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House Price Shocks and Household Savings:

Evidence from Dutch administrative data

Nancy van Beers
Michiel Bijlsma
Remco Mocking

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Nancy van Beers[1], Michiel Bijlsma[2], Remco Mocking[3,4]

- Abstract-

We study the effect of house price shocks on the savings behaviour of Dutch homeowners over the period 2006-2011. Using unique administrative data, we build a balanced panel of slightly less than 2 million Dutch home owning households, containing information on house values, wealth, income and other background characteristics. We find a negative relationship between house price changes and savings, with the largest effects for young households with negative housing equity. In our baseline specification, we find larger effects for house price increases compared to house price decreases. Households of age 30 with loan-to-value ratios above one, save roughly 3 euro less for a 100 euro increase in house prices, while they save around 1 euro more for a 100 euro decrease. The asymmetric effect of price declines versus increases holds in most, but not all specifications.

1. Introduction

The financial crisis has put the relationship between house prices and the real economy in the spotlight. The IMF (2012) shows that house price drops went hand in hand with a decrease in household consumption expenditures in 24 OECD countries during 1980-2011. The relationship between house price shocks and consumption is much stronger in countries where housing busts were preceded by large increases in household debt. The relationship between house prices and consumption at the macroeconomic level is also found by Case, Quigley, and Shiller (2005). They find a large effect of housing wealth on consumption by studying both a panel of quarterly data on US states and a panel of annual data for 14 countries.

Although there seems to be a clear relationship between house price changes and household consumption or savings at the macroeconomic level, this correlation may be driven by a *common factor*. For example, revisions to households' current or expected future income may simultaneously increase or decrease consumption and demand for housing (King, 1990; Pagano, 1990). Alternatively, financial liberalization may both drive up house prices and stimulate consumption by relaxing borrowing constraints (Muellbauer and Murphy, 1990).

In this study, we analyse the effect of house price changes on household savings behaviour using unique administrative panel data on slightly less than two million Dutch home owning households over the period 2006-2011. Our data contains information on house value, different components of wealth, income, and background characteristics such as age, household composition, and marital status at the household level.

[1] Ministry of Finance.

[2] CPB Netherlands Bureau for Economic Policy Analysis and extramural fellow at Tilburg Law & Economics Center (TILEC), e-mail address: m.bijlsma@cpb.nl.

[3] CPB Netherlands Bureau for Economic Policy Analysis, e-mail address: r.mocking@cpb.nl.

[4] During the project we received valuable comments from Mauro Mastrogiacomo, seminar participants at the Nederlandse Economendag, the ministry of Finance, the ministry of Economic Affairs, the ministry of the Interior and Kingdom Relations, CPB, the Danish National Bank, and the Free University of Amsterdam, and several colleagues at CPB.

The use of comprehensive micro data allows us to address the problem of common causality. We exploit regional variation in house price changes to study savings behaviour of individual households, while controlling for individual characteristics through household fixed effects, and for changing macroeconomic circumstances through time dummies and regional unemployment data. It is unlikely that people living in houses that exhibit large price drops are, at the same time, the people whose job prospects or expected future incomes are hit hardest. Common causality is therefore unlikely as an explanation for our findings.

In addition, the size of our panel dataset enables us to study the relation between saving behaviour and house price changes for relatively narrowly defined subgroups of the population. This allows us to test the predictions of two different mechanisms proposed by economic theory relating house price changes and household savings.

First, the *life-cycle hypothesis* states that individuals smooth consumption over their life-cycle by accumulating savings during earning years and spending savings during retirement (see e.g. Modigliani, 1966). If consumers treat their house as part of their wealth, they will increase consumption in response to capital gains due to an unexpected and permanent increase in house prices and will similarly decrease consumption in case of capital losses.

A second mechanism relating house prices and consumption is the *collateral hypothesis* or *credit-constrained hypothesis*. When house prices fall, households that want to move have less wealth available to make a down payment on their next home. For homeowners that have to renegotiate their mortgages, the decreased creditworthiness induces higher interest rates. Also, households can extract less equity to finance consumption (Aoki, Proudman and Vlieghe, 2002). The reverse is true in case of rising house prices. Because young households are more likely to be credit constrained than old households, this mechanism is expected to hit young households harder. Also, a drop in house prices will lower the creditworthiness of highly leveraged households more as compared to households with low leverage.

As pointed out by Dynan (2012), there is another factor that could affect consumption. A strong drop in house prices leaves many households with high levels of debt relative to their home value. If households target a certain loan-to-value (LTV) ratio, a sharp rise in leverage above this target may result in deleveraging, which in turn depresses consumption, independent of the loss in housing wealth or the reduced capacity to borrow. This would explain a different response of households with high and low leverage to a house price decline.

We contribute to the existing literature in two ways. First, we analyse an administrative panel dataset including all Dutch homeowners. Previous comparable studies such as Engelhardt (1996), Disney, Gatherhood, and Henley (2010), and Campbell and Cocco (2005) are based on survey data. Browning, Gørtz, and Leth-Petersen (2013) obtained administrative data for 10% of the Danish population. In contrast to our dataset, their data does not include house prices of individual households. Mian, Rao, and Sufi (2013) construct a dataset containing consumption (from credit card purchases) and house prices (from census data). However, their dataset is at the county/zip code level, while we have data on individual households.

Second, the Netherlands provides a unique setting to study the impact of house price changes on savings behaviour because of the large swings in house prices and consumption. Dutch house prices increased significantly since the 1990s, while the Netherlands is among the countries with the highest annual fall in house prices in the European Union since the beginning of the financial crisis. The period for which we obtained data, 2006-2011, is characterized by house price increases in the first half and house price decreases in the second half. In addition, Dutch households have the highest mortgage debt relative to income in the euro zone. An important cause of these high levels of mortgage debt and corresponding increase in house prices is the tax deductibility of mortgage interest payments, combined with the development of interest-only mortgage products in the 1990s. The high debt levels allow us to study whether more indebted households respond differently to house price changes.

On average, we find a weak negative effect of house price changes on household savings. However, our results change when we look at subgroups of the population. We find that young households with an underwater mortgage respond more strongly to house price changes than older households with loan-to-value (LTV) ratios below one. For households around age 30 with LTV-ratios above one, we find a marginal propensity to save (MPS) of about -0.02 for house price increases. This indicates that these households save on average 2 euro less when the house price increases by 100 euro. House prices increased by 10 thousand euro on average in 2007 and 2008, while average savings were about 2,300 euro in that period implying a 9 percent decrease in average household savings. We find weaker effects for house price decreases; the effect of a house price decrease would be around -0.01 for the same household. The effect of the average house price decline of 9,000 euro in 2011 is about 8 percent expressed relative to average dissavings of 1,150 euro in 2011. For households around age 50, the effects are close to zero. We also check for the possibility that self-employed households respond differently, for instance because they have higher income uncertainty during periods of economic downturn. However, we find that the effects are only slightly different for entrepreneurs.

Our results are most in line with the collateral hypothesis, since we find the strongest effects for young households with an underwater mortgage. The size of the effect is relatively small compared to previous comparable studies. Most studies find an average marginal propensity to consume (MPC) between 0.01 and 0.08.[5] For subgroups of the population the estimates are in the range of 0-0.35. In that respect our findings are best comparable to those of Browning, Gørtz, and Leth-Petersen (2013), who find the largest MPC of 0.05 for young households with low liquidity. For other groups of the population they find weak or no effects. Mian, Rao, and Sufi (2013) also find the largest effects in areas with a relatively high fraction of households with negative housing equity.

The remainder of this paper is organized as follows. In section 2 we provide a brief overview of the empirical literature on the relationship between house price changes and saving or consumption. Section 3 describes the dataset and provides summary statistics of the variables included in our regressions. In section 4 we describe the empirical strategy and we present our baseline results. Section 5 considers the robustness of our results. Section 6 concludes.

2. Literature

The impact of changing house prices on consumption or savings has been an active area of research for the past decades.

Campbell and Cocco (2007) find, in accordance with the life cycle hypothesis, evidence for a *wealth effect* from house prices on consumption expenditures. They estimate the effect of house prices on consumption using the UK Family Expenditure Survey (FES) for the period 1988-2000. Because the FES is a survey in which each household is interviewed only once, they construct a panel

[5] This also includes estimates of the marginal propensity to save (MPS), which we estimate in this study. The MPS and the MPC are equivalent, but with opposite sign if you assume that households can either consume or save their income.

from a time series of cross-sections, or a pseudo-panel. Consistent with the life-cycle hypothesis, they find heterogeneous effects across old and young households, with the largest estimated MPC of about 0.11 for older homeowners, and the smallest elasticity, insignificantly different from zero, for younger renters.

Lehnert (2004) finds evidence for both the life cycle and the collateral hypothesis. He estimates the MPC out of housing wealth gains for different age quintiles using US household-level data from the 1968-1993 waves of the Panel Study of Income Dynamics (PSID). He finds the highest MPC of between 0.025 and 0.039 for households aged 25-34, followed by an MPC of between 0.022 and 0.039 for the households aged 52-62. The MPCs of households aged 43-51 and 63-95 are between 0.020 and 0.035. Although differences are not large, he concludes that the young and late middle aged are most sensitive to housing wealth gains, while middle aged and elderly are the least responsive.

Several papers find evidence for the collateral hypothesis. Mian, Rao and Sufi (2013) conclude that the collapse of the house price bubble in the US in 2006-2009 negatively affected spending during the recession through tighter credit constraints. They combine estimates of total household spending per county with the 2000 Decennial Census data on housing stock at the zip code level to estimate the response of consumption to house price shocks, using cross-sectional variation in consumption and housing stocks between counties. They find an MPC out of housing wealth of 0.05 to 0.07. In particular, they find that MPCs are significantly larger for both low net worth and highly levered households.

Other papers provide evidence for the collateral hypothesis by showing that younger households have a higher MPC out of housing wealth than older households (Browning, Gørtz and Leth-Petersen, 2013). Browning, Gørtz and Leth-Petersen (2013) study the effect of a shift in 1992 from a regime where households could not use housing equity as collateral to a regime where they could. Using Danish administrative data for the period 1987-1996, they find no significant relationship between house prices and consumption before 1992, while young homeowners with low levels of liquidity react to house price changes after 1992 whereas old households do not. They find an MPC of 0.05 for the group of young homeowners with low levels of liquidity.

Part of the literature finds an asymmetry of response between gains and falls in home capital. Several papers argue that households do respond to capital losses but not to capital gains. One explanation could be that capital gains are anticipated but losses are not. Skinner (1996) examines the MPC from gains and losses in housing wealth for younger homeowners using data from the 1989 wave of the PSID. Using quantile regressions he finds an MPC of 0.1 for a fall in house prices, but no significant effect in case of rising house prices.

Engelhardt (1996) uses the 1984 and 1989 waves of the PSID to study the asymmetry in the saving response. Using quantile regressions, he finds that the response comes from households that experienced real housing capital losses. The marginal propensity to save in response to housing capital losses is about 0.35.

