 2000s, or the Nordic countries in the 1990s. There are also very few cross-country analyses on the drivers of residential investment, including the role of interest rates and their potentially asymmetric effects over the cycle. For policymakers this is an important issue: for instance, in an economy burdened by oversupply of housing after a real estate boom, lower interest rates may do little to kick-start residential investment and economic activity.

This paper intends to fill part of this gap. One contribution we make is to examine the proximate drivers of residential investment in a cross-country rather than single-country context. Another is that we conduct the analysis on data over the past half-century. This helps us uncover common financial, demographic, and real economy factors related to both demand and supply, rather than idiosyncratic, country- or time-specific factors. We also study the behavior of residential investment across the business cycle, in particular the leading indicator properties of residential investment in a simple benchmark recession-prediction model.

The paper highlights three main findings. First, we show that the main determinants of residential investment in advanced economies are real house prices, nominal interest rates, demographic factors, and the state of housing supply. House prices seem to play a prominent role by affecting the incentives to pursue residential investment, i.e., the numerator in Tobin's q for housing.

Second, we find that the effects of interest rates on residential investment are twice as large during housing booms compared with normal times, and are clearly stronger when interest rates are rising than when they are falling.

Third, drops in residential investment consistently lead economic downturns in the 99 recessions identified in our sample. This signaling property arises despite the small overall share of residential investment in GDP—around 6 percent on average over the past five decades. Prior to an economic downturn, house prices, growth in construction activity, and construction employment all decline. We show that information on declines in residential investment improves the performance of standard recession forecasting models that also feature the slope of the yield curve.

Our work is related to several strands of literature. One covers studies of residential investment over the business cycle—in particular, its recession prediction properties (Leamer 2007, 2015 and International Monetary Fund 2008). For instance, Leamer (2015) showed how 9 out of 11 recessions in the United States after the Second World War were preceded by large declines in residential investment. We confirm these properties in a broad cross-country setting, and highlight the economic mechanisms that may lie behind them. The relevance of housing dynamics for economic activity is consistent with the models of Iacoviello (2005) and Iacoviello and Neri (2010), in which housing wealth affects spending through changes in collateral values and hence borrowing constraints. More recently, Mian, Sufi, and Verner (2017) found that higher house price and household debt growth both predicted lower subsequent GDP growth. Herstad (2016) and Huang et al. (2018) also concluded that housing market developments predict business cycle variations. In addition, we build on the recession prediction models of Estrella and Hardouvelis (1991) and Rudebush and Williams (2009), who established that shifts in the yield curve anticipate downturns.

Another strand of the literature comprises studies of the determinants of residential investment. These have so far mainly focused on the United States. Our finding that residential investment in a broad range of advanced economies responds first and foremost to house price developments is in line with theoretical model predictions and empirical studies for individual countries (e.g., Topel and Rosen 1988, Tsoukis and Westaway 1994, Davis and Heathcote 2005, Glaeser, Gyourko, and Saiz 2008). Our study also relates to a number of papers that highlight the interest rate sensitivity of residential investment (e.g., McCarthy and Peach 2002, Erceg and Levin 2006, Jarocinski and Smets 2008, Aspachs-Bracons and

Rabanal 2011, Dokko et al. 2011, Calza, Monacelli, and Stracca 2013). One implication of this finding is that tighter monetary policy could have curtailed the magnitude of the pre-crisis housing boom in the United States (Taylor 2007, Leamer 2015, and Sutton, Mihaljek, and Subelyte 2017).

A third strand of the literature is studies of the asymmetric effects of interest rate changes on aggregate output (e.g., Angrist, Jordà, and Kuersteiner 2013, Vavra 2014, Tenreyro and Thwaites 2016). We find that the effects of interest rates on residential investment are stronger during housing booms and when interest rates are rising. We suggest that one source of this asymmetry could be downward house price rigidity, which forces adjustments through quantities rather than prices. Another is adjustment costs: labor shortages and other bottlenecks constrain the expansion of residential investment during the housing booms, but there are no constraints to slowing the activity during busts. More generally, our results corroborate the notion that booms that lead to a temporary oversupply of housing tend to be followed by periods of weak or unresponsive residential investment (Rognlie, Shleifer, and Simsek 2018). One implication of this feature of housing supply is that prolonged construction booms fueled by expansionary monetary policy could over time weaken the responsiveness of residential investment to monetary policy.

The paper is structured as follows. Section 2 describes the data and key stylized facts about residential investment. Section 3 outlines the empirical approach. Section 4 discusses the estimation results for determinants of residential investment. Section 5 presents results from a formal recession-prediction model that incorporates residential investment. Section 6 presents robustness tests. Section 7 concludes.

2. Data and Stylized Facts

The bulk of our residential investment data come from the Organisation for Economic Co-operation and Development's (OECD's) Economic Outlook database and national statistical authorities.[1]

[1]For Germany, pre-1991 data are for West Germany. For Switzerland, we use gross private domestic investment in construction.

To compute the size of the existing housing stock, we start from the estimates on initial housing stocks by Piketty and Zucman (2014). We then compute the stocks in subsequent periods by assuming a 1½ percent annual depreciation rate.[2]

For real house prices, we use residential property prices published by the Bank for International Settlements and deflated by the respective national consumer price indexes. For most countries in the sample, these series are based on transactions data. They also feature a quality adjustment based either on size or a more sophisticated approach such as hedonic regression (see Scatigna, Szemere, and Tsatsaronis 2014).

Our sample runs from 1970:Q1 to 2017:Q2 and is thus longer than in previous cross-country studies (e.g., International Monetary Fund 2008 and Calza, Monacelli, and Stracca 2013). We include 15 advanced economies: Australia, Canada, France, Germany, Italy, Japan, the Netherlands, New Zealand, Norway, Korea, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

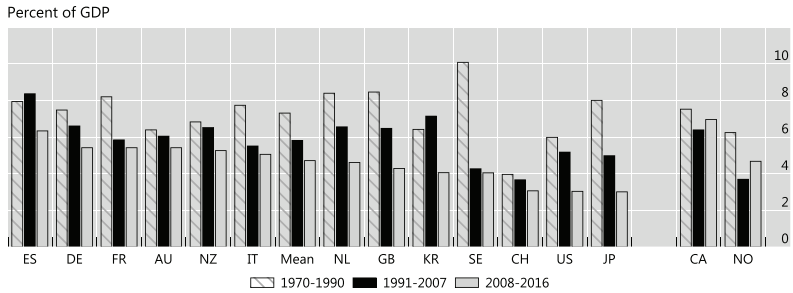
Residential investment generally accounts for a small share of GDP. Over the whole sample, it averaged 5.9 percent of GDP, compared with 12.5 percent for business investment. The share has fallen over time, from 7.3 percent in the first two decades to 5.8 percent between 1991 and the Great Financial Crisis (GFC), and then to 4.7 percent in 2008–16 (figure 1). Only Canada and Norway—shown on the right-hand side of the figure—have seen an increase in the share of residential investment post-crisis.

The share of residential investment in GDP was highest during the 1970s and 1980s, especially in Sweden (10 percent), where construction surged during the "Million Homes Programme" (1965–75) that aimed to overcome urbanization-induced housing shortages (Emanuelsson 2015). In the two decades before the GFC, the share of residential investment was the highest in Spain (8 percent), where easy financing conditions that accompanied the introduction of the euro, demographic factors, and purchases by other EU residents played a role (e.g., Garcia-Herrero and Fernandez de Lis 2008).

At the sectoral level, residential investment relates most closely to construction, whose value added in GDP has also generally fallen

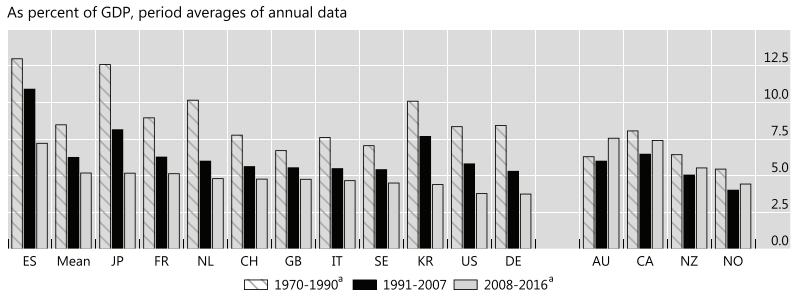
[2]In a robustness check we also estimated the model using a 2 percent depreciation rate. This change did not affect the results in a significant way.

Figure 1. Residential Investment over Time[a]



Sources: OECD, Economic Outlook database; national data; authors' calculations.
[a]Period averages of quarterly data. For Switzerland, annual data. Countries are ordered by the residential investment share in 2008–16.

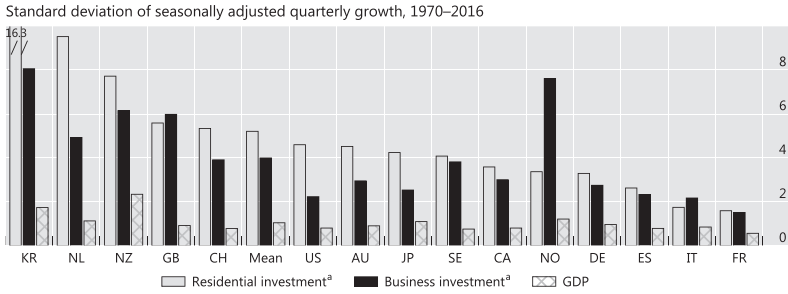
Figure 2. Construction Value Added



Sources: OECD; Datastream; national data; authors' calculations.
[a]For Japan, data are available to 2015; for New Zealand, data are available from 1971 to 2015. Countries are ordered by the construction value added share in 2008–16.

over time. In our sample, it averaged 8.5 percent in 1970–90; 6.2 percent in 1991–2007, and 5.2 percent in 2008–16 (figure 2). Post-crisis, the construction share of GDP has increased in Australia, Canada, New Zealand, and Norway, all of which have also seen housing booms during the period. Reflecting the high labor intensity of construction, the employment share has been relatively stable: it amounted on average to 7.8 percent of total employment in 1970–90 and 7.2 percent in 2008–16 (appendix figure A.1).

Figure 3. Residential and Business Investment Are Much More Volatile than GDP Growth[a]



Sources: OECD, Economic Outlook database; national data; authors' calculations.

