The Effect of Mortgage Interest Deduction and Mortgage Product Innovation on House Prices

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Abstract

In many countries, house prices are overvalued according to price-to-income ratios. These ratios ignore the fact that nominal interest rates have decreased since the 1980s. Models that try to explain house prices based on a standard annuity mortgage can incorporate the role of the interest rate. We extend these models to incorporate mortgage interest deduction and the recent innovation in mortgage products. Our results indicate that there exists a long-run relationship between house prices and borrowing limits adjusted for mortgage interest deduction and mortgage characteristics. We show that this measure Granger causes house prices while evidence in the other direction is almost nonexistent. The model allows a better interpretation of housing markets and is useful for scenario analysis to improve decision-making.

1 Introduction

From the mid-1990s house prices have increased in almost every developed country. The Economist (November 26th 2011) notes that "Never before had house prices risen so fast, for so long, in so many countries". This sharp increase raises concern about housing bubbles and strong overvaluation in the housing market. Assessing the possibility of overvaluation with price-to-income ratios or price-to-rent ratios would indeed suggest that many housing markets are overvalued. The overvaluation can appear enormous even when house prices are in fact reasonably priced (Himmelberg, Mayer and Sinai [2005]). There are several reasons why price-to-income and price-to-rent ratios fail to examine whether or not house prices are above fundamental levels. The metrics do not incorporate the interest rate and hence ignore the effect of the decreasing long-term interest rates since the 1980s on house prices. The maximum rate at which mortgage interest is deductible differs between countries and over time. This could lead do differences in affordability that standard price-to-income ratios or price-to-rent ratios ignore. Finally, in this low interest-rate environment, the standard 20-year annuity mortgage is recently loosing popularity in favor of longer terms or interest-only alternatives (Scanlon, Lunde and Whitehead [2008]). Mortgage product innovation can lead to higher borrowing limits such that income alone is insufficient to explain house prices.

For these reasons, income alone cannot explain house price behavior in the long run. Gallin (2006) shows that even his more powerful panel-data tests do not reject the null hypothesis of no cointegration between house prices and income. Without a correctly estimated long-run equation, error-correction specifications may be inappropriate. Studies that use error-correction models for house prices and income may thus produce biased estimates.

Our goal is to estimate the long-run equilibrium properly. We adjust the income variable because most households finance their home purchase with a standard annuity mortgage. Thus instead of using income

alone we compute a variable that can be interpreted as the borrowing limit or affordability for the average household. In a first extension we augment the model to allow for mortgage interest deduction. As the interest payments are higher in the first years in comparison to the last years of the mortgage, we assume that the average deducted interest is used to increase mortgage payments and ultimately the borrowed amount. A second extension will be the mortgage product innovations. Besides the standard annuity mortgage, we model two groups of mortgages. The first are the interest-only loans with repayment vehicle such as endowment or savings mortgages. The second group contains pure interest-only loans where the borrower has no repayment vehicle.

Our results indicate that there exists a long-run relationship between house prices and affordability adjusted for mortgage interest deduction and product innovation such that we can answer the following questions: "How does mortgage interest deduction influence the amount that people are allowed to borrow?", "What is the role of the interest rate?" and "What is the link between financial innovation and house prices?". These are questions that receive too little attention in the literature although they are highly relevant for policy makers and academics to get a deeper understanding of price forming in the housing market.

2 Overview of the Literature

McQuinn and O'Reilly (2006) propose an intuitive theoretical model of the housing market based on the observation that most house purchases are mortgage-financed. Hence the amount that households are able to borrow depends on their income and interest rates – given plausible assumptions of the fraction of income that goes to mortgage repayments and the duration of the mortgage terms. They apply their model to the Irish housing market and find evidence of a long-run relationship between house prices and the amount the average household can borrow. In McQuinn and O'Reilly (2007) the authors apply this model to a panel of 16 OECD countries. Their panel cointegration tests again indicate that a long-run relationship exists. Madsen (2012) proposes a model that explains house prices by demand in the short run and supply in the long run. In the short run, house prices are driven by the maximum obtainable loan and the number of house buyers. In the long run, the housing stock is unlikely to remain constant such that the most important determinant of housing will be the replacement cost. His model is able to explain the 1995-2007 house price run-up in the OECD countries with declining interest rates as one of the important factors. The model was not able to account for all the increase in the period 2001-2006. Madsen (2012) points to financial innovations, which lower initial mortgage payments, as a possible explanation.

Only a few studies have examined the financial innovation in the mortgage market and their effect on house prices. Addison-Smyth, McQuinn and O'Reilly (2009a) note that the period after 2000 corresponds to a period of excess credit due to the access to interbank markets of UK credit institutions. Their results indicate that the loan amount issued in itself caused UK house prices to increase to a level which is 30% greater than what they would have been without access to foreign credit markets. In another study Addison-Smyth, McQuinn and O'Reilly (2009b) apply their model to the Irish housing market. In addition to the funding in the form of interbank borrowing, the authors point to the greater importance of asset securitization since the late 1990s. This enabled financial institutions to raise funds at a lower cost, which was used by Irish banks to a large extent. The authors conclude that the inclusion of these financial innovations improves the model. De Greef and de Haas (2000) examine the interdependencies between house prices and mortgage lending in the Netherlands. The authors estimate a model for both the housing and mortgage market. The results offer support for the view that both markets are dependent on each other.

The literature that models residential credit often ignores the fiscal deductibility of mortgage interest payments. This has implications for the amount that people are able to borrow given their income. The ENHR

conference paper by Vastmans and Buyst (2011) incorporates this insight. They show that a long-run relationship exists between house prices and the amount of money people can borrow by modeling the evolution of the net tax relief in combination with a mortgage lengthening in 2005 for Belgium.

