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Søren Leth-Petersen

Henrik Yde Andersen

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University of Copenhagen
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Housing Wealth or Collateral:

How Home Value Shocks Drive Home Equity Extraction and Spending*

Henrik Yde Andersen† and Søren Leth-Petersen‡

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†Danmarks Nationalbank. Email: hya@nationalbanken.dk

‡University of Copenhagen, Department of Economics, Øster Farimagsgade 5, 1353 Copenhagen, Denmark, CEBI, Center for Economic Behavior and Inequality, and CEPR. Email: soren.leth-petersen@econ.ku.dk

Abstract

We examine whether unanticipated changes in home values drive spending and mortgage-based equity extraction. To do this we use longitudinal survey data with subjective information about current and expected future home values to calculate unanticipated home value changes. We link this information at the individual level to high quality administrative records containing information about mortgage borrowing as well as savings in various financial instruments. We find that the marginal propensity to increase mortgage debt is 3-5% of unanticipated home value gains. We find no adjustment to other components of the portfolio, and we find that mortgage extraction leads to an increase in spending. The effect is driven by young households with high loan-to-value ratios which is consistent with the effect being driven by collateral constraints. Further, we find that the effect is driven by home owners who actively take out a new mortgage. The price effect is magnified among FRM borrowers who have an incentive to refinance their loans to lock in a lower market rate. These results point to the importance of the mortgage market in transforming price increases into spending and suggest that monetary policy can play an important role in transforming housing wealth gains into spending by affecting interest rates on mortgage loans.

1 Introduction

The financial crisis made it clear that the mortgage market and housing equity extraction play critical roles in creating a link between housing wealth and spending. However, the evidence about the mechanisms through which house prices drive equity extraction and spending is limited, despite its importance for policy. In this paper we examine whether there is a housing wealth effect and what role the mortgage market may play in facilitating a link between home values and spending.

The wealth effect is theoretically pinned to the notion of unanticipated shocks. The life cycle framework predicts that if agents are forward looking and unconstrained, then their consumption should respond to unpredictable movements in home values. The objective of this study is to provide a clean test of the housing wealth hypothesis, i.e., whether individual agents respond to unanticipated changes in the price of their home by adjusting spending in the same direction, against the alternative hypothesis that the correlation between home values and spending is driven by incresed access to collateral.

Identifying unexpected movements in home values is fundamentally a matter of how subjective expectations about home values align with realizations. To perform a test of the housing wealth hypothesis we use Danish longitudinal data with *subjective* information about current and expected future home values collected using probabilistic survey questions, as proposed by Manski (2004). Using this information, it is possible to calculate unanticipated home value changes that do not rely on parametric assumptions about the formation of expectations. In this sense our data documents exactly what home owners believe about their wealth and not what the econometrician believes. Exploiting the unique Danish research data infrastructure, the subjective information about home values is linked to high quality third party reported administrative records with information about savings in bank accounts and in financial assets, such as stocks and bonds, as well as information about bank and

credit card debt. Finally, we link this information to administrative data obtained directly from mortgage banks which contain detailed information about mortgage debt and the timing of refinancing decisions. These data make it possible to regress mortgage debt and spending adjustments as well as savings in different types of assets and liabilities on direct measures of anticipated and unanticipated innovations to home values. This setup enables us to design a test of the housing wealth hypothesis that is close in spirit to the notion of a wealth effect as it derives from the life cycle framework.

We find that an unanticipated gain in housing wealth leads people to take up more mortgage debt, and we find no effect on other components of the portfolio. Overall, an unanticipated increase in housing wealth leads to an increase in mortgage extraction and spending of 3-5% of the unanticipated home value gain. We find no effect of negative shocks, i.e., the effect is asymmetrically related to positive and negative shocks. We test for the importance of collateral constraints by splitting the sample according to the level of the ex ante loan-to-value (LTV) ratio as well as by the age of the home owner. We find that unanticipated price increases are correlated with mortgage extraction and spending increases for young home owners with high LTV ratios, suggesting that the collateral effect is driving the overall correlation between home values, mortgage extraction and spending. Prior studies have pointed to the possibility that income expectations can confound the wealth effect because they potentially drive both house prices and spending. Using subjective data on expectations about income we find that it is important to control for anticipated income losses, but that unanticipated increases in home values also predict mortgage extraction and spending when controlling for this factor.

The response to unanticipated gains in housing wealth is driven by about 12% of the observations where the respondent is recorded as having actively taken out a new mortgage. When we zoom in on this group, we find that more than half of these hold a fixed rate mortgage (FRM). As in the US, FRMs are important in Denmark and the

mortgage system enables borrowers to refinance to lock in lower market rates. Danish mortgage banks advise their customers that it is potentially profitable to refinance an existing FRM loan when the market rate has dropped significantly relative to the coupon rate on the existing FRM loan, provided that the existing loan has a certain volume and that there is sufficient time until maturity. Rules of this type can be viewed as an approximation of the optimal refinancing rule developed by Agarwal et al. (2013).[1] Based on the mortgage data we are able to apply such a rule-of-thumb to categorize the FRM borrowers in our data according to whether or not it is potentially profitable to refinance in order to lock in a lower market rate. To the extent that future market interest rate developments are unpredictable at the point of loan origination, the incentive to refinance is quasi-randomly assigned to borrowers. We find that FRM borrowers with an incentive to refinance and who, at the same time, experience an unanticipated price gain, extract equity at a higher rate than owners who experience an unanticipated price gain without having an incentive to refinance. In this way, the effect of unanticipated home value gains on spending is amplified by falling market interest rates. Our findings complement a recent line of papers showing that mortgage rates are important for the transmission of monetary policy.[2] In particular, our results resonate with the findings of Bhutta and Keys (2016) who show that a drop in mortgage interest rates stimulates equity extraction and that house price growth further amplifies the relationship. Our study stand out by showing, in detail, how the mortgage market works together with unanticipated price gains in causing spending adjustments. This result suggests that monetary policy can affect private spending when the mortgage system makes it possible for FRM borrowers to actively lock in lower market interest rates and extract equity when housing wealth increases unexpectedly.

[1] There is empirical evidence that mortgage borrowers do not follow such an optimal refinancing rule exactly (Agarwal et al., 2015).

[2] See for example Agarwal et al. (2017), Berger et al. (2019), Cloyne et al. (2019), Di Maggio et al. (2017), and Wong (2019).

Our study feeds into a sizable literature that has debated the relevance of three different explanations for the association between housing wealth and spending. One explanation for the correlation is *the housing wealth hypothesis*. Campbell and Cocco (2007), Muellbauer (1990), Skinner (1996), among many others, find support for this hypothesis.[3] An alternative hypothesis is that home value gains generate additional collateral which households can borrow against. According to the *collateral channel hypothesis,* increases in home values loosen the collateral constraint thus opening up for additional borrowing that can be used to finance spending. We denote this channel the collateral effect. Agarwal and Qian (2017), Aron and Muellbauer (2013), Aladangady (2017), Browning et al. (2013), Cooper (2013), Disney and Gathergood (2011), and Leth-Petersen (2010) find evidence in support of this hypothesis. A third hypothesis, *the common factor hypothesis*, postulates that house prices and spending are driven by a third variable causing both house prices and spending. According to this idea, expected income changes, or a general easing of credit availability, could drive demand, which then drives both house prices and spending. This idea was proposed by King (1990) and Paganao (1990) as a response to the findings of Muellbauer (1990). Attansio and Weber (1994), Attanasio et al. (2009), and Windsor et al. (2015) find evidence in support of this hypothesis.[4]

Recently, this debate has gained new momentum in the context of trying to understand the causes and consequences of the US housing collapse and mortgage crisis. Mian and Sufi (2011) and Bhutta and Keys (2016) document how house prices drive housing equity extraction among younger home owners and that this is associated with a subsequent increase in loan defaults, indicating that housing equity was ex-

[3]The evidence is mixed, however. Engelhardt (1996), using the PSID, does not find any effect of capital gains on consumption. Hoynes and McFadden (1997) are not able to find any link between saving and capital gains on housing. Juster et al. (2006) find no evidence that capital gains in housing influence savings decisions.

[4]There is literature estimating propensities to spend out of housing wealth based on aggregate data, e.g., Slacalek (2009), Caroll et al. (2011), Case et al. (2005). However, discriminating between the underlying hypotheses requires micro level data that can accurately describe the heterogeneity of expectations and credit access and other consumer characteristics.

tracted for spending rather than kept for bad times. Mian et al. (2013) argue that the wealth loss associated with the housing collapse following the recent financial crisis is responsible for the significant coinciding spending decline, and that credit conditions played a critical role because the house price fall limited access to collateral for people who were already highly leveraged. However, these findings do not stand uncontested. Davidoff (2016) argues that local demand factors are responsible for the severity of house price cycles. Adelino et al. (2016) show that mortgage originations increased for borrowers across all income and FICO score levels and that the relation between mortgage growth and income growth at the individual level remained positive during the boom, which is consistent with a general expansion of mortgage credit rather than an expansion driven by people who are likely to be constrained. Foote et al. (2016) show that mortgage debt growth in the early 2000s and subsequent defaults happened throughout the income distribution. They conclude that this is not consistent with borrowing constraints but rather with the wealth hypothesis where the causality runs from house prices, or house-price expectations, to the accumulation of mortgage debt. In other words, the US crisis literature effectively debates the importance of the same three hypotheses. However, the literature concerned with the US housing collapse and mortgage crisis has drawn attention to the critical importance of the mortgage market for understanding the link between house prices and spending.

We contribute to the literature in several ways, and the contribution is facilitated by several unique features of our data. First, our new data allows us to consider both mortgage extraction as well as adjustments to the balance sheet and spending. In particular, we exploit detailed longitudinal mortgage records to document the key role of the mortgage market, and because the data cover the entire budget constraint, it is also possible to measure the effect of unanticipated shocks on other parts of the portfolio as well as on total spending. This is in contrast to most studies, which typically only observe mortgage debt (e.g. Bhutta and Keys, 2016), or spending (e.g. Campbell and Cocco, 2007). Second, the availability of subjective expectations data

about home values and income make it possible to perform a clean test of the housing wealth hypothesis, while controlling for the productivity hypothesis, without making parametric assumptions about how expectations are formed. In this way we provide a test that is close to the spirit of the theory. A few other papers have attempted to separate anticipated and unanticipated gains in housing wealth, but these studies typically have to make strong assumptions about the formation of expectations. Some studies estimate statistical models for house prices, as in Campbell and Cocco (2007), Disney et al. (2010), and Browning, Gørtz and Leth-Petersen (2013), but identification in these models essentially hinges on the parametric assumptions in the specification of the price process, and these are typically strong.[5] Paiella and Pistaferri (2017) use subjective asset price expectations to derive unanticipated asset price innovations for a sample of households in the Italian SHIW. However, the focus of their study is on measuring the effect of shocks to different asset prices and not on the role of mortgage-based housing equity extraction. Further, an important feature of our data is that it contains well-measured indicators of credit constraints, including the loan-to-home value ratio and holdings of liquid assets, and this allows us to undertake tests for the importance of collateral and liquidity constraints. We are thus able to provide a strong test of the housing wealth hypothesis while controlling for the two leading alternative explanations, the collateral hypothesis and the common factor hypothesis, as an explanation for the existence of the correlation between the value of the home, mortgage extraction, and spending, while imposing minimal parametric assumptions. Another advantage of combining data from survey and administrative sources is that it ensures that idiosyncratic response biases are not systematically driving both the information about shocks and about savings behavior. Finally, the combined data set is longitudinal in nature, i.e., it includes repeated in-

[5] That parametric specifications have important implications for the outcome is emphasized in an important paper by Cristini and Sevilla Sanz (2014). They replicate the studies by Campbell and Cocco (2007) and Attanasio et al. (2009), who use the same data but reach different conclusions, and find that the two studies reach different conclusions because they use different specifications.

formation about unanticipated changes in home values and incomes as well as savings and spending data for the individuals in our sample. This allows us to examine the dynamic response to unanticipated gains and losses in home values, and we exploit this to show that the spending effect is likely concentrated on durable spending. Furthermore, the longitudinal dimension permits us to examine whether unanticipated changes and the associated responses are tied to individuals with particular fixed unobserved characteristics. This turns out not to be the case, suggesting that personal traits, such as preferences, personality or other stable characteristics, are not driving the response to the unanticipated housing wealth gains. A final advantage is that our data set is relatively large compared to other data sets that include subjective information. This allows us to document the effects non-parametrically and to illustrate graphically how unanticipated price changes factor into spending and saving decisions, thus documenting the responses with a high degree of transparency.

