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Supply, Demand and Prices in the US Housing Market*

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Abstract

The slowdown in the US economy in 2008, and in the housing market in particular, has been accompanied by a sharp fall in house prices and a glut of homes for sale on the market. While the idea that this overhang of dwellings for sale should place downward pressure on house prices is intuitive, little empirical work has been done in this area. This paper explicitly models the relationship between changes in house prices and various measures of housing supply. The results show that months supply of new homes places greater downward pressure on house prices that the months supply of existing homes. We build a small simulation model to examine the evolution of the housing market.

JEL classification: R21, R31.

Keywords: Housing market, supply, prices.

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1 Introduction

The collapse in US house prices was a crucial contributor to the global financial crisis. Had house prices not declined, the absence of negative equity would have meant less subprime defaults, while the losses associated with any such defaults would have been small, related only to the bureaucratic costs associated with foreclosures. One of the most commonly-cited facts about the housing market over this period has been that there have been very substantial supplies of homes for sales, particularly when compared with the low prevailing level of home sales. It has been widely conjectured that this "glut" of houses for sale is likely to be a factor continuing to depress house prices for some time. While the underlying reasoning behind this idea—that excess supply should lead to price declines—is clear, there appears to have been very little empirical work done on this relationship. One exception was a chart reported in a post in 2008 by the highly respected blogger *Calculated Risk*, illustrating a strong negative relationship between the months supply of existing homes and the rate of change of US national home prices.[1]

The idea of a connection between price adjustment and excess supply in the market features prominently in other areas of macroeconomics. In particular, the literature on the Phillips Curve is based on the hypothesis that there exists a link between price or wage changes and a measure of the degree of slack in the labour market. Since the emergence of the financial crisis in the US over the course of 2007 and 2008 had its roots in the problems which materialised in the housing market, understanding the dynamics of the housing market is clearly also extremely important in assessing and monitoring the overall health of the macroeconomy. In this context, examining the relationship between excess housing supply and house prices—a sort of Phillips Curve for housing—may yield useful insights for assessing the state of the macroeconomy.

This paper has three goals. First, the paper provides a new econometric examination using US data of the relationship between house prices and the supply of homes for sale. In particular, we explore the question of which definition of housing supply- new homes, existing homes or vacant homes- has the most effect on house prices. The small amount of

[1] See calculatedrisk.blogspot.com/2008/05/scatter-graphs-months-of-supply-vs.html

existing work in this area has used the months supply of existing homes as the explanatory variable for house prices.

A particularly strong relationship is found between the change in house prices and months supply for new homes. Indeed, supply conditions in the market for existing homes, the vacancy rate, time on the market and other fundamental variables such as mortgage rates or GDP growth are found to have little impact on house prices once one controls for the role of supply conditions in the market for new homes. This is not to say that fundamental variables such as growth or interest rates have no effect on house prices. Rather, it is that they impact house prices via their effect on months supply of new homes: For instance, low mortgage rates may stimulate new homes sales, thus reducing months supply and so raising house prices generally.

Second, the paper examines the dynamics of this relationship. If we know that there is excess supply in the market and that it is depressing house prices, the obvious question is: What happens next? In other words, how does the housing market tend to unwind itself from this position and how long does it take? This is addressed by separately examining the behaviour of new home sales as well as the supply side of the market. Some interesting results are obtained. For example, a high level of months supply has a significant negative effect on the number of new homes put on the market for sale, which contributes to the excess supply being wound down. Slowing this unwinding from a situation of high supply and falling prices, however, is the fact that new home sales depend positively on the growth rate of house prices, so falling prices also tend to depress house price sales.

Finally, the empirical equations estimated in this paper produce a simple recursive dynamic model that can be simulated to project the future evolution of new home sales, supply, and house prices. Impulse-response analysis and forecast projections are presented.

2 Housing Market Slack and House Prices: Which Measure Works Best?

The existing literature on the relationship between house prices and supply in the housing market is sparse. Klyuev (2008) looking only at existing home sales- finds that the inventory-to-sales ratio and the number of foreclosures are significant determinants of changes in house prices in the short run. This focus on existing homes is not surprising since the majority of homes sold every period are existing homes. In the US data used in this study, over the period 1990 to 2008, existing homes sales accounted for around 80 per cent of total home sales.

However, it could be argued that the supply of new homes could have a stronger effect on house prices. To use an analogy with labour market search theory, existing homes for sale are analogous to workers engaging in on the job search while new homes for sale are analogous to the unemployed. A pool of unemployed workers may be more likely to accept jobs offering lower wages compared to workers engaged in on-the-job search. Similarly, those who have an empty or soon-to-be-completed new home available for sale may be more flexible in adjusting prices downward than those who are living in existing homes.

In addition to the supply of new and existing homes, a third possible source of price pressure in the housing market is the number of vacant homes. The Census Bureau define the vacancy rate as the proportion of the homeowner inventory that is vacant for sale. The long run average vacancy rate stood at 1.4 per cent over the period 1965 to 2004 but increased to almost 3 per cent in 2008 and currently measures 2.1 per cent. Using a broader definition of housing vacancy comprising the number of houses for sale and for rent, the vacancy rate stood at 4 per cent in Q1 2012, well above the long-run average rate of 3.4 per cent.

It could be argued that a high prevailing rate of home vacancy would place downward pressure on house prices. Drawing on labour market search theory, the vacancy rate in the housing market is similar to vacant jobs in the labour market. In labour market search theory models (Diamond,1981), vacant jobs are matched with unemployed workers with the same distribution if workers are laid off randomly. Employed workers can be encouraged to switch jobs if the vacant job has greater productivity. While this matching process could be applied to the housing market, Wheaton (1991) notes that the housing market is also significantly different to the labour market. Homelessness (equivalent to unemployment) is not widely observed in the housing market where moves are usually voluntary and involve the household owning two units. In contrast, voluntary job movements in the labour market usually involve periods of unemployment. Thus while the idea that changes in house prices and the vacancy rate should be negatively correlated is intuitive, it is not clear that vacant homes and new buyers in the housing market are matched in the same way as vacant jobs and workers in the labour market.

The empirical analysis in later sections of this paper investigates which measure of housing market slack performs best in explaining changes in house prices.

3 Review of Related Literature

3.1 House Prices and Fundamentals

A popular approach in the literature involves estimating a model of the housing market based on fundamentals where prices are determined by factors such as income, interest rates and demographics. While this literature is vast and has been applied to the analysis of housing markets in many countries (see Girouard, Kennedy, Van Den Noord, and André (2006), ECB (2006), Smyth, McQuinn, and O'Reilly (2009)) it is rare for these models to incorporate measures of supply in the housing market. Klyuev (2008) provides an example of this approach for the US housing market. Using both the fundamentals model and an asset pricing approach, where prices are linked to real rents and interest rates, both models indicate substantial overvaluation in the US housing market starting from 2001. Klyuev (2008) also examines the short-run dynamics of house prices but does not find a statistically significant error-correction relationship in which house prices respond to the gap between actual and equilibrium home prices. Rather, Kyluev- looking only at existing home sales- finds that the inventory-to-sales ratio and the number of foreclosures are significant determinants of changes in house prices in the short run.

The analysis in Klyuev (2008) and Girouard, Kennedy, Van Den Noord, and André (2006) based on fundamentals models of house prices indicates that house prices can deviate from equilibrium substantially and for long periods of time. As a result, Klyuev (2008) suggests that the extent of over- or undervaluation estimated using fundamentals-based models may not be a good predictor of future house price changes. Rather Klyuev argues that the inventory to sales ratio, by providing a measure of the imbalance between supply and demand in the market, is a more important determinant of short-run changes in house prices. We extend and develop this approach in Section 4 and Section 5 of this paper.

3.2 Labour Market Search Theory

The second stream of the literature on the determinants of changes in house prices which is of particular relevance for the analysis carried out in this paper is based on the application of search theory to the housing market. Search theory has been applied widely in labour economics to explain why labour markets do not clear, since at any point in time there are jobless workers who search for work (unemployment) and firms that look for workers (vacancies).

In the search and matching models of the labour market such as those developed by Burdett and Mortensen (1980) and Pissarides (1985), workers depart from jobs in response to an exogenous shock and then find new employment from among the vacancies so created. Since job search is time consuming, costly and uncoordinated decisions about job acceptance determine vacancy duration. When a job seeker and an employer are matched, the wage is determined by the tightness of the labour market, i.e., the ratio of unemployed workers to the number of vacancies. Equilibrium in the labour market (unchanging unemployment rate) implies that the inflow from employment into unemployment equals the outflow from unemployment to employment.

3.3 Search Theory and the Housing Market

The search and matching models from the labour market have been applied to housing reflecting the existence of a number of parallels between the housing market and the labour market. Similar to the labour market, the coexistence at any point in time of a stock of vacant houses and a pool of buyers searching for houses suggests that the housing market may not clear immediately. In the housing market, as in the labour market, the number of vacancies (or "unemployed houses") and the time it takes to sell a home both vary over time. Wheaton (1990) was the first to apply search theory to the housing market. In his paper, Wheaton notes that the assumption in labour market matching models of fixed jobs and workers fits well with the housing market's stock-flow character where prices adjust in the short run to equate demand to a fixed stock.

Wheaton (1990) develops a model which yields a strong theoretical inverse relationship between vacancy and prices. In the model, houses and households become mismatched in response to a shock. The prospect of remaining mismatched determines the search effort while sellers' reservation prices are determined by expectations about sales time and the cost of holding housing units. Higher vacancy in this model increases sales time, lowers seller reservations, speeds up search time and results in lower market prices. Over time, new units are added to the stock and vacancy adjusts until the marginal cost of such units equals the expected price, the price discounted by expected sales time. The vacancy rate at which the expected price equals the marginal cost is the market's long-term structural rate. The model explains the coexistence of vacancy and prices due to transactions costs in the search process.

A larger literature has grown out of this seminal work by Wheaton (1990). Williams (1995) develops a stocastically evolving version of Wheaton's model where the cost of being in each state (matched, unmatched etc.) changes over time. Krainer (2001) develops a model where agents experience idiosyncratic preference and aggregate demand shocks. Krainer's model generates a positive correlation in sales, prices and selling probabilities.