The ability to deduct mortgage interest is however already incorporated in the user cost literature. This methodology is based on a rational model of asset price equilibrium where a rational homebuyer should equate the price of a house with the present value of its future service stream (Poterba [1984]). Mayer and Sinai (2007) augment the user cost model to include proxies for low risk premia in the capital markets, inflation illusion and backwards-looking expectations of price growth. The results suggest that changes in lending market efficiency with increased subprime lending in recent years is related to excess growth in price-to-rent ratios. The user cost threats the financial cost as a life-time payment of interest, which makes the measure highly sensitive to changes in the interest rate. In reality, when the housing market is mainly driven by homeowners who use a mortgage, buyers face a financial constraint due to the initial mortgage payments. The homebuyer has to make a minimum down-payment while he doesn't want his initial monthly mortgage payments to exceed a certain threshold of income. Another drawback with user cost models is the expected capital gain. Poterba's (1984) original assumption of perfect foresight is unrealistic. Himmelberg, Mayer and Sinai (2005) assume that homeowners have the static expectation that house prices increase at the long-run average rate. As the increase in house prices since the 1980s is mainly driven by decreasing interest rates, the assumption of a static expected capital gain is likely incorrect with current record-low interest rates. For these reasons we model house prices by using an intuitive theoretical model that is based on the observation that the average house purchase is mortgage-financed by taking into account the mortgage interest deduction of the individual countries. In addition we will model the financial innovations through the specific mortgage products that are offered to the borrower.

3 Country Comparison: Mortgage Interest Deduction and Mortgage Characteristics

We make a selection of 8 OECD countries in which it is possible to deduct mortgage interest or where the maximum rate at which interest is deductible has changed over time. The countries of interest are Belgium (BEL), Netherlands (NLD), United Kingdom (GBR), United States of America (USA), Sweden (SWE), Norway (NOR), Finland (FIN) and Denmark (DNK).

In Belgium (Van der Reysen, Vanrijckeghem and Vlasselaerts [2007]) the mortgage tax relief before 2005 was mainly a capital deduction. In practice the tax relief was around 2500 euro per household for a mortgage of 20 years in 2004 (e.g. Valenduc [2008], cited in Vastmans and Buyst [2011]). The amount deductible was thus limited per dwelling in contrast to the new mortgage tax relief since 2005 (woonbonus) that is limited per person. In 2005, the tax relief was equal to 1870 euro per person. In the first 10 years this amount was increased by 620 euro. These amounts are indexed such that the maximum allowed tax relief was 2770 euro per person in 2010. For the majority of households the tax relief thus more than doubled from 2500 euro per household in 2004 to 4980 euro in 2005. During the whole period this tax relief was deductible at the marginal tax rate of the borrower.

Homeowners in the Netherlands can deduct interest payments at their marginal tax rate. Tax relief for second homes was abolished in 2001, and deductibility is limited to a 30-year period (Scanlon and Whitehead [2004]). More important in our analysis is the fact that since 1994, Dutch households can get a mortgage based on two full salaries. Before 1994, they were allowed to get a loan by taking into account only 25% of the second salary. On the other hand there are some significant changes in mortgage characteristics since the

1990s. During the last two decades interest-only mortgages (first savings-mortgages with repayment vehicle, later interest-only loans without repayment vehicle) increased in popularity. In 1995, 69% of new residential mortgages where interest-only of which only 14% had no repayment vehicle. In 2006 this share of pure interest-only mortgages had increased to 44,3% (Scanlon, Lunde and Whitehead [2008]).

The mortgage interest deduction has been limited over time in the United Kingdom (Hendershott, Pryce and White [2003]). From 1974 the deduction was restricted such that only mortgages below the £25000 threshold could deduct interest. From 1983, this limit was raised to £30000 and this amount was never adjusted to compensate for increasing house prices. The maximum rate at which interest could be deducted was limited to 25% from 1992 in comparison to maximum marginal income tax rates of 40% in the pre-1992 period. This limit decreased further to 20% (1994), 10% (1995) and 0% (1999). A popular mortgage in the United Kingdom was the endowment mortgage, which is interest only but contains a repayment vehicle in the form of a life insurance policy. As interest deductibility was limited over time, this mortgage decreased in popularity. According to the Mortgage Market Review (2009) there is a recent increase in interest only-loans from 13% in 2002 (7% without repayment vehicle) up to 30% in 2008 (20% without repayment vehicle).

In the United States of America owner-occupiers can deduct interest at their marginal tax rate on the first $1 million of debt used to acquire, construct or improve a house. The United States has a high proportion of long-term fixed-rate mortgages but during 2004-2006 a significant proportion of new mortgages had fixed rates for a limited period reverting to variable rates after a period (Lea [2010]). These loans were designed to improve affordability. The majority of mortgages have a 30-year term.

The accelerating inflation in the 1970s transformed the effective Swedish housing subsidies into huge general subsidies to housing consumption (Englund, Hendershott and Turner [1995]; Turner and Whitehead [2002]). Not only could they fully deduct mortgage interest payments, most new housing units were entitled to interest-subsidized loans and there was a scheme of housing allowances for low-income families with children. Since the 1985 tax reform interest payments can only be deducted at a maximum rate of 50%. The main goal of the 1991 tax reform was to reduce the distortions in housing. Mortgage interest is deductible at a flat-rate tax of 30% since these reforms.

Due to the 1987 tax reform in Denmark, borrowers were no more able to deduct interest payments at the highest marginal tax rates (up to 70%). The taxable value of tax relief on interest decreased to 50%. The 1993 tax reforms further reduced the tax rates at which interest payments could be deducted. This meant a continued decrease in the taxable value of tax relief on interest until it was equal to 33% for all taxpayers in 2001. Since 2003 interest-only products were allowed. This innovation was able to gain popularity such that 31,5% of mortgages where interest-only in 2005. Two years later this share increased further to 43% of owner-occupiers' outstanding mortgages (Scanlon & Whitehead [2008]).

Norway and Finland experienced tax reforms in respectively 1992 and 1993 (de Vries [2007]). Since then, mortgage interest is deductible at proportional rates of 28% in Norway and 29% in Finland. Deductions were possible at the progressive marginal tax rates before the tax reforms.

