Commercial Real Estate, Housing and the Business Cycle

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Abstract

We investigate the business cycle, property-price and investment dynamics when there is competition between households and firms for real estate. We introduce a construction sector into a RBC framework, which uses land, capital and labour to produce both commercial and residential real estate. This market structure activates a 'real estate substitution channel', where economic disturbances which alter the demand for one type of real estate, by affecting the overall costs of real estate production, endogenously create a substitution with its counterpart. For example, an increase in demand for residential real estate, also increases the cost of producing commercial structures which reduces the amount demanded by firms. In turn, this crowds out commercial real estate which affects the goods market in a similar way to an adverse aggregate supply shock. The estimated model reveals that housing preference shocks explain the largest part of the variation in property prices and residential investment, while commercial real estate prices are primarily driven by technology shocks.

Key Words: Commercial Real Estate; Land Price; Borrowing Constraints
JEL References: E32; E44; R21; R31

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1 Introduction

Real estate is a significant component of the economy's capital stock and households' wealth, which serves as both a crucial input for producers and provider of housing / residence for households. Investment in real estate can be categorised according to its use as either commercial or residential,[1] with commercial real estate (henceforth CRE) typically accounting for around half of business assets (Nelson et al., 2000) and residential real estate (henceforth RRE) constituting one-third of household net worth. Moreover, as the simultaneous supplier of this input for firms and final good for households, the construction sector lies in a unique and influential position (Case, 2000).

In this paper we argue that the inclusion of a construction sector as a producer of both commercial and residential real estate is pivotal when evaluating the driving forces behind property prices and economic activity. Firstly, CRE creation is an important indicator of macroeconomic activity since it constitutes a significant factor of production at the firm level. Secondly, the construction sector, as a creator of RRE, responds directly to the demand for residential housing over the business cycle. As a consequence, the competition for inputs that arises in the construction sector, such as land, labour and capital creates direct spillovers between the two types of real estate.

A closer look into the construction sector and the disaggregated construction spending for the US (Figure 1) reveals that despite both commercial and residential spending growing in a similar way until 2001, they behave quite differently following the two recession periods. After the *2001 dot.com* crisis there was a fall in commercial spending while residential spending continued its upward trend until the onset of the *2007 financial crisis*, when it dived sooner and greater than commercial spending. Thus, depending on the source of macroeconomic fluctuation these two types of real estate can potentially display quite different cyclical behaviours.

[Insert Figure 1]

The level of construction activity is one of the key mechanisms through which changes in real estate prices are transmitted to the wider economy. Since construction spending tracks the overall investment in real estate, i.e. the creation of new structures, investment seems to follows a very similar path. Figure 2 plots the property and land prices, alongside real estate investment. As was the case with construction spending, different type of real estate investment have quite different cyclic behaviours (Wheaton, 1999), this can be particularly evident prior to

[1] Commercial investment consists of new construction and improvements to existing structures in commercial and health care buildings, manufacturing buildings, power and communications structures, and other structures. Residential investment includes new construction of single-family homes and multifamily homes and spending on other residential structures (Lally, 2009) - BEA Briefing

the financial crisis. Analogous periods can also be considered, for example, the *2nd energy crisis of 1982*, where the demand for commercial real estate boomed and reached a speculative point in many markets followed by a immediate fall in commercial real estate prices and investment, and the aftermath of the early 1990s recession.

In line with evidence of Rosen (1979); Roback (1982) and Gyourko (2009), property and land prices appear to co-move contemporaneously and have similar time-series patterns. In particular, during the 2007-2008 financial crisis all three series displayed a sharp fall followed by a more gradual recovery. Finally, land prices have followed a steady upward trend during the whole sample, which appear to drive both commercial and residential real estate prices (Davis and Heathcote, 2007; Glaeser and Ward, 2009; Gyourko et al., 2013).

[Insert Figure 2]

We further investigate the dynamics out of residential and commercial real estate empirically. Figure 3 displays the estimated impulse response of RRE price, RRE investment, CRE investment and CRE prices following a shock to the RRE price series[2]. The impulse responses are estimated in a four-variable Bayesian vector autoregressive (BVAR) model with the Flat Prior (Doan et al., 1984; Litterman, 1986). We generate IRFs for a RRE price shock using recursive identification. We order RRE prices first, in order to approximate the effects of a housing demand shock in a DSGE framework that represents an exogenous shift to housing preferences.

A positive shock to the RRE price leads to a positive response of the RRE investment. On the other hand, CRE investment has the opposite response, which indicates a substitution between the two real estate sectors i.e. residential and commercial. Since property prices comove, the CRE price will increase following a positive shock to RRE prices.

[Insert Figure 3]

The aim of this paper is to shed light on the mechanism behind the relationship between the price of residential and commercial real estate, and the substitution between residential and commercial investment outlined in Figure 3. To do so we introduce a construction sector into a DSGE model, which undertakes the production of both commercial and residential real estate. Specifically, we introduce sectoral heterogeneity as in (Iacoviello and Neri, 2010) by differentiating between two groups of entrepreneurs - consumption good and construction sector. To achieve this multi-sector entrepreneur structure, we disaggregate the capital stock (Davis and Heathcote, 2005) into three components: consumption good, residential and commercial real estate. Whilst there is a growing literature whereby residential housing production allows

[2] In Appendix 1 there is a comprehensive explanation of the data, and the data-manipulations used in this paper.

households to consume both housing and nonhousing goods (Greenwood and Hercowitz, 1991; Benhabib et al., 1991; Chang, 2000; Davis and Heathcote, 2005; Fisher, 2007), we also allow the construction sector to facilitate the production of new commercial structures. In this way we can analyse the interplay between commercial and residential real estate, when there is both competition for land in the construction sector and competition for real estate between households and consumption good entrepreneurs.

According to Davis and Heathcote (2007) fluctuations in real estate values are primarily driven by changes in land prices, and land provides important collateral value for business investment spending. As a result, we assume entrepreneurs in both groups face credit constraints in the spirit of Kiyotaki and Moore (1997), where firms finance investment spending by using the value of the their inputs (beside labour) as collateral. By doing so, there are positive co-movements between land prices and business investment, as in (Liu et al., 2013). However, the additional requirement of commercial and residential investment for construction mean that the dynamics of real estate prices can differ between the commercial and residential production.

Our model is able to capture the substitution between commercial and residential investment, which is evident in the BVAR model in Figure 3. We refer to this mechanism as the "real estate substitution channel". The channel we address encapsulates the land reallocation channel as was initially established by Liu et al. (2013), however we claim that land does not equate real estate investment. Land has a unique quality, it's fixed on aggregate, however real estate investment clearly follows its own law of motion. By introducing a construction sector where investment decisions depends upon, not only land, but all of the inputs of real estate production we are able to connect the dynamics of the two series. Our results indicate that in general the residential / commercial land allocation acts as an anchor for the allocation of its real estate investment counterpart. However this is by no means always the case and, in particular following recession periods, there is a notable divergence between the movements of land and real estate investment which has non trivial implications for both real estate dynamics and real economic activity.

The paper proceeds as follows. The next chapter describes the theoretical model. Section 3 reports the calibration and estimation details. Section 4 explains the properties of the model. Section 5 describes the importance of land. Finally, Section 6 concludes.

2 Model

We consider an economy that consists of two types of agents: a representative household and an entrepreneur. The entrepreneur chooses to produce either consumption goods or build new property structures, for residential or commercial purposes. The representative household's utility depends on consumption goods, housing and leisure. Entrepreneur's utility depend only on consumption goods. Consumption goods production requires labour, capital and commercial

real estate as inputs. New structures require labour, capital and land as input. The entrepreneur in both sectors needs external financing for investment spending. Imperfect contract enforcement implies that the entrepreneur's borrowing capacity is constrained by the value of collateral assets. Collateral differ depending on the type of the production. Borrowing in the consumption good sector is constrained by the value of non-construction capital and the value of commercial real estate, while the construction side is constrained by the value of capital and land.

2.1 Households

There is a continuum of households indexed by $d \in [0,1]$. The representative household seeks to maximize its discounted, time separable lifetime utility. The utility function is given by

$$E_t \sum_{t=0}^{\infty} \beta_d^t z_t \Big\{ \ln\left(C_{d,t} - \gamma_d C_{d,t-1}\right) + \chi_t \ln\left(H_{d,t}\right) - \frac{\psi_t}{1+\eta}\big(N_{c,t}^{1+\xi} + (N_{hc,t} + N_{hd,t})^{1+\xi}\big)^{\frac{1+\eta}{1+\xi}} \Big\}, \quad (1)$$

where $C_{d,t}$ denotes consumption, $H_{d,t}$ denotes residential housing stock, $N_{c,t}$, $N_{hc,t}$ and $N_{hd,t}$ denote labour hours in consumption good, commercial and residential real estate production, respectively. The parameter $\beta_d \in (0,1)$ is a discount factor, the parameter γ_d measures habits in consumption and parameters ξ and η measure, the labour mobility among the different types of production and the inverse of the Frisch elasticity, respectively. The terms z_t and ψ_t capture shocks in intertemporal preference and labour supply respectively. Housing preference shock χ_t shifts preferences away from consumption and leisure towards housing. The shocks follow

$$\ln z_t = \rho_z \ln z_{t-1} + \sigma_z \epsilon_{z,t}, \qquad \ln \psi_t = \rho_\psi \ln \psi_{t-1} + \sigma_\psi \epsilon_{\psi,t},$$
$$\ln \chi_t = (1-\rho_\chi) \ln \bar{\chi} + \rho_\chi \ln \chi_{t-1} + \sigma_\chi \epsilon_{\chi,t},$$

where σ_z, σ_ψ, σ_χ are the standard deviations of the innovation, and $\epsilon_{z,t}$, $\epsilon_{\psi,t}$, $\epsilon_{\chi,t}$ are independent and identically distributed (i.i.d) normal processes.

