Housing Prices, Residential and Nonresidential Investments and Macroeconomic Fluctuations

Wei Ma

Department of Economics, University of Leicester, Leicester, United Kingdom

Weiqun Li

Department of Economics, University of Liverpool, United Kingdom

Keqin Qu

Department of Economics, University of Edinburgh, United Kingdom

John Oden (Corresponding author)

Adam Smith Business School, University of Glasgow, Glasgow, United Kingdom
E-mail: joden0213@gmail.com

Abstract

As witnessed during the recent financial crisis, the housing markets have played a notably important role in driving macroeconomic fluctuations. We investigate the correlation between housing dynamics and the business cycle for a variety of countries. Our empirical results exhibit the two daunting facts faced by lots of macroeconomic modelers: (i) house prices are highly volatile and closely correlated with the business cycle, which is at odds with the evidence that rental prices are relatively stable and almost uncorrelated with the business cycle; and (ii) residential investment leads the business cycle while nonresidential investment moves contemporaneously with the business cycle.

Keywords: housing market; lead-lag relationship; the business cycle

1. Introduction

The housing sector has served a more and more important role in macroeconomic modeling since the recent financial crisis that started in the U.S. in December 2007. In response to the recession, a growing literature has tried to incorporate the housing sector into standard macroeconomic models to explain stylized facts in the housing market and the business cycle. For instance, Iacoviello (2010) is a recent survey. A non-exhaustive reading list includes Iacoviello (2005), Davis and Heathcote (2007), Iacoviello and Neri (2010), Mian and Sufi (2011), Chaney, Sraer, and Thesmar (2012), Rupert and Wasmer (2012), Liu, Wang, and Zha (2013), Chatterjee and Eyigungor (2015), Burnside, Eichenbaum, and Rebelo (2016), Guo (2017a) and Favilukis, Ludvigson, and Nieuwerburgh (2017). However, there are two facts that existing quantitative macroeconomic models have difficulty explaining: house prices are highly volatile and closely correlated with the business cycle, which is at odds with the evidence that rental prices are relatively stable and almost uncorrelated with the business

cycle; and residential investment leads the business cycle while nonresidential investment moves contemporaneously with the business cycle.

The main goal of this paper is to present two empirical facts in the housing market and provides guidance for quantitative macroeconomic modeling. To incorporate the housing sector into the standard dynamic stochastic general equilibrium (DSGE) model, one usually assumes that firms need a collateral asset to secure their external financing as in Kiyotaki and Moore (1997), and specifies the collateral asset as houses, such as Iacoviello (2005), and Liu, Wang, and Zha (2013) et al. These types of models succeed in explaining either the close correlation between house prices and nonresidential investment or the close correlation between house prices and consumption, but fails in explaining the contrast between the high volatility of house prices and the low volatility of rental prices. Therefore to explain the observed difference between the volatility of house prices and the volatility of rental prices in a DSGE model, in addition to incorporating the financial frictions as in Liu, Wang, and Zha (2013), one should consider other types of mechanism, such as the information frictions in Guo (2017a), into the standard DSGE model for quantitative macroeconomic analysis of housing dynamics.

In the standard DSGE model with financial frictions, houses can be viewed as assets (see Equation (20) in Liu, Wang, and Zha (2013)). If we define the rental prices as the marginal rate of substitution (MRS) between housing consumption and goods consumption, the asset pricing theory implies that house prices are determined by the discounted sum of future rents. With consumption smoothing, the model predicts that the volatility of house prices is much lower than the volatility of output (see Liu, Wang, and Zha (2013) for a detailed discussion). However, if households have heterogeneous information about the future average MRS between housing consumption and goods consumption, house prices will also be determined by households' expectations of other households' expectations of the future average MRS, households' expectations of other households' expectations of other households' expectations of the future average MRS, and so on. In Guo (2017a, a similar idea can also be found in Guo (2017b)), it shows that higher-order expectations of the future average MRS play a potential role in determining the fluctuations of house prices and the disconnect between house prices and the discounted sum of future rents.

