House Prices, Credit and Willingness to Lend[*]

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Abstract. This paper establishes a Tobin's q model in which house prices fluctuate around their long run equilibrium due to fluctuations in credit availability and income. It is shown that house prices are positively related to credit in the short run, however, negatively related to the availability of credit in the long run. Using survey data on banks' willingness to lend and data on disintermediation for the U.S. over a long period and for nine OECD countries over a short period it is shown that the availability of credit is the principal variable driving house prices around their long run equilibrium. Shocks to interest rates and income have only secondary effects on house price fluctuations.

Key words: Willingness to lend, Tobin's q. House prices

JEL classification: E44; E51

I.   Introduction

Credit has often been considered as being important for business fluctuations. Financial considerations play an integral part in investment behaviour in Keynes' General Theory. Minsky (1975) notes that Keynes distinguishes between two states of confidence as determinants of investment behaviour. First, borrowers' belief in the returns to the investment project. Second, the 'state of credit' which is governed by lenders' confidence in financing borrowers. The Austrian economists such as Hayek and Mises have emphasised the role of credit in driving investment cycles (Machlup, 1974). The model of Blinder (1988) attributes supply side failures to credit. Bernanke (1983) finds that credit played a vital role in explaining the length and the depth of the Great Depression and Calomiris and Hubbard (1989) show that the availability of credit contributed substantially to output fluctuations in the U.S. during the period 1894-1909. Furthermore, Bernanke and Gertler (1989) and Stiglitz and Weiss (1981) show how differences in borrower risk and their ability to signal this can result in inefficient allocation of credit and, in turn, drive output fluctuations. The recent sub-prime crisis has brought credit as a lever of house price fluctuations to the centre of the debate. In particular, recent events internationally suggest an important role for credit in house price dynamics.

The large majority of the theoretical and empirical house pricing models do not consider credit as a source of house price fluctuations. The main theoretical house price models that are available such as Dougherty and Van Order (1982), Poterba (1984) and Mankiw and Weil (1989) do not include credit as a determinant of house prices. There are very few empirical studies of house prices testing for the influence of credit, and these are mainly for European housing markets. Surveying 22 empirical studies of house prices, an OECD paper (Girouard, *et al.*, 2006) looking at house price fundamentals identifies only one study that considers the influence of credit supply on house prices, namely Annett (2005). The study of Annett (2005) includes the log of real credit supplied as an explanatory variable for European wide house prices. Annett (2005) concludes that credit only matters for a small number of countries in the short to medium-term, but yields greater influence in the long run. Using mortgage stock as a proxy for credit availability, Muellbauer and Murphy (1997) find that credit constraints have been influential for house prices in the U.K. Koskela *et al.* (1992) find that the ratio of debt to income is influential for house prices in Finland. Meen (1990) proxies mortgage rationing by a measure of excess

mortgage demand above mortgage supply and finds that house prices in the U.K. are more responsive to exogenous shocks when mortgage rationing is reduced.

This paper suggests that credit plays a fundamental role for fluctuations in house prices around their long run trend. The highly pro-cyclical nature of house prices in the post-WWII period has often been attributed to income fluctuations (see, for a survey, Girouard *et al*., 2006). However, there is no clear rationale as to why this should be so in the neoclassical framework since income fluctuations on business cycle frequencies are expected to be temporary and, as such, should not affect permanent income. The pro-cyclicality of house prices in the post-WWII period is more likely to be a result of credit cycles because house purchases, to a large extent, are credit financed. The lumpiness of housing purchases as well as the tax advantages of debt financing investment means that credit is the preferred, and sometimes the only feasible, way for an individual to buy a house. Accordingly, if credit is constrained, the provision of credit to the residential market becomes important for house price dynamics; where credit supply is constrained, so is the effective demand for housing investment.

The contribution of this paper is to show how credit and demand constraints influence house prices in a Tobin's q model of housing investment and to test the model's implications empirically. The influence of banks' willingness to lend for residential mortgages is examined over several decades for the USA, and over a shorter time frame for a panel of 8 other OECD countries, the time frame determined entirely by data availability. The Tobin's q model establishes an empirical relationship between house prices, willingness to lend, interest rates, demand, and acquisition costs. From the investor's first order conditions it is shown that house prices are driven by acquisition costs and credit constraints in the long run and by credit, interest rates, acquisition costs, and demand shocks in the short run. While house prices are likely to be positively related to credit in the short run, we get the remarkable analytical result that house prices are *negatively* related to the availability of credit in the long run. The model extends Tobin's q models of Poterba (1984, 1991) and Madsen (2009) by allowing for credit and demand constraints.

In a similar fashion to the literature discussing the role of informational asymmetries and financial market imperfections (see Hubbard, 1998, for a comprehensive review) in the determination of non-residential investment, this paper looks at the importance of the availability of credit in influencing residential investment. Moreover, the analysis focuses on the ultimate

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effect of residential investment on fluctuations in the price of houses. The question that the empirical analysis aims to answer is: If willingness to lend to housing investors fall, do these tightened lending standards result in reduced housing investment, and in turn, significantly effect the price of houses?

The model, which is derived in Section 3, assumes that financial intermediaries prefer to reduce lending as tool to minimise the cost of risk rather than increase the price of lending to those borrowers considered more risky, following Stiglitz and Weiss (1981). The rationale is that while banks might specialise in distinguishing the riskiness of proposed investments, they are unable to reduce informational asymmetries to zero. The implication is that, at a given interest rate, if riskiness is perceived to have increased, the supply of credit could be constrained without a subsequent increase in the price of credit that would conventionally be observed in more complete markets. Further, banks may also constrain lending in riskier states of the economy due to reduced liquidity, or reductions in the quality of their own balance sheet position (see also Stiglitz, 1988).

In contrast to other empirical models looking at credit constraints, this paper uses survey evidence of bankers' willingness to lend and disintermediation as direct measures of the availability of credit. To our best knowledge, this is the first paper to consider the influence of banks' willingness to lend on house prices. Many papers on the relationship between economic activity and credit, and most of the few papers on house prices and credit, use credit aggregates as proxies for credit availability. The problem with using this measure of credit is that the amount of credit may not be indicative of the ease of obtaining credit. First, Kashyap *et al*. (1993) show that credit endogenously responds to output fluctuations. Second, housing credit tends to follow house prices simply because lending practices relate to the value of the collateral. It follows that if house prices increase due to factors that are unrelated to credit, housing credit will passively respond to the higher value of the collateral. Third, Jaffee and Modigliani (1969) argue that credit aggregates comprise of demand as well as supply of credit. In a state of low credit demand, credit may be reflected in low credit aggregates even if banks are willing to lend out.

The paper proceeds firstly with a discussion of the relationship between willingness to lend, disintermediation and house prices (Section 2). Section 3 establishes a Tobin's *q* model of house prices. In section 4, the influence of willingness to lend on house prices is tested for the

U.S. over the period 1966.1Q to 2008.2Q, and for a panel of countries including Japan, Belgium, France, Germany, Ireland, Italy, the Netherlands, the U.K. and the U.S. over the period 2003.1Q to 2009.1Q. The final section concludes.

2. House Prices and Willingness to Lend

While banks may have some capacity for distinguishing risk characteristics of potential borrowers and pricing each borrower's investment proposition accordingly, there are arguably many cases for which the cost of risk and the benefits of return cannot be perfectly reconciled. Stiglitz and Weiss (1981) show that in times of increased risk, instead of increasing interest rates to recover the expected increased costs of default, credit supply may be contracted and rationed to investments that can be assessed as low risk for any existing level of interest rates. The rationale is that there are some investment projects that are sensitive to interest rate changes. When interest rates are pushed up to cover expected losses, previously feasible investment projects of low risk (and low return) are now no longer feasible as the expected return for these projects does not exceed the opportunity cost of investment. Consequently, the quality of the remaining pool of borrowers deteriorates, further increasing the probability of default. Furthermore, higher borrowing costs induce some borrowers to undertake riskier projects. Therefore, as the price of credit directly impacts on the quality of willing borrowers, banks will balance their risk and expected return trade-off by restraining the quantity as well as the price of credit when faced with imperfect information about borrower risk. Conversely, Stiglitz (1988) argues elsewhere that there may be other cases where investors are not sensitive to interest rates at all within a certain range; interest rate changes are insignificant compared to large uncertainties associated with the returns to investment, which are often of magnitudes of 10, 15, 20 or 25 percent. Where the pool of willing borrowers does *not* deteriorate with increased interest rates, the quantity of credit will remain a more important determinant of investment than the cost of credit.

Housing investment, at first glance, appears to be less uncertain than non-residential investment because of high persistence in the demand for housing services and low short-term volatility of house prices. However, the large fluctuations in house prices on business-cycle and medium term frequencies and the high covariance between house returns and consumption growth, render residential investment a highly uncertain and risky investment; particularly for

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investors with a limited investment horizon and for house buyers for which future remortgaging depends on house price appreciations. This may explain why interest elasticities in house price models are often low and well below the theory-prediction of minus one (see for example Madsen, 2009, for the U.S., and Annett, 2005, for the OECD countries). The low interest rate elasticities suggest that credit may not be too influential for house prices through the cost of borrowing.

To measure the degree to which would-be house owners are credit constrained, survey data on intermediaries' willingness to lend is used as a preferable measure to distinguish lenders' attitudes towards credit standards. Survey data recording the willingness to lend of U.S. domestic banks and foreign bank's agencies in the U.S. has been collected since the 1961 by the Federal Reserve Bank (*Senior Loan Officer Opinion Survey* on bank lending practices, Federal Reserve Bank, 2008). The most recent survey collected responses from 55 U.S. domestic banks and 21 U.S. branches and agencies of foreign banks. For other OECD countries similar surveys are of quite recent data, usually from around 2003. We therefore focus only on the U.S. in this section.

