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Designing a property tax without property values: Analysis in the case of Ireland

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Abstract: We examine the implications of using hedonic regressions of house values as the basis for property tax assessment in the Republic of Ireland. Ad valorem property taxes are more equitable than flat rate taxes, but their equity benefits can be reduced if the relative values of dwellings are inaccurately assessed. Achieving greater accuracy in assessment tends to increase administrative costs, so policymakers face a trade-off between cost and accuracy. Using the Irish National Survey of Housing Quality of 2002, this study analyses the contribution that information about selected property characteristics can make to determine the relative values of residential properties in Ireland. These characteristics are the location of the dwelling, house size in square meters, the number of rooms and bedrooms in the home, the age of the house and the type of dwelling. The values of residential properties are estimated using these variables in turn and the prediction errors are presented in terms of the absolute value error and the assessment ratio (the estimated value divided by the market value). We find that it is possible to assign approximately 80% of houses nationally within the correct tax valuation band using just one of five house characteristics. Households whose house price is under assessed tend to be those with the greatest means (highly skilled professionals and high income earners), so a tax assessment system based on this type of valuation would tend to make regressive errors (while a property tax itself is regressive too). Consequently, checks would need to be put in place in order to more accurately estimate very highly priced properties as well as introducing exemptions for lower value properties and low income groups. The system could also be used to identify likely mis-reporting if using a self-assessment system.

Keywords: Property tax, Ireland, Hedonic regressions

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1. Introduction

The collapse in house prices in Ireland over the past three years has resulted in a much thinner property market with owners waiting for house prices to increase before selling and buyers waiting for prices to drop further before buying. The thin property market has had a direct effect on the tax yield from property in Ireland, as the main source of revenue in this area is a transactions based tax: stamp duty.

The Commission on Taxation Report of 2009 recommended the implementation of a property tax. In the first instance, the Commission suggests, house values under a property tax scheme should be self-assessed. The report also recommends that a national register of house prices should be established. The latter suggestion was recently taken up by the government but it will still require time and a lot of resources to establish a full dataset of dwelling prices.

In addition to self assessment and in advance of developing a national house price register, we suggest that hedonic methods can efficiently assign most residences to the correct tax bands. Indeed, hedonic methods are widely used as part of the valuation process in systems where property values are assigned by a valuation agency (McCluskey et al., 1997). In this paper we evaluate how closely one can predict house prices by using simple hedonic regression analysis, using readily available and verifiable variables. This study looks at whether or not it is possible to classify house values for taxation purposes in a manner that depends on more stable and robust criteria than the latest transactions on the housing market. How much information on a home would be required in order to accurately predict into which tax band this home falls? Could a system of this type be used to identify potential mis-reporting by home-owners through targeted audits?

Hedonic analysis decomposes the price of a good or service (a house in this case) into its components. With information on the structural characteristics of a dwelling, its precise location and neighbourhood characteristics, it is possible to closely predict the price of a home. The trade-off in this case is between more information (which is

administratively costly) and more accurate predictions, versus less information but more inaccurate predictions.

We study the errors in the predictions depending on the different explanatory variables used (area, rooms, age, dwelling type), the number of variables used and who they affect the most (by age groups, income groups, region). That is, we do not aim for the "perfect" regression model. Rather, we use a regression model that is deliberately simple: the kind that may be used by the tax authorities because of its transparency and robustness. We then study the patterns in the forecast errors of the simple regression, and test whether these errors correlate with distributional variables. We look at the absolute value of the errors in euro as well as the "assessment sales ratio" a measure developed by the International Association of Assessing Officers (IAAO), which indicates whether the valuation system produces errors which are progressive or regressive. Further aspects of the equitability of the different valuations are examined using a dispersion coefficient.

Property taxes existed previously in Ireland but due to the high number of exemptions only a very small proportion of households were taxed. Research on the design of a new property tax in the country has recently been published. Callan et al. (2010) look at how a property tax in Ireland could be designed in order to take account of ability to pay. They highlight the issues regarding which tax base is used (all land, owner-occupied, all residential) and how to set tax rates. They focus on the design of the tax and use the Economic and Social Research Institute's tax benefit model to estimate the distributional impact on household incomes for a given overall tax revenue target. The model also allows the examination of the effect of exemptions for poorer households. They find that even if the poorest households in the Republic were to be exempt it would still be possible to raise close to 1 billion euro a year. The provision of an income exemption limit, marginal relief as well as income-related reliefs would safeguard those on lower incomes. The present study looks at how the property *valuations* would be estimated and the consequences of different valuation methods on tax equity.

The remainder of this paper is set out as follows. Section 2 presents some background statistics on the housing sector during the Celtic Tiger and the current fiscal system relating to property in Ireland. Section 3 describes the Commission for Taxation recommendations in detail as well as the features of the previously existing property tax in Ireland. Section 4 reviews the literature in the area of property tax design,

property assessment as well as errors in assessment and studies on property tax equity issues. Section 5 presents the different methodologies used to predict house prices and evaluate the accuracy of the predictions that are used in this paper. Section 6 provides an overview of the data used in the analysis while Section 7 presents the results. Finally, Section 8 provides a discussion and conclusions.

2. The Irish housing market and fiscal system

The Celtic Tiger years in Ireland were characterised by rapid and sustained income growth. Increasing disposable incomes and a culture of home ownership resulted in massive increases in property prices as investors bought multiple properties, home owners sought to upgrade and first time buyers tried to get on the property ladder. As shown in Figure 1, average national house prices increased from €65'000 to €323'000 between 1990 and 2007. But, as is also clear from Figure 1, this rapid growth came to a sudden end that year.

In Ireland, property features in the taxation system in a number of ways. Capital gains tax is paid on the gains made from the disposal of assets including property, although principal private residences are excluded from this tax as it is aimed at investors. Capital acquisitions tax applies to property that is inherited or gifted. Property also features in relation to income tax through mortgage interest relief. Home owners receive tax relief in relation to their mortgages for a set number of years. In 2009 the government introduced a tax on second homes which was a flat rate tax of 200 euro on all non primary residences. The most important property related tax in Ireland over the last ten years and the main source of tax revenue from residential property during the boom years has been stamp duty.

Stamp duty is a transactions tax and is paid to the government at the sale of a property. The rules regarding the incidence of stamp duty did change over the course of the Celtic Tiger years but overall the level of duty to be paid was based on the value of the home and exemptions were made for first time buyers and purchases of second hand properties. Stamp duty receipts were very high during the boom years as the number of sales grew and prices rose. As is shown in Figure 2, property as a percentage of total stamp duty grew steadily over the period and stamp duties from

residential property resulted in 1.3 billion euro in tax revenue to the Exchequer in 2006.

One downside of using stamp duty as the main source of tax revenue on property is that receipts from it tend to be volatile and procyclical. When the current property market slump took hold in 2007 and the number of transactions fell dramatically, this had an immediate effect on tax revenues. The OECD (2009) stated that "tax revenues became too dependent on construction and housing transaction-related receipts as the market boomed". In one year alone (2006-2007) stamp duties from residential property fell by 300 million euro. The now relatively stagnant property market has resulted in a huge shortfall in tax revenue for the government which, combined with the reductions in tax revenue due to the recession is problematic. Consequently, the government has rightly decided to move away from stamp duty in favour of a more stable property tax.

A property tax is a tax on owners of property and can be levied as a flat rate (i.e. all owners pay the same amount for each property) or as an *ad valorem* tax (i.e. based on the value of the property). Receipts from such taxes tend to be more stable than stamp duty as they are based on the value of the housing stock and not on the flow of transactions. They may also decrease speculation and vacancy rates as people do not want to pay taxes on empty properties. A property tax can help lower transactions costs when purchasing property (as it would replace stamp duty). This would in turn make the housing market more liquid, so that fewer people would live in the "wrong" house (e.g., young families who cannot afford to move to larger houses, or empty nesters who stay in large family homes). Furthermore, property taxes should give rise to less deadweight loss and be less damaging to the competitiveness of Irish exports than income taxes; and they should be less damaging to Ireland as a destination for foreign direct investment than profit taxes. In sum, *if properly implemented* property taxes are seen as an efficient and stable source of revenue. The implementation of a property tax in Ireland was one of the subjects of a comprehensive review by the Commission on Taxation in 2009, which we discuss in the following section.

3. Commission on Taxation recommendations and the old property tax

In 2009, the Commission on Taxation issued a comprehensive report on possible changes in the structure of the Irish fiscal system. The relevant sections relating to the current study will be presented in Section 3.1 while Section 3.2 details the characteristics of the previously existing property tax in Ireland.

3.1 The Commission on Taxation

The Commission on Taxation was established in 2008 to "review the structure, efficiency and appropriateness of the Irish taxation system".[1] The final report was published in 2009 and part 6 deals with the taxation of property. The six main recommendations made by the Commission are presented in Box 1 and are discussed in further detail below along with the main comments on implementation issues and design.

Box 1. Recommendations on the Taxation of Property by the Commission on Taxation.

6.1	The provision of an up-to-date valuation base for all property and land in Ireland should be addressed as a priority issue.
6.2	Provide for an annual property tax on all residential housing units with the broad exceptions of local authority and social housing units and some other limited exceptions set out in section 4.2 of Part 6.
6.3	Stamp duty for purchasers of principal private residences should be zero-rated.
6.4	Stamp duty should continue to apply to investor purchasers of residential housing units. The rate should be competitive having regard to the transaction tax rates and thresholds that apply across the EU.
6.5	The windfall gains increases in land values due to rezoning decisions should be subject to an additional capital gains tax charge.
6.6	A recurrent property tax on land zoned for development should be introduced.

Source: CoT (2009:154).

[1] http://www.commissionontaxation.ie/

"*We consider that an annual property tax (APT) should be implemented at the earliest possible date, taking account of the very significant administrative challenge for the Revenue Commissioners who will have to develop an assessment, collection and accounting system*" (2009:157). The Commission acknowledges the implementation difficulties of introducing a property tax. The main difficulties usually cited with regards the implementation of this sort of tax are administration procedures, monitoring, setting up an appeals system, deciding rates, enforcing penalties and, evidently, assessment (Szalai and Tassonyi, 2004). Although introducing a property tax for inclusion in the next (2010) Budget is looking less likely, the government has indicated that it has not yet been examined in any detail[2]. The complexity of introducing a tax of this kind in an equitable manner is high and if a property tax based on house size or value is to be put into operation it will require time. The main issue and the one examined in this paper will be the assessment of house values.

The Commission on Taxation also broaches this subject. *"Options for the future taxation of property in Ireland are constrained by the absence of an up-to-date valuation database on which an annual property tax could be based. An up-to-date valuation database will also provide a database against which self-assessed property tax returns can be checked as part of the monitoring of our proposed annual property tax"* (2009:160). The Minister for Housing has since the publication of the CoT report announced the establishment of an expert group to look at the matter of establishing a national register of house prices.[3] To our knowledge the group has not yet produced any publications.

A flat rate tax (where all owners pay the same fee) was recently ruled out by the Minister for the Environment[4] and consequently an *ad valorem* tax is most likely. This system requires an estimate of relative house values. The Commission suggests self-assessment as a solution to the lack of property register. *"We consider self-assessment is an appropriate method of assessment for the tax subject to appropriate monitoring and audit mechanisms. It is greatly simplified by the banding of valuations. […] We acknowledge that direct assessment would provide greater certainty for taxpayers. However, in our view, it is not capable of being implemented*

[2] "Fall in values reduces scope for property tax – Lenihan", *The Irish Times*, 19th July 2010.

[3] "Government group looks at house price index", *AIB Global Treasury fxcentre*, 10th March 2010.

[4] "Gormley rules out flat-rate property and water taxes", *The Irish Times*, 09th June 2010.

within an appropriate time-frame due to the lack of an existing valuation database for residential properties" (2009:165). Although self-assessment may seem an attractive option due to a lack of national house price database, there are a number of issues with the method. First, had a self-assessing property tax been implemented during the Celtic Tiger years, when house transactions and sales were numerous, home owners would have had a lot more information about the possible value of their homes and the government would have had a lot more transactions to compare prices with when monitoring self-assessed values. Unfortunately, this policy is likely to be introduced at a time when the market is extremely thin. Volumes are so low that the ESRI/PTSB house price index has recently been reduced to a quarterly index (instead of monthly) because of insufficient observations of transactions. Consequently, not only will it be difficult for home owners to self-assess due to a lack of prices to compare their property with, but with prices still falling, the task is made even more difficult. Moreover, as is discussed in Section 4, self-assessment only tends to work if proper enforcement and penalties are put into place. This will take time and require significant resources to become effective, which may be problematic in the current tight fiscal climate. *"As with any self-assessment tax but particularly so in the case of a new tax such as the APT it is vital that there is a clear understanding from the outset by taxpayers that the tax will be subject to appropriate audit and compliance actions monitoring"* (2009:169). As all properties registering for the tax will be newly registered, monitoring at the national scale will be a very extensive enterprise and leave the door open to under-valuations and cheating on the part of home-owners. Consequently, in this paper we investigate whether or not an additional method of valuation is feasible.

"Each householder who is liable to pay the tax and who gets a professional assessment of the value of his or her property should get a tax credit of up to €75 in the first year to compensate for costs incurred" (2009:165). Although the use of professional valuers is a good idea and more likely to result in more accurate valuations, the thin property market issue still applies. Furthermore, determining house prices in the current market really depends on finding a buyer and to which year the current price is being compared to. It will be difficult to set a baseline "house value" without more accurate guidelines, even for valuers.

In this paper, we use property characteristics to examine how accurately one can estimate house prices using a limited set of house characteristics and county dummies. We are particularly interested in whether using any of the property characteristics would result in estimates of house value that would still be considered equitable. For example, *"We examined market value and floor space as possible bases for the tax. We consider that using floor space alone as a base for the tax would offend the principle of equity. A residential property owner who lives in or owns a 1200 square foot house in an affluent area should pay more tax than one who lives in a similar sized house in a less affluent area"* (2009:165). While this statement is true, taking into account regional differences could mitigate this problem. We will underline the importance of regional characteristics in the Section 6.