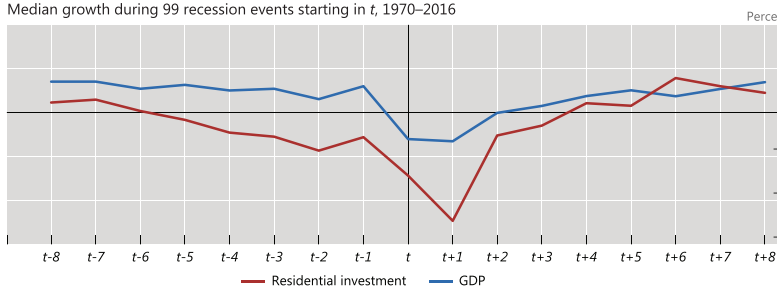
[a]Business investment includes investment in commercial property. For Germany (prior to 1991), Italy, and Spain, computed as total less housing investment. For Switzerland, construction is used for residential, and equipment and software for business investment.

Notwithstanding its generally small share in the overall economy, residential investment is often the most volatile component of GDP (figure 3). Volatility arises in part from the large housing stock: even small changes in desired housing stock require relatively large changes in investment. Measured by the standard deviation, volatility of residential investment in our sample is on average about five times that of overall GDP growth. This compares with a ratio of around four-to-one for business investment. Residential investment volatility in our sample has been highest in Korea and the Netherlands, at around eight to nine times that of GDP. Norway is an exception to this pattern, as growth in business investment, which is driven by oil production, is more volatile than that in residential investment. Yet, both series are far more volatile than GDP growth.

Consistent with high volatility, residential investment tends to fall sharply before recessions, with a notable lead over broader economic activity. Defining recessions conventionally, as a minimum of two consecutive periods of negative quarter-on-quarter GDP growth, figure 4 shows the median growth rates in real GDP (blue line) and residential investment (red line), before and after the start of a recession (in quarter t).[3] The sample includes 99 recessions. Residential

[3]For color versions of the figures, see the online version of the paper at http://www.ijcb.org.

Figure 4. Residential Investment versus GDP Growth during Recessions



Sources: OECD, Economic Outlook database; national data; authors' calculations.
Notes: Recession events are defined as at least two consecutive quarters of negative GDP growth based on seasonally adjusted data. t denotes the first quarter of recessions.

investment growth tends to become negative five quarters before the start of a recession, and then falls quite sharply before turning positive again four quarters after the start of a recession. Cumulatively, residential investment declines by a median of 7.3 percentage points of GDP during the quarters around a recession in our sample, while output falls by only 1.3 percentage points.[4]

Such dynamics are not merely mechanical, as real GDP declines over and above the fall in residential investment. We show this in appendix figure A.2, where the GDP series excludes the residential investment component. Moreover, the finding is robust to the inclusion of both country and time fixed effects, as shown in appendix figure A.3. These variables capture differences in the average growth rates between countries and control for any common shocks that may simultaneously affect residential investment and real GDP growth in several countries.

3. Empirical Methodology

To identify the main drivers of residential investment, we rely on direct single-equation estimations at multiple horizons. This

[4]While figure 4 shows growth outcomes during a median recession episode, the large cross-country data set features a rich set of recession events with diverse growth outcomes around such periods.

approach is flexible in that, contrary to a standard vector autoregression, it allows modeling asymmetric and nonlinear responses, which may occur due to pronounced booms and busts in the sample (see Agnello and Schuknecht 2011 and Dokko et al. 2011). This condition is fulfilled in our case given the long time span and wide geographic coverage of our data. More generally, this approach tends to be more robust to structural changes that may have occurred over the sample period.

Following the approach proposed by Jordà (2005), our estimated equations take the form

$$I_{i,t+h+1} - I_{i,t+h} = \alpha_i + \gamma_t + \beta' X_{i,t} + \varepsilon_{i,t+h+1}. \quad (1)$$

The equation is estimated by ordinary least squares, with inference based on standard errors that are clustered by country. The dependent variable is the change in the log of real residential investment I in country i between periods $t+h$ and $t+h+1$. We consider quarterly horizons from $h = 0$ to $h = 5$. The right-hand-side variables include country fixed effects, α_i, to capture country-specific unobserved heterogeneities; quarterly time fixed effects, γ_t, to capture common global trends; and a vector of explanatory variables, $X_{i,t}$. The explanatory variables are expressed in differences to avoid issues with nonstationarity and spurious correlations, and are lagged relative to the dependent variable to minimize reverse causality concerns. At the same time, we acknowledge that simultaneity issues cannot be fully eliminated in this estimating framework.[5]

The vector of explanatory variables $X_{i,t}$ includes various components of Tobin's q for residential investment that capture the incentives to invest in housing. Tobin's q for housing compares the market price of a home in the numerator with various costs of building a new home in the denominator. As in Tsoukis and Westaway (1994), we include the proxies for Tobin's q in the regression individually,

[5]It is important to note that including a lagged dependent variable did not lead to meaningful changes in the coefficients of other explanatory variables. This was found to be true irrespective of whether we used one or three lags of the dependent variable. Also, whether the housing stock variable (which is obviously correlated with the lagged dependent variable) was included or dropped did not produce material changes to the estimates. The lags of the dependent variable were generally not statistically significant and had coefficients below 0.10. These results are available upon request.

as there is considerable uncertainty regarding the measurement and weights of such components in any constructed measure of q.

Our house price series are computed as residential property prices deflated by the consumer price index. Time-to-build considerations imply that expected rather than observed house prices matter for investment decisions (Kydland and Prescott 1982). We estimate expected house prices from an adaptive expectations model: in the baseline regression we include house prices predicted by a simple AR(5) model, using lags of five quarters, based on the Akaike and Bayesian information criteria. As an alternative we simply use the last observation of real house price variation (results are available upon request). In theory, house price changes would be irrelevant for residential investment only if they were perceived to be entirely temporary. In practice, they are likely to carry new information about the trend and hence about rising or falling returns in the housing sector. The two series for expected house prices led to broadly similar results. Sutton, Mihaljek, and Subelyte (2017) argue that forecastable upward moves in house prices tend to persist because of the large search-and-transaction costs associated with house purchases. Similarly, Glaeser and Gyourko (2007) regard the serial correlation of house price changes as one of the key stylized facts of the housing market. In other words, the most recent changes contain information on the likely future trend in prices.

House prices should also reflect any additional effects of residential investment that are not well captured by other explanatory variables, and for which little comparable cross-country data are available. These include housing quality adjustments, the effects of restrictive regulations on housing supply, or, in some countries, the effects of foreign demand on residential investment. House prices also matter for the incentives to construct new housing and undertake home improvements, both of which are included in the residential investment series.

The components that enter the denominator of Tobin's q include three proxies for costs of residential investment. First, the producer price index (PPI) is a proxy for construction costs. Higher costs of raw materials, including energy, push up construction costs and could therefore negatively affect investment in new or the expansion of existing residential units. Second are short-term interest rates, which affect both housing supply through property developers'

funding costs, and housing demand through debt servicing costs. Interest rates also affect investment indirectly, through discount rates used in property valuations (the numerator of q). We use a short-term money market rate, in line with Mishkin's (2007) argument that builders construct houses relatively quickly, and express it in nominal terms, as money illusion phenomena may be important (Topel and Rosen 1988; Tsoukis and Westaway 1994).[6] Third, we include expected consumer price inflation, estimated by an adaptive AR(5) model, to allow for the possibility that rising inflation may depress investment, among other reasons because of the associated rise in uncertainty or macroeconomic instability.[7]

Among demand-side variables, we include income levels (GDP per capita), household size (number of persons per household), and net migration rates (net migrants per thousand residents). Higher income and greater inward migration are expected to boost residential investment (Monnet and Wolf 2017). Higher migration rates can also boost housing supply by increasing the number of construction workers.[8] Household size has a priori an ambiguous effect on residential investment: on the one hand, larger households normally imply higher density of living space, which should provide an incentive for developers to build more housing. On the other hand, smaller household size could reflect a cultural shift and over time might also boost demand. As an additional demographic variable we include the share of people aged 20 to 34 in total population, as the young are more likely to demand new housing units.

Finally, we include the value of the stock of housing in relation to GDP. A negative coefficient for this variable would imply that it effectively acts like a cointegration vector that pushes the economy back to its long-term equilibrium.[9] Larger existing stocks relative to the size of the economy should reduce the incentives to pursue additional residential investment.

[6] With real interest rates we also generally obtain the expected negative signs but with lower significance.

[7] Another variable that would enter the denominator of Tobin's q for housing is the price of land, as this affects the cost of producing a new home (see Corder 2008). Due to lack of comparable cross-country data on land prices, we did not include this variable in the estimation.

[8] Corder (2008) argued that labor shortages in the United Kingdom's construction sector eased in the 2000s when migrant workers entered the sector.

[9] We thank an anonymous referee for noting this point.

4. Estimation Results

4.1 Baseline Specifications

Table 1 presents our baseline estimates, based on around 2,700 country-quarter observations. t-statistics reported below the coefficients are based on robust standard errors clustered by country. Column 1 reports the drivers of residential investment growth between t and $t+1$, column 2 between $t+1$ and $t+2$, and so on. They indicate that several of our explanatory variables have an economically and statistically significant impact on residential investment over multiple horizons. This suggests that a sufficiently flexible modeling approach that considers a number of different lags is indeed appropriate. Furthermore, all coefficients have the expected sign whenever they are statistically significant at conventional levels.

Four findings are worth highlighting. First, higher real house prices are positively correlated with residential investment. A 1 percent increase in expected real house prices is associated with a 0.54 percent rise in residential investment already after one quarter, and 0.81 percent after two quarters. Changes in interest rates are negatively related to residential investment, with a lag. An increase in nominal interest rates by 100 basis points is associated with a 0.18 percent fall in residential investment after three quarters, and 0.37 percent after five quarters (if one considers coefficients that are at least significant at a 10 percent level).[10] Comparing normalized estimates instead (not shown), the relationship between residential investment and a one-standard-deviation change in real house prices is roughly twice as large, in absolute terms, as that of one-standard-deviation change in interest rates.[11]

Second, demographic factors are important. A higher rate of net migration is associated with more residential investment. Similarly,

[10]This effect is a bit smaller than the −0.6 percent reported in Calza, Monacelli, and Stracca (2013), who used a vector autoregressive (VAR) approach and data for 19 advanced economies.

