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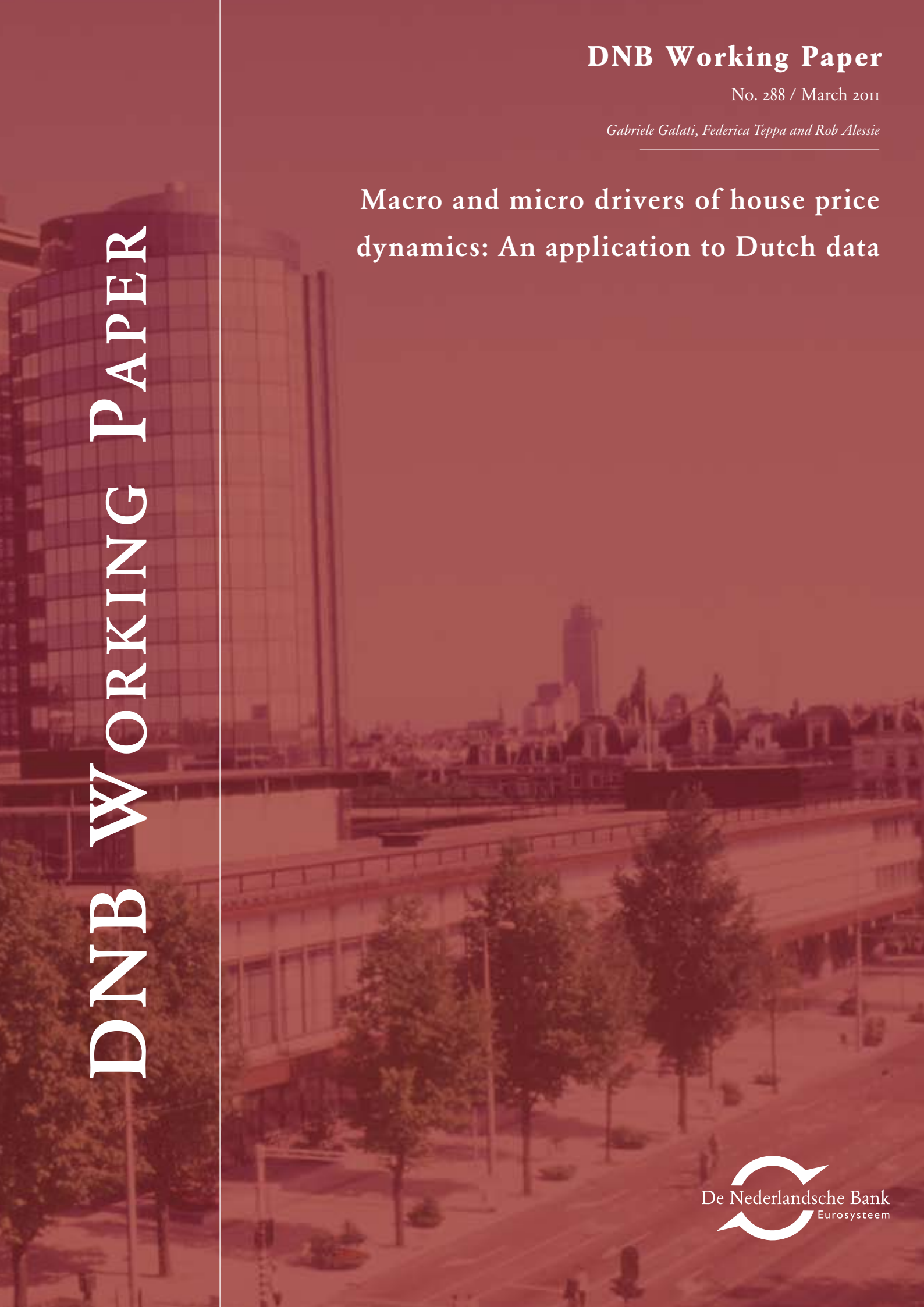

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* Views expressed are those of the authors and do not necessarily reflect official positions of De Nederlandsche Bank.

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Macro and micro drivers of house price dynamics: An application to Dutch data

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Abstract

What is the role of micro and macro factors in determining house prices? We address this question empirically by analysing survey data on housing and mortgages from the DNB Household Survey for the period 1993–2009. We focus on the determinants of house owners' subjective assessment of the value of their house. We highlight three main findings. First, subjective house prices are strongly related to household-specific and house-specific factors, including year of construction, cohort, education level, income and wealth. Financing conditions – in particular the presence of a mortgage as well as the mortgage type, and the mortgage rate – play an important role. Second, we find that macro variables such as the long-term interest rate also influence to an important extent how households value their home. Third, there is evidence of "well behaved" dynamics of subjective house prices, both in terms of persistence and in terms of mean reversion, indicating that house prices tend to converge to their long run equilibrium value. Finally, our findings support a certain degree of heterogeneity and segmentation in subjective house prices, especially along the dimensions of geographical region and degree of urbanization, funding conditions, and income expectations.

Key words: House prices, survey data, panel analysis

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1. Introduction

The housing market plays a key role in the economy through its influence on output growth, financial stability and the monetary policy transmission mechanism (Mishkin, 2007). Cross-country evidence points to the purchase of a house as one of the most relevant decisions for households, since it involves typically a large fraction of a household's total wealth as well as of its expenditure. In the United States, for example, the value of the residential capital stock exceeds that of business capital (Greenwood and Hercowitz, 1991), and the market value of the residential property stock in United States is approximately equal to the annual average GDP (Davis and Heathcote, 2005). Moreover, housing loans represent the main liability category for households and have substantially increased in the past decade. In the euro area, for example, the amount outstanding of mortgages increased from 27 percent of GDP in 1999 to 42 percent in 2007 (ECB, 2009).

The Netherlands is an interesting case: within the euro area, it has the highest households debt related to housing (90 percent of GDP in 2007 vs. 40 percent for the euro area as a whole) as well as the highest households' interest payments (10 percent of gross disposable income vs. 4 percent for the Euro area).[1] Housing wealth has also increased significantly in the past decades, from 31 percent of total household wealth in 1993 to 43 percent in 2009. This has been accompanied by a very strong growth in Dutch mortgage markets, which in part reflect a rapid trend in financial innovation. These trends have underpinned the sizeable and growing share of mortgages in the Dutch banking sector. Housing loans accounted for 27 percent of bank assets in 2009, up from 17 percent in 1997, well above the corresponding numbers for the EU (see Figure 1).

Figure 1 about here

These facts explain policy makers' attention to the role of house prices. The recent crisis has highlighted the need to improve our understanding of the drivers of booms and busts in the housing market.

In recent years, there has been growing interest in modelling the role of the housing market in macroeconomic fluctuations. In parallel, the micro literature on housing economics has started to look at the interactions with macroeconomic factors. This paper contributes to this effort to bridge macro and micro factors in housing markets. We investigate the role of microeconomic characteristics of the household and the property, and macro determinants in the housing cycle in the Netherlands. This cycle experienced particularly pronounced swings

[1] For an analysis of housing markets and house price dynamics in the Netherlands, see Swank *et al*. (2002).

between the mid-1990s and mid-2000s, when house prices rallied sharply by international standards, peaking at an almost 30 percent year-on-year growth around 2000.

To analyse the dynamics of the Dutch housing market, we use a data set on housing and mortgages from the DNB Household Survey (DHS), an annual survey of about 2,000 households in the Netherlands that started in 1993. This is the first time that micro and macro drivers of house price dynamics are investigated using a large panel of households. As we document in the paper, the characteristics of households in the DHS panel are overall fairly close to those of the Dutch population, although we find some differences in terms of education, geographical concentration, and wealth and income.

One important advantage of our data set is that it contains information on households' subjective assessment of the current value of their house. This enables us to analyze directly how house owners form views about house prices and how these views vary over time.

We estimate a random-effect model that explains changes in individual households' subjective assessments of the value of their house on micro and macro factors.

Our main findings can be summarized as follows. House prices are strongly related to microeconomic household-specific and house-specific factors, e.g. year of construction, cohort, education level, income and wealth. Financing conditions – the presence of a mortgage, the mortgage type and the mortgage rate paid by households – are also important determinants. On top of these, the long-term interest rate also affects how household value their home. Moreover, there is empirical evidence of "well behaved" dynamics of subjective house prices, both in terms of persistence and in terms of mean reversion. Finally, our findings also support a certain degree of heterogeneity and segmentation in subjective house prices, especially along the dimensions of geographical region and degree of urbanization, funding conditions, and income expectations.

The rest of the paper is organized as follows. The next section surveys the literature on the drivers of house price dynamics. Section 3 documents the characteristics of our panel data set and shows how they differ from the distribution of Dutch households. Section 4 presents our empirical model and the results. Section 5 concludes.

2. Literature review

The literature on the determinants of house prices starts from the idea that housing is a special type of asset because of its dual role as consumption and as investment good. In the long run, the equilibrium price a household is willing to pay for a house should equal the present discounted value of future services provided by the property, i.e. future rents and the

resale value. In the short run, house prices can deviate from their fundamental values, depending, among other things, on idiosyncratic characteristics of the real estate market (Leung and Chen, 2006; Wheaton, 1999; Davis and Zhu, 2004).