Disney, Gathergood and Henley (2010) also find evidence that household consumption asymmetrically responds to house price increases and decreases, but only in the case of negative equity. They combine the British Household Panel Survey (BHPS) for the period 1994-2003 with county level house price data. They find that households with negative equity experiencing a house price increase have an MPC of 0.126, while households with positive equity have an MPC of 0.017 in case of a house price increase. For households in negative equity there is no difference, their MPC is about 0.04 both in case of house price increases and decreases.

Since the financial crisis, there is increasing attention to the role of debt and leverage in explaining consumer spending. Dynan (2012) studies the effect of the debt overhang in the US on consumer spending in the period 2007-2009 and finds that highly leveraged homeowners had larger declines in consumption levels than other homeowners, even after controlling for wealth effects. Her OLS estimates suggest that an increase in the LTV ratio from 1 to 1.10 results in a consumption growth decline of 0.3 percentage point.

3. Data description

3.1 Data

We build our panel data set from six administrative data files from Statistics Netherlands. Our starting point is the *WoonruimteregisterPlus* (WRG) for the period 2006-2011, an administrative dataset containing several house-specific characteristics, such as home ownership status and house price, covering all addresses in the Netherlands at the start of the year.

From the WRG file we select all owner-occupied houses in the Netherlands. Our measure for house price is the administrative house value, or so-called WOZ-value[6]. Dutch municipalities determine this value for all owner-occupied houses at the beginning of the year according to the market value of comparable houses in the previous year.[7] The WOZ-value forms the tax base for the property tax that home owners have to pay. There is a high correlation between the WOZ-value and the market value of houses, which justifies its use as a proxy for the actual house price (CBS, 2014). We will refer to the WOZ-value as the house price.

We merge the WRG data with the *GBAADRESBUS* file, which links individuals to addresses. This dataset allows us to identify the individual household members living at the beginning of the year in each owner-occupied house. For all households, Statistics Netherlands determines the “head of the household” (*RINPERSOONKERN*). This variable enables us to add household-level data to our data set.

Next, we include data on income and household characteristics from the *Integraal Huishoudens Inkomen* (IHI) file. The Tax and Customs Administration is the most important source of the data in the IHI file. It provides information on size, composition, and income of the household. Moreover, it contains information on the main source of income of the household, which we use as control variables. The variables in the IHI file are measured at the end of the year. Therefore the IHI file of year t provides information about the income earned during year t and the household composition at the beginning of year $t+1$. For that reason we have to merge the IHI file of year t with the WRG file of year $t+1$.

Data on financial assets of households is available from the *Integraal Vermogensbestand* (IVB). The IVB dataset contains information about the assets and liabilities of all Dutch households. The Tax and Customs Administration is again the main source of this dataset. In addition, data on savings accounts is complemented with information that Dutch banks provide to the Tax and Customs Administration. Variables included are total wealth, financial wealth, amounts on savings accounts,

[6] *Wet Waardering Onroerende Zaken* (Wet WOZ) is the Dutch law on the valuation of real estate.

[7] Before 2008, the WOZ-value was determined according to the price level of two (2007) or three (2006) years earlier.

mortgages[8], and other liabilities of households. We did not obtain information on the type of mortgage. For so-called savings mortgages, the mortgage amount remains constant over time, while savings are accumulated on a special account. We do not have information on these mortgage savings and consequently overestimate the mortgage amount and LTV-ratio of households with a savings mortgage.

We include individual characteristics of the *RINPERSOONKERN* from the files *GBABURGERLIJKESTAATBUS* (GBS) and *GBAPERSOONTAB* (GPT), which are civil registration files[9]. The GBS file contains information about the marital status of persons, whereas the GPT file provides some time invariant personal characteristics, such as date of birth, ethnicity, and gender.

The dataset is further enriched with provincial unemployment data from Statistics Netherland. This enables us to take regional variation in economic conditions into account. The Netherlands is divided into twelve provinces with unemployment rates ranging from 3.7 percent to 6.3 percent in 2011.

All monetary variables in our dataset are converted to 2006 prices using the consumer price index (CPI) of Statistics Netherlands. In line with the literature (see e.g. Engelhardt, 1996; Browning et al., 2013) we remove households that moved during the period 2006-2011, because moving impacts both the house value and the savings of households. Similarly, we exclude households with a member that divorces or becomes widowed during the sample period, as well as households with major changes in household composition. Finally, we exclude outliers from our analysis by removing the top and bottom 1% of the savings distribution and selecting only houses with values between 50 thousand and one million euro. [10] In Appendix A we provide all details of the selections we made in our data set.

Table 1 gives an overview of all variables used in our analysis with a short description. The amount of savings of a household (ΔS_it) can be defined in different ways. Engelhardt (1996) distinguishes between active and passive savings. Depositing money in a savings account is an example of active savings, while interest revenues are a form of passive savings. In our baseline regressions we define the change in the real amount of money that households hold in savings accounts as our dependent variable. This amount could either increase as a consequence of active contributions by households or as a result of interest revenues. Our data does not allow us to distinguish between active and passive savings. However, it is reasonable to assume that (changes in) interest rates on savings accounts do not differ very much between households. Moreover, if differences in interest rates across households exist, they are unlikely to be correlated with differences in house price changes across households.

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[8] We cleaned the raw mortgage amount data for highly unlikely values. Most commonly, households moved from, say, a 200 thousand euro mortgage in year t-1, to a 0 euro mortgage in year t, back to a 200 thousand euro mortgage in t+1. Such entries are probably administrative mistakes. We replaced mortgage values by the average value of t-1 and t+1 in these cases. We allowed increases (decreases) of maximum 20% (20%) per year followed by decreases (increases) of maximum 16.7% (25%) per year. In the beginning and end years we allowed increases (decreases) of 50% (50%) per year.

[9] We recognize that the variable *RINPERSOONKERN* only has a statistical meaning. Especially in households with children we experienced some problems. The *RINPERSOONKERN* changes in many occasions during our sample period and in some cases one of the children was identified as the 'head of the household' during one or more years instead of one of the parents. By taking individual characteristics of the oldest *RINPERSOONKERN* that constantly lives on the same address we solve this problem.

[10] We check the robustness of our results against excluding outliers by also presenting results on the complete sample.

Mortgage payoffs constitute another form of savings. Households pay off mortgage debt when the nominal amount of outstanding mortgage debt decreases. Mortgage payoffs are therefore defined as the real value of the nominal decrease in mortgage debt outstanding. This measure is imperfect since we have no information on the type of mortgage and interest-only or endowment mortgages are very common in the Netherlands. We check the robustness of our results by using changes in savings accounts plus mortgage payoffs as an alternative dependent variable in our analysis. We do not include other financial assets, such as stocks and bonds, in our savings variable. The reason is that these components of financial assets are highly volatile and portfolio dependent, which makes it impossible to distinguish between active savings and passive price gains. Moreover, only a small fraction of households holds stocks or bonds in their portfolio.

Table 1: variables overview

Variable	Description
Savings	
$SAVINGS_{it}$	Real amount in savings accounts
ΔS_{it}	Change in real amount in savings accounts
$MORTGAGE_{it}$	Real amount of outstanding mortgage debt
ΔM_{it}	Real change in amount of mortgage debt
$PAYOFFS_{it}$	Real mortgage payoffs: equals 0 if $\Delta M_{it} \geq 0$ and equals ΔM_{it} otherwise
ΔS_{it}^2	Change in real amount in savings accounts plus mortgage payoffs: $\Delta S_{it} + PAYOFFS_{it}$
House prices	
$HOUSEPRICE_{it}$	Real house price (WOZ-value)
ΔH_{it}	Change in real house price
$DECLINE_{it}$	Dummy that equals 1 when $\Delta H_{it} < 0$
Controls	
$INCOME_{it}$	Real disposable income
$SOURCE_{it}$	Set of dummies for main source of income (salary, entrepreneurship, interest income, social benefits, pension income)
$HHSIZE_{it}$	Household size
$COMP_{it}$	Dummy for household composition (1 = with children, 0 = without children)
$MARITAL_{it}$	Set of dummies for the marital status of the head of the household (single, married/living together, divorced, widow)
AGE_{it}	Age of the oldest head of the household ("RINPERSOONKERN") that constantly lives at the address
$UNEMPLOYMENT_{it}$	Regional unemployment on the provincial level
LTV_{it}	Loan to value ratio defined as mortgage debt over house price
$NEGATIVE\_EQ_{it}$	Dummy variable equals 1 when $LTV_{it} > 1$
$LEVERAGE_{it}$	The ratio of total debt over total assets
$ENTREPRENEUR_{it}$	Dummy that equals 1 when $SOURCE_{it}$ is 'entrepreneurship'

3.2 Descriptive statistics

Savings

Table 2 shows the mean values of our two savings variables, with standard deviations in parentheses. The amount on savings accounts increases in the period 2006-2010 by 2,150 euro per year on average. From 2010 to 2011, we observe a decrease in the amount on savings accounts by about 1,150 euro on average. There is high volatility in household savings with standard deviations around 17 thousand euro. The volatility is also shown by the (capped) histograms of our two dependent variables in Appendix C. On average households payoff around 1,700 euro of mortgage debt during the years 2007-2009. During 2006 and 2010 average mortgage payoffs were on average at a lower level of about 1,300 and 900 euro respectively.

[INSERT TABLE 2 ABOUT HERE]

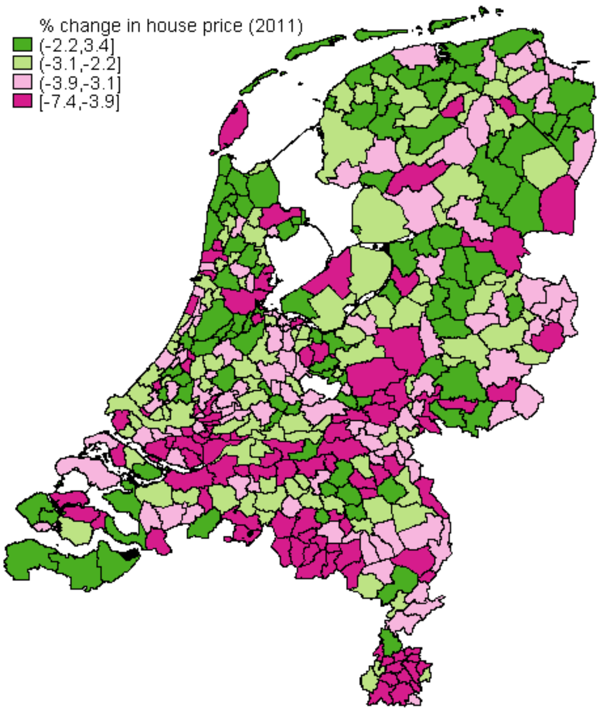
House price changes

Our independent variable of interest is the change in the real house price of a household. Table 3 provides summary statistics for the house price variable. We observe that real house prices increase, on average, until 2009. In the period 2006-2009, the average real house prices increased by approximately 24 thousand euro[11]. In 2010 and 2011 house prices declined, with the strongest decrease of nine thousand euro on average in 2011.