Diaz and Jerez (2010) build on the work of Wheaton (1990) and Krainer (2001) by also examining the effect of aggregate shocks in the per capita supply of housing. The authors develop a search model of the housing market where households experience idiosyncratic supply and demand shocks, become mismatched and seek to buy a new home. They characterise a stationary equilibrium for a fixed housing stock and then calibrate a stocastic version of the model to reproduce selected statistics for the US housing market. The model is consistent with a positive correlation of sales and prices in the market. Higher demand for houses implies that more housesholds become mismatched which raises sales and price. Since it becomes more difficult for buyers to find a suitable match, the increase in demand is propagated into the next period.

In a related paper, Ngai and Tenreyro (2009) develop a matching model to explain "hot" and "cold"' seasons in the US housing market. A hot season is defined as one in which there is high prices, many buyers and sellers and a high level of transactions. Ngai and Tenreyro (2009) explain the existence of hot seasons in the housing market using the notion of thick market effects. In their model the utility buyers derive from a house is determined by the match-specific quality of the buyer and the house. In a thick market (the hot season), there is a higher probability that better quality matches will be formed. This mechanism leads to a higher number of transactions and prices in the hot season when there are a large number of buyers and sellers.

This paper is concerned with estimating an econometric relationship betweeen changes in house prices and different measures of months supply of houses. Zuehlke (1987) uses a search theoretic approach to examine the relationship between probability of sale and market duration in the housing market. The results of this model suggest stronger incentives for sellers of vacant houses to accept lower reservation prices than the seller of an occupied house because the return to owner equity is foregone with a vacant house.

These insights from the search theory literature, in particular the explanations and predictions provided by the theortical models for the likely response of house prices to changes in supply and demand, provide a useful framework in which to explain the empirical results presented in Section 4 and Section 5 of the paper.

4 Months Supply and House Prices

4.1 Data Sources

The data used in later sections of the paper come from a number of different sources. The idea that seasonal factors would play an important role in the housing market is not immediately obvious. However, each year in most regions of the US and in the U.K., there are predictable seasonal cycles in both housing market activity and house prices. In both the US and the U.K., stronger house price growth tends to be recorded during Spring and Summer with less activity and lower prices during Autumn and Winter.[2]

Because of these seasonal factors, our analysis of house prices uses the seasonally adjusted Case-Shiller price index which is available from 1987:Q1 onwards (the last observation in our analysis is 2012:Q1). Because this index is based on repeat sales rather than on averages of house prices or hedonic regressions, it is widely thought to be the highest quality house price index available for the United States. The repeat sales method involves using data on properties which have sold at least twice in order to capture the true appreciated value of each specific sales unit.

Since the Case-Shiller index is only available from 1987, in order to compile a longer time series for estimation purposes we splice the Case-Shiller data with two other price indices to obtain a continuous series back to 1968. (The analysis only uses the year-over-year percentage change, so there are no issues relating to splicing levels together).

From 1976:Q1 to 1986:Q4, we use the FHFA (formerly OFHEO) price index and from 1968:Q1 to 1975:Q4, we use the median price for existing home sales from the National Association of Realtors.[3] The Case-Shiller index is seasonally adjusted while the indices

[2]Ngai and Tenreyro (2009) find that the differences between annualised growth rates between "hot" and "cold" seasons is 6 per cent for real house prices and 108 per cent for the volume of transactions.

[3]To address concerns that the use of this series containing seasonally adjusted and non-seasonally adjusted components could produce biased results, we also estimate our model using the FHFA non-seasonally adjusted series for the full period. The results obtained using the FHFA series are not significantly different to those obtained using the series constructed from the three separate house price indices.

produced by the FHFA and the National association of Realtors are not. As a result of the splicing together of the seasonally adjusted and non-seasonally adjusted series in this manner, in the regressions we focus on the year-over-year change in house prices. Our analysis uses changes in real house prices. We construct this series by deflating the nominal series using the consumer price index (all items) data from the Federal Reserve Bank of St. Louis database (FRED).

In this paper, we examine the relationship between house prices and two different measures of months supply along with other measures of slack in the housing market. The months supply of existing homes series comes from the National Association of Realtors and is available monthly from 1982:1. The majority of existing homes sales transactions are recorded when the sales contract is signed. The series for new single family houses for sale and the number of new homes sold come from the US Census Bureau New Residential Sales Statistics. The data for this series are available from 1963:1. We construct our own measure of months supply at the current sales rate is calculated by dividing the number of homes for sale in each period by the number sold during that period.

A new home can be at any stage of construction: not yet started, under construction or completed. The Census Bureau define the sale of a new house as occurring with the signing of a sales contract or the acceptance of a deposit. As a result, new home sales usually lead existing home sales as an indicator of changes in the property market by around a month or so. In addition to the two measures of months supply, we examine the relationship between house prices and the vacancy rate. The vacancy rate is calculated as the sum of the number of homes for sale plus the number for rent divided by the total number of housing units. The vacancy data are published on a quarterly basis since 1965:1 by the US Census Bureau. The data on time on the market, which will be used in the analysis in Section 4, come also from the Census Bureau and are available monthly since 1975:1.

The other series used in the analysis, namely GDP and the mortgage interest rate series come from the Federal Reserve Bank of St. Louis Economic Database (FRED). We use the 30-year conventional mortgage interest rate and construct the real interest rate taking the nominal rate and then subtracting CPI inflation.

The data on the number of households, which is used in section 6 to scale our supply and demand variables, come from the US Census Bureau Census of Population statistics.

4.2 House Prices and Two Measures of Months Supply

The first goal in the paper is to estimate a relationship between the change in house prices and a measure of the balance between supply and demand in the housing market. Calculated Risk's chart displayed the rate of change of nominal house prices and months supply of existing homes over a relatively limited sample, 1994:Q1 to 2008:Q1. Here, we use a longer sample (from 1968 to 2012) and use real house prices as the dependent variable controlling for movements in the general price level by dividing the house price index by the Consumer Price Index.

We also use two different measures of months supply: The existing homes measure used by Calculated Risk and by Klyuev (2008) and the months supply of new homes as measured by the US Census Bureau. An excess supply of new homes may exert more influence on the general level of house prices because building contractors stuck with excess houses are perhaps more likely to need a quick sale than those who can live in their homes and afford to wait for a higher price to come along. As mentioned above, the Census Bureau new homes series also has the advantage that is available over a longer time period.

Figure 1 shows a scatter plot of the year-over-year percentage change in real house prices against the months supply of existing homes. The sample for this chart is 1982:Q2 to 2012:Q1. The chart shows a reasonably strong relationship, with the underlying correlation being 0.61. Figure 2 shows, however, that the relationship between the growth rate of real house prices and months supply of *new* homes—which can be estimated over the longer sample of 1968:Q1 to 2012:Q1—is noticeably stronger, with a correlation of 0.75. In fact, this relationship has strengthened over time, so when compared over the same samples, the difference in correlation is 0.61 for the existing homes measure and 0.78 for the new home measure.

Figure 3 shows this scatter diagram is consistent with a striking time-series correlation

Figure 1

Real House Price Growth against Months Supply of Existing Homes (Correlation=-0.59)

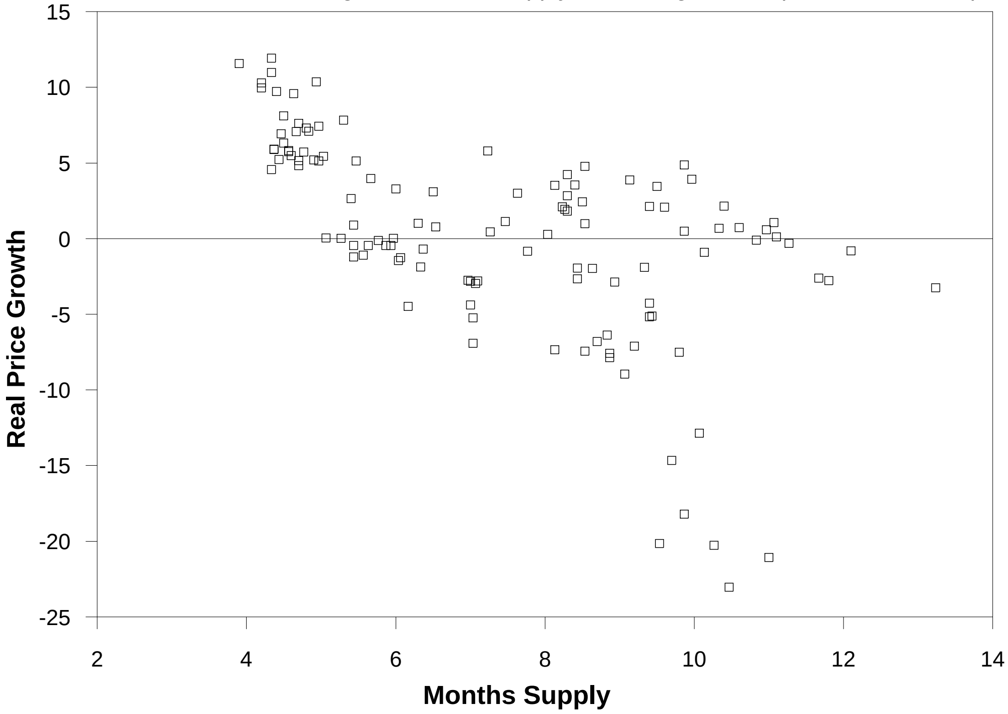


Figure 2

Real House Price Growth against Months Supply of New Homes (Correlation=-0.73)