4 The Model

In this section we model the different mortgages that will be used in the econometric analysis to examine the long-run relationship between house prices and borrowing limits. In subsection 4.1 we model the borrowing limit for the standard annuity mortgage. Throughout the remainder of this paper we refer to this limit as the "affordability" of the average borrower. Subsection 4.2 augments the standard annuity mortgage to allow for

mortgage interest deduction. Thereafter, we model interest-only loans with and without repayment vehicles in subsections 4.3 and 4.4. When we use the term "affordability adjusted for mortgage interest deduction and mortgage characteristics" we refer to the weighted average of the mortgages in subsection 4.2, 4.3 and 4.4 for the country of interest. The weights are the share of the particular mortgage product as a percentage of all new mortgages.

4.1 Standard Annuity Mortgage

As most home purchases are mortgage-financed, the amount the average house buyer is able to pay is critically dependent on how much mortgage providers are willing to lend. The most important mortgage product is the standard annuity mortgage such that the borrower's yearly mortgage payment is equal to a fixed percentage (α) of his income. The loan amount is then dependent on the income (Y_t), the interest rate (i_t) and mortgage length (n). The average person can borrow the following amount (L_t) by calculating the present value of his future payments:

$$L_t = \sum_{t=1}^{n} \frac{\alpha Y_t}{(1+i_t)^t} \tag{1}$$

In addition, the average borrower uses a down payment (D_t) such that the total amount he can pay (P_t) is equal to $P_t = L_t + D_t$. We model this down payment by using a parameter (β) that represents the down payment ratio such that the amount the average person can pay is equal to: $P_t = L_t/(1-\beta)$. The borrowing limit can then be written as:

$$\begin{aligned} P_t &= \left(\frac{\alpha Y_t}{1-\beta}\right)\left(\frac{1-(1+i_t)^{-n}}{i_t}\right) \\ &= \left(\frac{\alpha Y_t}{1-\beta}\right) a_{n,i} \end{aligned} \tag{2}$$

4.2 Standard Annuity Mortgage Adjusted for Mortgage Interest Deduction

Due to the availability of mortgage interest deduction in many countries, the yearly payments for a borrower can be higher than αY_t. He can spend (a part of) the mortgage interest deduction to increase his yearly payments ($\alpha Y_t + \tau_t.average\_yearly\_interest$) and ultimately the borrowing limit. An increase in the borrowing limit does not mean the borrower is able to buy a bigger house with the same monthly cost (αY_t) or the same house with lower monthly cost. This depends on whether or not the effect is capitalized into house prices. There is mixed evidence of this in the literature. Capozza, Green and Hendershott (1996) argue that land supply is completely inelastic. A change in tax rates will thus be capitalized into house prices. Hilber and Turner (2010) find that the mortgage interest deduction decreases homeownership in more regulated areas. More regulated markets will thus experience higher capitalization effects. Although studies outside the USA are scarce, Vermeulen and Rouwendal (2007) show that the housing supply in the Netherlands is rather inelastic. Brounen and Neuteboom (2008) conclude that a large part of the mortgage interest deduction is reflected in the Dutch housing market. We will therefore assume that the fiscal advantage is used to increase the yearly mortgage payments.

In the first years of an annuity mortgage, the interest payments will be higher and the borrower can deduct more interest. In the later years, his capital payments will be higher and he will deduct less. Hence it is reasonable to assume that that the average amount of interest deducted is capitalized into house prices such that his borrowing limit increases to:

$$P_t = \left(\frac{\alpha Y_t + \tau_t.average\_yearly\_interest}{1-\beta}\right) a_{n,i} \tag{3}$$

The rate at which the borrower can deduct interest is equal to τ_t. The average yearly interest paid is equal to:

$$\begin{aligned} average\_yearly\_interest &= \frac{1}{n}((\alpha Y_t + \tau_t.average\_yearly\_interest).n \\ &\quad -(\alpha Y_t + \tau_t.average\_yearly\_interest).a_{n,i}) \end{aligned} \tag{4}$$

Solve (4) for $average\_yearly\_interest$ and substitute this in (3) to get:

$$P_t = \left(\frac{\alpha Y_t}{1-\beta}\right)\left(\frac{1}{1-\tau_t.\left(1-\frac{a_{n,i}}{n}\right)}\right)a_{n,i} \tag{5}$$

This extension allows us to interpret the possible effects of the mortgage interest deduction on house prices under full capitalization of the deducted average yearly interest. For a 20-year mortgage at an interest rate of 5%, a ceteris paribus increase in the maximum rate at which mortgage interest is deductible from 0% to 30% would lead to a house price increase of 13%. An increase in the tax rate from 0% to 50% would even cause borrowing limits to increase by 23%.

4.3 Interest-Only Mortgage with Repayment Vehicle

An endowment mortgage or savings mortgage is an interest-only loan where the principal is repaid at the end of the mortgage term through a repayment vehicle. The borrower pays only the interest and makes payments to an endowment policy. The savings mortgage often takes the form of a life insurance policy that pays the proceeds at the end of the mortgage. If the repayment vehicle is sufficient to repay the loan at the end of the mortgage term, this mortgage type is not riskier than the standard annuity mortgage. The purpose of the savings mortgage is to make maximum use of the mortgage interest deduction. Because he is able to deduct all the interest over the whole mortgage duration, he is able to increase his payment to:

$$P_t = \left(\frac{\alpha Y_t + \tau_t.i_t.(1-\beta).P_t}{1-\beta}\right)a_{n,i} \tag{6}$$

Solve (6) for P_t to get:

$$P_t = \left(\frac{\alpha Y_t}{1-\beta}\right)\left(\frac{1}{1-\tau_t.i_t.a_{n,i}}\right)a_{n,i} \tag{7}$$

We can see that without the ability to deduct interest ($\tau_t = 0$), this mortgage wouldn't exist as it would be equivalent to a standard annuity mortgage. For a 20-year mortgage at a 5% interest rate, the borrowing limit would be 23% higher in comparison to a standard annuity loan when interest is deductible at 30%. At even higher rates of 50%, the affordability would be 45% higher than a standard annuity loan.