"We also considered using a combination of floor space and market value as the tax base. The introduction of a new annual property tax will be a significant challenge for the Government, who will have to convince taxpayers that it is an appropriate policy approach. For this reason, the rules that govern the assessment and calculation of the tax should be as simple as possible so that taxpayers can calculate their tax with reference to as few parameters as is feasible. We consider that the application of floor space in addition to the market value would add undue complexity for householders liable to pay the tax" (2009:165). Although the addition of parameters inevitably complicates a tax assessment, the calculation of the tax incidence tends to fall on the government side. Consequently, a professional assessment as recommended above could also include the number of rooms in the home and its square footage without any extra undue complexity. The reporting of additional parameters should not be difficult; however the administration of a tax based on a more complex system may be. The purpose of the analysis will also be to investigate the trade-off between the cost of additional variables and the resulting benefits in terms of equity and the reduction in the error in estimation.

"There should be a fixed valuation date, set at a date in advance of the commencement of the tax, so that all house owners self-assess at the same time" (2009:165). One advantage when starting a property tax scheme from scratch is that all valuations have a common date. The issue usually faced by other countries is that valuations do not have a common date. The main issue then is to determine how often

the valuations need to be updated. The Commission does not recommend a rate for the property tax and states that it is *"a matter for Government"* (2009:159).

Although the CoT does not recommend a rate for the tax it does give an example of possible valuation bands. *"The annual property tax should be calculated by reference to valuation bands within which a property owner would value his or her house. Our rationale is that there should be certainty about the tax base. Therefore, the classification of a property for the tax should be easily determined"* (2009:161). These bands increase in €150'000 steps and are presented in Table 6. We will try and determine how far the use of property characteristics leads to accurate assignment of properties to the specified bands.

The issue of who should pay the tax is also addressed by the Commission. *"The tax should apply to all residential housing units including holiday homes, second homes and houses that are let or available for letting. It should also apply to vacant houses […] and to bed and breakfast and guesthouse accommodation"* (2009:164). The dataset used in our analysis is presented in detail in Section 5. We concentrate our analysis on owner-occupiers as it allows us to analyse the impact of the tax based on the owners' household characteristics. The Commission stresses the issue of taking into consideration the ability to pay of the most vulnerable. *"Exemptions for local authorities and other social housing providers, care facilities, nursing homes, boarding school accommodation, charities"* (2009:164). Owners who paid stamp duty during the previous seven years *"would be exempted from paying the annual property tax for a seven year period from the year they paid stamp duty"* (2009:168). This would be to avoid double taxation those who not only bought at the height of the boom and paid stamp duty but who are also those most likely to currently be in negative equity. *"The annual property tax should be applied to all housing stock, including vacant units"* (2009:168). Property taxes are said to discourage speculation as they make holding on to vacant properties more expensive.

Finally, the main point stressed by the Commission is the issue of equity. *"We considered a flat charge per property but rejected it as inequitable. We consider that owners of more valuable properties should pay more tax than those who own less valuable properties. The banded valuation system we are proposing provides for a proportionate system of taxation […]. We also considered but rejected a progressive tax as it would be more difficult to administer than a proportionate tax using*

valuation bands" (2009:167) and *"In making these proposals we are aware of two issues which we consider are important aspects of an APT on residential property: […] the provision of a scheme to mitigate the impact of the recurrent property tax on low-income house owners, including those with relatively low income and large more valuable houses"* (2009:161). The property tax that existed in Ireland in the late 1980s and early 1990s was perceived by most to be inequitable. It is crucial, especially in a time of recession that those with more valuable properties pay more tax and those with less are given additional support. However, it will also be essential to take account of those in society who by circumstance have low incomes despite owning large properties. Making allowances for these cases will enhance the equity of the tax and make it more likely to be accepted by the public.[5]

The research conducted by the Commission on Taxation into the implementation of a property tax in Ireland is extensive and thorough. The main issue as underlined by the Commission is the lack of a property database in Ireland. Unfortunately, self-assessment as recommended by the Commission in response to the lack of database is more difficult in a thin property market. The object of the present paper is to examine the types of inequities that may or may not arise when using house characteristics such as floor space or number of rooms to value a dwelling. Estimating the scale of these inequities and who they would impact is important *prior* to a tax being implemented.

3.2 Historical property tax in Ireland

Property taxes are not new to Ireland. Indeed a Residential Property Tax (RPT) existed in Ireland between 1983 and 1997.[6] "The tax was charged at the rate of 1.5% on the excess of the market value of all relevant residential properties of a person over a market value exemption limit and was payable provided the income of the household exceeded an income exemption limit." [7] It was an annual tax, chargeable

[5] Two other points of interest are:"The tax should be applied on the gross value of the property without regard to borrowing to fund its purchase" (2009:164) and "After an appropriate introductory period, all of the revenues from an annual property tax should be used for local government financing" (2009:168).
[6] Commission on Taxation (page 156) provides an overview of the previous residential property taxation systems in Ireland. The main one of note is the RPT.
[7] http://www.revenue.ie/en/tax/rpt/index.html

on the market value of residential property, owned and occupied on the 5th April of each year which was the valuation date.

The RPT was a national tax but due to the number of exemptions related to it, only a very small number of home-owners actually paid it. Indeed, exemptions existed for owners of homes under a certain value (£101'000) and whose income was below a threshold (£30'100). Owners provided an assessment of their home value and if the Revenue Commissioners considered it to be too low it could re-value the property. The tax was very unpopular with the general public for its perceived lack of equity. It was considered a "Dublin tax as the capital accounted for almost two thirds of the revenue collected".[8] As a consequence it generated very little revenue and according to the CoT (2009:157) it resulted in only 17 million euro in receipts in 1996 and was paid by only 2% of all households.

Making sure that these mistakes are not repeated will be crucial in the implementation of a new property tax in Ireland. Indeed the CoT states that *"An important lesson to be learned from the residential property tax system that operated between 1983 and 1997 is that an overly narrow tax base led to an insignificant revenue flow for the Exchequer, high administrative costs and a perception of inequity" (2009:157).* The following section reviews the academic literature regarding various aspects of property tax design and assessment as well as the case of Northern Ireland.

4. Literature

This section reviews the literature in the area of property tax design, property value assessment and property tax equity. First the concepts of horizontal and vertical equity as well as regressivity and progressivity are defined. Then, existing studies on various aspects of property taxes are presented, first regarding the efficiency of self-assessment, then the assessment of property taxes in thin markets and implementation issues. Section 4.4 describes the case of Northern Ireland which has recently had to revalue its property database.

[8] "Property Investor" *Irish Times*, June 17th, 2010.

4.1 Equity and fairness in taxation

The issues of equity and fairness in taxation are central to most of the academic literature in the area. While they will not be discussed in depth in this paper it is worth underlining the main characteristics a tax can have and what features are used to assess it. The three aspects of a tax that tend to be used to evaluate it are: efficiency, equity and administrative simplicity.

Inevitably, the introduction of a new tax at a national level will incur additional administrative costs for the body or bodies in charge of collecting it. In the case of Ireland and in the case of the tax as proposed by the CoT the bulk of these administrative costs would be in compliance and monitoring of tax assessments. Costs would also need to be taken into account depending on the appeals system. If dwelling characteristics were used to determine house value, additional information and estimations would be required, resulting in more costs. The trade-off is then between additional information and hence cost, versus greater accuracy and fairness.

Tax assessment methods can lead to inequity in several ways depending on how and whom a tax targets. According to Allen and Dare (2002) a tax is vertically inequitable if there is systematic variation in the assessed value compared to the market value across property types and property value bands. Using the methodology described in Section 5, vertical inequity would occur if there was a systematic difference in the assessment sales ratios for properties that have low versus high market values. Horizontal inequity occurs when properties of similar market value are assessed differently. Inevitably some variation in assessment will occur depending on who values the property and a small amount of horizontal inequity is to be expected, however horizontal inequity can also be due to valuer bias. For instance, some valuers may systematically place a higher value on certain property attributes compared to others. It can also arise when neighbourhood characteristics are not known to the valuer.

A tax can also be deemed regressive or progressive depending on how it affects households. A regressive tax is a tax where the rate decreases as the amount subject to the tax increases, i.e. relative to their total income the poor suffer more than the rich. A progressive tax is a tax where the rate increases as the taxable amount increases; personal income taxes are often progressive. The rich pay a higher percentage of

income in tax than the poor. With regard to vertical inequity, if lower value house prices are always over-valued compared to high valued houses then the valuation method is regressive. If lower value house prices are always assessed at a lower rate than their market rate compared to high value houses then the valuation method is progressive. All of these possible impacts should be assessed when implementing a new tax and we will be looking at whether valuations based on dwelling characteristics satisfy the equity principles.

4.2 Self-assessment and the tax system

Plassmann and Tideman (2008) provide an accurate description of the common issue related to self-assessment: "A person who is subject to self-assessment can be expected to provide a truthful report of the (monetary equivalent of the) value that he attaches to a good that he owns if and only if truthful reporting maximises his utility". Consequently, when using self-assessment for tax purposes, any utility maximising agent under-estimates the value of the good that is taxed. Potential solutions to this problem date back centuries.

Bird (1984) presents examples of countries that use a property tax system with self-assessment that gives the government the right to purchase at declared value. The earliest documented example he gives is of New Zealand in the late 19th century. If home owners deemed their valuation excessive they could value it themselves at a lower rate on condition that the government could purchase the property at that rate plus a "fair margin". In parallel the land owner could force the government to purchase the property at the higher official value. Bird also quotes the example of Columbia in the 1950s and 1960s. However due to the economic situation at the time there was no credible threat from the government as it could not afford to purchase the properties. This might be the case of Ireland at the moment, especially in the aftermath of NAMA purchases. Niou and Tan (1994) discuss a similar method proposed in China in 1905. They examine this "truth-revelation mechanism" and find that with two forms of penalties (compulsory purchase and taxes) there is still a small probability that some land owners will under-report. This probability is reduced with important random audits but this entails an additional cost to the government. Their model does not discover a mechanism that induces correct self-assessment at no cost.

In cases where the threat of purchase on both sides is credible, self-assessment can work.

This is shown by Gstach (2009) who uses a theoretical model to prove that a Nash equilibrium among tax payers exists in a game where the property tax is based on the owner's self-assessment but only in the case where the credibility of the purchase threat is real and the government purchases a randomly selected number of properties based on the distribution of declared property values. This leads to all home-owners declaring their true property values and no purchases are required on the government's side. The equilibrium situation however rests on the credible threat of repurchase and the repurchasing price. Wolinsky (2000) offers a "softer" version of the scheme whereby an option would be given to home owners to have their assessment value defined though a centralised processed. Homeowners wanting to determine their own house price could still do so but this would constitute an obligation to sell. In reality and in Ireland this is unlikely to occur and the use of self-assessment will hence in all likelihood lead to dwelling values being under-declared. The problems relating to self-assessment are exacerbated when the property market is thin as it makes it difficult for home owners to correctly assess their house value when they do not have many prices to compare it to.

4.3 Thin markets and property tax assessment

Most of the literature on errors in property tax assessment is based on studies of markets with existing property taxes. Consequently the questions asked by authors of these studies are whether the current tax regime is equitable and if not how to best remedy the situation. The following papers, mostly from the United States, detail some of the methodologies used to assess the horizontal and vertical inequity of existing property tax regimes.

McMillen and Weber (2008) investigate the horizontal and vertical inequities in property taxation in Chicago. They use property tax assessment ratios (i.e. a property's assessed value divided by its market value) to determine when these inequities appear. Assessment ratios can vary between and within price segments of the market. Horizontal inequity occurs when there is a lack of information on property and neighbourhood factors available to agents (buyers, sellers and valuers). Vertical

inequity occurs when higher priced properties appreciate more quickly compared to repeat assessment times. The authors in this case investigate the effect of a thin market and low sales in certain areas on relative assessment ratios. They test the notion "that assessment ratios will be not only less uniform but also higher in areas where prices are relatively unpredictable". "Assessments of land and improvements in inactive markets may vary significantly for nearly identical properties in the same price strata and may well be biased systematically". The authors use data on sale prices in Chicago in 2004 and 2005 as well as assessment data from 2003 to conduct their analysis. They check to see if assessments are more uniform in areas with more sales. They look at thin markets (at the top and bottom ends of the scale) and find that there is regressivity: as prices increase the assessment ratios fall. They also find that the assessment ratio declines over time. The authors conclude that in areas with more sales, assessment ratios are more likely to cluster in the center of the distribution, i.e. having more sales makes it easier to produce uniform assessments. Thick markets improve horizontal equity.

Goolsby (1997) analyses house prices as assessed by valuers to determine whether systematic errors occur in valuation. In the United States assessors are legally required to assess a property at a level equal to the market value but when property prices are increasing this will tend to result in a ratio smaller than one. If the assessment ratios were the same across the board there would not be a problem however they are generally not uniform. Goolsby uses data from Washington State in 1993 on owner-occupied single family houses. He regresses the assessment ratio on variables that are thought to cause a consistent bias in the estimates. He finds that valuers tend to under-assess high value houses and older properties and over-assess very large houses across all counties. He concludes that using valuers' estimates of house values should be taken with caution and in the best case should be adjusted to take account of consistent assessor bias.

Allen and Dare (2002) also look at assessment error, in particular its impact on equity when using an *ad valorem* property tax. When dealing with this type of tax the issue of correctly assessing the relative house value is crucial. The authors concentrate on the issue of horizontal inequity using sample data from Florida. Florida uses computer aided mass appraisal models to estimate a property's value for tax purposes each year. Similarly to Goolsby (1995), they find that older and larger homes as well as

properties in neighbourhoods with a higher percentage of minority residents present the highest level of assessment error. They do not find much evidence of vertical inequity but do find indications that the middle quartiles of house values systematically differ from the bottom and top quartile, similarly to the results in Goolsby (1995). Allen et al. (2009) revisit the issue of vertical inequity due to property taxation for owners of hotels in Florida between 1999 and 2004. The issue of valuing hotels is more complex than homes as the value of the business must be separated from the value of the property. They find that lower value properties are systematically over assessed and that this is not the case for high value properties. This suggests that owners of lower value hotels should contest their valuations and get re-assessed.

