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Abstract

Why does residential investment lead output in the US and Canada but it is coincident in other industrialized countries? In this paper we explore the role of home-equity loans used to boost consumption as a channel that affects residential investment. Towards this end, we consider a multi-agent real business cycle model augmented with household borrowing constraints that reflect home-equity loans or refinancing constraints. The main contribution of our paper is to highlight that the severity of these borrowing constraints in the economy can generate *both* stylized facts of residential investment dynamics. In US and Canada, a greater proportion of households rely on home-equity loans relative to other industrialized countries. This difference matters for the distinct residential investment dynamics observed across countries.

Key words: Home-Equity Loans, Borrowing Constraints, Residential Investment, Business Cycles
JEL classification: E22, E32, R21, R31

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Of the components of GDP, residential investment offers by far the best early warning sign of an oncoming recession - Leamer (2008)

1 Introduction

Residential investment in the housing sector has long been viewed as important for understanding fluctuations in economic activity (Burns and Mitchell (1946)). More recently, Leamer (2008, 2015) has noted that the decline of cumulative residential investment in recessions accounts for about half of the overall decline in US GDP. In this context, two key stylized facts have been documented in the literature: First, residential investment leads the business cycle in US and Canada. Second, residential investment is coincident with the cycle in many other industrialized countries.[1] Kydland et al. (2014) present a model with long-term mortgage loans and multi-period time-to-build in residential construction to account for these stylized facts. Kydland et al. (2014) model the loan structure as 'first mortgage' loans and, therefore, does not capture an important source of financing household consumption, namely, home-equity or refinancing loans. Recently, Gorea and Midrigan (2015) note that mortgage refinancing accounts for about one-third of the rise and fall in household spending during the 2001-2011 period.

In this paper we explicitly explore the role of home-equity loans to refinance consumption. Towards this end, we consider a multi-agent real business cycle (RBC) model augmented with household borrowing constraints that reflect home equity loans or refinancing constraints. The main contribution of our paper is to highlight that the severity of these constraints in the economy can generate both stylized facts of residential investment dynamics as described above.

We show that residential investment leads output by one quarter when the fraction of households who face borrowing constraints is matched to US data. In European countries, the share of households facing borrowing constraints is, on average, relatively smaller than the US, which according to the model implies that residential investment is coincident with the cycle. There are two incentives for purchasing larger quantity of houses. First, housing services directly enter the

[1] Fisher (2007) studies a separate stylized fact of why might residential investment lead non-residential investment over the business cycle in the US. He emphasizes the complementarity of household capital—as proxied by the size of house—to labour and capital in market production in accounting for this fact.

workers' utility function. Since the positive technology shock induces a wealth effect, they decide to spend more on houses. However, this positive wealth effect alone is not sufficient to produce the leading pattern. Second, workers are borrowing-constrained. The accumulation of the housing stock, therefore, allows them to borrow more contemporaneously and in future periods, so that they are also able to consume greater quantities of the non-durable good. The household borrowing constraint and its effect on residential investment is important in understanding the two prominent stylized facts mentioned above.

Our paper is related to Ren and Yuan (2014) who attempt to explain why residential investment leads the cycle in the US, using a partial equilibrium model with collateral constraints, agent heterogeneity, and total factor productivity (TFP) news shocks. However, their model has the odd implication that agents prefer to purchase houses instead of consumption goods after a positive endowment shock. This is necessarily the case in their model because the mortgage interest rate is lower than the credit card rate, both of which are calibrated parameters. In actual economies, even though the mortgage rate is lower than the credit card rate, the use of credit card for consumer goods purchases is common place. Moreover, their model cannot explain the stylized facts for other industrialized countries.[2]

The rest of the paper is organized as follows. Section 2 presents the model. Section 3 describes the calibration of parameters. Section 4 presents the quantitative results and sensitivity analysis. Section 5 concludes.

2 The model

The model economy is populated by three categories of agents: workers, entrepreneurs and savers. The share of each category is respectively ω_W, ω_E, and $1 - \omega_W - \omega_E$. Agents are infinitely-lived and maximize a discounted sum of time-separable utilities. We assume that workers and entrepreneurs borrow from savers, therefore their discount factors, θ_W and θ_E, are lower than the savers' discount factor, β. Workers are employed by firms that produce non-durable goods and

[2] Another aspect that is ignored in the partial equilibrium setting of Ren and Yuan (2014) is that they do not have the labour supply decision in the model. This assumption is not innocuous for TFP news shocks, which are essential to their explanation, can produce wealth effects that mitigate business cycle comovements (Jaimovich and Rebelo (2009)).

houses — a durable good. They derive some utility from the consumption of non-durable goods and housing services. Their loans are collateralized by the expected value of their stock of housing. Entrepreneurs own both types of firms and make non-residential and residential investments. They also face a borrowing constraint, as the value of their debt cannot exceed a fraction of their capital stock. Finally, we assume that savers are risk-neutral agents whose only purpose is to channel funds to the two other categories of agents. In the appendix, we present a fully detailed description of the model's stationary version.