The data used to capture banks' willingness to lend in this analysis has been constructed from two of the survey questions. The primary data source spanning 1990.1Q–2008.4Q captures information pertaining to the question of whether the bank's credit standards for approving applications from individuals for mortgage loans to purchase homes has tightened over the past three months. Since data on this question is available first from 1990.1Q it is spliced and backdated to 1966.1Q with survey data on the question as to whether the bank's willingness to make consumer instalment loans has changed relative to three months ago. Willingness to make consumer instalment loans is an excellent proxy for credit standards for mortgage loans since the correlation coefficient between the two variables is 0.7over the overlapping period 1990.1Q– 2008.4Q. Furthermore, Bachetta and Gerlach (1997) found that the response of aggregate consumption showed no systematic difference to either consumer or mortgage credit. Finally, Leamer (2009) finds that cycles in homes and durables are very similar, which suggests that they are influenced by the same factors.

In this paper, credit standards measure the proportion of banks that report to have tightened the above-described credit standards over the past four quarters. The reported *levels* of credit standards are used to measure *changing* willingness to lend because respondents answer the question in relation to the previous quarter's standards. Credit standards are transformed to

four-quarter changes in standards by summing over the past four quarters of 'changing credit standards'. [†]

Figure 1 shows the four-quarter change in real house prices and willingness to lend which is computed as one minus the fraction of responding banks that affirmed tightened standards. The growth in real house prices is measured as the growth in nominal house prices minus expected inflation over the next 12 months. House prices are measured by the Freddie Mac Conventional Mortgage Home Price Index and the expected inflation is from the University of Michigan Surveys of Consumers. To render the two data series comparable they are normalized to have a mean of zero and a standard deviation of one. The data for the U.S. show a close relationship between willingness to lend and house prices over a large fraction of the considered period. Except for the period at the beginning of the 1980s and the period 1995-2006, it appears that house prices are explained almost entirely by willingness to lend. There is a tendency for credit to precede house prices with a lead time of around one to six quarters, which is supported in the empirical estimates below. Thus easier access to credit stimulates demand for houses. This, in turn, leads to higher house prices with a time-lag.

Figure 1. Growth in U.S. House Prices and Banks' Willingness to Lend.

[†] Defining $\Delta' \ln C_t$ as the change in credit standards relative to credit standards in the previous quarter, where Δ' as the one-quarter difference operator, then the four-quarter sum of changing credit standards can be written as:

$$\Delta' \ln C_t + \Delta' \ln C_{t-1} + \Delta' \ln C_{t-2} + \Delta' \ln C_{t-3} = (\ln C_t - \ln C_{t-1}) + (\ln C_{t-1} - \ln C_{t-2})$$
$$+(\ln C_{t-2} - \ln C_{t-3}) + (\ln C_{t-3} - \ln C_{t-4}) = (\ln C_t - \ln C_{t-4}) = \Delta \ln C_t ,$$

where C is the four quarter change in credit standards. The equation shows that the four-period sum of changing credit standards measures the change in willingness to lend relative to four quarters earlier.
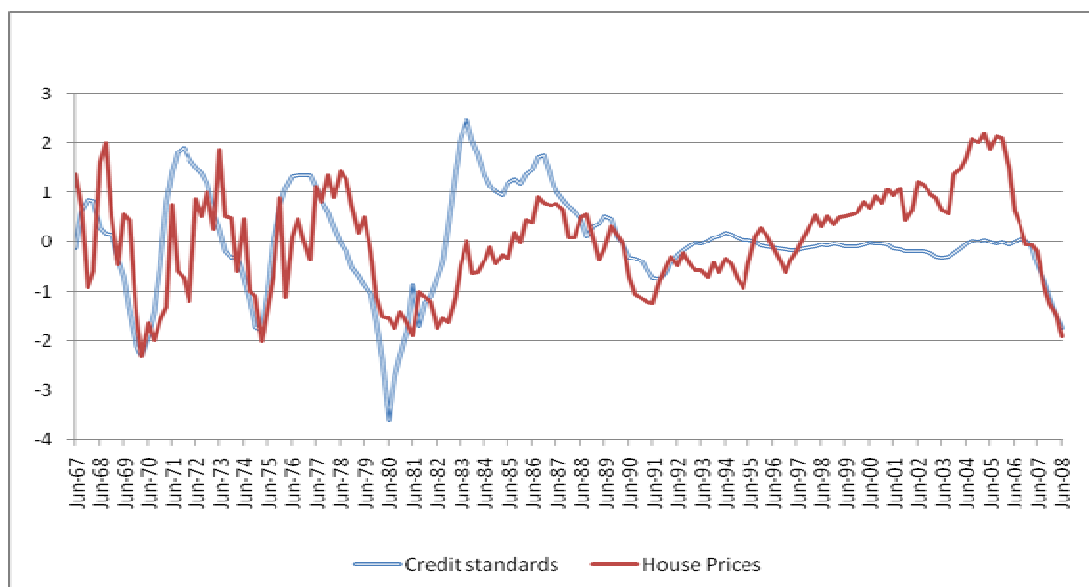
Notes. The data are measured as the percentage change from the quarter one year before. House prices are deflated by expected consumer price inflation over the next year (University of Michigan Survey of Consumers). Willingness to lend is measured as one minus the fraction of banks reporting tightened credit standards. Thus, credit standards measure the negative of tightened credit standards for mortgage loans. The data are normalized to a mean of zero and a standard deviation of one. See the data appendix for data sources.

The path of banks' willingness to lend may change in accordance with macroeconomic conditions, borrowers' net asset positions and the stance of monetary policy. According to Greenwald and Stiglitz (1993), Kiyotaki and Moore (1997) and Stiglitz (1988), risk is often identified with balance sheet indicators such as net worth and debt to equity ratios. Banks' perceived risk may also vary with general macroeconomic prospects (Stiglitz, 1988). An increasing likelihood of a recession increases expected default rates among borrowers and curbs willingness to lend. Monetary policies can also influence the willingness to lend when banks have no free reserves. However, in instances where banks have large excess reserves, as during the Great Depression, willingness to lend is decided quite independently of the monetary policy stance (Stiglitz, 1988).

The relative importance of each of these factors in the willingness to lend cycles for the U.S. shown in Figure 1 cannot always be easily distinguished because they tend to coincide. Willingness to lend was reduced significantly in the periods 1968-1969, 1972-1974, 1977-1980, 1986-1991 and 2006-present; in all events before business cycle downturns. Real stock prices declined significantly in 1969, 1974, 1982, and since 2008. These downturns have occurred in the later stages of willingness to lend cycles. Judging from changes in the FED funds rate and

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Romer and Romer's (1990) reading of the minutes of the Federal Open Market Committee, U.S. monetary policy was tightened in December 1968, April 1974, August 1978, and October 1979; again predominantly in the later stages of credit downturns. Thus, the turning points in banks' willingness to lend have preceded that of monetary policy, stock prices and business cycles. As such, bank's willingness to lend contains information that is independent of these factors.

There are two periods during which the relationship between willingness to lend and U.S. house prices is blurred. The first is the beginning of the 1980s during which the willingness to lend increased markedly while house prices only increased moderately. However, real interest rates on a 30-year mortgage loan, which was back then the dominant form of lending, increased no less than 11 percentage points from 1979 to 1982 and, as such, exerted strong downward pressure on house prices.

The second period is the approximate period from 1995 to 2006. In this period the willingness to lend was by and large neutral despite substantial house price inflation. The 3.5 percentage point reduction in real interest rates during the period from 2002 to 2006 has probably contributed to increasing house prices during the same period; however, it cannot have been the sole cause of house price inflation. Indeed, there is plenty of evidence suggesting that credit standards were extraordinary lax and credit abundant from 1995, when the house price ascent started, to the house price peak in 2006 (Mian and Sufi, 2009, Presidential Working Group on Financial Markets, 2008, Beattie, 2008). Seen in this light, the neutrality of banks' lending standards appears peculiar. However, results from the Federal Deposit Insurance Corporation's previously regular Report on Underwriting Practices give support to the neutral stance of banks during the most recent house price run-up. They show that regulated home equity loan providers did in fact have fairly secure mortgage standards over the 1998-2002 period (later figures are not available from this source because the last report was published in 2002).

This paper hypothesizes that the main reason for the marked increase in U.S. house prices during the most recent housing boom is due to the growth of non-traditional mortgage lending. Stiglitz (2008) argues that the ease of on-selling risk created by the growth of the mortgage securitization market, in combination with the increased prevalence of mortgage brokers, provides perverse incentives to mortgage originators and biases their lending decisions towards a greater number of riskier loans. The prevalence of the use of mortgage brokers reflects the growing choice of lenders and a larger variety of mortgage types to consider from the mid 1990s.

However, the introduction of broking agents has brought another layer of informational asymmetry and contradicting incentives into the market for credit (Stiglitz, 2008). While mortgage brokers are given incentives to originate loans, they are seldom able to be held accountable for loan defaults in the future. Because brokers get the benefit, but do not incur the risk of expanding mortgage products to marginal market segments, the introduction of an 'agent layer' in the mortgage market has significantly altered loan supply incentives.

No general and direct evidence of mortgage brokers exploiting their situation is available. However, evidence of borrowers in the U.S. accepting riskier loan types whilst being ill informed of their loan terms implies that there has been some exploitation of the perverse incentives of the market structure. In particular, surveys of mortgage holders with more complex, and inherently more risky, loan types such as Adjustable Rate Mortgage (ARM) variants like ARM hybrids, Option ARMs and interest only ARMs show that there is a prevalence for these borrowers to underestimate the interest rate risk and their ability to honour their future mortgage debt. The data suggests that lower income, less educated, minority group and elderly borrowers are those least financially literate and most prone to have misunderstood their loan terms and have made financial decisions indicating poor judgement given their financial circumstances (Bucks and Pence, 2008). To the extent that these groups rely on mortgage brokers to obtain loans, it is possible that financial incentives to brokers for originating loans may have encouraged less scrutiny of borrowers' long term ability to pay loans. All this has translated into an overall increasing willingness to lend.

A major U.S. regulatory change that further enhanced the availability of credit is the Gramm-Leach-Bliley Act (1999). This Act allowed commercial banks, brokerage firms, hedge funds, institutional investors, pension funds and insurance companies to freely invest in each other's businesses as well as fully integrate their financial operations. Relaxed regulation created a much broader market for off-balance sheet arrangements and the structured investment packages being backed by mortgage assets. Indeed, as a major source of mortgage funding growth from 1996 through to the recent housing market downturn, demand for purchases of overrated mortgage backed securities (MBS) added significantly to the liquidity of the mortgage asset market and was the most prevalent source of mortgage finance growth since the last major wave of mortgage refinancing in 2003 (Economic Report of the President: Table B-76, http://www.gpoaccess.gov/eop/tables09.html#top).