Empirical studies on the housing market distinguish three main types of drivers: macroeconomic drivers, institutional/geographic factors and funding arrangements. The close link of house price movements to both macro variables and market-specific conditions is documented in a number of papers, including Hofmann (2004), Tsatsaronis and Zhu (2004), Herring and Wachter (1999), Hilbers *et al.* (2001), Chen (2001) and Gerlach and Peng (2005). These papers typically use aggregated data, often for a set of countries. Berger-Thomson and Ellis (2004), for example, estimate an equation for median/mean house prices in four countries (Australia, Canada, United States and United Kingdom) that explains short-run fluctuations in house prices as driven by fluctuations in income, the prices of a house including land, improved housing quality and the price of finance (interest rates).

Much academic and policy work has focused on the role of interest rates and other credit market conditions in the US boom-bust cycle. One common explanation for the boom is that easily available credit and low real interest rates substantially boosted housing demand and prices (e.g., Himmelberg *et al*., 2005; Mishkin, 2007; Taylor, 2007: Favilukis, Ludvigson and Van Nieuwerburgh, 2010). Others have suggested that easy credit market terms, including low down payments and high mortgage approval rates, contributed to large swings in housing markets (Khandani, Lo and Merton, 2009).

Dokko *et al.* (2010) and Glaeser *et al.* (2010) report results suggesting that the role of interest rates is much smaller than often assumed.

The role of institutional/geographical factors is investigated more in detail in studies on data disaggregated by region or city, such as Garmaise and Moskowitz (2004), Green *et al*. (2005) and Himmelberg *et al*. (2005). The role of demographical factors is emphasized in Takáts (2010).

The role of mortgage financing and more generally housing finance system arrangements are documented in Warnock and Warnock (2007), Peek and Wilcox (2006), Estrella (2002), McCarthy and Peach (2002), Tsatsaronis and Zhu (2004), and – for emerging market countries – Egert and Mihaljek (2007). Calza *et al.* (2009) document how the transmission of monetary policy shocks to residential investment and house prices is significantly stronger in countries with more flexible and developed mortgage markets. They then use a two-sector DSGE model with price stickiness and collateral constraints, they analyze how the response of residential investment to monetary policy shocks is affected by

alternative values of the downpayment rate and the interest rate mortgage structure. Swank *et al.* (2002) investigate the role of mortgage interest deduction on the working of the housing market, how the tax treatment of homeowners interferes with credit constraints imposed by lending institutions, and its effect the profitability of the mortgage industry. Their theoretical model discerns starters and movers on the owner-occupied housing ladder, who demand different home types, who have different incomes and who face different relative user costs of home owning. Since movers supply their former dwellings to starters, the two segments of the housing market are closely connected, and so are the respective property prices. With expectations of future home prices entering into the user costs of starters and movers, expectation formation turns out to be crucial for the emergence of stable equilibrium prices. They find that the effects of tax-preferred treatment of owner-occupied housing are conditional upon country-specific features of both housing and mortgage markets: The efficiency of implicit tax subsidies depends critically on the price elasticity of newly built dwellings.

Shiller (2005, 2006) long has argued that mass psychology is more important than any of the mechanisms suggested by the research cited above.

In recent years, an increasing number of studies has looked at the role of the housing market in macroeconomic fluctuations (see e.g. Iacoviello, 2005; Campbell and Cocco, 2007; Mishkin, 2007; Darracq Pariès and Notarpietro, 2008; Agnello and Schulknecht, 2009; Aspachs-Bracons and Rabanal, 2009; Iacoviello and Neri, 2010; Lambertini *et al.*, 2010). Sterk (2010) for example examines the impact of a decline in house prices on real activity. The idea is that a house price bust deters geographical mobility, creating distortions in the labour market. Sterk (2010) first provides evidence that negative house price shocks reduce the efficiency of the matching process in the labour market. He then estimates a dynamic and stochastic general equilibrium model where borrowing constraints affect geographical mobility decisions, and unemployed agents occasionally receive job offers they can only accept if they move. He shows that output can fall substantially after a decline in house prices.

Another literature strand has focused on detecting bubbles in the housing market. Identifying a housing bubble is a difficult issue, which has been tackled in alternative ways. Early work that defined bubbles in terms of substantial deviations of the price-rent ratio or the price-income ratio from historical averages has been criticized because it ignores variations in the "equilibrium" value of those ratios in response to fluctuations in economic fundamentals (Case and Shiller, 2004). To address this problem, the literature has turned to two alternative solutions. The first compares observed price-rent ratios and time-varying discount factors.

Time-varying discount factors are determined by the user cost of owning a house, which can be decomposed into mortgage interest, property tax, maintenance costs, tax deductibility of mortgage interest payments and an additional risk premium (see Himmelberg *et al*., 2005; Ayuso and Restoy, 2006; Brunnermeier and Julliard, 2008). The second approach compares observed house prices with fundamental values predicted based on the long-run relationship between house prices and macroeconomic factors (Abraham and Hendershott, 1996; Kalra *et al.*, 2000; Capozza *et al.*, 2002, Glindro *et al.*, 2008).

3. The data

Unlike most of the existing literature, we use data on individual houses and households that are available for a fairly long time period. These data enable us to investigate the role of both micro and macroeconomic determinants of house prices. Our data source is the DNB Household Survey (DHS), formerly known as the CentER Savings Survey.

The DHS is an annual survey of households in the Netherlands that started in 1993 and is run at Tilburg University by CentERdata.[2] The DHS consists of a sample intended to be representative of the Dutch population; it consists of some 2,000 households in each wave, including refreshment samples compensating for panel attrition.[3]

The DHS consists of six questionnaires, which relate to work and pensions, accommodation and mortgages, income and health, assets and liabilities, and economic and psychological concepts. The dataset thus provides information on both economic and psychological aspects of financial behaviour. The questionnaires are self-administered: respondents receive them by modem, fill in the answers on their home computers, and return them at a time that is convenient for them.

In this paper we mainly focus on the accommodation and mortgages questionnaire. The database used for our analysis consists of home owners, for whom we have information about the price of their current house, and covers the period 1993-2009. Our data set has 4,536 different households and 16,267 point observations. Table 1 reports the summary statistics of the main variables used in the empirical analysis.

[2] In principle all household members aged 16 years and older are allowed to participate. In case of attrition, CentERdata recruits new participants to maintain the panel size, as well as to keep the panel representative with regard to a number of relevant background characteristics such as age, gender, income, education, and region of residence. More information on CentERdata, the CentERpanel and the DHS is available at their website (http://www.uvt.nl/centerdata/dhs).

[3] In addition, for the period 1993–1997, data were also collected separately for a sample (HIP) of some 900 households that was representative of the top 10 percent of the income distribution.

3.1. Characteristics of the data set

Table 1, which summarizes the main characteristics of the respondents of the questionnaire, shows that the characteristics of our sample of Dutch households are broadly similar to those of the entire Dutch population. Most notably, the age distribution closely matches that of the Dutch population. This is evident from Table 1, which distinguishes six age classes by year of birth.[4] Moreover, the estimated kernel density of years of birth is very similar to the normal density, with only two differences: the individuals who were born during the war are somewhat underrepresented compared to a normal distribution, and individuals born in the 1920s and 1930s, as well as of those born after 1960, are slightly overrepresented.

Table 1 about here

At the same time, Table 1 highlights four effects of the sample selection process. First, the great majority of the respondents are males (86 percent of observations, corresponding to 84 percent of households), as a consequence of the selection of home owners.

Second, the level of education of the respondents is on the high side compared to the Dutch population. Almost half of our sample consists of highly educated individuals, the other half consisting of the respondents with a middle (28.6 percent) and low (21.6 percent) education level. Again, this is very likely due to the selection procedure, based on home ownership.

Third, a strong effect of the selection process is visible in the geographical distribution of respondents. 30 percent of the sample respondents are located in the west of the country, while the north is the least represented (10.5 percent only), which fully corresponds to official statistics.[5] However, the three largest cities – Amsterdam, Rotterdam and The Hague – which are all located in the west and form the most densely populated part of the Netherlands, constitute only the second least represented area in our sample, as a result of the relatively low home ownership rate in these cities.

Fourth, both household income and net financial wealth are also on the high side compared to the Dutch population.[6] This is evident from Table 1, which splits our data set into four classes according to household income and net financial wealth. Selecting on home ownership has the effect of "shifting" about 10 percent of the observations from the lowest to the two highest income classes, while leaving the third class unaffected. Similarly, selecting

[4] In particular, the six year-of-birth classes consists of respondents born before 1930, between 1930 and 1939, between 1940 and 1949, between 1950 and 1959, between 1960 and 1969, and those born in 1970 or after. The first age class serves as reference group.

[5] The Ministry of Housing, Special Planning and the Environment in the Netherlands states that the Dutch population is unevenly spread over the country, with most people living in the western part

[6] It should be noted that we lose about 25% of observations due to missing values.

on home owners "shifts" almost 25 percent of the observations from the lowest to the other three net financial wealth classes.