2.1 Workers

The workers' maximization problem is as follows:

$$E_0 \sum_{t=0}^{\infty} \theta_W^t \left(\ln c_{Wt} + \psi \ln h_t + \eta \ln \left(1 - \left(n_{ct}^{1+\epsilon} + n_{ht}^{1+\epsilon} \right)^{1/(1+\epsilon)} \right) \right) \tag{1}$$

subject to

$$c_{Wt} + (1+\tau_h) q_{ht} h_t - q_{ht}(1-\delta_h) h_{t-1} = b_{Ht} - R_{t-1}^e b_{Ht-1} + (1-\tau_n) \sum_{i=c,h} w_{it} n_{it} + \xi_{Wt} \tag{2}$$

$$b_{Ht} \leq m_H E_t q_{ht+1} h_t. \tag{3}$$

Their period utility function is in logarithms and weighs their consumption of the non-durable good, c_{Wt}, their housing stock, h_t, and their leisure. The specification for leisure is not standard, as we assume that the labor force is split up between the production of non-durable goods, n_{ct}, and house production, n_{ht}. We follow Horvath (2000) and Iacoviello and Neri (2010) and allow for an imperfect substitution of labor between sectors that is govern by ϵ. A greater value of ϵ implies a lower reshuffle of workers from one sector to another in response to wage differentials. Moreover, we assume that mortgage debt carries a tax advantage such that interest payments can be deducted from taxable income. Therefore, the effective interest rate R_t^e is $R_t^e = 1 + r_t(1-\tau_m)$ where r_t is the interest rate and τ_m corresponds to the fraction of deductible interest payments. We consider adjustable rate mortgages, as they are renegotiated every period.

On the right-hand-side of their budget constraint, equation (2), impatient households have different sources of revenues: (i) they earn labor income that is taxed at rate τ_n, so that their total after-tax labor income is $(1-\tau_n) \sum_{i=c,h} w_{it} n_{it}$ where wages w_{it} are taken as given, (ii) they borrow b_{Ht} at the effective interest rate R_t^e, so that net borrowing is $b_{Ht} - R_{t-1}^e b_{Ht-1}$, and (iii) they receive transfers from the government: ξ_{Wt}. The left-hand-side consists in expenditures that these households have, (i) for the consumption of non-durable goods, and (ii) the accumulation of housing stock from which a fraction τ_h is taxed.

The second constraint, equation (3), is a collateral constraint. Specifically, the level of debt contracted every period cannot exceed a fraction m_H of the expected value of the households' stock of housing, *i.e.* $E_t q_{ht+1} h_t$. Since impatient households have a lower discount factor, this constraint is binding in the steady state. We consider small shocks and a sufficiently low discount factor so that it is also always binding in the neighborhood of the steady state.

2.2 Entrepreneurs

The entrepreneurs maximize the following problem:

$$E_0 \sum_{t=0}^{\infty} \theta_E^t \ln c_{Et} \tag{4}$$

subject to

$$c_{Et} + x_{ct} + s_t p_{st} = s_{t-1}(d_t + p_{st}) + b_{Kt} - R_{t-1} b_{Kt-1} + (1-\tau_k) r_{ct} k_{ct-1} + p_{lt} l_t + \xi_{Et}, \tag{5}$$

$$x_{ct} = k_{ct} - (1-\delta_c) k_{ct-1}, \tag{6}$$

$$b_{Kt} \leq m_K k_{ct}. \tag{7}$$

where c_{Et} corresponds to the entrepreneurs' consumption of non-durable goods.[3] They also invest in the capital used for the production of these goods, x_{ct}. Note that there is no accumulation of these structures as they are sold entirely every period, contrary to the capital used in the production of non-durable goods, k_{ct}, for which there is an accumulation every period determined by equation (26). Additionally, they decide how much equity shares, s_t to own. The revenues of entrepreneurs are shown in the right-hand-side of equation (25). First, since they own the firms, they receive dividend payments, $d_t s_{t-1}$. Second, firms pay a rental rate r_{ct} to use capital, k_{ct-1}. Their capital revenue income is taxed at rate τ_k. Third, investors are also endowed with l_t acreage in land every period that they sell to firms at price p_{lt}. Fourth, since they have a lower discount factor, they

[3] For simplicity, we assume that they do not work nor do they own houses.

borrow b_{Kt} at the interest rate R_t, so that their net borrowing is $b_{Kt} - R_{t-1}b_{Kt-1}$. Fifth, they receive governmental transfers ξ_{Et}. Similar to workers, entrepreneurs face a borrowing constraint, equation (27), that states that they cannot borrow more than a fixed fraction m_K of their capital stock.

