Attenuation bias, recall error and the housing wealth effect

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Abstract

The greater use of microeconomic and survey based data in addressing key financial stability related questions is a natural outcome of the recent financial crisis. Amongst other benefits, the use of such data enables a more precise understanding of the differing attitudes and responses of individual agents such as households to financial shocks. However, some difficulties can arise with the use, in particular, of survey data in this regard. In this paper we calculate measurement error in the house prices "recalled" by a representative sample of mortgaged Irish households and illustrate the degree of attenuation bias consequently introduced into estimates of housing wealth effects, when recall as opposed to actual house prices are used. Our results suggest that estimates of the housing wealth effect, based on survey data may be considerably smaller than what is actually the case; amongst other issues, this has significant implications for the perceived contribution of housing market developments to the overall economy.

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1 Introduction

One of the many outcomes of the international crisis of 2007/08 is the need to use more microeconomic and survey based data in assessing key financial stability concerns. While there are a number of advantages to such data, a particular benefit is a more precise appreciation of the differing attitudes and responses of individual agents to key economic shocks. However, some difficulties can arise with the use of survey data in this regard; in a number of recent contributions it has been shown that households do not always accurately recall or report their financial information. For example, Kreiner et al (2013) find that survey responses on household income display substantial variance and are mean-biased among their sample of Danish households. In an Irish context, it would appear that mortgaged households have considerable difficulty in accurately recalling and objectively stating the monetary amount paid for assets such as housing. This effect appears to be particularly pronounced in cases where house prices have witnessed large appreciation.

While such a finding can have a number of different implications, one area where it can be most significant is in microeconomic assessments of the consumption housing wealth effect. The relationship between consumption and housing has a heightened importance given the strong inter-linkages between housing and the real economy revealed by the recent financial crisis. Understanding the economy-wide benefits of policy responses to the ensuing difficulties being experienced in some property markets is contingent on the wealth effect out of housing.[1] While the question has been tackled using aggregate data for quite some time, the greater availability of survey data has resulted in an increased use of micro level information to address this question. In this paper, using a unique combination of two datasets, we highlight the bias, which is introduced into estimates of the housing wealth effect, when "recall" as opposed to actual house prices are used as indicators of housing wealth.

Although rarely quantified, this attenuation bias, when accurately measured, can have profound implications in econometric applications; Bertrand and Mullainathan (2001), for example, argue that measurement error in subjective data, which tends to be correlated with a large set of characteristics and behaviours, leads to biased estimation, especially when the mis-measured

[1] For example, debt relief has been cited as an option in markets experiencing significant negative equity and mortgage arrears.

subjective data is used as a dependent variable in a regression. Agarwal (2007) finds that the degree to which individuals over or under-estimate their house value has an impact on consumption or savings. The latter study is particularly noteworthy in the present context as it provides a review of earlier studies quantifying the degree to which homeowners mis-estimate their housing value. Additionally, an increasing number of studies recently have critically assessed the ability of households to accurately recall their mortgage information. These include but are not necessarily confined to Antoniewicz (2000), Bucks and Pence (2008), Zinman (2009), Johnson and Li (2009) and Brown et al. (2013).

In examining for wealth effects, this bias is quite serious. For example, take a standard model, estimated with survey data, to quantify consumption-wealth effects such as: $C_i^* = \alpha + \beta P_i^* + \epsilon_i$ where C_i^* is actual consumption, P_i^* is actual house prices and α and β are parameters to be estimated. If P_i is the house price recalled for the survey by the household, and $P_i = P_i^* + g_i$, where g_i is a random white noise error, it is well known that the larger the variance (σ^2) of g_i, the greater the degree of attenuation (towards zero) bias in β, causing the wealth effect to be underestimated. Clearly, in periods where house prices have changed considerably, the potential for σ_g^2 to be non-trivial increases.

In this paper, using two unique datasets, we observe a significant degree of attenuation bias due to *recall error* amongst a representative sample of mortgaged Irish households. We use administrative information from mortgage loan-level data (including the actual house price paid) gathered on a regular basis by the Central Bank of Ireland for the three main Irish financial institutions.[2] This information is then combined with data from a representative household survey conducted in 2012/2013 on the mortgage books of the same institutions, where respondents are asked their original house price.

Across countries, the mortgage market in Ireland stands out as an especially volatile case. Since the mid-1990s, the Irish property sector experienced, even by international standards, an unprecedented boom both in activity and price terms. In 2006, almost 90,000 residential units were constructed - just less than half the amount being built in the United Kingdom. By 2012, with the collapse in the market, less than 10,000 new units were supplied. House price increases were the largest across the OECD between 1995 and 2007, however, in 2012 prices had fallen

[2] This data is collected for prudential purposes. The three institutions are Allied Irish Bank (AIB), Bank of Ireland (BOI) and Irish Life and Permanent (ILP).

by 50 per cent (in nominal terms) since their peak in 2007. Thus, the average Irish mortgagee will have witnessed substantial fluctuations in the value of their property over the past 10 years.

The presence of "recall" or measurement error in house prices could be one reason for the relatively disparate housing wealth effects found across certain studies. Bover (2005), for example, cites measurement error in housing wealth estimates as a potential reason for such results.[3] If surveys are conducted, particularly across periods of significant house price movements, the associated wealth effect could be as much a function of the participant's recall accuracy as the underlying behavioural differences amongst households. We further explore this issue by also estimating the potential determinants of the actual recall error, examining both the influence of household characteristics and general housing market conditions.

The remainder of the paper is organised as follows; in the next section we describe the two datasets used in the analysis. In Section 3 we calculate the degree of recall error and consequent attenuation bias in an estimate of Irish housing wealth effects. A model is then estimated for the recall error of survey participants, while a final section offers some concluding comments.

2 Overview of data

Being able to quantify the actual recall error of survey participants is unique and arises out of two related but discrete datasets of the main Irish financial institutions. The first is a mortgage loan-level dataset collected by the Central Bank of Ireland as part of a prudential capital assessment review exercise of the Irish banking sector. Covering three Irish residential mortgage banks, which account for approximately 70 per cent of the loans issued in the Irish market, the dataset includes a snapshot of the entire residential mortgage book at June 2012. Amongst the variety of information collected on each mortgage loan are borrower and mortgage details from the point of loan origination as well as data on the actual purchase price of the property on which the mortgage is secured. It is important to note that this latter variable is not estimated; the loan-level dataset records the true purchase price of the property. Table 1 provides an overview of the contents of the dataset.

Complementing this information is a survey of the same residential loan book primarily de-

[3] See McCarthy and McQuinn (2013) for a recent review of micro-based housing wealth estimates.

signed to capture the current economic circumstances of Irish mortgagees.[4] The survey, which was administered to over 2,000 households, all of whom are included in the loan-level dataset, was conducted over the period May 2012 to February 2013 and includes 97 questions which were asked of participants. While the survey mainly asks questions concerning relevant economic considerations such as consumption, income and employment status, participants are also asked as to the value of their property at the time of its purchase.