4.4 Interest-Only Mortgage without Repayment Vehicle

Another mortgage product that lowers monthly payments is the pure interest-only loan. The borrower only pays interest throughout the whole mortgage duration. At the end of the mortgage term, the borrower has to repay the entire principal. This product differs from the interest-only loans with repayment vehicle because the borrower does not accumulate equity. They hope to refinance or pay off the mortgage through the sale of the house at the end of the term. One reason why interest-only mortgages have become popular in recent years is due to the low interest payments (Scanlon, Lunde and Whitehead [2008]). At low interest rates the percentage of principal repayments are high and hence the difference between mortgages with and without repayment vehicle becomes larger. Instead of repaying principal, the borrower can decide to spend his yearly

payments on interest payments such that $\alpha Y_t = i_t.P_t$ (assuming no down payment). If the borrower is able to deduct interest his yearly payments can increase from αY_t to $\alpha Y_t + \tau_t.i_t.P_t$ which has to equal the yearly interest for the mortgage:

$$\alpha Y_t + \tau_t.i_t.P_t = i_t.P_t \tag{8}$$

Solve (8) for P_t to get:

$$P_t = \frac{\alpha Y_t}{i_t.(1-\tau_t)} \tag{9}$$

Equation (9) is equivalent to the model by de Vries and Boelhouwer (2009), that seeks to identify a long-run equilibrium between interest payments and household income in the Netherlands from 1978 to 2008. We will however use a weighted average of the different mortgage types. Figure 1 shows that the borrowing limit increases significantly at low interest rates in comparison to other mortgage types. One can see that below certain interest rates, the ability to pay with pure interest only loans increases steep. The borrowing limit is indeed 157% higher in comparison to a standard 20-year annuity mortgage with an interest rate of 5%. In a country where interest rates are deductible at lower rates, this advantage only exists at lower interest rates. The borrowing limit is "only" 83% higher in comparison to a standard annuity mortgage when the maximum taxable value of the tax relief equals 30%. This could explain the relative late use of pure interest only loans in Denmark and the United Kingdom in comparison to the Netherlands.

4.5 Semi Interest Elasticity of (Adjusted) Borrowing Limits

The more the borrower is able to deduct mortgage interest, the less the percentage change in the borrowing limit when the interest rate changes. When interest rates increase, a part of this increase in costs is absorbed due to the mortgage interest deduction. Another insight is that the loan amount reacts differently to changes in the interest rate between different mortgage products. Percentage changes in the borrowing limits with respect to a 1% increase in the interest rate is shown in figure 2 for different interest rates. The borrowing limit of pure interest only mortgages is more sensitive to interest rate shocks as this borrower only pays interest. We note that for all mortgages (with the exception of interest-only with repayment vehicle) the borrowing limit reacts stronger to interest rate changes, the lower the interest rate is. This implies a convex relationship between house prices and interest rates, which is also present in the Gordon (1962) Growth Model. Mayer and Hubbard (2008) argue that this could lead to higher correlation between house prices when interest rates fall.

5 Data

For our econometric analysis we will use data from the OECD. The OECD database provides nominal house price, aggregate household real disposable income (which we transform to nominal income per capita), population and 10-year government bond rates. In our analysis we will use 10-year government bond rates for all countries, irrespective of the popularity of fixed or variable mortgage rates. This is in contrast to McQuinn & O'Reilly (2007) who use short and long-term interest rates depending on the popularity in the country. At first sight, lower short-term interest rates indicates that one can borrow more. On the other hand, a high spread indicates that it is very likely that rates will increase in the future. A prudent homebuyer will understand this risk and therefore it is not certain whether or not the term spread (i.e. the difference between the long-term and short-term rates) is capitalized into house prices.