The other fact which standard macroeconomic models have difficulty in explaining is the lead-lag relationship between residential investment and nonresidential investment over the business cycle(see Davis, 2010, for a survey). The reason why standard real macroeconomic models have difficulty in explaining the lead-lag relationship is because nonresidential capital produces market consumption and investment goods, whereas residential capital produces only home consumption goods (e.g. Fisher, 2007). The asymmetry in how many goods to substitute away from residential capital provides a strong incentive to substitute away from residential capital toward nonresidential capital after a productivity shock. In our model, with incomplete information firms cannot fully observe the true TFP shocks, so the model generates a dampened response of nonresidential investment to TFP shocks. On the other side, since the amplified response of house prices mainly comes from the rising demand of real estate from households, the response of residential investment to TFP shocks is dampened, but to a smaller degree. In total, the correlation between lead residential investment and nonresidential investment increases, as does the correlation between lead residential investment and output. Our calibration shows that the correlation between lead residential investment and nonresidential investment increases from a negative value to a large positive value.

The remainder of the paper is organized as follows. Section 2 provides empirical evidence

about the two facts in the housing market and the business cycle. Section 3 introduces two simple models to analyze the two facts. Section 4 discusses the empirical results of the two models. Finally, section 6 concludes.

2. Empirical Facts in the Housing Market

Figure 1 illustrates the cyclical components of house prices and rental prices with the business cycle for the United States from 1975Q1 to 2010Q3.We collect the data of output, consumption, residential investment, and nonresidential investment from the St. Louis Fed (all data are log-linearized and filtered using the Hodrick-Prescott filter). House prices are closely correlated with the business cycle and their correlation with U.S. GDP is around 0.52. In contrast, rental prices are almost uncorrelated with the business cycle and their correlation with U.S. GDP is less than 0.06. Furthermore, house prices are much more volatile than output and their standard deviation is around 1.55 times of the standard deviation of output. However, rental prices are much less volatile and their standard deviation is only 0.46 times of the standard deviation of output.
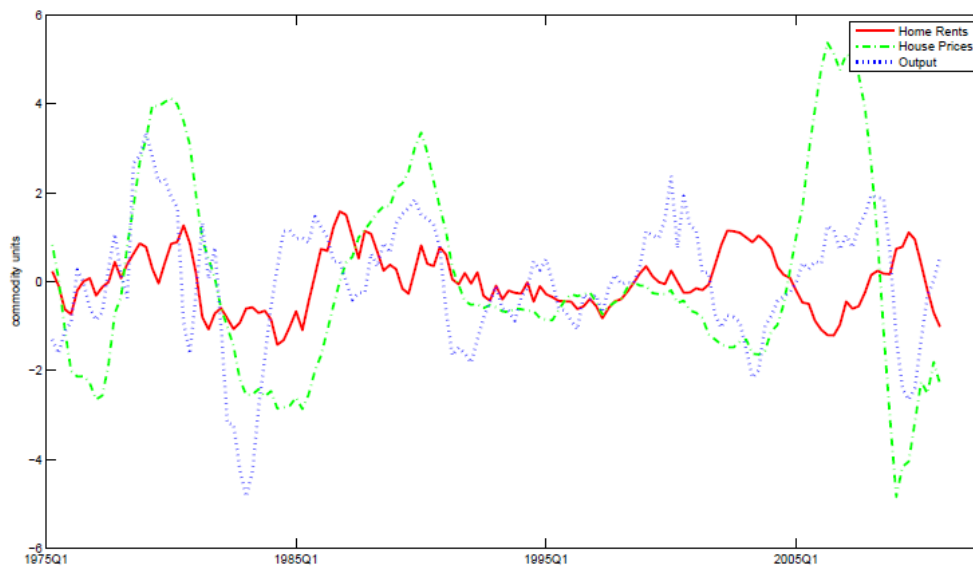