We construct the variable $DECLINE_{it}$ indicating whether the change in the real house price was positive or negative. The fraction of households experiencing a decline of their real house price increases significantly from 24 percent in 2006 to 89 percent in 2011. The histograms in Appendix C confirm this picture.

[INSERT TABLE 3 ABOUT HERE]

Figure 1: regional variation in house price changes



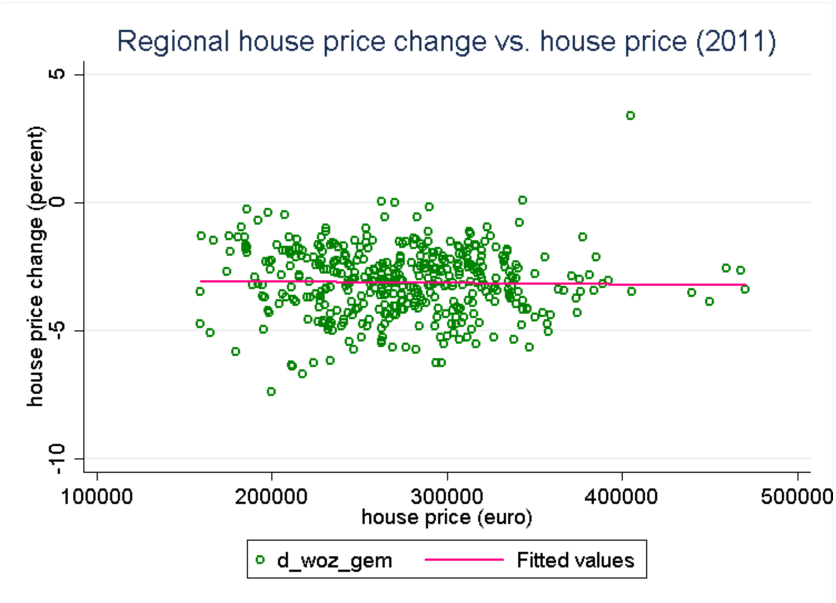
Mian, Rao, and Sufi (2013) exploit the regional variation between US ZIP codes to identify the effect of house price shocks on consumption. Similarly, we aggregate our data to the municipality level and check whether we observe the same large regional variation in the Netherlands. Figure 1 shows

[11] The average house price in 2006 was 254.020 euro, meaning that real house prices increased by almost 10% on average during the period 2006-2009.

the average price change at the municipality between 2010 and 2011 . In the first quartile of the municipalities house prices declined by more than 3.9 percent. In the top quartile house price changes were between -2.2 and +3.4 percent. Although we observe some clustering of municipalities, we still observe that municipalities with large house price declines border municipalities where the house price decline was relatively mild.

Figure 2 plots the average house price change at the municipality level against the average house price in the municipality. The figure shows that there is no relationship between house price changes and the value of the house. This indicates that all types of houses are affected in a similar way by the housing burst. This is important for a clear identification of the effect that house price changes have on savings. If, for instance, economically more vulnerable groups would have lived in houses that experienced larger house price declines, it would be more problematic to exclude a common factor as an explanation for the relationship between house prices and savings behaviour.

Figure 2: house price changes similar for all type of houses



Controls

Table 4 shows descriptive statistics for the control variables. The average age is 50.3 in 2006 and this number increases by one every year as a result of the fact that we have a balanced panel. For the same reason, we observe an increase in the share of households that have pension benefits as their main source of income. The share of households with income from labour decreases over the years, while the other shares remain relatively constant. Although we see a slight increase in the number of households with children, the average household size decreases from 2.8 to 2.7 persons per household.

Loan to value (LTV) ratios decrease over time on average, which is in line with the average increase in house prices during 2006-2009 and the decrease in the average amount of outstanding mortgage debt in our balanced panel. LTV ratios start to increase again from 2010 onwards as a result of decreasing house prices. This also translates into an increasing share of households with an LTV ratio above 1 and increasing leverage ratios after 2009.

[INSERT TABLE 4 ABOUT HERE]

4. Methodology

We study the relationship between house price changes and savings behaviour by estimating the following equation:

$$\Delta S_{it} = \alpha_i + \theta_t + \beta \Delta H_{it} + \gamma \Delta H_{it} \times Z_{it} + \delta Z_{it} + \varphi X_{it} + \varepsilon_{it} \qquad [4.1]$$

Here, ΔS_{it} denotes the year-to-year change in real savings and ΔH_{it} denotes the year-to-year change in real house prices for household i in year t. We interact house price changes with the variables in vector Z_{it}, which includes AGE_{it}, $NEGATIVE\_EQ_{it}$, $DECLINE_{it}$, and $ENTREPRENEUR_{it}$ (a dummy for main income source entrepreneurship) in our preferred specification[12]. The vector X_{it} contains our control variables and year dummies θ_t are included in all specifications.[13]

We estimate equation [4.1] using ordinary least squares (OLS) and panel data random effects (RE)[14] and fixed effects (FE). In the panel data models, the intercept α_i is a household specific random or fixed effect, whereas we have one intercept α in the OLS specifications. Note that after the within transformation in the FE models, the variable AGE_{it} is perfectly collinear with the year dummies. For that reason AGE_{it} is excluded from the FE models, while the interaction term $\Delta H_{it} \times AGE_{it}$ can still be included because of the time-invariant part ΔH_{it}.

We first present estimated coefficients for a variant of equation [4.1] where no interaction terms are included. The estimated coefficient $\hat{\beta}$ is then interpreted as the average effect in euros of a 1 euro change in house prices on savings for the entire population of Dutch home owners. We expect to find $\hat{\beta} < 0$, indicating that households start to save more when house prices decrease (and vice versa).

By including interaction terms we allow this effect to vary between subgroups of the population. Signs of the coefficients on the interaction terms provide indications for the different hypotheses that have been discussed in the literature section. When we find $\hat{\gamma}_{AGE} > 0$, young households respond more strongly to a change in house prices. This would be in line with the collateral hypothesis. On the opposite, a stronger response of old households would point to the life cycle hypothesis. Next, a negative estimate of $\hat{\gamma}_{NEGATIVE\_EQ}$ indicates that more indebted households respond more strongly. This would be in line with the collateral hypothesis or deleveraging effects. We included an interaction term with the entrepreneurship dummy as a proxy for the effect of income uncertainty. We expect a stronger response for entrepreneurs as they have higher income

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[12] We also tried specifications including an interaction with $LEVERAGE_{it}$ as an alternative measure for the indebtedness of the household. However, the interaction with leverage was not significant when substituted for the interaction with the negative housing equity dummy. When included together with the interaction term $\Delta H_{it} \times NEGATIVE\_EQ_{it}$, both $\Delta H_{it} \times NEGATIVE\_EQ_{it}$ and $\Delta H_{it} \times LEVERAGE_{it}$ became insignificant. The coefficients on other interaction terms do not change when an interaction with leverage is included.

[13] We also estimated a specification with municipality-year fixed effects to control for regional economic shocks that might impact both house prices and savings. This amounted to including about 2,200 dummy variables in our model and did not change the OLS results. Unfortunately, we were not able to estimate the RE and FE models with region-year effects, because of memory restrictions.

[14] The standard GLS RE estimator produces the same results as the OLS estimator when estimated in Stata. This arises because the Stata algorithm does not converge. We fit population averaged panel data model with exchangeable within-group correlation structure. See page 7 of www.stata.com/manuals13/xt**xtgee**.pdf. Unfortunately, this Stata command does not allow for estimation with cluster robust standard errors, meaning that standard errors are wrong in the RE model.

uncertainty.[15] Finally, a nonzero estimate of $\hat{\gamma}_{DECLINE}$ points to asymmetric responses to house price decreases versus increases. Most studies find asymmetric responses, but the direction of the effect varies between studies. Table 5 gives an overview.

Table 5: coefficients and different hypotheses

	Negative	**Positive**
$\hat{\gamma}_{AGE}$	life cycle hypothesis	collateral hypothesis
$\hat{\gamma}_{NEGATIVE\_EQ}$	collateral hypothesis / deleveraging	
$\hat{\gamma}_{ENTREPRENEUR}$	income uncertainty	
	Zero	**Non-zero**
$\hat{\gamma}_{DECLINE}$	no asymmetry between house price increases and declines	asymmetry between house price increases and declines

5 Results

5.1 Baseline regressions

Table 6 presents the OLS, RE, and FE baseline regression results. The first three columns present estimates without interaction terms. In columns (4) to (6) interactions between the house price change and AGE_{it}, $NEGATIVE\_EQ_{it}$, $DECLINE_{it}$, and $ENTREPRENEUR_{it}$ are included.

[INSERT TABLE 6 ABOUT HERE]

Before moving to our variable of interest, the change in house prices, we briefly discuss the effect of the included control variables on household savings. The OLS and RE estimates are very similar, while most coefficients on the household characteristics (size, main income source, marital status, composition) change sign in the FE estimates. This is probably caused by the fact that the within variation is too low to estimate the effect correctly for these variables.

In all specifications we find a positive and significant effect of disposable income on household savings. Households that experience a decline in the house price also save more on average according to the three estimates. The coefficient on negative equity is negative and significant in the OLS and RE specifications and not significant in the FE specification. We do not find a clear and significant effect of leverage on household savings.

In the OLS and RE specifications we find that households with main income sources other than the base category 'labour' save less on average. In the FE regression we find that entrepreneurs save more on average compared to households with main income source labour. Large households and households with children also save less on average according to the OLS and RE estimates, while we find opposite signs in the FE specification. Households with a marital status different from the base category 'single person household' save less according to the OLS and RE estimates. In the FE specification we find opposite effects of marital status categories 'divorced' and 'widowed'. The

[15] However, it could also be the case that entrepreneurs are less risk-averse, which would have an opposite effect on the relationship between house price changes and savings.

regional unemployment rate has a negative and significant impact on savings in the OLS and FE specifications, indicating that higher unemployment leads to lower savings.

Now we come to our variable of interest: changes in house price. In specifications OLS (1), RE (1), and FE (1) we find a negative effect of the change in house price ΔH_{it} on household savings. In the absence of interaction terms, the effect of ΔH_{it} on savings is interpreted as the average marginal propensity to save (MPS) out of housing wealth gains for the entire population of Dutch home owners. We find a statistically significant effect of -0.0030 in OLS (1) and -0.0039 in RE (1). In specification FE (1) the effect is much smaller (-0.0006) and not significant. The point estimates between -0.0006 and -0.0039 indicate that a 100 euro decrease in the value of the house translates into additional savings between 6 and 30 eurocents. The economic size of the effect is therefore small.