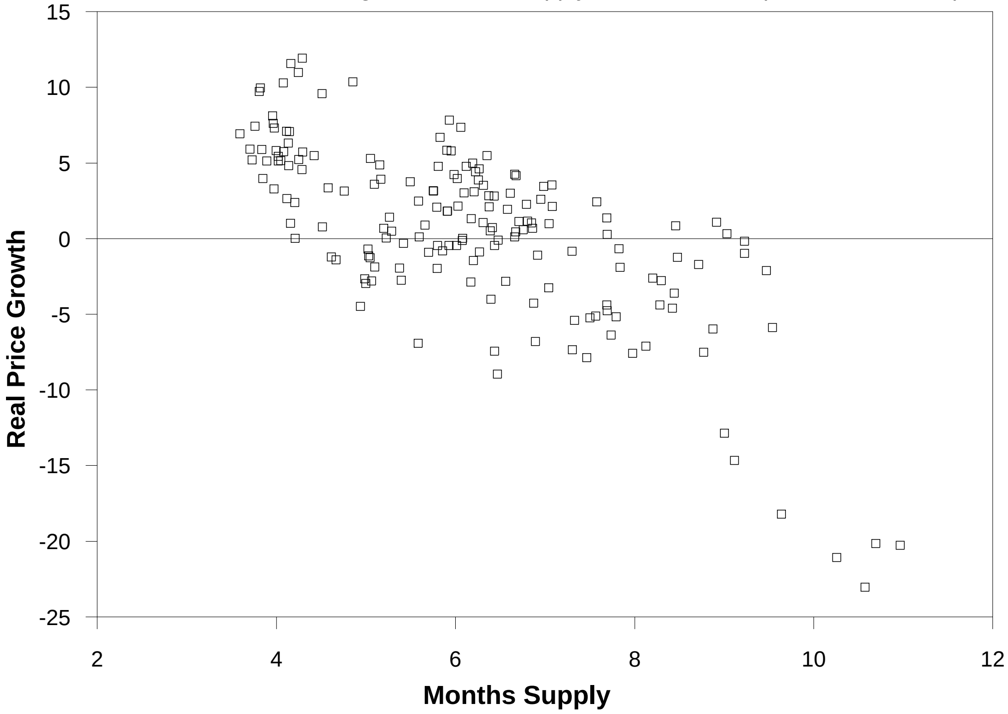
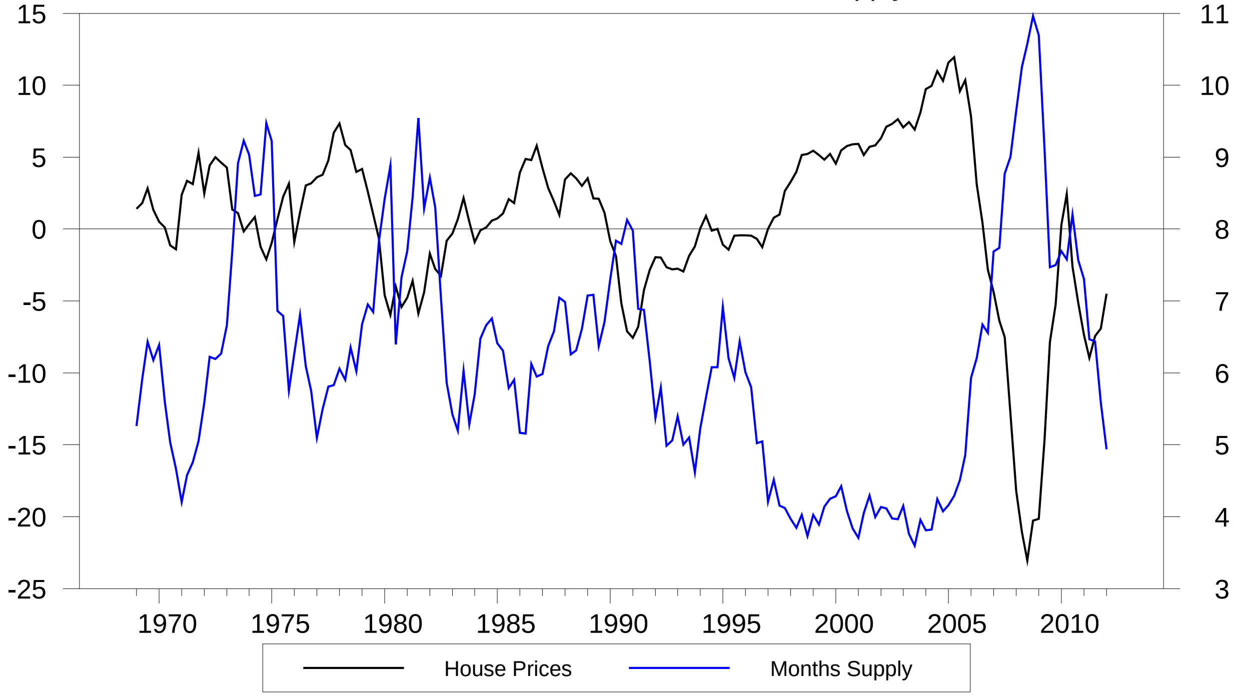


Figure 3

Real Year-over-Year House Price Growth and Months Supply of New Homes



between the rate of growth in house prices and the balance between supply and demand indicated by the months supply series. Each of the clear booms or busts in house prices have been accompanied by a corresponding movement downwards or upwards in months supply. Most notably, the recent house price bust saw the move in house prices from rapid growth to substantial declines mirrored by a similarly sharp swing in months supply. Months supply has increased sharply from around four months during the period of strong house price growth between 2002 and 2007 to over 11 months in the period coinciding with the contraction in house prices since 2008.

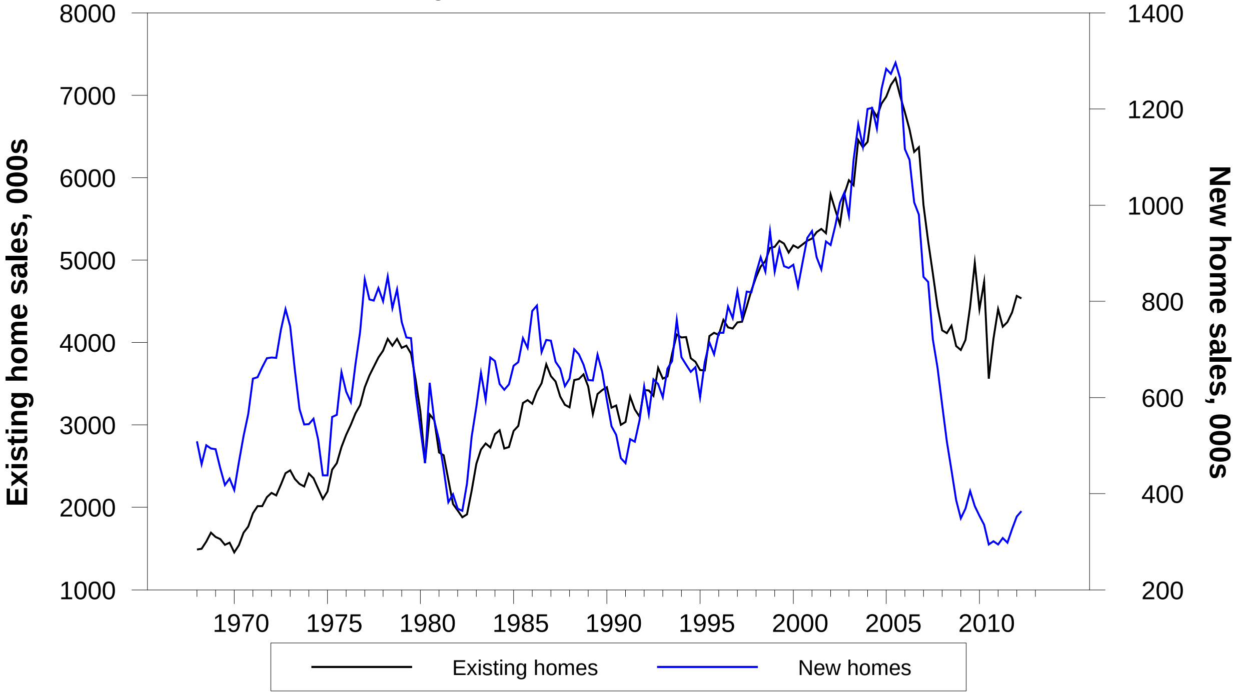
4.3 Recent Housing Market Developments

Figure 3 illustrates that a strong inverse relationship between house prices and months supply of new homes has existed over much of the period 1970 to 2012. However, over recent quarters there appears to have been some breakdown in this relationship with house prices and months supply both moving in the same direction as shown in Figure 3. There are a number of possible explanations as to why the recent relationship between supply and prices in the US has not been as strong as in the past. The homebuyer tax credit introduced by the US Congress in 2009 provided a temporary boost to home sales leading to a reduction in months supply and a recovery in prices. The tax credit expired in mid 2010 and this has coincided with renewed weakness in house prices but at a reduced level of months supply reflecting the earlier impact of the tax credit on home sales.

Another recent development in the US housing market has been the emergence of a widening gap between new and existing home sales since mid-2007. As shown in Figure 4, trends in new home sales closely tracked movements in existing home sales up to mid-2007 at which point new home sales continued to decline sharply while existing home sales stabilised from early 2008. The emergence of this gap between new and existing home sales has been attributed to the increase in distressed property sales following the bursting of the property market bubble. The National Association of Realtors (NAR) have reported that up to 45 per cent of total home sales over recent months have been accounted for by distressed properties. The increase in distressed property sales has helped stabilise existing home sales

Figure 4

Existing home sales and new homes sales



while at the same time reducing new home sales as home builders and owners of new homes find it difficult to compete with distressed property sales.

In the following sections, we estimate a model of house prices using different measures of months supply in order to provide more formal econometric evidence for the trends and relationships displayed in Figures 1 to 3. In particular we examine the hypothesis that the months supply of new homes in the market appears to exert more pressure on prices than the supply of existing homes. Having specified and estimated an equation for house prices, we then build and estimate a small dynamic simulation model to examine the response of the housing market to shocks.

5 Model Results and Discussion

5.1 House Prices and Different Measures of Housing Market Slack

Table 1 reports the results of year-over-year changes in new house prices regressed on the two different definitions of months supply as well as the vacancy rate.[4] In the first column, the results from the regression of year-over-year changes in house prices on months supply of existing homes are reported. Confirming the intuition from Figure 1, a negative and significant coefficient is reported on the months supply of existing homes variable. This mirrors the result obtained by Klyuev (2008) who reported a negative relationship between house prices and the inventory to sales ratio using data for existing homes only.