Crucially, each individual's survey responses can be linked back to their corresponding mortgage information in the loan-level dataset, where the respondent gave permission for this linking to take place. By linking the two datasets in this manner, we are able to compare the actual house purchase price recorded in the loan level data with the survey response of the household. The work in this paper is based on a cleaned subsample of the linked dataset. An overview of the sample is presented in Table 2.[5] It is worth noting that at the time of the survey, no property tax existed in the Republic of Ireland and a specific undertaking was provided by the Central Bank of Ireland to assure participants that the results of the survey would not be shared with any outside agencies. Consequently, we don't believe that taxation considerations would have any real impact on the survey responses of participants.

While the Irish property and mortgage market experienced significant change in the aftermath of the house price peak in 2007, by 2012, conditions (such as house price movements and changes in the number of households experiencing mortgage arrears) had stabilised. Therefore, survey responses obtained in that year are likely to be more representative of steady-state conditions in the Irish market than for any year since the mid-1990s.

3 Estimates of recall error and attenuation bias

The error associated with each household's recall of the price paid for their property can be defined as follows:

$$g_i = h_i^R - h_i^A \tag{1}$$

[4] This survey was commissioned by the Central Bank of Ireland and was carried out by ipsos MRBI on behalf of the bank. Further details on the survey are provided in the Appendix.

[5] Almost 9 out of 10 respondents gave permission for their survey information to be linked to their administrative data. We present an overview of the unlinked portion of the sample in Table 13 in the appendix.

where g is the recall error of household i, h_i^A is the actual price paid by the household to purchase its property, taken from the administrative loan-level dataset, and h_i^R is the house purchase price recalled by the household in the survey.

In Figure 1 we plot the distribution of both the error and the error as a percentage of actual house prices, while summary statistics of the errors are presented in Table 3. The error measures are skewed to the left indicating that most households are inclined to *understate* the true purchase price of their property. On average, we find that borrowers understate their house purchase price by 18.9 per cent. In a somewhat related piece of work, Benitez-Silva et al. (2010) use survey data from the Health and Retirement Study in the US to examine households' reported and actual property *selling* prices. They find that households tend to overestimate the selling price of their homes. Similarly Agarwal (2007) studies a sample of US borrowers who provide an estimate of their *current* property price to their financial institution when applying for a rate or cash-out refinance loan. He finds that borrowers on average tend to overstate the current value of their home by 3.1 per cent, but borrowers who under-estimate their current value do so by an average of 12.2 per cent. Of course, recalling a recent selling price or estimating a current valuation can involve a shorter recall time relative to recalling the original purchase price of one's property.

It is also clear that a subset of respondents make substantial errors in recalling their house purchase price (as shown in the right hand side chart in Figure 1). Specifically, there are 42 observations where the error is greater than 90 per cent of the true house purchase price.[6] In Section 4 we examine the relationship between the recall error, household characteristics and housing market developments.

3.1 Baseline model and comparison of wealth effects

To demonstrate the attenuation effect of the recall error, we estimate a standard reduced-form specification relaying household consumption to the household's actual house price, income level and a series of controls for household characteristics. The model, which is also estimated in McCarthy and McQuinn (2013), can be summarised in a cross-sectional sense as follows, where lower case denotes logs:

[6] As a robustness check in all of the analysis that follows, we remove these observations from the sample but find no substantial differences in our results. These results are available from the authors on request.

$$c_i = \beta_0 + \beta_1 h_i + \beta_2 y_i + \Sigma_{j=3}^{n} \beta_j \phi_{i,j} + \epsilon_i \quad (2)$$

c_i is household $i's$ annual consumption on all goods and services (excluding mortgage and other debt repayments)[7] , h_i is the current house price for household i, y_i is annual household income and $\phi_{i,j}$ are controls for household characteristics.

Note this specification is adopted to highlight the impact of bias when recall prices are used as the estimate of housing wealth. For example, we do not apply the more recent approach of Campbell and Cocco (2007) and Disney et al. (2010) who distinguish between expected and unexpected house price movements, although our findings would have implications for this distinction.

Table 4 provides a full overview of the independent variables used in the model. To control for household characteristics, we include variables capturing the number of people in the household as well as the gender, age, marital status, educational attainment and employment status of the main mortgage contributor. While our survey does not capture information on the euro amount of financial wealth holdings, we do know if households have savings or investments, so we include a dummy variable capturing this information in the regression.[8]

In the initial baseline estimation we use the actual house purchase price (h_i^A) (as reported in the loan level data) at the point of loan origination for h_i. In particular, we take this price and then "forecast" the data forward to the present using official regional house price data.[9] The results are presented in Table 5. From the table, we can see that the coefficient on house prices is 0.134, which, given the log-log estimation, is the elasticity of consumption with respect to housing wealth. As noted by McCarthy and McQuinn (2013), this estimate for the mean household is quite large when compared with other cross-country approaches. For example, Sierminska and Takhtamanova (2007), in a cross-country study, comment on the relatively high estimates of 0.123 and 0.135 for Canada and Italy respectively, so this result for the Irish market would appear to be

[7] To capture household consumption, respondents were presented with the following question: *Thinking of total household spending on all goods and services, but excluding mortgage and other debt repayments, how much would you say that your household spends in an average month? Please include spending on groceries, household utilities, clothing and footwear, travel expenses, childcare expenses, socialising, etc.*

[8] Specifically, we generate a dummy variable that captures people who save regularly, receive any income from savings or investments, or who report that they have savings or investments that they can use in financial difficulties.

[9] See the Appendix for further details. Of course, if there is a significant difference between the actual increase in price and that of the regional price indicator used, this would introduce another source of bias into the housing wealth estimates.

at the high end of the international spectrum.[10]

Over the same sample, we now re-estimate (2), this time using the recall price from the survey, (h_i^R), as opposed to the actual price in the loan level data for the household concerned. The recall prices are also forecasted forward using the same methodology applied to the actual house price. The results are in Table 6. It is clear that the wealth effect (0.038) has been reduced considerably with the re-estimated elasticity based on the recall price less than a *third* of the original effect.[11]

Given that we have the actual recall error, we also calculate the degree of attenuation bias with the familiar statistic:

$$plim\ \widehat{\beta_1} = \beta_1 - \beta_1 \frac{\sigma_g^2}{\sigma_{h^A}^2 + \sigma_g^2}. \tag{3}$$

where g is the recall error, i.e. the difference between the actual and recall price. Using (3) we calculate the attenuated coefficient as 0.040 - slightly larger than the 0.038 estimated in Table 6. The difference may be explained by the violation of the assumption that classical measurement/recall error is uncorrelated with the true variable i.e. $\rho(h^A, g) = 0$. We find a correlation of 0.46 between the actual house price and the error, therefore, attributing all of the attenuation bias in Table 6 to measurement/recall error is an overstatement of the effect as some of the bias is due to the positive correlation. Portela et al. (2010) demonstrate that, in the presence of such correlation, the expression for attenuation bias should be expanded to $plim\ \widehat{\beta_1} = \beta_1 - \beta_1 \frac{\sigma_g^2}{\sigma_{h^R}^2} - \beta_1 \frac{\sigma h^A, g}{\sigma^2 h^R}$ where h^R is the reported/recalled house price. The term $\frac{\sigma h^A, g}{\sigma^2 h^R}$ is added as it has implications for the estimate of the bias based on the degree of correlation between the measurement error g_t and the true house price h_t^A. It could also be the case, however, that the difference between 0.04 and 0.038 is due to sampling variability as the result in (3) is an asymptotic result and not a finite sample one.[12]

Nonetheless, the corrected estimate, based purely on measurement/recall error, is still only 30 per cent of the true wealth effect presented in Table 5. Clearly, using subjective estimates of house prices in the presence of such measurement error has significant implications for the associated wealth effect.