An important benefit of the large number of households in our sample is that we can study and compare subgroups of the population. In order to check whether people in different subgroups respond differently, we interact the house price change with AGE_{it}, $NEGATIVE\_EQ_{it}$, $DECLINE_{it}$, and $ENTREPRENEUR_{it}$. Both the coefficient on ΔH_{it} and the coefficients on the interaction terms have the same signs and are highly significant in specifications OLS (2), RE (2), and FE (2).

The coefficient on ΔH_{it} is negative and highly significant in all specifications. For the interpretation of this effect we should take the interaction terms into account. We first investigate the effect of a house price *increase* on savings of non-entrepreneurial households with positive housing equity. This means that the dummy variables $DECLINE_{it}$, $NEGATIVE\_EQ_{it}$, and $ENTREPRENEUR_{it}$ are all set to zero and that the effect of ΔH_{it} on savings only varies with age. The positive coefficient on the interaction term with AGE_{it} shows that the effect is stronger for young households. This result is in line with collateral hypothesis. Table 7a shows the effect on savings of a 100 euro house price increase according to specifications OLS (2), RE (2), and FE (2). Significance stars show that almost all marginal effects are significantly different from zero.

Table 7a: additional savings resulting from a 100 euro house price increase⁺

	OLS (2)	RE (2)	FE (2)
20 years	-3.2***	-3.2	-2.2***
30 years	-2.6***	-2.7	-1.7***
40 years	-2.0***	-2.1	-1.3***
50 years	-1.4***	-1.5	-0.8***
60 years	-0.8***	-0.9	-0.4***
70 years	-0.2***	-0.4	0.1

⁺ For non-entrepreneurial households, with positive housing equity. Significance: *p<0.05; **p<0.01; ***p<0.001. Significance of marginal effects not computed for RE model since estimation with cluster robust standard errors was not possible.

A 100 euro *decrease* of the house price would have a different effect. The coefficients on $\Delta H_{it} \times DECLINE_{it}$ show that a house price decline significantly reduces the negative effect we find for house price increases. This points to an asymmetric effect of house price declines versus increases, with a stronger effect for house price increases. Table 7b presents the additional savings resulting from a 100 euro house price decline for non-entrepreneurial households with positive housing equity. Only for the youngest households we find an increase in savings following a house price decrease. For the older households, the MPS changes sign and a house price decline goes hand in hand with lower savings.

Table 7b: additional savings resulting from a 100 euro house price decrease+

	OLS (2)	RE (2)	FE (2)
20 years	1.2***	1.1	1.0***
30 years	0.6***	0.5	0.6***
40 years	-0.0	-0.1	0.1
50 years	-0.6***	-0.6	-0.3**
60 years	-1.2***	-1.2	-0.8***
70 years	-1.8***	-1.8	-1.2***

+ For non-entrepreneurial households, with positive housing equity. Significance: *p<0.05; **p<0.01; ***p<0.001. Significance of marginal effects not computed for RE model since estimation with cluster robust standard errors was not possible.

However, we should take into account that a house price decline itself ($DECLINE_{it} = 1$) increases savings by about 60 to 115 euro on average depending on the specification. Based on these estimates we would thus conclude that a household experiencing a house price decline does save more on average, but only for the youngest group of households we find that the amount of extra savings increases in the size of the house price decline.

The interaction term with $NEGATIVE\_EQ_{it}$ is negative and significant in all specifications, showing that we find a larger MPS for households with negative housing equity. This finding is in line with both the collateral hypothesis and deleveraging effects. The point estimate of the interaction term varies between -0.0085 and -0.0049 indicating that households with negative housing equity save on average between 49 and 85 eurocent more (less) for every 100 euro decrease (increase) in the price of their houses.[16] Table 7c again shows the additional savings resulting from a 100 euro price decrease, but now for non-entrepreneurial households with an underwater mortgage.

To give an indication of the economic significance of these effects, we focus on the results in Table 7c and compare the size of the effects to household income. We calculate average house price changes for different groups of households. For the group of non-entrepreneurial households between 25 and 35 years old, with negative equity the average house price decrease was 6,000 euro in 2011. Based on the effects for 30 year old households from Table 7c, this would lead to additional savings between 66 euro (1.1 * 6,000/100) and 84 euro (1.4 * 6,000/100). This effect is relatively small when compared to the average disposable income of about 35,000 euro in this group. Note, however, that average savings are also small for this group of households (in 2011, non-entrepreneurial households between 25 and 35 years old, with negative housing equity dissave on average 80 euro).

[16] We also estimated a specification with a 'negative equity' dummy that equals 1 when the household's LTV ratio is above 1.1. In this specification the coefficients on the interaction term are only slightly larger (-0.0088 and -0.0059 respectively) while the other coefficients of interest do not change.

Table 7c: additional savings resulting from a 100 euro house price decrease[+]

	OLS (2)	RE (2)	FE (2)
20 years	2.0***	1.9	1.5***
30 years	1.4***	1.3	1.1***
40 years	0.8***	0.7	0.6***
50 years	0.2	0.2	0.2
60 years	-0.4*	-0.4	-0.3
70 years	-0.9***	-1.0	-0.7***

[+] For non-entrepreneurial households, with negative housing equity. Significance: *p<0.05; **p<0.01; ***p<0.001. Significance of marginal effects not computed for RE model since estimation with cluster robust standard errors was not possible.

We find a positive coefficient of between 0.0060 and 0.0075 on the interaction term with the entrepreneurship dummy. This implies that we find a smaller MPS for entrepreneurs compared to non-entrepreneurial households, holding everything else equal. Our estimates thus do not confirm the hypothesis that the effects are larger for entrepreneurs because of higher income uncertainty. Possible explanations are that our measure for income uncertainty is not perfect or that entrepreneurs have other characteristics (such as less risk aversion) that result in an opposite effect.

5.2 Mortgage payoffs

Down payments on mortgage debt can be seen as an active form of saving. Especially in case of falling house prices, this form of saving could be relevant. When house prices start to fall, people will start to pay off their mortgages in order to prevent a residual debt. This is particularly the case for people with high LTV-ratios. In other words, part of the additional savings may come in the form of early down payment of mortgage debt. We therefore expand our definition of savings by including mortgage payoffs in the savings definition. We estimate equation [5.1], which adds mortgage payoffs to the change in the amount on savings accounts (recall that $\Delta S_{it}^2 = \Delta S_{it} + PAYOFFS_{it}$):

$$\Delta S_{it}^2 = \alpha_i + \theta_t + \beta \Delta H_{it} + \gamma \Delta H_{it} \times Z_{it} + \delta X_{it} + \varepsilon_{it} \qquad [5.1]$$

The estimates presented in Table 8 are comparable to our baseline regression results presented in Table 6. The coefficients reported under FE (3) all have the same sign and order of magnitude as our baseline estimates. The main difference is the magnitude of the estimated effect of negative housing equity on the MPS. This coefficient is -0.0049 in our baseline estimates and equals -0.0239 in the FE estimate including mortgage payoffs in the savings definition. The fact that we find a substantially larger effect of negative housing equity on the MPS once we include mortgage payoffs in the savings definition indicates that households with an underwater mortgage start to payoff mortgage debt when house prices decline.

In the OLS specification, the effect of negative housing equity is not confirmed. In fact, we find a smaller MPS for households with negative housing equity (but only significant at the 5 percent level). The interaction with the decline dummy is not significant in the OLS specification meaning that we do not find evidence for an asymmetric effect of price declines versus increases when we include mortgage payoffs in the savings definition. In our baseline estimates we found a smaller MPS for price declines. Therefore, the OLS specification suggests that households start to payoff mortgage debt once house prices start to decline.

[INSERT TABLE 8 ABOUT HERE]

5.3 Non-linear interactions

In our specifications we introduced interactions terms to allow for different savings responses to house price changes in various subgroups of the population. So far, we introduced these interaction terms in a very specific way. For instance, by including the interaction term $\Delta H_{it} \times AGE_{it}$ we allow the effect of house price changes to vary over age, but only so in a linear way. Although we find significant coefficients on the interaction terms with age it could very well be the case that this relationship is non-linear. The same holds for the interaction term with the decline dummy. We only allow for a different response between house price declines and increases, but we do not allow for different effects depending on the magnitude of the house price increase or decrease.

In order to control for such nonlinearities we redefine our age and decline variables and include interactions between house price changes and our redefined variables. For age, we construct dummy variables for different categories: below 30 years, 30-40 years, 40-50 years, 50-60 years, 60-70 years, and above 70 years. We divide house price increases and decreases into two groups: small magnitude (0-4 percent increase or decrease) and large magnitude (more than 4 percent increase or decrease). The results of the estimates with these interaction terms are presented in Table 9, while Table 10 shows the additional savings in euros of a 100 euro house price change for different subgroups of non-entrepreneurial households with positive housing equity.

[INSERT TABLE 9 ABOUT HERE]

Table 10: additional savings resulting from a 100 euro price increase or decrease[+]

Panel a: OLS (4)

	increase >4% (1)	**increase <4%** (2)	**decrease <4%** (3)	**decrease >4%** (4)
< 30 years	-3.2	-5.9	-4.2	1.1
30-40 years	-2.2	-4.9	-5.2	0.1
40-50 years	-1.4	-4.2	-5.9	-0.6
50-60 years	-1.4	-4.1	-6.0	-0.7
60-70 years	-0.1	-2.9	-7.2	-1.9
>70 years	0.1	-2.7	-7.4	-2.1

[+] non-entrepreneurial households with positive housing equity

Panel b: FE (4)

	increase >4% (1)	**increase <4%** (2)	**decrease <4%** (3)	**decrease >4%** (4)
< 30 years	-0.5	-0.5	-2.4	-0.4
30-40 years	-1.0	-1.0	-1.9	0.0
40-50 years	-1.0	-1.0	-1.9	0.0
50-60 years	-1.2	-1.2	-1.7	0.3
60-70 years	0.6	0.6	-3.5	-1.5
>70 years	0.9	0.9	-3.9	-1.9

[+] non-entrepreneurial households with positive housing equity

Table 10 confirms our finding that MPS is the largest for young households experiencing house price increases. The OLS estimates shows that the MPS is the largest for moderate house price increases (<4 percent). In the FE specification we find no difference between strong and moderate increases. Next, we find some indications of nonlinear age effects, especially in the FE model. In the FE model we find a MPS out of house price gains between -0.5 and -1.0 for all age groups below 60 year. The effects are about equal for age groups 50-60 years, 40-50 years, and 30-40 years, while the effect is somewhat weaker for the youngest group of households below 30 years. For age groups above 60 year we find small positive estimates.

Again, we find that the MPS related to house price decreases is smaller than the MPS related to increasing house prices. For house price declines of more than 4 percent we still find that the youngest age groups start to save more. However, we find that all age groups start to save less when house price declines are relatively limited.