The disutility of labour, follows Horvath (2000) and Iacoviello and Neri (2010) specification that allows for imperfect labour mobility among sectors. The consumer allocate labour resources to the productive activities, for $\xi \geq 0$, hours worked are not perfect substitutes for the worker. Having a construction sector means that labour can easily move from commercial to residential real estate production and vice versa, facing the same wage. However, sector specificity would mean that moving between sectors would have to face sectoral wage differentials.

The households consume, accumulate houses, work for the consumption good and construction sector, and use bonds to smooth consumption. The flow of funds constraint for the household is given by

$$C_{d,t} + q_{hd,t} H_{d,t} + \frac{S_t}{R_t} \leq q_{hd,t}(1-\delta_{hd}) H_{d,t-1} + w_{c,t} N_{c,t} + w_{h,t} N_{hc,t} + w_{h,t} N_{hd,t} + S_{t-1} + q_{l,t} L_{d,t}^{ep} \quad (2)$$

where $q_{hd,t}$ is the price of residential homes, R_t is the gross real loan rate, and $w_{c,t}$, w_h the real wage of the consumption good and construction sector respectively. S_t is the loanable bond that the household buys in period t which pays off in period $t+1$. Finally, $L^{ep}_{d,t}$ is the amount of land that the household is left with after the depreciation of the housing stock. The household chooses C_d, H_d, N_c, N_{hc} , N_{hd} and S_t to maximize (1) subject to (2).

2.2 The Entrepreneur

We model the entrepreneurial sector with borrowing constraints *à la* Iacoviello (2005), where entrepreneurs consume in every period and can raise their net worth by lowering their consumption. To introduce sectoral heterogeneity we consider a representative entrepreneur that operates in two sectors - consumption good and construction sector, where residential and commercial real estate comprise the construction sector. The entrepreneur faces the utility function

$$E_t \sum_{t=0}^{\infty} \beta_e^t \Big(\log(C_{i,t} - \gamma_e C_{i,t-1}) \Big), \quad i = c, h \tag{3}$$

where c and h define the respective consumption good and construction good sectors. $C_{i,t}$ denotes the entrepreneur's consumption and γ is the habit persistence parameter. We ensure that the parameter $\beta_e \in (0,1)$ is smaller than the households discount factor $\beta_e < \beta_d$, so that the credit constraint is binding in a neighborhood of the steady state (Iacoviello, 2005). The entrepreneur owns all inputs beside labour, i.e. capital, land and commercial real estate.

2.3 The Consumption Good Sector

The entrepreneur in the consumption good sector produces goods using non-construction capital, labour and commercial real estate as inputs. The production function is given

$$Y_t = K_{c,t-1}^{\alpha_c} H_{c,t-1}^{\mu_c} \left(A_{c,t} N_{c,t}\right)^{1-\alpha_c-\mu_c} \tag{4}$$

where Y_t denotes output, $K_{c,t-1}$, $N_{c,t}$, $H_{c,t-1}$ denote non-construction capital, labour, and commercial real estate respectively. The entrepreneur is endowed with $K_{c,t-1}$ units of initial non-construction capital stock and $H_{c,t-1}$ of commercial real estate stock. Production functions in both sector are subject to an exogenous labour-augmenting productivity shock. The entrepreneur faces the flow of funds constraint

$$\begin{aligned} C_{c,t} + K_{c,t} + q_{hc,t} H_{c,t} + w_{c,t} N_{c,t} + B_{c,t-1} \\ = Y_t + (1-\delta_{kc}) K_{c,t-1} + (1-\delta_{hc}) q_{hc,t} H_{c,t-1} + \frac{B_{c,t}}{R_t} + q_{l,t} L^{ep}_{c,t} - \phi_{c,t}{}^{3} \end{aligned} \tag{5}$$

[3] $\phi_{c,t} = \dfrac{\phi_{kc}}{2} \left(\dfrac{k_{c,t}}{k_{c,t-1}} - 1 \right)^2 k_{c,t-1}$

where $B_{c,t}$ is the amount of debt used to finance investments in the non-construction sector, $q_{hc,t}$ denotes the price of commercial real estate and the variable $\phi_{c,t}$ describes capital adjustment costs. The amount of land that the entreprenuer is left with after the depreciation of the housing stock is $q_{l,t}L^{ep}_{c,t}$. Finally, $A_{c,t}$ measure the productivity in the non-construction sector. The shocks follow

$$lnA_{c,t} = \rho_{A_c} lnA_{c,t-1} + \sigma_{A_c}\epsilon_{A_c,t},$$

where σ_{Ac} is the standard deviations of the innovation, and $\epsilon_{Ac,t}$ is an independent and identically distributed (i.i.d) normal process. The entrepreneur faces the credit constraint

$$B_{c,t} \leq \rho_{bc} B_{c,t-1} + (1-\rho_{bc})\theta_c E_t \left(q_{hc,t+1} H_{c,t} + K_{c,t}\right), \tag{6}$$

where θ_c can be interpreted as a steady state loan-to-value (LTV) ratio, and ρ_{bc} measures the inertia in the borrowing limit Iacoviello (2015). Following Kiyotaki and Moore (1997) there is a limit on the obligations of entrepreneurs. The amount the creditor can borrow to invest is bounded by a fraction of the value of the collateral assets i.e. the commercial real estate and the non-construction capital. The entrepreneur in the consumption good sector chooses $\{C_{c,t}, K_{c,t}, H_{c,t}, N_{c,t}, B_{c,t}\}$ to maximize (3) subject to (4) through (6).

2.4 The Construction Sector

The entrepreneur in the construction sector produces new commercial and residential real estate using capital, labour and land as inputs. The production function for the former is given by

$$IH_{c,t} = K^{\alpha_h}_{hc,t-1} L^{\mu_h}_{hc,t-1} \left(A_{hc,t} N_{hc,t}\right)^{1-\alpha_h-\mu_h}, \tag{7}$$

where $IH_{c,t}$ denotes the commercial real estate, $K_{hc,t-1}$, $N_{hc,t}$, $L_{hc,t-1}$, denote the inputs; commercial real estate capital, labour in the housing sector, and land that is used for commercial real estate, respectively. The production function for residential real estate is

$$IH_{d,t} = K^{\alpha_h}_{hd,t-1} L^{\mu_h}_{hd,t-1} \left(A_{hd,t} N_{hd,t}\right)^{1-\alpha_h-\mu_h}, \tag{8}$$

where $IH_{d,t}$ denotes new homes, and $K_{hd,t-1}$, $N_{hd,t}$ and $L_{hd,t-1}$, are the corresponding inputs . $A_{hc,t}$ and $A_{hd,t}$ measure the productivity of commercial and residential construction and follow the processes

$$lnA_{hc,t} = \rho_{A_{hc}} lnA_{hc,t-1} + \sigma_{A_{hc}}\epsilon_{A_{hc},t}$$

$$lnA_{hd,t} = \rho_{hd} lnA_{hd,t-1} + \sigma_{Ahd}\epsilon_{Ahd,t}$$

where $\sigma_{A_{hc}}$ and σ_{Ahd} are the standard deviations of the innovation, and $\epsilon_{A_{hc}}$ and $\epsilon_{Ahd,t}$ are two independent and identically distributed (i.i.d) normal processes. The producer faces the flow of

funds constraint

$$C_{h,t} + K_{hc,t} + K_{hd,t} + q_{l,t}\left(L_{hc,t} + L_{hd,t}\right) + w_{h,t}\left(N_{hc,t} + N_{hd,t}\right) + B_{h,t-1} = q_{hc,t}IH_{c,t} + q_{hd,t}IH_{d,t} + (1-\delta_{kh})K_{hc,t-1} + (1-\delta_{kh})K_{hd,t-1} + \frac{B_{h,t}}{R_t} - \phi_{h,t}{}^{4}, \quad (9)$$

where $B_{h,t}$ is the debt for financing investments in the construction sector. The producer faces the credit constraint $\mathrm{B}_{h,t} \leq \rho_{bh}B_{h,t-1} + (1-\rho_{bh})\theta_h E_t\left(q_{l,t+1}\left(L_{hc,t} + L_{hd,t}\right) + K_{hc,t} + K_{hd,t}\right)$.(9)

The amount the entrepreneur can borrow in the constructions sector is limited by the total value of land and construction capital in the production of real estate. The entrepreneur in the construction sector chooses $\{C_{h,t}, K_{hc,t}, K_{hd,t}, L_{hc,t}, L_{hd,t}, N_{hc,t}, N_{hd,t}, B_{h,t}\}$ to maximize (4) subject to (7) through (10).