The next section presents the institutional context. After that the empirical model is outlined and the data presented. Results are presented in section 5. We start out presenting graphical bivariate evidence that unanticipated changes in home values drive debt accumulation and spending. We then move on to the multivariate analysis and estimate the housing wealth effect while controlling for competing explanations. Finally, we explore the importance of mortgage refinancing to lock in lower interest rates. The final section sums up and concludes.

2 Institutional context

As in many developed economies, home owners in Denmark experienced dramatic changes in house prices in the 2000s. Prices increased by more than 60% on average, during the run-up from 2003-2007, then plummeted in 2008-2010, and remained stable over the rest of the period. This pattern is shown in Figure 1, panel a, which also shows aggregate spending from the national account statistics. The figure documents the well-established fact that house prices and aggregate spending move together. Figure

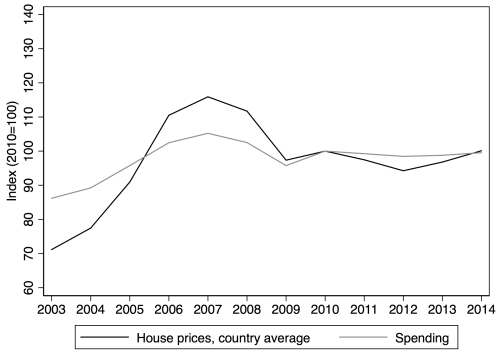
1, panel b, displays indices for prices for five selected regions in Denmark and it shows that prices developed very differently across the country over the period. In this study we analyze data collected over the period 2011-2014, and even in this period, where the overall price level was quite stable, prices developed quite differently across the regions shown in the figure, illustrating that there is, in fact, a lot of heterogeneity in how prices developed across the country. Later, we make use of individual level assessments of home values, which allows for very local price dynamics, and this increases the potential for heterogenous price dynamics even further.

More than half of the adult population in Denmark are home owners at any given point in time, and many more are home owners at some point during their life time. Only a relatively small fraction directly holds financial assets such as stocks and bonds, and even for owners of such financial assets, the value of these assets constitutes a relatively small fraction of total assets. For most home owners the housing asset and the mortgage make up the two dominant portfolio components. Housing is financed primarily through mortgage banks, which are financial intermediaries specialized in the provision of mortgage loans. When granting a mortgage loan for a home in Denmark, the mortgage bank issues bonds that are sold on the stock exchange to investors. A basic principle underlying the design of the Danish mortgage market is the balance-principle, whereby total payments from the borrower and total payments from mortgage banks to mortgage bond holders must balance. Once the bank has screened potential borrowers based on the valuation of their property at the time of the loan origination and on their ability to service the loan, i.e., their income, all borrowers who are granted a loan of a given type at a given point in time face the same interest rate, which is determined by the market.

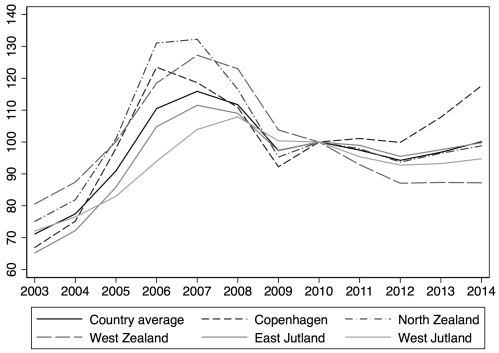
Mortgage banks offer both fixed rate and adjustable rate loans. Loans can be of varying maturity up to 30 years, and they can be issued up to a legally defined threshold of 80% of the value of the home at loan origination. A significant fraction of mortgage loans are fixed rate, and this is also the case in the sample analyzed here.

Figure 1: House Prices and Spending

(a)



(b)



Notes: Panel a shows the evolution of house prices and household sector spending in fixed prices. Panel b shows the evolution of house prices in selected regions in Denmark. All series are indexed (2010=100). Sources: The Association of Danish Mortgage Banks and Statistics Denmark.

Fixed rate loans can be prepaid without penalties at face value at any time prior to maturity. In this sense the Danish mortgage market is similar to the US market, where long term fixed rate loans are also common, and refinancing is also possible (Andersen et al., 2019). The possibility of prepaying the loan at face value enables FRM borrowers to exploit changes in the market rate of interest in order to reduce the costs of funding. If the interest rate falls, an FRM borrower may prepay his loan and raise a new mortgage loan at the lower coupon rate, and this is also possible for borrowers who have a LTV ratio that exceeds 80% if the balance is not increased as a result of refinancing. This implies that refinancing activity can be quite high when the market interest rate is declining. Refinancing with cash-out, i.e., where the principal is increased, is also possible as long as the new loan is within 80% of the current value of the home. For more details about the Danish mortgage system, see Andersen et al. (2019) and Campbell (2012).

3 The empirical approach

3.1 Background and hypotheses

The wealth effect hypothesis can be motivated by the life cycle framework in which agents smooth marginal utility and make consumption and savings decisions to achieve this. We have in mind a setup where agents consume housing and non-housing goods subject to a budget constraint where spending and savings has to be balanced with incomes related to human capital and income (realized or not) from assets. Human capital and labor supply are assumed given. There are two assets, housing and a mortgage. Housing assets and the mortgage are both costly to adjust and the agent is subject to a mortgage borrowing constraint. In Denmark the borrowing limit is 80% of the value of the home at the point of loan origination. Incomes and house prices are stochastic and potentially subject to aggregate shocks. Agents are forward looking and form *subjective* expectations about these and revise their spending and

savings plan when new information about future resources arrives. Based on this framework[6] we derive the three hypotheses.

The wealth effect hypothesis. An unanticipated change in the home value can affect total life time resources, and when agents are not constrained, this can lead them to revise their consumption plans. However, when house prices change, current and future housing costs also change (Sinai and Souleles, 2005). As there are transaction costs associated with adjusting housing assets it is unclear how these two forces balance exactly, but young home owners are arguably less willing to convert a house price increase into non-housing consumption than old home owners, since young owners have more years left in the housing market. Thus, if the wealth effect is operative, one would expect it to be driven primarily by the oldest among the owners in the sample. If households are entirely unconstrained, spending adjustments related to house price changes should not impact on mortgage borrowing, and spending adjustments should be symmetric for positive and negative price changes.

The collateral hypothesis. People who are collateral constrained, i.e. who have a high Loan-to-value (LTV) ratio, experience that the LTV constraint is loosened when house prices increase (be it anticipated or unanticipated) and respond by increasing mortgage borrowing and spending. In practice, the collateral effect may not only operate when the LTV ratio is exactly 80%. Taking out a new mortgage is associated with transaction costs and home owners may be concerned that the LTV constraint will bind in the future. Consequently, the collateral constraint likely operate with decreasing intensity as we move towards lower levels of LTV. Young owners tend, on average, to have higher LTV ratios than old home owners, and we would thus expect the collateral effect to be more pronounced among the young owners. The effect should be asymmetric in price increases and price decreases. The collateral constraint is only binding at the time of loan origination, i.e. banks do not ask borrowers to pay back

[6] Attanasio et al. (2011) provides an example where such a model structure is implemented.

the loan more quickly when prices are declining. For this reason, we should expect to see an effect when prices increase, while there should not be any relationship between prices and mortgage borrowing when prices decrease.

The common factor hypothesis. House prices may increase because income is generally increasing or is expected to increase in the community. This will create a spurious correlation between house prices and spending because it is, in fact, expected income that drives the correlation. If such a common factor exists, and it drives future income, then young people will be affected by it over a longer period than old people. For example, if an aggregate shock affects current and future incomes positively, young people will have more years to reap the benefits of such increases, and we should expect to see a stronger correlation between house price changes and spending changes for young owners than for old owners. If the common factor effect is at play, it will be important to control for subjective income expectations. The common factor effect is related to aggregate shocks, and when aggregate shocks are at play, it is important to control for time effects, which are potentially specific to the location, as such effects could potentially operate with different intensities in different locations.

The role of mortgage refinancing incentives. A mortgage refinancing motive can exist for people who hold a FRM. When the market interest rate decreases, it is possible to prepay an existing FRM loan and establish a new FRM loan with a lower interest rate. If the new loan has the same size and maturity as the old loan, then refinancing can lead to lower overall payments over the duration of the loan. In the context of the life cycle framework sketched above, such a motive can exist when the mortgage interest rate is stochastic. Holding principal and duration fixed, refinancing a long-term loan brings a persistent reduction in debt service. The pure refinancing incentive should be associated with no mortgage debt growth and possibly with some spending growth due to the lower debt service. However, refinancing is associated with transaction costs, and when it is profitable to refinance, we would expect that owners

who wish to extract equity for some reason would take advantage of this window of opportunity to take out equity at the same time, thus incurring transaction costs only once. For example, home owners faced with a refinancing incentive who are ex ante LTV constrained and experience a house price increase may wish to borrow against this additional equity when refinancing to economize on transaction costs. The refinancing channel can thus reinforce the effect of home value gains if the home owner is LTV constrained.

3.2 Empirical model

The wealth effect hypothesis says that unanticipated changes in home values drive spending. The empirical strategy is to measure whether unanticipated home value changes predict spending growth while controlling for potential confounding factors related to the common factor hypothesis. We examine how the portfolio, including mortgage debt, is adjusted, and we stratify by age and LTV to sort out the importance of the collateral channel as an underlying driver of the overall correlation. Finally, we examine whether the refinancing motive is relevant.