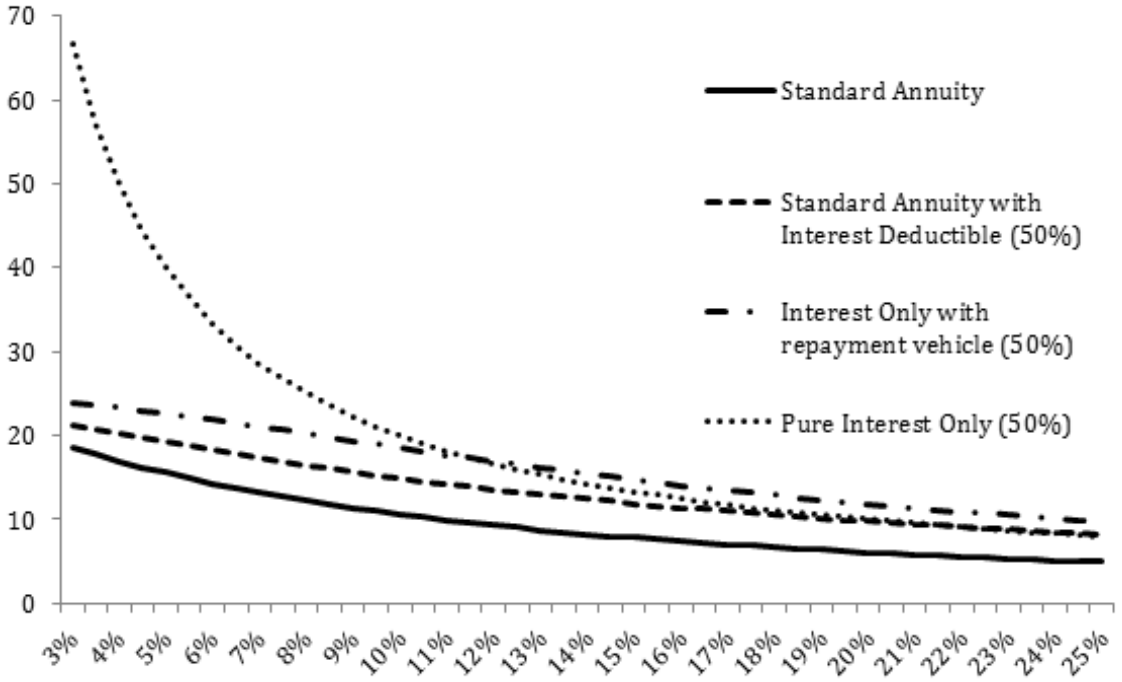

Figure 1: Borrowing Limits of Mortgage Products for Different Interest Rates

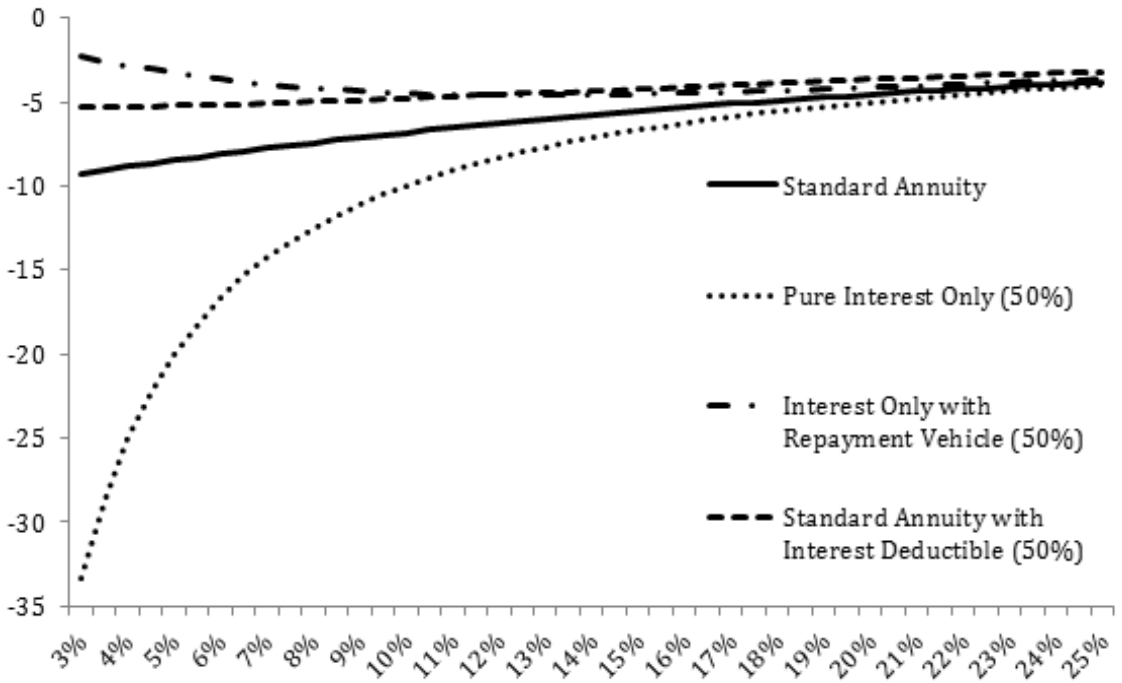

Figure 2: Semi Interest Elasticities of Affordability (in %)

Table 1: Unit Root Tests of Nominal House Price and Affordability (1980Q1-2009Q4)

Country	Nominal House Price	Affordability *
Belgium	0.00	0.00
Netherlands	0.03	0.00
United Kingdom	0.02	0.00
United States of America	0.07	0.00
Sweden	0.00	0.00
Norway	0.00	0.00
Finland	0.01	0.00
Denmark	0.00	0.00

H0: First difference of (log of) nominal house price or affordability has a unit root.

* The results for affordability adjusted for mortgage interest deduction and mortgage characteristics are exactly the same.

6 Empirical Results

6.1 The Long-run Relationship

If two time series achieve stationarity after differencing, but a linear combination is already stationary, these time series are said to be cointegrated according to Engle and Granger (1987). Table 1 presents results for Phillips-Perron stationarity tests (including an intercept) of nominal house prices and affordability in differences. The null hypothesis of no stationarity in differences is rejected in every country at the 10% significance level.[1] All variables are thus integrated of order one and cointegration tests can be applied. We follow the guidance of Haug (1996) and use more than one cointegration test to deal with the trade-off between power and size distortions. He advises to use the Philips & Ouliaris (1990) test statistics, that seem to have higher power when the researcher deals with weakly exogenous regressors. Because the test statistics are non-parametric with respect to nuisance parameters, they allow for a very wide range of time series models in which there is a unit root (Phillips and Perron [1988]). In addition he recommends to use the ADF test as this is one of the tests with the least size distortions. We report two ADF test statistics: the first is the standard t-statistic, the second test statistic is based directly on the autocorrelation coefficient after a correction such that the limiting distribution does not depend on nuisance parameters controlling serial correlation (Hayashi [2000]). Optimal lag length is determined by the Schwarz and Akaike Information Criteria.

Tables 2 and 3 provide test results for the null hypothesis of no cointegration according to the test statistics described before. In several countries there are large differences in p-values between the four cointegration tests. This could point to important differences in the power or size distortions of each test. Given these specific properties, we assume that a long-run relationship exists when one of the four tests reject the null hypothesis of no cointegration at the 10% significance level. Table 2 provides test results for the null hypothesis of no cointegration between nominal house prices and affordability measured as the borrowing limit with a standard 20-year annuity mortgage as defined in section 4.1 . At the 10% significance level, Norway and the United States of America are the only countries where we do find a long-run relationship between nominal house prices and affordability. In all other countries we cannot find a long-run equilibrium. The absence of cointegration in most countries indicates that the standard annuity mortgage is insufficient to explain the evolution of house prices.