Spahr and Sunderman (1998) also look at property tax inequities but concentrate on agricultural property taxation. In Wyoming, agricultural property tax is based on the land's productive value. They use land sales in Wyoming from 1989 to 1995 and data on the characteristics of the land to create a predictive hedonic model. They then estimate assessed value ratios and calculate the coefficients of dispersion and price related differentials. They compare their results to the standards used for residential property and find that there is excessive vertical, horizontal and market inequity in the taxing of agricultural land, and that farms and ranches under the existing system are being under-assessed by nearly 50%. Correct valuation could result in between 8 and 14 million extra dollars in revenue a year.

Chapman et al. (2009) focus on a land value tax and look at the effect of levying taxes on land that is mis-valued. As the use of a plot of land determines its economic value it can be difficult to determine its price and estimates can be prone to error. They find that mis-valuing the land essentially results in applying two tax rates: one to the true value of land and a different one to the capital. Land value taxation has neutrality advantages but are these eliminated if the value of the land is not assessed correctly.

Smith (2000) tests for vertical inequity in Indiana for sales data from 1993 to 1998 using the assessed value to market value ratio, and tests whether the assessment process in Indiana should be overhauled. Indeed, Indiana does not use the assessed market value of a property as the basis for the tax but rather the "true tax value" which uses rules, definitions and photographs as well as depreciation tables to determine value. The system was deemed unconstitutional in 1996 because it ignored hard data

on values. The full ruling was subsequently overturned but amendments were made to regulations requiring the valuation to be equitable. Smith employs the different methodologies available in the literature (most of which are explained in more detail in section 3) to test Indiana's property tax. He finds that in nearly all cases a progressive assessment system is observed. He concludes that focusing just on inequity in general is limiting and that it should be related to other aspects of properties (such as location, age and type of dwelling).

Bell and Kirschner (2009) look at the effects that public pressure has had on the level of property tax in the US. They look at two ways of calculating property tax burdens that are used by States and different jurisdictions in the US, namely the tax per capita and the tax as a percentage of housing value. They outline the different methodologies and tax bases used by different US bodies for calculating burdens. Some calculate the effective tax rates by using the assessment ratio times the nominal tax rate, some use the net tax liability, some present burdens by property type or by jurisdiction. They conclude that not using microdata for the calculations of these burdens hinders any type of equity related research at a within State or within jurisdiction level.

Szalai and Tassonyi (2004) look at the issues involved in implementing a value based property tax in Hungary using the United States as an example. Taxes on residential properties, which were imposed at a municipal level were terminated in the early 1990s mostly by local politicians looking for support. In light of EU accession, Hungary's very mixed fiscal structure needed to be overhauled and an *ad valorem* property tax coupled with economic growth and rising house prices would result in local governments having the necessary revenue to invest in the community. Hungary has much more defined local municipalities compared to Ireland and they already have fiscal responsibilities which would allow property taxes to be implemented more easily. The authors present the different administrative issues that would need to be taken into account in order to implement the new tax, such as the rates, the assessment method, the appeals procedure, and how to determine who should be exempt.

Existing property taxes in the US tend to result in some form of inequity. It is possible to determine which factors cause the inequity and consequently try and find a solution to the tax design but most of the issues which arise relate to the assessment of the property's value. The following section presents the case of Northern Ireland which recently had to update its property value database.

4.4 The case of Northern Ireland

In 2007, the domestic housing sector in Northern Ireland was subject to a complete revaluation of all properties for property tax purposes.[9] The last valuation of the domestic housing sector had occurred in 1976 and in the meantime the property market had changed drastically. Previously unwealthy areas had recorded very high growth rates and the rate system had not managed to keep up with price increases in wealthy neighbourhoods. The resulting system was unfair and considered to "disadvantage the less well off" and "the system was not progressive" (Parry, 2006:3). Householders were not paying rates in line with the more recent value of their home. After public consultations and numerous reviews, a new system was introduced in 2007. Discussion had centered around whether bands should be used for valuation (as used in Great Britain) or whether to introduce discrete individual capital assessments. Government commissioned research found that the introduction of a "banded system was likely to be a regressive step. Analysis on the likely impact of an individual capital value system shows it to be more positive" (Parry, 2006:4). The new system was based on individual assessments conducted by the Valuation and Lands Agency which aimed to value 700'000 homes with a common valuation date. Discounts and special procedures were put in place for those facing a significant price hike due to the new system, those in full-time education, and disabled persons. The next revaluation is due to take place in 2012.

The system used in Northern Ireland is one that is quite common in the United States and is based on the used of a type of Automated Valuation Model (AVM). The IAAO (2003) defines AVM as a: *"mathematically based computer software program that produces an estimate of market value based on market analysis of location, market conditions, and real estate characteristics from information that was previously and separately collected. The distinguishing feature of an AVM is that it is a market appraisal produced through mathematical modeling. Credibility of an AVM is dependent on the data used and the skills of the modeler producing the AVM".*[10] The system is based on property market sales between 2002 and 2005 which were recorded in a specially designed Sales Inspection Database, the data from which was

[9] Referred to as "rates".
[10] The system in Northern Ireland is called CAMA (Computer Assisted Mass Appraisal).

then used as the basis for the AVM (Gloudemans and Montgomery, 2008). The most important property characteristics affecting sales price were determined across 25 "sub-markets". Categories of dwellings (such as apartment, mixed properties) were examined separately. The final analysis produced capital values for homes based on their potential sales price on the 1st January 2005. These will then be updated again in 2012. The house price inflation followed by deflation that occurred between 2005 and 2007 was ignored for the most recent valuation.

The AVM used in Northern Ireland included significantly more variables than the present study as the valuation agency already had information about the house characteristics. The variables used were: habitable space, ancillary space, outbuildings size, primary classification (public or private build), sub-classification (detached, semi-detached, terraced), grade of construction, age band, number of storeys, heating, sewerage provision, water provision, power provision, external repair, garage, site positive features, site negative features, neighbourhood, location (rural, urban, suburban) and access type. As rates were pre-existing, the basic property database could be used for the analysis, and the addition of more information was not as costly. However the Government committed the funds to conduct a thorough revaluation of the full property stock so as to have a solid system and database on which to base any further revaluations. In Ireland, as currently no database associating geographical information system data on the location of dwellings (and then matched to their characteristics) exists, producing a database of this kind would be very expensive. In the present study we concentrate on a small number of variables, however it is clear that the more information on a dwelling the more accurate the valuation and the fairer the system.[11] The following section presents the different assessment methods used in this paper.

5. Methodology

This section reviews the different methodologies used here to assess the valuation method for a property tax. First, the use of hedonic analysis in the estimation of

[11] In the US, some states estimate each property's taxable value from the self-assessed values of the surrounding comparable properties, which also reduces the information cost.

property prices is discussed. Then, the various errors in house price assessments are presented, followed by the techniques used by the International Association of Assessing Officers (IAAO), which produces assessment standards for ratio studies and property tax policy.

5.1 Predicting house prices

The hedonic technique is based mainly on work by Griliches (1961) and Rosen (1974) and originated in the development of value indices for manufactured products that combined measures of quantity and quality. The seminal paper by Griliches (1961) derived a hedonic price index for motorcars. The technique centres on consumers' choices regarding composite goods. The assumption is that goods are valued for their utility-bearing attributes and that these attributes are internalised into the price of the good. A house has several attributes, including attributes of the house itself, such as the number of rooms, bathrooms and the availability of car park spaces, as well as attributes of its environs, such as crime rates, quality of schools, and air pollution. All of these attributes make different contributions to the price of the house. If you have a large enough sample of housing market transactions, it is possible to use econometrics to separate out the implicit price of the attributes. This is done using a hedonic house price model. The basic technique involves regressing the property price on the set of variables measuring quality, while controlling for unobserved time and area effects. The regression coefficients are then interpreted as marginal implicit prices of the quality components.

The hedonic price function takes the following form:

$$PRICE = f(S, N, E) + \varepsilon \tag{1}$$

where the price (or logged price of the house) is a function of the house's structural or physical characteristics (number of bedrooms, size in square meters etc.), neighbourhood or location characteristics (such as location in the city, access to transport routes etc.) and environmental characteristics (such as proximity to green spaces, to coast, quality of ambient air); ε is an error term. The house price is thus a function of all of the attributes relating to the house and the resulting coefficients are the marginal implicit prices of the attributes.

The attributes can also be used to produce estimates of the house value. We regress house price on one or more readily observable and verifiable house attributes and use the results to estimate a house price. How closely this estimate relates to the "correct" house price will determine the accuracy of the estimation method – and thus both horizontal and vertical equity if this valuation is used as the basis for taxation. The variables included in the analysis will be based on those used in Northern Ireland and in previous hedonic analyses, such as area in square meters, number of rooms and bedrooms, dwelling type (detached, semi-detached, terraced) and geographical indicators. It will then be possible to determine how much of house value is determined by a single criterion. It is possible that the "bulk" of a house price can be determined using just one dwelling characteristic (e.g. size) but it maybe that three or four variables are necessary in order to reach a suitably precise house price estimate. The following section details how we define "suitably precise".

5.2 Evaluating the house price assessments

We look at the errors in the predictions depending on the different explanatory variables used (area, rooms, age, dwelling type), the number of variables used and who they affect the most (by age groups, income groups, areas). We consider both the absolute value of the error in euro and the percentage of the house value.

The first type of error we identify is the difference between the estimated price and the true house price in absolute value. This error is calculated as follows:

$$ABV = EstimatedValue - TrueValue \quad (2)$$

That is, if the ABV is positive (negative), the dwelling's value is over-estimated (under-estimated). This is a negative (positive) outcome for the home owner as they end up paying less (more) tax than they should. Inevitably, some ABVs will be positive and some will be negative. There is an implicit cross-subsidy from those being over-valued to those being under-valued. The ABV error will give an indication as to the absolute amount in euro that is being mis-valued but does not allow us to evaluate the equity of the valuation system. For that, we need to check whether there is a *systematic* mis-valuation of certain kinds of houses.

5.3 The assessment to sales price ratio

The assessment to sales price ratio (A/S) measures the degree of accuracy of a valuation. The A/S ratio is the ratio of a property's assessed value to its sales price. It is used extensively in the US to assess the equity of property taxes and is one of the guideline ratios recommended by the International Association of Assessing Officers (IAAO, 2010). It is calculated as follows:

$$\frac{A}{S} = \frac{AssessedValue}{MarketValue} \tag{3}$$

In the case of this study, we consider the properties to be assessed at 100% of their market value so the assessed value will be equal to the appraisal value (i.e. the estimate of house price). Most studies of property tax equity are based on data from existing property taxes. These studies use the assessed or estimated values of properties as per government guidelines and compare them to the market value of homes when these are then sold. In the present paper we will be comparing the assessed value of the home, as estimated through hedonic regression, to the market value, as estimated by the interviewer. If a property is correctly valued then the A/S ratio will be one. The valuation method is regressive if the A/S ratio declines with increasing property values and is progressive when A/S ratios increase with higher property values. A/S ratios tend to be evaluated using the median A/S ratio for the full group or specific sub-groups. According to the IAAO (2010:13): "the median is the generally preferred measure of central tendency for evaluating overall appraisal level" as it is less affected by ratio outliers.[12]

From the A/S ratios it is possible to calculate measures of dispersion. Measures of variability can be calculated for different groups or sub-groups of data. The main one used in studies is the coefficient of dispersion (COD) which Spahr and Sunderman (1998) define as: "a non parametric statistic that measures the average deviation of a group of A/S ratios, taken around the median and expressed as a percentage of that measure". The COD taken around the median can be calculated using the following equation:

$$COD_{MED} = \frac{100}{A/S_{MED}}\left[\left\langle \sum_{i=1}^{n}\left|A_i/S_i - A/S_{MED}\right| \right\rangle / n\right] \tag{4}$$

[12] It is also possible to use the mean ratio to compare appraisals.

where COD_{MED} is the coefficient of dispersion based on the median value, A_i/S_i are the individual ratios, n is the number of ratios, and A/S_{MED} is the median ratio for the group being examined. It measures the average percentage deviation of the ratios from the median ratio. The interpretation of the COD does not depend on the assumption that the ratios are normally distributed which makes it the favoured method of evaluation. According to the IAAO (2010) "in general more than half the ratios fall within one COD of the median".[13] A lower coefficient of dispersion means more consistent valuation estimates and equitable treatment.

The International Association of Assessing Officers also offers guidelines as to the acceptable level of these figures. The median A/S ratio should be between 0.9 and 1.1 (Spahr and Sunderman, 1998). An acceptable coefficient of dispersion (COD) for residential dwellings in densely populated, large cities and new properties is between 5.0 and 10.0. For large to medium sized cities the COD should be between 5.0 and 15.0 and for rural areas with older properties it can be between 5.0 and 20.0. Figures above these boundaries indicate a low degree of assessment uniformity and the presence of horizontal inequity. These assessments would be considered more variable than acceptable.