[11]It is important to acknowledge that here we do not estimate the local supply elasticity separately. In countries in which the housing supply is inelastic, positive shocks to housing demand will increase prices but construction will rise by less. The degree of supply elasticity is also likely to affect the estimated relationship between lagged house prices and construction. We are indebted to an anonymous referee for noting this point.

Table 1. Determinants of Residential Investment Growth: 1970–2017

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$ (1)	$t+2$ (2)	$t+3$ (3)	$t+4$ (4)	$t+5$ (5)	$t+6$ (6)
PPI Inflation	−0.049	−0.037	−0.024	0.002	0.016	0.009
t-stat	1.06	1.09	0.89	0.07	0.58	0.42
Real House Price Growth Exp.	0.537***	0.276***	0.116	0.046	−0.046	0.009
t-stat	5.32	2.90	1.31	0.46	0.50	0.11
Interest Rate Change	−0.036	−0.148	−0.182**	−0.187***	−0.068	0.024
t-stat	0.35	1.47	2.14	2.45	1.24	0.30
Net Migration Rate Change	0.022***	0.025***	0.028***	0.030***	0.027***	0.030**
t-stat	3.15	3.54	3.08	3.33	3.33	2.52
Persons per House	0.009***	0.016***	0.018***	0.027***	0.015***	0.010***
t-stat	4.33	3.12	5.94	5.36	5.14	3.35
Share of Young	0.118***	0.106*	0.113*	0.072	0.123*	0.135**
t-stat	2.68	1.71	1.69	0.75	1.73	2.01
Housing Stock/GDP	−0.006*	−0.007**	−0.008**	−0.007**	−0.008***	−0.008***
t-stat	1.86	2.20	2.54	2.42	2.66	2.59
GDP per Capita Change	0.184	0.320	0.163	0.091	0.261	0.092
t-stat	0.71	1.54	0.95	0.85	1.46	0.79
CPI Inflation Exp.	0.000	−0.001	−0.001	−0.001	−0.001	0.000
t-stat	0.38	0.58	0.72	1.01	0.62	0.22
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,706	2,706	2,706	2,705	2,704	2,689
R2	0.147	0.140	0.134	0.140	0.135	0.133
F Statistic	15.58***	19.14***	13.26***	42.47***	25.48***	12.90***
RMSE	0.0517	0.0515	0.0517	0.0506	0.0490	0.0488

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

an increase in household size—which is strongly correlated with population density—is associated with higher residential investment.

Third, a larger existing housing stock acts as a break on new residential investment. As a corollary, countries with smaller housing stocks have seen faster growth in residential investment, an observation that is also consistent with the higher investment ratios observed in the earlier part of the sample (figure 1).

Fourth, the coefficients on GDP per capita are consistently positive, suggesting that higher income levels are associated with higher residential investment. From a statistical viewpoint, however, this effect is not significant. Nor are the mostly negative effects of PPI inflation (a proxy for construction costs) and expected consumer price inflation (a measure of macroeconomic uncertainty).[12]

The appendix shows the results for two variations of this baseline specification. When time fixed effects are omitted, the quantitative effects of interest rates and expected house price increases are stronger (table A.1). This is not entirely unexpected, given that time fixed effects are meant to capture global trends, such as the long-term decrease in interest rates and financial globalization.

When the time sample is limited to the post-2000 period, the responsiveness of residential investment to price variables increases (table A.2). This is not surprising, either. In the 1970s and 1980s, several countries had large government programs to increase housing supply. These naturally tended to be relatively unresponsive to market conditions. More importantly, many countries have seen financial liberalization since the 1980s, which resulted in increased availability of mortgages to households. Together, the lower share of housing financed by the government and the development of mortgage markets translated into greater sensitivity of residential investment to changes in house prices and financial conditions.[13]

[12]If run on a country-by-country basis, the explanatory power of the baseline model for six-quarter cumulative investment growth is largest for Spain ($R^2 = 0.73$), followed by France (0.58) and the United States (0.44). It is lowest for Sweden (0.20) and Australia (0.15), as shown in figure A.4.

[13]The more recent period was also characterized by heightened policy uncertainty in many economies, in particular after the GFC. Greater uncertainty could result in the postponement of construction projects due to uncertain returns. To address this issue, we used a measure from Baker, Bloom, and Davis (2016) that is based on the frequency of newspaper articles that discuss policy

4.2 Examining Asymmetries

Next we identify cyclical phases of residential investment in order to examine whether the effect of interest rates on residential investment is asymmetric across the cycle. We define residential investment upswings as periods when the quarterly change in the residential investment-to-GDP ratio is above the 75th percentile of the distribution (for each country) for at least one year. Thus, upswings are associated with a rapid increase in the share of residential investment in the economy. Similarly, residential investment downswings are defined as periods when the quarterly change in the residential investment-to-GDP ratio is below the 25th percentile of the distribution in each country. During such periods, the share of residential investment in the overall economy falls.

The cycles are computed using the four-quarter moving averages of the residential investment-to-GDP ratio to minimize the effect of temporary volatility in residential investment. Short upswings/downswings, i.e., those lasting less than four quarters, are not considered in order to have sufficient persistence in cyclical phases. Moreover, any gaps of less than four quarters between two identical phases (downswing or upswing) were eliminated, thus combining the two phases into a single one. The resulting 76 cyclical upswings and 65 downswings are shown in figures 5 and 6, while figure 7 shows the number of economies that are experiencing upswings and downswings at each point in time.

The earlier part of the sample saw a greater number of upswings in residential investment; since the mid-2000s, their occurrence has declined somewhat, only to rise again in the most recent period (figures 5 and 7). The longest upswing in the sample was the one in Spain, spanning the late 1990s and the early 2000s, when the share of residential investment in GDP rose by slightly more than 3 percentage points. Another recent case is Sweden, which went through an upswing in 2013–16, with the GDP share rising by 1.6 percentage points.

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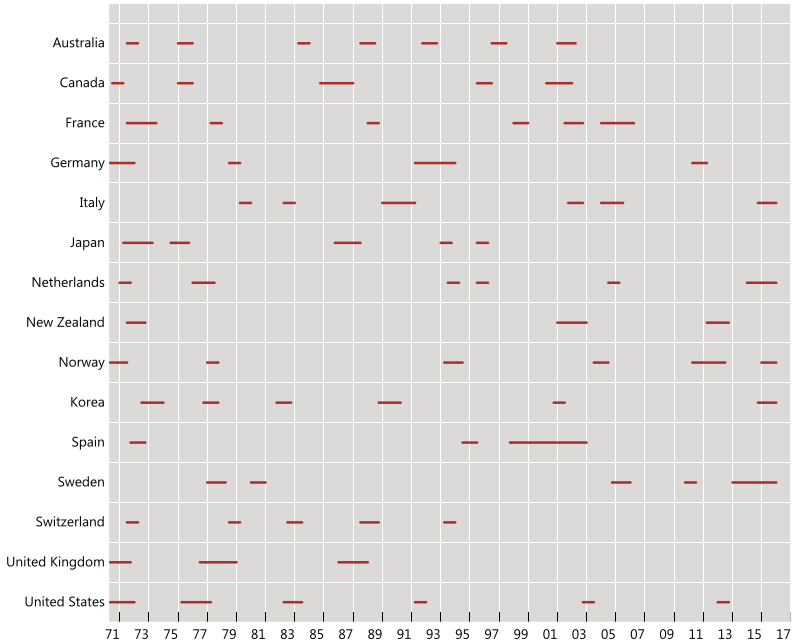
uncertainty. While we found that policy uncertainty is negatively associated with residential investment activity, the magnitude of the estimated effect was small. These results are available upon request.

Figure 5. Timeline of Upswings in Residential Investment, 1970–2016[a]



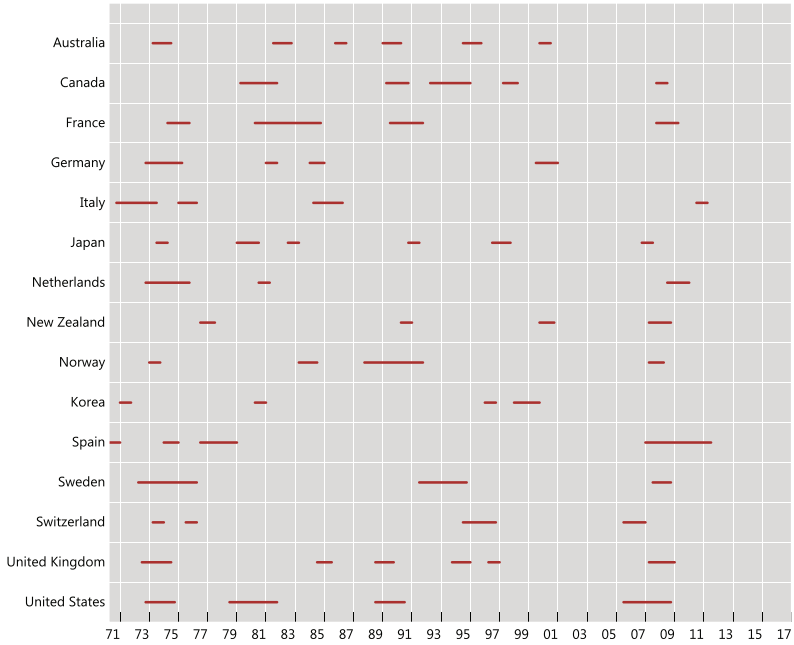
Sources: OECD, Economic Outlook database; national data; authors' calculations.

[a]Defined as quarterly growth (in percentage points) above the 75th percentile within each country, based on four-quarter moving averages of residential investment as a share of GDP. Short upswings lasting less than four quarters were dropped, and short gaps (less than four quarters between two upswings) were connected. For Switzerland, construction is used for residential investment.

Many countries saw downswings around the Great Financial Crisis (figures 6 and 7). Spain experienced a long investment slump during 2007–14, when the residential investment-to-GDP ratio fell by 5.5 percentage points. In the United States, the ratio declined by 3 percentage points in the aftermath of the GFC. In Norway, it fell by a similar amount in the late 1980s, and again in the early 1990s.