Table 1 also highlights that, in line with a common view, the mortgage market in the Netherlands is very developed (Andre', 2010). Box 1 reports briefly the main characteristics of a number of mortgage contracts, with the same wording as displayed to the DHS respondents. 82 percent of households in our sample reported to have contracted at least one mortgage for house purchase purposes.[7] Of these, the most popular type of mortgage is the improved traditional life-insurance mortgage, followed by the annuity mortgage and the interest only mortgage. The least common mortgage is the endowment mortgage.

Box 1 about here

3.2. House prices

In the DHS, information on our main variable of interest, the house price p of household i at time t, can be gained – for respondents that live in a house they own – from answers to two questions. One question asks directly for the actual price that was paid for the purchase of that house. The other question is as follows *"About how much do you expect to get for your residence (not including the business part) if you sold it today (empty and not let)?"*.

Answers to the first question provide information on actual transaction prices. However, for most houses this variable is constant in our sample, as a large majority of households in our data set does not change residence during the sample period. Moreover, when a house purchase occurred prior to the start of our sample period, the DHS does not provide information on the timing of the transaction.

Given these shortcomings, we decided to rely on information based on answers to the second question, which is clearly subjective, rather than capturing transaction prices. At the same time, it has two main advantages. First, the subjective assessment of households is an interesting variable that has received no attention in the literature because of lack of data. In addition, we can track how these assessments vary each year, instead of having to rely on much less frequent home purchases.[8]

[7] The number of households for which a information on the mortgage for the main residence is available is reduced to 3,915, for a total of 12,640 valid household/year observations.

[8] The difference between a variable that is constantly adjusted (the subjective house price) and one that changes at most once in the sample period (the price at which the house was purchased) may be one of the reasons of the low, albeit statistically significant correlation (correlation coefficient of 0.18; p-value of 0.00) between estimated house prices and corresponding actual house prices.

Figure 2a shows the level of average subjectively reported house prices, which increased almost monotonically over time, while Figure 2b displays their annual changes.

How accurate are subjective house values as proxy for prices of actual transactions? In the literature on housing, the bias of subjective house prices is typically found to lie between -2 and +6%. (Capozza *et al.*, 2002, Glindro *et al.*, 2008, Gonzalez-Navarro, M. and Quintana-Domeque, C., 2009), although recent evidence from economic experiments points to a bias of 14% (Bucchianeri and Miron-Schatz, 2011). The presence of bias in self-reports is well documented in the psychological literature, which highlights the "endowment effect" and the "status syndrome" as main potential causes of this bias.[9] The endowment effect is the tendency for people to overvalue what they own (Thaler, 1980; Knetsch, 1989; Kahneman *et al.*, 1990) and is a direct consequence of loss aversion. The status syndrome is the tendency of those who are better off – in terms of income, home value, or reported health – to display a larger reported-actual price discrepancy than others (Marmot, 2004).

We believe that for the Netherlands, subjective house prices are a good, albeit imperfect proxy, for several reasons. First, house owners know the value of their property for tax purposes, which is determined by their municipality based on the value of property with similar characteristics located in their neighbourhood. Second, the Dutch housing market is fairly transparent. Since 2001, for example, detailed information on characteristics and prices of most dwellings which are for sale through real estate agents is posted on the web by an organization of Dutch real estate agents.

Figure 2a about here

Indirect information on the size of the bias can be gained by comparing the average of our DHS variable with the average purchase price of owner-occupied dwellings in the Netherlands, which is published by the Centraal Bureau voor de Statistiek (CBS or Statistics Netherlands), the official national statistical office in the Netherlands.[10] Figures 2a and 2b highlight two important points.

First, the dynamics of the two series is very similar. The hypothesis that the two variables are independent is strongly rejected by a Pearson's chi-squared test, and the correlation between the two variables is very significant (the correlation coefficient is 0.99 and the p-value is 0.00). In addition, the mean value of annual house price changes of the two series is of a very similar order of magnitude (see Figure 2b). Between 1995 and 2009, house prices have increased by 117.5 percent in the DHS and by 125.7 percent in the CBS, resulting

[9] For an overview of these factors see Bucchianeri and Miron-Schatz (2011).
[10] The CBS variable is available only as of 1995.

in an average annual growth rate of 8.4 percent and 8.9 percent respectively. The correlation coefficient of the two series in changes is also strongly significant (with a p-value of 0.00) although somewhat lower than for the price level series (with a correlation coefficient of 0.54).

Figure 2b about here

Second, while the dynamics are similar, over the whole sample period the DHS house prices are systematically higher than the CBS house prices, resulting in visibly higher means (€218,390 vs. €178,310) and medians (€245,730 vs. €199,760).[11] Simple statistical tests indicate that over the period 1995–2009, the mean or median of the two price series are statistically different.[12] This difference can in principle be explained by two reasons: differences between the profile of the DHS respondents and the average Dutch population, in particular with respect to wealth, and/or an upward bias in subjective prices compared to transaction prices.

In our empirical work, we try to minimize the impact of the bias in self-reported house values in two ways. First, in addition to house-specific variables, we introduce household-specific variables in our regressions, that capture the factors identified by the literature as underlying the "endowment effect" and "status syndrome". These include household income and wealth, and financial education.

Second, for the years 2005-2009 we also include the so-called WOZ-value of a house (waardering onroerende zaken), which is the official value of a house determined by the municipality in which it is located. The WOZ-value is used to calculate an imputed home ownership value (eigenwoningforfait) and a residential property tax (OZB). Figure 2a shows that the WOZ-value virtually coincides with the CBS data. The difference between the CBS and the DHS prices, as well as the difference between the WOZ and the DHS prices can be viewed as an upper bound of the bias in self-reported values.

3.3. Potential micro drivers of house prices

Table 2 provides some statistical information on potential – house-specific or household-specific – microeconomic drivers of subjective house prices. Table 2 reports average house price values disaggregated by house characteristics (geographical region, year

[11] For the whole sample period 1993–2009, the average house price in the DHS is €201,100 and the median value is €200,760.

[12] We performed a paired t-test and a Wilcoxon signed-rank test for test equality of the mean and the median values, respectively.

of construction) as well as by the respondents' individual background characteristics (year of birth, level of education).

Table 2 about here

Since the literature has documented important geographical differences in housing market dynamics, we provide some information on house prices aggregated by geographic region. We find that over the full sample period, the three largest cities and the eastern region have a subjectively reported average house price level which is lower than the nationwide level (€197,640 and €193,050, respectively, vs. €210,100).

Another house characteristic which may affect house prices is the construction year. For each of the classes related to this variable and reported in Table 2, subjective house prices have an increasing trend over the sample period but houses built more recently (in particular after 1990) tend to have higher average prices than the whole stock of houses. Most notably, the average price of the oldest houses (built before 1945) is much higher than that of the whole house stock, possibly because of differences in location and style.

The literature on housing demand has found evidence of a life cycle mechanism?[13] Bajari *et al.* (2010) for example document the hump-shaped pattern of housing with respect to age – young households tend to move into progressively larger homes until they are middle-aged, while households close to retirement tend to live in smaller homes. Prima facie statistical evidence suggests that in our data set, the pattern is increasing rather than hump-shaped. The youngest households reported the lowest average house price level over the full sample period, while the averages for the middle cohorts are close to those of the whole population, and some of the older segments of respondents report the highest home value.

The dynamics of subjective house prices seem also to differ across owners depending on their level of education, possibly reflecting different types of house choices across different levels of education. Over the full period, average annual house prices of highly educated individuals are higher compared to the entire sample, whereas the opposite holds for both the low and the middle education level.

The behaviour of subjective house prices appears also to vary across different classes of households' financial situation. The average annual house prices for the first two household income classes are lower than the average values for the whole sample, whereas the opposite

[13] For an overview of research on the life cycle in models of housing demand, see Bajari *et al.* (2010).

is found for the highest income class.[14] Similar findings also hold for household net financial wealth.

The dynamics over time of average annual house prices is very similar across mortgage types. However, Table 2 shows that there is a visible dispersion of house prices levels across mortgage types. The highest average house price is for residences purchased with an interest only mortgage (€278,000) and with an investment mortgage (€217,000), while the lowest price is found for houses financed by an annuity mortgage (€154,000).

3.4. Macroeconomic variables

In order to capture the interaction between house prices and the macroeconomic environment, we consider a set of variables which the literature has identified as potentially relevant drivers of house price dynamics. In particular, we focus on the interest rate, the unemployment rate, inflation, and the old-age dependency ratio. These variables, which are displayed in Figures 3 and 4 are not taken from the CBS and Datastream.

Figure 3 shows several interest rates, both nominal and real, that are used in the empirical analysis, namely the short-term (3-months Euribor) rate and the long-term (10-year government bond) interest rate.[15] In addition, we exploit a direct question available in the DHS asking for the current interest rate paid on the first mortgage.

Figure 3 about here

The unemployment rate, which captures potential interactions between the labour market and the housing market, has fluctuated considerably during our sample period (Figure 4). By contrast, the inflation rate has been rather stable around 2 percent (with the exception of 2001 and 2002).

Figure 4 about here

The old-age dependency ratio, defined as the ratio between the population aged 65+ and the population aged 15-64, is used to capture demographic shifts that may have an impact on the housing market. Over the period 1993-2009, the dependency ratio has monotonically increased from 19 percent to more than 22 percent.