Figure 1. Home rents and house prices with the business cycle

Since residential investment and nonresidential investment are much more volatile than output, for illustration purpose we normalized the cyclical components of residential investment, nonresidential investment and output. Figure 2 displays the dynamics of residential investment, nonresidential investment and output over the business cycle for the United States from 1975Q1 to 2010Q3. The three components present quite close fluctuations over the business cycle, but residential investment leads the output and nonresidential investment moves contemporaneously with the business cycle.
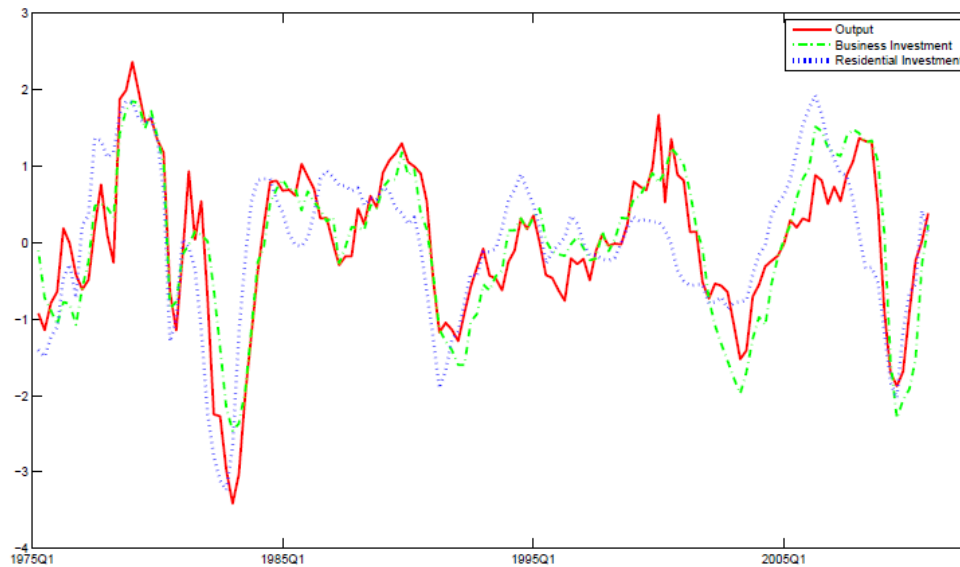
Figure 2. Residential investment and nonresidential investment with the business cycle

3. Simple Models for Analyzing Housing Dynamics

In this section, we empirically present the two facts that existing macroeconomic models have difficulty in explaining: the disconnect between house prices and the discounted sum of future rents; and the lead-lag relationship between residential investment and nonresidential investment. As discussed in Mayer (2011), to investigate the disconnect between house prices and the discounted sum of future rents, there are three alternative approaches commonly used in the literature: the user-cost methodology which compares the present discounted value of future rents with house prices; the construction-cost approach that compares the cost of constructing a new home with house prices; and the affordability approach which compares the ability of potential buyers of the house with house prices. In this paper, we consider the user-cost approach for its popularity used in the literature. This approach takes the simple non-arbitrage condition that the rent-price ratio should be equal to the user cost of housing, which is the sum of the after-tax equivalent-risk opportunity cost of capital and the expectation of future house prices appreciation excluding maintenance cost. This implies that the following relationship holds at each point in time:

$$\frac{R_t}{P_t} = \alpha_0 + \alpha_1 i_t + \alpha_2 \frac{(1-\delta_h)P_{t+1}-P_t}{P_t} + \varepsilon_t, \tag{1}$$

where R_t is the rental price for a representative home for one year at time t, P_t is the corresponding purchase price of the same home, i_t is the opportunity cost of capital, δ_h is the home depreciation rate, and ε_t is white noise.

The second fact that we want to investigate is the lead-lag relationship between residential investment and nonresidential investment over the business cycle. Let I_t^S, I_t, and Y_t denote residential investment, nonresidential investment and output respectively, we first calculate the simple Pearson correlation coefficient:

$$\rho(I_{t-i}^S, I_{t-j}), \quad \rho(I_{t-i}^S, Y_{t-j}) \text{and} \quad \rho(Y_{t-i}, I_{t-j}), \tag{2}$$

Where i and j are time lags.

To further investigate the causality effect between residential and nonresidential investment,

we conduct a bivariate vector autoregression (VAR) with a Granger-causality test for these two types of investment. To apply the Granger-causality test, we first test whether the two series have a unit-root process by the Dickey-Fuller test. If the two series are of I(1), we further test whether the two are co-integrated. If we cannot detect a cointegration relationship between the two series, the following formulation is used in testing the null hypotheses:

$$\begin{cases} \Delta I_t^s = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i}\, \Delta I_{t-1}^s + \sum_{i=1}^{k} \alpha_{2i}\, \Delta I_{t-i} + \varepsilon_{1t} \\ \Delta I_t = \beta_0 + \sum_{i=1}^{k} \beta_{1i}\, \Delta I_{t-1}^s + \sum_{i=1}^{k} \beta_{2i}\, \Delta I_{t-i} + \varepsilon_{1t} \end{cases} \quad (3)$$