To capture the effect of mortgage interest deduction and financial innovation we define the variable "Affordability Adjusted for Mortgage Interest Deduction and Mortgage Characteristics". This is a weighted average

[1] Phillips-Perron tests do not reject the null hypothesis of no stationarity of the time series in levels (results not reported here).

of the borrowing limits of the annuity and interest-only mortgages where mortgage interest deduction is allowed. The weights equal the share of the particular mortgage as percentage of the new mortgages. The test results in table 3 indicate that there does exist a long-run equilibrium from 1980Q1 to 2009Q4 in all countries except Sweden. The impossibility to find a long-run relationship in Sweden is likely due to the extraordinary asset price boom caused by the deregulated credit markets since 1985 (Englund [1999]). This was followed by the Swedish banking crisis in the early 1990s that triggered a downward spiral in real estate prices until the mid-1990s. An important finding is that a long-run relationship between nominal house prices and adjusted affordability does exist from 1995 to 2009, when the Swedish market recovered. Figure 3 shows the effect of changes in mortgage interest deduction, the interest rate and mortgage characteristics since 1980 on changes in adjusted affordability for Sweden (left figure) and the United Kingdom (right figure)[2]. The figure shows the downward pressure on adjusted affordability in Sweden due to the reductions in the rate at which mortgage interest was deductible. Swedish house prices bottomed out in the mid-1990s when decreasing interest rates caused an upward pressure on house prices. The evolution in Sweden is very different from the United Kingdom, where the decrease in mortgage interest deduction (and contemporaneous decrease in the endowment mortgage) was counteracted by decreasing interest rates. The simultaneous downward pressure on house prices due to the phased out mortgage interest deduction and upward pressure due to decreasing interest rates caused a comparatively minor change in house prices. The complete abolition in the United Kingdom can thus be seen as a perfectly timed counter-cyclical Keynesian policy.

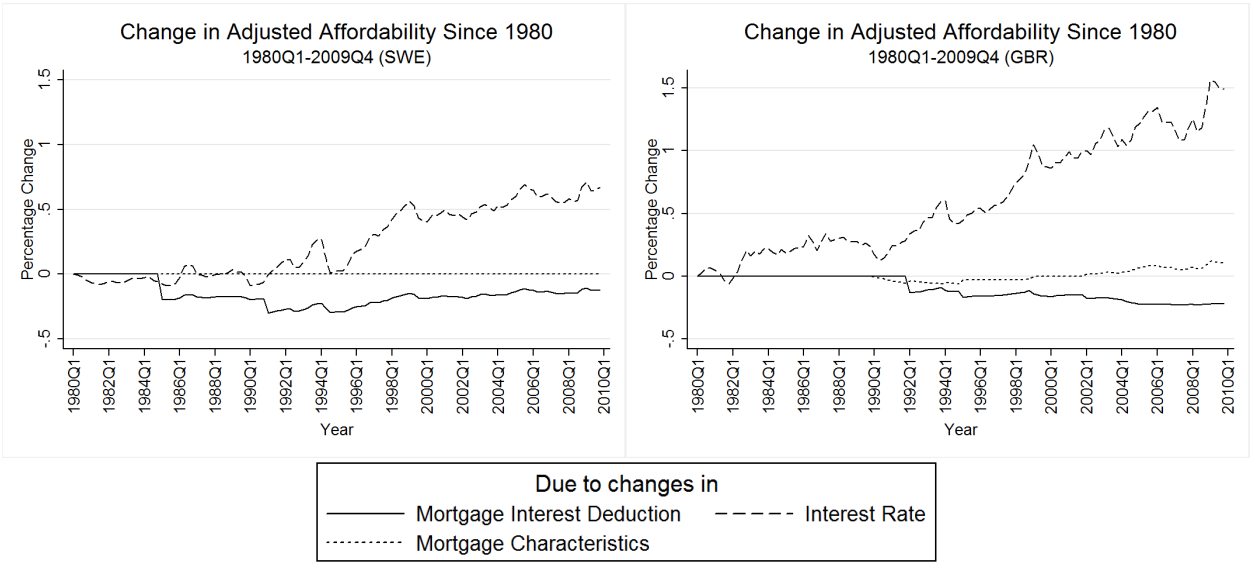

Figure 3: The Effect of Changes in Interest Rate, Mortgage Interest Deduction or Mortgage Characteristics on Adjusted Affordability

The use of the different mortgage types in the model is an important factor in the evolution of house prices in several countries. Including the popularity of the endowment mortgage in the 1980s and the increasing share of pure interest-only loans seem to improve the model significantly for the United Kingdom. In the Netherlands, the run-up in house prices since the mid-1990s was mainly driven by an increasing share of interest-only mortgages, whereas the recent increase in house prices in Belgium was caused by a simultaneous increase in the fiscal advantage for homeowners and a lengthening in the mortgage term (see figure 4 in the appendix). The results indicate that it is necessary to model changes in mortgage interest deduction and specific mortgage product innovations to explain house price behavior since the 1980s.

[2]More information on the construction of the variable can be found in the Appendix.

Table 2: Cointegration Results: Nominal House Prices and Affordability (1980Q1 - 2009Q4)

Country	**ADF t (SIC)**	**ADF z (SIC)**	**ADF t (AIC)**	**ADF z (AIC)**	**PO t**	**PO z**
Belgium						
Netherlands						
United Kingdom						
USA			x	xx		
Sweden						
Norway		x				
Finland						
Denmark						

The ADF and PO columns report the test results for the null hypothesis of no cointegration.
x, xx, xxx refers to respectively a p-value lower than 0.1, 0.05 and 0.01.

The optimal lag orders in the ADF tests are determined with the Schwarz (SIC) and Akaike (AIC) Information Criteria.