To do this, we estimate a reduced form equation linking spending growth to unanticipated gains in home values. We follow Browning et al. (2013) and consider an empirical model relating the growth in mortgage debt and spending to expected and unexpected changes in home values and incomes:

$$\Delta c_{it} = \pi_0 + \pi_1 \theta^p_{it} + \pi_2 E_{it-1}[\Delta p_{it}] + \pi_3 \theta^y_{it} + \pi_4 E_{it-1}[\Delta y_{it}] + \mu_i + \lambda_t + \nu_{it} \qquad (1)$$

where $\pi_1, .., \pi_4$ are the parameters to estimate. $E_{it-1}[\,]$ is the expectation operator indicating individual i's expectation at period $t-1$. p_{it} is the value of the home, and y_{it} is the income of individual i at time t. $\theta^p_{it} = \Delta p_{it} - E_{it-1}[\Delta p_{it}]$ is the unanticipated change in the home value and $E_{it-1}[\Delta p_{it}]$ is the anticipated change.

Similarly, $\theta_{it}^{y} = \Delta y_{it} - E_{it-1}[\Delta y_{it}]$ is the unanticipated income change and $E_{it-1}[\Delta y_{it}]$ is the anticipated income change. Since the expectation is measured at $t-1$, the expected change in the home value and income can be re-stated as $E_{it-1}[\Delta p_{it}] = E_{it-1}[p_{it}] - p_{it-1}$ and $E_{it-1}[\Delta y_{it}] = E_{it-1}[y_{it}] - y_{it}$. μ_i is an individual level fixed effect, which is potentially correlated with the observed regressors. This allows fixed factors, such as preference parameters, to be determinants of the spending response to a change in the home value, even if we do not observe these factors. λ_t is a year fixed effect, which can be common across the sample or be specific to the municipality where the home owner lives. ν_{it} is a random error term.

Equation (1) splits price changes into expected price changes and unexpected price changes. Dividing innovations into expected and unexpected innovations increases the focus on the theory-consistent notion that household consumption should only respond to unanticipated innovations. Hence, if there is a housing wealth effect, we would expect to see that π_1 is significant. If consumers are not affected by constraints in the credit market and are able to plan freely, then we would expect that anticipated home value changes would have no impact on spending, i.e. $\pi_2 = 0$. However, if they are affected by constraints, then anticipated increases in housing wealth could potentially be driving spending. However, this may not be a very powerful test for collateral constraints because myopic behavior may lead spending to respond to predictable changes in home values even in the absence of borrowing constraints (Campbell and Cocco, 2007). Furthermore, for lifting the collateral constraint, it is not important whether the increase in the home value is anticipated or unanticipated. In order to provide a more powerful test of the collateral hypothesis we will also characterize the individuals in our sample in terms of ex ante LTV and availability of financial assets and estimate equation (1) for different subgroups defined according to these indicators of the availability of credit and liquidity. Finally, equation (1) includes anticipated and unanticipated income growth. If (local) demand factors drive income, which in turn drives both spending and home values, then (un)anticipated

income gains would be potential confounding factors that could bias the estimated effect of the unanticipated change in the home value. The income terms potentially also capture mortgage extraction that is related to using housing equity as insurance against adverse income shocks (Leth-Petersen, 2010; Hurst and Stafford, 2004). Including year fixed effects, which may be specific to the municipal level, also helps to control for common factors to the extent that these summarize shocks and revisions to expectations that are common to households in a particular municipality in a particular year.

The primary outcome is mortgage debt growth, but we will also apply equation (1) to investigate wealth accumulation through other portfolio components. This enables us to pinpoint what types of assets and liabilities are adjusted and, thereby, to learn how households manage their balance sheets following the arrival of unanticipated changes to their housing wealth. We will also take advantage of the fact that our data includes information about both income and total wealth to impute total spending, as proposed by Browning and Leth-Petersen (2003). Finally, we will consider administrative records from the tax authorities, which document tangible spending related to home maintenance. More details about these outcome variables are presented in section 4.

In order to be able to identify the causal effect of unanticipated home value changs on spending, it is necessary that the unobserved components, μ_i and ν_{it}, be uncorrelated with the explanatory variables in Equation (1). In the baseline specification we assume that μ_i is uncorrelated with the regressors in equation 1. However, μ_i could, for example, be correlated with θ^p_{it} if the magnitude of the unanticipated home value gain is systematically related to unobserved characteristics, say, preference parameters. In a robustness check we estimate the equation by standard fixed effects methods and verify that this does not appear to be the case. Consequently, the effective identifying assumption is that ν_{it} is uncorrelated with the observed variables. This assumption could, for example, be violated if θ^p_{it} is driven by sentiments such

that individuals who are generally confident about the overall development of the economy tend to have more optimistic expectations about the development of the value of their home and/or income and consequently have lower unanticipated gains. In the survey we ask respondents about such sentiments and we will include these in the regressions.

4 Data

The data used for estimating equation (1) are constructed by combining data from many different sources. The core is a longitudinal survey data set where respondents are asked about subjective expectations concerning the value of their home and income. The survey data are combined at the individual level with third-party reported administrative register data from mortgage banks and from the Danish Tax Agency (SKAT), which contain information about all assets and liabilities for the interviewed person, as well as a host of other administrative data providing background information about the respondent. Combining such high-quality data sources, made possible by our ability to link individuals across modes of data collection using the Central Person Registry number, is, to our knowledge, unique and offers several advantages.

4.1 The survey data

To collect the subjective data about price and income expectations we commissioned the survey agency Epinion A/S to conduct a telephone survey in weeks 4-9 in the years 2011-2015. Each interview lasted 10-12 minutes and covered about 40 questions, including the questions about subjective expectations about the value of their home, income, and a range of other topics. The questions about expectations were placed near the beginning of the questionnaire following questions about the financial circumstances of the respondents. We asked about expectations about the value of the home using probabilistic questions inspired by the work of Manski (2004). Specifically, we asked:

- *What is the maximum price you could get for your home one year from now?*
- *What is the minimum price you could get for your home one year from now?*

We denote the answer to the first question $E_{it-1}\left[p_{it}^{max}\right]$ and the answer to the second question $E_{it-1}\left[p_{it}^{min}\right]$. Based on the answers we calculated the midpoint $p_{it}^{mid} = \left(E_{it-1}[p_{it}^{max}] - E_{it-1}[p_{it}^{min}]\right)/2$ and then asked

- *What is the chance that your home will be worth less than p_{it}^{mid}?*

The answer to this question is denoted p_{it}^{mid}.

In order to quantify the subjective probability distribution over the home value 12 months ahead, we interpret $p_{it}^{min}, p_{it}^{mid}, p_{it}^{max}$ as points on the support of a normal cumulative distribution function and assume that $F_{it}^1 = \Phi\left(p_{it}^{min}\right) = 0.01$, $F_{it}^2 = \Phi\left(p_{it}^{mid}\right) = F_{it}^{mid}$, and $F_{it}^3 = \Phi\left(p_{it}^{max}\right) = 0.99$.[7] Following Dominitz (1997) and Manski (2004), for each observation we then estimate the mean and standard deviation of the subjective probability distribution by solving the least squares problem $\underset{\mu_{it}^p, \sigma_{it}^p}{min} \sum_{k=1}^{3} \left[F_{it}^k - \Phi\left(\left(p_{it}^k - \mu_{it}\right)/\sigma_{it}\right)\right]^2$. The expected price one year ahead is then $E_{it-1}\left[p_{it}\right] = \mu_{it}$.

In the same survey we also ask

- *How much could you sell your home for today?*

[7] We also experimented with alternative assumptions ($\Phi\left(p_{it}^{min}\right) = 0.005$,$\Phi\left(p_{it}^{max}\right) = 0.995$), and ($\Phi\left(p_{it}^{min}\right) = 0.05$,$\Phi\left(p_{it}^{max}\right) = 0.95$) but that did not change the results in any important way. Moreover, we have re-estimated the baseline specification, cf. Table 2, assuming that the subjective probability distributions are triangular and uniform. Results based on these alternative distributions are reported in the online Appendix, Tables A14-A15, and they are practically identical to the results based on the normal distribution.

Denoting the answer to this question as p_{it-1}, we can now calculate the expected change in the value of the home as $E_{it-1}[\triangle p_{it}] = E_{it-1}[p_{it}] - p_{it-1}$, which is one of the terms in equation (1). In the survey wave issued in the following year we then return to the same respondent and ask the same questions including p_{it}. With this information we can calculate the unanticipated change in the value of the home, $\theta^p_{it} = \Delta p_{it} - E_{it-1}[\Delta p_{it}]$. We also ask corresponding questions about the respondents' annual income, and equipped with this information we are able to construct all the terms pertaining to anticipated and unanticipated changes in housing wealth and income on the right hand side of equation (1).

The survey population is based on a random sample from the population of Danes who are active in the labor market. In this analysis we use survey data collected in weeks 4-9 in the period 2011-2015.[8] Each year respondents who participated in the previous year was contacted and reinterviewed. The reinterview rate was about 75%, and in each round the sample was refreshed with new randomly selected subjects.

4.2 The administrative data

We use register data made available by Statistics Denmark from three different sources. First, we use a standard battery of merged administrative register data compiled by Statistics Denmark. These data include standard demographic information, such as age, sex, education, household composition, address and moving date, and data about income and wealth collected through income-tax returns. The latter gives information about disposable income during the year and about the stock of wealth, which can be broken down into a number of subcategories. This information allows us to construct asset classes such as net bank assets, including deposits and bank loans

[8]The survey waves used in this paper are a continuation of a survey that was originally issued in week 4-9 in 2010 and based on a random sample from the Danish population of people active in the labor market. The first round of the survey, which achieved a response rate of 50%, did, however, not include questions on expectations about the home values. See Kreiner et al. (2019) for details of the original survey.

as well as any other type of loan not secured with real estate, and financial assets including the market value of stocks and bonds. Information is only provided about the market value of these financial assets, and, therefore, we are not able to trace whether movements in the total value of financial assets are related to active trading or passive movements related to capital gains. Wealth components are measured by their market value on the last day of the year. We do not observe pension wealth, but we do observe contributions to pension accounts during the year. Because these data are collected annually for the entire Danish population, they are longitudinal by nature; for this study we make use of data covering the period 2008-2014. The tax return data are known to be of high quality (Kleven et al., 2011) and have been used extensively in previous studies of savings behavior, see for example, Browning et al. (2013), Leth-Petersen (2010) and Chetty et al. (2014).

The second type of register data includes detailed information about mortgage loans. These data cover the period 2009-2014 and include information about the terms of the mortgage, i.e., the principal, the size of the outstanding debt, the coupon rate, interest rate adjustment terms and the issue and closing dates. The data also includes the LTV ratio used by the mortgage banks to assess whether borrowers qualify for loans. The data are collected by Finance Denmark, which is the business association for (mortgage) banks in Denmark. They cover the five largest mortgage banks representing a total market share of 94.2% (Andersen et al., 2019). In combination with the income-tax return data, we then have an almost complete picture of the balance sheet for all individuals in the Danish population.[9]

Spending is not recorded in administrative data, but we construct a measure of total spending, c_{it}, by subtracting from disposable income, y_{it}, the value of net savings and pension contributions, i.e., $c_{it} = y_{it} - S_{it} - \triangle W_{it}$, where S_{it} is pension contributions and $\triangle W_{it}$ is the change in net wealth from period $t-1$ to t. The main

[9]We do not have information about informal borrowing and transfers outside the formal banking system, and we do not have information about high value items such as paintings and boats.

challenge is that the imputation counts capital gains on stocks and bonds as savings and this can potentially misrepresent actual spending decisions. In a robustness check we show that this is not important in the current analysis. The imputation was proposed by Browning and Leth-Petersen (2003) who showed that, while noisy, it performs well in terms of matching the individual level expenditures in the Danish Expenditure Survey[10], and it has been applied by Browning et al. (2013) and Leth-Petersen (2010) among others.