5.4 Testing the vertical inequity of the valuation method

Numerous models have been created that also test the vertical inequity of the house price assessments using the A/S ratios. This section provides an overview of these different models as detailed in Smith (2000), Allen et al. (2009) and McMillen and Weber (2008). The first and most straightforward model is the linear model devised by Paglin and Fogerty (1972) where the assessed value is regressed on the sales price:

$$A_i = \alpha + \beta S_i + \varepsilon_i \tag{5}$$

where A_i is the assessed value of dwelling i and S_i is the sales price of dwelling i. As the relationship is in this case considered to be linear, if no vertical inequity were present, the intercept α would be zero. If the intercept is positive and significant this is an indication of a regressive valuation method and if α is negative and significant then

[13] In fact, if the uncertainty about the assessed value is normally distributed, as assumed in our regression model, 67% of the observations fall in that range.

this would be an indication of a progressivity. A slightly updated version, which was created by the IAAO (1978), uses the A/S ratio defined in Section 5.3 and is defined as follows:

$$\frac{A_i}{S_i} = \alpha + \beta S_i + \varepsilon_i \tag{6}$$

In this case if β is positive and significant the valuation method is progressive. It is regressive if β is negative and significant and if there is no relationship between the A/S ratio and the sales price then it is considered neutral. A log model also exists:

$$\ln A_i = \alpha + \beta \ln S_i + \varepsilon_i \tag{7}$$

In this case β measures the vertical inequity in the model. If it is larger than 1 the valuation method is progressive and vice versa. If it is equal to 1 the valuation method is considered neutral.

Finally, Bell (1984) incorporated a quadratic term into the regression to take account of nonlinear relationships:

$$A_i = \alpha + \beta S_i + \chi S^2{}_i + \varepsilon_i \tag{8}$$

If χ is not statistically significant, the model in equation (5) is used. If χ is statistically significantly different from zero and negative then the assessment method "displays accelerating regressivity" (Allen et al., 2009:3) and if positive it displays accelerating progressivity. If the intercept and χ are both statistically insignificant then there is no inequity in the assessment method. The following section presents the survey data and the variables used in this analysis as well as summary statistics and checks on the reliability of the house price variables.

6. Data

Section 6.1 presents the survey and variables used in the analysis. It also includes details on any possible sample restrictions applied to the data. Section 6.2 discusses the "house value" variables in more detail.

6.1 The survey, sample and variables

The dataset used in this analysis is the Irish National Survey of Housing Quality (NSHQ) which was conducted in 2002 by the Economic and Social Research Institute on behalf of the Department of the Environment, Heritage and Local Government. It obtained information from a "representative sample of 40'000 householders on the characteristics and problems of the dwelling" (Watson, 2003). Previous national housing surveys had been conducted in 1981 and 1991 whoever these had been smaller surveys collected at a local authority level and then grouped. The 2002 survey is the latest one of its type to be conducted in Ireland.

The survey contains a number of different variables useful for this analysis. The main variable of interest is house value which will be discussed in further detail in Section 6.2. Variables relating to the properties' characteristics are used in the hedonic regressions. These include the type of dwelling, which contains 5 categories: detached house/bungalow, semi-detached house/bungalow, terraced house, flat-apartment and flat apartment in a converted house.[14] As too few observations were available, the final two categories were grouped into a single "apartment" category. Two thirds of the sample are detached houses followed by smaller fractions of semi-detached houses and terraced houses. This is not unexpected as the survey is a national survey including rural areas where the majority of dwellings would be one-off detached houses. There are very few apartments in our sample for two reasons: first, apartment living in Ireland is a fairly recent phenomenon which is restricted to the cities. Second we only kept owner-occupiers in this sample and most apartments bought at the beginning of that decade were for rental purposes. Information on the number of rooms and bedrooms in the house is available. Also stated is the age of the dwelling, which is grouped into 5 categories: pre-1940, 1941 to 1970, 1971 to 1980, 1981 to 1996 and post-1996.

Respondents were also asked to state, if known, the size of their dwelling in square feet or square meters. Approximately 30% of respondents declared they knew the area size of their home and gave a figure. Consequently our sample size for regressions using a square meter variable is much smaller. Despite the lower number of available

[14] Caravans/mobile homes were excluded from the analysis.

observations, the declared areas are fairly normally distributed (Figure 3).[15] The average size in square meters is 150m^2.

Geographical dummies are crucial variables as these take into account any area effects that influence house prices. A number of these variables are available in the NSHQ. It states which region (Border, Dublin, Mid-East, Midlands, Midwest, Southeast, Southwest, West), location (Dublin, urban or rural) and the size of the location the household is situated in (village, town, city, open country). These variables are useful when comparing the incidence of the tax by geographical area. However, more detailed geographical location data is needed for inclusion in the hedonic models to take account of geographic house price differences. There are 34 local authorities in Ireland including 29 county councils and 5 city councils. The NSHQ data lists which local authority the dwelling is located in and it is this data that is included in the hedonic regressions and is interacted with the variables of interest.

The full sample of the NSHQ comprises over 40'000 observations. We imposed some restrictions on the data. First, for the main analysis we focus on owner-occupiers as these are the households that will *directly* pay the tax. Rented dwellings will also be subject to the tax and this may be passed on to renters in whole or in part. Due to Ireland's very high ownership rates, this only reduced the sample by 5'000 observations. In order to take account of coding errors relating to the price of the house (e.g. some dwellings were stated as having a £1 value) we picked a lower end cut-off point for house prices. This cut-off was £40'000 for homes outside of Dublin and £90'000 for homes in Dublin. These cut-offs are based on the minimum value in 2002 (the year of the survey) for dwellings in and outside Dublin from the ESRI/PTSB house price index micro-data. This restricted the sample to only "realistic" house prices. In order to take account of the effect of outliers the top and bottom quarter of a percent of observations according to house value were also excluded. Due to a lack of sufficient observations we did not include owners of caravans or mobile homes in the sample. Finally, houses purchased from a local authority were also excluded as they would be likely to be exempt from tax. All

[15] The subsample containing values for the area in square meters is representative of the larger sample. Both samples have similar proportions of dwelling types and rooms however the sample with an estimate of area size have a larger proportion of newer dwellings (post 1996) than the larger sample. This can be taken as an indication that households who made more recent purchases are more knowledgeable about the size of their home, which is to be expected. Due to this slight difference between the samples, the analysis uses both area size and number of rooms throughout.

monetary values were converted from Irish pounds into euro. The final sample comprises 25’016 observations and 7’023 of these have a value for area size, in square meters.

The summary statistics for the variables included in the analysis are available in Table 1. It also includes household characteristics for the analysis of groups and sub-groups. Variables such as the occupational class of the household (manual, professional, skilled, unskilled), the age of the chief economic supporter, the principal economic status of the chief economic supporter (at work, unemployed, home duties, student, retired, ill) or which income quintile the household falls into are also available. As indicated in Table 1, the number of rooms in the dwelling ranges from 2 to 30 while the number of bedrooms ranges from 1 to 15. This variable seems to have a very wide range however, consistent with expectations, 50% of all dwellings have 3 bedrooms or less and 6 rooms or less.

6.2 The house value

The NSHQ provides three variables relating to house value. The first is the original purchase price of the home. This variable is not used in the analysis as it would result in homes being valued at different points in time. As we require a consistent estimate of house value, we considered the two other variables. The first was an estimate of house value made by the owner. The owner was asked: “What price do you think you would be able to get for the accommodation if you were to sell it now?”. The second estimate was made by the interviewer. Survey interviewers tend to have a good knowledge of the area and the local prices and in 2002 the market was far from thin, making estimation easier and more likely to be accurate. The interviewer was asked the “Estimated value of the accommodation if it were to be sold” (Watson, 2003).

We subtracted the owner’s estimate from the interviewer’s estimate. We would hope to see fairly similar figures and the corresponding difference would then centre around zero. The differences between the two estimates for the full sample are plotted in the top panel of Figure 4. Approximately 83% of all values are within 20’000€ of

the estimate. As is expected, the graph is skewed to the left, indicating the home owners tend to value their homes at a higher value than the interviewers do.[16]

The final mean house value is €118'000 with a standard deviation of €73'000. These figures vary quite a bit by region (Table 2) with Dublin having the highest mean house value (nearly double the mean house value at €198'000) however they are well distributed within regions (Figure 5). The following section presents the results and analysis.

7. Results

This section presents the different segments of the analysis. First the importance of geographical dummies when using hedonic analysis is highlighted. Then the absolute errors in estimation using different dwelling characteristics are presented followed by the A/S ratio analysis. Section 7.4 looks at who would be favourably and adversely impacted by different estimation methods followed by tests for vertical inequity and section 7.6 looks at what would happen if property tax bands were to be used.

7.1 The importance of geographical dummies in hedonic regressions

The first step in the analysis is to estimate house values using dwelling characteristics. The top panel of Table 3 shows the results of a regression, where house value is regressed on the dwelling size in square meters. The results are as expected; as dwelling size increases, the house value increases. The R^2 for this regression is very low, at 17%. If we estimate house values using these regression results and then plot the ABV error we get the top panel of Figure 6. This shows, in increasing order, by how many euro the model mis-predicts the house price. Anything below the x-axis represents an under-valuation of house price by the model and anything over the x-axis represents an over-estimation. There are some very high value outliers on either end of the spectrum and the median error is €18'300. This is not unexpected as we would anticipate that regional differences would have a significant effect on house

[16] As there are a few extremely high outliers (e.g. a difference of for instance 4.6 million euro) which could have been due to coding mistakes (or very optimistic owners!) we cut the top and bottom quarter percent of values and the final sample differences are presented in panel (b) of Figure 4.

prices. Consequently the regression is re-estimated using interactions with local authority dummies and the results are presented in the bottom panel of Table 3. The R^2 for this regression is already much higher, at 53%. Just one variable, the size in square meters of the house when coupled with geographical dummies accounts for 53% of the variation in house price. It is immediately clear that the ABV errors have reduced and the graph in the bottom panel of Figure 6 is leaner. The median error falls to 7'300€. Consequently, it is important to include geographical effects in the analysis. As it is possible that local authorities would administer the property tax and this is the most detailed location variable we have available, we use local authority dummies for the remainder of the analysis.[17] The following section takes a closer look at the different ABV errors depending on the dwelling characteristics used to estimate price.

7.2 Absolute value errors

The least administrative costly taxes are those which require the least amount of information to collect. Consequently, a property tax which could equitably be implemented using just one dwelling characteristic would be very efficient. The previous section showed the absolute value errors using just one variable, size in square meters. This section compares the different dwelling characteristics, both separately and combined.

We estimated house value using a series of single explanatory variables, namely, number of rooms, number of bedrooms, year built (pre-1940, 1941-1970, 1971-1980, 1981-1996, post-1996) and dwelling type (detached, semi-detached, terraced house or bungalow and apartment). The summary statistics for the ABV errors for these regressions are presented in Table 4. The median errors are very low with number of rooms being the lowest, followed by size in square metres, number of bedrooms, dwelling type and year built. In contrast the standard deviations are much higher at approximately €50'000 to €60'000, while the outliers (minimum and maximum) are fairly similar regardless of the variable used. The results when using size in square meters and number of bedrooms are quite similar, an indication that rooms are a fairly good proxy for area. The number of rooms also has a smaller standard deviation.

[17] An interaction of town size and county produced similar results.

Table 5 presents the same statistics but relating to multivariate regressions, where combinations of dwelling characteristics have been used to estimate house value. Including all variables in the regression improves the median error and standard deviation however it is clear that it is the inclusion of size related variables (number of rooms or square meters) that has the largest effect. The inclusion of five variables instead of one reduces the median error to €3'900.

Figure 7 plots the absolute errors depending on the explanatory variable used as in Figure 6, but all are plotted on the same graph. Ideally, we would prefer the lines to centre on the zero circle. The estimations are quite different at the extremes depending on which variable is used but overall the number of rooms tends to stay closest to the zero circle. If these results were presented individually, as in Figure 6, the bottom part of the graph would have been larger, i.e. dwellings are being under-valued at a higher level than those being over-valued. We would expect this to be a good result for homeowners, however, it depends on the proportion of the error in relation to total house price. Indeed, under-valuation could only occur on very high priced homes and over-valuations on lower priced homes, which would be inequitable. Consequently, we need to look at the errors in the context of house value, this is the subject of the following section.

7.3 A/S ratios and assessment errors

An estimation error of 50'000 euro is not very large for a home worth 1 million but is quite important in the case of a home worth 250'000 euro. We therefore look at relative errors. Table 8 presents the summary statistics for the assessment ratios for the full sample depending on which explanatory variable or variables are used to estimate house price. The mean and median A/S ratios are all larger than one, indicating that on average properties are overvalued. This is confirmed by the skewness values which are all positive signifying that there is more over-assessment than under-assessment. Indicators of size and type result in median A/S ratios that are smaller than 1.1, however year built, as a single explanatory variable, is beyond the recommended A/S boundary (IAAO). The addition of all variables into the model significantly reduces the median A/S ratio and brings it very close to 1. These results indicate in first instance that part of the sample is estimated to within a quite close

range. However, it is important to look at the dispersion of the estimates. The CODs for estimates using size in square meters only, number of rooms only and all explanatory variables are 28, 27 and 27 respectively. This is well above the range of 5 to 15 considered acceptable by the IAAO. This result indicates that the assessments are too variable. Figure 8 shows the different AS ratios plotted against house value. It is clear that the outliers at both ends of the scale are causing the variability in the AS ratios regardless of the model used. Although some are correctly assessed, due to the large variability in the assessment for the outliers there is considerable horizontal inequity.

Lin (2009) estimates the number of incorrectly assessed properties using the A/S ratio and defines incorrectly assessed properties as those with A/S ratios either one standard deviation above or below the mean A/S ratio. According to this criterion, the area-only model correctly values 93% of properties. An equal proportion is correctly estimated when using all five dwelling characteristics, and 72% when using the number of rooms only. This confirms the result above. Although a large number of properties are "correctly" assessed, those that are not have very large deviations. The next stage in the analysis is to investigate whether these assessment differences relate to a specific group of properties or owners. For the rest of the analysis we will only present results for three estimations: size in square meters only, number of rooms only, and the set of all 5 variables. We include number of rooms even though it relates quite well to size in square meters as this allows us to use the much larger sample as a check of the consistency of the results.