2.5 Market Clearing Conditions and Equilibrium

The goods market produces consumption and business investment. The clearing condition implies that

$$Y_t - \phi_t = C_t + IB_t, \quad (10)$$

where $C_t = C_{d,t} + C_{c,t} + C_{h,t}$ is the aggregate consumption and IB_t is the business investment. Business investment is describe as

$$IB_t = IK_{c,t} + IK_{h,t} + q_{hc}^{-}IH_{c,t},$$

where $IK_{c,t} = K_{c,t} - (1-\delta_{kc})K_{c,t-1}$ can be described as investment on nonresidential equipment and intellectual property products. The second part of business investment $IK_{h,t} = K_{hc,t} - (1-\delta_{kh})K_{hc,t-1} + K_{hd,t} - (1-\delta_{kh})K_{hd,t-1}$ denotes the investment in construction machinery, which is a small part of the total machinery. CRE is used as an intermediate input in the production of consumption good output and built into the capital stock of the sector in the economy, hence the last term $q_{hc}^{-}IH_{c,t}$ describes the value of new RRE. $H_{c,t}$ evolves according to the law of motion

$$IH_{c,t} = H_{c,t} - (1-\delta_{hc})H_{c,t-1}. \quad (11)$$

The construction sector produces new homes $IH_{d,t}$

$$IH_{d,t} = H_{d,t} - (1-\delta_{hd})H_{d,t-1}, \quad (12)$$

where $H_{d,t}$ is the stock of residential real estate. The GDP is the sum of the value added of the consumption good and residential real estate, that is

$$GDP_t = Y_t + q_{hd}^{-}IH_{d,t}. \quad (13)$$

[4] $\phi_{h,t} = \frac{\phi_{hc}}{2}\left(\frac{k_{hc,t}}{k_{hc,t-1}} - 1\right)^2 k_{hc,t-1} + \frac{\phi_{hd}}{2}\left(\frac{k_{hd,t}}{k_{hd,t-1}} - 1\right)^2 k_{hd,t-1}$

Available land does not evolve over time (without loss of generality we can assume land to fixed at $\bar{L_h} = 1$). In the spirit of Liu et al. (2013), we assume land market clearing with the following condition

$$\bar{L_h} = L_{hc,t} + L_{hd,t}. \tag{14}$$

Ex post land, L_d^{ep} and L_c^{ep} is owned by the respective household and entrepreneur following the depreciation of their housing stock. This is then sold to the construction entrepreneur who uses it as an input. Since all land has a positive value it is always built upon when it becomes available, thus it follows that $L_c^{ep} + L_d^{ep} = \bar{L_h}$ with the following shares applied to each sector

$$L_{c,t}^{ep} = \frac{\delta_{hc} H_{c,t-1}}{\delta_{hc} H_{c,t-1} + \delta_{hd} H_{d,t-1}} \bar{L} \qquad L_{d,t}^{ep} = \frac{\delta_{hd} H_{d,t-1}}{\delta_{hc} H_{c,t-1} + \delta_{hd} H_{d,t-1}} \bar{L}. \tag{15}$$

2.6 Real Estate Substitution

In this section, we use a static model to explain the mechanism of real estate substitution in the presence of a housing preference shock. Figure 4 includes the four markets we consider in our analysis, residential real estate (top left), land market (top right), labour market (bottom left) and commercial real estate (bottom right).

[Insert Figure 4]

Consider a positive RRE price shock (house price shock - demand shock) that shifts demand curve in RRE market from D_A to D_B. Higher demand for houses, will increase RRE prices (q_{hd}) and cause RRE investment to rise. To facilitate, this increase in production the demand for construction machinery, labour in the construction sector and land will also increase. In the land market, the residential land demand curve will shift from L_{hd}^A to L_{hd}^B increasing competition for the available land, which leads to an increase in land prices and a substitution towards RRE land use. Similarly, the increased demand for labour for residential construction will, raises construction sector wages. This hike in construction costs generates an vertical shift in the supply of commercial real estate, displayed by the shift from S^A to S^B which increase the CRE price, q_{hc} and cause a fall in CRE investment.

Thus "real estate substitution" in the presence of a residential real estate demand shock will crowd out commercial real estate which affects the CRE market in the same way as a adverse aggregate supply shock.[5] As can be seen in Figure 4, the overall effects of real estate substitution

[5]There is a strand of literature in urban economics that indicate that the demand for both residential and commercial real estate are similar. In this framework introduced by Rosen (1979) and Roback (1982) land prices is the entry fee that households and firms must pay to access the productivity and the amenities of a labour market area. Because land is substitutable between uses, the price of both residential and commercial ,property will move together.

on both real estate prices and investment depend upon the price elasticity's of supply an demand in the real estate, land and labour markets. To shed further light upon the quantitative and state contingent behaviour of this channel we fully estimate the model in the following section.

3 Estimation

We use Bayesian methods to estimate our model. The posterior density is constructed by simulation using the Metropolis-Hastings algorithm (with 200,000 draws) as described in An and Schorfheide (2007)[6]. The model due to the innate characteristics of the RBC can only allow for a limited number of shocks, which in this case amount to six. Since we can not accommodate more than 6 shocks in the model we are restricted to 6 observables: consumption, residential real estate investment, residential real estate price, commercial real estate investment, commercial real estate prices and total hours. All variables are denoted in real terms. All the data have been gathered from freely available sources such as BEA, BLS and FRED. We demean the hours, and detrend the logarithm of the rest of the variables independently using a quadratic trend.[7]. The detrended and demeaned data are plotted in Figure 5. The sample covers the period from 1975:Q1 to 2016:Q4.

[Insert Figure 5]

Due to the low number of observables we are unable to to estimate a wide range of structural parameters, hence we focus our estimation strategy primarily to the shocks' processes.

3.1 Calibrated Parameters

To calibrate we use data on the US market. Table 1 summarizes our calibration. We set $\beta_d = 0.9925$, that corresponds to a annual 3% bank prime loan rate. We fix the discount factor at $\beta_e = 0.975$ which makes the credit constrain binding in the steady state (Iacoviello, 2005). Since entrepreneurs can use bonds to smooth consumption we assume a higher degree of habit persistence $\gamma_e = 0.65$ than households $\gamma_d = 0.5$. The depreciation rates for residential real estate, non construction capital, commercial real estate, and capital in the construction sector are set to $\delta_{hd} = 0.01$, $\delta_{kc} = 0.025$, $\delta_{hc} = 0.025$ and $\delta_{kh} = 0.04$ (Iacoviello and Neri, 2010). Parameter χ is calibrated to 0.2 to set the steady state of the ratio of residential investment to output.

Real estate also typically accounts for about half of business assets, so we set $\alpha_c = 0.20$ for the capital share and $\mu_c = 0.20$ for the real estate share (Liu et al., 2013). It is important to note

[6] Appendix C plots the prior and posterior densities, details on the estimation strategy and tests of convergence for the stability of the estimated parameters

[7] Appendix A describes further details of the data construction

that the construction sector is more labour-intensive, hence the labour share ought to be larger than the consumption good sector, thus the construction factor shares are set to $\alpha_h = 0.20$ for the capital share and $\mu_h = 0.1$ for the land share (Davis and Heathcote, 2005).

Finally, the LTV ratios have to take values less than 0.75, since commercial mortgage-backed securities loans permit maximum LTV of 75%. Grovenstein et al (2005) measures LTV ratios to be 71.01% in five major commercial real estate property types orginating from 10547 loans. Downing et al. (2008) report an average LTV of 67.40% for over 14.000 commercial mortgages between 1996 and 2005. Arsenault et al (2013) finds a mean of 66% for the period of 1991 to 2011. For our purpose we set consumption good LTV to 70% ($\theta_c = 0.70$), while real estate firms correspond to an aggregate loan-to-value ration to 50% (Gyourko, 2009), thus we set $\theta_h = 0.5$.

[Insert Table 1]

Table 2 shows the steady steady ratios of the model. The sum of the consumption share (68%) and the business investment (22%) is the consumption good share, which amounts to 90%. The remaining 10% is the residential real estate share. We split the business investment share into three sub-components. The commercial real estate share which accounts for 34% of business investment or 7% of GDP. The other two components are software and non-construction capital and construction capital, that constitute the largest part of business investment 53% and 11% respectively. To calculate the business capital in the consumption good sector, we have to sum the capital used in the production of the consumption good and the commercial real estate wealth. The business capital for the construction good is 25% higher than the residential housing wealth, while the business capital of the construction is only 4% of the business capital stock. This means, that construction firms possess only a smart part of the total capital.

[Insert Table 2]

3.2 Prior & Posterior Distributions

Table 3 summarizes the estimation of the model. We report the estimates of shock and structural parameters at the posterior mean, median and mode, along with the 90% posterior probability intervals.

[Insert Table 3]

For the shock processes, we use Beta distribution for the persistence with prior mean of 0.8 and a standard deviation of 0.1, and Inverse-Gamma distribution for the standard errors with prior mean 0.001 and standard deviation 0.01.

For labour supply elasticity (η) we use a normal distribution centered around 0.5, and we observe a moderate response of labour supply to wages with a median estimate to 0.64. Also, agents exhibit little preference for labour mobility with a median estimate of 0.89.

In the construction sector, we observe that the autoregressive terms are relative high, indicating persistent and prolonged effect on the construction technology, consistent with Iacoviello and Neri (2010). The standard errors, are really close 0.03 and 0.031 for commercial and residential respectively.

4 Properties of the Model

For the main part of the analysis we will focus on two shocks: a RRE preference shock and a technology shock to the consumption good sector. All impulse responses plots correspond to a 1 standard deviation shock. The *y-axis* measures deviation from the steady state.

4.1 Estimated IRFs

Figure 6 shows IRFs for the housing preference shock. As was explained in section 2.6, the housing preference shock or else as it was established by Iacoviello and Neri (2010) a "housing demand shock", causes RRE prices and investment to increase. Increases in the production of residential real estate requires more inputs, thus increasing the land prices, wages in the construction sector, construction capital and RRE investment itself. However, CRE production also require these inputs, and it is the rise of these input prices that activate the *real estate substitution* channel and causes a fall in CRE investment.

[Insert Figure 6]

In Iacoviello and Neri (2010) a housing preference shock creates a small but negative response to business investment, which was due to a combination of a rise of capital in the construction sector and a decrease in capital in the consumption sector, which occurred by the shift of the resources from one sector to the other. In our model, CRE investment by definition is included in the business investment, therefore with a reduction in CRE investment, business investment will follow. However, in our model rather than the shift of resources between construction and non-construction capital, the effect takes place in the construction sector, where the substitution occurs between the two types of real estate.

The increase of land prices also raises the collateral capacity of the entrepreneurs in the construction sector, allowing them to increase borrowing and consumption. On the other hand, the increase in RRE prices and the fall in CRE investment, reduces the household consumption and the collateral capacity of entrepreneurs in the consumption good sector, respectively.

The behaviour of consumption resembles the case of heterogeneous households (Iacoviello, 2005; Iacoviello and Neri, 2010), where constrained-households produce positive co-movement of consumption and house prices. However, in our model we generate this co-movement, by utilizing the borrowing characteristic of entrepreneurs in the construction sector.