[4] While we favour the use of year-over-year price changes given the way in which our house price series is constructed (Section 3), we experimented by estimating our model using quarter-over-quarter house price changes. While the magnitude of the estimated coefficients is different compared to the case when year-over-year changes in house prices is used, the overall regression results and hence the implications of the results do not change dramatically when the quarter-over-quarter change is used.

Table 1: House Prices and Months Supply

Dependent Variable: $\log(PH_t/CPI_t) - \log(PH_{t-4}/CPI_{t-4})$							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Constant	12.92	19.72	19.78	16.67	17.32	15.50	18.26
	(1.55)	(1.36)	(1.35)	(1.53)	(1.46)	(1.51)	(1.64)
$MSupply_t^e$	-1.72		-0.04				
	(0.25)		(0.16)				
$MSupply_t^{new}$		-3.30	-3.26	-2.62		-2.49	-2.72
		(0.24)	(0.31)	(0.26)		(0.25)	(0.26)
$MSupply_{t-1}^{new}$					-2.73		
					(0.26)		
GDP_t						0.56	
						(0.38)	
r_t							-0.19
							(0.12)
Sample	1982:2-2012:1	1982:2-2012:1	1970:1-2012:1	1970:1-2012:1	1970:1-2012:1	1970:1-2012:1	1970:1-2012:1
$\bar{R}^2$	0.35	0.69	0.68	0.54	0.58	0.54	0.58

Notes: Standard errors in brackets.

In column 2, the relationship between months supply of new homes and changes in prices is examined. The regression results are in keeping with the trend evident in Figures 1 and 2, that the months supply of new homes appears to drive house prices more than the supply in the larger existing home market. The coefficient on the new homes variable is almost twice as large as the coefficient on the existing homes variable in column 1 while the R^2 statistics indicate a substantially better fit in the second regression.

In column 3, we show the results when both measures of months supply are included in the same regression. The results in the third column show that when both months supply variables are included in a regression specification for the rate of change of real house prices, the existing homes series is statistically insignificant. This suggests that most of the variation in the house price series is driven by changes in months supply of new homes. Column 4 of the table estimates the relationship over the full sample. The coefficient on the months supply of new homes does not change substantially when the equation is estimated over this longer time period. Column 5 shows that the months supply series tends to lead house prices, with a specification based on a single lag having an R^2 of 0.58 compared with the 0.54 for the model based on the contemporaneous effect.

The result from the regression analysis indicating that months supply of new homes is a more important determinant of changes in house prices than the existing homes measure is confirmation of the intuition discussed in Section 1.

Zuehlke (1987) shows that the owner of a vacant house has stronger incentives to adopt diminishing reservation prices than the owner of an occupied house. Zuehlke argues that as search continues over time, the seller's wealth is reduced by the costs of search. Since this return to owner equity (or wealth effect) is forgone for the owner of a vacant house, the seller of a vacant house has a stronger incentive to accept lower prices than the owner of an occupied house.

Another factor mentioned by Zuehlke (1987) which makes it more likely for owner of vacant houses to accept diminishing prices is that such houses are more likely to deteriorate as a result of vandalism and neglect making a quick sale a more urgent priority for the owner of a vacant home. The results presented in Table 1 showing the importance of months supply of new homes on prices over the supply of existing homes provide empirical support that both hypotheses presented by Zuehlke (1987) are important in understanding the factors influencing changes in US house prices.

In addition to the months supply of existing and new homes, as noted in section 2 another possible source of price pressure in the housing market is the stock of vacant dwellings. Table 2 shows the results of the house price regression when the vacancy rate is included along with the two measures of months supply. Column (1) of the table shows that when the vacancy rate is included along with months supply of existing homes, the coefficients on both variables are significant and show the expected negative signs. Including the vacancy rate along with the months supply of existing homes improves the overall fit of the regression compared to the results in Column 1 of Table 1 where only the existing homes measure is used. The R^2 increases from 0.35 to 0.51 for the regression including the vacancy rate. The results indicate that high levels of vacancy in the housing market place downward pressure on house prices.

The results in Table 1 showed that months supply of new homes is a more important driver of house prices than the supply of existing homes. Column (2) of Table 2 shows the relationship between prices, months supply of new homes and the vacancy rate. The results mirror the earlier findings regarding the importance of months supply of new homes in driving house price changes. Although the coefficient on the vacancy rate has the expected sign, it is no longer significant when included with the months supply of new homes. When the vacancy rate and both measures of months supply are included in the same regression, the months supply of new homes again dominates with the coefficients on months supply of existing homes and the vacancy rate both insignificant.

5.2 House Prices, Months Supply and Fundamentals

Column 6 and column 7 of Table 1 show the regression results when two variables, GDP and real mortgage interest rates, typically included in fundamentals models of the housing

Table 2: House Prices, Months Supply and Vacancy

Dependent Variable: $\log(PH_t/CPI_t) - \log(PH_{t-4}/CPI_{t-4})$			
	(1)	(2)	(3)
Constant	32.15	20.88	22.01
	(4.53)	(3.25)	(3.17)
$MSupply_t^e$	-1.83		-3.06
	(0.21)		(0.36)
$MSupply_t^{new}$		-3.25	-0.16
		(0.23)	(0.21)
$Vacancy_t$	-4.85	-0.38	-0.67
	(0.96)	(0.67)	(0.85)
Sample	1982:2-2012:1	1982:2-2012:1	1982:2-2012:1
$\bar{R}^2$	0.51	0.69	0.68

Notes: Standard errors in brackets.

market, are added as explanatory variables along with our months supply measure.

The GDP variable, while displaying the correct sign is not significant in the regression. The mortgage interest rate variable enters with the correct sign and is statistically significant, however, its inclusion does not improve dramatically the overall fit of the equation compared to the case where the months supply variable is included on its own. When the latter equation is estimated over the shorter time period 1982-2012, the interest rate variable is no longer significant.

The mixed results obtained after including the GDP and interest rate variables suggest that after controlling for months supply, these fundamentals variables do not have significant explanatory power for house prices in this model. This is not to say that fundamentals do not have an important influence on house prices, rather the results indicate that months supply of new homes functions well as summary measure of the price pressures in the housing market. Variables such as interest rates and GDP are likely to effect months supply of new homes on the market and through this channel are likely to impact on house prices.

5.3 House Prices, Months Supply and Time on the Market

In both their theoretical model and in the empirical analysis, Diaz and Jerez (2010) illustrate the existence of a negative relationship between price and time on the market. Using his search theory model, Wheaton (1990) also argues that sales time and the market price for houses are negatively correlated. The data, which come from the US Census Bureau, show that median time on the market which averaged around four months over the period 2000 to 2008, increased sharply after 2008 and peaked at around 14 months in mid 2010.

Table 3 shows the results when we include the variable for time on the market (TOM) in our regression equation for changes in house prices. As reported in column 1, time on the market enters with a negative and significant coefficient when it is included in the house price regression along with months supply of existing homes. The addition of time on the market to the equation explaining changes in house prices improves slightly the overall fit of this regression with the R^2 increasing from 0.35 (column 1 of Table 1) to 0.45. As

Table 3: House Prices, Months Supply and Time on the Market

Dependent Variable: $\log(PH_t/CPI_t) - \log(PH_{t-4}/CPI_{t-4})$				
	(1)	(2)	(3)	(4)
Constant	15.39	20.45	9.79	17.89
	(1.79)	(1.49)	(1.68)	(1.69)
$MSupply_t^e$	-1.17		-1.94	
	(0.25)		(0.28)	
$MSupply_t^{new}$		-2.92		-2.83
		(0.29)		(0.27)
TOM_t	-1.12	-0.51	-0.43	-0.48
	(0.34)	(0.28)	(0.30)	(0.28)
GDP_t			2.27	0.57
			(0.80)	(0.50)
r_t			1.10	0.28
			(0.26)	(0.16)
Sample	1982:2-2012:1	1982:2-2012:1	1982:2-2012:1	1982:2-2012:1
$\bar{R}^2$	0.45	0.69	0.63	0.72

Notes: Standard errors in brackets.

indicated in the earlier regression results, months supply of new homes appears to exert greater influence on house prices that the supply of existing homes.

Column 2 of Table 3 reports the results from the regression model incorporating time on the market and months supply of new homes. In contrast to the results when the existing homes measure of months supply is used, the time on the market variable is only significant at the 10 per cent significance level when it is included along with the months supply of new homes as an explanatory variable. Column 3 and column 4 show the results when the fundamentals variables are included in the model along with the two months supply measures and time on the market. As shown in column 4, months supply of new homes performs best as an explanatory variable for changes in house prices. This result is consistent with the findings from the analysis reported earlier which indicated that months supply of new homes provides a good summary measure of the factors affecting changes in real house prices.

6 Robustness Checks

In the previous section we specified and estimated a regression model where the rate of change of real house prices was defined as a function of the months supply of new and existing homes and a number of other explanatory variables. The model results indicated that months supply of new homes is a key driver of changes in house prices. However, it is reasonable in this case to ask whether the causality could be running in the opposite direction, i.e. could prices be affecting months supply rather than visa versa? While the equation estimated in Section 4 posits that the tightness of the housing market as reflected by the level of months supply influences house prices, it is plausible that months supply could be responding to changes in house prices.

To test this hypothesis, we carry out a series of Granger causality tests to confirm the validity of the model estimated in Section 4. The Granger causality test is implemented by carrying out a series of regressions using house prices and months supply and lagged values of these two variables. The Granger regression results are reported in Table 4. Row

1 of the table reports the results from the standard regression of house prices on its own lag and on lagged months supply of new homes. In the regressions, the coefficients on both explanatory variables are significant and show the expected signs. An F test is carried out to examine the hypothesis that months supply lagged one period does not effect house prices. The reported F statistic and p-value lead to a rejection of this hypothesis.

The second row of the table shows the results when the ordering of the variables is changed so that months supply appears as the dependent variable with house prices and lagged months supply on the left-hand side. This regression is used to test whether months supply is sensitive to changes in house prices. The coefficient on lagged house prices is not statistically significant in this regression, indicating that the house price variable does not have any explanatory power for months supply of new homes. The reported F-statistic confirms this result.