7.4 Horizontal inequity across groups

If the assessment model correctly estimates house prices, we should not detect any difference in assessment ratios among different types of properties or across owner groups. As indicated above, the three estimations produce median results that are within an acceptable range, however the dispersion of the results is too large. By breaking down the analysis into sub-groups we identify which properties are causing the bulk of the errors. We can also identify which household groups are more likely to be mis-assessed. Consequently, we break down the A/S ratios by region, by income,

by age of the chief economic supporter, by employment class and occupational status and rural versus urban dwellings. The results are presented in Tables 9 to 14.

The regional breakdown indicates that the A/S ratios using 5 variables are all below 1.1 (both for the mean and the median figures) across all regions. Using just one dwelling characteristic increases the ratios, however the median ratios remain below 1.1 across all regions. A result worth noting in the regional breakdown is that the median A/S ratios for Dublin (1.102 and 1.094) are the largest compared to all other regions when using just one explanatory variable (rooms or square meters). However it is much lower when all five dwelling characteristics are included. This is not unexpected as price variability *within* Dublin would be much higher than anywhere else and the geographical dummies only split the city into four. Consequently, additional information of dwellings within Dublin is required and the age or type of dwelling may well, in the case of Dublin, reflect neighbourhood differences.

Table 10 shows that the dwellings of people with high incomes are under-assessed. The median assessment ratio gets smaller the higher the income. This would tend to suggest that any assessment method imposed would be regressive; this is investigated further in Section 7.5. The results according to employment class also confirm this result, with high professionals' homes being under-valued (Table 12). Estimation results for the unskilled are not within acceptable ranges and the same applies to unemployed owners, and those in the "Home duties" and "Other" categories (Table 13). These results however could be due to small samples in these categories. Assessment ratios are too high for the youngest and oldest owners when using just square meters as an explanatory variable (Table 11). However they are all within acceptable ranges when using the full set of explanatory variables. Finally, there is only a slight difference between assessment ratios depending on whether the dwelling is located in a rural or urban area. Consequently, the value of properties of younger owners, the unskilled and unemployed tend to be over-assessed while high income and high professional owners win out. The initial indications seem to be that should this type of valuation method be implemented in this case it would be regressive. We investigate the issue of vertical inequity in more detail below.

7.5 Vertical inequity

Table 15 presents the results of the models listed in Equations 5 to 8 in Section 5.4. The results indicate that for all three models, assessment ratio errors based on hedonic valuation would be regressive. For Equation 5, the positive and significant intercept in all cases suggests a regressive valuation structure. The coefficient on the house value in Equation 6 is negative and statistically significant in all cases, also indicating a regressive valuation method. However the coefficient on the slope is extremely small as has been found in other studies (Smith, 2000). The coefficient on log house value in Equation 7 is smaller than one, again indicating regressivity. Finally, in the case of the Bell (1984) model, which incorporates a quadratic term, the results indicate that there is accelerating regressivity as the intercept is positive and the coefficient on the quadratic variable is negative. Consequently, regardless of the dwelling characteristic used to estimate the house price, the resulting valuation method would make regressive errors. Lower value dwellings would be over-valued and high value homes would be under-valued. Consequently, the inclusion of exemptions for lower income groups (the most likely owners of low value homes) and more individual audits for very high value homes would be recommended.

7.6 Predicting the tax band and difficulties in self-assessment

The Commission on Taxation suggested the use of tax bands for self-valuation. This allows us to relax the need to precisely assess property.[18] The bands suggested by the Commission are presented in Table 6 and increase in increments of €150'000. The proportion of dwellings correctly assessed using the different models is presented in Table 7. Table 7 also shows whether the dwelling was incorrectly put into a higher or a lower band than it should have. The proportion of households that are correctly assessed is on average above 78%. The use of all five available explanatory variables results in the lowest mistake rate (16%). It is also worth noting that of those incorrectly assessed, regardless of the explanatory variable used, a higher proportion end up in a lower band than their correct band. Therefore, a system based on hedonic

[18] With assessment ratios of 1.1 the "acceptable" band is within 10% of the house value (i.e. within 40'000 euro of a 400'000 euro dwelling) which even at much higher average house prices is well below the CoT bands (which increase in increments of 150'000 euro). Consequently, the proportion of homes "correctly" attributed will be higher using this criterion.

regressions could be used to check fairly accurately whether self-assessed households have assessed their property into the right tax band. However, considering the results in the previous sections, it would still be necessary to put in place checks to more accurately audit very highly priced properties. At the same time, the regressivity of the system could be reduced by introducing exemptions for lower value properties and low income groups. A tax system using property characteristics as a supplement to self-assessment might also help households who are unsure about the price of their property to more accurately estimate it. Figure 9 shows that the error in self-assessment as a proportion of the total property value decreases as household income increases. This indicates that lower income households are more likely to self-assess incorrectly. A property tax based on self-assessment therefore makes regressive errors too, and requires auxiliary policies just like a hedonic-based tax would. However, Figure 9 also shows that the errors in a hedonic tax would be larger – unsurprisingly, as less information is used to estimate the house value – and more regressive.

8. Discussion and conclusions

This paper examines the implications of using hedonic regressions or a very basic type of automated valuation system to estimate the values of properties in Ireland, in view of introducing an *ad valorem* property tax in the Republic. Flat rate property taxes are deemed unfair as lower income households pay the same amount as higher income households. Consequently, taxes based on the value of the property are considered more acceptable[19] and a tax on the ownership of property is less volatile than the existing stamp duty. The implementation of a property tax does however require that a price valuation of the property exists.

We find that a system based on a handful of property characteristics (as well as location dummies) can produce estimates which are within the acceptable bounds as defined by the International Association of Assessing Officers. These estimates are produced using county dummies. Size characteristics (such as area in square meters

[19] Note that a linear ad valorem tax would be regressive, as lower income groups tend to spend a higher proportion of their income on housing (based on shares from the Central Statistics Office Household Budget Survey, 2005).

and number of rooms) produce more accurate estimates compared to, for instance, the age of the house. However, the more variables included, the more precise the prediction. The precision of the geographical dummies is also important. If a system of tax bands, as proposed by the Commission on Taxation (2009) were to be used, the hedonic regressions allocate approximately 80% of the sample properties into the correct band. However, we found that a valuation system of this type is regressive, resulting in lower value homes being over-valued and higher value homes being under-valued. At the extremes, using just one property characteristic does not produce equitable results.

Two important issues arise from this exercise. The first is the issue of timing and the second is the issue of funding. With regard to the former, if an ad valorem property tax were to be introduced in Ireland in the near future, time constraints would result in a simple valuation system. Self-assessment has been offered as a potential solution. However in a thin recessionary property market, it is difficult for households to estimate the value of their property. Without adequate checks and penalties, there are incentives to underreport house values. Hedonic house prices, or self-assessment with hedonic validation are alternative solutions. It could in parallel be used as a basis for collecting information about dwelling characteristics and help build a national geo-coded database of self-assessed price and house features. It could also be envisaged that if a banded system is used, a model based on house characteristics combined with geographical dummies could be used to help homeowners identify their own tax band. However, as was demonstrated in Northern Ireland, a system based on specific (rather than banded) assessments would be fairer.

Nevertheless, a system of this type should not be seen as an adequate replacement for a properly administered automated valuation model. The ultimate objective with a tax of this type should be to create a more equitable and precise valuation system as soon as possible. The creation of a national house price database is already underway. However, with existing house price volatility it will be ineffective unless combined with the gathering of information on the house *characteristics*. All homes included in the database will also have to be geocoded so as to facilitate any future valuations and so that exact spatial sub-markets can be identified. The range of variables used in this analysis is constrained by the variables available in the dataset. Collecting information on the total size of the property *site* including gardens and any land would be more

useful than solely using the size of the constructed property. Special consideration would also need to be given regarding the valuation of apartments. If funds are going to be put towards creating a database, this should be done properly and the experience of neighbours should also be considered. As was found in Northern Ireland, "the need for good data is imperative and the data must be in place before successful modelling is possible" (Gloudemans and Montgomery, 2008: 30). As with any type of tax, putting in place exemptions and adjustments for the most vulnerable income groups is essential.

Finally, the issue of the date the valuations are made is important. The Irish property market has fluctuated enormously in the last few years and house prices have been on a downward course since the beginning of the recession. According to the PTSB/ESRI house price index (Q2 2010), property prices in Ireland have fallen by 35% since the peak at the end of 2006. Valuing houses based on transactions that took place during the boom would result in most cases in homeowners paying tax on a value for their home that is unrepresentative of its current market value. If a national valuation of properties is to take place, it will be crucial that all properties are valued at the same date.

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Tables

Table 1. Summary statistics for the main variables in the analysis.

Variable	Obs	Mean	Std. Dev.	Min	Max
Interviewer Value	25016	118078	73178	33077	763937
Owner Value	25016	122528	76087	31502	930310
Number of rooms	25016	7.04	1.84	2	30
Number of bedrooms	25016	3.68	0.99	1	15
Year built	25016	2.60	1.24	1	5
Dwelling type	25016	1.55	0.75	1	4
Local authority	25016	16.81	9.93	1	34
Region	25016	4.30	2.35	1	8
Occupational class	25016	3.86	1.98	1	7
Rural	25016	0.50	0.50	0	1
CES[a] age	25016	2.91	0.81	1	4
Employment status	25016	2.25	1.74	1	7
Square metres	7023	147.26	66.90	2.00	928.57

[a] Chief Economic Supporter

Table 2. House values by region, full sample

Variable	Obs	Mean	Std. Dev.	Min	Max
Border	4,031	96,253	48,086	33,865	590,673
Dublin	3,930	198,456	102,448	70,881	763,937
MidEast	2,015	141,695	67,360	39,378	669,429
Midland	3,068	93,315	45,644	35,440	551,295
Midwest	2,731	92,671	47,067	33,078	393,782
Southeast	3,895	98,679	50,721	34,114	708,808
SouthWest	2,423	115,636	58,219	35,440	630,051
West	2,923	101,431	56,207	33,078	630,051

Table 3. Regression results house value regressed on square meters, with (bottom panel) and without (top panel) geographical dummies and interactions

HouseValue	**Coefficient**	**Std. Err**
Square meters	457.38***	14.317
Constant	70024.51***	2315.762

Observations: 7023, R^2: 0.17

HouseValue	**Coefficient**	**Std. Err.**
Square meters	580.20***	99
Dublin city council	93802.45***	16771
Dublin south	-745.07	18742
Dublin Fingal	49571.09***	17329
Dun Laoghaire/Rathdown	119598.6***	17184
Kildare	21687.85	19459
Kilkenny	-4191.70	19695
Laois	3883.70	18716
Longford	-16938.75	19303
Louth	48653.31***	17989
Meath	39773.84**	18040
Offaly	-5346.65	18003
Westmeath	8807.76	19764
Wexford	5951.04	18938
Wicklow	-8200.98	20452
Clare	22940.94	18321
Cork city	16198.20	17674
Cork county	29187.22	17824
Kerry	26347.85	18536
Limerick city	19079.13	18249
Limerick county	40626.15**	17884
Tipperary north	-16306.38	17730
Tipperary south	-31983.04	23533
Waterford city	55392.86***	17927
Waterford county	-57643.69**	23226
Galway city	25276.53	20240
Galway county	-37438.72*	19975
Leitrim	14462.84	17510
Mayo	-26377.72	18761
Roscommon	22634.56	17301
Sligo	24993.97	17466
Cavan	2121.43	19131
Donegal	21123.51	17607
Monaghan	6419.79	20422
Constant	36387.13**	15320

Observations: 7023, R^2: 0.53, interactions of square meters and Geographical dummies included in regression but not shown.

Table 4. ABV Error statistics depending on which individual explanatory variable is used.

Variable	Obs	Mean	Std. Dev	Median	Min	Max
Square meters	7023	0.0001	58319	7322.373	-490157	633198
Dwelling Type	25016	0.0002	56582	9585.908	-606166	244145
Number of rooms	25016	0.0001	49083	6100.632	-542236	369864
Num of bedrooms	25016	-0.0003	53876	8299.977	-575954	415567
Year Built	25016	0.0000	59508	12353.17	-594469	228144

Table 5. ABV Error statistics depending on which combinations of explanatory variable are used.