Figure 7 shows the IRF for a technology shock in the consumption good sector. In a technology shock, investment and output go up on impact. However, with the separation of investment we can observe that it is CRE investment that drives business investment, which in turn increases production and output, while RRE investment declines, by a smaller proportion, which is not enough to offset the increase in output.

[Insert Figure 7]

Specifically, a positive productivity shock increase the demand and price of the inputs required to produce consumption good, that is consumption good capital, CRE capital and commercial land. In turn, the increase in demand for CRE increase CRE investment, wages in the construction sector and land prices. Higher input prices set up the the real estate substitution mechanism which generate a cost push increase in residential prices and reduces residential investment. Thus what we initially considered a positive supply shock to the consumption good, insigates the equivalent of a positive demand shock to CRE and, in turn, an adverse supply shock to residential property. Borrowing, faces a double increase that stems from the increased value of CRE and the increase in land prices. Consumption follows residential house prices very closely since household utility retains the same relative weights on housing and consumption.

4.2 Relative Importance of the shocks

Table 4 reports variance decomposition for the key macroeconomic variables across the 6 type of structural shocks at forecasting horizons between the impact period (1Q) and the five years after the initial shock (20Q).

[Insert Table 4]

It is clear that the largest variation in RRE prices stems from the housing preference shocks, especially at short horizons. Indeed over longer horizons changes in household income are spread across both the consumption good and house prices which also explains why the two components of household utility are highly correlated. CRE prices react in a similar way, in short horizons most of the variation is attribute to demand (consumption technology shock), while more weight is allocated to supply (CRE technology) as you go in longer horizons. Additionally, discount shocks play a non-trivial role in determining property prices.

More than half of the RRE investment variation is attributed to the technology shock to the residential construction, and around a quarter of the variation is driven by a housing demand shock. On the other hand CRE investment, on impact is primarily explained by a technology shock to the consumption good i.e. CRE demand shock, and secondarily by the technology shock to the commercial construction. However, the effect of the shock in the end changes, and allocates more weight into the supply shock and less to the demand shock.

Figure 8 shows the historical decomposition of the prices and investment of residential and commercial real estate. The solid lines display the detrended historical data, obtained by applying a quadratic filter on the observed series. The filled regions show the historical contribution of the four shocks under our estimated parameters. In order to observe the technology shock in the construction sector, we combine residential and commercial real estate technology as real estate technology.

[Insert Figure 8]

The sum of these four shocks account for most of the variation in the filtered observed series. As we seen before the *real estate substitution* channel indicates that a positive shock in either the housing preferences or consumption good technology will increase the prices, however the response of real estate investment will be contingent on the source and the dominance of the shock. A housing preference shock would boost the residential investment and diminish commercial investment, while consumption good technology works in the opposite way where residential investment drops and commercial investment increases. However, in the bottom two graphs that display the property quantities (investments) the two shock work against each other, a result that is attributed to the real estate substitution channel. The investment cycles now correspond to the difference of the shocks and not the sum.

Finally, the housing preference shock seems to be the main driver of the 2007 financial crisis, which is evident in all variables beside the CRE prices. CRE prices are primarily driven by technology shocks in the consumption good, which means that they are more affected from demand shocks, and supply shocks are trivial throughout the sample period.

5 The role of Land

Land although passive its an important factor of production, that does not possess any ability to produce on its own. Competition for land, stems from the fact that not only land is finite[8], but also both households and firms need it for new RRE and CRE respectively. In their novel

[8]Land can grow at a very small rate if you consider the land zoning restriction lifts, that enable commercial and residential building to overtake farmlands or previously unzoned territories

paper, Liu et al. (2013) were the first to introduce competition for land and the "land reallocation channel" in a DSGE framework. In their paper, there was no need for real estate production since land prices are able to capture the largest part of the business cycle fluctuations (Davis and Heathcote, 2007). With the abstraction of real estate production and the construction sector, land prices are identical to property prices, and guarantee that the land reallocation channel will be always present and dominant. However, the price and the quantity of land has very different time-series properties than the price and quantity of land in commercial use (Davis, 2009).

In our framework, land reallocation channel is encapsulated in a broader definition of competition in the construction section, where the competition is not between land but between the two types of real estate. Land reallocation is always present but in comparison with Liu et al. (2013) it is not always dominant. The rationale behind the "real estate substitution channel" is that the two types of real estate do not always follow an adverse path, so an assumption of complete substitution would be unreasonable. A prime example is an innovation in labour supply, where hours worked in all sectors would react similarly.

Figure 9 shows IRFs for a positive labour supply shock. A positive labour supply will decrease the hours worked in both the consumption good and the construction sector. Since hours are used as an input for the construction of real estate then both RRE and CRE investment will fall and the corresponding prices will rise. On the other hand, a reduction in hours in the consumption good sector will lead to a a fall in the consumption good and CRE investment, which means that less demand for CRE investment will trigger the "real estate substitution channel" that will increase RRE investment. These two effects oppose each other where the supply effect dominates the real estate substitution channel.

[Insert Figure 9]

By increasing the share of land in the production of real estate, CRE and RRE will respond more than their land counterparts, consequently the real estates substitution channel collapses to the land reallocation channel. As $\mu_h \to 1$ real estate will be equal to land, basically making the construction sector redundant. In Figure 9 dashed and dot-dashed lines display a positive supply shock when the μ_h is 0.2 and 0.5 respectively. By increasing the land share the we can observer that the effect on RRE investment becomes positive, since the substitution overtakes the effect from the supply. As $\mu_h \to 1$ CRE investment starts to exactly mirror the RRE investment, a fact that is assumed in Liu et al. (2013).

5.1 Land Shares

To investigate the contribution of land in the real estate cycle we plot the simulated path of investment and land share for both residential and commercial real estate.Figure 10 displays

the simulated path of RRE investment and residential land in the top panel, and the CRE investment and commercial land in the bottom panel. Land and investment cycles seem to be in synchronisation for most of the sample, however there are significant divergence, in particular following recession periods.

[Insert Figure 10]

For example, after the office overbuilding of the 1980s and the consequently collapse, demand for residential land followed a steady upward trend which peaks in the 2007. Post 2007 there is large shift that changes the composition of land share towards the commercial side. Due to the model flexibility, we can observe movements in investment that is not restricted by the supply of land, hence in the post financial crisis period we see a significant fall in both RRE and CRE investment that is not attributed to the substitution of land. By ignoring the construction sector, and using land as only input, the supply land would be significantly overestimated. Eventually towards the end of the sample where RRE demand shocks were starting to keep up,residential investment in converging to its land counterpart.

Finally, we compare our estimate of land share with the estimate derived from Davis and Palumbo (2008). Figure 11 plots model estimate of residential land share (dotted line), the aggregate residential land shares (solid line) along with the 68% error bands (dashed lines) that correspond to the bottom 16% and and top 84% percentile of the MSA land shares. According to Davis and Heathcote (2007), land values can also been conceptualised as the value of the real estate when you exclude the cost of the structures, thus the mentioned estimate does not correspond to land measurement, but instead as the ratio of residential real estate value to residential land value.

[Insert Figure 11]

Consistent with the data, our model estimate shows an upward trend which indicates that residential housing is much more land-intensive than it used to be. The crisis in 2007 reverts this trend to 1980s levels.

6 Concluding Remarks

This paper has shown both the existence and potential mechanism behind the real estate substitution channel as well as captured the way it manifests. Importantly, the inputs of the construction sector play a significant role in explaining the detail and scale of the processes that create this effect. The channel is reciprocal, meaning that it can either originate in residential or the commercial real estate. However, the magnitude is not symmetrical, which highlights that

even though construction has a lot of commonalities in the production of the two types of real estate, the specificity of each type is non-trivial.

We give a unique interpretation to the housing preference shock, where it does not simply generate a shift in the preference for housing, instead it is shown to have of a structural connection with commercial real estate. In turn, this relationship explains how demand shocks in the residential real estate can be easily crowd out commercial real estate which affects the goods market in a similar way to an adverse aggregate supply shock

The Bayesian estimation of the model reveals that housing preference shocks determines much of the movements in aggregate variables. Moreover, the historical decomposition reveals that whilst movements in housing demand drives all variables, it was the collapse in CRE prices that was particularly dominant in the 2007 crisis, which stemed from a fall in productivity in the consumption good sector. As a result, whilst the co-movement of RRE and CRE prices is close, our results reveal that there are different mechanisms at play which are very important for explaining the short run dynamics in both the construction sector and economy as a whole.