In sum, the establishment of a broad market for MBS and other mortgage based derivates, in combination with more lax underwriting standards in the U.S. (Mian and Sufi, 2009), encouraged extensive lending to those on the fringe of the housing market. The subprime lending market consequently grew substantially from under 4 per cent in 2000 to over 30 per cent by 2006 (Coleman *et al*., 2008). Disintermediation accommodated this trend. The aggregate willingness to lend grew as alternative lending types grew and these lenders steadily increased their market share until the peak in house prices in the second quarter of 2007. According to one real estate industry news site, *National Mortgage News* (Blake, 2008), mortgage brokers in the U.S. received no less than 80 per cent of the market share one year before house prices peaked. The shift from traditional to alternative mortgage origination reflects the corresponding shift in mortgage funding. In terms of outstanding mortgage debt, at the start of our data sample in 1966 major commercial banking and savings institutions comprised 79 per cent of the market. However, by 2006 it had dropped to a low of only 35 per cent (Report of the President, Table B-76, http://www.gpoaccess.gov/eop/tables09.html#top). The accommodative role of disintermediation has been associated with an easing of overall credit standards. Mian and Sufi (2009) show that the extent of disintermediation in the mortgage market is inversely correlated with loan approval standards. To the extent that mortgage brokers, and indeed other financial intermediaries, have different incentives and willingness' to lend than banks, the survey data on bank's willingness to lend used to capture ease of credit supply is likely to be deficient in capturing the willingness to lend among all lenders during the most recent housing boom.

To capture the willingness to supply credit from non-commercial banking sources in the U.S., the flow of MBS is used. This measures the funding of mortgages from those parties most instrumental in funding subprime loans during the last boom and least interested in the long term performance of the loan asset. The flow of MBS, on a quarterly basis is available from the Federal Reserve Bank's Flow of Funds Accounts (2009). This data is used to capture the extent of funding in the mortgage market due to securitisation. A comparison of the MBS flow data with the Security Industry and Financial Markets Association's (SIFMA, 2009) data on MBS issues in the U.S. since 1996 shows comparable trends.

Figure 2. Quarterly change in issues of Mortgage Backed Securities as a proportion of total mortgage issues.

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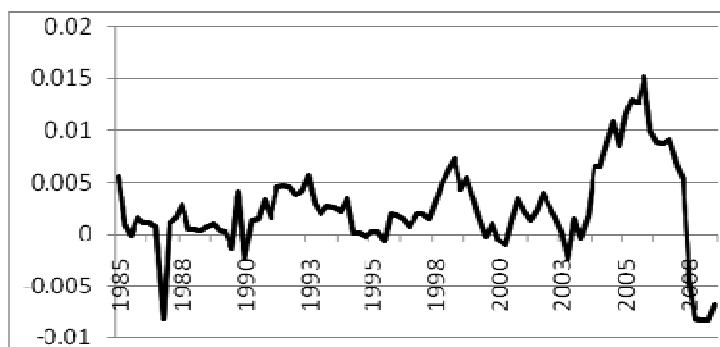
Source: Federal Reserve Bank's Flow of Funds Accounts (2009).

Figure 2 maps the Federal Reserve Bank's Flow of Funds Accounts' data showing the change in density of MBS in total lending. Being only 2-3 percent of total mortgage issues in the 1980s, MBS did not play any significant role for the availability of credit. Over time, however, the MBS density has increased to significant levels. The 1990s saw the availability of credit for housing gradually increased through MBS issuance. However, it was really in the period 2003 to 2007 where MBS became the most important contributor to credit provision and thus an important driver of the recent house price boom. The increasing importance and rate of issuance of MBS in total mortgage during the periods 1998-1999 and 2003-2006 explains why access to housing credit gained momentum during the resent housing price boom, despite banks' willingness to lend remaining neutral. The sharp fall in the willingness to lend since the beginning of 2006 and the fall in the density of MBS since the end of 2007 have resulted in a sharp contraction in credit availability.

3.   A Tobin's *q* model with quantitative demand and credit constraints

The model presented in this section incorporates credit and income constraints into the optimisation problem of the representative residential house investor following the Tobin's *q* models of Poterba (1984, 1991) and Madsen (2009). These constraints influence house prices because of adjustment costs in investment, downward price rigidities, time-varying willingness to lend, habits and regulatory constraints that prevent markets from clearing instantaneously. Using a Tobin's *q* model for non-residential investment, Blanchard (1983) shows that demand is influential for non-residential investment because goods markets fail to clear. Similarly, non-clearing conditions can be observed in the housing markets given that income is the principal scale variable in almost all empirical house prices models (Girouard *et al.*, 2006). The

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importance of income for house prices may, to some extent, reflect that some households are credit rationed. An unexpected increase in income eases the credit constraint of credit constrained households.

It is assumed that the cost of borrowing is set exogenously by the international credit market in a fixed exchange rate regime, or by monetary authorities under flexible exchange rates. An endogenous discount rate is not considered since it increases the complexity of the model without affecting the steady-state properties of the model nor giving additional insight into the influence of credit and demand shocks on house prices (see Madsen, 2009, for an endogenous discount rate in a Tobin's *q* model of house prices). The assumption of an exogenous interest rate appears to be realistic in the current economic environment in which new mortgage loans have been increasingly dominated by the adjustable interest rate loan types (Girouard *et al*. 2006), which to a large extent, are determined by the FED funds rate.

3.1   The objective problem of the residential investor

The objective problem of the housing investor can be summarised as follows:

$$\max V = \int_t^\infty \gamma \cdot e^{-r_t} \tag{1}$$

where *V* is the present value of residential investment, *r* is the required return to the investor and *γ* is the investor's real cash flow defined as the gross earnings after investment cost deductions. This is given as follows:

$$\gamma = \Phi(H(h)) - b \cdot i \cdot h - (1-b)\big(1 + \phi(\dot{h}/h)\big)I + b \cdot h \cdot \pi, \tag{2}$$

where *b* is the fraction of housing investment financed by debt; *i* is the nominal interest rate paid by the investor on the housing loan; ϕ is the investment adjustment costs; *h* is the housing stock of the individual investor; *H* is the economy-wide housing stock; *I* is the amount of gross residential investment undertaken; and *π* is the inflation rate. A dot over a variable signifies the change over time. The investment adjustment cost function is assumed to be convex and symmetric in investment. $\Phi(H)$ is the value of housing output or rental payment to the property owner, which is a declining function of the economy-wide housing stock due to diminishing returns to housing stock. Accordingly, the term $\Phi(H(h)) - b \cdot i \cdot h$ is the profit after payment of

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interests on debt. The term $(1-b)(1+\phi(\dot{h}/h))I$ is investment costs which consist of the fraction of both direct investment and adjustment cost expenses that are not debt financed. The two first right-hand-side terms are cash-flows. The last term, $b \cdot h \cdot \pi$, is the inflation-induced reduction in the real value of debt. In this model it is assumed that housing investment, including both direct and adjustment cost expenses, is debt financed and as such, $b = 1$. This is not a severe restriction since the majority of housing investments are debt financed and rarely equity financed. As becomes clear below, the credit constraint cannot be binding if alternative financing is available and if the borrower is not constrained in these markets.

The investor takes their decision subject to the capital accumulation constraint where depreciation is ignored for simplicity without affecting the results (see Madsen, 2009):

$$\dot{h} = I, \tag{3}$$

and a credit constraint such that investment is capped at $\bar{I}$:

$$I[1+\phi(\dot{h}/h)] = \bar{I}. \tag{4}$$

This constraint is valid as all investment, including adjustment costs, is debt financed and therefore $\bar{I}$ is entirely determined by credit provision. Limitations on demand for housing services are also considered as a constraining influence for housing investment. As property investors are assumed to be rational and forward looking, housing output is therefore also potentially constrained by the quantity of housing services demanded, $\bar{Q}$:

$$\Phi(H(h)) = \bar{Q}. \tag{5}$$

Under perfect market clearing this constraint would not apply as prices would adjust to clear the market. However, there is plenty of evidence suggesting that house prices do not clear instantaneously; particularly not in declining markets in which the stock of houses for sale substantially exceeds that in booming markets (Stein, 1995). Under these circumstances demand becomes influential for house sales and house prices.

Combining (1)-(5) yields the current-value Hamiltonian of the representative investor:

$$\Psi_{h,I,\lambda,q,\mu} = \{\Phi(H(h)) + bh(\pi - i)\} - (1-b)[1+\phi(I/h)]I$$
$$- \lambda[I \cdot [1+\phi(I/h)] - \bar{I}] - q(\dot{h} - I) - \mu(\Phi(H(h)) - \bar{Q}) \tag{6}$$

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where λ, q and μ are the shadow values, $0 \le \lambda \le 1$ and $0 \le \mu \le 1$. Here, λ is the present value to the investor of loosening up the credit constraint by one unit, q is the capitalized value on investment from having one additional value of housing stock and μ is the present value to the investor of loosening up the demand constraint by one unit.