Besides the data described above, we have obtained data from the tax authorities about tax deductions for home maintenance and improvements (henceforth, home improvements), which is a subcomponent of total spending. Since 2011 it has been possible to make tax deductions for expenditure related to home improvements, as well as expenditure for cleaning and housing services. The scheme only covers expenditure related to the labor input (not materials), and it is possible to deduct up to 15,000 DKK (1USD$\simeq$7DKK) per year. To get the deduction, receipts with information about the identity of the provider have to be uploaded to the tax authorities through a dedicated internet page, and it is the data collected here that we have gained access to directly from the tax authorities. These data provide the basis for actual tax subsidies and are audited. We will use these data to complement the data with information about total spending by documenting one specific type of tangible spending.

4.3 The combined data

Estimation of (1) relies critically on data where the timing of the measurement is accurate. The administrative register data are summarized at the end of the year and the survey data are collected in the beginning of the year. The survey period was

[10]Browning and Leth-Petersen (2003) examine the quality of the imputation using data drawn from the Danish Family Expenditure Survey (DES) for the years 1994–1996. The DES gives diary and interview-based information on expenditure on all goods and services, which can then be aggregated to give total expenditure in a sub-period within the calendar year for each household in the survey. The households in the DES can be linked to their administrative income/wealth tax records for the years around their survey year, making it possible to directly check the reliability of the imputation against the self-reported total expenditure measure at the household level.

chosen to match the timing of the measurement of the administrative data as closely as possible. For example, the unanticipated change in the value of the home recorded for a given respondent in 2012 is $\theta^p_{i2012} = p_{i2012} - p_{i2011} - (E_{i2011}[p_{i2012}] - p_{i2011})$. p_{i2012} is collected in the survey in week 4-9 of 2013, p_{i2011} in week 4-9 of 2012, and $E_{i2011}[p_{i2012}]$ in week 4-9 in 2011. θ^p_{i2012} thus pertains to the end of 2012 which corresponds closely to the timing of $\triangle c_{i2012} = c_{i2012} - c_{i2011}$, where c_{i2012} is summarized at the end of 2012. Since the survey was issued in 2011-2015, we are able to construct up to four consecutive terms summarizing the unanticipated home value change for an individual who participated in all survey rounds.

An advantage of the combined administrative and survey data is that they do not suffer from the same types of measurement errors. Throughout we use the subjective data to construct the terms on the right hand side of equation (1) and the objective third party reported data to construct the outcomes, i.e., the left hand side of equation (1). In this way we are sure that idiosyncratic measurement errors related to the survey are not systematically driving both the left and the right hand side of the equation, a point formalized by Kreiner et al. (2015).

For carrying out the analyses we make a few sample selections. First, we only include observations for which we can identify the right hand side variables in equation (1), i.e., cases where we have answers from at least two consecutive survey waves. Second, we use only observations for home owners. This is because we only have subjective information about home values for home owners. Third, we omit people who are self-employed. This is because the administrative wealth information does not separate business wealth and private wealth. Fourth, we omit observations for individuals who moved during the sample period.[11] We do this because the change in value of the home now includes an adjustment to the home value that is the result of an active choice, thus obstructing the identification of passive movements in the value

[11]The moving rate is 4.3%. The moving rate in the general population is 15-16%. However, the moving rate for the general population of home owners is 4-5%.

of the home. As a result, we are left with 12,949 observations for 5,353 individuals.

Table 1 presents summary statistics for the sample. The sample includes people aged 21 to 73, and, on average, the respondent is 52 years old. The respondents are all home owners and the average level of pre-tax income is about 400,000 DKK, which is above the average of the population in total, but matches the average among home owners in the population.[12] The average respondent holds a simple portfolio, which is dominated by the home and the associated mortgage. Typically, the respondent holds a very small amount of money in deposit accounts, and a limited amount in financial assets. In fact, 43% of respondents have liquid wealth corresponding to less than two month's disposable income. 60% hold no financial wealth, i.e., stocks or bonds, at all, and, conditional on having financial wealth, about half hold financial wealth worth less than 10% of annual income (not reported). 73% have a mortgage, and the average LTV is about 49%, and among mortgage holders, about half have a FRM.

Income and wealth levels differ across respondents. In order to get measures that are relative to the scale of each individual's financial position, we normalize variables on both the left and the right hand-sides of (1) by the average of the individual's incomes as measured in the administrative data over the period 2008-2010. To reduce the influence of outliers, we censor all non-categorial variables at the 2nd and the 98th percentile of their distributions year-by-year. In our reference setup we analyze how individual level outcomes are related to unanticipated shocks. We do this because the survey is administered to individuals and the survey questions literally ask the respondent to state his/her home value and income. However, many of the decisions arguably relate to household level decisions, and we will therefore return to this and present robustness analyses that consider outcomes calculated at the household level.

[12] We also know the identity of the non-respondents. In the online Appendix, Table A1, we compare the characteristics of the respondents and the non-respondents based on information available in the administrative records. Non-respondents tend to be slightly younger, have slightly more expensive homes and more mortgage debt. However, in terms of demographics and income, the differences are small, and overall, the respondents look quite similar to the non-respondents.

Table 1: Summary Statistics

	Mean	SD	p25	p50	p75
Female (%)	47.6	49.9			
Age	51.9	10.8	44.0	53.0	61.0
Single (%)	13.5	34.1			
Gross Income	392.4	179.3	278.1	365.5	469.1
Bank Deposits (net)	5.6	300.4	-129.2	11.9	124.8
Has Low Liquid Wealth (%)	43.2	49.5			
Financial Wealth	70.2	208.9	0.0	0.0	14.3
Has No Financial Wealth (%)	60.5	48.9			
Housing Wealth	1,043.5	915.2	485.0	880.0	1,400.0
Mortgage Loan to Home Value, LTV (%)	49.4	34.4	17.8	53.8	78.5
Has Mortgage (%)	73.0	44.4			
Has FRM (if have mortgage) (%)	48.0	50.0			
Number of observations			12,949		

Notes: Monetary variables are reported in 1,000 DKK. 'Low liquid wealth' is a dummy variable taking the value 1 when the respondent starts the period with liquid wealth worth less than two month's of disposable income. 'No financial wealth' is a dummy variable taking the value 1 if the respondent does not hold stocks or bonds.

5 Results

In this section we present results from estimating the response to unanticipated changes in home values on mortgage extraction, savings and spending decisions. We start by presenting graphical evidence characterizing the anticipated and unanticipated home value changes and how they are correlated with the main outcome variables. After that, the multivariate analyses are presented.

5.1 Descriptive analysis

Individual expectations about future home values are very heterogenous. This could reflect that prices develop very differently across locations or that respondents have little sense of how house prices in their area will develop. In order to examine whether respondents' expectations about their future home values have any relation to how prices have actually developed when we ask them about this one year later, we present, in panel a of Figure 2, a binned scatterplot of stated home values at *t*, p_{it}, against expected home values at *t-1*, $E_{t-1}[p_{it}]$. The figure shows that respondents' expectations accurately capture stated home values one year later.[13] Panel b of Figure 2 presents a histogram of the unanticipated home value change, $\theta_{it}^{P} = p_{it} - E_{t-1}[p_{it}]$, and it shows that, at the individual level, expectations about home values stated in $t-1$ do not align perfectly with actual home values as perceived one year later. In terms of testing the wealth effect hypothesis, the theory posits that individuals make spending and savings decisions according to their subjective expectations and the

[13] According to the framework outlined in section 3.1, it is not essential that respondents perceptions' about home values line up with actual house prices. However, it is reassuring if they broadly match actual realized house prices. To verify whether this is the case, we have compared stated price changes at *t*, p_{it},with the price index obtained from the association of mortgage banks, Finance Denmark. The price index supplied by the Finance Denmark is at the municipal level. To facilitate comparison, we have aggregated changes in subjective price changes within municipalities as any particular home may follow a process that looks different from the aggregate. The result from this exercise is reported in the online Appendix, Figure A2. The two measures are proportional, and a linear regression through the data suggest that the slope of 0.99, indicating that the subjective measure, on average, match actual price increases well. As another check of the respondents' ability to give correct answers we have compared income stated in the survey to income recorded in the tax registry. For this measure there is also a very close correspondence between the stated measure and the third party reported objective measure. These results are also reported in the online Appendix, Figure A3.

associated unanticipated home value changes.

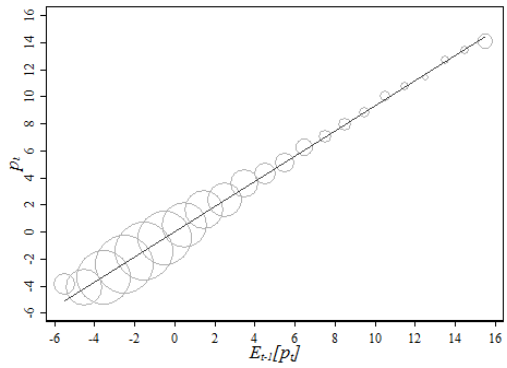
We now turn to describe how unanticipated changes in house values are related to mortgage borrowing as well as other savings and spending decisions. In Figure 3 we investigate how unanticipated house price changes are related to the accumulation of mortgage debt. The figure has unanticipated home value growth on the horizontal axis, and mortgage debt growth on the vertical axis. The relationship is shown as a binned scatterplot with a regression line fitted separately for positive and negative values of the unanticipated home value growth, θ^p_{it}. The scatters are indicated by circles scaled in size according to the number of observations in each bin. The panel shows a compelling relationship between the unanticipated home value growth and the growth of mortgage debt where positive values of the unanticipated home value growth are associated with mortgage debt growth whereas there is no systematic relationship with mortgage debt growth for negative values of θ^p_{it} .

In Figure 4 we investigate how other components of the balance sheet are adjusted. Again, the unanticipated home value growth is on the horizontal axis. Net bank asset growth (panel a) and the growth in financial assets (panel b) is on the vertical axis. Negative unanticipated gains in the home value, $\theta^p_{it} < 0$, appear to stimulate bank asset accumulation somewhat, but for positive values of $\theta^p_{it} > 0$, the relationship is not systematically increasing with the size of θ^p_{it}. Panel b of Figure 4 shows no evidence that unanticipated home value growth is systematically related to the growth in the value of the stock of financial assets.

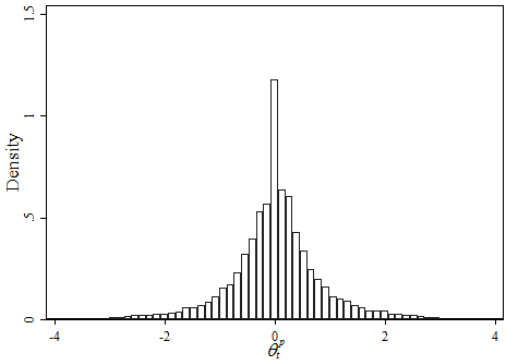
In Figure 5 we consider how two spending outcomes relate to unanticipated changes in home values. Panel a shows a binned scatterplot of spending growth against unanticipated home value changes. It illustrates that the spending growth variable is quite noisy, but the regression lines suggest that there might be a positive association between positive values of the unanticipated growth in home values and spending growth. Based on the slope of the regression line, the marginal propensity to spend out of unanticipated home value gains is about 3%. The spending increase for positive

Figure 2: The Relationship between Expected and Actual Home Values, and the Distribution of Unanticipated Changes in Home Values.