Appendix A: Data and Sources

Aggregate Consumption: Real Personal Consumption Expenditure (seasonally adjusted, chain-type quantity index, base year 2009, table 1.1.3) divided by the Civilian Noninstitutional Population (CNP16OV, source: Bureau of labour Statistics). Source: Bureau of Economic Analysis (BEA)

Business Investment: Real Private Nonresidential Fixed Investment (seasonally adjusted, chain-type quantity index, base year 2009, table 1.1.3) divided by CNP16OV. Source: BEA

Residential Investment Real Private Residential Fixed Investment (seasonally adjusted, chain-type quantity index, base year 2009, table 1.1.3) divided by CNP16OV. Source: BEA

Commercial Real Estate Investment Real Private Nonresidential Structures Fixed Investment (seasonally adjusted, chain-type quantity index, base year 2009, table 1.1.3) divided by CNP16OV. Source: BEA

Residential Real Estate Prices : Real House Price Index, United States (NSA) deflated with the implicit price deflator for the nonfarm business sector (table 2 , source: BLS). Source: Census Bureau

Commercial Real Estate Prices : Real Commercial Real Estate Price Index, United States (NSA) deflated with the implicit price deflator for the nonfarm business sector (table 2 , source: BLS). Source: Federal Reserve System

Hours in Consumption Sector: Hours of Wage and Salary Workers on Nonfarm Payrolls: Private(seasonally adjusted, Billions of Hours, Series ID: PRSCQ) less Hours of Wage and Salary Workers on Nonfarm Payrolls: Construction (seasonally adjusted, Billions of Hours, Series ID: CNSTQ). Source: FRED

Hours in Construction Sector: Hours of Wage and Salary Workers on Nonfarm Payrolls: Construction (seasonally adjusted, Billions of Hours, Series ID: CNSTQ). Source: FRED

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Tables & Figures

Table 1 – Calibrated Parameter Values

Households		
β_d	Discount factor	0.9925
χ	Housing services	0.2
γ_d	Habit persistence	0.5
Entrepreneur		
β_e	Discount factor	0.975
γ_e	Habit persistence	0.65
Entrepreneur: Consumption Good		
α_c	Non-construction capital share	0.2
μ_c	Commercial real estate share	0.2
δ_{kc}	Depreciation of non-construction capital	0.025
δ_{hc}	Depreciation of commercial	0.025
ρ_{bc}	Borrowing inertia	0.8
θ_c	LTV consumption good sector	0.70
Entrepreneur: Construction		
α_h	Construction capital share	0.2
μ_h	Land share	0.1
δ_{hd}	Depreciation residential real estate	0.01
δ_{kh}	Depreciation of construction capital	0.04
ρ_{bh}	Borrowing inertia	0.8
θ_h	LTV construction sector	0.5

Table 2 – Steady State Ratios

C/GDP	Consumption share	68%	
IB/GDP	Business investment share	22%	
– IK_c/IB	Software and non-construction equipment share		53%
– IK_h/IB	Construction equipment share		11%
– $q_{hc}IH_c/IB$	Commercial structure share		34%
$q_{hd}IH_d/GDP$	Residential structure share	10%	
$q_{hd}H_d/(4 \times GDP)$	Residential real estate wealth	2.46	
$(q_cH_c + K_c)/(4 \times GDP)$	Consumption good capital	3.1	
$(K_{hc} + K_{hd)}/(4 \times GDP)$	Construction capital	0.16	

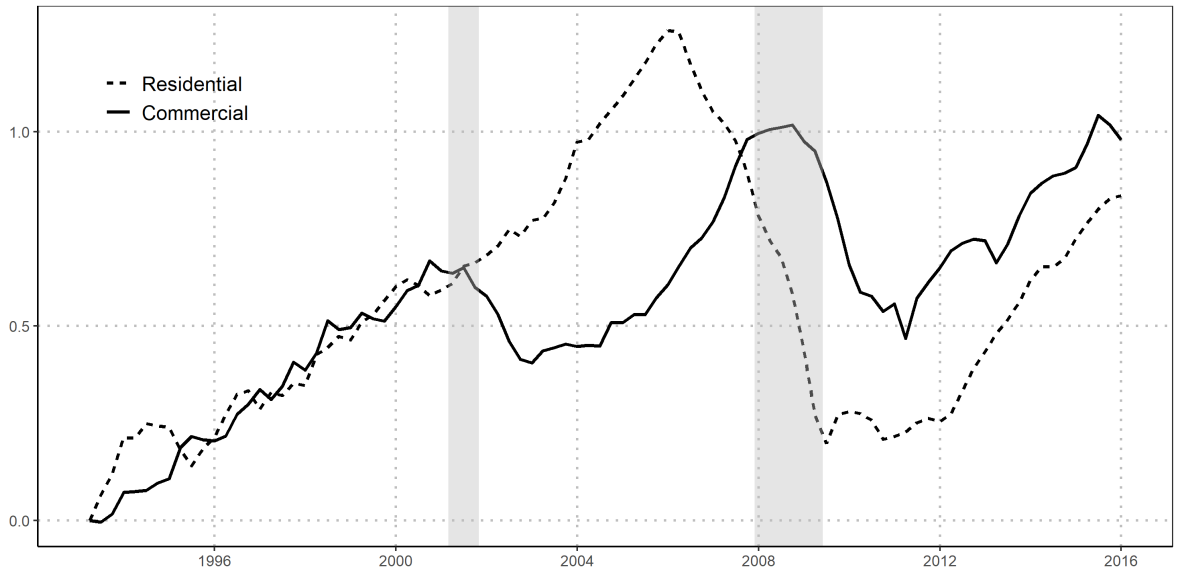
Table 3 – Prior and Posterior Distribution of the shock processes

	Prior Distribution			Posterior Distribution				
Parameter	Density	Mean	SD	Mean	2.5%	Median	Mode	97.5%
σ_z	Inv Gamma	0.00	0.00	0.069	0.061	0.069	0.068	0.077
σ_χ	Inv Gamma	0.00	0.00	0.081	0.063	0.08	0.08	0.099
σ_ψ	Inv Gamma	0.00	0.00	0.017	0.016	0.017	0.017	0.019
σ_{Ac}	Inv Gamma	0.00	0.00	0.02	0.017	0.02	0.02	0.023
σ_{Ahc}	Inv Gamma	0.00	0.00	0.03	0.028	0.03	0.03	0.033
σ_{Ahd}	Inv Gamma	0.00	0.00	0.031	0.028	0.031	0.031	0.035
ρ_z	Beta	0.80	0.01	0.78	0.75	0.79	0.79	0.82
ρ_χ	Beta	0.80	0.01	0.95	0.93	0.95	0.95	0.96
ρ_ψ	Beta	0.80	0.01	0.98	0.98	0.98	0.98	0.99
ρ_{Ac}	Beta	0.80	0.01	0.98	0.97	0.98	0.98	0.99
ρ_{Ahc}	Beta	0.80	0.01	0.98	0.97	0.98	0.98	0.99
ρ_{Ahd}	Beta	0.80	0.01	0.96	0.95	0.96	0.96	0.97
ξ	Beta	1	0.1	0.89	0.84	0.89	0.9	0.94
η	Normal	0.5	0.1	0.64	0.41	0.64	0.65	0.88
ϕ_c	Gamma	10.00	6.25	13	10	13	13	17
ϕ_h	Gamma	10.00	6.25	14	8.9	14	10	19

Table 4 – Variance Decomposition

Horizon	Shocks					
	Discount	Housing Preferences	Labour Supply	Consumption Technology	CRE Tecnology	RRE Technology
RRE Prices						
1Q	8.37	62.91	0.26	7.16	7.44	13.87
5Q	12.76	56.94	0.47	16.99	2.17	10.67
10Q	12.34	49.58	0.59	25.54	2.11	9.85
20Q	9.33	38.91	0.76	36.82	2.46	11.73
CRE Prices						
1Q	7.71	1.71	2.41	46.92	39.55	1.70
5Q	14.48	2.86	1.42	35.34	43.01	2.88
10Q	12.61	2.81	1.15	33.44	47.06	2.93
20Q	9.14	2.39	0.99	33.70	51.21	2.57
RRE Investment						
1Q	0.40	16.29	1.47	10.57	2.02	69.26
5Q	1.77	21.33	1.50	7.72	0.73	66.94
10Q	1.01	23.25	2.14	4.51	1.34	67.75
20Q	1.12	23.66	2.96	2.65	3.69	65.91
CRE Investment						
1Q	4.28	1.69	18.77	66.54	7.50	1.22
5Q	11.18	9.21	11.81	36.12	23.51	8.17
10Q	5.97	11.21	8.50	19.18	44.35	10.78
20Q	2.93	10.02	6.34	9.65	60.52	10.55
Consumption						
1Q	83.12	0.02	2.68	14.15	0.00	0.02
5Q	65.68	0.00	5.12	28.99	0.21	0.01
10Q	44.26	0.01	7.95	46.97	0.80	0.01
20Q	25.06	0.01	10.68	63.07	1.18	0.01

Figure 1 – Construction Spending

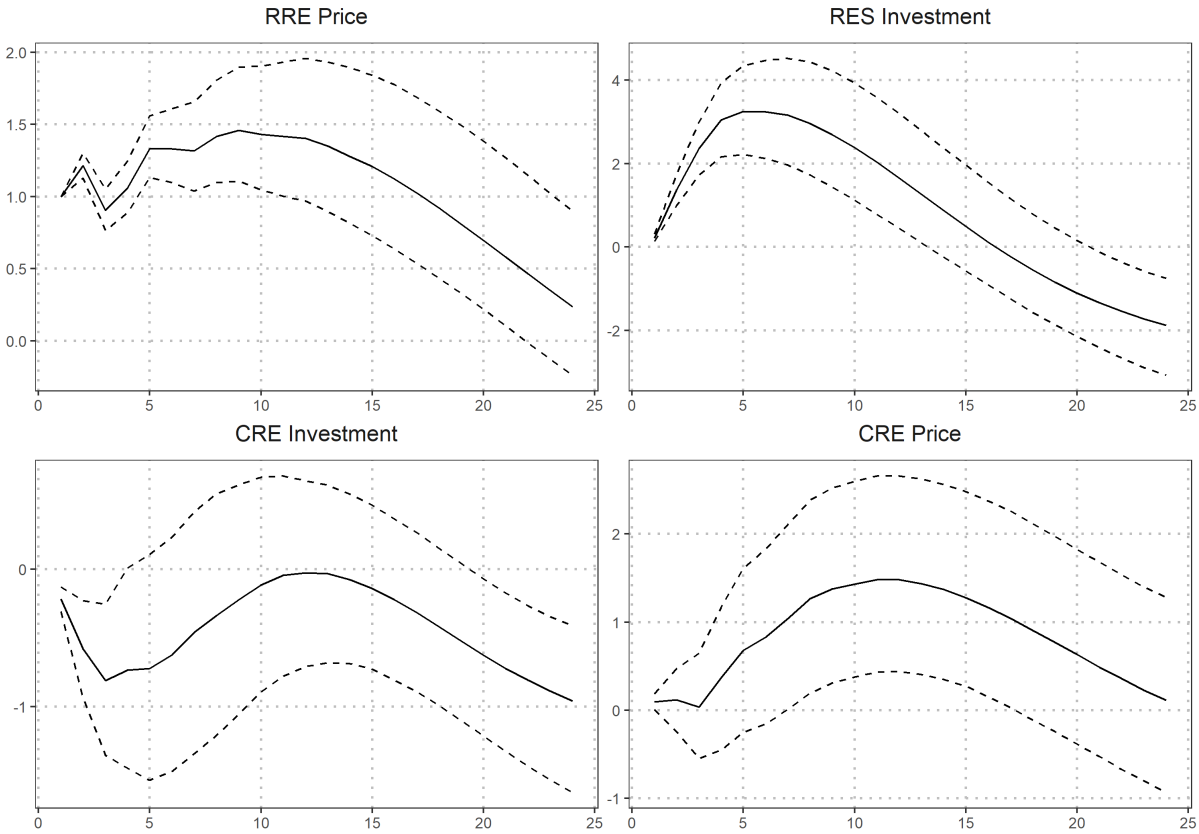


Notes: Commercial construction spending (solid line) and residential construction spending (dotted line). Variables are in log units and normalised to the origin of the sample. The shaded bars mark the NBER recession dates. Private construction spending covers the dollar construction work done on new structures or improvements to existing structures. Data estimates include the cost of labour and materials, cost of architectural and engineering work, overhead costs, interest and taxes paid during construction, and contractor's profits. Source: data.gov