Failing to reject the H₀: $\alpha_{21} = \alpha_{22} = \cdots = \alpha_{2k} = 0$ implies that nonresidential investment does not Granger cause residential investment. Likewise, failing to reject H₀: $\beta_{11} = \beta_{12} = \cdots = \beta_{1k} = 0$ implies that residential investment does not Granger cause nonresidential investment. If the series are cointegrated, we need to incorporate an error correction term in testing the null hypotheses:

$$\begin{cases} \Delta I_t^s = \alpha_0 + \delta_1(I_t^s - \lambda I_t) + \sum_{i=1}^{k} \alpha_{1i}\, \Delta I_{t-i}^s + \sum_{i=1}^{k} \alpha_{2i}\, \Delta I_{t-i} + \varepsilon_{1t} \\ \Delta I_t = \beta_0 + \delta_2(I_t^s - \lambda I_t) + \sum_{i=1}^{k} \beta_{1i}\, \Delta I_{t-i}^s + \sum_{i=1}^{k} \beta_{2i}\, \Delta I_{t-i} + \varepsilon_{2t} \end{cases} \quad (4)$$

in which δ₁ and δ₂ denote speeds of adjustment. Failing to reject the H₀: $\alpha_{21} = \alpha_{22} = \cdots = \alpha_{2k} = 0$ and δ₁=0 implies that nonresidential investment does not Granger cause residential investment. Likewise, failing to reject H₀: $\beta_{11} = \beta_{12} = \cdots = \beta_{1k} = 0$ and δ₂=0 implies that residential investment does not Granger cause nonresidential investment.

5. Model Results

We collect house prices and rent data from 1960Q1 to 2010Q3 from the Federal Housing Finance Agency (FHFA) home price index, and use the data with the same period from the Case-Shiller-Weiss (CSW) home price index as a robustness check. The FHFA series is well-known for its broad geographic coverage, but it covers only conventional mortgages. On the other hand, the CSW series covers both conventional and unconventional mortgages (see Davis and Heathcote (2007) for a detailed description of the data set). By assuming that the risk premium of house price fluctuations is constant, we take the federal funds rate to approximate the opportunity cost of capital. To introduce maintenance costs, we assume that houses depreciate at a constant rate δ_h=0.01 as in Iacoviello and Neri (2010). Table 1 presents the regression results of Equation (1). The results show that appreciation in house prices has almost no explanatory power in the fluctuations of the rent-price ratio. One percent increases in house prices predict around 0.09 increases in rent-price ratio for the FHFA series, and around 0.02 increases for the CSW series. The null hypothesis α₂=1 is rejected at any significance level for both of the two data sets. Thus, the regression results confirm the disconnect between house prices and the discounted sum of future rents.

Table 1: House price appreciation and rental prices

	α_0	α_1	α_2
The FHFA series	0.0449**	0.0022**	0.0899**
The CSW series	0.0439**	0.0024**	0.0191**

** indicates rejection at 1% significance level.

The literature in home production has demonstrated that residential investment leads the business cycle and nonresidential investment lags the business cycle for the U.S. economy. However, Kydland, Rupert, and Šustek (2016) empirically show that the lead-lag relationship

in the developed countries only holds for the two Western-Hemishpere countries: USA and Canada, and in other developed economies there is no such a clear feature of the lead-lag relationship between either residential investment or nonresidential investment and the business cycle. We reconsider the fact and calculate the correlations among the lead (lag) residential investment, the lead (lag) business investment, and the lead (lag) output as in Equation (2) for the following countries and periods: Austria (1988Q1-2012Q2), Finland (1975Q1-2012Q2), France (1978Q1-2012Q2), Netherlands (1988Q1-2012Q2), the U.K. (1970Q1-2012Q2), the EU (1988Q1-2012Q2), Australia (1959Q3-2012Q2), Canada (1981Q1-2012Q2), and the U.S. (1960Q1-2012Q2). The EU is aggregated by the five following countries: Austria, Finland, France, Netherlands, and the U.K.. We collect the data for the European countries from the Eurostat, for Canada from the OECD, for Australia from Australian Bureau of Statistics, and for the U.S. from the St. Louis Fed, and all the data are logged and Hodrick-Prescott filtered. In Table 2, our main results confirm the leading (lagged) role of residential (nonresidential) investment over the business cycle in the U.S. and Canada. In other developed countries, there is no clear order among the second moments except Finland, which also shares this feature to some extent. One interesting thing in our calculation is that if we aggregate the five countries in the Europe together, the aggregate will also somewhat perform like the U.S. and Canada.