The impact of having an underwater mortgage and being an entrepreneur on the MPS is not shown in Table 10. In both the OLS and the FE specification we find a significant negative coefficient on the interaction term with the negative housing equity dummy. This indicates again that the MPS is larger for households with an underwater mortgage. Households with an underwater mortgage save an additional 0.6 to 0.8 euro for a 100 euro house price decrease, compared to households with LTV-ratios below one, which is comparable to our baseline estimates. The effect for entrepreneurs is the opposite and also similar to our baseline estimates.

6. Robustness

6.1 Home improvements

The fact that we are unable to identify households that invest in their home trough constructions is a possible source of endogeneity. Home improvements impact both savings and home values, as money from savings accounts may be used for these improvements. In line with Disney, Gathergood and Henley (2010), we deal with this source of endogeneity by calculating yearly percentage price changes at the municipality level. By doing so, the effect of possible home improvements is smoothed over a large number of households and is no longer reflected in our house price variable. We thus estimate the following equation (where l is an indicator for the municipality of the household):

$$\Delta S_{ilt} = \alpha_i + \theta_t + \beta \Delta H_{lt} + \gamma \Delta H_{lt} \times Z_{it} + \delta Z_{it} + \varphi X_{it} + \varepsilon_{it} \qquad [6.1]$$

In equation [6.1] ΔH_{lt} is the average percentage house price change in municipality l, from year $t-1$ to year t. The interaction terms with household variables Z_{it} now measure how the impact of regional house price changes varies between households with different characteristics. We estimate the coefficients of equation [6.1] using both OLS and panel data FE. The results are presented in Table 11.

[INSERT TABLE 11 ABOUT HERE]

Note that the house price change variable is measured in percentages instead of euros now, such that the coefficients are not directly comparable to previous estimates. The signs of the coefficients, however, are comparable to our baseline estimates. We find a negative relationship between regional house price changes and household savings. The coefficients on the interaction terms with AGE_{it}, $NEGATIVE\_EQ_{it}$, and $ENTREPRENEUR_{it}$ have the same sign as in our baseline estimates. The coefficient on the interaction with the house price decline dummy is negative and significant in this specification, indicating a stronger relationship between house prices and savings when prices decrease. In previous estimates we found an opposite effect of house price decreases.

6.2 Unexpected house price changes

In line with the literature (see e.g. Browning, Gørtz and Leth-Petersen; 2013 or Disney, Gathergood and Henley; 2010) we calculate a proxy for *unexpected* house price changes and estimate the MPS out of unexpected price changes. We estimate AR(1) and AR(2) models[17] to predict house prices from their lagged values. The unexpected house price change is then defined as the difference between the actual house price and the predicted house price.

[INSERT TABLE 12 ABOUT HERE]

The estimates in Table 12 confirm our baseline findings. All coefficients on the house price change variables and the interaction terms are consistent with our baseline estimates. Moreover, the estimates are all significant and have the same order of magnitude as in previous findings.

6.3 Consumption

In line with Browning, Gørtz, and Leth-Petersen (2013) we calculated household consumption using the accounting identity stating that income equals savings plus consumption. We calculate consumption using three versions of the accounting identity (all RHS variables are available at the household level, no subscripts for readability).

$$C1 = INCOME - \Delta SAVINGS \quad [6.2]$$
$$C2 = INCOME - \Delta SAVINGS - \Delta STOCKS - \Delta BONDS \quad [6.3]$$
$$C3 = INCOME - \Delta SAVINGS - \Delta STOCKS - \Delta BONDS + \Delta DEBT \quad [6.4]$$

During the period 2006-2011 stock price fluctuations were huge. Since we only observe the value of the stock and bond portfolio at the beginning of the year, we cannot identify whether changes in the value are due to changes in prices or quantities. We tried to correct for stock price fluctuations by using the average annual return on the Dutch stock market index (AEX) as a proxy for price changes, but it proved to be very hard to predict consumption for households with a large share of stocks in their portfolios. Therefore we decided to restrict the consumption analysis to households without stocks in their portfolio. The results of our regressions are displayed in Table 12.

[17] We first estimate house prices H_{it} on their lagged values $H_{i,t-1}$ in an AR(1) model. We find a highly significant coefficient of 0.99. Second, we also include $H_{i,t-2}$ and estimate an AR(2) model. Both coefficients are highly significant. The coefficient on $H_{i,t-1}$ equals 1.02 and the coefficient on $H_{i,t-2}$ is -0.03. Both models have an R^2 above 0.95.

[INSERT TABLE 13 ABOUT HERE]

The fact that we only select households without stocks in their portfolio could impact our baseline results. Therefore we also re-estimate equation [4.1] on the sample of households without stocks. The results in the last column of Table 12 show that this selection does not impact our baseline results.

The coefficients in the first three columns of Table 12 should now be interpreted as the marginal propensity to consume (MPC) out of housing gains instead of the MPS. The estimates become less precise once we account for changes in more wealth components than just savings on savings accounts. One possible explanation is a technical one; we restricted our sample by dropping the top and bottom 1 percent of the savings distribution. We did not drop large outliers of the change in bonds and household debt, which could make the estimates of consumption according to definitions [6.3] and [6.4] less precise. Still, Table 12 shows that the point estimates are consistent according to the three definitions of consumption.

As expected, we find a positive MPC in all three specifications indicating that house price increases (decreases) lead to increased (decreased) consumption. Moreover, the predicted MPC is the largest for young households with negative housing equity. However, we now find that the MPC is larger when households experience house price declines. This contradicts our previous findings on the asymmetric effect of house price gains versus losses.

6.4 Outlier analysis

Remember that our results are based on a sample that excludes house prices below 50 thousand euro and above 1 million euro. Moreover, we excluded households in the top and bottom 1 percent of the savings distribution. In order to check the impact of these selections on our results we re-estimate the specifications presented in Table 6 on the complete sample. The results are presented in Table 13.

[INSERT TABLE 14 ABOUT HERE]

The coefficients in Table 13 broadly confirm our previous findings presented in Table 6. The coefficients are very similar, but less precise (i.e. standard errors are larger). In OLS (6), most of the coefficients of interest are just significant at the 5 percent level. Only for the interactions with the negative housing equity and entrepreneurship dummy we no longer find significant results. In FE (6) we only find a different sign for the interaction with the entrepreneurship dummy. For the other coefficients of interest we find similar estimates, although we no longer find statistically significant effects in the FE specification. We conclude that excluding outliers increases the precision of the estimates, but it does not drive our results.

7. Conclusion

We study the effect of changing house prices on savings behavior of slightly less than 2 million Dutch home owning households using a unique administrative dataset from Statistics Netherlands including all Dutch owner occupiers over the period 2006-2011. We estimate the relationship between house price changes and savings using simple OLS and panel data random effects (RE) and fixed effects (FE).

On average, we find a significant negative effect of house price changes on household savings. The economics size of the effect is small, however. We find much larger effects for subgroups of the population. First, we find that young households respond more strongly to house price changes compared to old households. For households at age 30, we predict a MPS between -0.026 (OLS) and -0.017 (FE) of house price increases on savings. In other words, a house price increase of 100 euro is estimated to decrease savings by 1.7 to 2.6 euro on average. For households at age 50, this effect is in the range of 0.8 to 1.4 euro according to our baseline estimates.

Second, we find evidence for an asymmetric response to house price declines compared to house price increases in most, but not all specifications. In both the OLS and the FE specification, the MPS of a house price decline for a household at age 30 is estimated to be -0.006. For households aged 50, the MPS out of house price declines is weakly positive, meaning that we predict slightly lower savings for these households once they experience a house price decline. Once we include mortgage payoffs in our savings definition, we no longer find an asymmetric response to price increases versus decreases for all specifications.

Third, we find a stronger MPS for households with negative housing equity in all specifications. In our baseline specification, the MPS out of a house price decline for a 30-year old household changes from -0.006 to -0.014 (OLS) or from -0.006 to -0.011 (FE) when the household has a LTV-ratio above one. However, the FE model gives an indication of nonlinearities in age. We still find negative effects for households below age 60, but the size of the effect does not differ much between the various age groups below 60.

Our findings are robust to a number of specification checks. Our baseline results are confirmed in the estimates with regional average house price changes at the municipality level as an indicator for house price changes to control for the possibility that our results are driven by home improvements. We also estimate the MPC instead of the MPS for a subsample of households without stocks in their portfolio for whom we calculated household consumption. Again, we confirm our baseline estimates and find the strongest MPC for young households with negative equity. In both robustness checks, however, we find stronger effects for house price declines compared to increases.

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Appendix A - Selections dataset

Our initial dataset has 19,202,453 records. Each record represents a household in a particular year. The number of households in our initial dataset increases from 2,653,471 in 2006 to 3,575,732[18] in 2011. This number increases because for each household the raw data only includes the address where the household was living in 2011. Therefore we end up with two types of households in our dataset. First, households that did not move in the period 2006-2011. Such households have six records in our dataset. Second, households that moved at some point during 2006-2011. This group is divided into households that move for the first time into an owner-occupied house and households that move from one owner-occupied house to another. As a result, the initial dataset constitutes a panel with entry but without exit.

We select only owner-occupied houses from the WRG file to ensure we have no renting households in our dataset. The ownership status of a house is registered on the address level, but in some cases two or more households are registered at the same address. For instance, the owner-occupier is a member of one household and the other household is renting part of the house. The IHI file enables us to identify and remove all renting households from our dataset. In this step, most of the addresses with two or more households are deleted. The remaining addresses with two or more households are also excluded from our dataset. With two or more households on one and the same address it is not possible to determine how to spread the house value over the households.

Furthermore, we removed households if house price data is missing in two or more subsequent years. In case the house price is missing in one single year, we estimate the house price by simple linear regressions on the lagged house price.[19] The problem of missing house prices is the most severe for the group of houses with a high value in the year 2007. For some households we have gaps in our data, meaning that they disappear from our dataset in one year and reappear on the same address in the next year. The explanation for this is that the ownership status in the WRG-file changes from 'owner-occupied' to 'renting' and back to 'owner-occupied'. These households are removed from our dataset.

We also remove households with a member that divorces or becomes widowed during the sample period, as well as households with major changes in household composition. Specifically, we remove single person households that changed to multi-person households and vice versa. Such a change means people started to live together or have been separated. These are major changes that potentially have a large impact on savings behavior[20]. It is common in the literature to make these selections (see e.g. Engelhardt, 1996; Browning et al., 2013).

In addition, we delete households from our dataset of unclear composition. The major category is "couple with third person". It is not known how this 'third person' is related to the household. It is likely that this person is not the owner-occupier of the house. However, income and capital are measured at the household level meaning that income and capital of the third person are included.

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[18] Note that this is the number of houses with the owner-occupier actually living in the house. The total number of owner-occupied dwellings in the Netherlands is just below 4 million in the Netherlands in 2011.

[19] These regressions have very high explanatory power; R^2 between 0.93 and 0.97.We also tried to estimate missing house prices by linear interpolation. This leads to very similar results. We prefer imputation by predicted values from regressions on lagged house prices, since this enables us to impute house prices for 2011. In contrast, linear interpolation requires house price data for 2012.