[10] Many housing wealth studies prefer to use the marginal propensity to consume (MPC) concept as a point of comparison. McCarthy and McQuinn (2013) argue for the use of the elasticity in the Irish context. The MPC associated with the 0.134 coefficient is 0.01.

[11] The associated MPC is now 0.004.

[12] We are grateful to an anonymous referee for this observation.

This degree of correction has significant implications when one considers the growing array of studies estimating housing wealth effects with survey data. Table 7 summarises some of these estimates along with their findings for wealth effects or the marginal propensity to consume (MPC) out of housing wealth. From the table, it can be seen that, in general, wealth effects would appear to be quite small based on both the MPC and the elasticity measures, however, the elasticity values can vary quite a lot. As can also be seen, many of the indicators of housing wealth used in these studies are self-reported house prices, thereby, potentially exposing the estimates to attenuation bias due to recall error. In the next section, we examine the nature of the measurement/recall error in more detail.

While some studies, such as Christelis et al. (2011), argue that the perceived rather than the actual price should be used in such consumption studies despite the fact that "in some cases the perceived losses might not reflect exactly the actual asset price movements", we argue that, particularly when a household is seeking credit, the actual price, where available, is the relevant variable. If a mortgaged individual approaches a financial institution with a view to securing more funding for consumption purposes, it is the actual house price as opposed to the perceived price which would be considered for collateral purposes by the institution. Households may also display greater accuracy about their house price, when confronted by a consumption decision as opposed to a survey question.

3.2 Robustness checks

It is plausible that household consumption may respond to housing wealth at the *beginning* of the period of analysis rather than to the current value of housing wealth. Muellbauer (2007), for example, contains a discussion of this issue in considering appropriate consumption functions for estimating wealth effects. As a robustness check of the results in Tables 5 and 6, we therefore re-run the regressions replacing both the current actual house price and the current survey house price with its equivalent one-year lag. The results are broadly unchanged; the coefficient on the actual house price lagged is 0.14 and 0.04 in the case of the survey house price.

A common criticism of the analysis of wealth effects is that it suffers from endogeneity bias, i.e. house prices and consumption could be related to *expected* future income rather than current income. To control for this, we replace household income in Tables 5 and 6 with its expected

value. We follow the recent literature (Himmelberg et al. (2005) and Duca et al. (2011), for example) and proxy for expected income using the average of the lagged levels of income over the previous four year period (see A.2 in the Appendix for further details). The results, which are available in Tables 8 and 9, reveal little differences relative to those reported in Tables 5 and 6.

4 Modelling recall error

To better understand the nature of the recall error, we plot the absolute value of the error amount against key variables in the dataset. In Figure 2, we plot the error against actual house prices and loan seasoning. The first chart shows a positive relationship between the error amount and the actual house price, suggesting that as house prices increase, the size of the recall error also increases. Loan seasoning captures the number of months since the loan was originated. Again, there appears to be some evidence of a positive relationship between the two; as loan seasoning increases, i.e. as the recall period lengthens, the size of the recall error tends to rise.

In Figure 3, we plot the distribution of the absolute value of the error across different groups in the sample. In general the differences in groups do not appear stark. However, a slightly higher proportion of the younger, more highly educated and employed groups make no error in recalling the purchase price of their property, relative to their counterparts. In the next section, we examine if these patterns remain in a multivariate setting when we control for the various factors that might impact the recall error.

4.1 Recall price and price uncertainty

Why might households have such difficulty in recalling the original price paid for their properties? While individual household characteristics will obviously impact on the recall performance, there may also be factors germane to the Irish property sector which affect households' performance in this regard. For example, the Irish market experienced very high house prices, particularly in the period up to 2007. Figure 4 presents a plot of actual Irish house prices from 1990 to 2012 - the sharp increase in prices from 1998 is readily apparent. Consequently, the scale of recall error could be a function of the initial house price.

Two further factors that may impact the recall error include the loan seasoning variable and the volatility of house price movements. On the one hand, the further back a household has to recall,

and the more volatile house prices are over the period, the greater the potential for error in the house price subsequently cited. On the other hand, however, the stock of mortgages in Ireland is relatively young, especially when compared with other euro area countries. For example, up to 40 per cent of the current stock of Irish mortgages was issued between 2004 and 2007.

We examine the importance of these factors, along with other potential determinants of the household's recall error, in a more formal context by regressing the error on the original house price, (h_i^A), an indicator of recent house price variance for the region in which the household resides, (var_i), a seasoning variable, ($season_i$), denoting the number of months since the house was purchased, and the same set of household controls, ($\phi_{i,j}$), used earlier in (equation 2). For the variance of house prices, we calculate the change in house prices in the household's county over the period 2006 quarter 4 to 2012 quarter 1.[13] This results in the following model:

$$|g_i| = \alpha_0 + \alpha_1 h_i^A + \alpha_2 var_i + \alpha_3 season_i + \Sigma_{j=4}^{n} \alpha_j \phi_{i,j} + \xi_i. \tag{4}$$

where $|g_i|$ is the *absolute* value of the errors. As is evident from Figure 1, g_i is not normally distributed, therefore, we use a quantile regression approach where the estimation takes place at the median as opposed to the mean.[14] The results from the model are presented in Table 10.

The results show that a number of factors are important determinants of a respondent's recall error. Firstly, in terms of the variables capturing general market conditions, as expected, the actual house price has a positive impact on the scale of the error and this result is highly significant. Both the variance of house prices and loan seasoning have a positive impact on the recall error, however, these effects are not significant.[15] In terms of household characteristics, it would appear that, even controlling for the seasoning effect, younger households are better able to recall the price paid for their property. This result mirrors that of Agarwal (2007), who finds that older borrowers are more likely to make an error in estimating their current house price. Education is also important; individuals with a third level degree tended to report a recall error of about €17,000 less than their counterparts with a lower level of education. Finally, households with a

[13] The regional house price data were kindly supplied by Ronan Lyons of daft.ie and are available for each of the twenty six counties in the Irish Republic. The house prices are then matched to households from the particular county in question.

[14] We also model the error at the 25th and 75th percentile of the distribution. The results, which are available in Section C of the Appendix, are similar to those presented here.