Next, we use the identified cyclical phases as zero-one dummy variables interacted with interest rates. We find that a change in interest rates by 100 basis points is associated with a decline in residential investment by 0.78 percent after four quarters during

Figure 6. Timeline of Downswings in Residential Investment, 1970–2016[a]



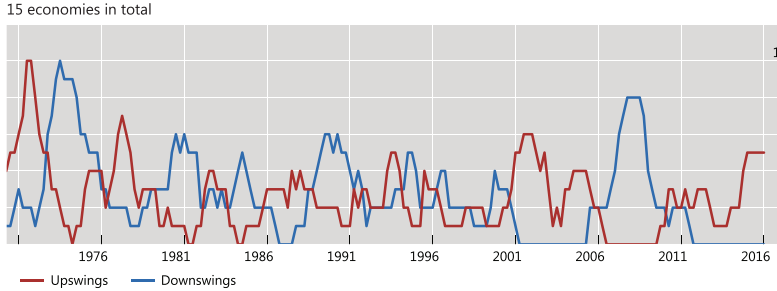
Sources: OECD, Economic Outlook database; national data; authors' calculations.

[a]Defined as quarterly growth (in percentage points) below the 25th percentile within each country, based on four-quarter moving averages of residential investment as share of GDP. Short downswings lasting less than four quarters were dropped, and short gaps (less than four quarters) between two downswings were connected. For Switzerland, construction is used for residential investment.

residential investment upswings (table 2), and with a bit less than half that during normal times (0.33 percent).[14] When we interact interest rate changes with downswings, we obtain much lower coefficient estimates (appendix table A.3). Intuitively, this asymmetry is not surprising: for a property developer, the real cost of borrowing is the interest rate minus the expected appreciation of the property's price. Thus, when house prices are expected to fall, the real cost

[14]These results use coefficient estimates that are statistically significant at a 10 percent level at least.

Figure 7. Number of Economies in Upswings and Downswings in Residential Investment



Sources: OECD, Economic Outlook database; national data; authors' calculations.
Notes: Upswings (downswings) are defined as quarterly growth, in percentage points, above the 75th percentile (below the 25th percentile) within each country, based on four-quarter moving averages of residential investment as share of GDP. Short swings lasting less than four quarters were dropped, and short gaps (less than four quarters) between two upswings were connected. For Switzerland, construction is used for residential investment.

of building may be too high even if interest rates were to drop to zero.[15]

We get similar results when we use quantile regressions instead of the above classification of upswings and downswings. The effects of interest rates on building activity are strongest when residential investment growth is peaking, and not statistically significant during a slump, as shown in table A.4 in the appendix.[16] This evidence is broadly in line with findings for aggregate output by Tenreyro and Thwaites (2016), among others.

One explanation for such dynamics is that borrowers become more sensitive to higher interest rates when residential investment is expanding rapidly. Both property developers and buyers may be incurring higher debt levels, and if the upturn coincides with a financial boom, marginal borrowers may benefit from greater availability of credit. We find some support for this narrative, as real total

[15]We thank an anonymous referee for this point.
[16]We thank an anonymous referee for suggesting this alternative test.

Table 2. Effects of Interest Rates during Upswings

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$ (1)	$t+2$ (2)	$t+3$ (3)	$t+4$ (4)	$t+5$ (5)	$t+6$ (6)
PPI Inflation	−0.054	−0.040	−0.025	0.003	0.018	0.010
t-stat	1.28	1.26	0.95	0.09	0.64	0.44
Real House Price Growth Exp.	0.449***	0.224**	0.093	0.053	−0.030	0.035
t-stat	4.93	2.36	1.09	0.50	0.35	0.44
Upswing	0.017***	0.010***	0.004**	−0.001	−0.003*	−0.005**
t-stat	5.71	5.07	2.05	0.45	1.67	2.37
Interest Rate Change	−0.011	−0.147	−0.152*	−0.173**	−0.045	−0.015
t-stat	0.10	1.36	1.92	2.24	0.72	0.19
Interest Rate Change*Upswing	−0.331	0.026	−0.451**	−0.224	−0.372	0.580
t-stat	1.44	0.12	2.33	0.88	1.52	1.02
Net Migration Rate Change	0.020***	0.024***	0.027***	0.030***	0.027***	0.031**
t-stat	3.35	3.94	3.41	3.34	3.37	2.57
Persons per House	0.010***	0.016***	0.018***	0.027***	0.015***	0.010***
t-stat	4.98	3.26	6.06	6.69	5.08	3.22
Share of Young	0.083***	0.086*	0.104*	0.075	0.129*	0.146**
t-stat	3.32	1.86	1.77	0.79	1.74	1.99
Housing Stock/GDP	−0.006***	−0.007**	−0.008***	−0.007**	−0.008***	−0.008**
t-stat	3.11	2.33	2.58	2.40	2.60	2.54
GDP per Capita Change	0.149	0.300	0.153	0.093	0.266	0.104
t-stat	0.58	1.49	0.93	0.85	1.45	0.91
CPI Inflation Exp.	0.000	0.000	−0.001	−0.001	−0.001	0.000
t-stat	0.21	0.49	0.67	1.01	0.64	0.29
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,706	2,706	2,706	2,705	2,704	2,689
R2	0.159	0.144	0.135	0.140	0.136	0.136
F Statistic	1,089.47***	54.22***	23.65***	311.00***	24.76***	24.14***
RMSE	0.0513	0.0514	0.0516	0.0506	0.0490	0.0487

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

credit growth is more than twice higher during residential investment upturns than downturns (median growth rates of 1.5 percent and 0.6 percent, respectively).

Does the relationship between interest rates and residential investment differ for interest rate increases and decreases? Previous research has highlighted the asymmetric effects of monetary contractions and expansions on economic activity, with interest rate hikes generally having stronger effects than interest rate cuts (e.g., Angrist, Jordà, and Kuersteiner 2013). Table 3 concurs with that evidence, as interest rate increases are found to be associated with lower residential investment, over multiple horizons, with economically and statistically significant coefficients. In contrast, and perhaps surprisingly, the correlation of residential investment with interest rate declines is not statistically significant at any horizon. This result is not driven by the Great Financial Crisis and its aftermath, as additional estimates show that similar dynamics prevailed from 1970 to 2006.[17]

Why would interest rate increases have greater effects on residential investment than interest rate decreases? A key reason could be downward rigidity in real house prices. Sellers may be unwilling to let prices fall sufficiently to generate expectations of new price increases. Figure 8 supports this conjecture, showing that house prices rose much more strongly (1.5 percent quarter on quarter) during median residential investment upswings than they fell during median downswings (−0.6 percent). Another reason is that the tightening and easing of financial conditions have asymmetric effects on creditworthiness of property builders. The default rate of unhedged property developers tends to rise after an interest rate increase, but is bounded when interest rates decrease, as the default rate cannot fall below zero. A third reason is that the pass-through of changes in interest rates from financial intermediaries to final users of funds might be larger when interest rates rise than when they fall.

Construction value added relative to GDP also displays asymmetry between upswings and downswings: during a median upswing, it rises by less than 0.1 percentage point a year on average, while during a median downswing it falls by close to 0.3 percentage point.

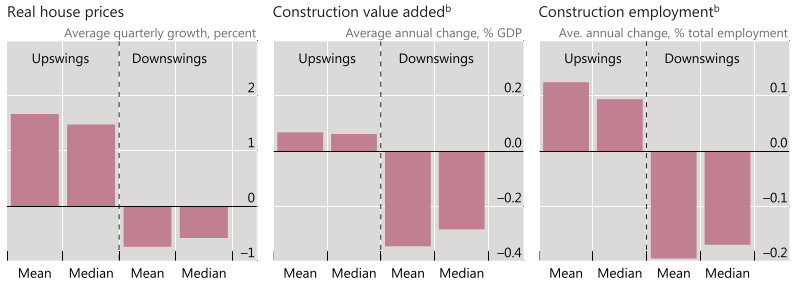
[17]These results are available upon request.

Table 3. Testing for Asymmetries: Rate Hikes versus Rate Reductions

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$ (1)	$t+2$ (2)	$t+3$ (3)	$t+4$ (4)	$t+5$ (5)	$t+6$ (6)
PPI Inflation	−0.049	−0.037	−0.024	0.001	0.016	0.009
t-stat	1.09	1.10	0.90	0.05	0.57	0.43
Real House Price Growth Exp.	0.530***	0.271***	0.113	0.040	−0.050	0.005
t-stat	5.30	2.88	1.29	0.42	0.55	0.07
Interest Rate Increase	−0.309**	−0.335	−0.294***	−0.418***	−0.228**	−0.115
t-stat	2.53	1.45	4.15	3.77	2.00	0.90
Interest Rate Decrease	0.262	0.056	−0.058	0.067	0.107	0.175
t-stat	1.23	0.43	0.40	0.54	0.80	1.38
Net Migration Rate Change	0.022***	0.024***	0.028***	0.030***	0.026***	0.030***
t-stat	3.08	3.49	3.06	3.29	3.30	2.50
Persons per House	0.009***	0.016***	0.018***	0.027***	0.016***	0.010***
t-stat	4.56	3.98	6.00	6.80	5.23	3.43
Share of Young	0.107***	0.099*	0.109*	0.063	0.117*	0.130**
t-stat	2.84	1.91	1.79	0.73	1.79	2.09
Housing Stock/GDP	−0.006**	−0.007**	−0.008***	−0.008***	−0.008***	−0.008***
t-stat	2.05	2.33	2.62	2.58	2.77	2.69
GDP per Capita Change	0.151	0.298	0.149	0.063	0.241	0.075
t-stat	0.57	1.45	0.88	0.56	1.39	0.65
CPI Inflation Exp.	0.000	0.000	−0.001	−0.001	0.000	0.000
t-stat	0.16	0.44	0.63	0.82	0.49	0.11
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,706	2,706	2,706	2,705	2,704	2,689
R2	0.150	0.141	0.134	0.142	0.136	0.134
F Statistic	29.65***	33.99***	15.95***	56.50***	29.65***	11.10***
RMSE	0.0516	0.0515	0.0517	0.0506	0.0490	0.0487

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

Figure 8. House Prices, Construction Output, and Employment during Residential Investment Upswings and Downswings[a]



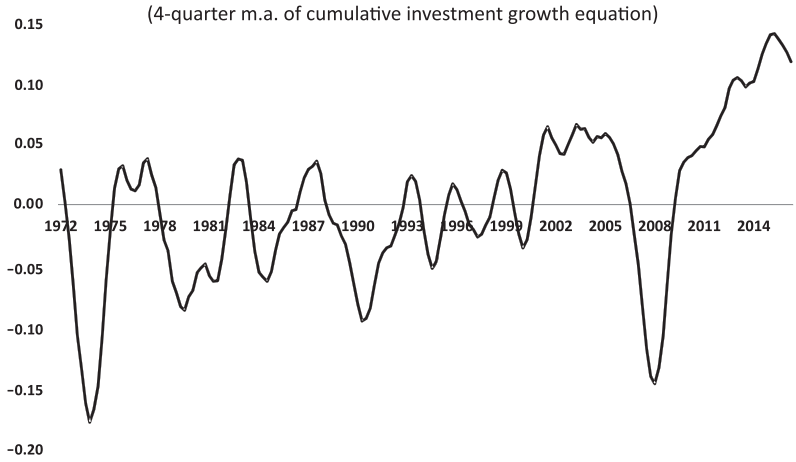
Sources: OECD; Datastream; national data; authors' calculations.
[a]See figures 5 and 6 for definitions of upswings and downswings.
[b]When two or more quarters within a calendar year are upswing or downswing quarters, the whole year is considered an upswing or downswing period.