[14] The highest income group also displays a greater volatility of annual mean values, especially for the first sample years. This is driven by the reduced number of observations falling in this highest income class for the years between 1985 and 2000.

[15] Berger-Thomson and Ellis (2004) argue that both real and nominal interest rates can play a role – real rates enter into underlying arbitrage conditions but nominal rates capture the effects of some credit market imperfections. Alternatively, nominal interest rates and inflation could be included, and the difference between the absolute values of the resulting estimated coefficients attributed to the effect of nominal rates independent of that of real rates

4. Empirical models and main results

Our empirical work aims at assessing the role of micro and macro determinants of house prices. The analysis of micro – both household and house-specific – factors is novel in the literature on house price dynamics, which has generally relied on aggregated data. We can investigate whether adding micro variables to our empirical model leads to different conclusions on the role of drivers of house prices.

We proceed in two steps. We first estimate a simple panel model of the main determinants of subjective house price levels (section 4.1). We then investigate house price dynamics in a more sophisticated econometric model, which takes into account the role of time-varying fundamental house prices which has been highlighted in the literature (section 4.2).[16] In both models, subjective annual house prices are deflated by the GDP annual deflator and taken in logs.

4.1. Determinants of house price levels

The starting point of our empirical analysis is a simple, standard model for subjective house price levels and their main determinants. The aim of this exercise is to understand how much subjective house prices incorporate some of the driving forces identified in the literature. We distinguish macroeconomic factors (e.g. interest rates) and microeconomic factors (e.g. funding conditions, type of house). Formally, we model the subjective price P_{it} of a house owned by household *i* at time *t* as follows:

$$P_{it} = a_0 + X_{it}a_1 + Z_i\, a_2 + W_t\, a_3 + b_i + u_{it}, \qquad (0)$$

where X_{it} is a set of time-varying household-specific regressors consisting of household income and household net financial wealth; Z_i is a set of time-invariant house-specific regressors that includes the year of construction, the size of the living room (as a proxy for the size of the house), the presence of a garage, and the presence of a garden. W_t captures the house- or household-invariant set of regressors. These include the monetary policy rate and the yield curve (the ten-year government bonds interest rate and the short–term Libor 3 months interest rate), other variables related to the economic cycle (e.g. inflation rate and unemployment rate), and long-term factors (such as demographical changes proxied by the

[16] An alternative approach that has been used in the literature consists in estimating a model of the user cost, which captures long-term equilibrium values and the annual cost of home ownership (see e.g. Himmelberg *et al.*) We cannot follow this approach since our data set does not contain information on rents, or maintenance costs.

old-age dependency ratio). In addition, b_i is the unobserved individual effect, and u_{it} is the error term.

We exploit the panel dimension of our dataset and run random effects estimations on the above mentioned micro and macroeconomic control variables. We produce standard errors by bootstrapping with 50 replications. The results are reported in Table 3 and Table 4.

Table 3 and Table 4 about here

The most general specification of the model is reported in Table 3 column (I) and consists of the full sample of respondents, irrespective of whether they took out a mortgage for house purchase purposes or not. A slightly different specification is reported in Table 3 column (II) and column (III) for households that, respectively, did not and those that did take out a mortgage. The reason for this distinction is twofold. On the one hand, it allows us to investigate whether there is any difference between these two groups of households due to the home financing behaviour. On the other hand, for the subsample of households with a mortgage, we can directly gauge the impact of the current rate which the respondents report for their mortgage.[17]

For all specifications, we start by including the full set of variables, both micro and macro. We then repeat the same exercise on the corresponding estimation samples by dropping all the micro factors, in order to assess whether the macro variables change their effect on subjective house prices. Table 3 reports the two sets of regressions on the top part and on the bottom part, respectively.

Several important results emerge. First, our model fits the data reasonably well. The R^2s range between 0.56 and 0.64. These values are on the high side for panel regressions and in line with findings of empirical work on aggregated time series data (Glindro *et al.* (2008), for example, report adjusted R^2s ranging between 0.36 and 0.77).

Second, household- and house specific variables are important determinants of the variation in house prices. Including micro variables raises the R^2 range from 0.53 – 0.62, reduces the explanatory power of some macro variables (the short term interest rate and the inflation rate). Moreover, most of the house-specific dummies are highly significant at the 1 percent level. The highest prices are reported for the houses built before 1945 and for those most recently built. The size of the living room, the presence of a garage and the presence of a garden are positively correlated with subjective house prices, although their significance level

[17] While it would be interesting to collapse the seven mortgage classes described in Box 1 into two groups – mortgages with and without capital repayment during the loan life – it is not possible to test differences in house price behaviour because more than 80 percent of the observations in our dataset falls into the latter category.

varies across the three specifications. We also find that reported house prices are positively linked to household income and household net financial wealth.

Third, there is also a strong role for macroeconomic drivers of house prices. Macro variables generally exhibit significant coefficients of the expected sign. Overall, the real long-term interest rate has very strong explanatory power for house prices. By contrast, house prices do not always react significantly to the short-term interest rate. This is consistent with the idea that the current long-term rate proxies for the marginal funding rate for new borrowers, and thereby affects the subjective evaluation of house prices. When we split the sample into households that hold a mortgage and those that do not, we still find a strong role for the long-term interest rate (see column (II) and column (III)). The same is true when we add the mortgage rate as explanatory variable, whose coefficient is very significant.

One conjecture for the explanatory power of the mortgage rate is that the current subjective house price depends on the price at which the house was purchased in the past. It is also worth mentioning that the great majority (about 80 percent) of mortgages in the sample are fixed rate.

The other macro variable with strong explanatory power is the dependency ratio, which implies that higher fractions of elderly people are associated with higher house prices. This finding is very relevant in a context of ageing populations. It points to the relationship between ageing and trends in house prices as an important issue, in addition to the financial sustainability of social security systems and health-related issues.

In regressions over the full sample, the coefficient on inflation is positively and weakly statistically significant (at the 10-percent level) for the individuals with a mortgage only. This somewhat contrasts with the argument that higher inflation raises the cost of mortgage financing and hence dampens house prices. As Tsatsaronis and Zhu (2004) argue, if financing decisions are more sensitive to nominal rates than to real rates, changes in inflation and inflation expectations are likely to affect housing demand and hence real house prices.[18]

In order to better assess the role of different types of interest rates, we run our model for the subset of households that have a mortgage by including the short-term rate and dropping one by one the mortgage rate and the long term real interest rate (Table 4, column (II) and column (III), respectively). Table 4 shows that when the short-term interest rate is included, the coefficient on the long-term rate remains highly significant and its magnitude fairly constant.

[18] In order to control for inflation expectations we run a number regressions by including the 5 to 10 year inflation expectations from Consensus Forecast. The findings are robust to this specification.

4.2. House price dynamics: empirical evidence

Once we have established the main determinants of the level of subjective house prices by estimating equation (0), we can use these variables in a more complete model that describes house price dynamics. The model consists of two equations. Equation (1) describes the evolution of the long-term, fundamental value for house prices P_{it}* for household *i* at time *t* as:

$$P_{it}^{*} = X'_{it}\,\delta + c_i + v_{it} \qquad (1)$$

where X_{it} are time-varying household characteristics, c_i is a set of time-invariant household specific regressors, u_{it} is a white noise unobserved residual.

Equation (2) describes the short-term dynamics of subjective house prices P_{it} for household *i* at time *t*, and is specified in first differences:

$$\Delta P_{it} = \alpha \Delta P_{it-1} + \beta (P_{it-1}^{*} - P_{it-1}) + \gamma \Delta P_{it}^{*} + u_{it} \qquad (2)$$

where the parameters α, β and γ capture, respectively, the degree of serial correlation, the extent of mean reversion to the fundamental value and the contemporaneous adjustment to fundamentals. v_{it} is a white noise unobserved residual.

This type of model has been used in a number of studies on the dynamics of the housing market (e.g. Capozza *et al.*, 2002; Gao *et al.*, 2009), which mostly focus on the United States. In these studies, it has typically been estimated with time series data following a two-step strategy. In the first step, the fundamental house price value described by equation (1) is estimated, generally with quarterly data on US house price indices such as the S&P/Case-Shiller index or the actual repeat-transactions house price index. In the second step, the dynamic equation (2) is estimated separately, where P_{it}* is the fitted fundamental price from the first step.

We depart from this methodology for two main reasons. First, there is no theoretical basis for identifying the complete set of microeconomic and macroeconomic drivers of fundamental house prices in equation (1). Second, using fitted values from equation (1) to capture P_{it}* in equation (2) creates an endogeneity problem because they come from the same data used as dependent variable in that equation. This endogeneity invalidates inferences based on standard econometric techniques.