(a)

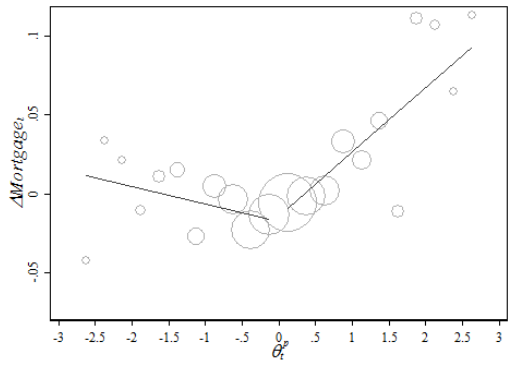


(b)



Notes: Panel a shows the relationship between stated actual home value in period t, p_{it} and expected home values at $t-1$, $E_{it-1}[p_{it}]$. Before constructing the graph p_{it} and $E_{it-1}[p_{it}]$ are regressed on year dummies, and it is the residuals from these regressions that enter the plot. The panel shows a binned scatterplot (grey circles) where the bins are defined over equal intervals of $E_{it-1}[p_{it}]$ and the size of the circles is proportional to the number of observations in the bin. A regression line (black) is overlaid. Panel b shows a histogram of unanticipated home value changes. All variables are normalized on average income during 2008-2010 and censored at the 2nd and 98th percentile of their distribution in each calendar year.

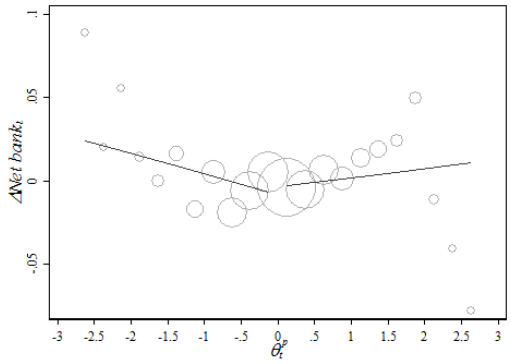
Figure 3: Unanticipated Home Value Growth and Mortgage Debt Growth



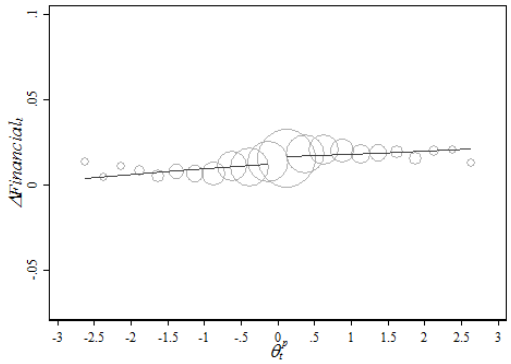
Notes: The horizontal axis shows unanticipated home value growth, θ_{it}^p. The vertical axis shows mortgage debt growth. The dependent variable is first regressed on year dummies and it is the residual from this regression that is used for constructing the panel. Mortgage debt growth is derived directly from records reported by mortgage banks. The panel shows a binned scatterplot (grey circles) where the bins are defined over equal intervals of θ_{it}^p and the size of the circles scaled by the number of observations in the bins. Regression lines weighted by number of observations are estimated separately for $\theta_{it}^p \lesseqgtr 0$ (black) and are overlaid. All variables are normalized on average income during 2008-2010 and censored at the 2nd and 98th percentile of their distribution in each calendar year.

Figure 4: Unanticipated Home Value Growth and the Accumulation of Deposits and Financial Wealth

(a)

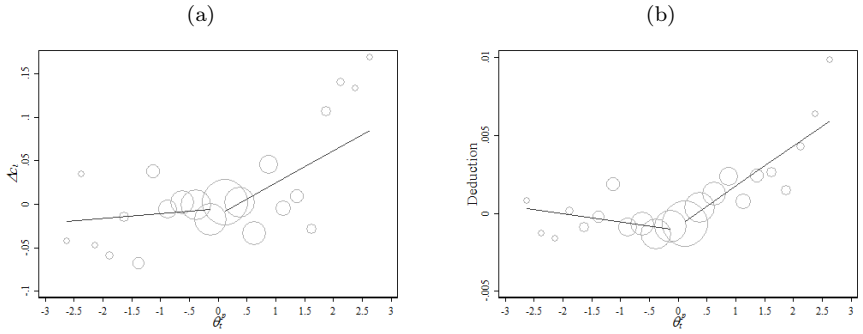


(b)



Notes: Both panels have unanticipated home value growth, θ_{it}^p, on the horizontal axis. Net bank asset growth (panel a), and financial asset growth (panel b) is on the vertical axis. In both cases, the dependent variable is first regressed on year dummies and it is the residual from this regression that is used for constructing the panel. Net bank assets include all assets held in banks less any type of non-mortgage debt, Financial assets include the market value of stocks and bonds. Both panels show binned scatterplots (grey circles), where the bins are defined over equal intervals of θ_{it}^p and the size of the circles scaled by the number of observations in the bin. Regression lines weighted by the number of observations estimated separately for $\theta_{it}^p \lesseqgtr 0$ (black) are overlaid. All variables are normalized on average income during 2008-2010 and censored at the 2nd and 98th percentile of their distribution in each calendar year.

Figure 5: Unanticipated Home Value Growth and Spending and Tax Deduction



Notes: Both panels have unanticipated home value growth, θ_{it}^{p}, on the horizontal axis. Total spending growth (panel a) and tax deduction for home improvements (panel b) are on the vertical axes. In both cases the dependent variable is first regressed on year dummies and it is the residual from this regression that is used for constructing the panel. Total spending is imputed from income and wealth data as described in section 4.2. Tax deductions are obtained from the Danish tax authorities. Both panels show binned scatterplots (grey circles) where the bins are defined over equal intervals of θ_{it}^{p} and the size of the circles scaled according to the number of observations in the bins. Regression lines weighted by the number of observations and estimated separately for $\theta_{it}^{p} \lessgtr 0$ (black) are overlaid. Spending and the tax deduction are normalized on average income during 2008-2010 and censored at the 2nd and 98th percentile of their distribution in each calendar year.

values of θ_{it}^{p} is consistent with the pattern of extraction of mortgage debt. In panel b the outcome is the amount of spending on home improvements that has been reported to the tax authorities. The scale is different (about 1/10) compared to the other panel, which reflects the fact that the tax deduction only concerns a specific sub-component of total spending. There is a positive association between unanticipated increases in the home value and the reported tax deductions for home improvements.[14]

Overall, Figures 3-5 show evidence that unanticipated gains in the value of homes drive the accumulation of mortgage debt and, to a lesser extent, deposits, but there is no evidence that home value gains drive the accumulation of financial assets. The graphical analysis also suggests that unanticipated home value changes drive spending.

[14] A potential caveat related to the association shown in the right hand-side panel is that respondents who have undertaken home improvements may subsequently report a higher value of their home. In the robustness section we perform two checks, and they show that endogenous responses are not likely to be the driving force behind the results.

The bivariate graphical analysis does not, however, take into account all the potential confounding explanations that we listed in section 3.1, including expected future adjustments to income. To address this, we now turn to the multivariate analysis where we can simultaneously take all three channels into account.

5.2 Multivariate analysis

The multivariate analysis is based on estimating equation (1). Because the descriptive analysis clearly suggested that responses to positive and negative unanticipated changes in home values are asymmetric, we allow for this in the multivariate analysis by estimating separate parameters for positive and negative values of θ_{it}^{p}, $E_{it-1}[\Delta p_{it}]$, θ_{it}^{y}, and $E_{it-1}[\Delta y_{it}]$.

The baseline estimates of equation (1) estimated by OLS are presented in Table 2. Each column in Table 2 shows the results from estimating independent OLS regressions with different dependent variables. In all regressions we control for year fixed effects as well as municipality fixed effects, variances of the subjective home value and income distributions. As discussed in section 4, one threat to identification could be that sentiments are correlated with subjective projections. To address this, we include two dummy variables for positive and negative sentiments.[15] Standard errors are clustered at the municipal level.[16] The first three columns focus on balance sheet adjustments and columns 4-6 consider spending outcomes.

The dependent variable in column 1 is mortgage debt growth. The estimated parameters for unanticipated home value increases and decreases, which are the parameters of main interest, are presented in rows (a) and (b). Negative changes in home values are coded as positive values, such that a positive parameter estimate is

[15] In each round of the survey we ask respondents: *Thinking about the Danish economy, how do you think it will develop this year?* Respondents are given the option to answer: *improve, no change, deteriorate.* The dummy variable for negative sentiments takes the value 1 if the respondent answers *deteriorate,* and the dummy variable for positive sentiments takes the value one if the respondent answers *improve.*

[16] House prices arguably vary at some local level. Our analyses suggest that this level is more local than the level of the municipality. Clustering standard errors at the municipal level is therefore conservative in terms of rejecting the null-hypothesis of no wealth effects.

Table 2: Effect of Unanticipated Price Changes

		(1) $\Delta Mortgage$ b/se	(2) $\Delta NetBank$ b/se	(3) $\Delta Financial$ b/se	(4) $\Delta Spending$ b/se	(5) $\Delta Spending, t+1$ b/se	(6) $Deduction$ b/se
(a)	Unanticipated price increase, $\theta^p > 0$	0.033***	-0.004	0.002	0.038***	-0.039***	0.001***
		(0.006)	(0.005)	(0.002)	(0.007)	(0.011)	(0.000)
(b)	Unanticipated price decrease, $\theta^p < 0$	-0.000	0.004	-0.001	0.004	-0.010	0.000
		(0.005)	(0.005)	(0.003)	(0.008)	(0.010)	(0.000)
(c)	Anticipated price increase, $[\Delta p] > 0$	0.028*	-0.023**	0.001	-0.009	-0.039	0.001
		(0.016)	(0.012)	(0.008)	(0.029)	(0.041)	(0.001)
(d)	Anticipated price decrease, $[\Delta p] < 0$	-0.028**	0.012	0.004	-0.023	0.024	-0.000
		(0.012)	(0.010)	(0.005)	(0.020)	(0.026)	(0.001)
(e)	Unanticipated income increase, $\theta^y > 0$	-0.012	0.061***	-0.009	0.032	-0.025	0.004***
		(0.020)	(0.021)	(0.013)	(0.038)	(0.049)	(0.001)
(f)	Unanticipated income decrease, $\theta^y < 0$	-0.014	-0.003	-0.012*	-0.013	-0.048	0.001*
		(0.015)	(0.014)	(0.006)	(0.025)	(0.032)	(0.001)
(g)	Anticipated income increase, $[\Delta y] > 0$	-0.014	0.037**	0.015*	-0.008	0.024	-0.000
		(0.016)	(0.017)	(0.008)	(0.040)	(0.041)	(0.001)
(h)	Anticipated income decrease, $[\Delta y] < 0$	-0.056**	-0.011	0.031**	-0.177***	-0.028	-0.000
		(0.024)	(0.027)	(0.014)	(0.044)	(0.064)	(0.001)
(i)	Subjective price variance, σ^p	0.000***	0.000	-0.000	0.000***	0.000***	-0.000
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
(j)	Subjective income variance, σ^y	-0.000	-0.000	-0.000*	-0.001***	-0.000	-0.000*
		(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
(k)	DK economy +	0.003	-0.000	-0.003	-0.001	-0.028	0.001
		(0.006)	(0.006)	(0.003)	(0.014)	(0.017)	(0.000)
(l)	DK economy −	0.005	0.006	-0.001	0.009	-0.020	-0.001**
		(0.006)	(0.007)	(0.004)	(0.014)	(0.017)	(0.001)
	N	12,946	12,946	12,946	12,946	7,594	12,946