Figure 2 – Real Estate Dynamics

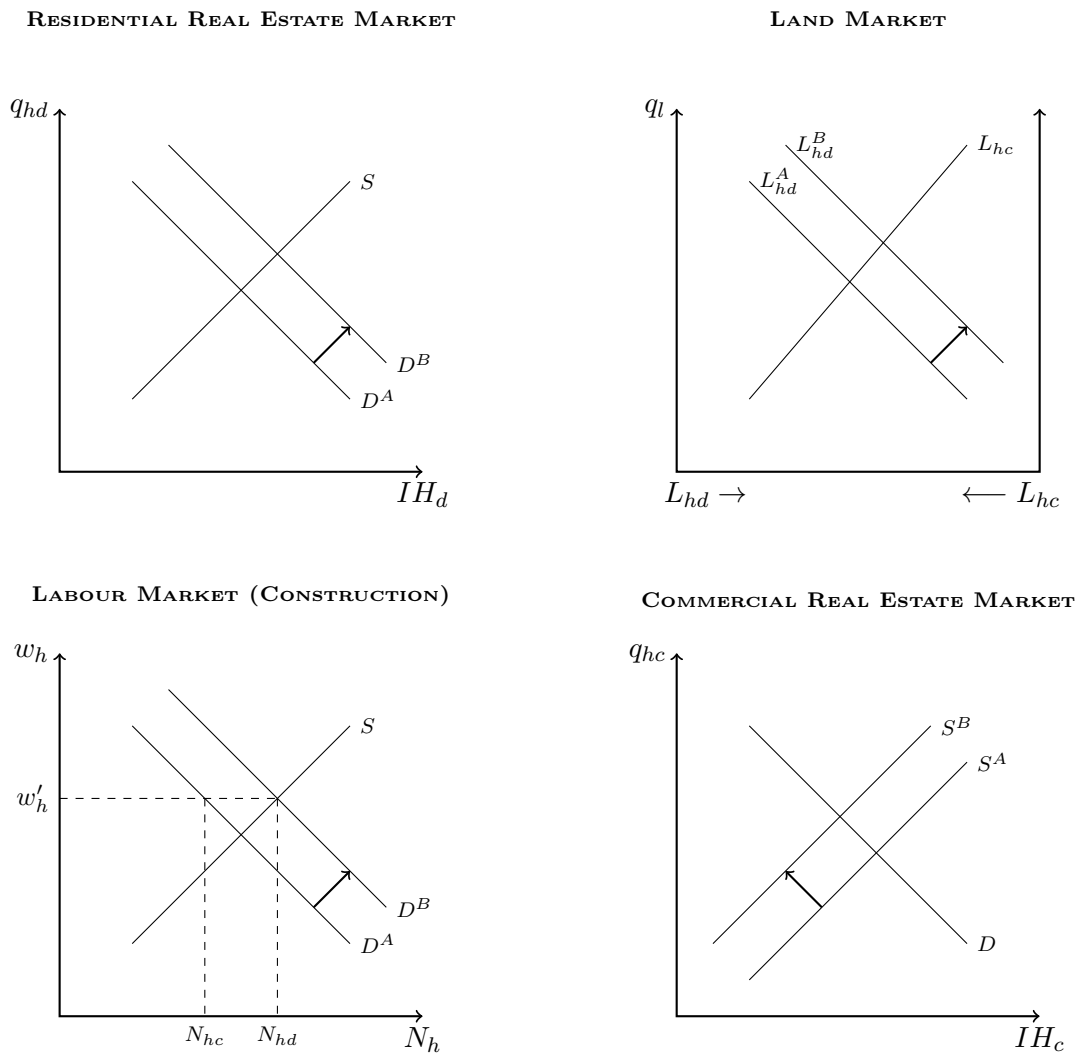
Notes: Real commercial property price (solid line), real land price (dotted line) and real house price (dashed line). All variables are in log units and normalized to the origin of the sample. The shaded bars mark the NBER recession dates.

FIGURE 3 – RRE PRICE SHOCK



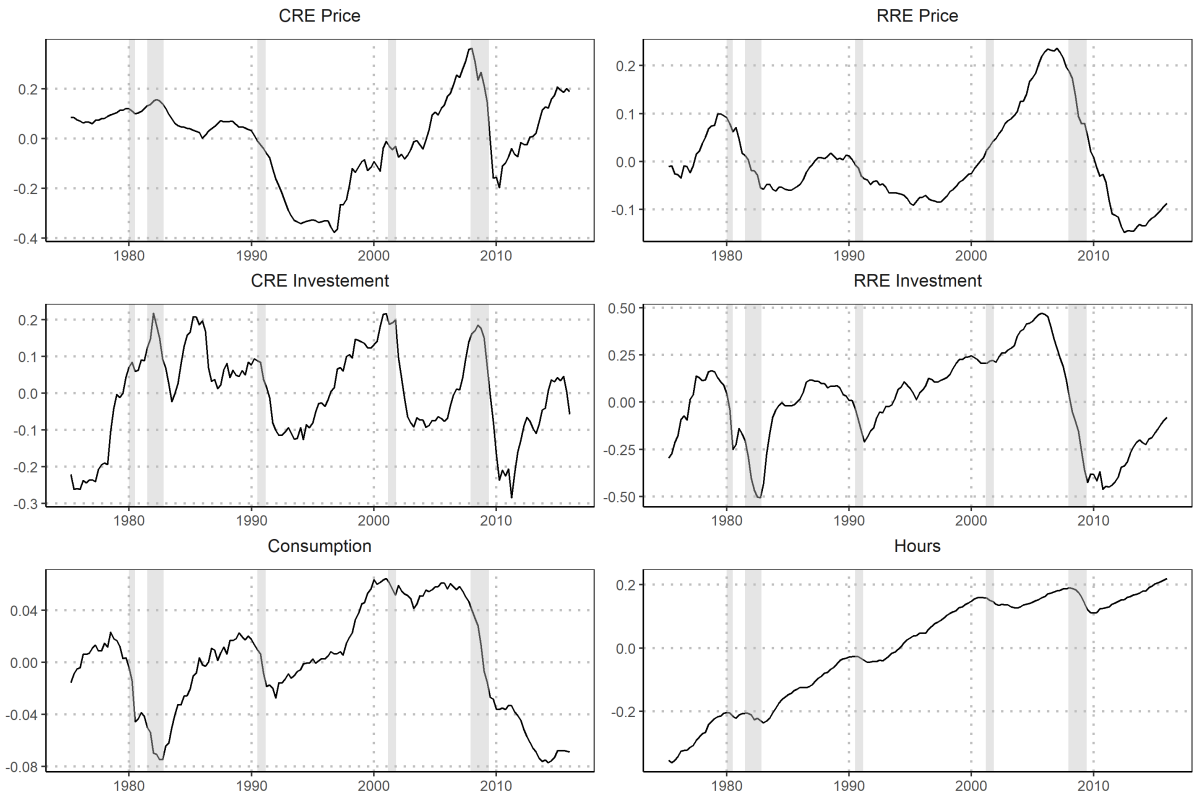
Notes: Impulse response to a positive shock to the residential real estate price from a recursive BVAR model with Diffuse Prior. Identification is achieved through Cholesky decomposition with the following ordering {RRE Price, RRE Investment, CRE Investment, CRE Price }, all in real terms. Solid lines represent the median estimated responses and dotted lines the 68% probability bands.