To avoid this endogeneity problem and estimate the model consistently, we adopt instead a one-step strategy, which is based on a single reduced-form equation combining equations (1) and (2) above. In particular, we rewrite equation (2) in levels:

$$P_{it} - P_{it-1} = \alpha P_{it-1} - \alpha P_{it-2} + \beta P_{it-1}^{*} - \beta P_{it-1} + \gamma P_{it}^{*} + \gamma P_{it-1}^{*} + u_{it}$$

$$P_{it} = (1 + \alpha - \beta) P_{it-1} + \gamma P_{it}^{*} + (\beta - \gamma) P_{it-1}^{*} - \alpha P_{it-2} + u_{it} \qquad (3)$$

By substituting equation (1) into (3), we get:

$$P_{it} = (1 + \alpha - \beta) P_{it-1} + X_{it}'\delta\gamma + X_{it-1}'\delta(\beta - \gamma) - \alpha P_{it-2} + [\beta c_i + \beta v_{it-1} + \gamma \Delta v_{it}] + u_{it}$$

$$P_{it} = (1 + \alpha - \beta) P_{it-1} - \alpha P_{it-2} + \Delta X_{it}'\delta\gamma + X_{it-1}'\delta\beta + \beta c_i + \beta v_{it-1} + \gamma \Delta v_{it} + u_{it}$$

$$P_{it} = \theta_1 P_{it-1} + \theta_2 P_{it-2} + \theta_3 \Delta X_{it}' + \theta_4 X_{it-1}' + \varepsilon_{it} \qquad (4)$$

where $\theta_1 = (1 + \alpha - \beta)$; $\theta_2 = -\alpha$; $\theta_3 = \delta\gamma$; $\theta_4 = \delta\beta$

We can now estimate equation (4) by means of the within estimator. Since there is more than one possible estimate of the parameters and hence a problem of overidentifying restrictions, we impose that θ_3=0, which implies that $\gamma = 0$. This is not an innocuous assumption, as it means that housing markets are inefficient, in the sense that subjective prices do not respond to contemporaneous changes in fundamentals. This strong – but not implausible – economic assumption allows us to estimate the parameters a and β, as well as the long-run parameter δ, uniquely and consistently.

Table 5 reports the results from estimating equation (4). The first row shows estimates of the baseline specification with the full number of observations. In order to assess whether there is any heterogeneity in the parameters across different house market segments, we also run the same regression with data broken down along several dimensions: the degree of urbanization, the geographic region, the type of house, the type of mortgage, and the year of construction. In addition, we also exploit information on households' expectations of their future income, derived from answers to the following DHS question, which is available for the entire survey period: [19]

When you think of the NEXT 12 months, do you think the expenditures of your household will be higher than the income of the household, about the same as the income of the household, or lower than the income of the household?

[19] We also experimented with another potentially relevant question asking for expectations of the future general economic situation (i.e. not the situation of the household) over the next 5 years. Unfortunately, information on this question is only available as of 2003, so we decided against including this variable.

In all regressions, we control for the mortgage rate, the level of education, household income, the level of unemployment, the size of living room, and the presence of a garden. All regressors enter in first differences and in first lags. In addition to the estimates for α, β and δ, Table 5 also reports F-statistics for the test of equal coefficients.

Table 5 about here

Several interesting results emerge. A first thing to highlight is that all the parameters of interest (a, β and δ) are always strongly statistically significant (i.e. at the 1-percent level).[20] Second, the estimates of α - which measures the degree of serial correlation - are always negative. This indicates that at time t, subjective house prices change in the opposite direction with respect to their change at time *t-1*. This can be interpreted as suggesting that on average, households do not value their house in a persistently adaptive way.

Third, the estimates of β – which measures the degree of mean reversion to the fundamental value β – are always positive, implying that a misalignment between fundamental house prices and subjective house prices induces a change in the same direction of subjective house prices in the following period. If in the previous period subjective house prices are below their fundamental value (i.e. $P_{it-1}{}^{*} - P_{it-1} > 0$) then subjective prices are revised upward in the current period. Similarly, if in the previous period subjective house prices are above their fundamental value (i.e. $P_{it-1}{}^{*} - P_{it-1} < 0$) then subjective prices are revised downward.

Note that the parameter δ does not have a straightforward economic interpretation, because we impose that the coefficients of the components of X_{it} in equation (1) are all the same. In other words, we constrain δ to be uniquely estimated and representing the vector of constant parameters associated to the long-run coefficients α and β. We therefore do not discuss interpretations of this parameter and rather focus our attention on α and β.

Fourth, while in the baseline specification, the estimated coefficients for α and β are -0.20 and 0.45, respectively, these estimates can change – sometimes substantially – when we break down our sample along different dimensions. This heterogeneity is particularly pronounced for estimates of α. When we estimate our model separately for different *degrees of urbanization*, we observe substantial differences between regions both in terms of α and β. The price elasticity α ranges between -0.31 and -0.12, and is highest in absolute value for strongly urbanized regions, lowest for regions with a limited degree of urbanization and takes intermediate values in

[20] There are only two exceptions to this pattern: the parameter α is not significant for detached independent houses and significant at only the 5-percent level for respondents who expect their household expenditure to be higher than their income in the next 12 months.

moderately urbanized regions.[21] In parallel, the coefficient of mean reversion β is smallest for strongly urbanized areas and highest for limitedly urbanized regions (0.32 vs. 0.52).

The findings for regressions run separately by *geographic region* are fully consistent with those for those run by degree of urbanization. The three largest cities – which roughly correspond to the most urbanized areas - are associated with the lowest coefficient for the degree of serial correlation and the lowest coefficient for the degree of mean reversion. The estimated coefficients α look very different for the areas Rest West, East and South. We also find evidence of heterogeneity – albeit less pronounced – for the estimates of the mean reversion parameter β across geographical areas.

The analysis by *type of house* provides further evidence of a segmented housing market. Subjective house prices for flat/apartments have a substantially higher serial correlation than those of any kind of house. We also find some differences in the degree of mean reversion across different types of houses.

Results also differ markedly across *type of mortgage*. The interest-only type of mortgage is associated with the highest degree of serial correlation compared to other types of mortgages, such as the improved life insurance and annuity or traditional mortgage. In contrast, the highest degree of mean reversion is found for improved life insurance mortgages, while the coefficient for interest-only mortgages is somewhat lower.

The individuals with optimistic *income expectations* (i.e. those reporting household expenditures lower than income in the next 12 months) have a larger degree of serial correlation than the individuals with pessimistic income expectations. However, the two groups do not differ significantly in terms of degree of mean reversion.

Finally, distinguishing houses by *year of construction* shows that more recently built houses stand out in terms of a very high serial correlation coefficient. The degree of mean reversion instead turned out to be homogeneous across houses with different year of construction.

In sum, we generally find a negative serial correlation coefficient (α) and a positive estimated mean reversion coefficient (β), implying that house price dynamics lead to a convergence towards their long-run equilibrium value. This is true for the whole sample, as well as for different market segments we investigate.

At the same time, the empirical evidence also highlights an important heterogeneity across different market segments, in particular for the persistence coefficient α. This means that although generally converging to the fundamental value, the speed of convergence of house prices varies across market segments. The higher the serial correlation and the higher

[21] Strongly urbanized regions are defined as those with at least 1,500 addresses per km^2, while regions with a limited degree of urbanization are defined as those with at most 1,000 addresses per km^2.

the mean reversion coefficients, the faster the convergence to the equilibrium level. We find that segments with the lowest estimated α and β are the biggest cities, or those with the highest degree of urbanization. It seems then that these prices converge to the fundamental value more slowly than the prices of smaller cities. Similarly we find that funding conditions as well as income expectations display some heterogeneity. Individuals with interest only mortgages and those expecting lower expenditures in the coming 12 months have a lower persistence coefficient.

5. Concluding remarks

This paper explores the role of micro and macro factors in determining house prices dynamics. A novel aspect of this study is that we focus on the determinants of house owners' subjective assessment of the value of their house. To do this we rely on survey data on housing and mortgages from the DNB Household Survey for the period 1993–2009. We find several interesting results.

First, subjective house prices are strongly related to microeconomic house-specific factors. These include factors such as the year of construction, geographical location or the type of house. Financing conditions – in particular the presence of a mortgage as well as the mortgage type, and the mortgage rate – play a particularly important role. In addition, we find that household-specific factors – such as education level, income and wealth – matter. We argue that this might reflect the influence of these factors on the bias of households' subjective views of the value of their house, compared to the actual transaction price it could fetch on the market.

Second, in addition to micro drivers, we find support that macro variables such as the long-term interest rate also influence to an important extent how households value their home.

Third, there is empirical evidence of "well behaved" subjective dynamics of house prices, both in terms of persistence and in terms of mean reversion. House prices tend to converge to their long run equilibrium value.

Finally, our findings also support a certain degree of heterogeneity and segmentation in subjective house prices, especially along the dimension of geographical region and degree of urbanization, funding conditions, and income expectations. A deeper understanding of what stands behind these results may provide very useful insights for policy and is left for future research.