[15] We tried including a quadratic term on the seasoning variable in the model, but this was not significant.

higher level of income are associated with lower recall error. This finding is in keeping with the literature on financial planning and financial awareness which shows that the propensity to plan (financially) increases with income and wealth levels (see Lusardi and Mitchell (2005) or Ameriks et al. (2003) for examples).

Notwithstanding the importance of the original house price, the relevance of household specific factors in affecting the scale of the error would suggest that these findings are quite likely to be observed in other housing markets.

4.2 An alternative error structure

In the previous section, we assumed that the recall error was additive in nature, i.e. $h_i^R = h_i^A + g_i$. However, it is also possible that the recall error is some proportion of the actual / true house price - in other words, the recall error could have a multiplicative structure instead of an additive one.[16] In this case, the recall error, $\hat{g}_i$, can be represented as: $h_i^R = h_i^A * \hat{g}_i$, where $\hat{g}_i$=$(1 + \frac{h_i^R - h_i^A}{h_i^A})$.[17] In this section, we assess the importance of the independent variables for this form of the recall error. Specifically, we estimate the following model, where the dependent variable is equal to $\hat{g}_i$-1, or the proportion of the actual house price accounted for by the error:

$$\left|(\frac{h_i^R - h_i^A}{h_i^A})\right| = \alpha_0 + \alpha_1 h_i^A + \alpha_2 var_i + \alpha_3 season_i + \Sigma_{j=4}^{n} \alpha_j \phi_{i,j} + \xi_i . \quad (5)$$

The results, which are shown in Table 11, are consistent with those for the additive error structure. In this context, the original house purchase price, household income, age and education remain important determinants of the error term. Specifically, a €10,000 increase in the original house purchase price raises the error by 0.4 percentage points while a €10,000 increase in household income raises the error by 1.1 percentage points.

[16] We are grateful to an anonymous referee for pointing this out.

[17] In terms of the implications for the degree of attenuation bias in the earlier estimate of β_1 in the consumption equation (2), the degree of attenuation is very often broadly similar under the two different error structures, however, in some circumstances, it can be shown that the scale of attenuation may be larger with a multiplicative error structure (see Cameron and Trivedi (1998) for a discussion of this issue).

5 Conclusions

The interaction between the housing market and the broader economy has assumed an increased importance over the past 10 years. The fluctuations observed in house prices across certain OECD countries are likely to have had significant impacts on key macroeconomic variables such as consumption and investment. Consequently, an increasing number of studies, particularly, at a micro level, are concerned with estimating the consumption wealth effect out of housing.

Using unique survey and bank level prudential data, this paper has highlighted a potentially serious problem with certain survey based approaches to this issue. In the case of the Irish property market, it would appear that mortgaged households have considerable difficulty in accurately recalling the actual house price paid for their property. As most survey based approaches rely on a household's subjective view of its house price as an estimate of housing value, this may lead to significant measurement error and consequent attenuation bias in the estimated wealth effect.

In an Irish context, were the recall price to be used as the indicator of housing wealth, then the resulting wealth effect would be over 70 per cent less than that estimated with the actual price. The error itself would appear to be both a function of market conditions and individual household characteristics with the scale of house price movements being a particularly important factor. Therefore, survey data in housing markets which have experienced significant house price appreciation would appear to be most susceptible to this bias.

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A Creation of Variables from Loan-Level Dataset

The analysis in this paper relies, in part, on variables that are generated from the loan-level data (described previously). Here we detail precisely how these variables are calculated.

A.1 Current house price

The loan-level dataset includes the value of the house for which the original mortgage was taken out as well as the valuation date. The current house price (P_t) is calculated as follows:

$$P_t = P_0 \times \frac{\overline{P}_t}{\overline{P}_0} \tag{6}$$

where P_0 is the latest valuation of the property, and $\frac{\overline{P}_t}{\overline{P}_0}$ is the change in the average value of 'similar' properties between *t=0* and *t=t*.

For loans originating from 2003 onwards, we use the CSO property price index to calculate the change in house prices over time. We match 'similar' properties on the basis of region (Dublin and non-Dublin) and type (house, apartment, other). For loans originating prior to 2003 we use the ptsb/ESRI house price index, which has a similar geographic breakdown as the CSO price index, but not a similar breakdown by property type. We therefore apply the ptsb/ESRI price index changes to all house-types.

A.2 Expected Income

The dataset that we use in the current analysis includes only the current gross income for each household in 2012. To calculate expected income in 2012 for household i, we follow the recent literature such as Himmelberg et al. (2005) and Duca et al. (2011) who argue (in the case of house prices) that expected values can be tracked by lagged values over the previous five and four years respectively. We therefore proxy for expected household income in 2012 using the average of the annual values over the 2008-2011 period.

Since our dataset does not include the value of household income in previous years, we calculate this by backcasting the current value of household income (in 2012) by the annual growth rate of household income in the region in which the household resides. These annual growth rates are available from the Irish Central Statistics Office (www.cso.ie) under the heading "Total Household Income by County and Region and Year".

B The survey of mortgage holders

The survey used in the present study was conducted by ipsos MRBI on behalf of the Central Bank of Ireland. The primary purpose of the survey was to collect up-to-date information on a mortgage holder's financial position, which could be appended to the mortgage loan level information held by the Central Bank for the three main Irish financial institutions (AIB, BOI and ILP). The survey was designed to be representative of the loan books of the three main institutions along five dimensions: lender type, borrower type, interest rate type, arrears and county of residence.

A two-stage sampling approach was used for the selection of cases for interview. In the first stage, representative clusters were formed from the loan-level data. In the second stage, clusters were randomly selected for interview. The total sample size achieved was 2,086 households. The survey included questions in the following categories:

1. Mortgage background, including questions on the contributors to the mortgage repayment, the educational and employment characteristics of such contributors and details of unemployment where relevant.
2. Income and finances, including detailed questions on household income, recent income changes, details on household expenditures and questions on repayment difficulties where relevant.
3. Buy-to-lets and other financial holdings, details of institutions where borrowings and savings are held and questions on credit applications and rejections, and future expectations.
4. The mortgage arrears resolutions process (MARP), including questions on participation in the MARP process and the degree and nature of contact with the mortgage lender.

In order to maximise the number of participants who would allow the survey company to link their survey responses with administrative information in the loan level dataset, a detailed letter was sent in advance to each participant (authored by the Governor of the Central Bank of Ireland) which outlined that (a) the survey would be totally anonymous and (b) the details in the survey would only be used for research purposes and no information would be shared with any other agency outside of the Central Bank such as the Irish tax authorities or the respondents' commercial bank. Furthermore, the data from the survey were anonymised by the survey company before being transmitted to the Central Bank of Ireland. Respondents were made aware of this fact before agreeing to take part in the survey. They were also provided with a contact person at the Central Bank of Ireland who could confirm that the survey would be totally anonymous and who could answer any queries that the respondent might have about the survey. We believe that these factors should minimise the potential for deliberate misreporting on the part of survey respondents.