The first order conditions are as follows:

$$\frac{\partial \Psi}{\partial h} = -\dot{q} + rq \quad \Rightarrow \dot{q} = rq - \left[\Phi'_h \cdot (1 - \mu) + \phi'_h \cdot (I/h^2)(1 - b + \lambda) + b(\pi - i) \right], \tag{7}$$

$$\frac{\partial \Psi}{\partial I} = 0 \quad \Rightarrow q = \left(1 + \phi'_I \cdot (I/h)^2 \right)(1 - b + \lambda) - (1 + \phi)(1 - b + \lambda), \tag{8}$$

$$\frac{\partial \Psi}{\partial \lambda} = 0 \Rightarrow \bar{I} = I\left(1 + \phi\left(\frac{\dot{h}}{h}\right)\right), \tag{9}$$

$$\frac{\partial \Psi}{\partial q} = 0 \Rightarrow I = \dot{h}, \tag{10}$$

$$\frac{\partial \Psi}{\partial q} = 0 \Rightarrow \Phi(H) = \bar{Q}, \tag{11}$$

$$\lim_{t \to \infty} qh \cdot e^{-r_t} = 0. \tag{12}$$

Inserting the housing stock adjustment costs function $\phi(\dot{h}/h) = I^2/\alpha h$, where α is a constant, into equation (8) yields the following investment function:[‡]

$$\dot{h} = \left[\frac{\alpha}{3} h \left(\frac{q}{1 - b + \lambda} - 1 \right) \right]^{1/2}. \tag{13}$$

This equation shows that the housing stock is increasing if the shadow value of housing is in excess of the costs of building a house after adjusting for the decrease in costs due to debt financing and the shadow costs of credit. In the conventional case of no credit constraints and no debt financing equation (13) reduces to the conventional Tobin's q model in which investment is positive when the shadow value of houses exceeds 1. In other words investment takes place when the house price exceeds its acquisition costs. Where debt is 100 per cent debt financed, $b = 1$. In this case, when the shadow value of housing exceeds the real cost of credit, new investment in housing is profit maximising. This is becuase houses command a higher price from the market

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[‡] This particular adjustment function is used because it gives an explicit solution. For the adjustment cost function used by Summers (1981) there is no explicit solution.

than their cost of construction. In other words, the less credit constrained the market and the higher the level of debt financing, the larger the investment in housing.

The housing market no arbitrage condition (equation (7)) can be expressed more simply as:

$$r = \frac{\dot{q}}{q} + \frac{\gamma}{q},$$ (14)

where $\gamma = q\left[\Phi'_h \cdot (1-\mu) - \left(I + \frac{1}{\alpha}\left(\frac{I}{h}\right)^4\right)(1-b+\lambda) + b(\pi - i)\right]$ is the net rental income per unit of housing capital, and r is the required returns to housing investment. It is here that demand for housing services matter as demand reduces μ and thus increases the revenue product of housing investment. In steady state equation (14) is a standard asset market equilibrium condition in which the shadow value of the house is equal to expected dividends divided by the required returns.

3.2   Steady state

Imposing the steady state conditions that $\dot{q} = \dot{h} = 0$ on equations (13) and (14), and assuming that all individuals are acting in the same way so that h aggregates to H, yields, after some manipulations, the following macro relationships, where asterisks signify steady state:

$$H^* = \Phi'^{-1}\left[\frac{r(\lambda + 1 - b) - b(\pi - i)}{(1-\mu)}\right],$$ (15)

$$q^* = 1 - b + \lambda,$$ (16)

where H^* is the level of the housing stock for which the market valuation of housing assets is exactly equal to the acquisition cost of housing adjusted for credit constraints and therefore there are no incentives to invest or disinvest. Note that equation (15) expresses a negative relationship between H^* and the terms inside the squared bracket. Increased revenue product through reduced credit and demand constraints, as well as increased debt financing and increased inflationary erosion of real debt result in arbitrage opportunities for housing investors and therefore increases in housing stock. q^* is the market valuation of the present value of the expected returns to the investment in one unit of housing. When investment is financed completely with debt ($b = 1$), the

only up-front acquisition costs required are shadow costs due to credit constraints. Increased constraints on credit, relative to the non-constrained case, increase the shadow costs of investment and thus reduce incentives to invest in housing. The existing housing stock will yield a higher per-unit return in this case, raising the market value of housing.

3.3 Shadow cost of houses

As earlier defined, q is the marginal capitalised value of a unit of housing; it is the market price of housing at the margin. Provided that the usual homogeneity assumptions are satisfied, the marginal q equals the average q (Hayashi, 1982). Conventionally, Tobin's q for housing is measured as house prices deflated by construction costs (Summers, 1981, Poterba, 1991, Abraham and Hendershott, 1996, and Meen, 2002). Madsen (2009) computes the acquisition costs of housing as a geometric average of agricultural land prices and construction costs. Using the broader definition of acquisition costs yields the following shadow price of the housing stock:

$$q = \frac{p^h}{lc^\alpha cc^{(1-\alpha)}},$$ (17)

where p^h is the price of a unit of housing, lc is the cost of agricultural land, cc is a construction cost index and α measures the proportion of total acquisition costs made up by the purchase of land.

3.4 The dynamic effects of credit and demand shocks on house prices

The dynamic effects of demand and credit on house prices and housing stock are analyzed in Figures 3 and 4[§]. Figure 3 shows the dynamic effects of an unexpected increase in real interest rates when investors have perfect foresight. Starting from the steady state equilibrium at the point E_0, the $\dot{q}_0 = 0$ schedule shifts to the left (more correctly it changes slope) and the perfect foresight house market jumps to the point A because housing rents are capitalized at a higher discount rate. In contrast to the myopic market, the perfect foresight market will not jump the whole way down to the $\dot{q}_1 = 0$ line, because it knows that the relatively lower present value of housing rent will only last for the period in which the housing stock remains fixed. Since q is

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[§] The steady state multipliers for credit constraints, interest rate and demand shocks are derived in Carrington and Madsen (2009).

below its equilibrium value at the point *A*, it is profitable to lower the stock of houses; the steady state housing stock is reduced by the increase in the cost of capital. The reduced housing stock increases the rental income per unit of housing; thus bringing *q* back up towards its long run value. Under the assumption that the developers financing costs are not influenced by the interest rate increase, the shadow price of houses remains unaffected by interest rates in the long run; thus, the position of the $\dot{H}=0$ remains unaffected.

Figure 3. Unanticipated increase in interest rates and an unanticipated positive demand shock with perfect foresight
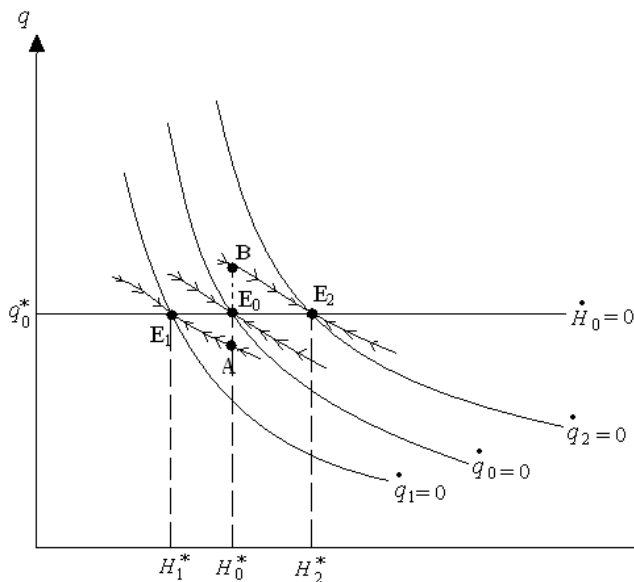
Figure 4 An unanticipated expansion in credit supply
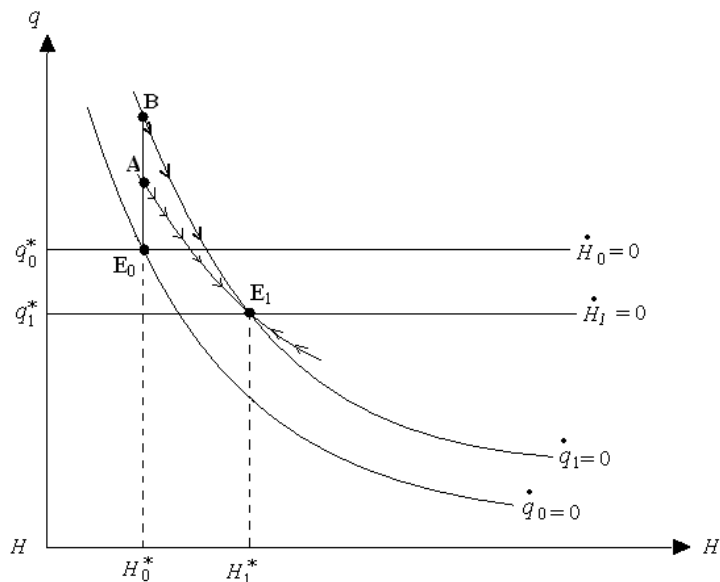
Demography and income influence the housing market through the channel of the demand constraint. A positive unexpected shift in demand or the demographic composition leads to a rightward shift in the $\dot{q}=0$ schedule from $\dot{q}_0=0$ to $\dot{q}_2=0$. The dynamics are symmetrically opposite to the interest rate analysis; the perfect foresight market will jump up to point B and from this point move towards the point E_2 as the housing stock adjusts to its optimal level. From the dynamics it can be concluded that the shifts in income and in demography have only short term effects on house prices because the housing stock levels will adjust until the net rental income equals the required returns.

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Figure 4 considers the case of an unanticipated expansion in the supply of credit, which is equivalent to a relaxation of the credit constraint for the credit constrained housing investor. When credit constraints are permanently reduced, both the supply and demand side of the housing investment market are stimulated. The initial easing of credit, when housing stocks have not yet adjusted, leads to an excess demand for housing investment and an initial increase in the market price of housing. Simultaneously, the easing in credit reduces the shadow price of credit and the acquisition costs of housing accordingly; the $\dot{h}$ line shifts downwards representing the reduced steady state value of capital in the new equilibrium. As the market price of housing now exceeds the cost of building, housing construction is stimulated in the search for profit. As the housing stock increases, the marginal revenue to housing stock decreases. The housing investment market will move along the stable saddle path until the expected future returns to housing are again equal to the credit constraint-adjusted acquisition costs. In net terms, total housing stock is increased and the value of housing is reduced from q_0^* to q_1^*.

The stable saddle path to the point E_1 is drawn so that the point A is above E_0 in Figure 4. However, it cannot, a priori, be ruled out that point A is below E_0, particularly not if the adjustment costs are low. The empirical finding below of a positive relationship between house prices and credit fluctuations is not a proof of the jump being positive. Conversely, if housing investors are myopic, they fail to account for the supply response to disequilibrium, and the house market jumps to the point B. In this event house prices are unambiguously positively related to the willingness to lend in the short run.