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Table 1: Descriptive statistics

Characteristic	Mean value	Std.dev.	N.Obs.
House prices – levels in euros	201,100	134,260	16,267
Male indicator	0.8623	0.3446	16,267
Year of birth			
Before 1930 (ref. group)	0.0875	0.2825	16,267
Between 1930 and 1939	0.1623	0.3687	16,267
Between 1940 and 1949	0.2339	0.4233	16,267
Between 1950 and 1959	0.2654	0.4416	16,267
Between 1960 and 1969	0.1697	0.3754	16,267
After 1969	0.0812	0.2732	16,267
Level of education			
Low education (ref. group)	0.2161	0.4116	15,749
Middle education	0.2862	0.4520	15,749
High education	0.4976	0.5000	15,749
Geographical region			
Three largest cities (ref.group)	0.1390	0.3460	16,257
Rest West	0.3085	0.4619	16,257
North	0.1052	0.3069	16,257
East	0.2032	0.4026	16,257
South	0.2437	0.4293	16,257
HH income classes			
Less than 15,000 euros (ref.group)	0.1234	0.3289	12,706
Between 15,000 and 22,000	0.3228	0.4676	12,706
Between 23,000 and 40,000	0.4111	0.4921	12,706
More than 40,000	0.1426	0.3497	12,706
HH net financial wealth classes			
Less than 7,960 euros (ref.gr.)	0.2500	0.4330	13,967
Btw 7,960 and 25,500	0.2500	0.4330	13,967
Btw 25,500 and 68,600	0.2500	0.4330	13,967
More than 68,600 euros	0.2500	0.4330	13,967
Mortgage type			
Annuity (ref.group)	0.2131	0.4095	12,640
Traditional life-insurance	0.1246	0.3302	12,640
Improved tradit. life-insurance	0.2830	0.4505	12,640
Linear mortgage	0.0428	0.2025	12,640
Endowment mortgage	0.0209	0.1432	12,640
Investment mortgage	0.0931	0.2906	12,640
Interest only mortgage	0.2222	0.4157	12,640
Macroeconomic variables			
10 yrs gov't bonds interest rate	4.7834	1.0915	16,267
Euribor 3 months	4.5507	2.0888	16,267
Dependency ratio	0.2012	0.0096	16,267
Unemployment rate	6.1311	1.6306	16,267
Year	2000	5.2322	16,267

Table 2: House prices by several house or individual background characteristics

Characteristic	Average values (euros)	N. Obs.
Geographical region		
Three largest cities	197,640	2,260
Rest West	211,460	5,015
North	165,430	1,711
East	193,050	3,309
South	211,780	3,962
p-value	*0.011*	
Year of construction		
Before 1945	215,630	3,211
Between 1945 and 1954	190,160	576
Between 1955 and 1959	162,100	662
Between 1960 and 1964	176,530	965
Between 1965 and 1969	178,980	1,184
Between 1970 and 1974	187,770	2,144
Between 1975 and 1979	184,430	1,893
Between 1980 and 1984	186,080	1,400
Between 1985 and 1989	194,760	1,815
Between 1990 and 1994	229,470	1,377
Between 1995 and 1999	291,110	726
Between 2000 and 2004	295,400	147
After 2004	328,930	82
p-value	*0.000*	
Year of birth		
Before 1930	187,980	1,423
Between 1930 and 1939	223,220	2,640
Between 1940 and 1949	210,560	3,805
Between 1950 and 1959	197,250	4,317
Between 1960 and 1969	181,200	2,761
After 1969	197,000	1,321
p-value	*0.000*	
Education level		
Low education	184,940	3,404
Middle education	190,070	4,508
High education	215,100	7,837
p-value	*0.000*	
Whole sample	201,100	16,267

- House prices are subjectively reported by the DHS respondent. See text for the definition of this variable.
- The reported *p-values* refer to one way analysis of variance of each of the house prices on the characteristics considered

Table 2 cont.: House prices by several house or individual background characteristics

Characteristic	Average values (euros)	N. Obs.
HH income classes		
Less than 15,000 euros	118,200	1,568
Between 15,000 and 22,000	154,160	4,101
Between 23,000 and 40,000	227,400	5,224
More than 40,000	322,760	1,813
p-value	*0.000*	
HH net financial wealth classes		
Less than 7,960 euros (ref.gr.)	154,900	3,491
Btw 7,960 and 25,500	179,000	3,492
Btw 25,500 and 68,600	207,000	3,491
More than 68,600 euros	245,000	3,491
p-value	*0.000*	
Mortgage type		
Annuity	153,570	2,964
Traditional life-insurance	194,950	1,575
Improved tradit. life-insurance	175,000	3,578
Linear mortgage	164,460	542
Endowment mortgage	200,100	265
Investment mortgage	217,120	1,177
Interest only mortgage	278,690	2,809
p-value	*0.000*	
Whole sample	201,100	16,267

- House prices are subjectively reported by the DHS respondent. See text for the definition of this variable.
- The reported *p-values* refer to one way analysis of variance of each of the house prices on the characteristics considered

Table 3: Determinants of subjective house prices (levels) – random effects estimates

With micro variables

Variable	(I) Coeff. (B.Std. Err.) *Full sample*	(II) Coeff. (B.Std. Err.) *No mortgage*	(III) Coeff. (Std. Err.) *With mortgage*
Long term real interest rate	-0.126 (0.005) ***	-0.138 (0.016) ***	-0.112 (0.005) ***
Libor 3 months	-0.005 (0.001) **	-0.004 (0.004)	-0.002 (0.002) **
Mortgage rate			-0.004 (0.003) ***
Inflation rate	0.003 (0.004)	-0.009 (0.008)	0.010 (0.005) *
Unemployment rate	-0.022 (0.003) ***	-0.024 (0.008) **	-0.015 (0.004) ***
Dependency ratio	22.254 (0.003) ***	22.323 (1.716) ***	20.858 (0.687) ***
Presence of mortgage (D)	YES ***	NO	NO
Year of construction (D)	YES ***	YES **	YES ***
Size of living room (D)	YES ***	YES	YES ***
Presence of garage (D)	YES ***	YES	YES ***
Presence of garden (D)	YES ***	YES **	YES ***
Household income (D)	YES ***	YES ***	YES ***
Househ. net fin. wealth (D)	YES ***	YES ***	YES ***
R-squared	0.6370	0.5589	0.6363

Without micro variables

Long term real interest rate	-0.147 (0.005) ***	-0.143 (0.015) ***	-0.128 (0.006) ***
Libor 3 months	-0.009 (0.002) ***	-0.009 (0.005) *	-0.011 (0.002) ***
Mortgage rate			-0.044 (0.004) ***
Inflation rate	0.017 (0.004) ***	-0.001 (0.009)	0.020 (0.005) ***
Unemployment rate	-0.027 (0.003) ***	-0.030 (0.010) **	-0.026 (0.003) ***
Dependency ratio	25.441 (0.882) ***	24.091 (2.834) ***	23.282 (0.868) ***
R-squared	0.6105	0.5324	0.6149
N. of observations	11,771	2,089	9,094
N. of households	3,444	787	2,849

- The dependent variable is the self assessed house price valuation (deflated by GDP deflator, in logs)
- Bootstrap standard errors in parenthesis
- (D) denotes in dummies
- *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 4: Determinants of subjective house prices (levels) - sample of households with mortgage

Variable	(I) Coeff. (B. Std. Err.)	(II) Coeff. (B. Std. Err.)	(III) Coeff. (B. Std. Err.)
Mortgage rate	-0.027 (0.004) ***		
Long term real interest rate	-0.107 (0.007) ***	-0.114 (0.005) ***	
Libor 3 months	-0.005 (0.002) **	-0.005 (0.002) **	-0.035 (0.002) ***
Inflation rate	0.009 (0.006) *	0.006 (0.005)	-0.021 (0.004) ***
Unemployment rate	-0.016 (0.004) ***	-0.019 (0.003) ***	-0.043 (0.003) ***
Dependency ratio	20.316 (0.696) ***	21.384 (0.776) ***	23.189 (0.779) ***
Year of construction (D)	YES ***	YES ***	YES ***
Size of living room (D)	YES ***	YES ***	YES ***
Presence of garage (D)	YES ***	YES ***	YES ***
Presence of garden (D)	YES ***	YES ***	YES ***
Household income (D)	YES ***	YES ***	YES ***
Househ. net fin. wealth (D)	YES ***	YES ***	YES ***
Mortgage type (D)	YES ***	YES ***	YES ***
N. of observations	8,697	9,203	9,203
N. of households	2,756	2,881	2,881
R-squared	0.6503	0.6464	0.6239

- The dependent variable is the self assessed house price valuation (deflated by GDP deflator, in logs)
- Bootstrap standard errors in parenthesis
- (D) denotes in dummies
- *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$