Similarly, the share of employment in the construction sector rises less during a median upswing (0.09 percentage point a year on average) than it falls during a median downswing (−0.17 percentage point).

These findings corroborate previous evidence that the bulk of adjustment during housing downswings occurs through volumes rather than prices (Poterba 1984; Leamer 2015). In contrast, during upswings, labor shortages and supply and administrative bottlenecks make it more difficult to expand construction, so house prices rise more than housing volumes (Corder 2008).[18]

[18]In additional estimations focusing only on upswings, we find that interest rate reductions increase residential investment growth by less in absolute magnitude than interest rate increases reduce it, consistent with adjustment costs that make it difficult to expand construction. We also test the robustness of the findings in figure 8 to two other definitions of upswings and downswings. First, we construct the 25th and 75th percentiles based on the entire sample distribution (rather than the country-specific distributions) of the change in residential investment-to-GDP ratios. Second, we use the growth in real residential investment, rather than the change in its GDP share, to compute the 25th and 75th percentiles. The asymmetries identified in figure 8 are robust to these alternative definitions. These results are available upon request.

Figure 9. Estimated Global Factor in Residential Investment Growth



Upswings and downswings in residential investment are partly synchronized across countries, suggesting that there may be some important common global factors in their dynamics. The quarterly time fixed effects can be regarded as a proxy for "global" residential investment growth, after controlling for country fixed effects and other determinants of residential investment. Figure 9 shows that there are three periods during which time fixed effects turned strongly negative. The first was in the early 1970s, in the immediate aftermath of the first oil shock, when the Federal Reserve tightened monetary conditions aggressively. The second was in the early 1990s, when global credit contracted sharply. Finally, the time dummies turned strongly negative between the second half of 2007 and early 2010, during the GFC.

The inclusion of time fixed effects stacks the cards against finding significant effects from other explanatory variables. Indeed, if time fixed effects are omitted, the coefficients on other explanatory variables increase in statistical significance (appendix table A.1). We nevertheless include time fixed effects in our baseline estimations given the higher explanatory power of the models that include them and the possibility that they capture relevant and otherwise omitted global conditions.

Finally, residential investment dynamics could be affected by credit market developments.[19] Indeed, when we divide the sample according to whether the International Monetary Fund's mortgage market development index (MMI) is above or below the sample median, we find that the response of residential investment to interest rates and expected house prices is larger in countries with more developed mortgage markets (last column of table 4). We also find indicative evidence on a smaller sample size that higher credit spreads inhibit residential investment (table A.5 in the appendix).

5. Evidence from Recession-Prediction Models

The finding in section 2 that downturns in the housing cycle precede those in GDP can be formally tested for its recession-prediction properties. We build on Estrella and Hardouvelis (1991) and Rudebusch and Williams (2009), who presented evidence that the yield curve was the best single predictor of recessions. Using logistic regressions for the nine economies in our sample for which long time series on the yield curve are available (at least from 1994 onward), we found that information on residential investment growth consistently improved the performance of the yield curve as a predictor of recessions across countries.

Column 1 of table 5 confirms the result in previous literature that the term spread provides useful information for forecasting the start of a recession (defined as two quarters of consecutive negative growth) during the following four quarters. Column 2 shows that the incidence of negative residential investment growth over the past four quarters also helps predict a recession. Notably, the statistical significance of both variables remains high when they are included in the same regression, as shown in column 3. In such a model, the pseudo R^2 more than doubles relative to the specification that features the yield curve slope alone (column 1). Strikingly, column 5 shows that business—unlike residential—investment declines are not very useful on their own for predicting recessions, and only add marginal prediction value to the benchmark model with the yield curve slope. Current GDP growth cannot match the forecasting properties

[19]Global credit market developments or secular trends are inevitably captured in the time dummies.

Table 4. Results by Mortgage Market Development

Dependent Variable: Residential Investment Growth (Real, Log Differences)		
	Cumulative Growth between Quarter t and $t + 6$	
	MMI $<$ 0.575	**MMI $>$ 0.575**
PPI Inflation	-0.523^{***}	0.034
t-stat	3.90	0.33
Real House Price Growth Exp.	0.413^{*}	1.014^{***}
t-stat	1.81	3.52
Interest Rate Change	-0.412^{**}	-0.753^{**}
t-stat	2.24	2.48
Net Migration Rate Change	0.184^{***}	0.178^{***}
t-stat	8.78	5.94
Persons per House	0.079^{**}	0.089^{***}
t-stat	2.39	4.25
Share of Young	0.610^{***}	0.042
t-stat	3.35	0.11
Housing Stock/GDP	-0.023^{***}	-0.060^{***}
t-stat	2.90	4.02
GDP per Capita Change	0.869^{**}	1.415^{***}
t-stat	2.13	3.16
CPI Inflation Exp.	0.003	-0.006^{***}
t-stat	1.59	2.92
Country Fixed Effects	Yes	Yes
Time Fixed Effects	Yes	Yes
Observations	1,082	1,607
R2	0.441	0.317
F Statistic	20.27^{***}	15.28^{***}
RMSE	0.0775	0.1465

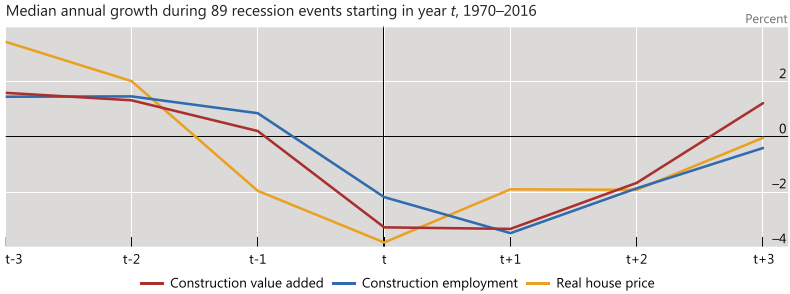
Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

Table 5. Logistic Regressions for Probability of Recession Starting within Next Four Quarters

Probability of Start of Recession between $t+1$ and $t+4$ (Log Odds-Ratio)							
	Residential Investment				Business Inv.	GDP Growth	HP Growth
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Yield Curve Slope (10 y − 3 m)	-0.330**		−0.264***	−0.259***	−0.342***	−0.329***	−0.277***
t-stat	5.08		4.01	3.93	5.26	5.07	3.96
Number of Quarters of Negative *Residential* Investment Growth between $t-3$ and t		0.581***	0.548***				
t-stat		7.35	6.76				
Number of Quarters of Negative *Business* Investment Growth between $t-3$ and t					0.146*		
t-stat					1.82		
Negative Residential Investment Growth in t				0.683***			
t-stat				3.45			
Negative Residential Investment Growth in $t-1$				0.488**			
t-stat				2.42			
Negative Residential Investment Growth in $t-2$				0.660***			
t-stat				3.32			
Negative Residential Investment Growth in $t-3$				0.354*			
t-stat				1.81			
GDP Growth, Annual ($t-4$ to t)						0.024	
t-stat						0.19	
Resid. House Price Growth, Annual ($t-4$ to t)							−0.199***
t-stat							3.75
Observations	941	941	941	941	941	941	926
Number of Countries	9	9	9	9	9	9	9
Pseudo R2	0.034	0.077	0.098	0.101	0.038	0.034	0.061
Chi-Square	25.6	57.5	73.8	75.4	28.8	25.6	43.5
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, CH, DE, ES, IT, JP, GB, and US. Inclusion based on availability of all time series above since at least 1994. Recession quarters after starting period dropped from the sample.

Figure 10. Construction-Sector and Real House Price Growth during Recessions



Sources: OECD; national data; BIS Residential Property Price Statistics; authors' calculations.
Note: Recession events are defined as negative annual GDP growth in real terms.

of residential investment, either (column 6). House price variation, however, does add value, even though its significance is below that for residential investment growth (column 7).

To further illustrate these findings, we plot in appendix figure A.5 the recession probabilities obtained from the parsimonious specification 3 for Australia, the United Kingdom, and the United States. The strong rise in estimated recession probabilities prior to downturns is particularly noticeable for the United States but can also be seen for the recessions Australia and the United Kingdom experienced in the early 1990s.

Through which channels could residential investment contribute to output recessions? Figure 10 plots median growth in construction value added, construction-sector employment, and real house prices over the business cycle. As the data related to the construction sector are annual, recessions in this graph are defined simply as years of negative real GDP growth (periods on the horizontal axis denote years).[20] The first turn is noted in house prices: real house price

[20]Figure 10 uses annual data due to a lack of higher-frequency data on the construction sector. When we use quarterly data on residential investment for the economies included in the recession prediction exercise, we find that growth in residential investment becomes negative five quarters before the start of a recession.

growth decelerates two years before a recession and then becomes negative (–2 percent) in the year preceding the output decline. It then dips further and remains negative overall for four consecutive years. Construction value added then decelerates and drops by 3 percent in the year the recession starts. Employment in the sector follows the same path and falls by around 2 percent in the year when GDP growth turns negative. In addition to these real activity channels, wealth and credit collateral channels induced by the fall in house prices may also restrain activity (e.g., Campbell and Cocco 2007). House price declines may also sap consumer confidence, restraining private consumption.

6. Robustness Checks

We performed a number of additional robustness checks. First we replaced residential investment growth with its GDP share as the dependent variable. The results (not shown) did not change the above findings.