2.3 Savers

Savers are risk-neutral unconstrained agents who lend to workers and investors. Since their discount factor is greater than discount factors of the two other categories of agents, they are savers in the economy. Their maximization problem is as follows:

$$\sum_{t=0}^{\infty} \beta^t c_{St} \tag{8}$$

subject to

$$c_{St} = \frac{1}{1-\omega_W-\omega_E}\left[\omega_W\left(R_{t-1}b_{Ht-1} - b_{Ht}\right) + \omega_E\left(R_{t-1}b_{Kt-1} - b_{Kt}\right)\right]. \tag{9}$$

where c_{St} corresponds to the consumption of savers. Since we assume that categories of agents can have different shares in the total population, the total amount lent to workers and entrepreneurs corresponds to $\frac{\omega_W}{1-\omega_W-\omega_E}b_{Ht}$ and $\frac{\omega_E}{1-\omega_W-\omega_E}b_{Kt}$.

2.4 Firms and production

Firms operate in a perfectly competitive market to produce non-durable goods, y_t, and houses, h_t. They maximize the expected of the future dividend stream paid to entrepreneurs by picking the levels of dividends, capital, labor, and land, as described as follows:

$$E_0 \sum_{t=0}^{\infty} m_t d_t$$

subject to

$$d_t + \sum_{i=c,h} w_{it}n_{it} + r_{ct}k_{ct-1} + k_{bt} + p_{lt}l_t = y_t + q_t ih_t,$$

$$y_t = z_t k_{ct-1}^{\alpha_C}\left(\frac{\omega_W}{\omega_E}n_{ct}\right)^{1-\alpha_C},$$

$$ih_t = z_t k_{bt}^{\alpha_B} l_t^{\alpha_L}\left(\frac{\omega_W}{\omega_E}n_{ht}\right)^{1-\alpha_B-\alpha_L}.$$

where m_t corresponds to the stochastic discount factor that is taken exogenously by firms. New houses are denoted by ih_t and intermediate inputs by k_{bt} that refer to materials used in the construction of houses. From the entrepreneurs' first order condition with respect to equity shares, s_t, $m_t = (\theta_E)^t \frac{c_{E0}}{c_{Et}}$.[4] Every period, the firms pay dividends and factors of production from the sale of non-durable goods and houses. The labor inputs have to be adjusted to account for the difference in population shares between workers and entrepreneurs. We assume that both production functions are Cobb-Douglas and that neutral technology, z_t, enters both of them. This shock follows an AR(1) process:

$$\ln z_t = \rho \ln z_{t-1} + \epsilon_t, \qquad \epsilon_t \sim N(0, \sigma^2) \tag{10}$$

where ρ corresponds to the persistence parameter and σ^2 to the variance of the innovation.

2.5 Government

In this economy, the government does not play any productive role. It levies distortionary taxes on workers and entrepreneurs and makes lump-sum transfers, so that the total value of transfers corresponds exactly to the amount that these two categories of agents pay in taxes:

$$\xi_{Wt} = \tau_n \sum_{i=c,h} w_{it} n_{it} + \tau_h q_{ht} h_t - r_t \tau_m, \tag{11}$$

$$\xi_{Et} = \tau_k [r_{ct} k_{ct-1} + p_{bt} k_{bt}]. \tag{12}$$

2.6 Market clearing conditions

There is a resource constraint in the economy, so that output corresponds to the sum of consumption and investment:

$$y_t = \sum_{i=W,E,S} c_{it} + x_{ct} + k_{bt}. \tag{13}$$

Additionally, the law of motion for houses is as follows:

$$ih_t = h_t - (1 - \delta_H) h_{t-1}. \tag{14}$$

[4]Specifically, from the entrepreneurs' first order condition with respect to equity shares, s_t, $p_{st} = \theta_E c_{Et} E_t \frac{p_{st+1} + d_{t+1}}{c_{Et+1}}$. By forward substitution, $p_{st} = E_t \sum_{j=1}^{\infty} \left(\frac{\theta_E^j c_{Et}}{c_{Et+j}} \right) d_{t+j}$. The firms' stochastic discount factor needs to be consistent with how equity prices discount future dividends.