Notes: (a) θ^p is interacted with a dummy variable for $\theta^p > 0$. (b) θ^p interacted with a dummy variable for $\theta^p < 0$ and multiplied by -1, so that unanticipated changes in home value decreases enter the regression analysis with positive values. (c) $E[\triangle p]$ is interacted with a dummy variable for $E[\triangle p] > 0$. (d) $E[\triangle p]$ is interacted with a dummy variable for $E[\triangle p] < 0$ and multiplied by -1, so that anticipated home value decreases enter the regression analysis with positive values. (e) θ^y is interacted with a dummy variable for $\theta^y > 0$. (f) θ^y is interacted with a dummy variable for $\theta^y < 0$, and multiplied by -1, so that unanticipated income decreases enter the regression analysis with positive values. (g) $E[\triangle y]$ is interacted with a dummy variable for $E[\triangle y] > 0$. (h) $E[\triangle y]$ is interacted with a dummy variable for $E[\triangle y] < 0$, and multiplied by -1, so that anticipated income decreases enter the regression analysis with positive values. All outcome variables are normalized on average income during 2008-2010 and censored at the 2nd and 98th percentile of their distribution in each calendar year. Standard errors are clustered at the municipal level. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

to be interpreted as an increase. Rows (c) and (d) contain parameter estimates for anticipated price increases and falls. Rows (e) to (h) present the estimated parameters for unanticipated as well as anticipated income changes that are positive and negative in direction. Concentrating on the effect of unanticipated changes in home values, we find that an unanticipated price increase leads to accelerated mortgage debt growth, and the effect is about 3%. The fact that there appears to be a significant effect for positive unanticipated changes in home values only is consistent with the graphical evidence and the magnitude is also similar to the unconditional graphical analysis. Anticipated home value increases, row (c), do not significantly predict mortgage growth, but anticipated price falls, row (d), are significant. Interestingly, the results show that anticipated income declines, row (h), lead to deleveraging. This suggests that it is important to control for expected income growth, cf. the common factor hypothesis. The variance of the subjective price distribution is significant. We have also estimated the model without including the variances of the subjective price and income distribution (not reported), and the parameters of interest are not affected in any important way by their exclusion. Finally, the sentiment dummies are generally not significant and thus do not appear to have any important impact on the estimated price dummies. In columns 2 and 3 we look into the balance sheet and consider adjustments in net bank assets, i.e., bank deposits less all non-mortgage debt, and financial assets. The results indicate that there are no adjustments related to unanticipated home value increases or decreases.

The dependent variable in column 4 is spending growth. There is a significant effect of unanticipated home value increases, and it is of the same order of magnitude as the effect estimated for mortgage debt growth. It is interesting to note that the parameter for anticipated income losses is significant, indicating that spending is reduced when an expected adverse income change arrives. In column 5 the outcome is the spending adjustment in the following year. Here, the parameter on unanticipated increases in home values is significant. The estimated parameter is negative, indicat-

ing that spending spikes up in the year where the unanticipated home value increase arrives but then reverts back in the following year. This indicates that unanticipated housing wealth gains are transformed into spending on goods that are only purchased infrequently, such as durable goods. In column 6, the outcome is the amount spent on home improvements that is reported to the tax authorities in order to claim a tax deduction. This is significant for unanticipated home value increases only. The effect is much smaller than for total spending, but this is natural as home improvements constitute only one component of total spending.[17] Overall, the findings for total spending mimic those of mortgage debt accumulation, suggesting that spending increases are financed through housing equity extraction.

5.2.1 Robustness

The results presented are potentially sensitive to some aspects of the design of the analysis. To confirm that the effects found are robust, a number of consistency checks are carried out. First, imputed spending is potentially sensitive to capital gains on stocks and bonds, and this could have influenced the results if home value increases are correlated with capital gains on these assets. Second, we have used anticipated and unanticipated income growth as proxies for demand factors in order to control for the common factor channel. However, these may not capture all relevant demand factors, and we examine whether our results are sensitive to including municipal-specific year dummies. Third, since, in some cases, housing equity has been extracted for making home improvements this may have led respondents to report a higher actual value of the home after the improvement was carried out. If this happens, then the causality does not go from measured unanticipated home value increases to spending, but rather the other way around. We will perform two tests for whether this drives the results. Fourth, in the analysis we have used measurements at the level

[17] We note that mortgage loans are not always the cheapest way to finance all types of spending. For example, in the online Appendix, Figure A4, we show that interest rates on car loans match those on mortgage loans. This is consistent with the results reported by McCully, Pence, Vine (2015).

of the individual. However, spending decisions may have been taken at the household level, and we will investigate whether this influences the results. In Table 3 we present the results from a series of robustness checks that address these issues. For each of the robustness checks the estimated parameters pertaining to the unanticipated changes in the home value are included, but the results are based on estimations including the full set of covariates also included the estimations reported in Table 2.[18]

We start out by considering the importance of controlling for individual fixed effects. An interesting and unique feature of the data is the longitudinal dimension which makes it possible to control for fixed unobserved factors. Fixed unobserved factors could, for example, include preference parameters or other fixed factors. If such factors are determinants of the propensity to spend out of unanticipated home value gains, then they could bias the estimated effects. The results are presented in Table 3, row (a). They show that controlling for fixed unobserved effects still leaves the parameter estimate pertaining to unanticipated housing wealth increases positive and significant. The results suggest that the response to such unanticipated housing wealth gains is not driven by fixed idiosyncratic factors.

One important potential confounding factor is that movements in the value of housing assets might be correlated with movements in the prices of stocks and bonds. Also, the imputation may count capital gains on stocks and bonds as savings when, in reality, they are merely passive movements in asset prices. In order to assess whether this drives our results, we have reproduced the result from Table 2 for a subsample of the observations where the respondent does not hold bonds or stocks at the beginning of the period, and the results are reported in Table 3, row (b). The omission of stock/bond holders does not change the results.

One of the hypotheses states that there may be a third factor driving both spending and home values. The previous analysis included anticipated as well as unanticipated

[18]The complete set of estimates from all the robustness checks are reported in the online Appendix, Tables A8-A13.

Table 3: Robustness Checks

		(1) $\Delta Mortgage$ b/se	(2) $\Delta NetBank$ b/se	(3) $\Delta Financial$ b/se	(4) $\Delta Spending$ b/se	(5) $\Delta Spending, t+1$ b/se	(6) $Deduction$ b/se
(a)	Unanticipated price increase, $\theta^p > 0$	0.052***	-0.004	0.001	0.065***	-0.060***	0.001**
		(0.008)	(0.006)	(0.003)	(0.012)	(0.017)	(0.000)
	Unanticipated price decrease, $\theta^p < 0$	0.021***	0.003	-0.004	0.028**	-0.025	0.000
		(0.006)	(0.006)	(0.003)	(0.013)	(0.017)	(0.000)
(b)	Unanticipated price increase, $\theta^p > 0$	0.041***	0.002	0.001	0.037***	-0.056***	0.001***
		(0.009)	(0.005)	(0.001)	(0.009)	(0.015)	(0.000)
	Unanticipated price decrease, $\theta^p < 0$	-0.001	0.003	0.004**	0.002	0.001	-0.000
		(0.006)	(0.005)	(0.002)	(0.009)	(0.011)	(0.000)
(c)	Unanticipated price increase, $\theta^p > 0$	0.032***	-0.003	0.002	0.036***	-0.035***	0.001***
		(0.006)	(0.005)	(0.002)	(0.007)	(0.010)	(0.000)
	Unanticipated price decrease, $\theta^p < 0$	-0.000	0.004	-0.001	0.004	-0.008	0.000
		(0.005)	(0.005)	(0.003)	(0.008)	(0.010)	(0.000)
(d)	Unanticipated price increase, $\theta^p > 0$	0.025***	-0.003	0.003	0.024***	-0.023*	-
		(0.007)	(0.005)	(0.002)	(0.009)	(0.012)	
	Unanticipated price decrease, $\theta^p < 0$	-0.003	-0.001	-0.002	0.004	-0.007	-
		(0.005)	(0.006)	(0.003)	(0.009)	(0.011)	
(e)	Unanticipated price increase, $\theta^p > 0$	0.030***	-0.008	0.002	0.030	-0.027	0.002**
		(0.012)	(0.011)	(0.007)	(0.026)	(0.033)	(0.001)
	Unanticipated price decrease, $\theta^p < 0$	-0.008	-0.003	0.001	0.000	0.002	-0.000
		(0.012)	(0.012)	(0.007)	(0.026)	(0.032)	(0.001)
(f)	Unanticipated price increase, $\theta^p > 0$	0.049***	-0.006	0.003	0.051***	-0.046***	0.001***
		(0.011)	(0.010)	(0.003)	(0.013)	(0.018)	(0.000)
	Unanticipated price decrease, $\theta^p < 0$	-0.008	0.001	-0.003	0.006	-0.018	0.001
		(0.010)	(0.009)	(0.005)	(0.015)	(0.019)	(0.000)

Notes: The table reports results from a series of robustness checks. Each row reports estimation results of a model that involves all the covariates used in Table 2, but where only estimates of $\theta^p > 0$ and $\theta^p < 0$ are reported. (For each of the robustness checks the full set of estimates are tabulated in the online Appendix, Table A8-A13). As in Table 2, each (column, row) cell is estimated by independent OLS regressions. (a) repeats the estimations in Table 2 while controlling for individual fixed effects. (b) repeats the estimations in Table 2 but is based on a sample of observations where no stock or bond holdings are observed at the beginning of the period. (c) repeats the estimation reported in Table 2 but includes municipality×year fixed effects. (d) is based on a sample excluding all observations where deductions for home improvements are recorded. (e) is based on estimation by two stage least squares where the unanticipated price increase/decrease is instrumented with the municipal level house price growth obtained from a house price index published by the association of Danish mortgage banks, Finance Denmark. (f) repeats the estimation in Table 2, but where the outcome is calculated at the household level. All outcome variables are normalized on average income during 2008-2010 and censored at the 2nd and 98th percentile of their distribution in each calendar year. Standard errors are clustered at the municipal level. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

income growth. However, an alternative third factor could, for example, be a general local expansion of credit that stimulates local demand. This is difficult to measure directly, but we can add municipality by year fixed effects. This will pick up municipality specific time varying factors including such local aggregate effects. The results are reported in Table 3, row (c). For all practical purposes, the results from this analysis are identical to the original analysis, confirming that common factors have been controlled for appropriately in Table 2. It also indicates that much of the identifying variation in the analysis comes from an even more local level, either because there are indeed very local markets within municipalities, or because the expectations of the respondents really reflect subjective expectations about how prices will develop.[19]