Next we excluded the years of the Great Financial Crisis (2007–09) from the sample. During those three years, all countries in the sample saw a decline in the residential investment-to-GDP ratio, ranging from 0.3 percentage in Italy and Switzerland to 3 percentage points in Spain. Appendix table A.6 shows, however, that the results largely remain robust to the exclusion of the GFC years.

We have also examined whether the results are driven by individual economies with outlier observations. In these tests, we found that the results are robust to excluding either Korea or Italy, i.e., the economies with the highest and lowest average residential investment growth rates, respectively, in our sample.[21]

Finally, we evaluated the relevance of public housing for the results. Our estimated model, including determinants such as construction costs and income levels, is more relevant for economies where public-sector residential investment is unimportant. One should recognize, however, that variables such as real house price growth are relevant for both private and public housing provision,

[21]These results are available upon request.

through a higher Tobin's q and the objective of guaranteeing adequate supply of low-cost housing for lower-income groups. To capture the impact of public housing, we estimated the baseline model excluding all countries where social rental dwellings accounted for at least 10 percent of the total housing stock in 2000 and/or 2015 (France, the Netherlands, and the United Kingdom, based on data from the OECD's Affordable Housing Database). As one would expect, the fit of the model improves a bit when countries with the highest public housing provision are excluded (appendix table A.7). More importantly, the sensitivity of residential investment to real house prices and interest rates increases.

7. Conclusions

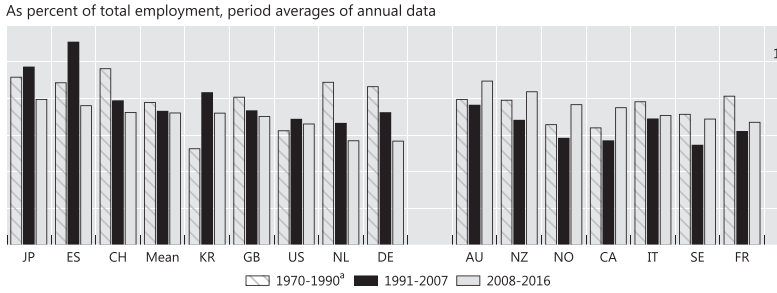
In this paper we analyzed the behavior and main drivers of residential investment using a panel data set for 15 advanced economies since the beginning of the 1970s. Our estimations suggest that house price growth, net migration inflows, and the size of the existing housing stock are the most important drivers of residential investment. We further show that interest rate increases affect residential investment more than interest rate decreases, and that interest rate changes have larger effects on residential investment when its share in GDP is rising strongly.

Also, residential investment consistently anticipates economic downturns across countries. Adding information on residential investment dynamics noticeably improves the performance of standard recession-prediction models.

One interesting issue for future research is the relevance of country-specific institutional factors such as housing supply regulations for residential investment. Such factors cannot be incorporated easily in a cross-country study but they could matter for country-specific investment dynamics. Another interesting issue relates to the use of macroprudential policies directed at the housing sector, which have gained prominence in advanced economies over the past decade. To the extent that they become widely used, macroprudential policies may also affect the short-term dynamics of residential investment activity in the future.

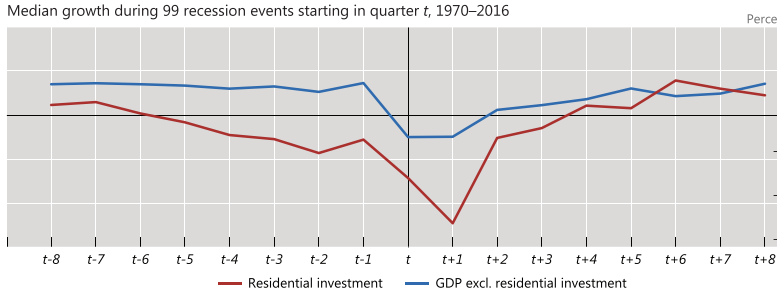
Appendix

Figure A.1. Construction Employment Generally Highest before the 1990s, Fell Post-Crisis



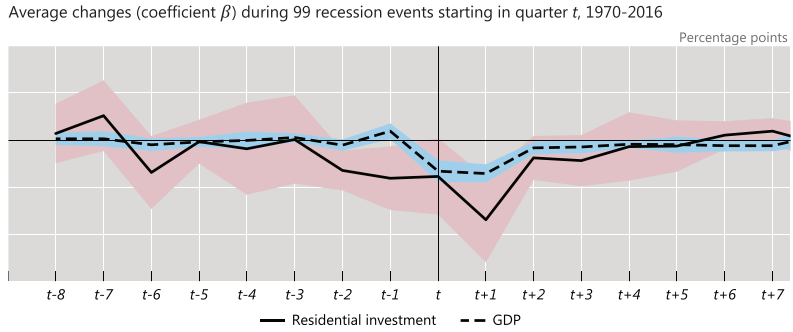
Sources: OECD; Datastream; national data; authors' calculations.
[a]For New Zealand, data are available from 1978.

Figure A.2. Residential Investment, and GDP Excluding Residential Investment, during Recessions



Sources: OECD, Economic Outlook database; national data; authors' calculations.
Note: Recession events are defined as at least two consecutive quarters of negative GDP growth based on seasonally adjusted data.

Figure A.3. Residential Investment versus GDP Growth during Recessions



Sources: OECD, Economic Outlook database; national data; authors' calculations.
Notes: This graph estimates the average changes of residential investment and GDP growth during eight quarters before and after 99 recession events relative to normal times, controlling for country and time fixed effects. The regression is of the following type:

$$IHV \text{ or } GDP \text{ } growth_{i=country,\ t=time,\ rec=start\ of\ recession} = \sum_{k=-8}^{8} \beta_k 1_{t=rec+k} + \gamma_i + \delta_t + \varepsilon_{i,t,rec}.$$

The ranges indicate the 95 percent confidence intervals.