Table 4: Granger Causality Regression Results

Null Hypothesis	F-Stat	Probability	Number of Lags
MSupply does not cause changes in PH	30.25	0.00	1
PH does not cause MSupply	0.52	0.47	1
MSupply does not cause changes in PH	5.29	0.00	4
PH does not cause MSupply	0.78	0.55	4
Sample	1969:1-2012:1	1969:1-2012:1	1969:1-2012:1

The third row of Table 4 shows the results when house prices are regressed on the four period lags of months supply and house prices. The null hypothesis that the coefficients on the lagged months supply variables is zero is rejected. A similar result is obtained when two period and three period lags are used. Column 4 repeats the results from the regression of months supply on the four period lags of the variable itself and house prices. An F-test is carried out to examine the hypothesis that the coefficients on the lagged house price terms are zero. The low value of the reported F-statistic and the high p-value indicate a failure to reject the null hypothesis. In keeping with the result in the second row of the table where just one lag is used, the results in row 4 show that house prices do not appear to exert any significant influence on months supply of new homes. These results indicate that the direction of the causality in this case appears to run from months supply to house prices, hence, the specification of our house price equations in Section 4 is valid.

7 A Simulation Model of Sales and Supply

The relationship just described between the rate of change in real house prices and the months supply of new homes gives a snapshot of how supply and demand conditions interact in the housing market. In this Section, we build on the house price model specified in Section 4 to examine the dynamics of how the housing market responds to changes in supply, demand and prices. The model is used to provide insights into how a position of high months supply and falling prices in the housing market gets unwound. The search theory literature discussed earlier describes how the housing market evolves in line with flows into and out of the market. We examine these flows by modelling separately the flow of new homes onto the market (supply) as well as new home sales (demand) and prices.

7.1 Modelling Sales and Supply

Let ZH_t be year-over-year change in real house prices, S_t be new home sales, F_t be the flow of new homes brought to the market, FS_t be the number of homes for sale, M_t be months supply, GDP_t be GDP growth and R_t be the real mortgage rate. The model consists of two identities which are used to define our key months supply variable as well as the house price regression accompanied by a quasi-VAR in sales and flow of new homes.

The consequences in general regression analysis of including $I(1)$ variables are serious and imply that standard regression methods may be invalid and misleading. To address concerns over stationarity, the variables F_t, the flow of new homes brought to the market and S_t, the number of new homes sold are divided by the number of households. See the appendix for more details.

We begin by defining an identity for the months supply of new homes as the number of homes for sale divided by the number sold.

$$M_t = \frac{FS_t}{S_t} \tag{1}$$

The number of homes for sale evolves in line with the flow of homes into and out of the housing market.

$$FS_t = FS_{t-1} + F_t - S_t \tag{2}$$

We can thus model the changes over time in months supply using an approach that forecasts F_t and S_t. Thus, our simulation model consists of an equation linking house prices to months supply, equations for F_t and S_t and a set of identities defining the stock-flow dynamics and the months supply variable.

With this approach in mind, the first equation in our simulation model relates the year-over-year change in house prices to its lags and to lagged months supply.

$$ZH_t = \beta_{11} + \sum_{k=1}^{4} \beta_{12k} ZH_{t-k} + \beta_{13} M_{t-1} \tag{3}$$

The next equations in our system comprise a quasi-VAR is sales and the flow of homes brought to the market. The equations both for S_t and F_t have two lags of S_t and F_t, the year-over-year change in real house prices (ZH), the growth rate of GDP and the real mortgage interest rate.

$$S_t = \beta_{21} + \sum_{k=1}^{2} \beta_{22k} S_{t-k} + \sum_{k=1}^{2} \beta_{23k} F_{t-k} + \sum_{k=0}^{1} \beta_{24k} ZH_{t-1} + \beta_{25} M_{t-1} + \beta_{25} GDP_t + \beta_{27} R_t \tag{4}$$

$$F_t = \beta_{31} + \sum_{k=1}^{2} \beta_{32k} S_{t-k} + \sum_{k=1}^{2} \beta_{33k} F_{t-k} + \sum_{k=0}^{1} \beta_{34k} ZH_{t-1} + \beta_{35} M_{t-1} + \beta_{36} GDP_t + \beta_{37} R_t \tag{5}$$

By specifying the equations for supply and demand in this way, the model does not impose any restrictions on the direction of the causality between changes in house prices and months supply. While the results of the Granger tests carried out in Section 5 provide reassurance that the relationship between house prices and months supply of new homes specified in Section 4 is valid, the flexible specification of the model in equation (4) and equation (5) ensures that no particular structure is imposed on the relationship between the variables.

Table 5 reports the results from the estimation of the equation for new home sales (4) and the equation for the flow of homes put on the market (5). The results provide some early insights into the likely behaviour of the housing market as represented in our simulation model. The sum of the coefficients on house price growth is positive and significant for both sales and the flow of new homes. Similarly, the results in Table 5 show that the flow of homes put on the market for sale as well as new home sales are positively related to changes in GDP. The coefficients on real mortgage interest rates are negative in both equations but not statistically significant in the regression analysis. Finally, the sum of the coefficients on lags of months supply is negative for F_t but effectively zero for S_t, suggesting that an excess supply of homes curbs new home production but has little direct effect on sales.

7.2 Simulation Results

We use the model specified above to examine the dynamics of the relationship between supply, demand and prices in the US housing market. We begin the analysis by simulating values for the three exogenous variables in the model, GDP, inflation and the mortgage interest rate. Equations 3-5 are then estimated over the period 1970:1 to 2012:1 and the resulting estimated coefficients are saved. Using the values for the exogenous variables calculated earlier, the model is simulated to obtain baseline values for house prices, the flow of homes put on the market, new home sales and months supply. We implement shocks to five variables in the model: (1). house prices, (2). the flow of homes put on the market (supply), (3). new home sales (demand) (4). GDP and (5). interest rates. We ascertain the impact of the shock to each of these variables on the housing market by comparing the simulated values from the baseline to the values from the shock scenario.[5]

[5]Due to the non-linearity in the estimation system, the calculation of bootstrapped impulse response functions proved problematic. An attempt to calculate error bands using standard bootstrapping techniques

Table 5: Supply, Demand, Months Supply and House Prices

Dependent Variable	(F_t)	(S_t)
Constant	9.17	8.94
	(3.00)	(4.86)
F_{t-1}	0.65	0.13
	(0.09)	(0.13)
F_{t-2}	0.16	0.02
	(0.78)	(0.11)
S_{t-1}	0.17	0.76
	(0.18)	(0.27)
S_{t-2}	-0.08	-0.05
	(0.14)	(0.21)
$MSupply^{new}_{t-1}$	-1.79	0.91
	(1.18)	(1.76)
$MSupply^{new}_{t-2}$	1.14	-0.89
	(1.13)	(1.69)
ZH_t	1.39	1.14
	(0.17)	(0.23)
ZH_{t-1}	-1.14	-0.83
	(0.18)	(0.25)
GDP_t	1.44	0.89
	(0.40)	(0.55)
r_t	-0.01	-0.12
	(0.12)	(0.18)
Sample	1970:1-2012:1	1970:1-2012:1
$\bar{R}^2$	0.97	0.97

Notes: Standard errors in brackets.

7.3 1 % Shock to House Prices

In the first simulation, we increase house prices by one per cent for one period and examine the response of the housing market over the following quarters. In response to this shock, the level of house prices rises initially by over 2 per cent before settling around 1.5 per cent above the baseline over the medium-term, as shown in Figure 5. Thus the initial shock to house prices proves persistent by maintaining the level of house prices above their baseline level 10 years after the initial shock.

The response of sales and the flow of new homes put on the market to the price shock is illustrated in the right-hand panel of Figure 5. The figure shows that both sales and new supply increase initially in response to the increase in house prices. The increase in sales (demand) in response to an increase in prices is counter to the predictions of the standard economic theory of frictionless markets where higher prices typically lead to a decrease in demand. However, the positive correlation of sales and prices shown in Figure 5 is a well established empirical result in the search theory literature. Diaz and Jerez (2010), using search theory explain how the co-movement of sales and prices shown in Figure 4 comes about. A higher probability of becoming mismatched raises the number of households seeking to buy a new home and since these buyers are willing to pay a higher price, prices and sales rise simultaneously. This is what Ngai and Tenreyro (2010) refer to as the "thick market" effect. The increase in supply following the price shock results in a moderation in prices beginning around two years following the initial shock. This in turn leads to lower sales and supply in later periods as shown in Figure 5.

7.4 1 % Shock to Supply

This shock examines the response of the housing market to a one per cent increase in the flow of new homes put on the market. The responses shown in Figure 6 conform to the predictions of search theory models of the housing market. An increase in the supply of

was not successful as the non-linearity in the system means that over many simulations, a percentage of the draws generate explosive dynamics.