The analysis in this sub-section gives two important insights. First, interest rate and demand shocks have only temporary effects on house prices. This stands in contrast to conventional house price models in which house prices are driven by income and interest rates in the long run (see for survey Girouard *et al*., 2006). In the model here, reductions in interest rates and demand constraints increase q, which in turn, stimulates building investment until real house prices have reverted to their initial equilibrium. Second, loosening of credit constraints, if permanent, will permanently lower house prices. This may seem counterintuitive since credit expansions are usually associated with a booming house market. Furthermore, previous attempts to allow for credit constraints in house prices implicitly assume that house prices are positively related to credit in the long run. Here, the ease of access to credit renders it easier for builders to meet demand and the supply of houses will, consequently, increase in the long run. The recent

house price boom in most OECD countries has been associated with a massive increase in the number of new dwellings as has been the case in previous housing price booms. To the extent that these booms have been driven by credit, the housing stock is permanently higher than would have been the case with no loosening of credit constraints.

4. Empirical estimates

The model derived in the previous section shows that credit, interest rates, and income determine house prices in the short run, while house prices are determined by credit constraint-adjusted acquisition costs in the long run. This suggests that the error-correction model is the appropriate way of testing the properties of the model. The error-correction framework is employed for the U.S. using data over more than four decades while panel data estimates of nine OECD countries is undertaken in Section 4.3 covering only five years of data.

Equation (18), which is nested within equation (19), is estimated using data over the period 1966.1Q-2008.4Q, while equation (19) is estimated using data over the period 1975.1Q to

The following two models are estimated for the U.S.:

$$\Delta \ln p_t^{hr} = \alpha_0 + \alpha_1 \Delta C_t + \alpha_2 \Delta UC_t + \alpha_3 \Delta \ln Y_t + \alpha_4 \Delta Sec_t + \varepsilon_{1t}, \tag{18}$$

$$\Delta \ln p_t^{h} = \beta_0 + \beta_1 \Delta C_t + \beta_2 \Delta UC_t + \beta_3 \Delta \ln Y_t + \beta_4 \Delta Sec_t + \beta_5 \Delta \ln cc_t + \beta_6 \Delta \ln lc_t + \beta_6 ECT_{t-1} + \varepsilon_{2t}, \tag{19}$$

where Δ is the four-quarter difference operator, p^{hr} is real house prices, p^{h} is nominal house prices, C is intermediaries' willingness to lend, Y is real per capita disposable income, UC is the user costs of housing capital, Sec is the fraction of new loans that are securitized, lc is the cost of agricultural land, cc is a construction cost index, ECT is an error-correction term, which certifies that house prices gravitate toward their long-run equilibrium, and ε is a stochastic error term. Two different variables are used to deflate house prices in equation (18): consumer prices, which are conventionally used in empirical house price models, and expected inflation from the University of Michigan's Surveys of Consumers. Expected inflation is the correct deflator because house prices are asset prices that reflect the present value of expected returns from investing in houses or expected housing services. Data sources are detailed in the data appendix.

Equation (18), which is nested within equation (19), is estimated using data over the period 1966.1Q-2008.4Q, while equation (19) is estimated using data over the period 1975.1Q to 2008.2Q because data on land prices are first available from 1975. Two different measures of the cost of capital are used: user costs (UC) and the after-tax nominal interest rate ($i(1-\tau)$). User costs are estimated as:

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$$UC = i(1-\tau) + \delta - \pi^e,$$

where i is a 30-year mortgage interest rate, τ is the income tax rate used for interest deductions, δ is the depreciation rate, and π^e is measured as the average annual real house price appreciation from 1967 to 2008 plus the expected rate of inflation. This measure is used as it captures the long-term expected house price change, the decision variable most relevant for housing investors (see Hubbard and Mayer, 2009). The income tax rate is set to 30 percent, the depreciation rate is set to 2 percent, and inflation expectations are measured as survey expected inflation over the next 12 months. The other measure of the cost of capital is the after tax nominal interest rate, ($i(1-\tau)$). This measure is used because Brunnermeier and Julliard (2008) find strong evidence of inflation illusion among house buyers; several house buyers fail to take into account that inflation lowers the real value of debt on a one-to-one basis. Below, the interest rate is also measured as a weighted average of fixed and adjustable mortgage interest rates (*wai*) to account for the increasing importance of variable interest loans in mortgage lending. However, it is important to note that *wai* is *not* the correct lending rate under the assumption that the long rate is an unbiased and efficient forecast of variable interest rates.

The variables were initially lagged up to six periods to capture the dynamic adjustment of house prices. However, only lagged values of willingness to lend were statistically significant. Thus, the models were regressed using lagged willingness to lend lagged two to six periods and contemporaneous values of all the other regressors. The model is estimated in four-quarter differences 1) to filter out the effects of time-varying seasonality on the estimates; 2) because the survey data on inflation expectations refer to expected inflation changes over the next four quarters; and 3) because the data are very noisy in quarterly first differences. The standard errors are based on the Newey-West heteroscedasticity and autocorrelation consistent covariance matrix.

The error-correction term is the residual from regressing the following cointegration model:

$$\ln P_t^h = \kappa_0 + \kappa_1 \ln lc_t + \kappa_2 \ln cc_t + ECT_t, \tag{20}$$

where ECT is the disturbance term and is used as an error-correction term in the estimates of equation (19). This model shows whether house prices in the long run gravitate towards

acquisition costs as predicted by the Tobin's *q* model. Credit constraints are not included in equation (20) since we were not able to find variables for the long-run credit constraints. It would be erroneous to include the accumulated willingness to lend as a proxy for credit conditions because of the potential random walk nature of its error term.[**] The model is estimated over the period 1975.1Q to 2008.2Q because data on land prices are first available from 1975. Regression of equation (20) yields:

$$\ln P_t^h = -3.29 + 0.25 \ln lc_t + 1.27 \ln cc_t \qquad\qquad DF = -2.69 \qquad \overline{R}^2 = 0.98$$

where DF is a Dickey-Fuller test for cointegration. The null hypothesis of no cointegration cannot be rejected at the 10% level but can at the 15% significance level. The low degree of cointegration is likely to reflect 1) that the sample period is too short to test for cointegration; 2) that the data for land prices and agricultural prices are interpolated from annual data; 3) that agricultural land prices are bad proxies for residential land prices; and 4) that house prices may be out of their long-run equilibrium for prolonged periods. The sum of the cost elasticities is 1.28, which is only slightly above the prediction of one. Land's share of acquisition costs is on the low side; probably for the same reasons as those explaining the lack of cointegration.

The results of regressing restricted and unrestricted versions of equations (18) and (19) are displayed in Table 1. The adjusted R^2's suggest that the model explains a large proportion of the variation in the growth in house prices. The parameter estimates are very robust to whether nominal or real house prices are used as the dependent variable and whether the growth in real house prices are based on *ex ante* or *ex post* inflation. This is a very important result because it shows that the model captures the essential house price dynamics and is not contingent on spurious correlations between the regressors and expected or actual inflation. As the model results are robust to the different measures of house prices, only the results from estimations using the real *ex ante* house prices as the dependent variable are reported in the table.

The estimated coefficients of per capita income are mostly significant and the elasticity is on average 0.3, which suggests that income fluctuations have some, but not much, influence on house price variations. The estimated coefficients of user costs are positive and significant,

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[**] Suppose that willingness to lend has a measurement error that follows a random walk, $e_t = e_{t-1} + \upsilon_t$, where υ_t is a random disturbance term. Accumulating willingness to lend over time leads yields the accumulated measurement error of $t \cdot e_0$, where t is the time from period t_0. This implies that the trend in the accumulated willingness to lend is potentially severely biased.

which is inconsistent with the predictions of standard user cost based models. The estimated coefficients of the nominal after-tax interest rate are negative and significant in most cases, which is consistent with the results of Brunnermeier and Julliard (2008) and highlights that the after-tax nominal loan mortgage costs are the relevant cost variable for the majority of house buyers. The estimated after-tax interest rate elasticity is in the range of -0.10 and -0.20, which is above the predictions of minus one in conventional house price models.[††] Finally, a comparison of the estimates in column 4 with those in column 1 indicates that the weighted average mortgage interest rate is significant; however lenders and borrowers correctly consider the 30 year long run rate as the relevant mortgage interest rate.

The estimated coefficients of willingness to lend and securitization are highly significant in almost all the estimates. Willingness to lend significantly affects house prices with lags from two to six periods in almost all the estimates. These results give very strong empirical support to our hypothesis that willingness to lend is an essential factor behind house price dynamics and confirms the visual impression in Figure 1 that *banks'* willingness to lend can explain a large part of house price fluctuations up to 1995 and after 2007. Further support for the credit hypothesis is given by the fact that the willingness to lend precedes house prices with a median lead time of one year. While precedence is no proof of causality, it nevertheless suggests that house prices do not drive willingness to lend but rather the other way around. If willingness to lend was not leading house prices, the following possibility could not have been ruled out: Increasing house prices increases the willingness to lend because they increase the collateral of existing house owners on their way up the property ladder. Furthermore, the estimated coefficients of securitization are highly significant in all the estimates. That the relationship between securitization and house prices is contemporaneous makes sense because *Sec* is measured at the time of the lending transaction.

Table 1. Parameter estimates of equations (18) and (19).

	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Dep var.	$\Delta E(p^{hr})$	$\Delta E(p^{hr})$	Δp^h	$\Delta E(p^{hr})$	$\Delta E(p^{hr})$	$E(p^{hr})$ *pre1994*	$E(p^{hr})$ *post1994*	$E(p^h)$	$\Delta E(p^{hr})$

[††] Standard house price models assume that house prices are the discounted value of housing services or rent. If real rent or house services per square and real interest rates are expected to remain constant to infinity, house prices are equal to rent divided by the nominal interest rate in the case in which house owners suffer from inflation illusion.