Figure A.4. Explanatory Power of Baseline Model by Countries: R^2s

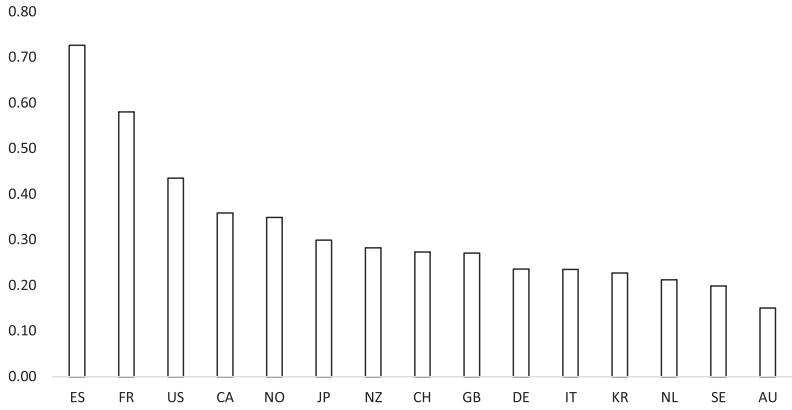


Figure A.5. Estimated Recession Probabilities

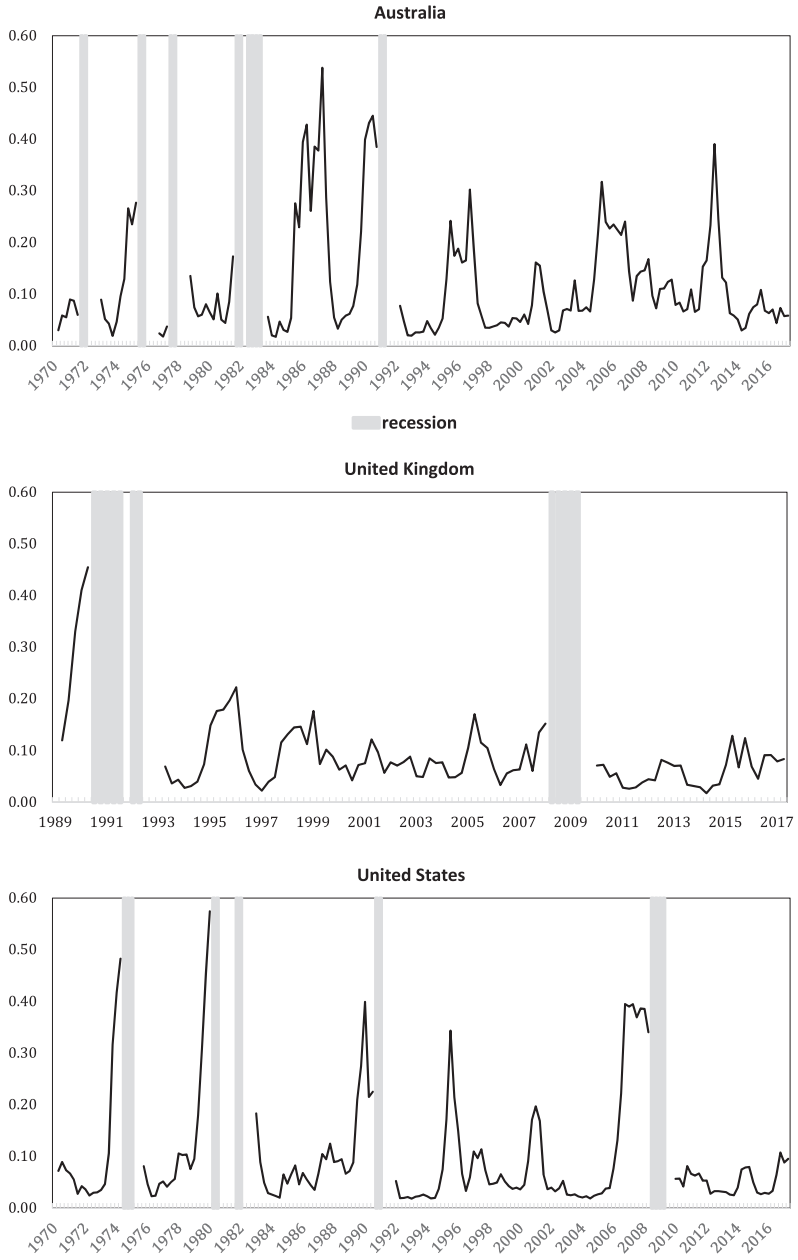


Table A.1. Specification without Time Fixed Effects

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$ (1)	$t+2$ (2)	$t+3$ (3)	$t+4$ (4)	$t+5$ (5)	$t+6$ (6)
PPI Inflation	-0.103^{**}	-0.095^{***}	-0.078^{***}	-0.050^{**}	-0.035	-0.033
t-stat	2.25	2.70	2.79	2.51	1.17	1.31
Real House Price Growth Exp.	0.584^{***}	0.314^{***}	0.101	0.020	-0.080	-0.021
t-stat	6.56	3.82	1.18	0.19	0.80	0.23
Interest Rate Change	-0.140	-0.275^{**}	-0.248^{**}	-0.211^{**}	-0.065	-0.069
t-stat	1.09	2.31	2.07	1.99	1.13	1.06
Net Migration Rate Change	0.021^{***}	0.025^{***}	0.029^{***}	0.030^{***}	0.029^{***}	0.029^{***}
t-stat	3.06	4.12	3.60	3.80	3.57	2.62
Persons per House	0.009^{***}	0.013^{*}	0.014^{**}	0.018^{**}	0.005	-0.001
t-stat	2.99	1.80	2.31	2.28	0.88	0.19
Share of Young	-0.012	-0.047	-0.049	-0.084	-0.036	-0.014
t-stat	0.37	1.17	1.09	1.15	0.73	0.33
Housing Stock/GDP	-0.005^{*}	-0.006^{*}	-0.007^{**}	-0.006^{***}	-0.006^{**}	-0.007^{**}
t-stat	1.74	1.84	2.21	2.96	2.15	2.28
GDP per Capita Change	0.261	0.220	-0.009	-0.054	0.012	-0.080
t-stat	1.09	1.11	0.06	0.45	0.08	0.74
CPI Inflation Exp.	0.000	0.000	-0.001	-0.001	0.000	0.000
t-stat	0.11	0.30	0.57	0.84	0.42	0.08
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,706	2,706	2,706	2,705	2,704	2,689
R2	0.058	0.042	0.029	0.028	0.017	0016

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

Table A.2. Post-2000 Sample

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$ (1)	$t+2$ (2)	$t+3$ (3)	$t+4$ (4)	$t+5$ (5)	$t+6$ (6)
PPI Inflation	−0.005	0.015	0.047	0.043*	0.006	−0.036
t-stat	0.12	0.41	1.55	1.71	0.18	0.96
Real House Price Growth Exp.	0.700***	0.614***	0.462***	0.176	0.167	0.017
t-stat	4.73	4.12	3.75	1.42	1.19	0.10
Interest Rate Change	−0.488	−1.133*	−0.975**	−1.205**	−1.105***	−1.329*
t-stat	1.20	1.74	2.08	2.47	2.67	1.78
Net Migration Rate Change	0.011	0.011	0.014	0.012	0.003	0.002
t-stat	1.34	1.25	1.13	1.02	0.22	0.11
Persons per House	−0.040	−0.011	−0.021	−0.044	−0.044*	−0.042
t-stat	1.55	0.34	0.65	1.62	1.77	1.56
Share of Young	0.401***	0.274	0.358*	0.460**	0.392**	0.358*
t-stat	2.62	1.47	1.81	2.50	2.29	1.83
Housing Stock/GDP	−0.016***	−0.016***	−0.021***	−0.023***	−0.027***	−0.028***
t-stat	3.15	2.74	3.51	3.84	4.50	4.74
GDP per Capita Change	0.272	0.421	−0.222	−0.066	−0.032	−0.030
t-stat	1.04	0.98	0.68	0.42	0.16	0.10
CPI Inflation Exp.	−0.003**	−0.001	−0.002	−0.003	−0.001	0.000
t-stat	2.57	0.58	0.81	1.30	0.35	0.14
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,020	1,020	1,020	1,019	1,018	1,003
R2	0.250	0.253	0.249	0.252	0.255	0.259

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

Table A.3. Downswings

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$ (1)	$t+2$ (2)	$t+3$ (3)	$t+4$ (4)	$t+5$ (5)	$t+6$ (6)
PPI Inflation	−0.045	−0.036	−0.023	0.003	0.017	0.009
t-stat	1.03	1.07	0.90	0.12	0.61	0.42
Real House Price Growth Exp.	0.433***	0.212**	0.103	0.077	−0.025	0.021
t-stat	4.38	2.26	1.22	0.74	0.32	0.27
Downswing	−0.017***	−0.010**	−0.002	0.004	0.003	0.002
t-stat	4.13	2.43	0.53	0.86	0.76	0.48
Interest Rate Change	−0.259	−0.113	−0.253*	−0.432***	−0.202**	0.002
t-stat	1.17	0.78	1.80	3.57	2.33	0.01
Interest Rate Change*Downswing	0.303	−0.064	0.102	0.363**	0.200*	0.034
t-stat	1.31	0.39	0.56	2.54	1.90	0.21
Net Migration Rate Change	0.018***	0.023***	0.027***	0.030***	0.027***	0.031**
t-stat	2.58	3.28	3.01	3.34	3.35	2.55
Persons per House	0.010***	0.016***	0.018***	0.027***	0.015***	0.010***
t-stat	4.90	3.22	6.00	6.69	5.12	3.32
Share of Young	0.111***	0.104*	0.112*	0.070	0.121*	0.135*
t-stat	2.64	1.77	1.72	0.73	1.71	2.02
Housing Stock/GDP	−0.005***	−0.006**	−0.008**	−0.007**	−0.008***	−0.008***
t-stat	2.67	2.16	2.53	2.41	2.66	2.60
GDP per Capita Change	0.155	0.298	0.161	0.108	0.271	0.097
t-stat	0.61	1.43	0.93	0.99	1.45	0.81
CPI Inflation Exp.	0.000	−0.001	−0.001	−0.001	−0.001	0.000
t-stat	0.36	0.60	0.71	0.97	0.60	0.22
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,706	2,706	2,706	2,705	2,704	2,689
R2	0.159	0.144	0.134	0.142	0.136	0.134

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

Table A.4. Quantile Regression

Dependent Variable: Residential Investment Growth (Real, Log Differences)			
	Cumulative Growth between Quarter t and $t+6$		
	5th Quantile	50th Quantile	95th Quantile
PPI Inflation	−0.236	−0.338***	−0.383**
t-stat	1.16	4.02	2.52
Real House Price Growth Exp.	1.844***	0.947***	0.479
t-stat	4.59	4.88	1.36
Interest Rate Change	−0.592	−0.895***	−1.291***
t-stat	1.50	2.79	3.45
Net Migration Rate Change	0.156***	0.152***	0.189***
t-stat	3.81	8.47	6.53
Persons per House	−0.051***	0.037*	0.142***
t-stat	3.21	1.88	4.30
Share of Young	0.322	−0.201	0.144
t-stat	1.28	1.34	0.56
Housing Stock/GDP	−0.093***	−0.029***	−0.001
t-stat	5.48	3.65	0.09
GDP per Capita Change	−0.317	0.394	−0.661
t-stat	0.56	1.38	1.18
CPI Inflation Exp.	−0.007**	−0.003***	0.000
t-stat	2.28	3.05	0.02
Country Fixed Effects	Yes	Yes	Yes
Observations	2,689	2,689	2,689
Pseudo R2	0.200	0.077	0.252

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on bootstrapping, with 100 replications. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

Table A.5. Including Credit Spreads

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$
	(1)	(2)	(3)	(4)	(5)	(6)
PPI Inflation	0.013	0.024	0.043	0.036	−0.001	−0.039
t-stat	0.37	0.65	1.25	1.35	0.03	1.14
Real House Price Growth Exp.	0.823***	0.572***	0.536***	0.249*	0.301***	0.206*
t-stat	5.45	3.94	3.23	1.83	3.58	1.87
Interest Rate Change	−0.937**	−0.631	−0.736**	−0.742	−0.793*	−1.446*
t-stat	2.39	1.06	2.20	1.56	1.91	1.67
Corporate Spread Change	−1.062***	0.706	0.623	−0.126	0.415	−0.900***
t-stat	2.66	1.18	0.89	0.31	1.04	2.25
Net Migration Rate Change	−0.056	−0.069	−0.082	−0.114	−0.092	−0.091
t-stat	0.16	0.41	0.05	0.16	0.42	1.03
Persons per House	0.360**	0.479**	0.538***	0.713***	0.544***	0.555***
t-stat	2.24	2.30	2.56	4.06	2.97	2.95
Share of Young	−0.016**	−0.019**	−0.023***	−0.027***	−0.029***	−0.031***
t-stat	2.46	2.52	2.60	3.90	3.30	3.19
Housing Stock/GDP	0.384**	0.155***	0.068***	0.002***	−0.034***	0.201***
t-stat	2.22	2.74	3.32	3.79	4.18	5.15
GDP per Capita Change	−0.002	−0.003	−0.003	−0.004	−0.001	−0.001
t-stat	1.33	0.65	0.26	0.01	0.15	1.00
CPI Inflation Exp.	−0.011	0.007*	0.006*	−0.001**	0.004	−0.009
t-stat	0.92	1.73	1.70	2.20	0.58	0.31
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	882	882	882	881	880	866
R2	0.306	0.285	0.285	0.279	0.271	0.288

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NO, ES, SE, CH, GB, and US.

Table A.6. Sample without GFC

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$	$t+2$	$t+3$	$t+4$	$t+5$	$t+6$
	(1)	(2)	(3)	(4)	(5)	(6)
PPI Inflation	−0.059	−0.049	−0.034	−0.008	0.015	0.020
t-stat	1.13	1.39	1.22	0.26	0.51	1.01
Real House Price Growth Exp.	0.496***	0.244**	0.088	0.020	−0.042	0.020
t-stat	4.56	2.49	1.03	0.20	0.47	0.26
Interest Rate Change	−0.029	−0.146	−0.179**	−0.188**	−0.067	0.033
t-stat	0.28	1.44	2.08	2.41	1.20	0.44
Net Migration Rate Change	0.022***	0.025***	0.029***	0.031***	0.029***	0.032***
t-stat	2.76	3.55	3.19	3.49	4.09	2.66
Persons per House	0.009***	0.017***	0.018***	0.027***	0.014***	0.007*
t-stat	4.58	4.22	6.01	6.75	4.71	1.82
Share of Young	0.124***	0.110*	0.110	0.059	0.110	0.127*
t-stat	2.64	1.69	1.53	0.57	1.50	1.87
Housing Stock/GDP	−0.007**	−0.007**	−0.007**	−0.007	−0.006**	−0.006**
t-stat	2.25	2.43	2.48	1.64	2.02	2.07
GDP per Capita Change	0.177	0.304	0.168	0.107	0.282	0.083
t-stat	0.64	1.46	1.04	0.92	1.38	0.73
CPI Inflation Exp.	−0.000	−0.001	−0.001	−0.001	−0.001	0.000
t-stat	0.34	0.50	0.64	0.91	0.59	0.31
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,526	2,526	2,526	2,525	2,524	2,509
R2	0.130	0.124	0.119	0.125	0.120	0.120

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, FR, DE, IT, JP, KR, NL, NZ, NO, ES, SE, CH, GB, and US.