Figure 4 – Housing Demand Shock



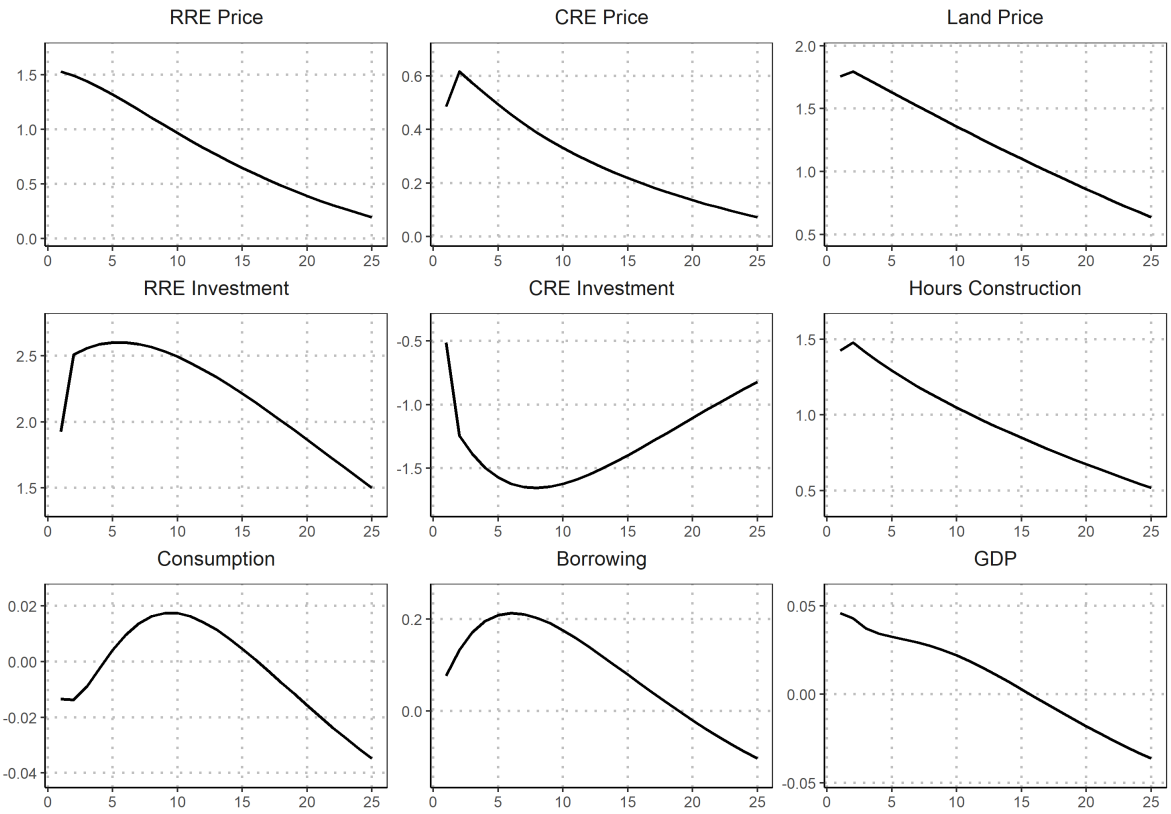
Notes: The figure display the residential real estate market (top left), the land market (top right), tha labour market (bottom left) and the commercial real estate market (bottom right), following a housing demand shock.

Figure 5 – Detrended Data



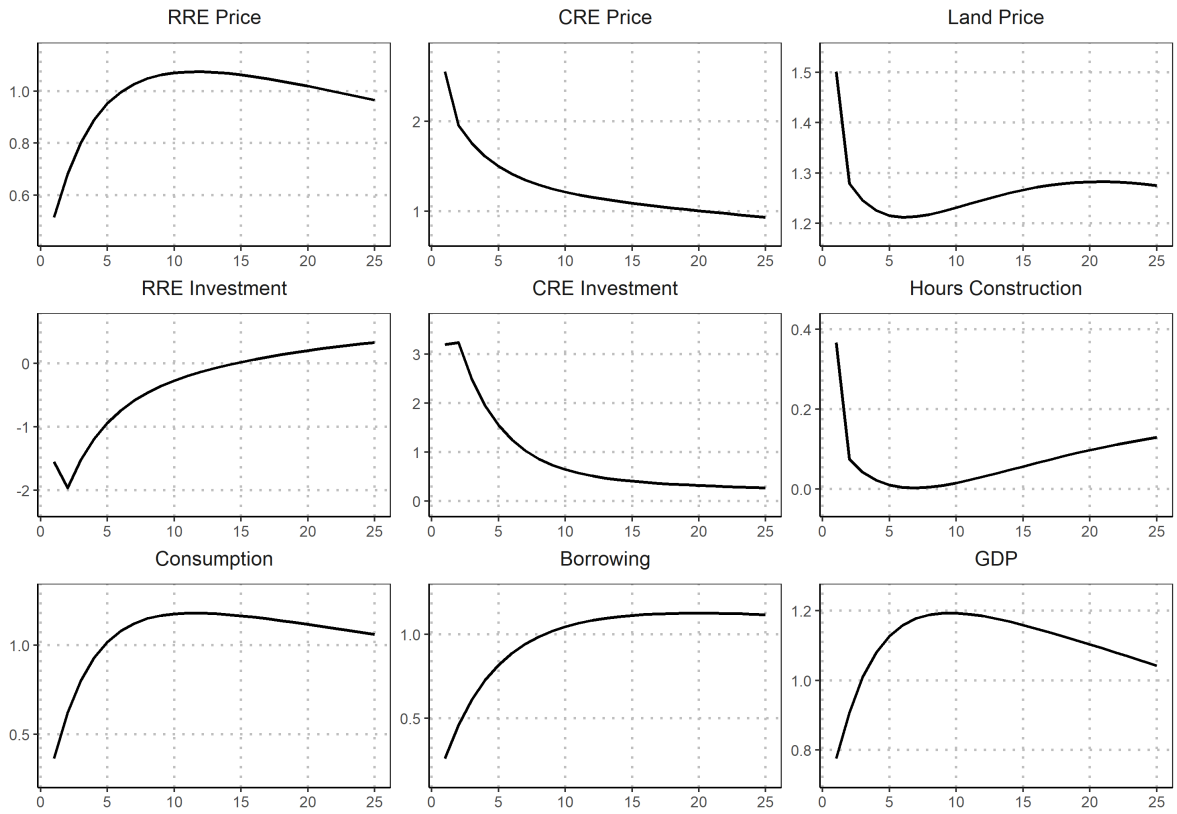
Notes: Prices, investment and cosumption have been detrended using a quadratic trend and normalized to the beginning of the sample. Hours are demeaned. The model parameters are estimated using data from 1975Q1-2016Q4. Shaded regions indicate the NBER recession periods.

FIGURE 6 – HOUSING PREFERENCE SHOCK



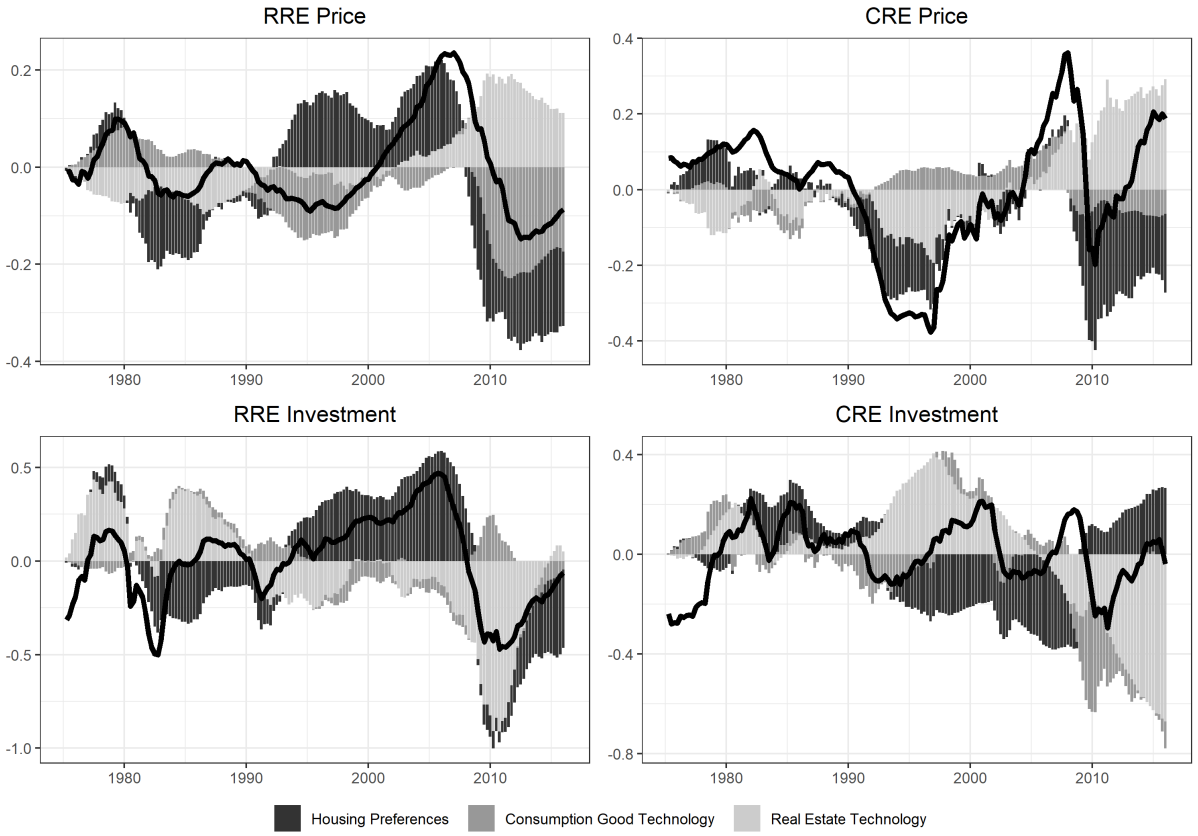
Notes: Impulse responses to a positive (one standard deviation) shock to housing preferences. The y-axis measures percent deviation from the steady state.