Variable	Obs	Mean	Std. Dev	Median	Min	Max
All variables	7023	0.000047	48031	3888.27	-449697	333510
Square meters, bedrooms, yr built, dwelling type	7023	0.000078	50483	3950.39	-448209	336543
Square meters and dwelling type	7023	-0.000196	55299	5711.44	-489675	502641
Rooms, bedrooms, yr built, dwelling type	25016	0.000055	45887	4526.06	-531562	377553
Rooms and dwelling type	25016	0.000330	47241	4993.05	-541901	359081
Bedrooms, dwelling type and rooms	25016	0.000091	47162	5026.39	-542436	354930

Table 6. Valuation bands as proposed by the Commission on Taxation (2009:166)

	Valuation Band
A	0-150’000
B	150’001-300’000
C	300’001-450’000
D	450’001-600’000
E	600’001-750’000
F	750’001-1’000’000
G	1’000’001-1’500’000
H	1’500’001 and higher

Table 7. Proportion of households being put in the incorrect estimation band by explanatory variable used

Variable	Obs	Proportion in incorrect valuation band (%)	Proportion in lower band than correct	Proportion in higher band than correct
Square meters	7023	22.53	13.58	8.94
Dwelling type	25016	20.03	11.86	8.17
Number of rooms	25016	17.15	10.39	6.76
Year built	25016	21.40	12.77	8.63
Number of bedrooms	25016	19.05	11.99	7.06
All 5 variables	7023	19.95	10.85	9.10
Rooms, bedrooms, year built, dwelling type	25016	16.18	9.32	6.86
Square meters, bedrooms, year built, dwelling type	7023	20.65	11.28	9.37
Rooms, bedrooms, dwelling type	25016	16.63	9.71	6.92
Rooms, dwelling type	25016	16.67	10.02	6.65
Square meters, dwelling type	7023	22.40	12.07	10.32

Table 8. A/S ratio summary statistics for entire sample depending on explanatory variables used in the hedonic regression

Variable	Mean	Std. Dev	Median	Min	Max	Skewness	Kurtosis
Square meters	1.131	0.427	1.066	0.119	8.385	2.72	26.42
Dwelling type	1.166	0.448	1.098	0.145	4.875	1.03	5.12
Number of rooms	1.114	0.372	1.066	0.129	4.306	1.03	5.58
Year built	1.176	0.449	1.141	0.138	4.353	0.75	4.07
Number of bedrooms	1.142	0.410	1.090	0.145	4.196	0.92	4.74
All 5 variables	1.084	0.340	1.036	-0.049	5.235	1.53	9.99
Rooms, bedrooms, year built, dwelling type	1.100	0.356	1.048	0.159	4.823	1.21	6.87
Square meters, bedrooms, year built, dwelling type	1.095	0.360	1.037	-0.466	5.038	1.60	10.12
Rooms, bedrooms, dwelling type	1.107	0.367	1.053	-0.022	4.817	1.20	6.62
Rooms, dwelling type	1.107	0.367	1.053	0.120	4.875	1.20	6.65
Square meters, dwelling type	1.117	0.403	1.053	-1.129	5.820	2.12	16.12

Table 9. Assessment ratios by region, using just square meters (top), just number of rooms (middle) and using all variables (bottom)

Region	Obs	Mean	Std. Dev.	Median	Min	Max
Border	1241	1.135	0.430	1.059	0.17	5.80
Dublin	1225	1.138	0.428	1.102	0.24	5.32
Mideast	604	1.111	0.399	1.061	0.19	3.85
Midland	884	1.116	0.376	1.069	0.28	4.92
Midwest	784	1.167	0.528	1.074	0.32	8.38
Southeast	835	1.119	0.403	1.040	0.22	3.78
Southwest	677	1.141	0.446	1.051	0.29	4.22
West	773	1.114	0.387	1.065	0.12	3.50

Region	Obs	Mean	Std. Dev.	Median	Min	Max
Border	4031	1.113	0.376	1.059	0.19	3.96
Dublin	3930	1.103	0.347	1.094	0.20	4.24
Mideast	2015	1.107	0.373	1.050	0.24	3.42
Midland	3068	1.114	0.371	1.052	0.18	3.33
Midwest	2731	1.125	0.388	1.071	0.24	3.20
Southeast	3895	1.114	0.375	1.064	0.15	3.90
Southwest	2423	1.120	0.382	1.069	0.13	3.21
West	2923	1.119	0.371	1.094	0.17	4.31

Region	Obs	Mean	Std. Dev.	Median	Min	Max
Border	1241	1.085	0.343	1.044	0.08	3.21
Dublin	1225	1.075	0.342	1.031	-0.05	5.23
Mideast	604	1.077	0.331	1.029	0.43	3.08
Midland	884	1.089	0.329	1.037	0.28	2.86
Midwest	784	1.093	0.348	1.050	0.32	3.79
Southeast	835	1.071	0.316	1.021	0.34	2.82
Southwest	677	1.099	0.367	1.043	0.38	3.30
West	773	1.084	0.340	1.029	0.29	3.27

Table 10. Assessment ratios by income quintile, using just square meters (top), just number of rooms (middle) and using all variables (bottom)

Income	Obs	Mean	Std. Dev.	Median	Min	Max
Quintile 1	534	1.288	0.477	1.230	0.32	5.54
Quintile 2	1282	1.209	0.456	1.151	0.22	8.38
Quintile 3	1517	1.152	0.426	1.088	0.12	5.80
Quintile 4	1790	1.106	0.401	1.038	0.17	4.92
Quintile 5	1900	1.041	0.393	0.979	0.19	5.32

Income	Obs	Mean	Std. Dev.	Median	Min	Max
Quintile 1	2971	1.200	0.392	1.164	0.20	3.90
Quintile 2	5380	1.159	0.374	1.115	0.24	3.96
Quintile 3	6026	1.135	0.374	1.084	0.17	3.21
Quintile 4	5870	1.088	0.360	1.038	0.17	3.50
Quintile 5	4769	1.014	0.343	0.967	0.13	4.31

Income	Obs	Mean	Std. Dev.	Median	Min	Max
Quintile 1	534	1.113	0.349	1.090	0.33	2.74
Quintile 2	1282	1.132	0.356	1.085	0.37	3.79
Quintile 3	1517	1.112	0.347	1.064	0.28	3.27
Quintile 4	1790	1.078	0.328	1.028	-0.05	3.30
Quintile 5	1900	1.025	0.322	0.980	0.08	5.23

Table 11. Assessment ratios by age of reference person, using just square meters (top), just number of rooms (middle) and using all variables (bottom)

Age	Obs	Mean	Std. Dev.	Median	Min	Max
Under 30	324	1.201	0.498	1.125	0.45	5.80
30-45	2280	1.098	0.391	1.046	0.19	5.32
46-64	3133	1.125	0.427	1.058	0.12	8.38
65+	1286	1.186	0.462	1.112	0.17	5.54

Age	Obs	Mean	Std. Dev.	Median	Min	Max
Under 30	994	1.078	0.345	1.018	0.26	3.39
30-45	6449	1.069	0.350	1.020	0.13	4.31
46-64	11417	1.116	0.366	1.070	0.15	3.38
65+	6156	1.162	0.402	1.112	0.17	3.96

Age	Obs	Mean	Std. Dev.	Median	Min	Max
Under 30	324	1.085	0.333	1.046	-0.05	3.21
30-45	2280	1.074	0.328	1.025	0.29	5.23
46-64	3133	1.091	0.339	1.046	0.32	3.79
65+	1286	1.082	0.362	1.035	0.08	2.92

Table 12. Assessment ratios by employment class of reference person, using just square meters (top), just number of rooms (middle) and using all variables (bottom)

Employment	Obs	Mean	Std. Dev.	Median	Min	Max
High Professional	1293	1.021	0.393	0.961	0.19	5.32
Low Professional	1543	1.072	0.387	1.012	0.17	4.39
Other non	1228	1.148	0.411	1.076	0.12	4.37
Skilled	1113	1.161	0.381	1.114	0.22	4.11
Semi-skilled	571	1.194	0.461	1.128	0.36	5.54
Unskilled	357	1.302	0.427	1.308	0.39	4.48
Unknown	918	1.221	0.525	1.136	0.35	8.38

Employment	Obs	Mean	Std. Dev.	Median	Min	Max
High Professional	2963	1.006	0.345	0.956	0.13	4.24
Low Professional	4635	1.048	0.362	0.991	0.15	4.31
Other non	4610	1.124	0.374	1.070	0.26	3.96
Skilled	4178	1.138	0.358	1.098	0.24	3.20
Semi-skilled	2498	1.145	0.357	1.105	0.26	3.33
Unskilled	1731	1.204	0.368	1.164	0.31	3.42
Unknown	4401	1.168	0.393	1.117	0.25	3.38

Employment	Obs	Mean	Std. Dev.	Median	Min	Max
High Professional	1293	1.028	0.340	0.978	0.28	5.23
Low Professional	1543	1.056	0.334	1.013	0.08	2.98
Other non	1228	1.095	0.334	1.042	0.32	3.27
Skilled	1113	1.100	0.322	1.058	0.43	2.48
Semi-skilled	571	1.098	0.317	1.069	-0.05	2.77
Unskilled	357	1.158	0.348	1.124	0.41	2.78
Unknown	918	1.135	0.370	1.085	0.33	3.79

Table 13. Assessment ratios by employment status of reference person, using just square meters (top), just number of rooms (middle) and using all variables (bottom)

Employment	Obs	Mean	Std. Dev.	Median	Min	Max
At work	4924	1.110	0.409	1.048	0.12	8.38
Unemployed	163	1.341	0.591	1.212	0.43	5.45
Home duties	537	1.170	0.424	1.119	0.37	3.33
Student	28	1.328	0.928	1.068	0.78	5.80
Retired	1328	1.162	0.446	1.083	0.30	5.54
Other	43	1.188	0.319	1.170	0.54	1.87

Employment	Obs	Mean	Std. Dev.	Median	Min	Max
At work	15417	1.093	0.363	1.046	0.13	4.31
Unemployed	602	1.207	0.377	1.154	0.28	3.24
Home duties	2792	1.140	0.387	1.103	0.24	3.96
Student	92	1.076	0.282	1.064	0.53	1.76
Retired	5877	1.142	0.383	1.101	0.20	3.90
Other	236	1.217	0.401	1.126	0.37	2.88

Employment	Obs	Mean	Std. Dev.	Median	Min	Max
At work	4924	1.084	0.335	1.033	-0.05	5.23
Unemployed	163	1.143	0.401	1.080	0.38	3.30
Home duties	537	1.082	0.331	1.044	0.44	2.82
Student	28	1.142	0.451	1.099	0.79	3.21
Retired	1328	1.073	0.347	1.026	0.32	2.92
Other	43	1.156	0.354	1.164	0.57	2.07

Table 14. Assessment ratios by rural versus urban, using just square meters (top), just number of rooms (middle) and using all variables (bottom)

Rural/Urban	Obs	Mean	Std. Dev.	Median	Min	Max
Urban	3288	1.104	0.437	1.043	0.19	8.38
Rural	3735	1.155	0.417	1.088	0.12	5.54

Rural/Urban	Obs	Mean	Std. Dev.	Median	Min	Max
Urban	12556	1.078	0.331	1.049	0.15	4.24
Rural	12460	1.150	0.406	1.096	0.13	4.31

Rural/Urban	Obs	Mean	Std. Dev.	Median	Min	Max
Urban	3288	1.044	0.311	1.003	-0.05	5.23
Rural	3735	1.118	0.360	1.067	0.08	3.30

Table 15. Indicators of vertical inequity, regression model results

		Square Meters		Num. Rooms		All var	
		Coef.	Std. Err	Coef.	Std. Err	Coef.	Std. Err
Eq.	HseVal	0.539***	0.006	0.550***	0.003	0.687***	0.006
5	Constant	63326.69***	963.848	53121.34***	436.953	42953.62***	896.376
Eq.	HseVal	-2.44E-06***	5.17E-08	-2.51E-06***	2.79E-08	-1.56E-06***	4.34E-08
6	Constant	1.466***	0.008	1.410***	0.004	1.297***	0.007
Eq.	LnHVal	0.573***	0.006	0.599***	0.003	0.731***	0.006
7	Constant	5.046***	0.069	4.676***	0.038	3.177***	0.069
Eq.	HseVal	0.838***	0.016	0.847***	0.008	0.969***	0.015
8	HseValSq	-6.23E-07***	3.09E-08	-6.86E-07***	1.63E-08	-5.88E-07***	2.87E-08
	Constant	38662.13***	1539.166	31299.48***	668.974	19662.64***	1430.13

Figures

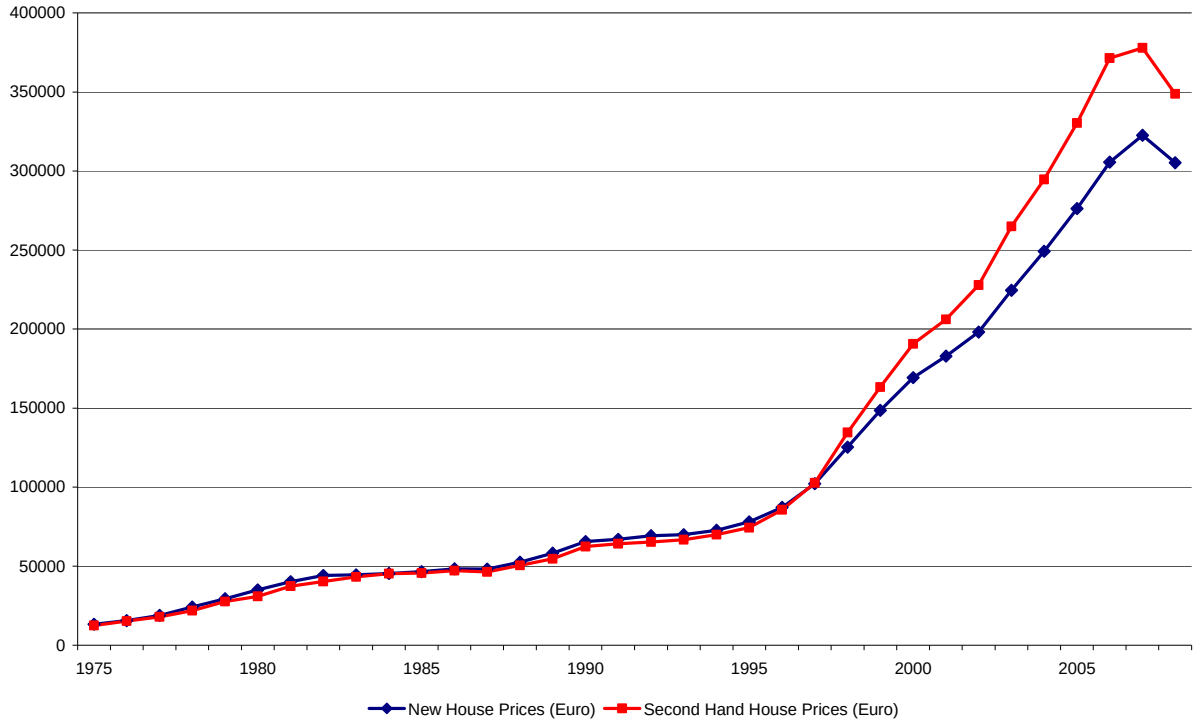

Figure 1. Average national house prices (1975-2008) in Ireland for new and second hand houses. Source: Department of the Environment, Heritage and Local Government.