Almost 9 out of 10 survey respondents allowed for their survey information to be linked back to their administrative information contained in the loan-level dataset. We report the descriptive statistics for the unlinked portion of the sample in Table 13 below. The figures can be compared to those for the regression sample (reported earlier in Table 2). The unlinked sample contains a slightly larger proportion of single person households and households headed by individuals with less than tertiary level education. Reflecting the differing household composition, the median income and consumption of households in the unlinked sample is also somewhat lower than in the regression sample.

Despite these differences, it should be noted that the regression sample used in this paper matches closely to the demographics of the mortgaged Irish population as captured in other large-scale household surveys. For example, a recent nationally representative household survey, the Household Finance and Consumption Survey (HFCS), conducted by the Irish national statistical agency in 2013, and based on a sample of over 5,000 households, showed that 58 per cent of heads of mortgaged households in Ireland are aged less than 45 years.[18] This compares to 59 per cent in the regression sample used here. Furthermore, about 80 per cent of heads of mortgaged households are employed in the HFCS dataset as compared to 84 per cent in the regression sample. The HFCS dataset shows that 47 per cent of heads of mortgaged households have a college education; the corresponding figure in the regression sample is 45 per cent. Finally, the HFCS dataset shows that 1 adult households with no children account for 9 per cent of mortgaged households in Ireland. In the regression sample used in this paper, that figure is approximately 10 per cent. It is clear that the sample employed in this paper is demographically close to the Irish mortgaged population.

C Error Regression - Interquartile Results

We assess if the impact of the independent regressors (Equation (4)) on the recall error differs along the distribution of the recall error. In Table 12 we present the results from quantile regressions at the 25th and 75th percentiles. For comparison purposes we also include the median results from Table 10. Across all groups, the original house price is an important determinant of the error reported in house purchase

[18] See CSO (2015) for further detail.

prices. It has the most sizeable impact among the 75th percentile, where a one-unit increase in house prices leads to a 0.7 unit increase in the error variable. The age of the respondent is also important across the distribution; among all three groups, the size of the recall error increases with age. The income variable is only significant at the 50th percentile. Finally, respondents with a college education tend to report lower recall errors than individuals with lower education levels, but this result is only significant at the 50th and 75th percentiles of the error distribution.

Figure 1: Distribution of Recall Errors Across Sample

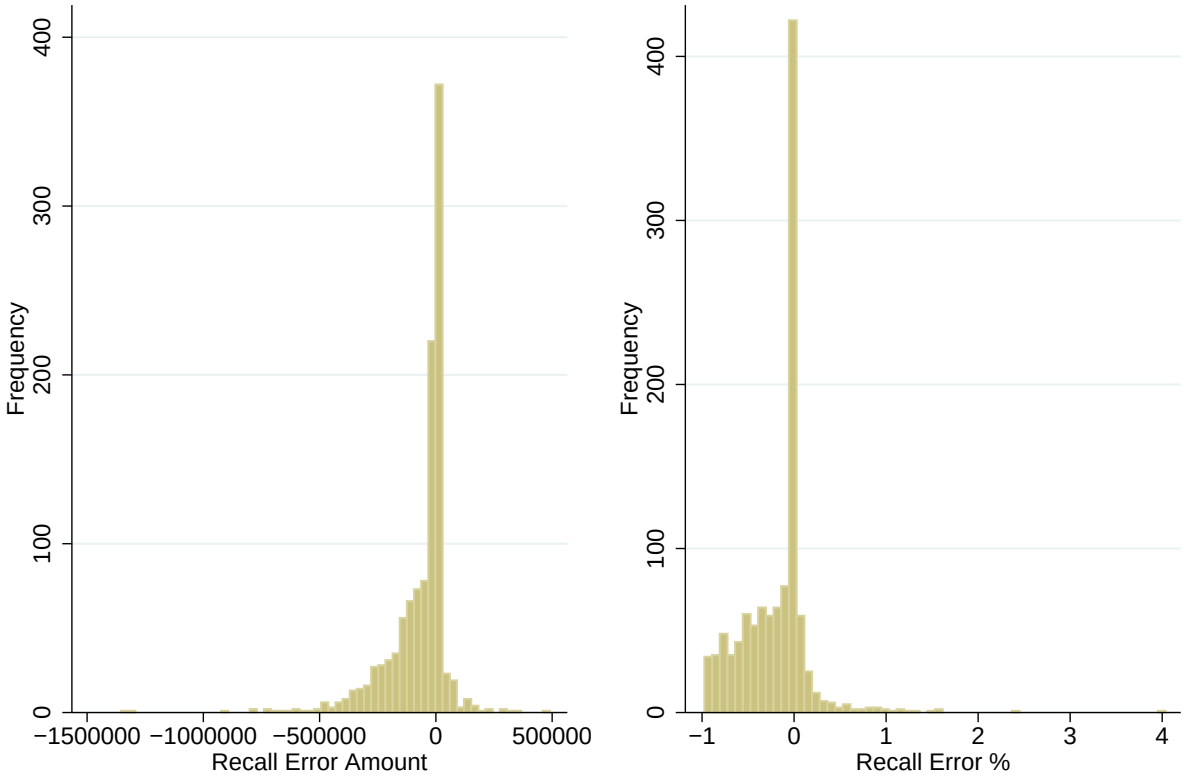

Table 1: Loan-Level Data Fields / Information Content

Unit Identifier	Borrower	Property	Loan	Interest Rate	Performance
Bank Borrower Property Loan	Borrower Type (FTB, BTL, etc.) Income Income Verified Credit Quality	Geographic Location Property Type New or Existing Original Valuation (and date) Original LTV Construction Year	Origination Date Original Loan Balance Current Loan Balance Loan Term Loan Purpose Current Repayment Payment Type Interest Rate Info. Performance Info.	Current Interest Rate Interest Rate Type Interest Rate Margin Rate Revision Date	Arrears Balance (June-2012) Arrears Balance for Past 12 months Collection Status Modification / Forbearance Flag

Notes: The above fields are not always populated in full.

Table 2: Demographic and economic characteristics of the sample, % of respondents unless otherwise stated

Variable		%
Age Group (years)	18-34	16.6
	35-44	42.4
	45-54	28.1
	55-64	10.9
	65+	2.1
Marital Status	Married / Couple	81.0
	Widowed/Separated	6.4
	Single	12.6
Work Status	Employed	84.3
	Unemployed	6.8
	Inactive	8.9
Education Status	Low	11.7
	Medium	43.9
	High	44.5
Household Composition	1 Adult, 0 kids	10.4
	2 Adults, 0 kids	14.9
	3+ Adults, 0 kids	6.7
	1+ Adults, with kids	59.6
	Other	8.4
Median Financial Data (€)	Income	55,000
	Consumption	15,300
	Current House Price	180,278
	Mortgage Outstanding	149,409
Negative Equity	% of Group	41.8
Any Arrears	% of Group	18.8
Has Savings/Investments	% of Group	60.1
N		1,133

Note: Low education includes individuals with a lower second level education or less. Medium education captures individuals with upper second level education and non-degree third level education. The high education category includes people with a third level degree. In terms of work status, the inactive category includes individuals who are retired, homemakers and students.