We assume that land supply is equal to one for all periods.[5]

3 Calibration

Table 1 shows the calibration of the baseline model. A study by the IMF (2011) approximates the share of households with a mortgage to be 45 percent in 2004-05 for the US. In the economy, we choose to have the same share of workers that are borrowing-constrained, *i.e.* $\omega_W = 0.45$. From the Survey of Consumer Finances (SCF), Cagetti and De Nardi (2006) report that the percentage of business owners in the population is 9.1 percent, therefore we set $\omega_E = 0.09$. The value of the savers' quarterly discount factor is set so that the real interest rate is 3 percent in the steady state. Since workers and entrepreneurs are borrowing-constrained, they face a shadow cost of borrowing in addition to interest payments. This cost can be considered as an interest premium. Similar to Bernanke, Gertler and Gilchrist (1999), we choose the impatient households' discount factor to match a two percent interest premium, *i.e.* $\theta_W = \theta_E = 0.973$. For a reasonable size of the TFP shock, this value of the discount factor ensures that the borrowing constraint is always binding.

The weight on housing in the impatient's household utility function is governed by ψ and is set to match the average mortgage debt to GDP ratio in the US from 1984 to 2014, *i.e.* 2.79. The weight assigned to leisure, η, is picked so that households work 30 percent of their allocated time in the steady state. The parameter that governs the degree of sectoral labor mobility, ϵ, is the only one that is determined outside the steady state. It is set to match the relative volatility of residential investment to GDP. From the 2001 SCF data, Gorea and Midrigan (2015) find a mean loan-to-value from all mortgage holders of 0.52, therefore we set $m_H = 0.52$. As for the entrepreneurs' loan-to-value, m_K, we pick a value so that the baseline model in the steady state generates the same ratio of non-financial businesses debt securities and loans liabilities to GDP from 1984 to 2014, *i.e.* 2.47.

Taxation distorts the decisions of workers and entrepreneurs. For labor and capital taxes, τ_n and τ_k, we take the values estimated by Gomme and Rupert (2007) who use Mendoza et al. (1994) methodology to calculate effective average tax rates. We set the property tax rate, $\tau_h = 0.025$,

[5] In similar fashion to Davis and Heatcote (2005), we do not model land dynamics over the business cycle.

TABLE 1: Calibration of the baseline model

Population		
ω_W	0.45	fraction of workers
ω_E	0.09	fraction of entrepreneurs
Discount factors, preferences and loan-to-values		
β	0.9925	discount factor (savers)
θ_W	0.973	discount factor (workers)
θ_E	0.973	discount factor (entrepreneurs)
ψ	0.55	weight on housing (workers)
η	1.92	weight on leisure (workers)
ϵ	0.25	sectoral labor mobility
m_H	0.52	workers' loan-to-value
m_K	0.49	entrepreneurs' loan-to-value
Taxation		
τ_n	0.22	labor income tax
τ_k	0.29	capital tax
τ_h	0.025	property tax
τ_m	0.4	fraction of deductible mtg. interest payments
Depreciation, and technology		
δ_m	0.025	dep. of capital
δ_h	0.004	dep. of housing
α_C	0.36	el. wrt capital (non-durable goods)
α_B	0.53	el. wrt material inputs (housing)
α_L	0.1	el. wrt land (housing)
ρ	0.95	TFP persistence

that is the value reported for the US by Girouard et al. (2006) in their survey of housing taxation across OECD countries. Mortgage interest payments can be deducted from taxable income in the US. We also follow Girouard et al. (2006) work, so that the after-income tax mortgage rate, τ_m, corresponds to 60% of the real interest rate's value.

The depreciation rate of capital is standard, *i.e.* $\delta_m = 0.025$. We follow Gomme and Rupert (2007) in computing the housing depreciation rate from BEA data and set $\delta_h = 0.004$. We set the capital share in the production of houses, $\alpha_C = 0.36$. We follow Davis and Heatcote (2005) and Iacoviello and Neri (2010) and set the share of land in the production of new houses to $\alpha_L = 0.1$. In the production function of houses, we do not distinguish between capital in structures and intermediate goods. Yet material costs compose a large share of total house production costs. Specifically, in the US input-output tables from 1997 to 2014, this share is 15% greater than workers' compensation. We set α_H to match this ratio to which we add a 10% share for structures in similar fashion to the two studies aforementioned. Finally, we choose the persistence parameter of the TFP shock, $\rho = 0.95$.

4 Quantitative results

In this section, we present the results for two different calibrations of the baseline model: one that matches moments of the US data (values presented in Table 2) and another one for which we lower the share of households that have mortgage debt (workers). A first set of results is that the presence of borrowing constraints is critical to replicate the lead in residential investment and many co-movements and relative volatilities for the United States that a standard RBC model fails to deliver. Second, we show that when we lower the share of workers in the economy to the share that prevailed in the euro zone, the lead in residential investment vanishes.