Table 3: Cointegration Results: Nominal House Prices and Adjusted Affordability (1980Q1-2009Q4)

Country	**ADF t (SIC)**	**ADF z (SIC)**	**ADF t (AIC)**	**ADF z (AIC)**	**PO t**	**PO z**
Belgium	x	x	x	x		
Netherlands		xx		xxx		
United Kingdom	x	xx	x	xx		
USA	x	xxx	x	xxx		
Sweden						
Norway	x	xx	x	xx		
Finland				xx		
Denmark		x		x		

The ADF and PO columns report the test results for the null hypothesis of no cointegration.
x, xx, xxx refers to respectively a p-value lower than 0.1, 0.05 and 0.01

The optimal lag orders in the ADF tests are determined with the Schwarz (SIC) and Akaike (AIC) Information Criteria

Table 4: Granger Causality (1980Q1 - 2009Q4)
H0: Nominal House Price Does Not Granger Cause Adjusted Affordability

Country	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Belgium									
Netherlands	x								
United Kingdom	xx	x					xxx	xxx	xx
United States of America		x	x					x	x
Sweden									
Norway	xxx	xx	xx	x					
Finland									
Denmark				x					

x, xx, xxx refers to respectively a p-value lower than 0.1, 0.05 and 0.01

Table 5: Granger Causality (1980Q1 - 2009Q4)
H0: Adjusted Affordability Does Not Granger Cause Nominal House Price

Country	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Belgium	xxx	xxx	xx	xx	xxx	xxx	xxx	xxx	xxx
Netherlands	xx	xx	xxx	xxx	xx	xx	xx	xxx	xxx
United Kingdom	xxx	xxx	xxx	xx	xxx	xxx	xxx	xxx	xxx
United States of America	xx	xx	xx	xx	xx	xxx	xx	xx	xx
Sweden	xx	xx	xx	x		x	x	x	
Norway	xxx	xx	xx	xx	xx	xx	x	xx	xx
Finland	xxx	xxx	xxx	xx	xx	xx	x	x	x
Denmark	xxx	xx	x	x	x				

x, xx, xxx refers to respectively a p-value lower than 0.1, 0.05 and 0.01

6.2 Granger Causality

Our results indicate that a long-run relationship between nominal house prices and the borrowing limit exists. There could however exist a problem of endogeneity if increases in house prices demand innovations or longer maturities in the mortgage market to counteract affordability problems. To study the direction of causality we will perform Granger causality tests (Granger [1969]). Because there exists a long-run relationship between nominal house prices and adjusted affordability we can apply the Granger causality tests to the I(1) series. The results in table 4 and 5 are in favor of the view that changes in affordability cause changes in house prices and not the other way around. At the 10% significance level, adjusted affordability Granger causes house prices in every country for a various selection of lags. In the other direction the effects seem almost inexistent, suggesting that higher house prices do not stimulate mortgage product innovation in order to keep housing affordable.

6.3 Implications

Models that try to explain house prices by using borrowing limits as in this paper have the advantage that the role of the interest rate becomes very intuitive. Whereas econometric estimates in reduced form cannot always find a clear role of nominal interest rates in housing markets, our evidence clearly shows the existence of a long-run equilibrium between nominal house prices and adjusted affordability. The borrowing limits and their semi interest elasticities are a non-linear function of the interest rate and hence it is not unlikely that the interest rate is insignificant when only the first power is included or a sample is chosen with high nominal interest rates. There is a whole discussion in the literature about the role of interest rates in housing bubbles (see f.e. Dokko, Doyle, Kiley, Kim, Sherlund, Sim and Van Den Heuvel [2011]). Our model argues that the interest rate has a causal effect on house prices. More concerning is that a low interest-rate environment is a necessary condition for the (risky) pure interest-only mortgage.

Our model indicates that house prices can change due to changes in the share of mortgage payments to income (α), down payment ratio (β), disposable income (Y_t), mortgage length (n), interest rate (i_t), the rate at which mortgage interest is deductible (τ_t) and mortgage characteristics. When policy makers think about reforming the mortgage interest deduction they should take into account that it is the combination of these factors that determine house prices. When the United Kingdom phased out mortgage interest deduction in the 1990s, the negative effect on house prices was counteracted by the large decrease in nominal interest rates since the mid-1990s. This is the reason why there does not seem to be a relationship between the abolishment of mortgage interest deduction and house prices in the United Kingdom. In a country with mortgage interest deduction, already low interest rates and pure interest loans, a reform in times of interest rate increases could make pure interest only loans less interesting. These three factors can all have a negative impact on house prices such that this negative effect has to be tempered by income increases that are very likely not strong enough.

The results indicate that in countries with mortgage interest deduction or specific mortgage characteristics, house prices could react differently to changes in the interest rate. Pure interest-only and standard annuity loans without mortgage interest deduction react stronger to a change in interest rates than an annuity loan with mortgage interest. This could explain why house prices in the United Kingdom, even as they have tighter monetary policy, react stronger to an interest rate change than for example the United States. The increasing popularity of pure interest only loans can in addition explain (part of) the British house price increases. This is also the case for the Netherlands where pure interest only loans increased even earlier in popularity due to the mortgage interest deduction, which made pure interest only loans attractive at even higher nominal interest rates.

The capitalization of increased borrowing limits due to pure interest-only loans raises some concern about the risk in housing markets. When interest rates increase in the future, maybe contemporaneous with a reform of the mortgage interest deduction, the borrowing limit and house prices could decrease significantly. Interest-only borrowers who want to refinance their mortgage or sell their house in the future to repay the loan, could end up with a negative balance if income increases are not strong enough to keep house prices rising.

7 Conclusion

In this paper we studied the housing markets of 8 OECD countries. The theoretical model is based on the observation that the average household faces borrowing limits because most house-purchases are mortgage-financed. The annuity mortgage induces a convex relationship between house prices and interest rates such that house prices are more responsive to interest rate changes when the interest rate is already low. The decrease in nominal interest rate since the 1980s increased borrowing limits which can explain the increase in price-to-income ratios. We extend the model such that the borrower is able to increase his monthly payments with the deducted mortgage interest. Furthermore we model the recent financial innovation in the mortgage market such as interest-only loans with a repayment vehicle and pure interest-only loans to capture the different borrowing limits. When the taxable value of the tax relief is 50%, an interest-only loan with repayment vehicle increases the borrowing limit with 45% in comparison to a standard 20-year annuity loan. The pure interest-only borrower is only dependent on the interest rate. The steep increase in the borrowing limit for low interest rates could explain the recent increase in popularity of this mortgage. Another insight is that the semi interest elasticity of the borrowing limits differ between mortgage products and hence will react differently to interest-rate shocks.