Figure 5

Response to 1% Price Shock

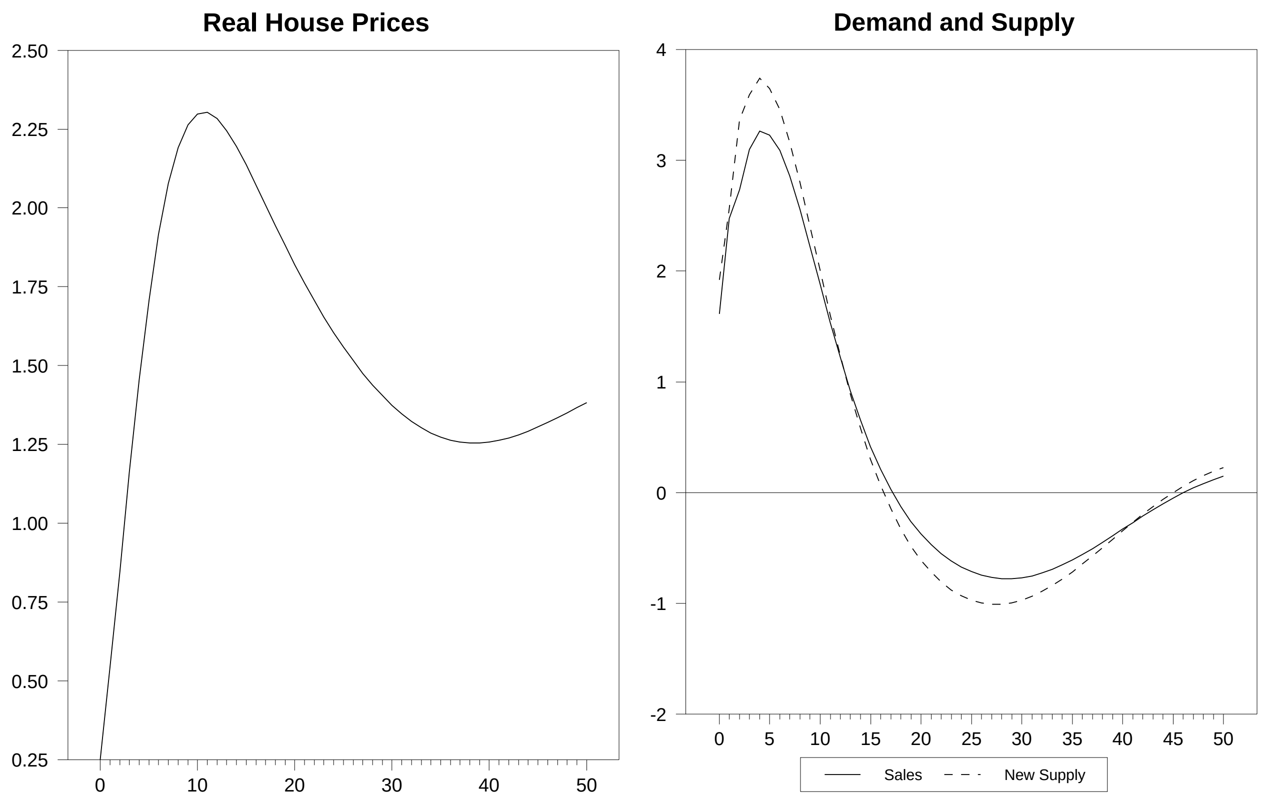
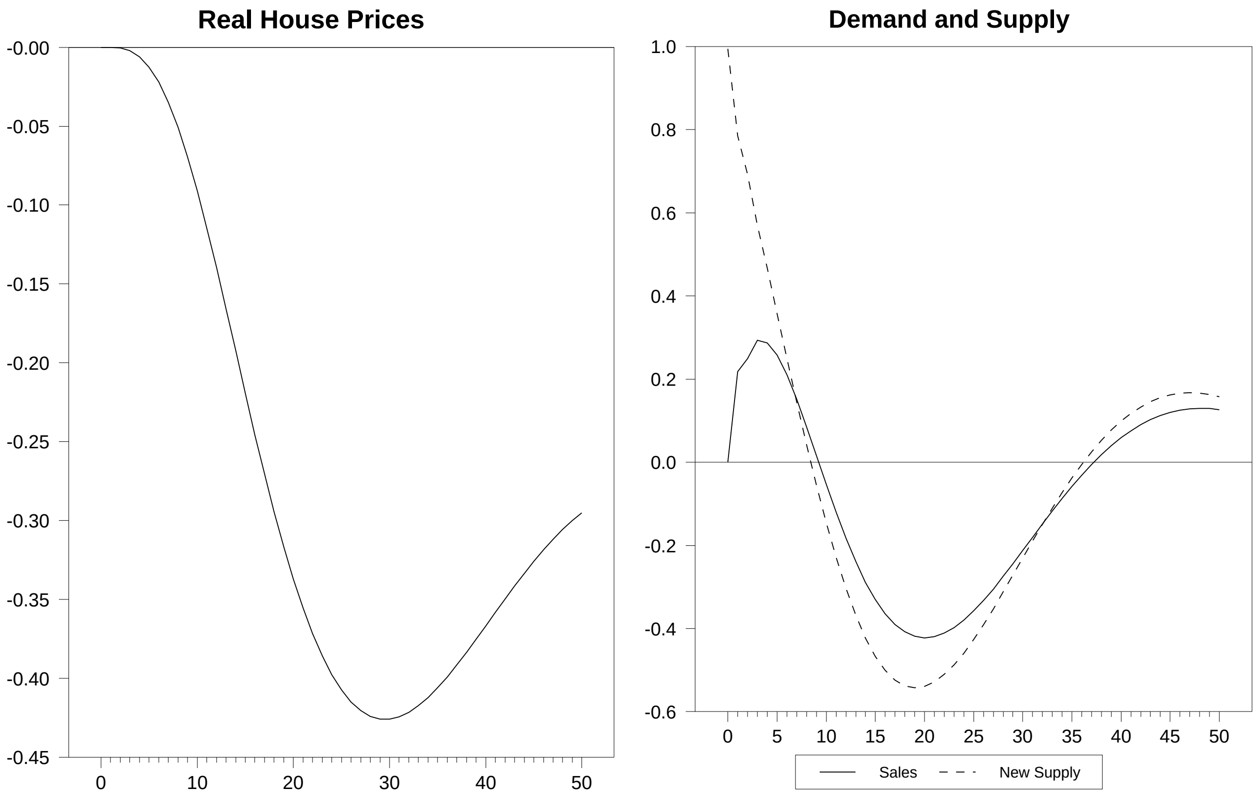


Figure 6

Response to 1% Supply Shock



homes on the market leads to an initial increase in sales (right-hand panel of Figure 6) because the ratio of buyers to sellers in the market decreases which in turn reduces buyer time on the market. This effect, in addition to the fact that higher supply implies fewer mismatched households in the future, results in lower sales in later periods. In the model developed in this paper, this effect kicks in after around one year.

The simulation results shown in Figure 6 provide some insights into how the housing market unwinds from a position of high months supply. A high level of supply in this period leads to a significant reduction in the number of homes put on the market for sale in later periods which contributes to reducing the supply overhang in the market. However, as shown in the Figure, the increase in supply also leads to lower prices and since prices and sales tend to move in the same direction, sales in later periods also decline. This slows down the pace at which the housing market unwinds from a position of high supply.

7.5 1 % Shock to Demand

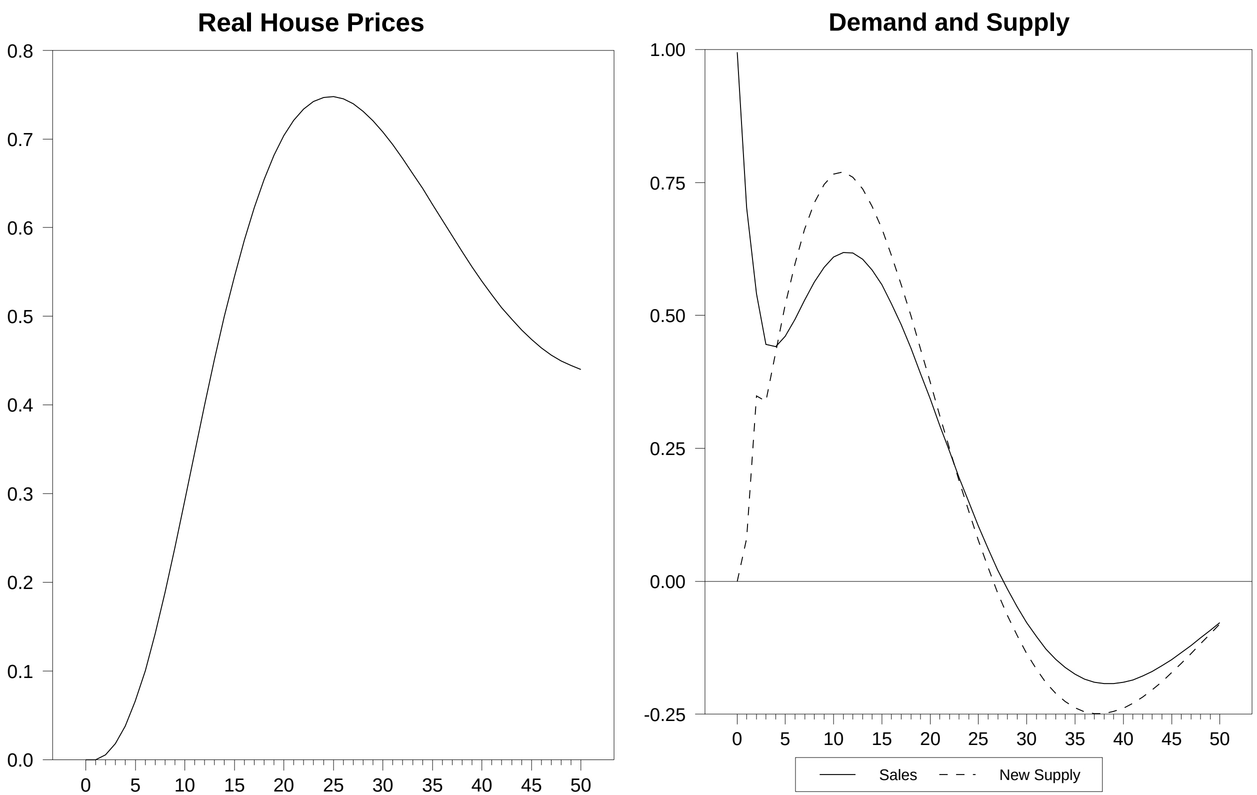
This simulation examines the effect on the housing market of a one per cent increase in demand. Figure 7 shows that sales and prices respond positively to the demand shock. Higher sales reflect a higher level of mismatch in the market which increases sales and prices. This makes it more difficult for buyers in the market to find a suitable housing unit and as a result the increase in demand is propagated into the next period. The flow of new homes put on the market eventually increases in response to the demand shock which brings about a moderation in the increase in the price over the long run.

7.6 1 % Shock to Macro Variables

Figure 8 and Figure 9 show the response of supply, demand and prices to a 1 per cent increase in the real mortgage interest rate and a one per cent increase in the real GDP growth rate respectively. Consistent with the results in Table 1, Figure 8 shows that house prices fall in response to an increase in the interest rate. The fall in prices in response to the positive shock to interest rates is accompanied by an initial increase in both sales and supply followed by a reducton after around 6 quarters. Lamont and Stein (1999) and Chan

Figure 7

Response to 1% Demand Shock



(2001) explain how falls in prices can generate lower sales. When prices decline, liquidity constrained owners experience a loss of equity meaning fewer households can afford to move house. The reduction in new supply eventually leads to a recovery in prices and sales.