Table A.7. Without Countries Where Social Dwelling Is Above 10 Percent of Housing Stock

Dependent Variable: Residential Investment Growth (Real, Log Differences)						
	Growth in Quarter $t+h$					
	$t+1$ (1)	$t+2$ (2)	$t+3$ (3)	$t+4$ (4)	$t+5$ (5)	$t+6$ (6)
PPI Inflation	−0.062	−0.055	−0.030	−0.008	0.019	0.018
t-stat	1.13	1.31	0.95	0.26	0.70	1.01
Real House Price Growth Exp.	0.615***	0.284***	0.203**	0.151*	−0.033	−0.013
t-stat	5.64	2.84	2.07	1.68	0.27	0.13
Interest Rate Change	0.020	−0.213**	−0.164*	−0.169**	−0.108*	0.009
t-stat	0.25	2.20	1.90	2.06	1.86	0.13
Net Migration Rate Change	0.023***	0.028***	0.030***	0.033***	0.031***	0.033***
t-stat	3.22	4.05	3.33	3.62	5.20	2.96
Persons per House	0.008***	0.019***	0.019***	0.028***	0.017***	0.012***
t-stat	4.10	4.70	6.30	7.05	5.71	4.14
Share of Young	0.145***	0.136**	0.147**	0.104	0.154**	0.165**
t-stat	3.72	2.22	2.29	1.06	1.97	2.14
Housing Stock/GDP	−0.005*	−0.006	−0.008*	−0.008*	−0.008*	−0.008*
t-stat	1.82	1.64	1.88	1.89	1.90	1.93
GDP per Capita Change	0.395***	0.152	0.182	0.057	0.262	0.080
t-stat	3.47	0.69	1.03	0.59	1.26	0.67
CPI Inflation Exp.	−0.000	−0.001	−0.001	−0.001	−0.001	−0.001
t-stat	0.27	0.68	0.77	1.04	0.80	0.66
Country Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2,160	2,160	2,160	2,159	2,158	2,146
R2	0.169	0.152	0.147	0.153	0.148	0.145

Notes: Time span is from 1970:Q1 to 2017:Q2. All right-hand-side variables are at period t. Reported t-statistics below coefficients are based on robust standard errors clustered by country. ***, **, and * denote statistical significance at 1 percent, 5 percent, and 10 percent, respectively. Countries covered are AU, CA, DE, IT, JP, KR, NZ, NO, ES, SE, CH, and US.

References

Agnello, L., and L. Schuknecht. 2011. "Booms and Busts in Housing Markets: Determinants and Implications." *Journal of Housing Economics* 20 (3): 171–90.

Angrist, J., O. Jordà, and G. Kuersteiner. 2013. "Semiparametric Estimates of Monetary Policy Effects: String Theory Revisited." NBER Working Paper No. 19355.

Aspachs-Bracons, O., and P. Rabanal. 2011. "The Effects of Housing Prices and Monetary Policy in a Currency Union." *International Journal of Central Banking* 7 (1, March): 225–74.

Baker, S., N. Bloom, and S. Davis. 2016. "Measuring Economic Policy Uncertainty." *Quarterly Journal of Economics* 131 (4): 1593–1636.

Borio, C. 2014. "The Financial Cycle and Macroeconomics: What Have We Learnt?" *Journal of Banking and Finance* 45 (August): 182–98.

Calza, A., T. Monacelli, and L. Stracca. 2013. "Housing Finance and Monetary Policy." *Journal of the European Economic Association* 11 (Supplement 1): 101–22.

Campbell, J., and J. Cocco. 2007. "How Do House Prices Affect Consumption? Evidence from Micro Data." *Journal of Monetary Economics* 54 (3): 591–621.

Claessens, S., M. A. Kose, and M. E. Terrones. 2012. "How Do Business and Financial Cycles Interact?" *Journal of International Economics* 87 (1): 178–90.

Corder, M. 2008. "Understanding Dwellings Investment." *Quarterly Bulletin* (Bank of England) (Q4): 393–403.

Davis, M., and J. Heathcote. 2005. "Housing and the Business Cycle." *International Economic Review* 46 (3): 751–84.

Dokko, J., B. Doyle, M. Kiley, J. Kim, S. Sherlund, J. Sim, and S. van den Heuvel. 2011. "Monetary Policy and the Global Housing Bubble." *Economic Policy* 26 (66): 237–87.

Emanuelsson, R. 2015. "Supply of Housing in Sweden." *Economic Review* (Sveriges Riksbank) 2: 47–75.

Erceg, C., and A. Levin. 2006. "Optimal Monetary Policy with Durable Consumption Goods." *Journal of Monetary Economics* 53 (7): 1341–59.

Estrella, A., and G. A. Hardouvelis. 1991. "The Term Structure as a Predictor of Real Economic Activity." *Journal of Finance* 46 (2): 555–76.

Garcia-Herrero, A., and S. Fernandez de Lis. 2008. "The Housing Boom and Bust in Spain: Impact of the Securitisation Model and Dynamic Provisioning." BBVA Working Paper No. 806.

Glaeser, E., and J. Gyourko. 2007. "Housing Dynamics." Discussion Paper No. 2137, Harvard Institute of Economic Research.

Glaeser, E., J. Gyourko, and A. Saiz. 2008. "Housing Supply and Housing Bubbles." *Journal of Urban Economics* 64 (2): 198–217.

Herstad, E. I. 2016. "Is Housing the Business Cycle?" Mimeo, University of Oslo.

Huang, Y., Q. Li, K. Liow, and X. Zhou. 2018. "Is Housing the Business Cycle? A Multi-resolution Analysis for OECD Countries." Mimeo, National University of Singapore.

Iacoviello, M. 2005. "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle." *American Economic Review* 95 (3): 739–64.

Iacoviello, M., and S. Neri. 2010. "Housing Market Spillovers: Evidence from an Estimated DSGE Model." *American Economic Journal: Macroeconomics* 2 (2): 125–64.

International Monetary Fund. 2008. "The Changing Housing Cycle and the Implications for Monetary Policy." *World Economic Outlook: Housing and the Business Cycle* (April). Washington, DC: International Monetary Fund.

Jarocinski, M., and F. Smets. 2008. "House Prices and the Stance of Monetary Policy." *Review* (Federal Reserve Bank of St. Louis) (July/August): 339–66.

Jordà, O. 2005. "Estimation and Inference of Impulse Responses by Local Orojections." *American Economic Review* 95 (1): 161–82.

Jordà, O., M. Schularick, and A. Taylor. 2016. "The Great Mortgaging: Housing Finance, Crises and Business Cycles." *Economic Policy* 31 (85): 107–251.

Kydland, F., and E. Prescott. 1982. "Time to Build and Aggregate Fluctuations." *Econometrica* 50 (6): 1345–70.

Leamer, E. 2007. "Housing *is* the Business Cycle." In *Housing, Housing Finance, and Monetary Policy,* 149–233. Federal Reserve Bank of Kansas City.

———. 2015. "Housing Really is the Business Cycle: What Survives the Lessons of 2008–09?" *Journal of Money, Credit and Banking* 47 (S1): 43–50.

McCarthy, J., and R. W. Peach. 2002. "Monetary Policy Transmission to Residential Investment." *Economic Policy Review* (Federal Reserve Bank of New York) 8 (1): 139–58.

Mian, A., A. Sufi, and E. Verner. 2017. "Household Debt and Business Cycles Worldwide." *Quarterly Journal of Economics* 132 (4): 1755–1817.

Mishkin, F. 2007. "Housing and the Monetary Transmission Mechanism." NBER Working Paper No. 13518.

Monnet, E., and C. Wolf. 2017. "Demographic Cycles, Migration and Housing Investment." *Journal of Housing Economics* 38 (December): 38–49.

Piketty, T., and G. Zucman. 2014. "Capital is Back: Wealth–Income Ratios in Rich Countries 1700–2010." *Quarterly Journal of Economics* 129 (3): 1255–1310.

Poterba, J. 1984. "Tax Subsidies to Owner-Occupied Housing: An Asset-Market Approach." *Quarterly Journal of Economics* 99 (4): 729–52.

Rognlie, M., A. Shleifer, and A. Simsek. 2018. "Investment Hangover and the Great Recession." *American Economic Journal: Macroeconomics* 10 (2): 113–53.

Rudebusch, G., and J. Williams. 2009. "Forecasting Recessions: The Puzzle of the Enduring Power of the Yield Curve." *Journal of Business and Economic Statistics* 27 (4): 492–503.

Scatigna, M., R. Szemere, and K. Tsatsaronis. 2014. "Residential Property Price Statistics across the Globe." *BIS Quarterly Review* (September): 61–76.

Sutton, G., D. Mihaljek, and A. Subelyte. 2017. "Interest Rates and House Prices in the United States and around the World." BIS Working Paper No. 665 (October).

Taylor, J. B. 2007. "Housing and Monetary Policy." NBER Working Paper No. 13682.

Tenreyro, S., and G. Thwaites. 2016. "Pushing on a String: US Monetary Policy is Less Powerful in Recessions." *American Economic Journal: Macroeconomics* 8 (4): 43–74.

Topel, R., and S. Rosen. 1988. "Housing Investment in the United States." *Journal of Political Economy* 96 (4): 718–40.

Tsoukis, C., and P. Westaway. 1994. "A Forward Looking Model of Housing Construction in the UK." *Economic Modelling* 11 (2): 266–79.

Vavra, J. 2014. "Inflation Dynamics and Time-varying Volatility: New Evidence and an Ss Interpretation." *Quarterly Journal of Economics* 129 (1): 215–58.