[20] Households who get children or have children that are leaving the household during the sample period are still included.

This will lead to measurement errors as we measure the behavior of a third person that is not affected by changes in house prices.

The literature recognizes that excluding moving households improves identification of the effect of housing wealth on savings behavior (e.g. Engelhardt, 1996). For instance, a household that moves from a high value house to a low value house is expected to experience an increase in savings while the house value drops. That would imply a negative relationship between housing wealth and savings, but it is not the relationship we are interested in. To avoid this issue, we construct a balanced panel of non-moving households by only including households with six records (2006-2011) in our dataset.

Finally, we delete outliers by removing the top and bottom 1% of the savings distribution[21]. In addition, we only include households living in a house with a value between 50,000 and 1,000,000 euro. The rationale for excluding these outliers is twofold. First, extremely high or low savings could be explained by rare events such as winning a lottery or receiving an inheritance, which are unrelated with savings decisions. Second, every large administrative dataset most likely contains administration errors: house prices below 50,000 are highly unlikely. Finally, consumers living in houses priced above 1,000,000 euro are most likely unrepresentative. Our final sample constitutes a balanced panel of 1,987,620 households totaling 11,925,720 observations.

Table A1 gives an overview of the impact of all these selections on the total number of observations in our dataset.

Table A1: selection dataset

Selection	**Number of households**
dataset before selections	19,202,453
two or more households, one address	18,992,386
divorce/widow	18,306,227
household composition	17,249,991
delta household composition	16,417,537
gaps in data	16,136,998
two or more subsequent missing house prices	16,073,483
household head on two or more addresses	16,037,326
selection house prices	15,952,275
selection savings (1% top/bottom)	15,693,255
house price missing after imputation	15,640,720
balanced panel	11,925,720

[21] This amounts to removing increases in the amount on savings accounts above 114,000 euro and decreases below 93,000 euro.

Appendix B - Tables

Table 2: descriptive statistics savings variables (standard errors in parentheses)

Variable	2007	2008	2009	2010	2011
ΔS	2,441	2,150	1,422	2,583	-1,150
	(16,541)	(16,813)	(17,034)	(16,744)	(18,165)
$\Delta S + PAYOFFS$	3,802	3,890	3,211	4,303	-275
	(31,197)	(89,558)	(72,691)	(38,285)	(19,319)
N	1,987,620	1,987,620	1,987,620	1,987,620	1,987,620

Table 3: descriptive statistics house price changes (standard errors in parentheses)

Variable	2007	2008	2009	2010	2011
ΔH	12,006	9,592	2,659	-4,550	-9,059
	(26,935)	(21,422)	(17,371)	(15,867)	(16,355)
$DECLINE$					
0 ($\Delta HOUSEPRICE \geq 0$)	0.76	0.77	0.58	0.22	0.11
1 ($\Delta HOUSEPRICE < 0$)	0.24	0.23	0.42	0.78	0.89
N	1,987,620	1,987,620	1,987,620	1,987,620	1,987,620

Table 4: descriptive statistics (standard errors in parentheses)

Variable	2006	2007	2008	2009	2010	2011
$INCOME$	35,927	37,610	39,596	39,616	39,647	39,118
(euro's)	(18,434)	(18,304)	(21,314)	(20,091)	(19,915)	(19,738)
$SOURCE$						
Labour	0.65	0.63	0.62	0.60	0.58	0.56
Entrepreneurship	0.12	0.13	0.14	0.14	0.14	0.15
Wealth	0.00	0.00	0.01	0.00	0.00	0.00
Social welfare	0.04	0.04	0.03	0.03	0.03	0.03
Pension	0.18	0.20	0.21	0.22	0.24	0.26
Other and no income	0.00	0.00	0.00	0.00	0.00	0.00
$HHSIZE$	2.8	2.8	2.8	2.7	2.7	2.7
	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)	(1.3)
$COMP$						
Without children	0.50	0.50	0.51	0.51	0.52	0.53
With children	0.50	0.50	0.49	0.49	0.48	0.47
LTV	0.51	0.49	0.46	0.45	0.46	0.47
	(0.86)	(0.71)	(0.59)	(0.37)	(0.35)	(0.36)
$NEGATIVE\_EQ$						
1	0.14	0.11	0.08	0.07	0.08	0.09
0	0.86	0.89	0.92	0.93	0.92	0.91
$LEVERAGE$	48.0	43.7	41.8	41.1	41.1	42.1
	(3,252.6)	(103.7)	(61.3)	(100.0)	(123.0)	(484.3)
$MARITAL$						
single	0.20	0.20	0.19	0.18	0.17	0.13
married or partners	0.68	0.69	0.70	0.71	0.72	0.75
divorced	0.06	0.06	0.06	0.06	0.06	0.06
widowed	0.06	0.06	0.06	0.06	0.05	0.06
AGE	50.3	51.3	52.3	53.3	54.3	55.3
	(12.9)	(12.9)	(12.9)	(12.9)	(12.9)	(12.9)
$UNEMPLOYMENT$	5.5	4.5	3.9	4.8	5.5	5.3
	(0.7)	(0.8)	(0.6)	(0.7)	(0.6)	(0.7)
N	1,987,620	1,987,620	1,987,620	1,987,620	1,987,620	1,987,620

Table 6: OLS, RE, and FE baseline regressions (standard errors adjusted for household clusters in parentheses)

dependent variable: ΔS_{it}	**OLS (1)**	**RE (1)**	**FE (1)**	**OLS (2)**	**RE (2)**	**FE (2)**
ΔH_{it}	-0.0030***	-0.0039***	-0.0006	-0.0439***	-0.0435***	-0.0304***
	(0.0004)	(0.0003)	(0.0005)	(0.0015)	(0.0012)	(0.0016)
$\Delta H_{it} \times AGE_{it}$				0.0006***	0.0006***	0.0004***
				(0.0000)	(0.0000)	(0.0000)
$\Delta H_{it} \times DECLINE_{it}$				0.0203***	0.0213***	0.0113***
				(0.0009)	(0.0007)	(0.0011)
$\Delta H_{it} \times NEGATIVE\_EQ_{it}$				-0.0085***	-0.0078***	-0.0049**
				(0.0013)	(0.0010)	(0.0015)
$\Delta H_{it} \times ENTREPRENEUR_{it}$				0.0075***	0.0073***	0.0060***
				(0.0008)	(0.0006)	(0.0009)
AGE_{it}	2.6**	-2.0**	omitted	-1.4	-3.0***	omitted
	(0.7)	(0.6)		(0.7)	(0.6)	
$DECLINE_{it}$	78.3***	60.0***	115.3***	89.8***	79.1***	107.3***
	(15.0)	(14.5)	(17.2)	(15.2)	(14.8)	(17.5)
$NEGATIVE\_EQ_{it}$	-1172.2***	-1263.1***	4.9	-1196.1***	-1286.0***	-24.6
	(23.2)	(17.4)	(38.2)	(23.3)	(17.4)	(38.2)
$LEVERAGE_{it}$	-0.5	-0.7***	-0.2	-0.5	-0.7***	-0.2
	(0.4)	(0.0)	(0.1)	(0.4)	(0.0)	(0.1)
$INCOME_{it}$	0.09***	0.09***	0.13***	0.09***	0.09***	0.13***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
$HHSIZE_{it}$	-69.0***	-73.3***	1987.0***	-62.8***	-66.8***	1951.8***
	(7.9)	(7.6)	(30.4)	(7.9)	(7.6)	(30.4)
$SOURCE_{it}$ +						
entrepreneurship	-315.6***	-318.8***	371.0***	-299.4***	-298.5***	333.0***
	(16.1)	(13.8)	(56.0)	(16.3)	(13.9)	(56.1)
wealth	-2657.8***	-2666.4***	-4572.3***	-2634.3***	-2632.5***	-4555.3***
	(169.9)	(80.1)	(287.0)	(170.0)	(80.1)	(286.9)
social welfare	-239.6***	-187.3***	-1463.4***	-239.5***	-183.0***	-1474.1***
	(27.7)	(28.2)	(62.2)	(27.7)	(28.2)	(62.2)
pension	-880.5***	-859.2***	-2086.0***	-852.8***	-831.8***	-2049.4***
	(20.4)	(17.5)	(57.8)	(20.4)	(17.5)	(57.9)
other and no income	-82.0	-37.2	-1095.5***	-41.8	9.7	-1096.6***
	(134.8)	(119.9)	(294.0)	(134.9)	(119.9)	(294.1)
$COMP_{it}$ ++						
with children	-304.4***	-416.0***	435.3***	-322.1***	-433.4***	437.9***
	(19.5)	(18.7)	(53.6)	(19.5)	(18.7)	(53.6)
$MARITAL_{it}$ +++						
married or partners	-760.0***	-700.1***	-280.2***	-763.5***	-703.3***	-330.8***
	(13.4)	(13.5)	(52.2)	(13.4)	(13.5)	(52.2)
divorced	-193.2***	-209.9***	943.7***	-197.7***	-212.7***	922.8***
	(20.9)	(22.3)	(133.2)	(20.9)	(22.3)	(133.2)
widowed	-422.8***	-427.2***	1622.7***	-416.2***	-418.4***	1655.1***
	(25.7)	(24.9)	(252.7)	(25.7)	(24.8)	(252.8)
$UNEMPLOYMENT_{it}$	-23.0**	-10.7	-322.8***	-38.5***	-27.2***	-325.8***
	(6.7)	(6.8)	(19.7)	(6.7)	(6.9)	(19.7)
year dummies	YES	YES	YES	YES	YES	YES
R-squared	0.0186		0.0158	0.0188		0.0159
N	9,937,039	9,937,039	9,937,039	9,937,039	9,937,039	9,937,039

significance: * p<0.05; ** p<0.01; *** p<0.001

+ labour base category, ++ without children base category, +++ single base category