Intercept	-0.006 (0.471)	-0.003 (-0.367)	0.000** (2.279)	-0.005 (-0.699)	-0.006 (-0.744)	-0.011 (-1.582)	-0.007 (-0.269)	0.051 (2.082)	-0.020 (-0.729)
ΔC_{t-2}	0.065** (1.953)	0.079** (2.463)	-0.001 (0.048)	0.070** (2.062)	0.064** (1.929)	0.063* (1.650)	-0.124 (-0.495)	0.015 (0.603)	-0.004 (-0.018)
ΔC_{t-3}	0.072** (2.114)	0.0118*** (3.406)	0.067*** (2.716)	0.072** (20.65)	0.079** (2.116)	0.052 (1.331)	0.095 (0.351)	0.081*** (2.829)	0.057 (0.241)
ΔC_{t-4}	0.079** (2.314)	0.065** (1.991)	0.040* (1.619)	0.066** (1.922)	0.081** (2.358)	0.058 (1.525)	-0.194 (-0.667)	0.052** (1.801)	-0.066 (-0.249)
ΔC_{t-5}	0.080** (2.367)	0.083** (2.514)	0.033* (1.362)	0.079** (2.282)	0.076** (2.261)	0.078** (2.073)	-0.208 (-0.705)	0.051** (1.823)	-0.045 (-0.175)
ΔC_{t-6}	0.095*** (2.905)	0.112*** (3.471)	0.075*** (3.426)	0.093*** (2.768)	0.097*** (2.939)	0.086** (2.306)	-0.273 (-0.923)	0.086*** (3.486)	-0.065 (-0.230)
ΔlnY_t	0.340*** (3.919)	0.166** (1.887)	-0.044 (-0.696)	0.307*** (3.464)	0.348*** (3.935)	0.460*** (3.926)	-0.042 (-0.390)		-0.024 (-0.221)
$\Delta i_t(1-\tau)$	-0.008*** (-3.240)		-0.006*** (-3.940)		-0.008*** (-3.255)	-0.004 (-1.494)	-0.011*** (-3.538)	-0.003** (-2.294)	-0.010*** (-3.467)
ΔSec_t	0.826*** (2.840)	0.840*** (2.963)	0.413** (2.302)	0.846*** (2.876)	0.831*** (2.838)	-0.229 (-0.338)	1.105*** (3.385)	0.848*** (4.290)	1.014*** (3.225)
$\Delta ln\,UC_t$		0.004*** (4.270)							
ECT			0.009 (0.160)						
$\Delta ln\,CC_t$			0.173*** (2.834)						
$\Delta ln\,LP_t$			0.627* (1.367)						
Δwai_t				-0.004* (-1.663)					
$\Delta ln\,risk_t$					0.001 (0.471)				
$\Delta rent_t$								-0.077 (-0.339)	
ΔlnQ_t									-0.000 (-0.336)
R^2	0.822	0.830	0.950	0.813	0.821	0.710	0.920	0.8033	0.926
DW	1.858	1.809	1.865	1.869	1.852	1.764	1.682	1.909	1.627

Notes: The numbers in parentheses are *t*-statistics. *, ** and *** signify 10%, 5% and 1% levels of significance, respectively. The Cochrane-Orcutt estimation method is used to correct for first-order serial correlation. The estimation period is 1968.3Q-2008.2Q except for the estimates in column 3, 6, 7 and 9 in which the estimation periods are 1977.3Q-2008.2Q, 1968.3Q-1994.4Q, 1994.4Q-2008.2Q and 1992.1Q-2008.2Q, respectively. $E(p^{hr})$ is real house prices based on expected inflation, p^{hr} is *ex post* real house prices, and p^h is nominal house prices.

Turning to the regressions of the error-correction model (equation (19)) in column 3, banks willingness to lend and *Sec* remain highly significant. The estimated coefficient of income is insignificant suggesting that income is not a robust determinant of house prices. The error-

correction term is insignificant, which is consistent with the cointegration regression above. Land prices are mildly significant and positive while construction costs are strongly significant determinants of nominal house prices. This result is consistent with the predictions of the model that supply factors are influential for house prices in the short run as well as in the long run.

4.1 Robustness checks

This section tests the sensitivity of the estimates to estimation period, and the allowance for macro risk, rental income, and demand for credit. First consider macro risk. Thus far it has been assumed that the availability of credit has been the major force behind house price dynamics under the assumptions that banks prefer not to increase interest rates in times of heightened risk because high interest rates may attract high risk borrowers and because higher interest rates increase the likelihood of default. However, while not directly related to the housing market, research by Bernanke and Gertler (see for example Bernanke and Gertler, 1995) suggests lenders have a greater capacity for distinguishing risk characteristics of potential borrowers and can optimally price each borrower's investment proposition such that reduced lending only occurs as a result of lenders being priced out of the market, rather than rationed out. Correspondingly, Bernanke (1983) and Mishkin (1990) use interest rate spreads between lower grade corporate and long-term treasury bonds as a proxy for the availability of credit to assess the influence of credit markets on aggregate economic activity.

Unlike the corporate sector, there are limitations on interest rates available for high risk borrowers in the residential housing market because the freedom of banks to increase interest rates is restricted by regulation.[‡‡] Therefore, the interest rate spread between a one year low grade corporate bond (BAA) and a one-year treasury bond is used as a proxy for the prevalence of risky borrowers under the assumption that macroeconomic risk reflects the overall riskiness of mortgage borrowers. This measure is likely to be highly correlated with the riskiness of mortgage lending. Specifically, a large interest rate spread indicates uncertain prospects for the corporate sector. Since a large fraction of house owners are employed in these companies, their capacity to pay their mortgage must ultimately be related to the prospects of the firms by which they are employed.

[‡‡] This suggests that the extent to which higher interest rates can be charged on risky borrowers is limited. To some degree, banks can charge higher fees on risky borrowers. Furthermore, the non-banking mortgage lending sector is not subject to the same strict regulations as banks and, as such, is able to use interest rate charges to distinguish between borrower risk types more easily.

The interest rate spread is included as an additional variable in the regression in column 5. The estimated coefficient of the spread is insignificant. Adding up to six lags of the spread did not change the results; all lagged coefficients were insignificant. Using an AAA rated bond to estimate the spread did not change the results either (the results are not shown). This result is consistent with the finding of Greasley and Madsen (2006) who find that the spread was not an important determinant of investment during the Great Depression in the U.S.

In order to test for the sensitivity of the estimates to sample period, the estimation period is split before and after the last house price run-up started in 1994.4Q in Columns 6 and 7. The regressions show that income, nominal interest rates and, particularly, banks' willingness to lend were the key drivers of house prices before the mid 90s. There was found to be very little role for securitized mortgages before 1994 as one would expect given the fraction of securitized mortgages was less than 2 per cent of all mortgages, on average, during that period. After 1994, nominal interest rates and securitization are shown to play very significant roles for the house price dynamics while the role of the traditional channel of bank lending is shown to subside. With the decline in the influence of bank lending, credit constraints can be expected to have been reduced and the conventional relationship between per capita disposable income and house prices to be substantially weakened. The results confirm that since the mid 1990s, disposable income per capita has lost some of its influence on the behaviour of house prices. The rising disintermediation in the mortgage market has resulted in a disconnection between the change in ability to pay for a home out of income flows, and the change in the rate of house price appreciation. These results, in combination with the insignificance of the willingness of banks to lend to home owners for house prices since 1994, lends support to the theory that disintermediation has destroyed originators' incentives to ensure long term performance of mortgage loans through prudent verification of borrowers' abilities to pay. Indeed, the provision of mortgage funding through the issuance of MBS played a highly significant and economically important role in house price fluctuation since 1994.

Rent has been included as an additional regressor in the regression whose results are displayed in column 8. Note that nominal house prices are used as the dependent variable in this regression because the theory predicts that nominal house prices are related to nominal rent. Income has been omitted because rent is the earnings from renting out properties and income should not have any independent effect on house prices. The rent-model follows the idea that

house prices are a function of the present value of rent which reflects the earnings on housing investment. The estimated coefficient of rent is insignificant and may reflect that rent is measured as the average rent and not the rent charged at the margin. The estimated coefficients of banks' willingness to lend and *Sec* are again highly significant, which is further evidence of credit playing a key role in driving house price fluctuations.

Thus far, demand for credit has been suppressed in the regressions. However Jaffee and Modigliani (1969) argue that demand for credit may be influential for the demand for durables. Demand for credit may be low if would-be housing investors consider their financial prospects less advantageous. As a measure of the demand for credit, the Federal Reserve's *Senior Loan Officer Opinion Survey's* results reporting the net percentage of domestic respondents reporting stronger demand for residential mortgage loans are included as an additional explanatory variable in the estimates in column 9. The estimated coefficient is insignificant and further lags (up to six) were also insignificant. Thus, it appears that it is the ease of obtaining credit that is driving *ex post* credit.

4.2 Simulations

To show the factors that have been responsible for house price fluctuations in the U.S. over the estimation period, Table 2 displays the contribution of credit, nominal interest rates, and income to house price growth over the period from 1966 to 2008. Only the third quarter in each year is displayed in Table 2 to preserve space. The simulations are based on the estimates in column 1 in Table 1 (the simulations are almost identical for all the regressions). The last column shows actual real house price changes in percentage terms based on expected inflation. The model simulations show that willingness to lend is the dominant driver of house price growth rates up to 1994 and again after 2007, while securitization is the dominating force between 1994 and 2007. Banks' willingness to lend typically contributes a two percent increase in house prices per annum during upturns and detracts two percent per annum during downturns. These contributions account for more than half the growth rates during house price cycles. The two-percent rule has been repeated during the last housing boom; however, not through banks' willingness to lend but through the channel of securitization. During the ten-year boom period 1998-2007, securitization explains annual real house price growth rates of 2 per cent per annum, on average.

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Interest rates have contributed to the recent house price run-up by about 0.2 percent a year. The interest rate variations are generally not that important for house price fluctuations. Income growth rates have, on average, contributed to a 0.4 percentage increase in house prices. Since per capita income is increasing over time it is tempting to infer permanent effects of income growth on house price growth. However, house prices are entirely determined by acquisition costs in the long run and income can only influence the long run path of house prices to the extent that land prices are not perfectly elastic. Finally, the last two columns in Table 2 suggest that the model explains a large fraction of house price fluctuations and the average growth rate in real house prices. Real house prices have, on average, increased 1.1 percent annually. The model predicts a 0.8 per increase, on average.

Table 2. Simulations of estimates in column 1 in Table 1.