The analysis is based on the assumption that the difference between actual and anticipated price changes identifies a truly unanticipated price change, i.e., $\theta_{it}^{p} = p_{it} - p_{it-1} - (E_{it-1}[p_{it}] - p_{it-1})$, and that this surprise is uncorrelated with the decision to spend in period t. However, we have found that there is significant mortgage based extraction of housing equity and that at least some people use this to renovate or maintain their home. A potential threat to our approach to identifying the effect of unanticipated home value increases is that home owners may improve their homes and subsequently report a higher value of p_{it} because improvements have been made during the year. For this to bias the results, the decision to make home improvements must not have been taken before $E_{it-1}[p_{it}]$ was reported, because the value of the improvements would then have already been included in the expectation. To check for the possibility that the reporting of p_{it} is endogenous, we make a robustness check where we re-estimate the basic specification but omit observations for those who have claimed deductions for home improvements. This reduces the sample size by some 20%, arguably also removing some relevant variation. These results are shown in Table 3, row (d), and they show that there is still a significantly positive

[19]The results are also robust to controlling jointly for $year \times municipality\, FE$ and $individual\, FE$. This set of results is not reported, but is available upon request.

effect of an unanticipated increase in the home value on mortgage debt growth and on spending, although the point estimates are slightly smaller than the reference estimates in Table 2. This confirms that the main estimates are not purely the result of endogenous home value reporting. This analysis does not take into account that people may have improved their home without having claimed the tax deduction. In order to address this concern, we also take another approach where the model is estimated by two stage least squares and the unanticipated price gain is instrumented with the aggregate municipal level growth in the prices of traded houses. This is based on a municipal level house price index published by the association of Danish mortgage banks, Finance Denmark. This approach effectively exploits variation that is not collected at the individual level and hence cannot be the result of endogenous reporting. The findings are reported in Table 3, row (e). Two stage least squares is notoriously inefficient and the standard errors more than double in size compared to the standard errors reported in Table 2[20], and this generally reduces the level of significance. However, mortgage debt growth is still significant and of the same order of magnitude as the baseline estimates, and all the remaining point estimates are generally similar to, and lie within two standard errors of, the estimates reported in Table 2. These findings suggest that endogenous reporting did not cause the estimated parameters to be biased.

The analysis has so far been based on individual level information, but obviously some of the spending decisions could have been made at the household level. In Table 3, row (f), we have implemented the analysis where all outcome variables are measured at the household level. This analysis confirms the previous findings that unanticipated increases in home values drive mortgage debt accumulation and expenditure growth, and the point estimates are of a similar magnitude to those in the baseline model.

Overall, the results presented in Table 3 confirm that the mortgage debt accumu-

[20]The t-statistics in the first stage regression of θ^p_{it} on the instrument are 34 for the regression of positive unanticipated and 40 for the regression of unanticipated negative changes.

lation result is robust to a range of potentially important confounding factors. All the alternative specifications tested are more data demanding than the specification used in Table 2 and are therefore generally associated with larger standard errors. However, mortgage debt growth remains significantly related to unanticipated home value increases, and the point estimates for the other outcomes remain similar, even if they are not estimated as precisely as in the reference specifications presented in Table 2.

5.2.2 Collateral constraints

One of the main hypotheses for explaining the correlation between home values and mortgage extraction is the collateral channel. As outlined in section 3.1, the collateral channel is likely to be at work when the correlation between home values and mortgage extraction and spending is driven by young home owners with high leverage. Moreover, the association between changes in home values and spending changes should be asymmetric in price increases and price falls. In order to investigate this, we split the sample at the median age of the home owners and at the median value in the LTV distribution, where LTV is summarized at the beginning of the period, i.e., before a potential wealth gain is realized. We then estimate the model separately on each of the four subsamples. Results from doing this are reported in Table 4. We only include the estimated parameters pertaining to unanticipated changes in the home values in Table 4 and report the full set of estimates in the online Appendix, Tables A16-A19. Row (a) shows the results for the young home owners with a high LTV ratio, i.e. the group who are likely to drive the effect if the collateral channel is relevant. Row (b) shows results for young home owners with a low LTV ratio, i.e. young home owners for whom the collateral constraint is less binding. Rows (c) and (d) show results for older home owners with high and low LTV ratios, respectively. Table 4 clearly shows that the overall effect is driven by young home owners with a high LTV level. For this group the marginal propensity to increase mortgage debt

is 0.09 and the effect is precisely estimated. Price falls have no effect on spending. Spending effects are of the same magnitude as the mortgage effects, and they show the same dynamic pattern as in the overall sample where the spending increase reverts in the following year. There is some indication of an effect among young home owners with an above median LTV ratio, but the effect is small. There is no effect among the oldest half of the sample.

The legal LTV constraint is 80%. We have also experimented with splitting the sample at the 75th percentile of the LTV distribution (where LTV=79). The results based on this split are very similar to the results presented here and we have therefore relegated them to the online Appendix, Tables A20. Furthermore, we have examined whether cash-constraints matter by splitting the sample according to whether the respondent starts out the period with liquid assets corresponding to less/more than two months of disposable income, a measure of liquidity constraints often used in previous studies (e.g. Zeldes, 1989, Leth-Petersen, 2010). The results showed no effect among the older home owners, but a clear effect among the young home owners. However, there was no differential effect among young home owners with high/low levels of liquid assets, suggesting that cash-constraints are not important. These results are also reported in the online Appendix, Table A21.

In summary, Table 4 shows that the effect is driven primarily by young home owners with a high LTV who extract equity, and that the effect is asymmetric in price increases/decreases, and this is consistent with the pattern predicted by the collateral hypothesis. In the next section we will look into the pattern of equity extraction in more detail.

5.2.3 Refinancing

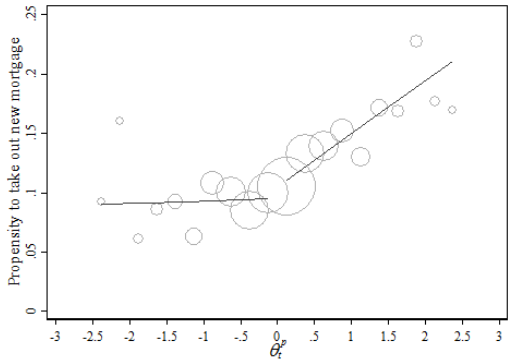
The results presented so far relate unanticipated home value gains to mortgage debt growth. In order to establish the pattern of housing equity extraction more precisely, we identify observations where an active mortgage transaction is recorded.

Table 4: Effect of Unanticipated Price Changes by Age and Loan-to-Value Ratio

		(1) $\Delta Mortgage$ b/se	(2) $\Delta NetBank$ b/se	(3) $\Delta Financial$ b/se	(4) $\Delta Spending$ b/se	(5) $\Delta Spending, t+1$ b/se	(6) $Deductions$ b/se
				Young, High LTV			
	Unanticipated price increase, $\theta^p > 0$	0.093***	-0.006	-0.001	0.091***	-0.099***	0.001***
(a)		(0.013)	(0.007)	(0.002)	(0.019)	(0.026)	(0.000)
	Unanticipated price decrease, $\theta^p < 0$	0.005	0.003	0.001	0.018	-0.007	-0.000
		(0.012)	(0.008)	(0.002)	(0.017)	(0.024)	(0.000)
				Young, Low LTV			
	Unanticipated price increase, $\theta^p > 0$	0.022**	0.001	0.000	0.034**	-0.023	0.001
(b)		(0.010)	(0.012)	(0.004)	(0.015)	(0.023)	(0.001)
	Unanticipated price decrease, $\theta^p < 0$	0.001	0.005	0.005	-0.012	-0.007	-0.000
		(0.007)	(0.010)	(0.005)	(0.017)	(0.023)	(0.000)
				Old, High LTV			
	Unanticipated price increase, $\theta^p > 0$	0.021*	0.000	-0.001	0.019	-0.042*	0.001*
(c)		(0.011)	(0.010)	(0.004)	(0.020)	(0.024)	(0.001)
	Unanticipated price decrease, $\theta^p < 0$	0.017	-0.005	-0.006	0.035	-0.050	0.002**
		(0.015)	(0.009)	(0.005)	(0.025)	(0.032)	(0.001)
				Old, Low LTV			
	Unanticipated price increase, $\theta^p > 0$	0.003	-0.006	0.005	0.013	-0.013	0.001
(d)		(0.009)	(0.008)	(0.003)	(0.013)	(0.015)	(0.000)
	Unanticipated price decrease, $\theta^p < 0$	-0.014**	0.006	-0.002	-0.017	0.005	-0.000
		(0.006)	(0.009)	(0.006)	(0.015)	(0.016)	(0.000)

Notes: The table reports results from estimations performed on sample splits according to median LTV (50) and median age (54), where 'low LTV' refers to beginning of period LTV being less than the median and 'Young' refers to being aged less than 54. Each set of cells reports estimation results of a model that involves all the covariates used in Table 2, but where only estimates of $\theta^p > 0$ and $\theta^p < 0$ are reported. (The full set of results are tabulated in the online Appendix, Tables A16-A19). All outcome variables are normalized on average income during 2008-2010 and censored at the 2nd and 98th percentile of their distribution in each calendar year. Standard errors are clustered at the municipal level. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

Figure 6: Propensity to Actively Take Out New Mortgage



Notes: The panel has unanticipated home value growth, θ_{it}^{p}, on the horizontal axis and a dummy variable indicating whether a loan has been refinanced on the vertical axis. The graph shows a binned scatterplot (grey circles) where the bins are defined over equal intervals of θ_{it}^{p}, and the circles vary in size according to the number of observations in the bins. Regression lines weighted by the number of observations and estimated separately for $\theta_{it}^{p} \lessgtr 0$ (black) are overlaid. The unanticipated home value growth is normalized on average income during 2008-2010.

By an active mortgage transaction, we mean that a new mortgage loan has been taken out. 1,497 observations fall into this category. Figure 6 presents a binned scatter plot of the propensity to actively take out a new mortgage against the unanticipated home value growth. The figure shows very clearly that the propensity to actively take out a new mortgage is increasing with the size of the unanticipated home value growth when this is positive. For negative values of the unanticipated home value growth there is no systematic relationship. This confirms the suspicion that the spending effect documented above is driven by people who actively take out a new mortgage. This claim is further backed by the fact that the spending response documented in the previous section disappears (not reported) when these observations are excluded from the data set.