Following an initial small decline, house prices increase sharply in response to an increase in the GDP growth rate. The increase in prices leads to an increase in sales and supply after about two years (Figure 9).

7.7 Forecasting Sales, Supply and Prices

Finally, we use our model to simulate future values for new home sales, the flow of homes put on the market, house prices and months supply. Using forecasted values for the exogenous variables and the estimated coefficients form the regression model, we generate projections for the future path of key housing market variables. Figure 10 shows the model's forecasts for new homes sales and supply. The correction in US house prices which has taken place since 2008 has coincided with a sharp fall in the number of homes put on the market as well as a sharp fall in sales. Our model predicts a gradual recovery in new homes sales and supply over the medium-term.

Figure 11 shows the model's predictions for house prices and months supply of new homes. Months supply of new homes increased sharply from around four months prior to the collapse in house prices to over 11 months during 2008 and 2009. Months supply has fallen back slightly from the high levels reached in 2008 and currently stands at around 5 months. The model projects a recovery in house prices and a reduction in months supply of homes to below pre-crisis levels by the middle of this decade. Thereafter months supply of houses is expected to return to close to its long run average level of around 6 months.

Figure 8

Response to 1% Interest Rate Shock

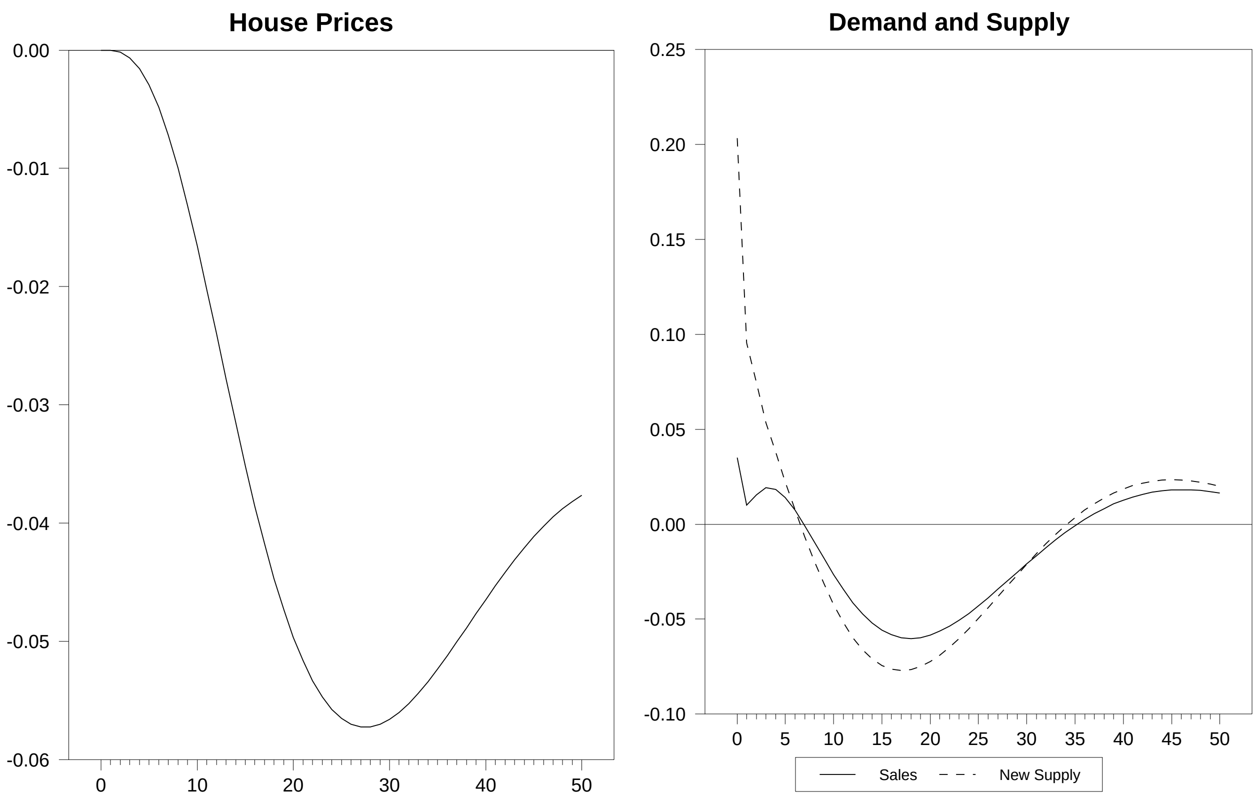


Figure 9

Response to 1% GDP Shock

Figure 10

Forecast Simulation of New Homes Sales and New-to-Market Homes

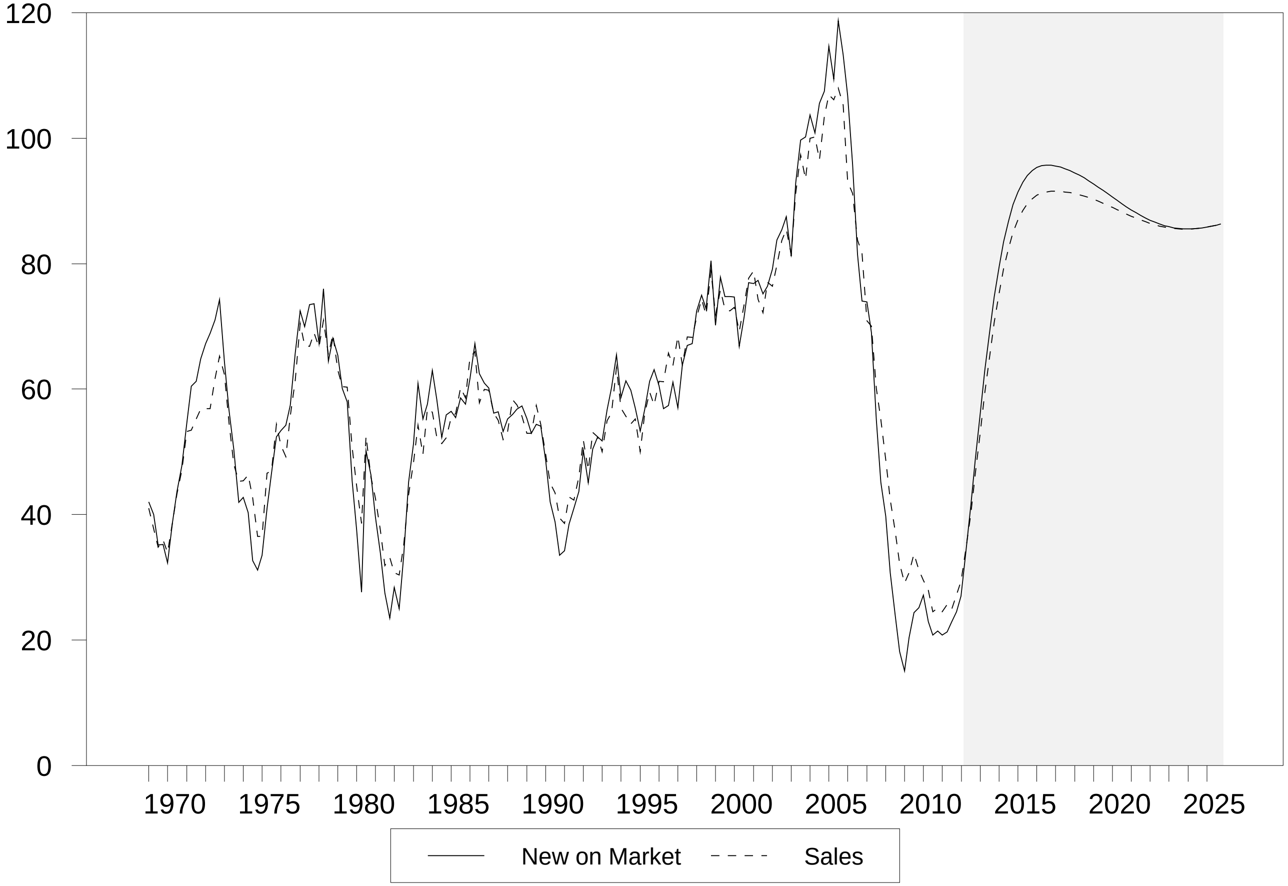
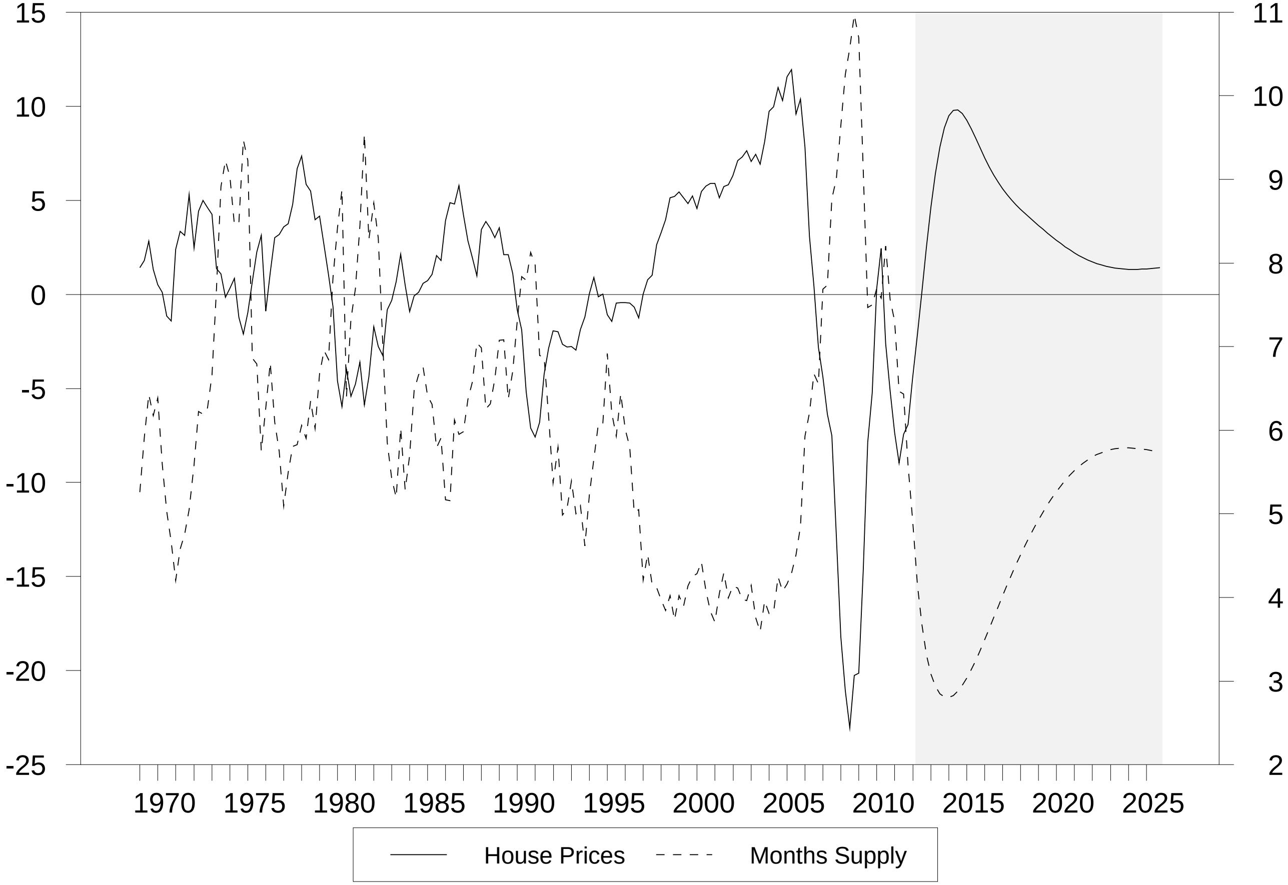