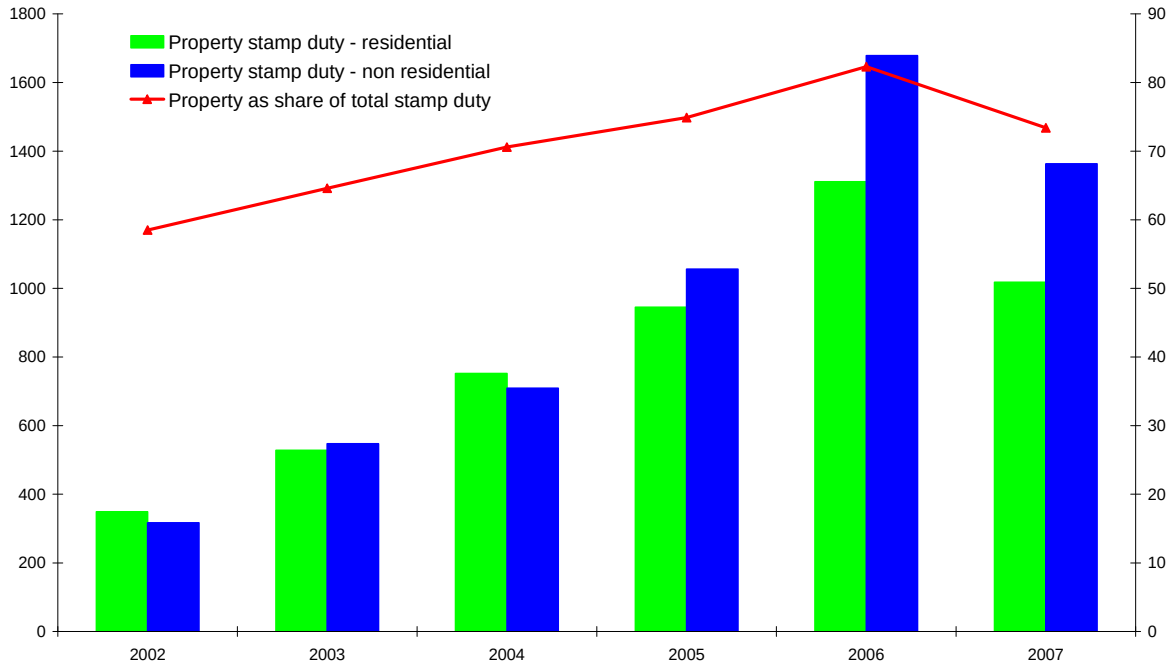

Figure 2. Net receipts of stamp duties (2002-2007) in Ireland (€m). Source: CSO *Construction and Housing in Ireland Report,* 2008 Edition. Based on figures in Table 5.4.

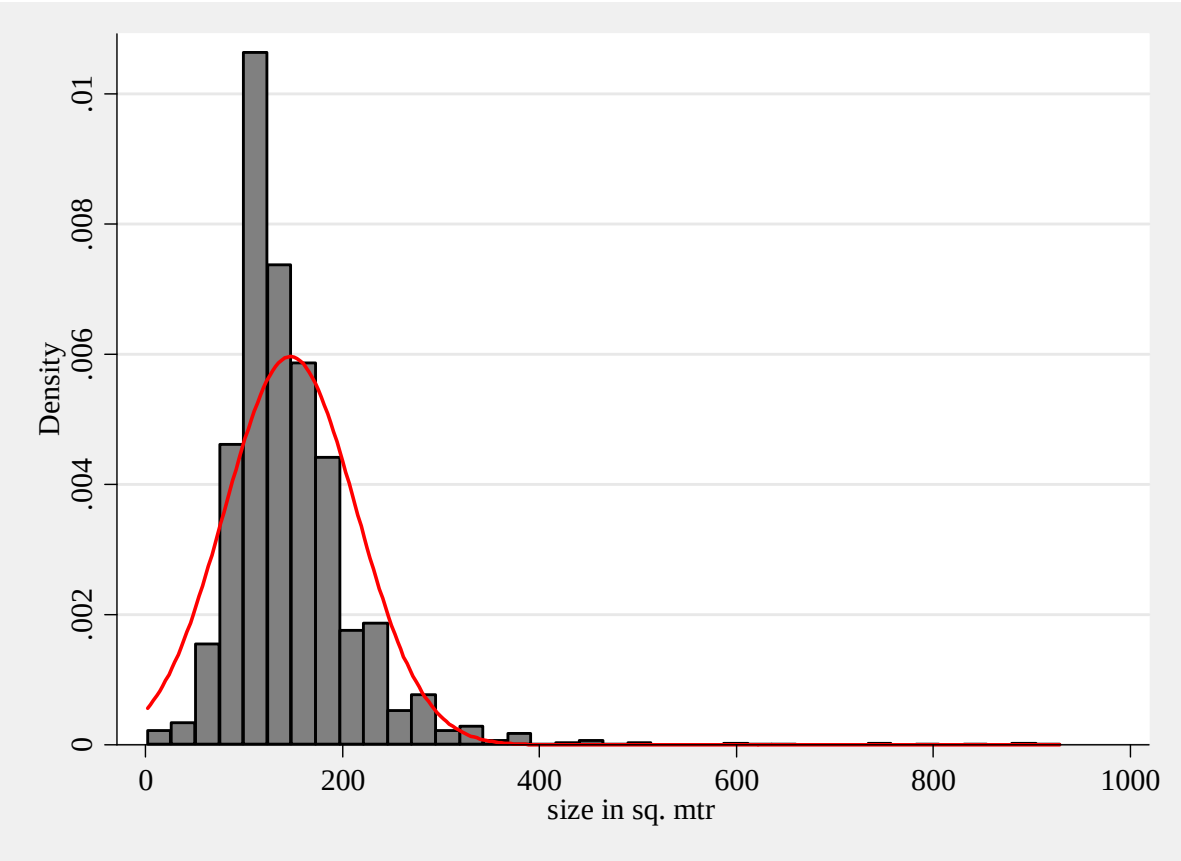

Figure 3. Distribution of dwelling area size (in square meters) for respondents who knew the size of their home with a normal distribution plot.

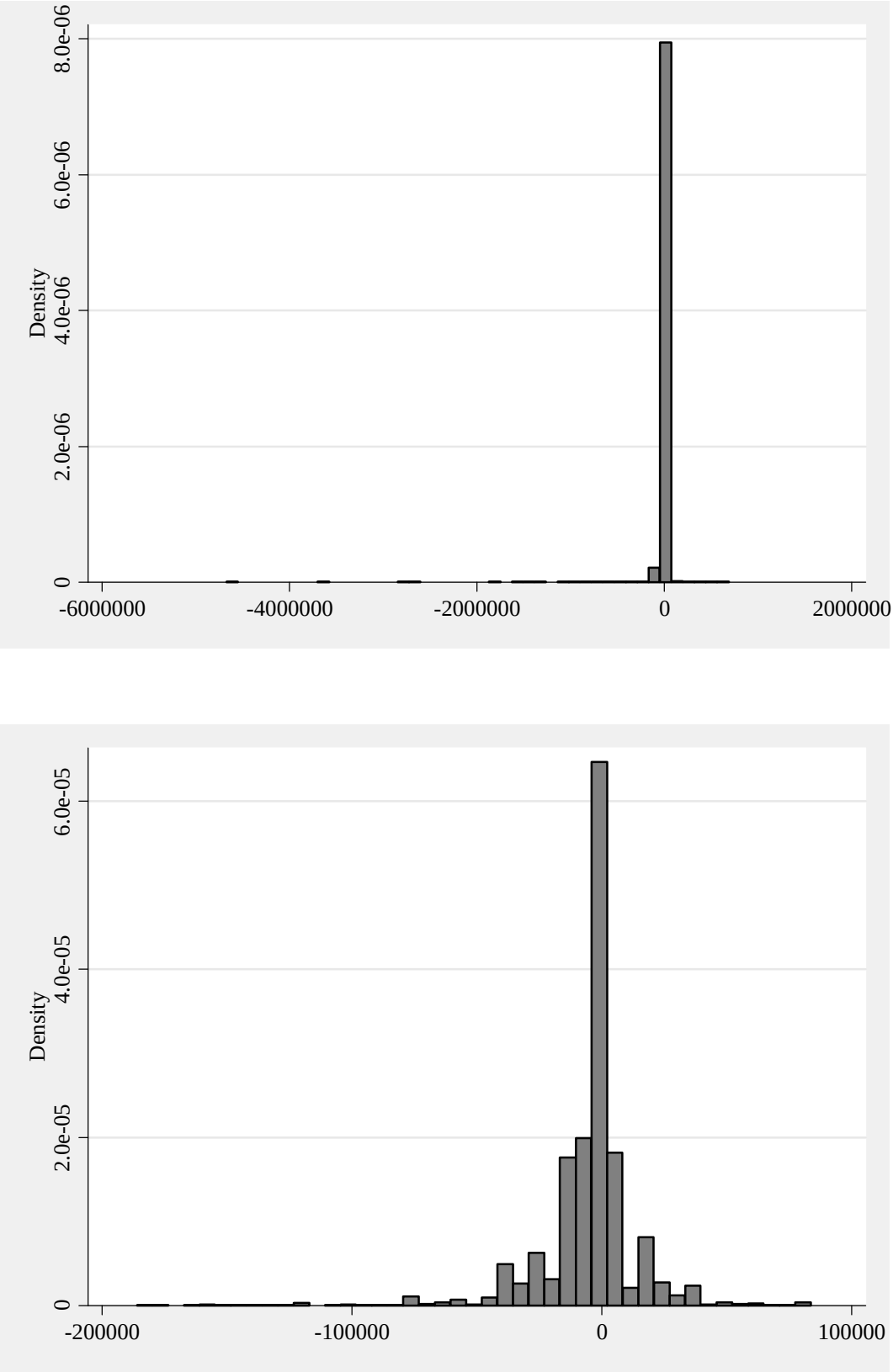

Figure 4. Plot of interviewer estimate minus owner estimate of house value. The top panel is the original sample. The bottom panel is the reduced sample.

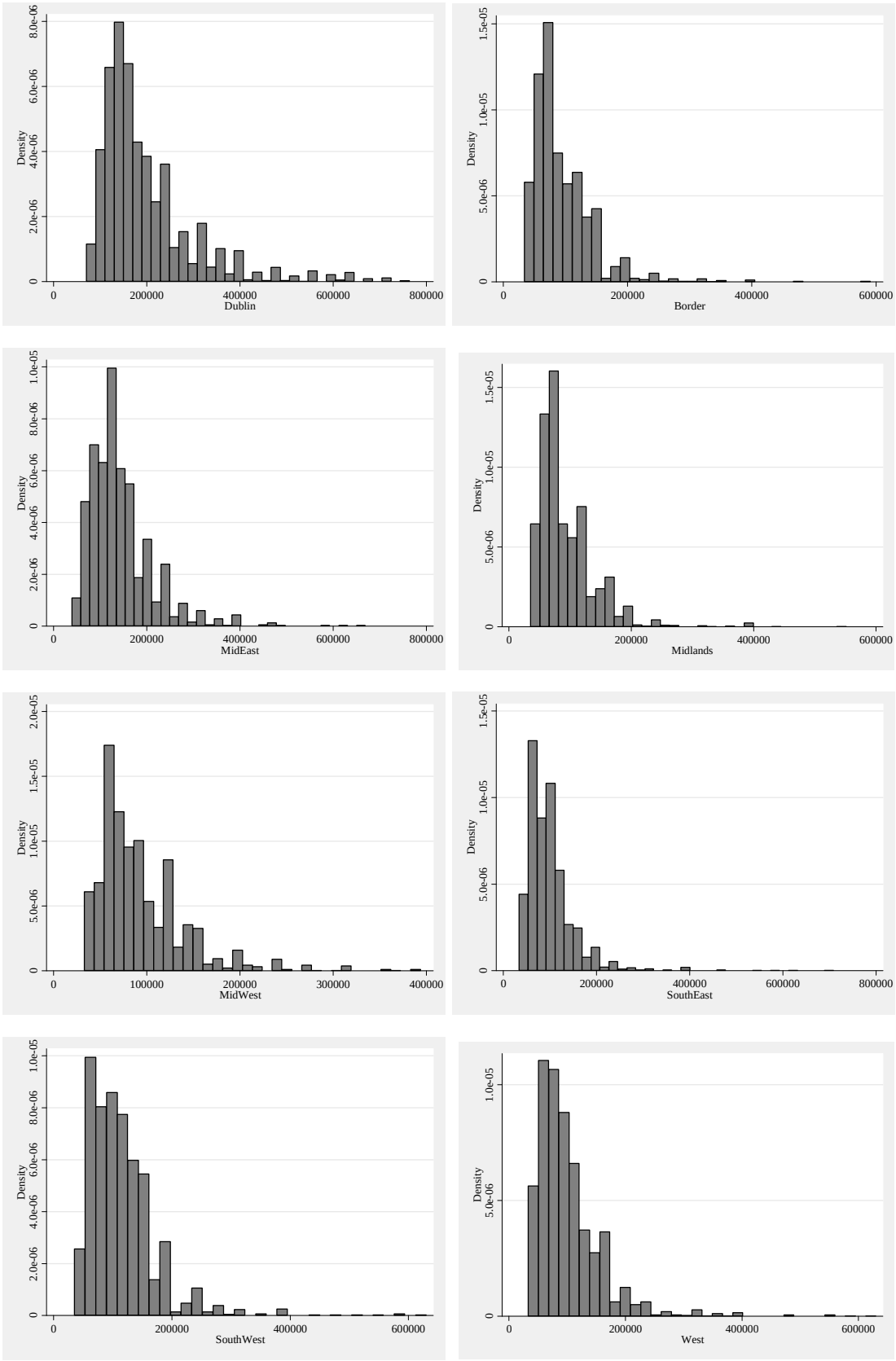

Figure 5. Histogram plots of house value by region: Dublin, Border, Mideast, Midlands, Midwest, Southeast, Southwest, West.