4.1 Benchmark calibration

In Table 2 we report the relative volatilities and co-movements of consumption, residential investment, non-residential investment, hours worked in construction and in other sectors, and housing prices. We have set the degree of sector labor mobility measured by ϵ to match the relative standard deviation of residential investment, so we have imposed the model to match this moment. How-

TABLE 2: Baseline Model Properties

STATISTIC	U.S. DATA	BENCHMARK CALIBRATION	EUROZONE MORTGAGE DEBT ($\omega_W = 0.2$)
Co-movements			
$\rho(c_t, y_t)$	0.89	0.94	0.95
$\rho(k_{bt}, y_t)$	0.6	0.74	0.97
$\rho(x_{ct}, y_t)$	0.85	0.97	0.97
$\rho(n_{ht}, y_t)$	0.8	0.77	0.97
$\rho(n_{ct}, y_t)$	0.8	0.43	0.73
$\rho(ih_t, y_t)$	0.59	0.76	0.97
$\rho(q_{ht}, y_t)$	0.61	0.46	0.93
Relative volatilities			
σ_c/σ_y	0.87	0.52	0.5
σ_{kb}/σ_y	6.74	6.77	6.07
σ_{xc}/σ_y	4.13	3.8	3.81
σ_{kb}/σ_{xc}	1.63	1.78	1.59
σ_{nh}/σ_y	5.25	4.62	4.26
σ_{nc}/σ_y	1.05	0.82	0.29
σ_{ih}/σ_y	10.93	6.21	5.66
σ_{qh}/σ_y	3.54	0.62	0.43

Notes: The U.S. data spans from 1984Q1 to 2015Q1 (except for hours worked series that start in 1985Q1). All series are logged and detrended with the HP-filter (λ=1600). Data sources are in the appendix.

ever, there are no restrictions on the values of all other moments. The model reproduces very well the relative volatilities of non-residential investment and sectoral hours worked. Specifically, the volatility of investment is significantly higher in the housing construction sector both in the data and generated by the model. This success is shared with previous work, *e.g.* Davis and Heatcote (2005), Kydland et al. (2014), and Fisher (2007), however, a standard RBC multi-sector as the one exposed by Greenwood and Hercowitz (1991) fails at replicating this relative volatility. The effects of borrowing constraints are not at work here — it is simply the consequence of a lower depreciation rate of houses than capital used in the production of non-durable goods. In fact, the effects of investing in housing production last longer with a lower depreciation rate.

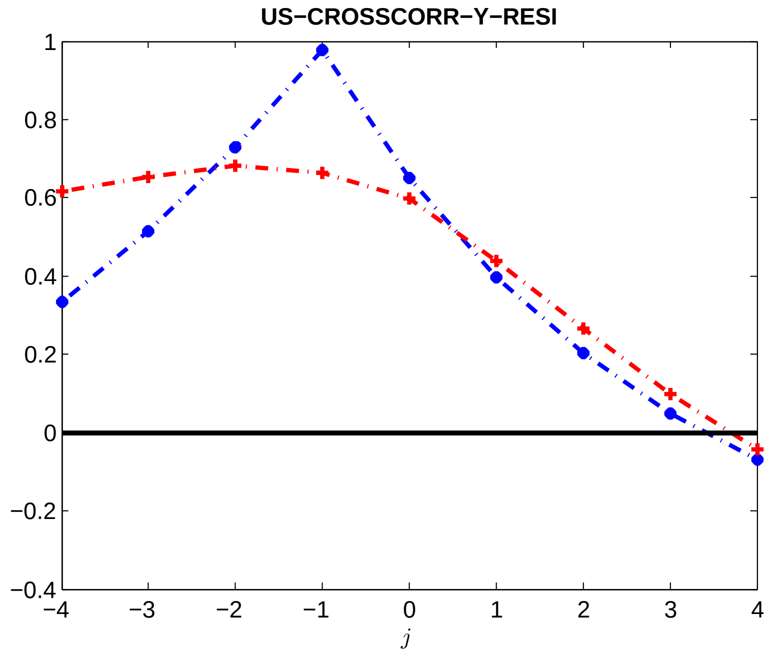
Moreover, the hours worked in the housing production sector are more volatile than hours worked in the production of non-durable goods. This result is simply due to the greater volatility of the production of houses itself, which in return is related to durability of this category of goods. Accounting for the high volatility of housing prices in the data remains a challenge for our model. In the literature, it appears that technology shocks are not sufficient to explain the radical shifts in housing prices. Finally, the model is able to replicate the positive co-movements in all aggregate quantity variables as well as in housing prices.

In Figure 1, we present the cross-correlation functions between output and residential investment computed from the actual data and those generated by the benchmark model. Residential investment leads output by one quarter. The one period lead generated by the model overshoots its data counterpart, but the predictions for the remaining leads and lags are extremely accurate.