Table 8: OLS and FE regressions savings plus payoffs (standard errors adjusted for household clusters in parentheses)

dependent variable: $\Delta S_{it} + PAYOFF_{it}$	**OLS (3)**	**FE (3)**
ΔH_{it}	-0.0319***	-0.0269***
	(0.0027)	(0.0028)
$\Delta H_{it} \times AGE_{it}$	0.0006***	0.0004***
	(0.0000)	(0.0000)
$\Delta H_{it} \times DECLINE_{it}$	-0.0007	0.0103***
	(0.0015)	(0.0020)
$\Delta H_{it} \times NEGATIVE\_EQ_{it}$	0.0115*	-0.0239***
	(0.0048)	(0.0056)
$\Delta H_{it} \times ENTREPRENEUR_{it}$	0.0068***	0.0069***
	(0.0014)	(0.0015)
AGE_{it}	12.5***	omitted
	(3.2)	
$DECLINE_{it}$	130.3**	166.9**
	(47.3)	(50.4)
$NEGATIVE\_EQ_{it}$	-970.0***	-4637.7***
	(81.3)	(331.1)
$SOURCE_{it}{}^{+}$		
entrepreneurship	220.3***	463.6***
	(41.8)	(129.5)
controls	YES	YES
year dummies	YES	YES
R-squared (within for FE)	0.0027	0.0030
N	9,937,039	9,937,039

significance: * p<0.05; ** p<0.01; *** p<0.001

$^{+}$ labour base category

Table 9: OLS and FE regressions non-linear interactions (standard errors adjusted for household clusters in parentheses)

dependent variable: ΔS_{it}	**OLS (4)**	**FE (4)**
ΔH_{it}	-0.0315***	-0.0052**
	(0.0016)	(0.0017)
$\Delta H_{it} \times AGE30\_40_{it}$	0.0098***	-0.0048**
	(0.0016)	(0.0017)
$\Delta H_{it} \times AGE40\_50_{it}$	0.0173***	-0.0047**
	(0.0016)	(0.0017)
$\Delta H_{it} \times AGE50\_60_{it}$	0.0179***	-0.0071***
	(0.0016)	(0.0017)
$\Delta H_{it} \times AGE60\_70_{it}$	0.0301***	0.0109***
	(0.0017)	(0.0018)
$\Delta H_{it} \times AGE70_{it}$	0.0325***	0.0145***
	(0.0018)	(0.0020)
$\Delta H_{it} \times WEAK\_INCR_{it}$	-0.0277***	0.0000
	(0.0035)	(0.0042)
$\Delta H_{it} \times WEAK\_DECL_{it}$	0.0735***	0.0293***
	(0.0030)	(0.0037)
$\Delta H_{it} \times STRONG\_DECL_{it}$	0.0203***	0.0095***
	(0.0011)	(0.0014)
$\Delta H_{it} \times NEGATIVE\_EQ_{it}$	-0.0081***	-0.0060***
	(0.0013)	(0.0015)
$\Delta H_{it} \times ENTREPRENEUR_{it}$	0.0076***	0.0072***
	(0.0008)	(0.0091)
$AGE30\_40_{it}$	-152.5***	omitted
	(16.5)	
$AGE40\_50_{it}$	-625.1***	omitted
	(19.0)	
$AGE50\_60_{it}$	-331.7***	omitted
	(22.9)	
$AGE60\_70_{it}$	225.1***	omitted
	(33.1)	
$AGE70_{it}$	495.9***	omitted
	(38.2)	
$WEAK\_INCR_{it}$	91.4***	75.6**
	(24.9)	(28.8)
$WEAK\_DECL_{it}$	287.6***	253.1***
	(23.9)	(27.5)
$STRONG\_DECL_{it}$	102.0**	90.7**
	(30.0)	(33.9)
$NEGATIVE\_EQ_{it}$	-1332.2***	-11.2
	(23.7)	(38.3)
$SOURCE_{it}{}^{+}$		
entrepreneurship	-319.6***	325.9**
	(16.4)	(56.1)
controls	YES	YES
year dummies	YES	YES
R-squared (within for FE)	0.0191	0.0160
N	9,937,039	9,937,039

significance: * p<0.05; ** p<0.01; *** p<0.001.

[+] labour base category

Table 11: OLS and FE regressions home improvements (standard errors adjusted for household clusters in parentheses)

dependent variable: ΔS_{ilt}	**OLS (5)**	**FE (5)**
ΔH_{ilt}	-235.3***	-118.3***
	(5.7)	(6.5)
$\Delta H_{ilt} \times AGE_{it}$	5.1***	2.8***
	(0.1)	(0.1)
$\Delta H_{ilt} \times DECLINE_{it}$	-18.8***	-13.0**
	(3.4)	(4.5)
$\Delta H_{ilt} \times NEGATIVE\_EQ_{it}$	-69.9***	-39.4***
	(4.1)	(4.6)
$\Delta H_{ilt} \times ENTREPRENEUR_{it}$	110.1***	109.6***
	(4.8)	(5.2)
controls	YES	YES
year dummies	YES	YES
R-squared (within for FE)	0.0027	0.0030
N	9,937,039	9,937,039

significance: * p<0.05; ** p<0.01; *** p<0.001.

Table 12: OLS and FE regressions unexpected price changes (standard errors adjusted for household clusters in parentheses)

	AR(1) – OLS	**AR(2) – OLS**	**AR(1) – FE**	**AR(2) – FE**
ΔH_{it}	-0.0425***	-0.0558***	-0.0302***	-0.0399***
	(0.0015)	(0.0020)	(0.0016)	(0.0022)
$\Delta H_{it} \times AGE_{it}$	0.0006***	0.0008***	0.0004***	0.0006***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$\Delta H_{it} \times DECLINE_{it}$	0.0184***	0.0190***	0.0100***	0.0100***
	(0.0009)	(0.0011)	(0.0011)	(0.0014)
$\Delta H_{it} \times NEGATIVE\_EQ_{it}$	-0.0098***	-0.0093***	-0.0049**	-0.0045*
	(0.0013)	(0.0018)	(0.0015)	(0.0021)
$\Delta H_{it} \times ENTREPRENEUR_{it}$	0.0073***	0.0100***	0.0061***	0.0079***
	(0.0008)	(0.0010)	(0.0009)	(0.0012)
controls	YES	YES	YES	YES
year dummies	YES	YES	YES	YES
R-squared (within for FE)	0.0188	0.0195	0.0159	0.0169
N	9,937,039	7,949,560	9,937,039	7,949,560

significance: * p<0.05; ** p<0.01; *** p<0.001

Table 13: OLS regressions consumption (standard errors adjusted for household clusters in parentheses)

	$\Delta C1$	$\Delta C2$	$\Delta C3$	ΔS
ΔH_{it}	0.0239***	0.0248***	0.0346*	-0.0438***
	(0.0040)	(0.0043)	(0.0170)	(0.0022)
$\Delta H_{it} \times AGE_{it}$	-0.0005***	-0.0004***	-0.0007*	0.0005***
	(0.0001)	(0.0001)	(0.0003)	(0.0000)
$\Delta H_{it} \times DECLINE_{it}$	0.0199***	0.0127**	0.0169	0.0205***
	(0.0024)	(0.0044)	(0.0094)	(0.0013)
$\Delta H_{it} \times NEGATIVE\_EQ_{it}$	0.0099*	0.0107**	0.0553	-0.0115***
	(0.0039)	(0.0040)	(0.0396)	(0.0022)
$\Delta H_{it} \times ENTREPRENEUR_{it}$	0.0005	0.0023	0.0076	0.0099***
	(0.0027)	(0.0029)	(0.0075)	(0.0013)
controls	YES	YES	YES	YES
year dummies	YES	YES	YES	YES
R-squared (within for FE)	0.0278	0.0134	0.0007	0.0173
N	4,394,255	4,394,255	4,394,255	4,394,259

significance: * p<0.05; ** p<0.01; *** p<0.001

Table 14: OLS and FE regression results (standard errors adjusted for household clusters in parentheses)

dependent variable: ΔS_{it}	**OLS (6)**	**FE (6)**
ΔH_{it}	-0.0369*	-0.0181
	(0.0177)	(0.0208)
$\Delta H_{it} \times AGE_{it}$	0.0006*	0.0004
	(0.0002)	(0.0003)
$\Delta H_{it} \times DECLINE_{it}$	0.0261**	0.0179
	(0.0090)	(0.0114)
$\Delta H_{it} \times NEGATIVE\_EQ_{it}$	-0.0264	-0.0353
	(0.0227)	(0.0298)
$\Delta H_{it} \times ENTREPRENEUR_{it}$	0.0010	-0.0044
	(0.0075)	(0.0088)
AGE_{it}	-16.5**	omitted
	(4.6)	
$DECLINE_{it}$	247.6	302.3
	(137.0)	(165.3)
$NEGATIVE\_EQ_{it}$	-1514.8***	388.2*
	(59.8)	(173.9)
$SOURCE_{it}{}^{+}$		
entrepreneurship	-111.8	938.3**
	(89.6)	(280.4)
controls	YES	YES
year dummies	YES	YES
R-squared (within for FE)	0.0046	0.0033
N	10,783,403	10,783,403

significance: * p<0.05; ** p<0.01; *** p<0.001.