Third Q	Willing. Lend	Sec.	Nom. Interest	Income	Pred. Tot.	Actual ex ante
1968	1.4	0.0	-0.4	0.7	1.7	4.5
1969	0.3	0.0	-0.7	0.6	0.2	0.7
1970	-3.1	0.0	-0.7	0.6	-3.2	-8.7
1971	0.1	0.0	0.9	0.5	1.5	0.5
1972	3.4	0.0	0.2	0.7	4.4	1.5
1973	1.9	0.0	-0.7	1.1	2.4	2.0
1974	-0.2	0.0	-0.8	-0.4	-1.3	-1.4
1975	-2.1	0.0	0.4	0.3	-1.4	-2.3
1976	1.3	0.0	0.0	0.6	2.0	1.6
1977	2.2	0.0	0.0	0.5	2.7	3.8
1978	0.9	0.0	-0.5	0.7	1.1	4.2
1979	-0.8	0.0	-0.9	0.1	-1.5	0.4
1980	-3.0	0.0	-1.0	-0.1	-4.1	-1.4
1981	-3.2	0.0	-3.1	0.6	-5.6	-2.9
1982	-1.7	0.0	0.8	0.1	-0.7	-4.4
1983	1.4	0.0	1.6	0.5	3.4	-0.9
1984	3.3	0.0	-0.5	1.4	4.2	-0.1
1985	1.9	0.0	1.5	0.3	3.7	0.9
1986	2.1	0.4	1.2	0.6	4.3	3.0
1987	2.6	-0.3	-0.2	0.1	2.3	2.5
1988	1.1	0.2	0.0	0.7	1.9	0.5
1989	0.7	0.0	0.3	0.3	1.3	1.8
1990	0.1	0.4	-0.1	0.2	0.7	-3.1

1991	-0.6	1.3	0.5	-0.2	1.0	-2.5
1992	-0.8	1.7	0.8	0.4	2.1	-0.7
1993	0.1	0.9	0.6	0.0	1.5	-2.6
1994	0.3	0.5	-1.0	0.4	0.2	-1.9
1995	0.2	0.0	0.6	0.2	1.0	-0.1
1996	0.0	0.5	-0.3	0.4	0.7	-1.0
1997	-0.1	0.8	0.4	0.4	1.6	1.0
1998	0.0	2.1	0.4	1.0	3.4	2.3
1999	0.0	0.9	-0.6	0.2	0.6	2.2
2000	0.0	0.1	-0.2	0.9	0.8	3.3
2001	0.1	0.8	0.7	0.3	1.9	4.5
2002	-0.1	0.8	0.4	0.1	1.2	3.9
2003	-0.3	0.0	0.2	0.5	0.4	3.0
2004	-0.2	3.0	0.1	0.3	3.3	8.3
2005	0.1	4.2	0.1	0.0	4.4	7.3
2006	0.2	3.9	-0.5	0.6	4.1	2.9
2007	0.0	1.5	0.0	0.4	2.0	-2.3
2008	-1.	-2.9	0.2	-0.1	-4.6	*NA*

4.3 Empirical estimates for a panel of several OECD countries

While the results for the U.S. data are strongly suggestive of a role for financial intermediaries' willingness to lend in influencing house price fluctuations, the general validity of this premise would be stronger where similar results were derived for other countries. Unfortunately, data pertaining to banks' willingness to lend in other countries have only recently become available.[§§] In the aim of drawing some results from such a short data sample, a panel of quarterly data has been collected for nine OECD countries consisting of Japan, Belgium, France, Germany, Italy, Ireland, the Netherlands, the U.K. and the USA. We were not able to find data for other countries. Panel data estimates are undertaken since the short time-span of the data renders the reliability of the single country estimates very low.

The following equation is estimated using OLS:

$$\Delta \ln p_{it}^{hr} = v_1 \Delta C_{it} + v_2 \Delta i_{it} + v_3 \Delta \ln Y_{it} + v_4 D_i + \varepsilon_{3,it}, \qquad i = 1, 2, \ldots 9 \qquad (21)$$

[§§] The *Senior Loan Officer Opinion Survey on Bank Lending Practices at Large Japanese Banks* in Japan commenced in 1999, surveys initiated by the European Central Bank entitled *The Bank Lending Survey for the Euro Area* started in 2003, and the U.K *Credit Conditions Survey* started being collected from 2007.3Q, (see the data appendix for details).

where D_t represents country dummies and the other variables are defined as above. House prices are deflated by consumer prices and i is measured by a long-term nominal mortgage interest rate since the real interest rate was insignificant in all regressions. The data span over the period 2003.1Q-2009.1Q except for France and the UK whose data span only 2007.1Q-2009.1Q, and 2007.3Q-2009.1Q, respectively. Since data on construction costs and land prices are available for a couple of countries and not up-to-date, they are omitted from the estimates. The data and their sources are detained in the data appendix in Carrington and Madsen (2009). The model is regressed using the general-to-specific method with the variables again estimated in four quarter differences. Only up to two lags are included in the regressions because the sample estimation period is already limited to the maximum period 2004.3Q-2009.1Q by the lags and the fourth-difference operations.

Table 3. Parameter estimates of equation (21)

	(1)	(2)	(3)
Dep var.	Δp^{hr}	Δp^{h}	Δp^{hr}
ΔC_{t-1}	0.644(2.704***	0.372(4.704)***	0.383(4.935)***
ΔC_{t-2}	0.312(1.251)		
Δir_{t-1}	0.010(0.573)		
Δir_{t-2}	-0.049(-2.844)***	-0.036(-2.962)*	-0.041(-3.236)***
ΔlnY_{t-1}	0.511(3.901)***	0.485(4.261)***	0.470(4.442)***
ΔlnY_{t-2}	0.094(0.643)		
Adjusted R^2	0.383	0.407	0.386

Notes: The numbers in parentheses are *t*-statistics. *, ** and *** signify 10%, 5% and 1% levels of significance, respectively. The standard errors are based on the Newey-West heteroscedasticity and autocorrelation consistent covariance matrix. The coefficients of the willingness to lend variables have been multiplied by 1000. The estimation period is 2004.3Q-2009.1Q except for France and the UK whose estimation period is 2008.3Q-2009.1Q, and 2008.2Q-2009.1Q, respectively.

The results of regressing (21) are displayed in Table 3. The unrestricted results are displayed in column (1). In line with the results for the U.S. data, willingness to lend is found to have a significant influence on house prices, but unlike the U.S. data, the panel countries' house prices respond much faster to changes in credit standards; the first lag is very significant. The second lag of the annual difference in interest rates and the first lag of the four quarter growth rate of real per capita income are also significant determinants of house price fluctuations. Almost

similar results apply if the dependent variable is measured as nominal house prices (results are not shown).

The restricted estimates are shown in columns (2) and (3). Whether house prices are measured in nominal or real terms does not influence the results. Willingness to lend, interest rates and income are all highly significant determinants of house prices. Importantly, the estimated willingness to lend elasticity is approximately the same as the long-run elasticity for the U.S. This result suggests that credit has the same force in shaping house price growth in the OECD countries and is not only limited to the U.S. In other words, credit is equally important for house price paths in the U.S. and other OECD countries.

5.   Conclusion

House prices are, in conventional models, predominantly driven by income, demographics, and the user cost of capital (Girouard *et al.* 2006). Establishing a Tobin's *q* model of house prices with demand and credit constraints, the model presented in this paper suggests that house prices fluctuate around their slow-moving equilibrium due to changes in credit availability, income and nominal interest rates in the OECD countries. Demand and interest rate shocks have only temporary effects on house prices because any discrepancy between house values and acquisition costs is closed by supply responses over time. However, where supply-side adjustment is slow due to regulations, permit requirements, and building time, demand shocks can have long-lasting effects on house prices.

Willingness to lend and, therefore, the availability of credit for house investment, were analytically shown to have opposite effects on house prices in the short run and in the long run. In the short run, house prices are most likely to increase in response to a positive credit shock in a perfect foresight market and will unambiguously increase in a myopic market that fails to take account for the supply response to disequilibrium. In the long run, however, house prices were shown to be negatively related to the willingness to lend. The intuition behind this result is that a permanent easing of credit constraints allows builders increased access to credit. The consequence is a higher stock of buildings than would have prevailed under credit constrained conditions.

Two empirical analyses were undertaken to test the implications of the model using direct measures of the availability of credit. Firstly, using U.S. survey evidence on Banks' willingness

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to lend and securitization data, the empirical estimates confirm that house prices fluctuate around their slow moving trend predominantly due to creditors' willingness to lend. Interest rates and income are shown to play a secondary role for house price fluctuations in the U.S. While bank's willingness to lend has been the major driving force behind house price variations before 1995 and after 2007 in the U.S. the most recent house price run-up has been predominantly driven by the willingness to lend among the non-banking financial institutions. Measuring the non-banking financial sector's willingness to lend by the density of securitized mortgage loans, it was shown that a combination of the entire financial sector's willingness to lend and reduced nominal interest rates can explain the majority of the most recent U.S. housing run-up. Considering the entire estimation period from 1966 to 2008 tor the U.S., simulations of the model reveal that willingness to lend has explained the lion's share of house price fluctuations. Structural changes in the mortgage finance market, and particularly the growth of disintermediation, have resulted in a divorce of the relationship between the change in home buyers' ability to pay and house price appreciation. The reduced power of income to explain house price variations are reflective of this trend.

The second analysis included a shorter period of data for a panel of 9 OECD countries. The results of this analysis were also strongly suggestive of the power of banks' willingness to lend in driving house price changes. In comparison with the U.S., the panel countries' house fluctuations showed a stronger correlation with both changes in real per capita income growth as well as changes in nominal interest rates. This is likely to present significant challenges for monetary policy authorities in the future; housing market recovery is only likely to be established along side a broader economic recovery. However, it is precisely at this time that interest rates will tend towards neutrality. The non-U.S. OECD countries are then likely to find themselves in a similar boat as the U.S.: the tension between the objective of establishing the foundations of a strong, non-inflationary economic recovery and that of reigniting confidence in mortgage credit markets is likely to require a difficult balancing act.