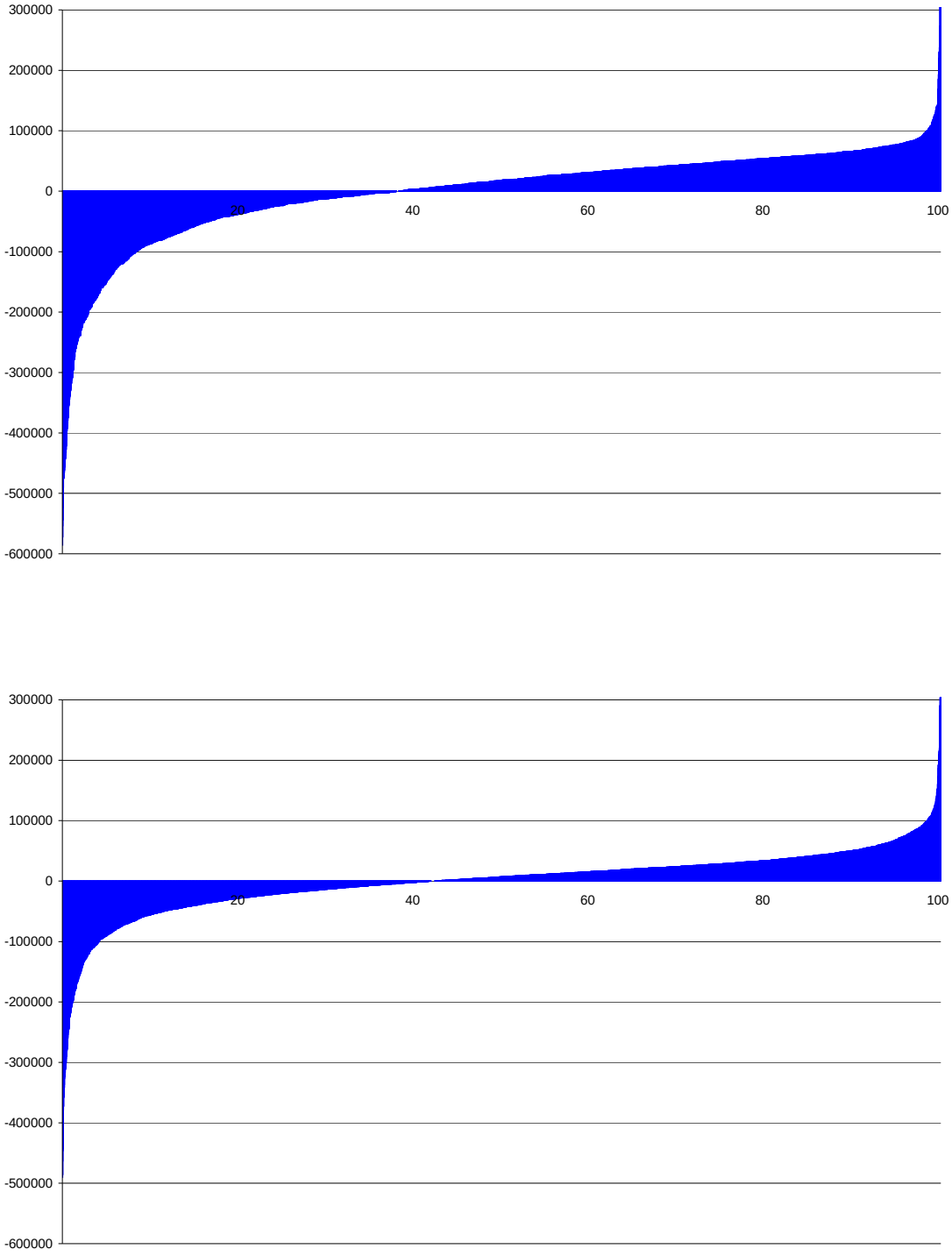

Figure 6. ABV errors from a regression using square meter dummies without geographical dummies (top panel) and with geographical dummies (bottom panel)

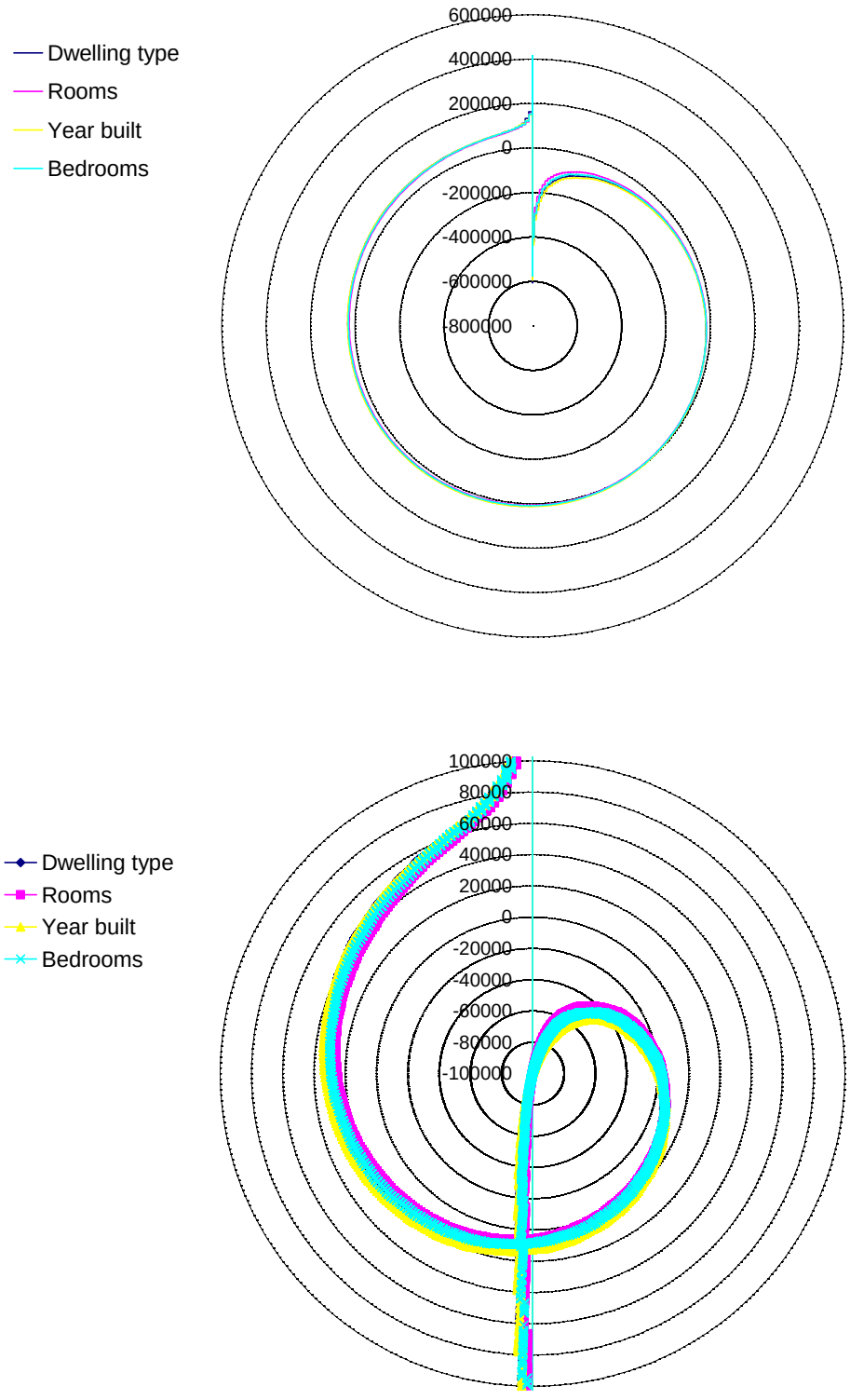

Figure 7. ABV errors from regressions using dwelling type, number of rooms, number of bedrooms and year built as individual explanatory variables with local authority dummy variables.

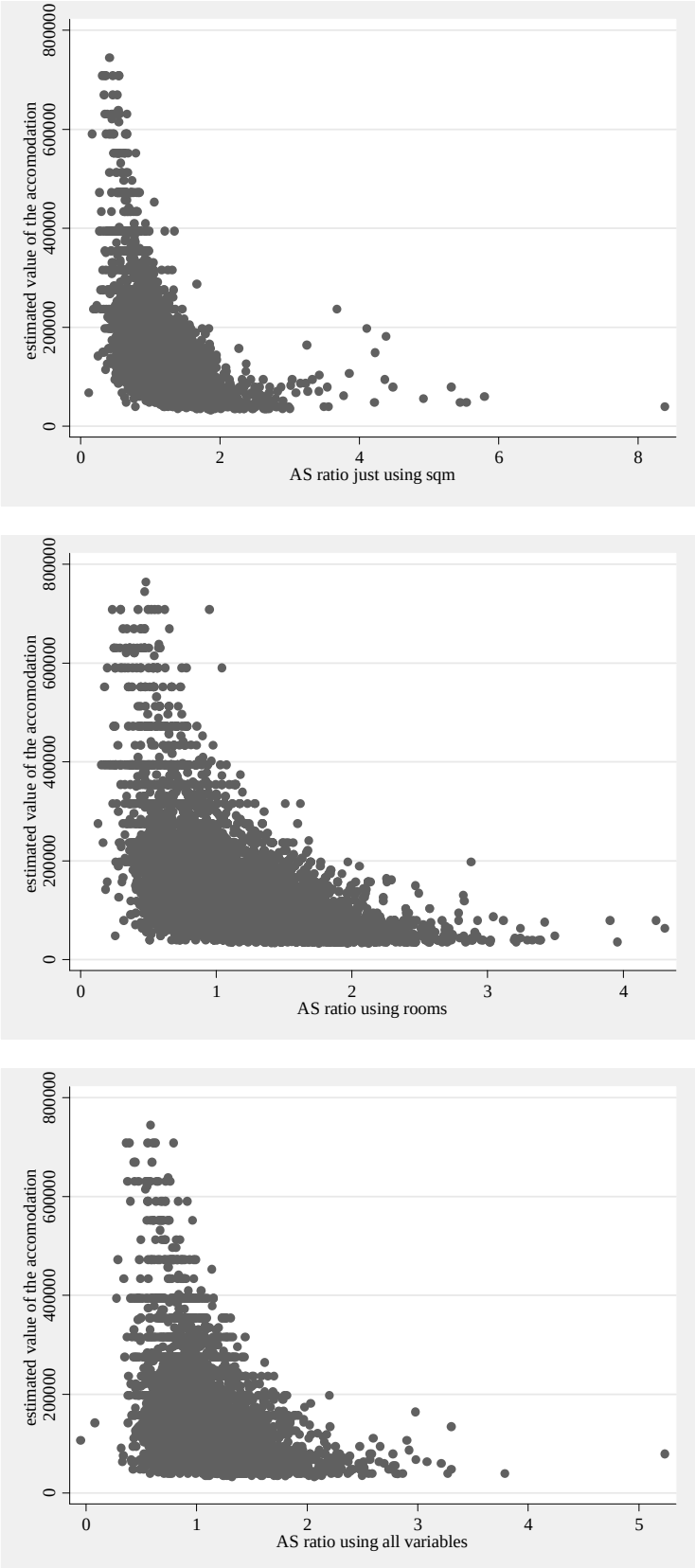

Figure 8. Assessment ratios against property price calculated using just size in square meters (top), just number of rooms (middle) and all five explanatory variables (bottom)

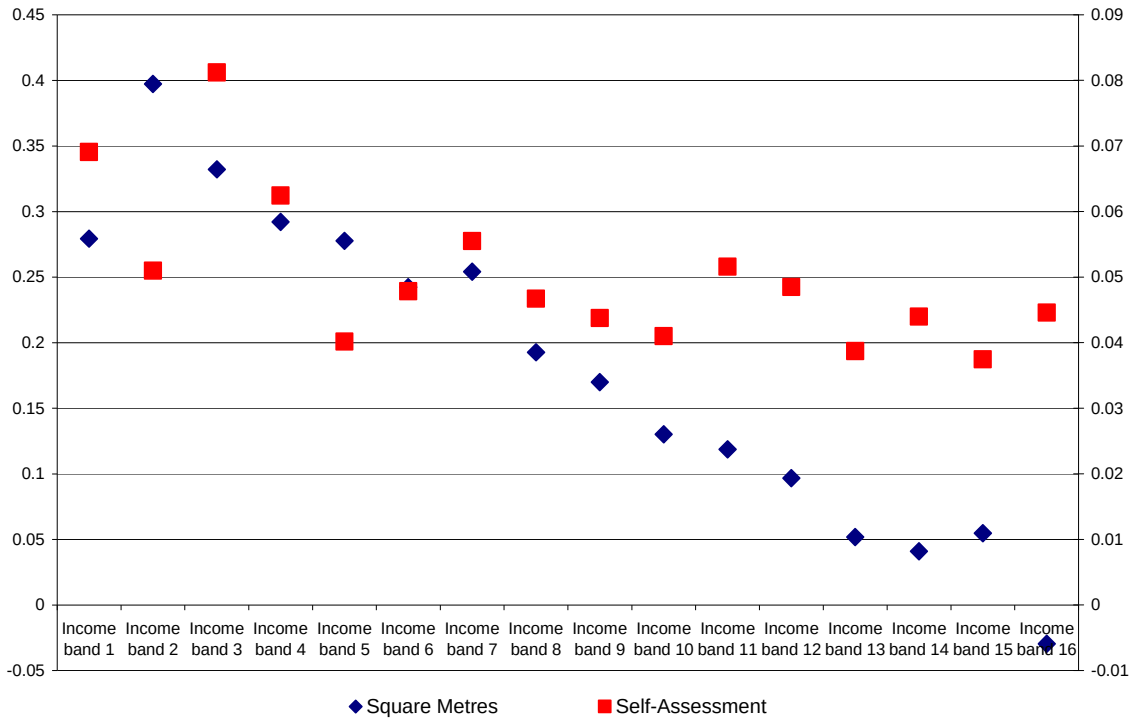

Figure 9. Mean assessment error (by self-assessment and using just square meters) as a proportion of the property value, by income band.

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