Figure 11

Forecast Simulation of Real House Prices and Months Supply (Shaded Area is Simulation)



8 Conclusions

This paper carries out a new empirical examination of the relationship between house prices and two measures of months supply. In Section 3, some graphical analysis was presented which indicated that months supply of new homes may be a more important determinant of changes in house prices than the months supply of existing homes and the vacancy rate. Section 4 specified and estimated a formal econometric model which was used to test the significance of the relationship between these variables. The model confirmed the intuition from the scatterplots: that months supply of new homes has a larger impact on house prices than the months supply of existing homes. This relationship was found to hold even after controlling for a range of other factors likely to impact on house prices. The analysis suggests that months supply of new homes provides a good summary measure of the price pressures in the US housing market.

In the final sections of the paper, we examined the dynamics of this relationship between months supply and house prices by building and estimating a simulation model of house prices, months supply, the flow of homes put on the market and home sales. The simulation results provide some insights into how the housing market might get unwound from a position of high months supply such as persists today. The model results indicate that a reduction in the number of new homes put on the market for sale is important in driving the evolution of the housing market from a position of depressed house price growth and high months supply. A number of our empirical results also corroborate some well established findings from the search theory literature, for e.g. the co-movement of sales and prices in the housing market.

The analysis in this paper could be extended in a number of different directions. Housing markets are idiosyncratic and so the results obtained in this paper in respect of the US housing market nationally may not be representative of housing markets in particular States which may have different characteristics. Applying the model developed here to data for other states or countries is one practical avenue for further research. In particular, the Irish housing market has experienced a similar boom-bust cycle to that witnessed in the US over the past decade. Work is underway to apply the approach and methodology developed in this paper to an analysis of Irish housing market data.

Further development of search models of the housing market discussed in this paper would be useful in providing a theoretical foundation for the key empirical question examined in the paper concerning the relative importance of new versus existing homes in determining price changes in the housing market.

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9 Appendix

9.1 Stationarity Tests

This Appendix reports the results of stationarity tests carried out on a number of the series used in estimating the model specified in Section 6. Many economic time series, when displayed graphically, exhibit a persistent increasing or decreasing trend over time which is indicative of non-stationarity. Including a unit root variable in a general regression model has serious consequences as standard asympotic theory such as consistency and normality which underpin the use of OLS is undermined. Figure 12 shows a line graph of two of the series used in the estimation of the simulation model specified in Section 6. Since both new home sales and the flow of new homes put on the market display a gradually increasing trend over time, it is possible that one or both of these series could be non-stationary.

The first row of Table 6 reports the results of Augmented Dickey Fuller (ADF) tests carried out on the new homes sales and the flow of new homes brought to the market. The 5 per cent MacKinnon critical values are shown in the second row of the Table. In the case of both the flow of new homes brought to the market and new home sales, the computed ADF statistic is larger than the MacKinnon critical value indicating a failure to reject the null hypothesis that the series are non-stationary.

A number of data transformations, such as taking first differences of the non-stationary series, can be used to induce stationarity. Here, we transform the new home sales series and the series for the number of homes put on the market by dividing these series by the number of households. The trends evident in the transformed series plotted in Figure 13 are more consistent with stationarity than trends shown in the data in Figure 12.

Column 3 and column 4 of Table 6 report the results of the ADF tests carried out on the transformed variables. The ADF test statistic for the flow of new homes brought to the

Table 6: Augmented Dickey Fuller Unit Root Test Results

Null Hypothesis: series contains a unit root				
	(1)S	(2)F	(3)S_{PHH}	(4)F_{PHH}
ADF Test Statistic	-1.86	-2.49	-2.66	-2.99
5% Critical Value	-2.89	-2.89	-2.89	-2.89
Number of Lags	2	2	2	2

market per household is less than the critical value. The null hypothesis of a unit root is rejected and we can conclude that the data are stationary. In the case of the second transformed variable, new home sales per household, the ADF statistic is still marginally greater than the critical value at the 5 per cent significance level. At 10 per cent significance, however, the null hypothesis is rejected and we can conclude that the sales per household variable is stationary.

Figure 12

New Homes Sales and Number of New Homes Just Put on Market

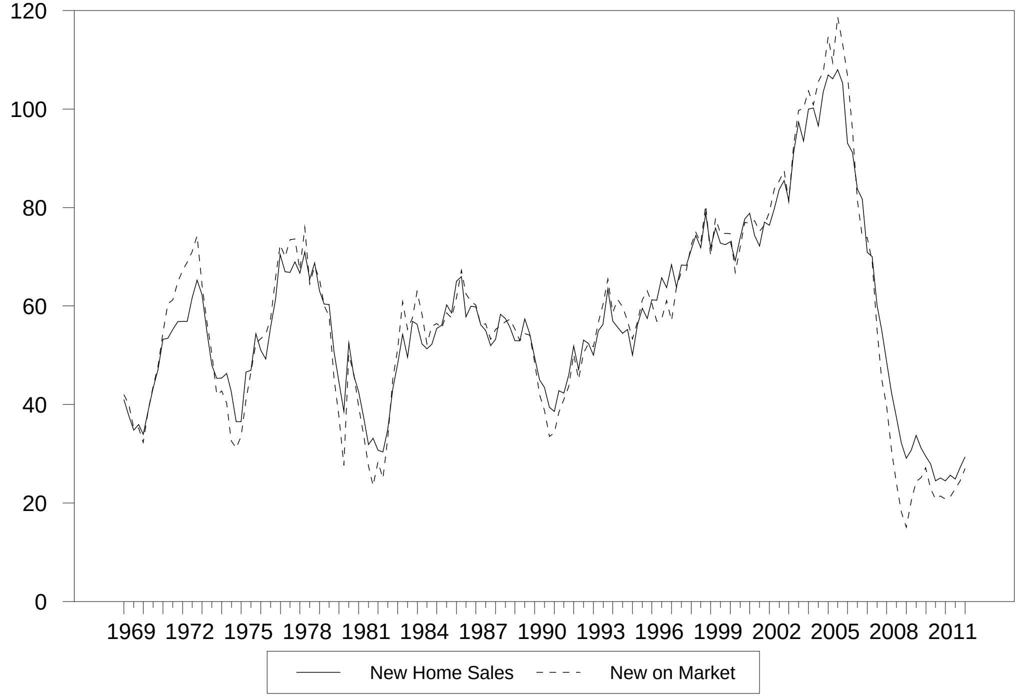
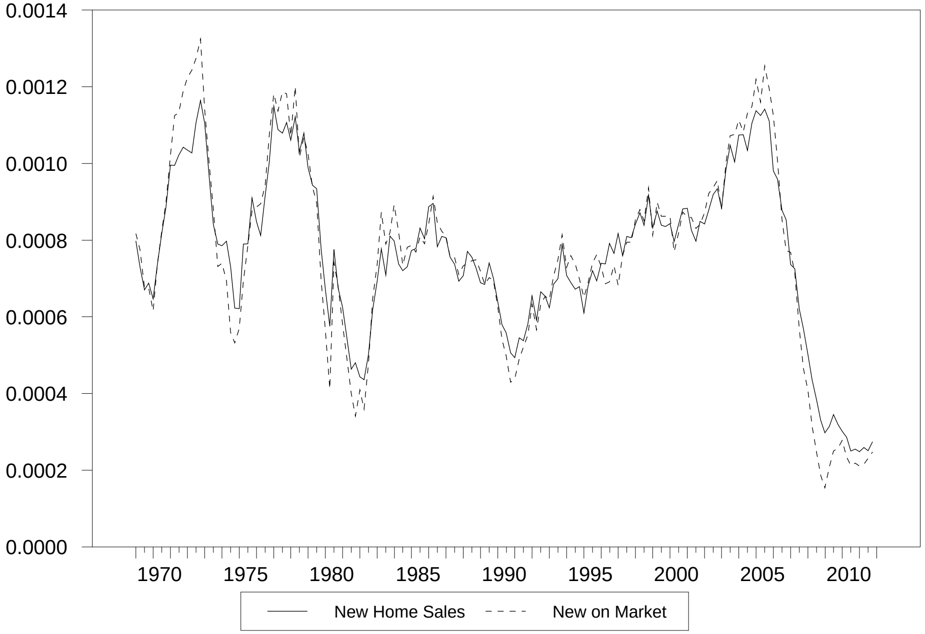


Figure 13

New Homes Sales Per Household and New Homes Just on Market Per Household



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