The impulse responses displayed in Figure 2 gives evidence of the borrowing constraint mechanism at play. There are two incentives for purchasing larger quantity of houses. First, housing services directly enter the workers' utility function. Since the positive technology shock induces a wealth effect, they decide to spend more on houses. However, this positive wealth effect alone is not sufficient to produce the leading pattern. The key characteristic is that these workers are borrowing-constrained. Therefore, the accumulation of the housing stock allows them to borrow more contemporaneously and in future periods, so that they are also able to consume greater quantities of the non-durable good.

The increase in residential investment after a technology shock is much stronger than the in-

Figure 1: Cross-correlation function between output and residential investment.



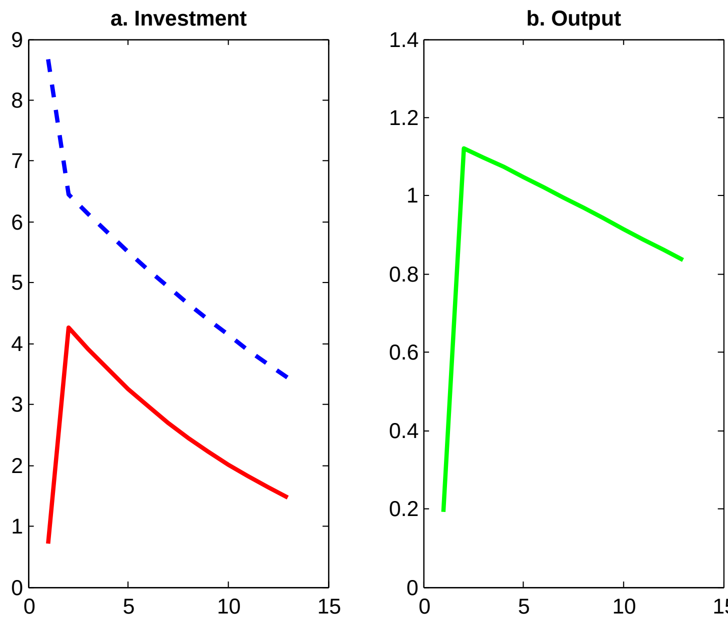
Notes: Specifically, this function corresponds to the correlation between residential investment at time $t + j$ and output at time t. The blue line corresponds to the correlations generated by the benchmark model and the red line to the correlations estimated from US data between 1984Q1 and 2015Q1. All series are logged and detrended with the HP-filter (λ=1600).

crease in non-residential investment, since the demand for houses is greater than for non-durable goods. Because the entrepreneurs' borrowing constraint is also relaxed from the accumulation of capital, however, the initial response of non-residential investment is remains positive. In subsequent periods, its response follows the one of output which explains the strong contemporaneous correlation. As for hours worked, the reallocation from the non-durable sector to the housing sector is stronger as a wage differential arises.

4.2 Eurozone calibration for household borrowing

After having stressed the role played by borrowing constraints for the lead of residential investment for the US, we calibrate the financial frictions parameters to match the data of European countries. As seen in the introduction, there is a high degree of heterogeneity across countries when we examine

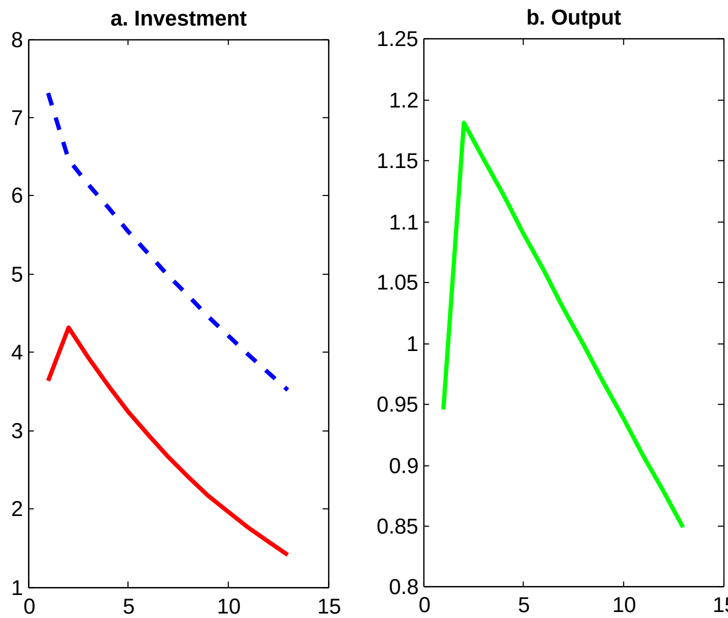
Figure 2: Impulse responses to a one percent technology shock.



Notes: In *panel a*, the dashed blue line corresponds to the response of residential investment and the solid red line to non-residential investment. In *panel b*, the solid green line corresponds to output.

mortgage-debt-to-GDP ratios. According to the IMF (2011), in 2004-05, the share of households that had a mortgage was 20 percent in the eurozone. This smaller share is the only parameter that we re-calibrate relative to the benchmark calibration, *i.e.* $\omega_W = 0.2$.