Table 3: Summary statistics of recall error

	g (€)	$\frac{g}{h^A}$ (%)
Mean	-70,960	-18.9
Standard deviation	139,988	38.0
Skewness	-2.72	1.64
Kurtosis	18.36	19.16

Table 4: Independent Variables

Variable	Description
h_i	Logged house price (at June-2012) for household i.
y_i	Logged gross annual income for household i.
$male$	Dummy variable indicating that the survey respondent is male.
$married$	Dummy variable indicating that the survey respondent is married.
$HH\ size$	Continuous variable indicating the number of people in the household.
$age : 18 - 34$	Omitted category - captures survey respondents who are aged between 18 and 34 years.
$age : 35 - 44$	Dummy variable indicating that the survey respondent is aged between 35 and 44 years.
$age : 45 - 54$	Dummy variable indicating that the survey respondent is aged between 45 and 54 years.
$age : 55 - 64$	Dummy variable indicating that the survey respondent is aged between 55 and 64 years.
$age : 65+$	Dummy variable indicating that the survey respondent is aged 65 years or more.
$college\ education$	Dummy variable indicating that the survey respondent has a high level of education (third level degree or above).
$unemployed$	Omitted category - captures respondents who are unemployed.
$employed$	Dummy variable indicating that the survey respondent is employed.
$retired/inactive$	Dummy variable indicating that the survey respondent is retired or inactive (student, stay at home parent, etc.).
$saves/invests$	Dummy variable indicating if the responding household has savings or investments.

Table 5: Baseline consumption regression - using actual house prices

Variable	Coefficient	Standard Error	P-Value
$constant$	3.760***	0.491	0.000
h_i	0.134***	0.040	0.001
y_i	0.329***	0.029	0.000
Additional Controls			
$male$	-0.007	0.031	0.814
$married$	0.066	0.049	0.179
$HHsize$	0.117***	0.015	0.000
$age: 35-44$	0.091**	0.044	0.039
$age: 45-54$	0.115***	0.047	0.014
$age: 55-64$	0.079	0.059	0.183
$age: 65+$	0.096	0.114	0.399
$college\ education$	-0.027	0.033	0.412
$employed$	0.084	0.065	0.192
$retired/inactive$	0.003	0.080	0.974
$saves/invests$	-0.013	0.033	0.687
N		1,133	
F(13, 1119)		38.55	
Prob>F		0.000	
Adj. R^2		0.3013	

Note: *** Significant at 1 per cent level; ** Significant at 5 per cent level; * Significant at 10 per cent level. Omitted categories for dummy variables are: age group 18-34 and unemployed.

Table 6: Baseline consumption regression - using recall house prices

Variable	Coefficient	Standard Error	P-Value
$constant$	4.718***	0.361	0.000
h_i	0.038	0.022	0.085
y_i	0.346***	0.029	0.000
Additional Controls			
$male$	-0.009	0.031	0.772
$married$	0.063	0.049	0.197
$HHsize$	0.123***	0.015	0.000
$age: 35-44$	0.100**	0.044	0.024
$age: 45-54$	0.144***	0.048	0.003
$age: 55-64$	0.116**	0.060	0.054
$age: 65+$	0.141	0.114	0.215
$college\ education$	-0.027	0.034	0.424
$employed$	0.081	0.065	0.210
$retired/inactive$	0.014	0.080	0.866
$saves/invests$	-0.013	0.033	0.692
N		1,133	
F(13, 1119)		37.64	
Prob>F		0.000	
Adj. R^2		0.2962	

Note: *** Significant at 1 per cent level; ** Significant at 5 per cent level; * Significant at 10 per cent level. Omitted categories for dummy variables are: age group 18-34 and unemployed.

Table 7: Summary of micro-survey based estimates of housing wealth effects

Study	Country	Data Sources	Measure of Housing Wealth	Reference Period	MPC	Elasticity
Attanasio et al (2005)	UK	Family Expenditure Survey (FES)	Regional house prices from the Office of the Deputy Prime Minister. Matched to households on the basis of region. Specifications include changes and levels of regional house prices.	1978 - 2001	-	0.04 - 0.21 (varies with age)
Bostic et al (2009)	US	Survey of Consumer Finances (SCF) and the Consumer Expenditure Survey (pooled cross-sections)	Self-reported home values.	1989 - 2001	-	0.06
Bover (2005)	Spain	Survey of Spanish Household Finances (EFF)	Self-reported home values (instrumented for in various specifications).	2002	0.01 to 0.02 (varies with age)	-
Campbell and Cocco (2005)	UK	FES Pseudo Panel	Regional house prices from Nationwide. Matched to households on the basis of region.	1988 - 2000	-	As large as 1.7 for older households
Disney et al (2003)	UK	British Household Panel Survey	Regional house price variation, sourced from Halifax Bank.	1993 - 1999	0.01 - 0.03	-
Engelhardt (1996)	US	Panel Study of Income Dynamics (PSID)	Self-reported home values less improvement value.	1984 and 1989	0.03 (median saver household) or 0.14 (mean saver household)	-
Lehnert (2004)	US	Panel Study of Income Dynamics (PSID)	Self-reported home values.	1968 - 1993	0.02 - 0.03 (varies with age)	0.04 - 0.05 (varies with age)
Levin (1998)	US	Retirement History Survey	Net equity in home (self-reported home values less outstanding mortgage).	1969 - 1979	-0.006 - 0.05 (varies with credit constraints). However, estimates are generally not significant.	-

Table 8: Robustness Check: Consumption regression - using actual house prices and expected income

Variable	Coefficient	Standard Error	P-Value
$constant$	3.742***	0.492	0.000
h_i	0.134***	0.040	0.001
$expected\ y_i$	0.330***	0.029	0.000
Additional Controls			
$male$	-0.006	0.031	0.836
$married$	0.067	0.049	0.172
$HHsize$	0.116***	0.015	0.000
$age: 35-44$	0.091**	0.044	0.039
$age: 45-54$	0.116***	0.047	0.014
$age: 55-64$	0.083	0.059	0.161
$age: 65+$	0.096	0.114	0.398
$college\ education$	-0.029	0.033	0.387
$employed$	0.084	0.065	0.193
$retired/inactive$	0.002	0.080	0.981
$saves/invests$	-0.012	0.033	0.710
N		1,131	
F(13, 1117)		38.56	
Prob>F		0.000	
Adj. R^2		0.3017	

Note: *** Significant at 1 per cent level; ** Significant at 5 per cent level; * Significant at 10 per cent level. Omitted categories for dummy variables are: age group 18-34 and unemployed.