Table 5: Determinants of house prices – reduced form parameter estimates

Specification	α (Std.Err.)	β (Std.Err.)	δ (Std.Err.)	F-test	N.Obs.	N.hhs
Baseline	-0.198 *** (0.018)	0.449 *** (0.017)	0.206 *** (0.022)	0.1506	3875	1351
By degree of urbanization						
Very strong or strong	-0.307 *** (0.032)	0.315 *** (0.027)	0.211 *** (0.029)	0.7039	1340	486
Moderate	-0.193 *** (0.028)	0.524 *** (0.028)	0.205 *** (0.032)	0.2824	1484	521
Limited or very limited	-0.115 *** (0.035)	0.499 *** (0.032)	0.239 *** (0.052)	0.7588	1051	369
By geographic region						
Three largest cities	-0.562 *** (0.063)	0.338 *** (0.048)	0.189 *** (0.046)	0.9503	534	188
Rest West	-0.105 ** (0.031)	0.444 *** (0.027)	0.242 *** (0.043)	0.8529	1178	439
East	-0.168 *** (0.039)	0.448 *** (0.040)	0.097 * (0.050)	0.1049	786	262
South	-0.155 *** (0.033)	0.509 *** (0.034)	0.276 *** (0.038)	0.5276	979	319
By type of house						
Detached independent	-0.032 (0.040)	0.607 *** (0.038)	0.230 *** (0.060)	0.6992	804	294
Corner independent	-0.250 *** (0.067)	0.377 *** (0.049)	0.274 *** (0.054)	0.7114	500	184
Two under one roof	-0.166 *** (0.040)	0.467 *** (0.043)	0.242 *** (0.047)	0.1343	833	313
In-between house	-0.236 *** (0.025)	0.376 *** (0.025)	0.224 *** (0.028)	0.7030	1126	388
Flat/apartment	-0.536 *** (0.066)	0.431 *** (0.061)	0.250 *** (0.067)	0.9459	428	156
By type of mortgage						
Annuity or traditional	-0.176 *** (0.044)	0.447 *** (0.040)	0.193 *** (0.040)	0.3851	1086	491
Improved life-insurance	-0.158 *** (0.039)	0.616 *** (0.044)	0.353 *** (0.061)	0.0432	907	383
Interest only	-0.333 *** (0.033)	0.492 *** (0.029)	0.286 *** (0.038)	0.5644	1133	380
By income expectations						
Expenditures higher than income	-0.175 ** (0.081)	0.466 *** (0.070)	0.334 *** (0.083)	0.8436	394	258
Expenditures lower than income	-0.339 *** (0.035)	0.418 *** (0.031)	0.256 *** (0.032)	0.8149	1357	643
By year of construction						
Before 1945	-0.281 *** (0.050)	0.522 *** (0.053)	0.288 *** (0.052)	0.8847	675	277
Between 1970 and 1975	-0.201 *** (0.041)	0.520 *** (0.041)	0.300 *** (0.059)	0.6905	532	212
Between 1980 and 1985	-0.160 * (0.086)	0.402 *** (0.073)	0.180 *** (0.087)	0.5711	341	127
Between 1985 and 1990	-0.622 *** (0.055)	0.468 *** (0.045)	0.328 *** (0.048)	0.6008	488	171
Between 1990 and 1995	-0.192 *** (0.043)	0.534 *** (0.050)	0.305 *** (0.058)	0.8340	372	137

- Delta refers to the delta associated to the long run estimate
- Very strong or strong: 1500 addresses per km2 or more; Moderate: 1000 to 1500 addresses per km2; Limited or very limited: less than 1000 addresses per km2

Box 1: Mortgage types in the Netherlands

ANNUITY MORTGAGE: the total amount of periodic payments on interest and repayment remains the same (at least) during the period for which the interest rate was fixed. During the first part of this period, the amount due consists of a relatively large part of interest and a relatively small part of repayment. In later years, it is the other way around.

TRADITIONAL LIFE-INSURANCE MORTGAGE: it consists of a loan and a life-insurance policy. There is no repayment, but only paying interest on the loan, and paying a premium for the life-insurance policy. There is no direct relation between the interest rate of the mortgage loan and the savings interest rate of the life-insurance policy (in contrast with an improved life-insurance mortgage, where there is a relation between those two interest rates).

IMPROVED LIFE-INSURANCE MORTGAGE: this is a modernized version of a traditional life-insurance mortgage. It consists of a loan and a life-insurance policy. There is no repayment, but only paying interest on the loan, and paying a premium for the life-insurance policy. In this case, the interest rate of the mortgage-loan and the savings interest rate of the life insurance policy are related, which causes monthly net-costs to be rather stable.

LINEAR MORTGAGE: the periodic payments include paying off a fixed percentage of the total mortgage loan, and paying interest on the loan that is left at that moment. Over time, the amount you pay on interest becomes less and less, such that total monthly costs go down through the years. In the first period of the term of the mortgage, the costs of a linear mortgage are higher than the costs of an annuity mortgage.

ENDOWMENT MORTGAGE: it is possible, during the term of the mortgage, to get a new loan on (part of) the amount that you have already paid off.

INVESTMENT MORTGAGE: this is a new variation on the (traditional) life-insurance mortgage. As is the case with the other life-insurance mortgages, also for most of the investment mortgages the loan is paid off out of the benefits of a whole life-insurance policy linked to the mortgage at the end of the mortgage period. Contrary to an (improved) life-insurance mortgage, the returns of the life-insurance policy are based on the returns of an investment portfolio.

INTEREST ONLY: one only pays interest during the term of the mortgage with a balloon payment due at the end.[22]

[22] In addition the DHS contains two other mortgage types, namely the annuity construction and the life-insurance mortgage. We do not include them in our analysis because of the very limited number of observations associated to these mortgage types. For informative purposes we report their characteristics below.

ANNUITY CONSTRUCTION: During the term of the mortgage one pays interest only, but at the same time one contributes to an annuity, which becomes available at the end of the mortgage period. The annuity does not have to be used to pay off the mortgage at the end of the mortgage period. It can be used as a supplementary pension provision.

LIFE-INSURANCE: the lifelong mortgage with life-insurance is a variation on the interest only mortgage. This mortgage is taken out for an indefinite period. To be sure that the mortgage is paid off after death (at the latest), the mortgage holds a term life insurance policy.

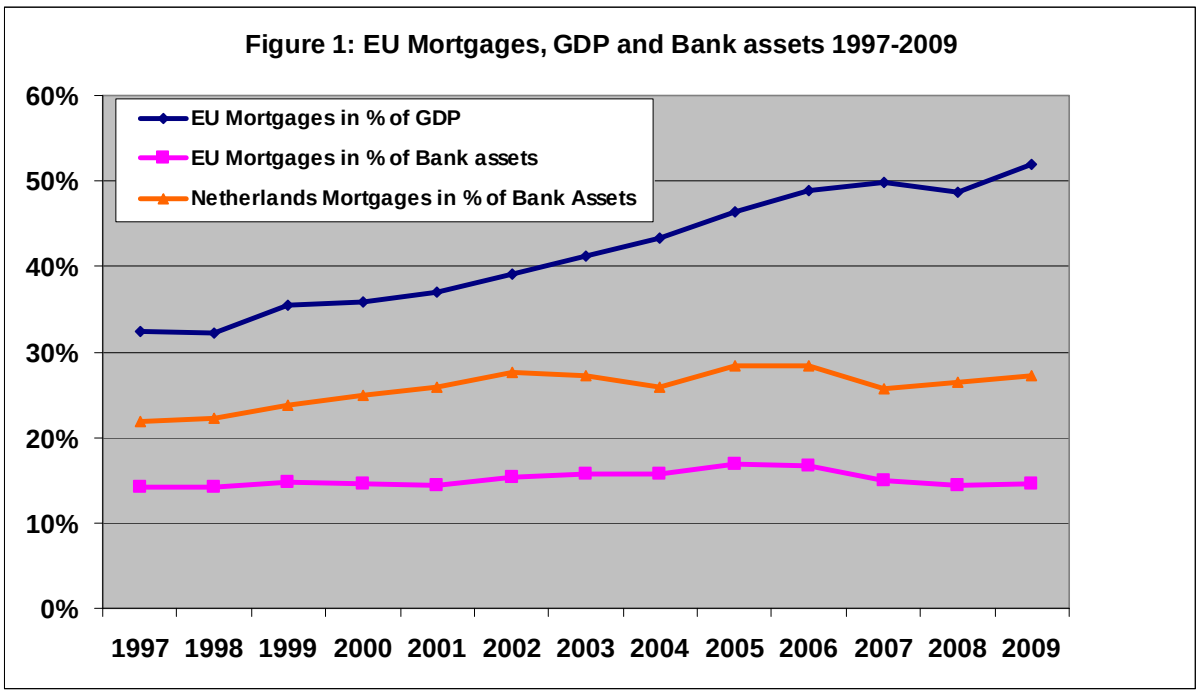


Figure 1: EU Mortgages, GDP and Bank assets 1997-2009
60%
50%
40%
30%
20%
10%
0%
EU Mortgages in % of GDP
EU Mortgages in % of Bank assets
Netherlands Mortgages in % of Bank Assets
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