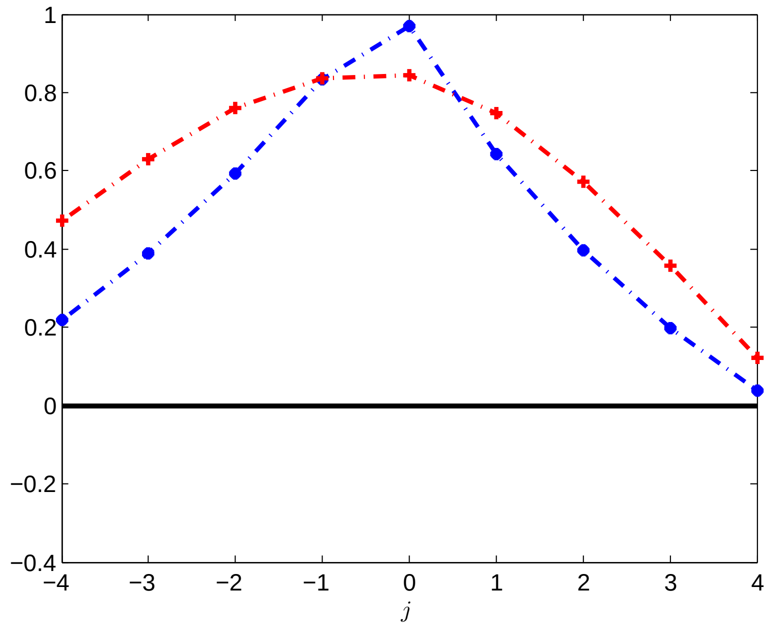
Figure 3: Impulse responses to a one percent technology shock: Eurozone calibration



Notes: In *panel a*, the dashed blue line corresponds to the response of residential investment and the solid red line to non-residential investment. In *panel b*, the solid green line corresponds to output.

We report the results in the fourth column of Table 2. Most relative volatilities are not affected by the change in calibration. The two exceptions are the volatilities of the price of houses and the hours worked for the production of non-durable goods. The incentives to build more houses are lessened, simply because less households are facing borrowing constraints for which their houses are used as collateral. Since the demand for houses is not as strong, the volatility of its relative price is lower. For the same reason, the substitution of sectoral labor is reduced and non-residential investment increases following the technology shock as shown by the initial response of n_{ct} in Figure 3. Since the technology shock has similar effects for the production of non-durable goods and houses, the aggregate quantity variables are strongly correlated. As a consequence, the lead in residential investment vanishes as can be seen in Figure 4. This result is compatible with the cross-correlation pattern estimated for France. In fact, the fit of the model is good.

Figure 4: Cross-correlation between residential investment and output: Eurozone calibration



Notes: Specifically, this function corresponds to the correlation between residential investment at time $t + j$ and output at time t. The blue line corresponds to the correlations generated by the benchmark model and the red line to the correlations estimated from French data between 1984Q1 and 2015Q1. All series are logged and detrended with the HP-filter (λ=1600).

5 Conclusion

Residential investment leads the business cycle in the US and Canada. In other industrialized countries, however, residential investment is coincident with the output. The main contribution of this paper is to show that home-equity loans used for consumption can influence residential investment dynamics in ways that can account for the stylized facts. We show that when a larger proportion of households face borrowing constraints on home-equity loans, as in the US and Canada, residential investment can lead the business cycle. If this proportion is relatively smaller, as in other industrialized countries, residential investment becomes coincident with the output and no longer serves as a leading indicator in the economy.

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A Data

A.1 US

The series for output, consumption, residential investment, and non-residential investment are from NIPA, Table 1.1.3. New houses are from the US Bureau of Census, specifically this series "Housing Starts: Total: New Privately Owned Housing Units Started. The hours worked series are from the BLS, n_{ht} is the number of employees in the residential construction sector, whereas n_{ct} consists in the difference between total employment and n_{ht}. The housing price index is constructed from FRB data, following the decomposition proposed by Davis (2009), which is divided by the CPI index from the BLS.

A.2 France

Data is from the Quarterly National Accounts published by the INSEE.