We test for a long-run relationship between house prices and affordability on the one hand, and affordability adjusted for mortgage interest deduction and mortgage characteristics on the other hand. Our results indicate that evidence for a long-run relationship between house prices and affordability is rather limited for every single country. When affordability is adjusted for mortgage interest deduction and mortgage product innovation, the null hypothesis of no cointegration is rejected in almost every country. Granger causality tests indicate that borrowing limits have a causal effect on house prices while evidence in the other direction is almost nonexistent. This is important for the interpretation of the long-run relationship as it indicates that an increase in the borrowing limit causes an increase in house prices. The statement that high house prices cause product innovation and therefore higher borrowing limits seems incorrect according to the Granger causality tests.

We argue that it is important to look at all factors that determine affordability. The United Kingdom abolished the mortgage interest deduction without a significant fall in house prices due to a simultaneous decrease in interest rates. The absence of a house price decrease does not mean that the abolishment has no effect on house prices. A reform of the mortgage interest deduction with an unchanged interest rate, or a simultaneous increase in the interest rate, could have a significant negative effect on house prices.

In the United Kingdom and the Netherlands, we can only find a long-run equilibrium by modeling the recent increase in popularity of pure interest-only loans. The increase in borrowing limit from pure interest-only loans is thus capitalized into house prices, suggesting that there is risk capitalized in these housing markets. In any case, the model makes it possible to analyze house price changes for a whole range of scenarios.

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8 Appendix

Figure 4 presents the percentage change in adjusted affordability at time t due to a change in a specific variable from 1980 to t conditional on the other variables at time t. Due to the conditioning on the other variables at time t, the influence of a variable can change over time without a change in the variable itself. The effect of each determinant is thus dependent on the value of the other variables. This emphasizes the importance to model the adjusted affordability as one variable instead of including the variables separately into a regression. Changes in "Mortgage Interest Deduction" refer to the effect of the marginal tax rate at which interest is deductible and the expansion of the fiscal advantage for homeowners in Belgium. "Interest Rate" refers to the effect of changes in the 10-year government bonds. "Mortgage Characteristics" includes the changes in the share of specific mortgage types and the lengthening of mortgage terms since 2005 in Belgium.

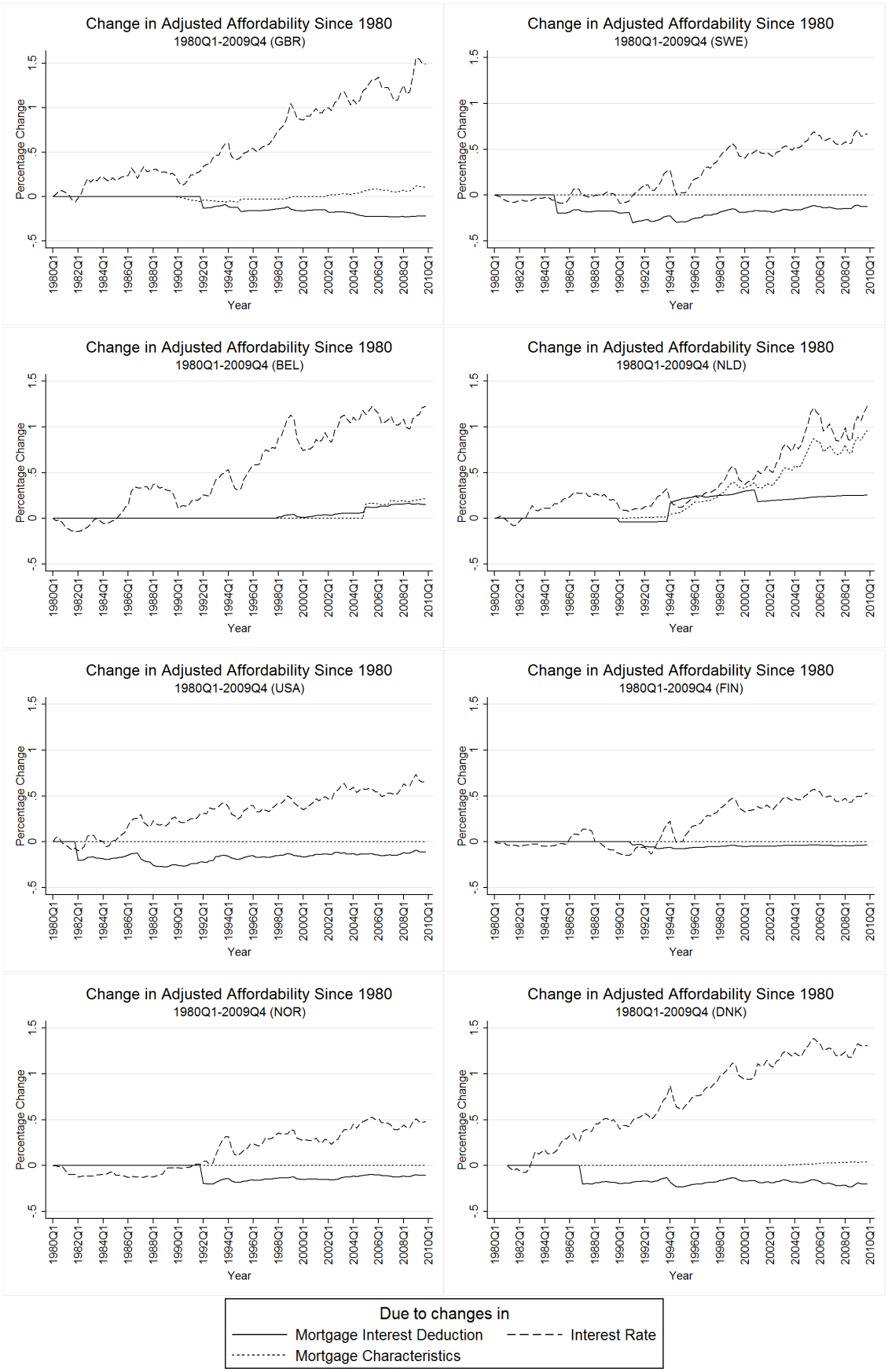

Figure 4: The Effect of Changes in Interest Rate, Mortgage Interest Deduction or Mortgage Characteristics on Adjusted Affordability