Table 2: Second Moments - Empirical lead-lag correlations

	Austria	FIN	FRA	NET	UK	EU	AUS	CAN	US
$\rho(I^s_{t-1}, I_t)$	−0.359	0.453	0.576	0.227	0.210	0.301	0.355	0.398	0.503
$\rho(I^s_t, I_t)$	−0.268	0.378	0.618	0.567	0.094	0.288	0.267	0.228	0.289
$\rho(I^s_{t+1}, I_t)$	−0.161	0.202	0.448	0.138	−0.029	0.182	0.137	0.018	0.021
$\rho(I^s_{t-1}, Y_t)$	0.047	0.669	0.540	0.378	0.467	0.722	0.519	0.640	0.689
$\rho(I^s_t, Y_t)$	0.029	0.668	0.595	0.489	0.513	0.715	0.578	0.580	0.571
$\rho(I^s_{t+1}, Y_t)$	0.019	0.560	0.604	0.463	0.454	0.618	0.503	0.378	0.345
$\rho(I_{t-1}, Y_t)$	0.381	0.452	0.082	0.416	−0.063	0.495	0.335	0.491	0.498
$\rho(I_t, Y_t)$	0.473	0.653	0.186	0.584	0.007	0.596	0.479	0.662	0.724
$\rho(I_{t+1}, Y_t)$	0.484	0.737	0.261	0.610	0.089	0.621	0.510	0.745	0.797

I^s_t, I_t, and Y_t denote residential investment, nonresidential investment and output respectively.

The data we use in testing Equation (3) or (4) are the same as in Table 2. However, we conduct the Granger-causality test for the period from 1984Q1 to 2005Q4 in the U.S. as a robustness check to avoid the potential problem of structural changes, since this period is well-known for its low volatility of the business cycle in contrast to other periods. The lag parameter k is selected by the Akaike information criterion (AIC). Table 3 shows the fact that in the U.S. and Canada residential investment Granger causes nonresidential investment and nonresidential investment does not Granger cause residential investment. This fact is very clear in Canada, but in the U.S., we can reject the null hypothesis that residential investment does not Granger cause nonresidential investment at any significance level, whereas we cannot reject the null hypothesis that nonresidential investment does not Granger cause residential investment for the period from 1984Q1 to 2005Q4 at 5% significance level, and for the period from 1960Q1 to 2010Q3 at 1% significance level. In other developed countries, there is no such feature similar as in the U.S. and Canada, except in Australia and the U.K. In contrast to the lead-lag relationship that the European aggregate shares with the U.S. and Canada, we cannot see such a similarity for the Granger causality of the two types of investment between the two regions.

Table 3: The causality test between residential and business investments

Country	Lag	$I_t^s \longrightarrow I_t$		$I_t \longrightarrow I_t^s$	
		χ^2 Value	p Value	χ^2 Value	p Value
Austria	4	4.120	0.390	8.199	0.085
Finland	6	13.63	0.034	12.318	0.055
France	6	116.52	0.000	99.495	0.000
Netherlands	4	5.311	0.257	7.454	0.114
UK	2	8.121	0.017	5.052	0.080
Euro	2	2.331	0.312	5.874	0.061
Australia	4	22.649	0.000	5.303	0.258
Canada	2	10.190	0.006	5.611	0.060
USA (1960Q1~2012Q2)	4	181.9	0.000	13.8	0.014
USA (1984Q1~2005Q4)	2	158.8	0.000	5.1	0.076

6. Conclude

The recent standard quantitative business cycle models with financial frictions succeed in explaining the close correlations among house prices, consumption, and investment. However, the models cannot explain two facts: the disconnect between house prices and rental prices, and the lead-lag relationship between residential investment and nonresidential investment. In this paper, we test the two facts using data from a variety of countries. Our results confirm the two daunting facts faced by most of the macroeconomic modelers: (i) house prices are highly volatile and closely correlated with the business cycle, which is at odds with the evidence that rental prices are relatively stable and almost uncorrelated with the business cycle; and (ii) residential investment leads the business cycle while nonresidential investment moves contemporaneously with the business cycle. Guo (2017a) presents a potential framework by introducing information heterogeneity into a standard real business cycle model with real estate production and financial frictions to explain the two facts. By assuming that agents are rationally confused about the sources of shocks, the model generates an amplified response of house prices to technology shocks, which explain the disconnect puzzle. Since the amplified response mainly comes from the rising demand of real estate from households, the model also partially explains the lead-lag relationship between residential investment and nonresidential investment. How to rigorously calibrate the model parameters is left for future research.

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