+ labour base category

Appendix C - Figures

Figure C1: histogram ΔS_{it}

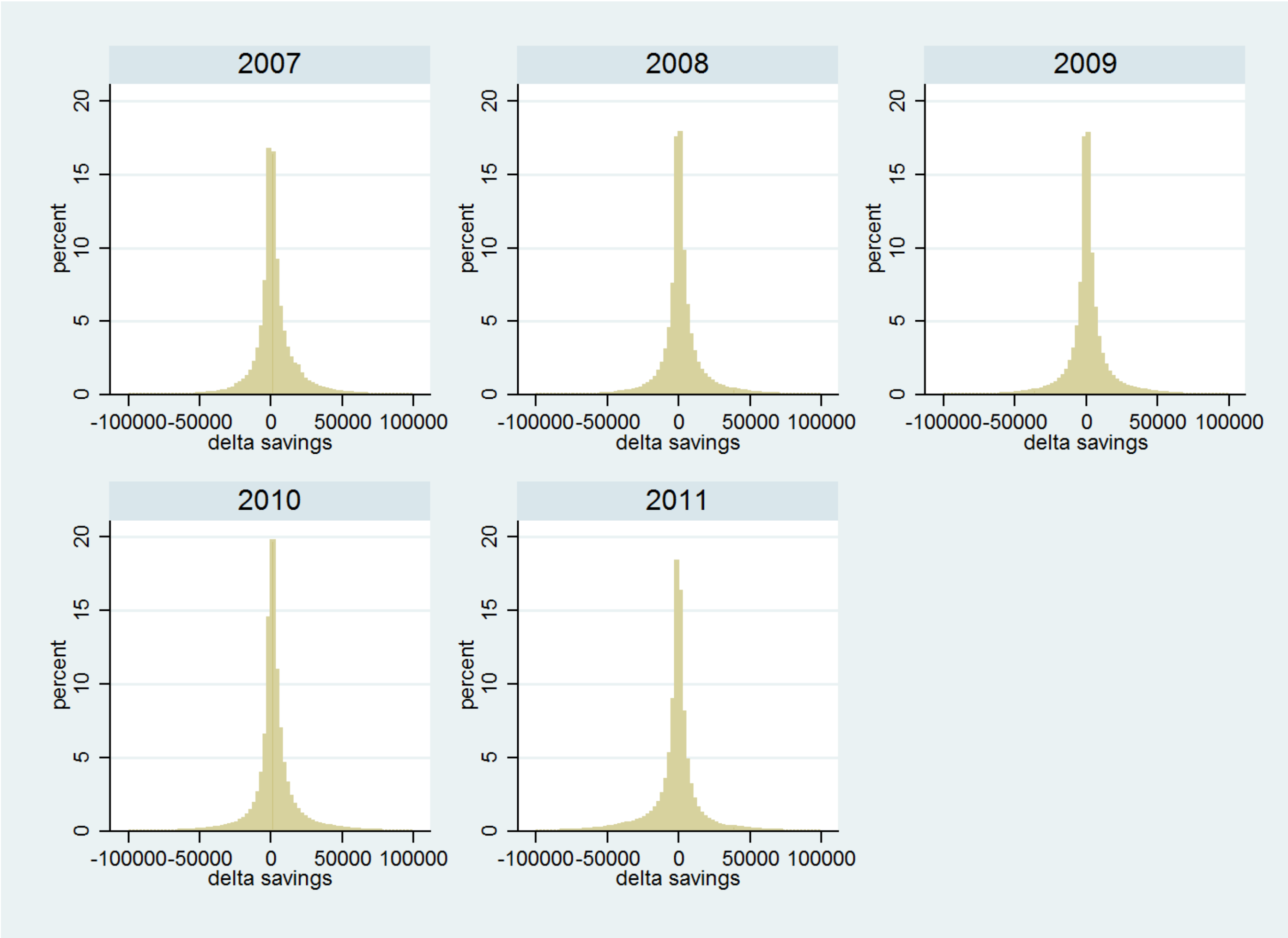


Figure C2: histogram $\Delta S_{it} + PAYOFFS_{it}$

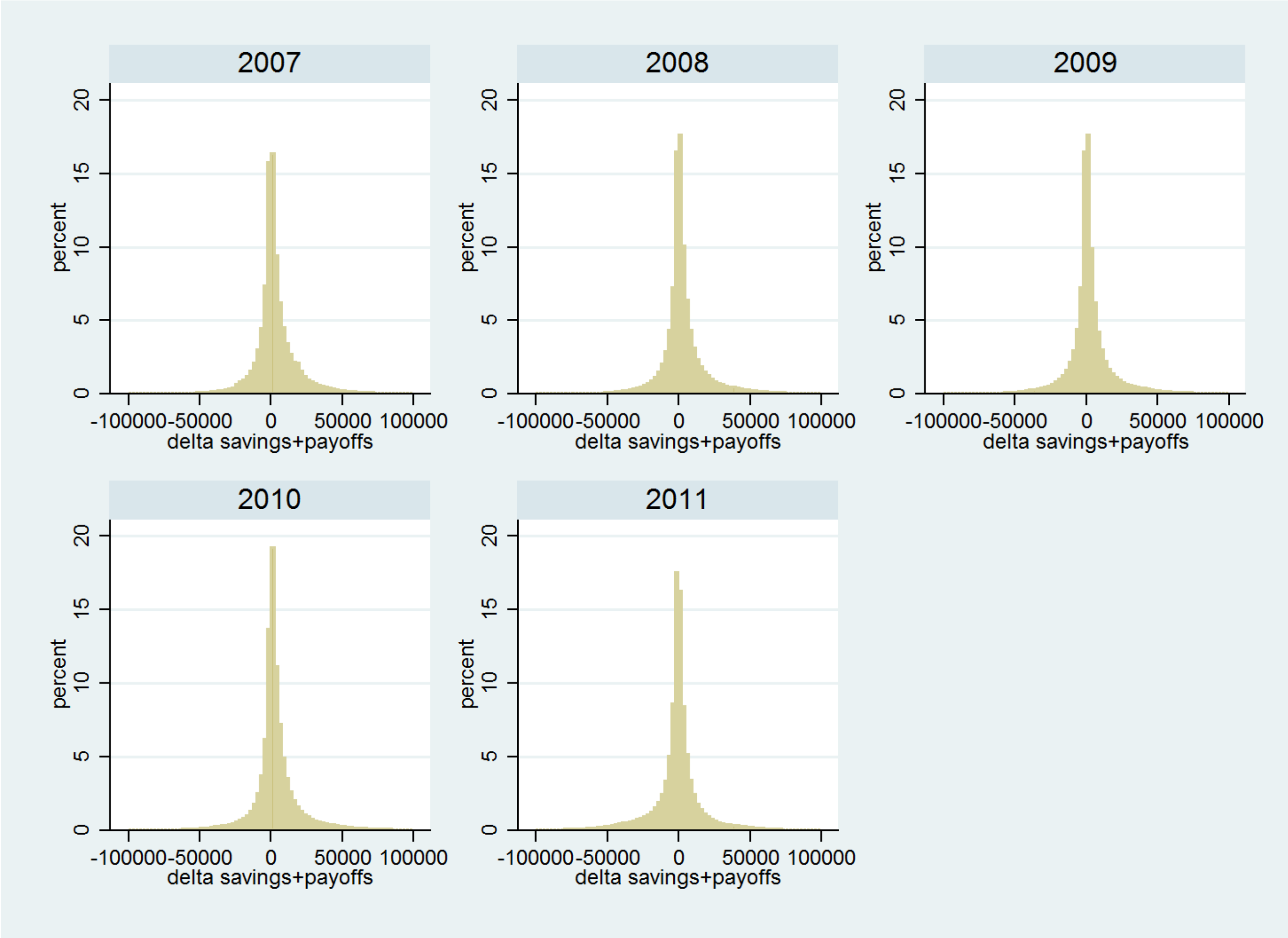
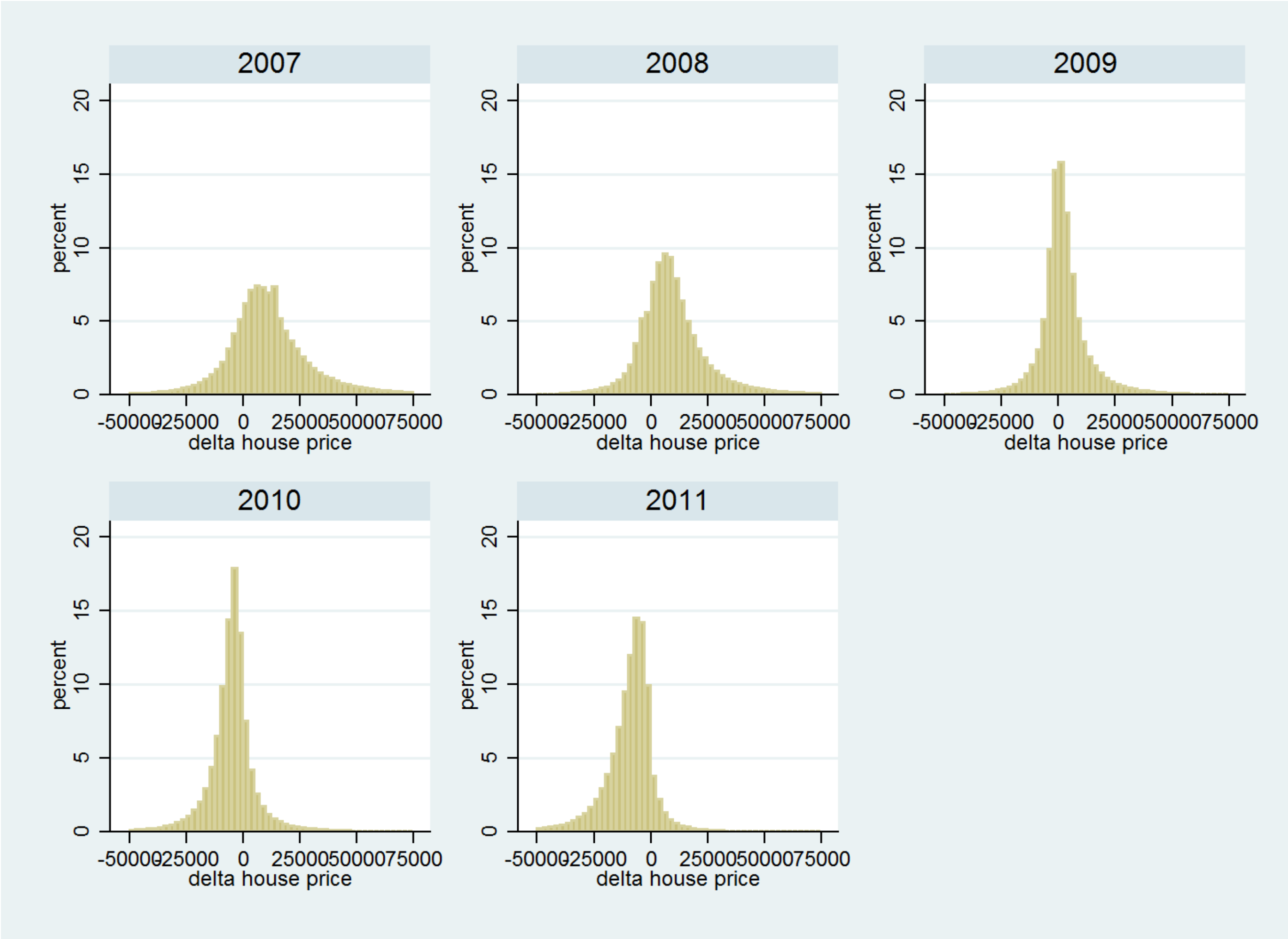


Figure C3: histogram ΔH_{it}



Appendix D - Overview housing effects selected studies

Table D1: studies overview

	Dependent variable	Effect of housing wealth on consumption/savings		Channel
		Average effect	*Effects of sub-groups*	
Studies using survey data				
Campbell and Cocco (2005)	Consumption	MPC between 0.04 and 0.08	• old homeowners: MPC of 0.107 • young homeowners: MPC of 0.050 • old renters: MPC of 0.048 • (no effect for young renters)	Wealth effect
Lehnert (2004)	Consumption	MPC between 0.019 and 0.031	• ages 25-34: MPC of 0.025-0.039 • ages 52-62: MPC of 0.022-0.039 • ages 43-51: MPC of 0.020-0.035 • ages 63-95: MPC of 0.020-0.026 • (no effect for ages 35-42)	Collateral and wealth effect
Skinner (1996)	Active saving	MPS of -0.01	• Effect for households under 45 years facing a wealth loss: MPS of - 0.1 • (no effect for wealth gains or for older households)	Wealth effect
Engelhardt (1996)	Active saving	mean saver: MPS of -0.14 median saver: MPS of -0.03	• Effect for wealth loss: MPS of -0.35 for the median saver • (no effect for wealth gains)	Wealth effect
Disney et al. (2010)	Active saving	MPC of 0.01	• positive equity and wealth gain: MPC of 0.017 • negative equity and wealth gain: MPC of 0.126 • (no significant differences for wealth loss)	Collateral effect
Studies using administrative data				
Mian et al. (2013)	Consumption	MPC between 0.05 and 0.07	• MPC low income three times as large as for richest households • MPC for zip codes with >50% negative housing equity five times as large	Collateral effect
Browning et al. (2013)	Consumption	no effect	• Young households with low liquidity: MPC of 0.05 • (no effect for other subgroups)	Collateral effect

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CPB Netherlands Bureau for Economic Policy Analysis
P.O. Box 80510 | 2508 GM The Hague
T (070) 3383 380

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