Data Appendix

Willingness to lend: <u>USA</u>: Sourced from the Federal Reserve Bank's quarterly survey, the *Senior Loan Officer Opinion Survey* on bank lending practices (Federal Reserve Bank, 2008, http://www.federalreserve.gov/boarddocs/SnLoanSurvey/200811/fullreport.pdf.). The most recent survey collected responses from 55 US domestic banks and 21 US branches and agencies

of foreign banks. The data used reports the percentage of responding banks that affirmed tightened standards. The primary data source spanning 1990.1Q–2008.4Q is data pertaining to the question of whether the bank's credit standards for approving applications from individuals for mortgage loans to purchase homes has tightened over the past three months. Since data on this question is available first from 1990.1Q it is spliced and backdated to 1966.1Q with survey data on the question as to whether the bank's willingness to make consumer instalment loans has changed relative to three months ago. JAPAN: Sourced from the *Senior Loan Officer Opinion Survey on Bank Lending Practices at Large Japanese Banks*. The survey question asked is "Over the past three months, how have your bank's credit standards for approving applications from firms and households changed?". The net figure reported represents the proportion of banks that have loosened credit standards. The data can be downloaded at http://www.stat-search.boj.or.jp/ . EU COUNTRIES: data is sourced from data collected for *The Bank Lending Survey for the Euro Area* from the relevant national central bank websites. The survey question asked for all EU countries is "Over the past three months, how have your bank's credit standards as applied to the approval of loans to households changed?" The net figure reported represents the proportion of banks that have loosened credit standards. The data can be downloaded for Belgium at www.nbb.be/doc/DQ/BLS/fr/data/BLS_results.htm, France at http://www.banque-france.fr/gb/stat_conjoncture/stat_mone/page6b.htm, Germany at http://www.bundesbank.de/volkswirtschaft/vo_veroeffentlichungen.en.php, Ireland at http://www.centralbank.ie/frame_main.asp?pg=euro_area.asp&nv=sta_nav.asp, Italy at http://www.bancaditalia.it/statistiche/indcamp/bls., and the Netherlands at http://www.statistics.dnb.nl/index.cgi?lang=uk. The U.K.: *Credit Conditions Survey* asks "How has demand for the following types of secured lending from HOUSEHOLDS changed over the LATEST 3 MONTHS relative to the previous 3 months?" The category used is "House Purchase". The net figure reported represents the proportion of banks that have loosened credit standards. The data can be found at http://www.bankofengland.co.uk/publications/other/monetary/creditconditions.htm.

House price indices: USA: The Freddie Mac Conventional Mortgage Home Price Index is available from 1970 – 2008 at the national level, http://www.freddiemac.com/finance/cmhpi/#old. This data set, interpolated back to 1966 with data from the National Realtors Association (http://www.realtor.org/research/research/ehspage?lid=ronav0010) with data reaching back to 1966, was the primary house price index used for the empirical estimates. Other house prices indices used for robustness checks were the Office of Federal Housing Enterprise Oversight (OFHEO) quarterly house price index available from 1975 to present, (http://www.ofheo.gov/hpi_download.aspx), and the Standard & Poors/Case-Shiller House Price Index from 1987 – present (http://www2.standardandpoors.com/portal/site/sp/en/us/page.topic/indices_csmahp/2,3,4,0,0,0,0,0,0,0,1,0,0,0,0,0.html). Belgium: quarterly Belgium house prices were interpolated from the annual data provided by the statistical division of the National Bank of Belgium, Belgostat, available at http://www.nbb.be/belgostat/. France: Quarterly index of French house prices are available on the National Institute of Statistics and Economic Studies website at http://www.insee.fr/fr/themes/info-rapide.asp?id=96&date=20090528. Germany: a quarterly house price index for Germany is available from Statisches Bundesamt Deutschland at http://www.destatis.de/jetspeed/portal/cms/. Ireland: Quarterly average house prices were

obtained from The Department of Environment, Heritage and Local Governement and were updated from 2008.3Q to 2009.1Q with the Global Property Guide. The websites, respectively are http://www.cso.ie/px/Doehlg/Dialog/varval.asp?ma=HSQ06&ti=Average+Price+of+Houses+by+Quarter,+Statistic+and+Area&path=../Database/DoEHLG/Housing%20Statistics/&lang=1, and www.globalpropertyguide.com. Italy: A biannual house price index for Italian houses is available from the appendix in the quarterly Banca D'Italia Economic Bulletin, available from http://www.bancaditalia.it/pubblicazioni/econo/bollec/2009/bolleco57/en_bollec53/eb53_appendix.pdf. Biannual house prices were interpolated to quarterly frequency. Japan: Japanese quarterly house prices were sourced from the Japanese Real Estate Institute's Residential Urban Land Price Index. These figures are reported twice a year and were converted to quarterly frequency by interpolation. The data are available at www.reinet.jp/. Netherlands: Quarterly house prices are available as the Dutch Central Bureau of Statistics, found at http://statline.cbs.ne UK: UK quarterly house price statistics are available from the website of the Office of the Deputy Prime Minister at http://www.communities.gov.uk/housing/housingresearch/housingstatistics/housingstatisticsby/housingmarket/livetables/.

Mortgage Interest rates: USA - Fixed-mortgage interest rate and weighted average interest rate: The weighted average interest rate data has been collated for the period 1982.3Q to 2008.2Q. For the earlier years of the sample period, the 30 year average fixed-mortgage interest rate was used as the average interest rate on residential mortgages. The data for these rates come from the Federal Reserve Bank of St Louis website's economic data base (known as FRED) (http://research.stlouisfed.org/fred2). The series is the Average Contract Rate on Commitments for Fixed-Rate First Mortgages. From the 1980s, adjustable rate mortgages (ARMs) became more prevalent for residential mortgage loans. Data on the adjustable rate index are available from the Federal Housing Finance Board - National Average Contract Mortgage Rate Index History, (http://fhfb.gov/GetFile.aspx?FileID=6968). This index was the only index rate that federally chartered savings and loan associations could use as an adjustable-rate mortgage index in the early 1980s. This data was used to capture ARM interest rate movements from 1980.3Q to 1984.4Q. Proceeding 1984, and before 1992, 1 year ARM data was interpolated using the Federal Reserve prime rate data, one of the main indices used to index the ARMs in the US (http://www.federalreserve.gov/releases/h15/data/Monthly/H15_PRIME_NA.txt). From 1992 until 2008, the 1 year average ARM rate available again from the Reserve Bank of St Louis's FRED was used. To create the weighted average interest rate for residential mortgages in the US, data pertaining to the proportion of total loans classified as ARM was used as the weight. This data, converted from annual to quarterly, was available from 1982.3Q to 2008.Q2 and obtained from two sources. From 1982 until 2005, annual data was obtained from the Federal Housing Finance Board summary data, Table 9: Terms on conventional single-family mortgages, annual national averages, all homes. For the final part of the sample, quarterly figures were acquired from the Quarterly Review of Interest Rate Risk, produced by The Office of Examinations, Supervision and Consumer Protection, - Risk Modelling and Analysis Division of the Office of Thrift Supervision, (http://www.ots.treas.gov/?p=QuarterlyReviewOfInterestRateRisk). Belgium, Germany, France, Ireland, Italy, Netherlands: European Central Bank Statistical data Warehouse: http://sdw.ecb.europa.eu/browse.do?node=2018783. Mortgage interest rates were 10 year mortgage interest rates on new loans, except Ireland, whose longest fixed interest rate reported

was 5 years. <u>UK</u>: Mortgage interest rate used is the secured lending mortgage interest rate for 10 year fixed mortgages with a 75% loan to value ratio.
(http://www.bankofengland.co.uk/mfsd/iadb/index.asp?Travel=NIxIRx&levels=1&C=EP3&C=RO&FullPage=X40727&FullPageHistory=X40727&Nodes=X40727X40728X40754X40755X45786X40729X40749X40752&SectionRequired=I&HideNums=-1&ExtraInfo=true&G0Xtop.x=54&G0Xtop.y=6). <u>Japan</u>: Interest rate on mortgages is that for long-term loans provided by domestically licensed banks.(http://www.stat-search.boj.or.jp/ssi/html/nme_R020MM.10358.20090730092456.01.html)

Mortgage Backed Security Issues: The flow of MBS created by private issuers of asset backed securities was obtained from Federal Reserve Bank Flow of Funds Accounts of the United States, statistical release Z.1, table F.126. The annualised quarterly flow data was converted to quarterly flow data. The data are first available from December 1984. The fraction of mortgages that are securitized are set to zero before December 1984. The fraction of mortgages that are securitized are additively scaled down so it is zero December 1984 to ensure that the change in securitization is gradual in the first four quarters at which the data are available.

Inflation expectations: Sourced from the University of Michigan Surveys of Consumers. The survey question is: *'By what percent do you expect prices to go up, on the average, during the next 12 months?'*. The data used records the mean expectation. The data can be found at http://www.sca.isr.umich.edu/

Real disposable income USA: FRED, (http://research.stlouisfed.org/fred.)
Real per capita income OECD: Income data for all panel countries except Japan was obtained from the European Central Bank Statistical Data Warehouse, http://sdw.ecb.europa.eu/. The GDP measure used was Chain linked GDP without seasonal or working day adjustments. <u>Japan</u>: Japanese non seasonally adjusted real GDP was obtained from the Japanese Government's Cabinet office website: http://www.esri.cao.go.jp/en/sna/qe091-2/gdemenuea.html. All **population** data for the entire panel of countries was obtained from the European Central Bank Statistical Data Warehouse, http://sdw.ecb.europa.eu/.

CPI: FRED, (http://research.stlouisfed.org/fred.)

Population: FRED, (http://research.stlouisfed.org/fred.)

Construction Costs: The quarterly construction cost index was constructed from annual data from the Case-Shiller data set on house prices available from Robert Shiller's Home page at http://www.econ.yale.edu/~shiller/data.htm. The data was converted to quarterly data by taking the annual observation as the middle point of five, interpolating between observations with a growth trend series and retaining the interpolated data.

Land prices: Economic Report of the President. The data are interpolated to quarterly data using the same method as for construction costs.

Rental price index: The quarterly rent price index was obtained from the Bureau of Labour Statistics website available at http://data.bls.gov/PDQ/outside.jsp?survey=cu

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