Table 9: Robustness Check: Consumption regression - using recall house prices and expected income

Variable	Coefficient	Standard Error	P-Value
$constant$	4.694***	0.362	0.000
h_i	0.039*	0.022	0.082
$expected\ y_i$	0.347***	0.029	0.000
Additional Controls			
$male$	-0.008	0.031	0.794
$married$	0.065	0.049	0.186
$HHsize$	0.122***	0.015	0.000
$age: 35-44$	0.100**	0.044	0.024
$age: 45-54$	0.145***	0.048	0.002
$age: 55-64$	0.120**	0.060	0.046
$age: 65+$	0.141	0.114	0.216
$college\ education$	-0.029	0.034	0.397
$employed$	0.081	0.065	0.210
$retired/inactive$	0.013	0.080	0.873
$saves/invests$	-0.012	0.033	0.717
N		1,131	
F(13, 1119)		37.67	
Prob>F		0.000	
Adj. R^2		0.2967	

Note: *** Significant at 1 per cent level; ** Significant at 5 per cent level; * Significant at 10 per cent level. Omitted categories for dummy variables are: age group 18-34 and unemployed.

Table 10: Recall error regression estimates

Variable	Coefficient	Standard Error	P-Value
$constant$	-20032.450	50673.200	0.693
h_i^A	0.349***	0.033	0.000
var_i	747.749	768.669	0.331
$season_i$	76.322	122.226	0.532
y_i	-0.285**	0.146	0.051
Additional Controls			
$male$	-1785.884	9526.473	0.851
$married$	-13338.850	14858.090	0.370
$HHsize$	4269.061	4554.730	0.349
$age: 35-44$	17361.050	13714.440	0.206
$age: 45-54$	54002.740***	14975.960	0.000
$age: 55-64$	54165.580***	18980.860	0.004
$age: 65+$	57031.960*	34928.940	0.103
$college\ education$	-17123.500*	10224.720	0.094
$employed$	10062.950	18955.840	0.596
$retired/inactive$	14237.080	24183.870	0.556
N		1,132	
Pseudo R^2		0.1166	

Note: *** Significant at 1 per cent level; ** Significant at 5 per cent level; * Significant at 10 per cent level. Omitted categories for dummy variables are: age group 18-34 and unemployed.

Table 11: Recall error regression estimates - multiplicative error structure

Variable	Coefficient	Standard Error	P-Value
$constant$	0.168	0.144	0.246
h_i^A	0.004***[1]	0.000	0.000
var_i	0.003	0.002	0.125
$season_i$	-0.000	0.000	0.791
y_i	-0.011***[1]	0.000	0.011
Additional Controls			
$male$	0.000	0.027	0.990
$married$	-0.010	0.042	0.813
$HH\ size$	0.015	0.013	0.248
$age: 35-44$	0.045	0.039	0.249
$age: 45-54$	0.177***	0.043	0.000
$age: 55-64$	0.207***	0.054	0.000
$age: 65+$	0.193**	0.099	0.052
$college\ education$	-0.072**	0.029	0.014
$employed$	0.045	0.054	0.410
$retired/inactive$	0.102	0.069	0.138
N		1,132	
Pseudo R^2		0.0860	

Note: [1]The coefficients on h_i^A and y_i have been re-scaled by 10,000. *** Significant at 1 per cent level; ** Significant at 5 per cent level; * Significant at 10 per cent level. Omitted categories for dummy variables are: age group 18-34 and unemployed.

Table 12: Recall error regression estimates (quantiles)

Variable	25th percentile Coefficient	25th percentile Standard Error	50th percentile Coefficient	50th percentile Standard Error	75th percentile Coefficient	75th percentile Standard Error
$constant$	6290.182	12379.243	-20032.451	50673.200	-57013.188	50884.737
h_i^A	0.016**	0.008	0.349***	0.033	0.712***	0.033
var_i	124.903	187.782	747.749	768.669	1075.263	771.877
$season_i$	-22.883	29.859	76.322	122.226	127.141	122.736
y_i	-0.046	0.036	-0.285**	0.146	-0.224	0.146
Additional Controls						
$male$	-1069.912	2327.276	-1785.884	9526.473	-4688.070	9566.241
$married$	778.250	3629.768	-13338.850	14858.090	-2071.247	14920.119
$HHsize$	319.392	1112.701	4269.061	4554.730	5822.393	4573.744
$age: 35-44$	2208.441	3350.379	17361.050	13714.440	31026.097*	13771.695
$age: 45-54$	7905.670**	3658.563	54002.740***	14975.960	79147.559***	15038.480
$age: 55-64$	11059.917**	4636.942	54165.580***	18980.860	89306.288***	19060.098
$age: 65+$	20102.749**	8532.988	57031.960*	34928.940	86372.671***	35074.751
$college\ education$	-3058.157	2497.854	-17123.500*	10224.720	-34041.506***	10267.400
$employed$	2695.341	4630.829	10062.950	18955.840	14436.807	19034.970
$retired/inactive$	2732.643	5908.014	14237.080	24183.870	18814.514	24284.825
N	1,132		1,132		1,132	
Pseudo R^2	0.0124		0.1166		0.3063	

Note: *** Significant at 1 per cent level; ** Significant at 5 per cent level; * Significant at 10 per cent level. Omitted categories for dummy variables are: age group 18-34 and unemployed.

Table 13: Demographic and economic characteristics of the unlinked sample, % of respondents unless otherwise stated

Variable		%
Age Group (years)	18-34	14.5
	35-44	43.8
	45-54	22.9
	55-64	15.3
	65+	2.4
Marital Status	Married / Couple	75.5
	Widowed/Separated	5.2
	Single	18.9
Work Status	Employed	87.6
	Unemployed	4.0
	Inactive	8.4
Education Status	Low	11.2
	Medium	51.4
	High	35.7
Household Composition	1 Adult, 0 kids	18.1
	2 Adults, 0 kids	20.9
	3+ Adults, 0 kids	9.2
	1+ Adults, with kids	49.0
	Other	2.4
Median Financial Data (€)	Income	45,000
	Consumption	11,700
	Current House Price	n/a
	Mortgage Outstanding	n/a
Negative Equity	% of Group	n/a
Any Arrears	% of Group	n/a
Has Savings/Investments	% of Group	49.4
N	249	

Note: Low education includes individuals with a lower second level education or less. Medium education captures individuals with upper second level education and non-degree third level education. The high education category includes people with a third level degree. In terms of work status, the inactive category includes individuals who are retired, homemakers and students.