FIGURE 7 – CONSUMPTION GOOD TECHNOLOGY SHOCK



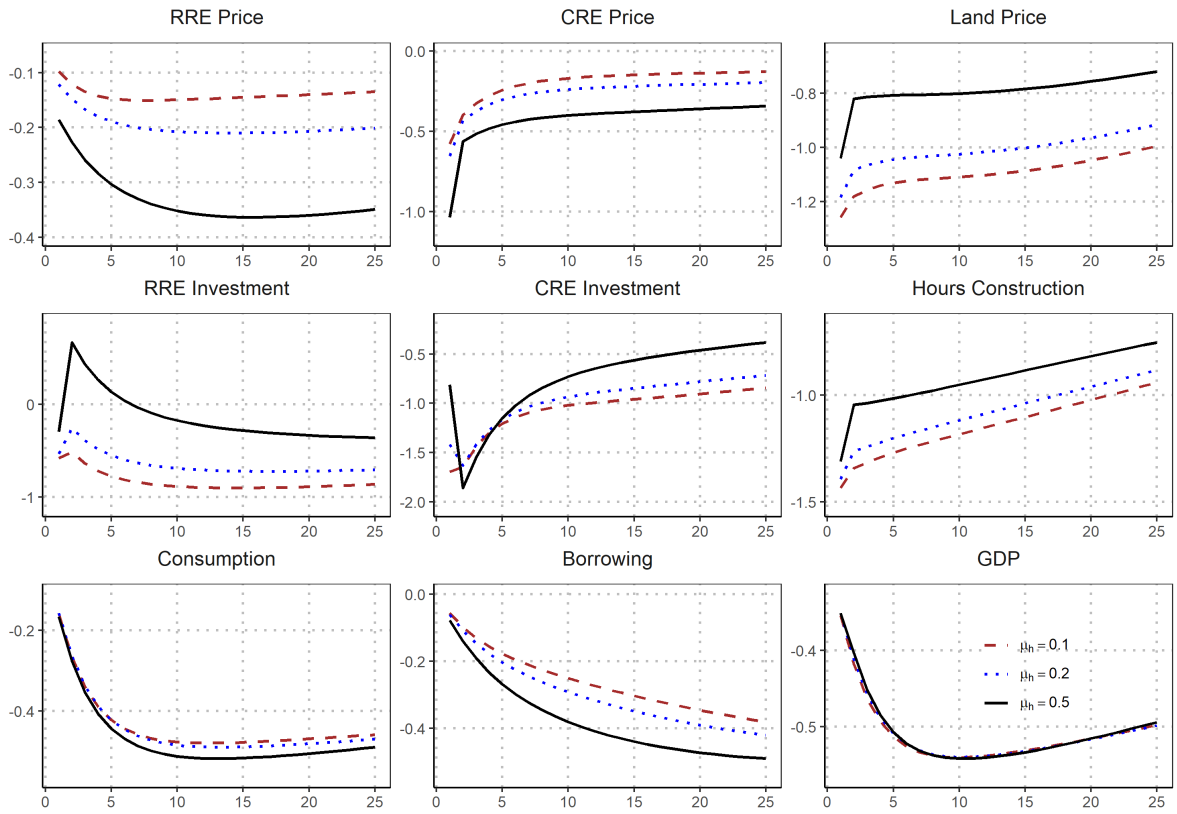
Notes: Impulse responses to a positive (one standard deviation) shock to consumption-good technology. The y-axis measures percent deviation from the steady state.

FIGURE 8 – HISTORICAL DECOMPOSITION OF STRUCTURAL SHOCKS



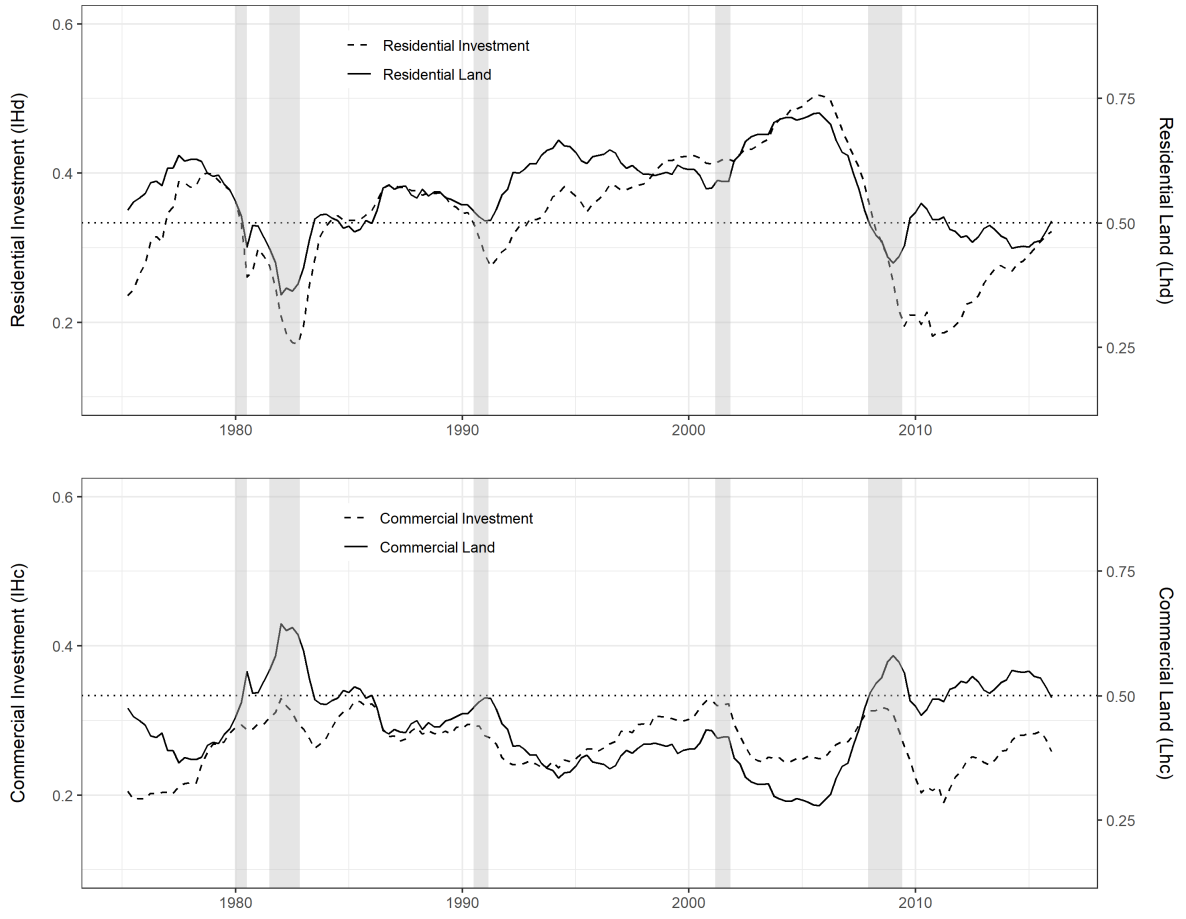
Notes: The solid line represents the data. Housing preferences and consumption good technology include only their corresponding shock. Real estate technology shock includes both CRE and RRE technology shocks. All series are in deviation from the estimated trend.

FIGURE 9 – LABOUR SUPPLY SHOCK SENSITIVITY



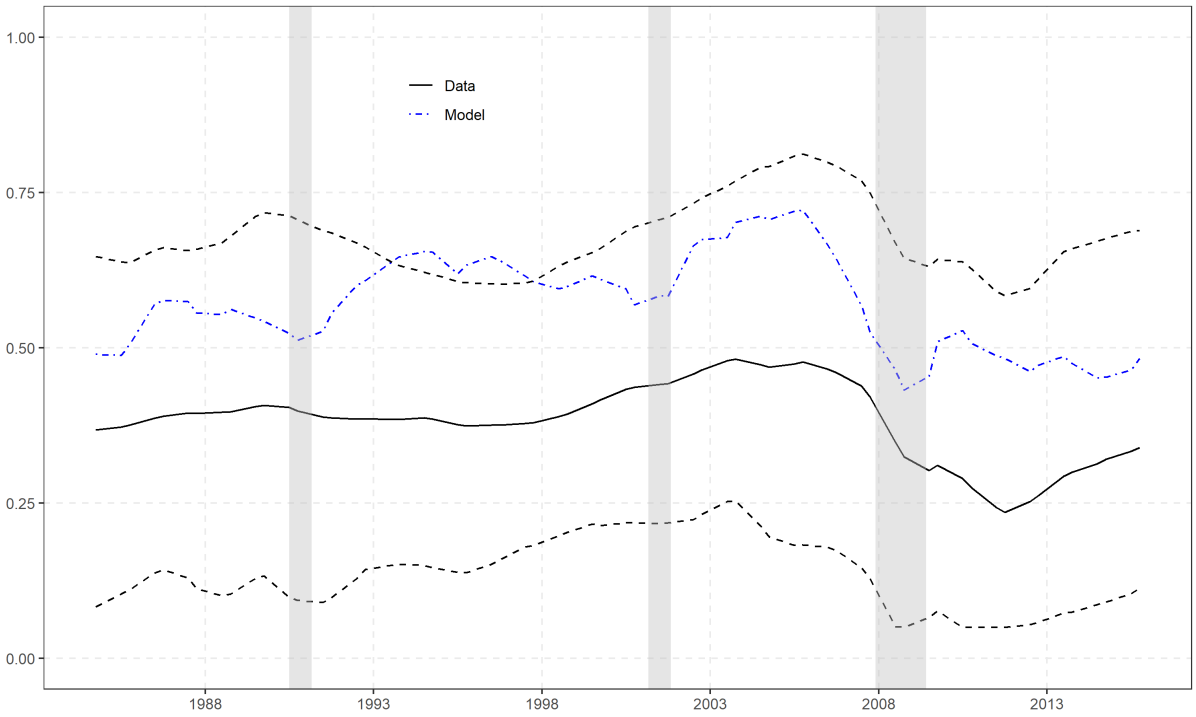
Notes: Impulse responses to a positive (one standard deviation) shock to labour supply. The y-axis measures percent deviation from the steady state.

Figure 10 – Estimated Path of Variables



Notes: Top figure display the residential investment (solid line) and the residential land (dashed line). The bottom figure display the the commercial investment (solid line) and the commercial land (dashed line). The sum of land should always be one. Investment is measured on the left axis and land on the right. The shaded bars mark the NBER recession dates.

FIGURE 11 – LAND SHARES



Notes: Empirical land shares are calculated as the ratio of land value over the home value. The dashed bands indicate the top and bottom decile of the MSA areas land share. The shaded bars mark the NBER recession dates. *Source www.aei.org/housing/land-price-indicators/*