B The model equations

B.1 Workers

$$E_0 \sum_{t=0}^{\infty} \theta_W^t \left(\ln c_{Wt} + \psi \ln h_t + \eta \ln \left(1 - \left(n_{ct}^{1+\epsilon} + n_{ht}^{1+\epsilon} \right)^{1/(1+\epsilon)} \right) \right) \tag{15}$$

subject to

$$c_{It} + (1+\tau_h) q_{ht} h_t - q_{ht}(1-\delta_h) h_{t-1} = \begin{array}{l} b_{Ht} - R_{t-1}^e b_{Ht-1} + \\ (1-\tau_n) \sum_{i=c,h} w_{it} n_{it} + \xi_{Wt}, \end{array} \tag{16}$$

$$b_{Ht} \leq m_H E_t q_{ht+1} h_t, \tag{17}$$

$$n_t = \left(n_{ct}^{1+\epsilon} + n_{ht}^{1+\epsilon} \right)^{1/(1+\epsilon)}, \tag{18}$$

$$R_t^e = 1 + r_t (1 - \tau_m). \tag{19}$$

First-order conditions

c_Wt:

$$\frac{1}{c_{Wt}} = \lambda_{1t} \tag{20}$$

b_Ht:

$$\lambda_{1t} - \lambda_{2t} = \theta_W R_t^e E_t \lambda_{1t+1} \tag{21}$$

h_t:

$$q_{ht}\lambda_{1t}(1+\tau_h) - m^H\lambda_{2t}E_t q_{ht+1} = \theta_W(1-\delta_h)E_t q_{ht+1} + \frac{\Psi}{h_t} \tag{22}$$

n_it i=c,h:

$$\lambda_{1t}(1-\tau_n)w_{it} = \frac{\eta_I}{1-n_t}\left(\frac{n_{it}}{n_t}\right)^{\epsilon} \tag{23}$$

B.2 Entrepreneurs

$$E_0 \sum_{t=0}^{\infty} \theta_E^t \ln c_{Et} \tag{24}$$

subject to

$$c_{Et} + x_{ct} + s_t p_{st} = \begin{array}{l} s_{t-1}(d_t + p_{st}) + b_{Kt} - R_{t-1}b_{Kt-1} + \\ (1-\tau_k)r_{ct}k_{ct-1} + p_{lt}l_t + \xi_{Et}, \end{array} \tag{25}$$

$$x_{ct} = k_{ct} - (1-\delta_c)k_{ct-1}, \tag{26}$$

$$b_{Kt} \leq m_K k_{ct}. \tag{27}$$

First-order conditions

c_Et:

$$\frac{1}{c_{Et}} = \mu_{1t} \tag{28}$$

b_Kt:

$$\mu_{1t} - \mu_{2t} = R_t\theta_E E_t\mu_{1t+1} \tag{29}$$

k_ct:

$$\mu_{1t} - \mu_{2t}m_K = \theta_E E_t\left(\mu_{1t+1}(1-\delta_c + (1-\tau_k)r_{ct+1})\right) \tag{30}$$

s_t:

$$\mu_{1t}p_{st} = \theta_E E_t\mu_{1t}\left(d_{t+1} + p_{st+1}\right) \tag{31}$$

B.3 Savers

$$\sum_{t=0}^{\infty} \beta^t \ln c_{St} \tag{32}$$

subject to

$$c_{St} = \frac{1}{1 - \omega_W - \omega_E} \left[\omega_W \left(R_{t-1} b_{Ht-1} - b_{Ht} \right) + \omega_E \left(R_{t-1} b_{Kt-1} - b_{Kt} \right) \right]. \tag{33}$$

First-order conditions

c_St:

$$\frac{1}{c_{St}} = \chi_{1t} \tag{34}$$

b_Ht and **b_Kt**:

$$\chi_{1t} = \beta R_t E_t \chi_{1t+1} \tag{35}$$

B.4 Firms and production

$$E_0 \sum_{t=0}^{\infty} m_t d_t$$

subject to

$$\begin{aligned}
& d_t + \sum_{i=c,h} w_{it} n_{it} + r_{ct} k_{ct-1} + p_{bt} k_{bt} + p_{lt} l_t = y_t + q_t i h_t, \\
& y_t = z_t k_{ct-1}^{\alpha_C} \left(\frac{\omega_W}{\omega_E} n_{ct} \right)^{1-\alpha_C}, \\
& i h_t = z_t k_{bt}^{\alpha_B} l_t^{\alpha_L} \left(\frac{\omega_W}{\omega_E} n_{ht} \right)^{1-\alpha_B-\alpha_L}.
\end{aligned}$$

First-order conditions

d_t:

$$E_t m_t = \vartheta_{1t} \tag{36}$$

n_ct:

$$w_{ct} = (1 - \alpha_C) \frac{y_t}{n_{ct}} \tag{37}$$

n_ht:

$$w_{ht} = (1 - \alpha_B - \alpha_L)\frac{q_t i h_t}{n_{ht}} \tag{38}$$

k_ct-1:

$$r_{ct} = \alpha_C \frac{y_t}{k_{ct-1}} \tag{39}$$

k_bt:

$$p_{bt} = \alpha_B \frac{q_t i h_t}{k_{bt}} \tag{40}$$

l_t:

$$p_{bt} = \alpha_L \frac{q_t i h_t}{l_t} \tag{41}$$