Figure 2: Absolute Error Amount

by Actual House Price and Loan Seasoning

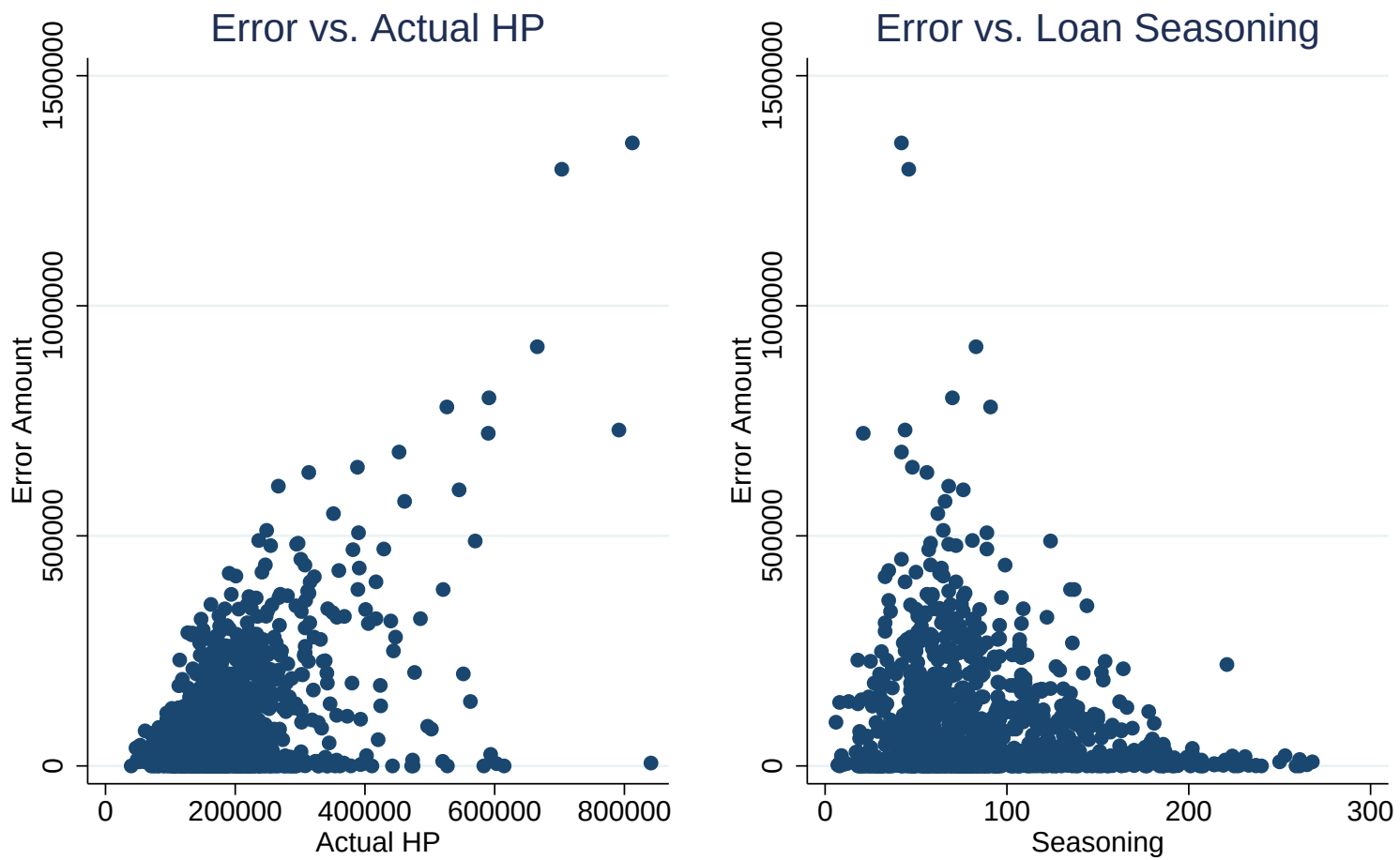

Figure 3: Absolute Error Amount, by Groups

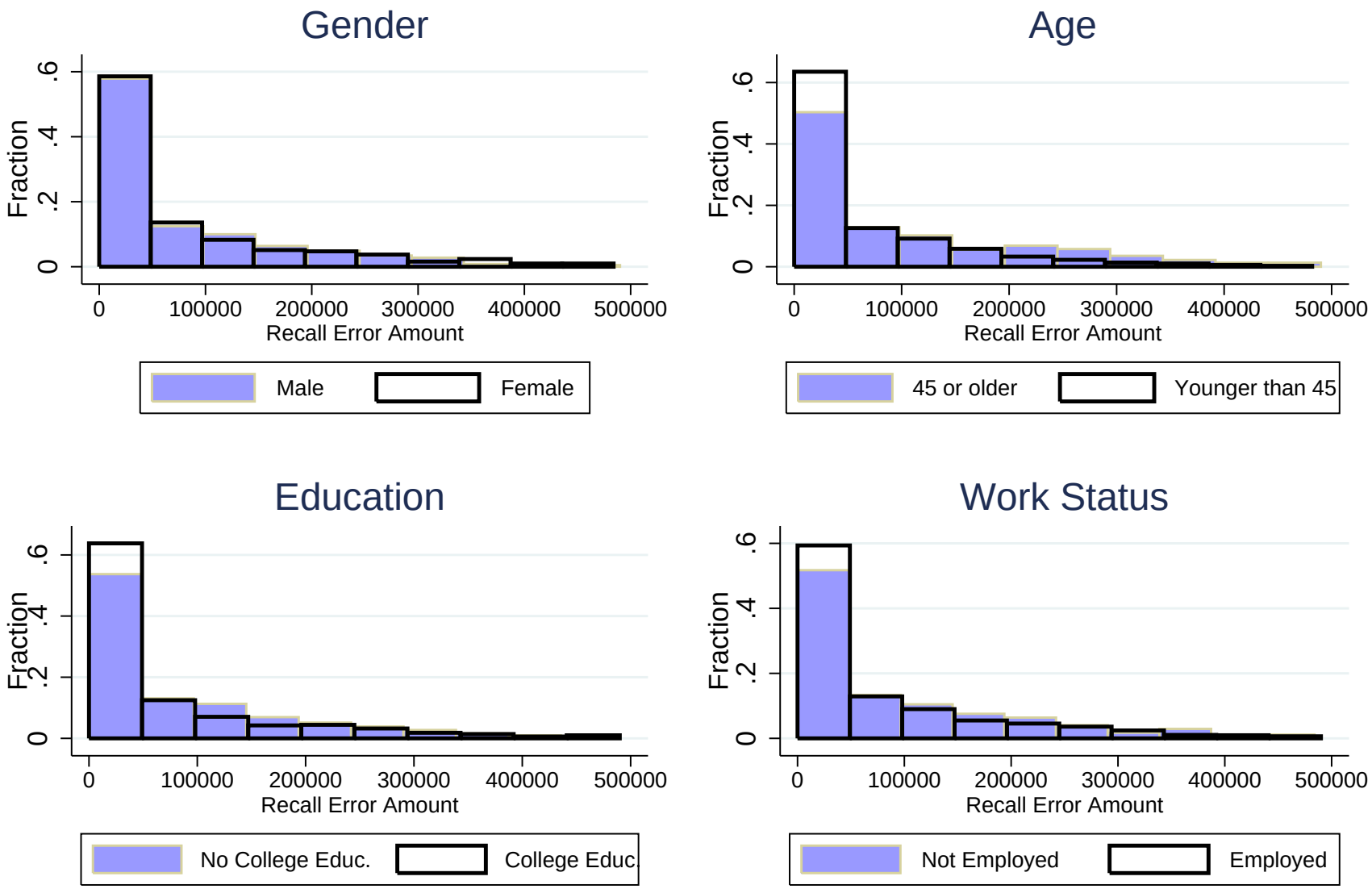

Figure 4

Irish house prices (nominal): 1990 - 2012