Recently, Bhutta and Keys (2016) proposed that a drop in mortgage interest rates stimulates equity extraction and that house price growth further amplifies the rela-

tionship. This can, for example, take place if FRM borrowers face an incentive to refinance in order to lock in lower market rates and at the same time experience an unanticipated increase in the value of the home, and take advantage of the opportunity to refinance and extract equity at the same time. Many Danish mortgage borrowers have FRMs, and, like in the US, it is possible for borrowers to refinance in order to lock in lower market rates and to extract equity at the same time if the borrower has sufficient home equity. Figure A1 in the online Appendix plots the market interest rate of 30-year mortgage bonds, and it documents that market interest rates has declined significantly in the period considered. In order to examine the relevance of this mechanism, we take a simple and transparent approach to identity FRM borrowers with an incentive to refinance. Mortgage banks and financial advisors apply simple rules-of-thumb when advising their customers about the potential profitability of refinancing FRMs. The exact rules vary slightly across mortgage banks and financial advisors, but a typical rule is that it would potentially be profitable to refinance if the volume of the loan is at least 500,000 DKK, time until maturity is at least 10 years, and if the market interest rate is at least 1 percentage point lower than the coupon rate on the existing loan.[21] Based on the mortgage data we are able to apply this rule-of-thumb in order to identify whether it is potentially profitable to refinance an existing FRM for all the observations in our data set.[22]

There are 4,729 cases in the data set where the respondent starts out the period with a FRM, and in 710 of these cases the rule-of-thumb suggests that it is potentially profitable to refinance.[23] As noted above, there are 1,497 cases in the data where an

[21] See for example, https://www.bolius.dk/omlaegning-af-dit-realkreditlaan-17799/ and https://www.rd.dk/da-dk/privat/Omlaegning-af-laan/Guides/Pages/Guides.aspx and https://www.brf.dk/omlaeg-laan/vaerd-at-vide/hvornaar-skal-du-omlaegge.

[22] Agarwal et al. (2013) have developed a formula describing when it is optimal to refinance. According to this, optimal refinancing depends, among other things, on the size of the outstanding principal, transaction costs and the mortgage interest gain from refinancing. Andersen et al. (2018) show evidence that simple refinancing rules, such as the one applied here, can generate refinancing-thresholds comparable to those derived from the Agarwal et al (2013) rule.

[23] In the online Appendix, Table A22, we have implemented an alternative rule-of-thumb where the threshold value for the size of the outstanding principal and the time until maturity is varied in order to confirm that our results are not driven by the exact threshold values examined here.

active mortgage transaction is recorded. 47% of those either take out a new mortgage without closing another or start out the period with an ARM and open a new loan of some type. The remaining 53% start the period with an existing FRM, and 69% of these refinance into a new FRM. In order to examine whether equity extraction takes place when it is profitable to refinance, we construct a dummy variable, $D_{it}^{Incentive}$, taking the value 1 if the borrower starts the period with a FRM and has an incentive to refinance according to the rule-of-thumb defined above. We then re-estimate equation (1) adding $D_{it}^{Incentive}$ as a regressor as well as interactions between unanticipated home value changes and D_{it}. To the extent that future market interest rate developments are unpredictable at the point of loan origination, the incentive to refinance is quasi-randomly assigned to borrowers, i.e., $D_{it}^{Incentive}$ identifies the subgroup in the sample who will potentially profit from refinancing based on plausible exogenous variation.

The results are shown in Table 5. The first column shows the results from a regression of a dummy variable taking the value 1 if the respondent engages in mortgage activity that is not associated with refinancing a FRM, i.e., taking out a new mortgage without closing down an existing FRM. In column (2), the dependent variable is a dummy variable which takes the value 1 if the respondent refinances a FRM loan, i.e. closes an existing FRM and establishes a new FRM. In this column we add a dummy indicator for having an incentive to refinance, $D_{it}^{Incentive}$, and its interaction with the unanticipated price changes. In column (3) the dependent variable is mortgage debt growth. The results in column (1) show that taking out a mortgage, but not in connection with refinancing a FRM, is correlated with the unanticipated price increase. This is consistent with the pure collateral effect, i.e. a situation where an additional mortgage is taken out as a result of the price increase. Turning to the results in column (2) the parameter estimates show that, irrespective of whether the respondent

Specifically, we have examined the impact of changing the required time until maturity to 5 years and reducing the required outstanding principal to 250,000DKK. This did not affect the results in any important way.

Table 5: Rule-of-Thumb Refinancing

	(1) New Mortgage b/se	(2) FRM Refinance b/se	(3) Δ Mortgage b/se
Unanticipated price increase, $\theta^p > 0$	0.019***	0.008**	0.029***
	(0.005)	(0.003)	(0.008)
Unanticipated price decrease, $\theta^p < 0$	-0.000	0.006**	0.005
	(0.004)	(0.003)	(0.007)
Unanticipated price increase × Incentive, $\theta^p > 0$		0.062*	0.219***
		(0.034)	(0.049)
Unanticipated price decrease × Incentive, $\theta^p < 0$		-0.023	0.081
		(0.051)	(0.062)
Incentive to refinance		0.598***	-0.084***
		(0.028)	(0.031)
N	11,933	11,933	11,933

Notes: The table reports results from regressions corresponding to regression (1), except that $D_{it}^{Incentive}$ is added as a regressor as well as its interactions with $\theta^p \lessgtr 0$. D takes the value 1 if the volume of the loan is at least 500,000 DKK, time until maturity is at least 10 years, and if the market interest rate is at least 1 percentage point lower than the coupon rate on the existing loan. All the regressions includes the same set of covariates used in the regressions reported in Table 2. The sample is restricted by omitting extreme values of the unanticipated price change, i.e. including $-2.5 < \theta^p < 2.5$. The dependent variable in column (1) is a dummy variable taking the value one if the respondent is recorded as having taken out a new mortgage without refinancing. The dependent variable in column (2) is a dummy variable taking the value one if a FRM mortgage has been refinanced, i.e., both established a new mortgage and closed another. The dependent variable in column (3) is the mortgage debt growth (normalized on average income calculated over the period 2008-2010). This is similar to the outcome modelled in column 1 in Table 2. Standard errors are clustered at the municipal level. * significant at the 10% level, ** significant at the 5% level, *** significant at the 1% level.

has experienced an unanticipated home value gain, $D_{it}^{Incentive}$ significantly predicts that the respondent will refinance. This is as expected because it is profitable to refinance, with or without extracting housing equity, in order to lock in the lower market interest rate. The results presented in column (2) also suggest that the propensity to refinance increases slightly with unanticipated gains and losses in home values. This could reflect that these home owners refinance even when it is not profitable or that the rule-of-thumb is too crude to capture all the circumstances that make it advantageous for borrowers to refinance. Perhaps more interestingly, the propensity to refinance tends to increase with unanticipated gains in home values when there is also an incentive to refinance. This pattern, however, does not tell whether such an interaction effect is also responsible for the equity extraction. We turn to this in column (3) where the dependent variable is mortgage debt growth. The results show that unanticipated price increases are associated with mortgage growth. This is consistent with the finding in column (1) documenting that some home owners take out a new mortgage loan without having an incentive to refinance. The interaction effect between having an incentive to refinance a FRM and experiencing an unanticipated price gain is also significant and the parameter estimate reveals a relatively large effect of gains in home values on equity extraction for owners who also face a refinancing incentive.

Overall, the results presented in Table 5 show that a significant fraction of refinancing takes place without extracting additional equity. However, mortgage debt growth is significantly positively correlated with the unanticipated price increases, and the effect is much bigger for members of the subgroup who, according to the rule-of-thumb, have an incentive to refinance their mortgage to lock in a lower market interest rate while at the same time experiencing an unanticipated home value gain. In summary, the results presented in this section show that housing equity extraction is amplified when borrowers have an incentive to refinance to lock in a lower market interest rate.

5.2.4 Link to previous studies

We estimate a marginal propensity to increase mortgage debt and to spend out of unanticipated housing wealth gains of 3-5%, and the effect is higher for home owners who refinance their mortgage and extract equity when refinancing. The effect is precisely estimated and broadly in line with most of the existing evidence finding a marginal propensity to consume that is no bigger than 10%. Methodologically, our study is most directly linked to the studies by Browning et al. (2013), Campbell and Cocco (2007), Disney et al. (2010), and to Paiella and Pistaferri (2017) who also attempt to identify the effect of unanticipated changes in home values. Using Danish data for the early 1990s Browning et al. (2013) find an overall MPC of about 3% and show that it is driven by young liquidity constrained home owners. Campbell and Cocco (2007) use UK household budget data and find an MPC of 10%. Disney et al. (2010) use the British Household Panel Survey 1994–2003 and find a marginal propensity to consume out of surprise innovations to housing wealth of maximally 1%. Paiella and Pistafferri (2017) use data from the Italian SHIW. They find an MPC of 3%, and the effect is related to expected price changes, suggesting that the effect is driven by home owners who are liquidity constrained. Common to these studies is that the effects are quite imprecisely estimated. Given this and the fact that these studies are based on different types of data covering different periods and countries, it is not surprising that conclusions about the underlying driving factors differ. Unlike any of these previous studies, we are able to tie the spending decision to a subset of households engaging in mortgage based housing equity extraction, and to show that the response is more intense among home owners with high ex ante LTV ratios who also have an incentive to refinance an existing FRM loan to lock in a lower market interest rate. This transparently shows that the mortgage market can play a key role in transforming gains in home values into spending via mortgage borrowing. These findings are broadly consistent with those of Bhutta and Keys (2016).

6 Conclusion

By implication of the life cycle framework, unanticipated gains in home values potentially cause spending to grow. This study investigates the empirical relationship between unanticipated home value gains, mortgage extraction and spending decisions by using longitudinal survey data with subjective information about current and expected future home values to calculate unanticipated changes in home values. The subjective information is linked at the individual level to high quality administrative records that contain information about savings in various financial instruments to provide a test of the housing wealth hypothesis that is close in spirit to the theoretically motivated hypothesis.

We estimate the average marginal propensity to increase mortgage debt and to spend out of unanticipated gains in home values to be 3-5%. This estimate conceals important heterogeneity in the responses. Unlike any of the existing studies, our study highlights the importance of being able to consider both spending effects and adjustments to the balance sheet. We do not find evidence that unanticipated home value falls have any effect on spending or any important effects on the balance sheet. However, we show that unanticipated increases in home values factor into spending through the extraction of home equity. The estimated effect is robust to controlling for expected future income changes, and we find that the effect is driven by young home owners who ex ante have a high level of mortgage debt relative to their home value and therefore are likely to be affected by collateral constraints. Moreover, and unique to this study, we have longitudinal data on unanticipated home value gains, balance sheets, and spending, and we use this to show that the spending increase associated with an unanticipated gain in the home value is accompanied by a corresponding drop in spending in the following period. This finding suggests that spending is concentrated on durable goods. We are thus able to paint a detailed and precise picture of how unanticipated housing wealth gains factor into the household budget

and spending decisions. In particular, we show that the effect is driven by about 12% of the respondents who are recorded as having actively taken out a new mortgage loan. Among these respondents, we show that those who have a strong motive to lock in lower market rates by refinancing an existing mortgage do so, and at the same time extract equity when they have experienced an unanticipated gain in housing wealth. Interest rate declines thus boost the effect of (unanticipated) increases in home values on mortgage extraction and spending when the mortgage system makes it possible for FRM borrowers to actively lock in lower market interest rates *and* extract equity when housing wealth increases. These results point to the existence of a collateral effect that is connected to the functioning of the mortgage market, suggesting that monetary policy can play a role in amplifying the effect of house price gains on spending by affecting interest rates on mortgage loans.

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