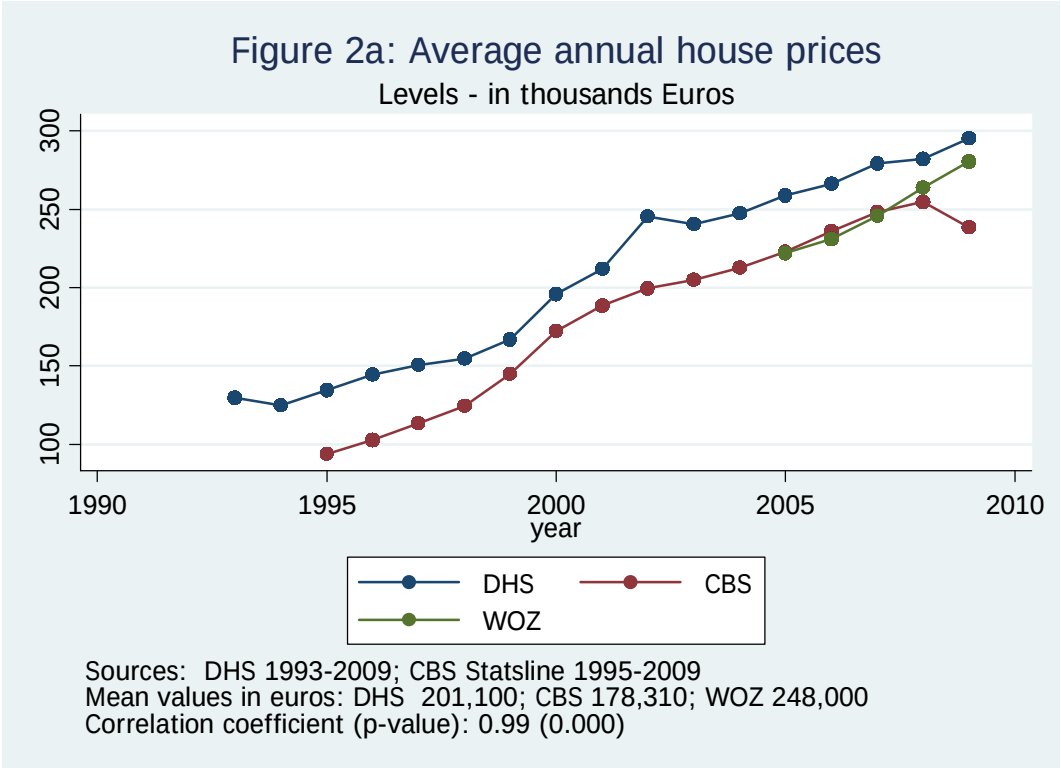
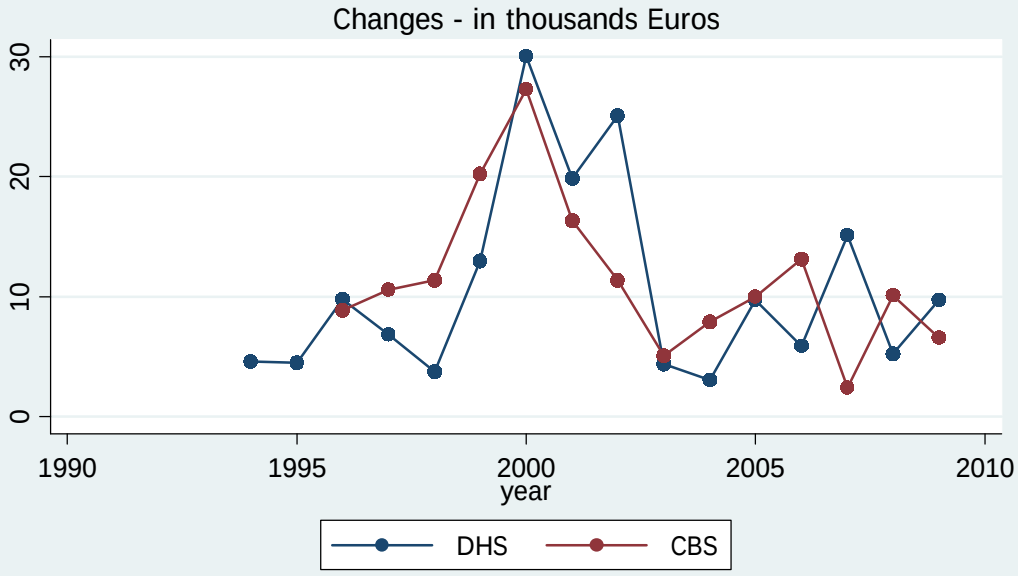


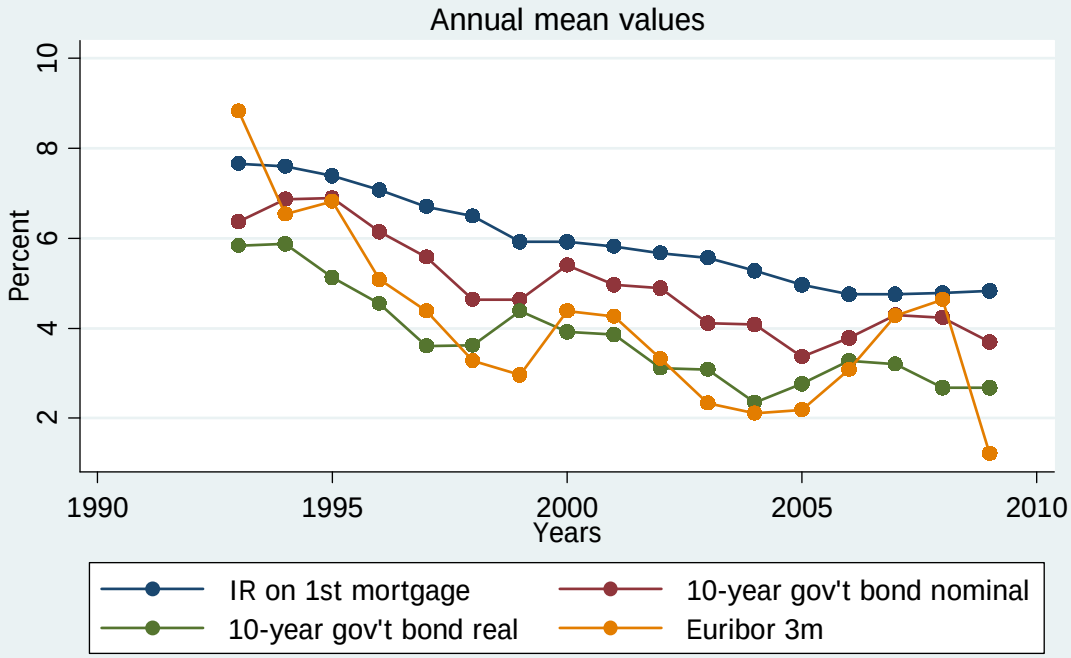
Figure 2a: Average annual house prices
Levels - in thousands Euros
100
150
200
250
300
1990
1995
2000
2005
2010
year
DHS
CBS
WOZ
Sources: DHS 1993-2009; CBS Statsline 1995-2009
Mean values in euros: DHS 201,100; CBS 178,310; WOZ 248,000
Correlation coefficient (p-value): 0.99 (0.000)

Figure 2b: Average annual house prices



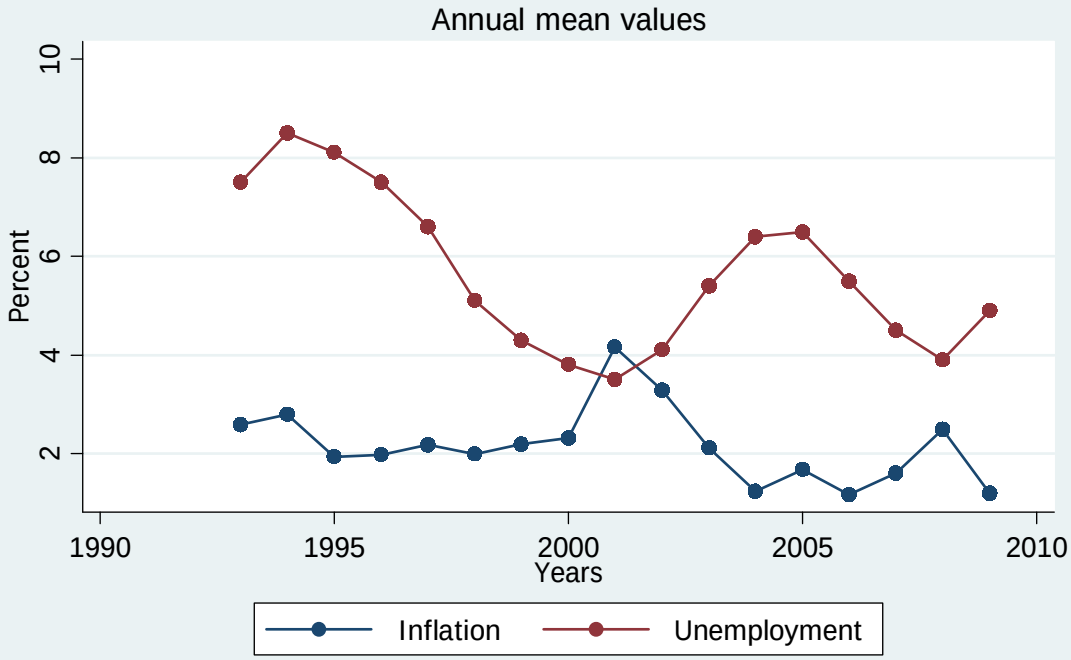
Sources: DHS 1993-2009; CBS Statsline 1995-2009
Mean values in euros: DHS 9,390; CBS 10,610
Correlation coefficient (p-value): 0.54 (0.000)

Figure 3: Interest rates



Source: DHS & CBS Statsline 1993-2009

Figure 4: Inflation and unemployment rates



Source: CBS Statsline 1993-2009

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