Inside a bubble and crash: Evidence from the valuation of amenities

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Abstract Housing markets and their cycles are central to understanding macroeconomic fluctuations. As housing is an inherently spatial market, an understanding of the economics of location-specific amenities is needed. This paper examines this topic, using a rich dataset of 25 primary location-specific characteristics and over 1.2 million sales and rental listings in Ireland, from the peak of a real estate bubble in 2006 to 2012 when prices had fallen by more than half. It finds clear evidence that the price effects of amenities are greater than rent effects, something that may be explained by either tenant search thresholds or buyers' desire to "lock in" access to fixed-supply amenities. Buyer lock-in concerns would be most prevalent at the height of a bubble and thus would be associated with pro-cyclical amenity pricing. Instead there is significant evidence that the relative price of amenities is counter-cyclical. This suggests the Irish housing market bubble was characterized by "property ladder" effects, rather than "lock-in" concerns.

Keywords: Housing markets; amenity valuation; search costs; market cycles.

JEL Classification Numbers: R31, E32, H4, D62, H23.

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1 Introduction

The housing market is among the most important markets in modern economies. It constitutes perhaps the single most important class of consumption good, making up 32% of the U.S. urban CPI basket and 24% of the UK's RPI. Housing is also the most prevalent investment asset, comprising for example 54% of US household wealth in 2001 and 72% of Irish wealth in 2007 (Bank of Ireland 2007, Luckett 2001). It is therefore unsurprising that the housing market has assumed a central role in explaining business cycles (see, for example, Leamer 2007). Indeed, there is evidence of a strong link between housing and business cycles not just throughout the postwar era (e.g. Holly & Jones 1997), but even predating the Industrial Revolution (Eichholtz et al. 2012, O'Rourke & Polak 1991).

Understanding the link between housing market cycles and the macroeconomy is particularly important given the aftermath of the global economic and financial crisis starting in 2007. The group of OECD economies enjoyed an unprecedented boom in housing prices over the late 1990s and early 2000s. This was followed by a rise in defaults in the U.S. mortgage market, in particular its sub-prime segment, which – due to a range of financial innovations such as securitization – had an impact on the global financial system (Duca et al. 2010). The following years have seen the effects spread to global trade (2008-2009) and sovereign debt (from 2010).

Ireland's economic fortunes have in many respects been a microcosm of those globally. The period from the mid-1990s to 2007 was one of very strong economic growth in Ireland, initially export-led but in later years fuelled by the availability of cheap credit and an unprecedented building boom. From 2007, the economic downturn was severe. National income fell from €163bn in 2007 to €128bn in 2011 (GNP in current prices), while government finances deteriorated sharply, with fiscal deficits of 10% of GDP per year by 2010. Unemployment rose from below 5% in 2007 to almost 15% by 2011, while large inward migration flows changed to emigration. Despite the global nature of the crisis, central to the dramatic change in Ireland's economic fortunes were domestic factors, in particular the end of a domestic real estate bubble.

The case of Ireland highlights the links that exist between housing and other aspects of the economy, including financial stability, the labour market, the government finances, and public service provision. To understand how a housing cycle can affect economic fluctuations, it is important not only to understand the channels through which housing and the wider economy are related (see, for example, Muellbauer 2012), but also how the housing market itself works. Yet the mechanics of the housing market and its cycles remain poorly understood. The housing market is an inherently spatial one and, property-

specific attributes aside, differences in price across the market reflect location-specific amenities. With nominal house prices falls of over 50% between 2006 and 2012, Ireland is a natural case study for studying the ups and downs of housing markets.

This paper uses a new and detailed dataset of property listings in Ireland, both sales and lettings, over the period 2006-2012 – and a large dataset of location-specific amenities – to investigate the relationship between amenities and the housing market cycle. Taking the hedonic regression literature started by Rosen (1974), that amenities will be reflected in property prices, it explores two related hypotheses. The first is that price and rent effects of amenities may differ. Theory suggests that, either due to renter search thresholds or a desire on the part of buyers to lock in access to amenities, the price effect should be greater than the rent effect. Secondly, the effect of amenities on the cost of accommodation may vary with the cycle. This may be pro-cyclical, reflecting buyer lock-in concerns, or counter-cyclical, reflecting "property ladder" effects.

The paper is structured as follows. Sections 2 and 3 outline briefly the economic theory and existing literature in relation to amenity valuation and the structure of prices in the housing market, while section 4 provides details on the data used in this analysis. Section 5 outlines the model and empirical strategy and Section 6 presents the results. Section 7 concludes.

2 Theory

2.1 Urban economics & bid-rent gradients

Von Thünen's (1863) theory of farmers sorting by opportunity cost of distance to a market extends in a straightforward fashion to models of household location selection. Models along these lines date from Alonso (1964), where, in a monocentric city, one would expect those households with the highest opportunity cost of distance from a given central business district (CBD) to locate closest to it. As outlined by Straszheim (1987), in a standard monocentric model, a household derives utility from its quantity of land consumed (q), its location or distance from the centre (u), and the numeraire composite consumption good (z). Its expenditure includes rent per unit of house size (r) and transport costs (T).

The optimization problem yields an equation of the marginal rate of substitution across housing and non-housing with their price ratio: $V_z/V_q = 1/r(u)$. Choice of location must satisfy a condition equating the change in rent to the trade-off between monetized value of the disutility of a longer commute and the change in transport expenditure: $\partial r/\partial u \cdot q = V_u/V_z - \partial T/\partial u$. The bid-rent gradient from the CBD outwards can

be assumed, via partial equilibrium analysis, or derived, via general equilibrium analysis, where assumptions are made about utility levels at different locations. Either way, households will move away from the centre, along the rent gradient, until the marginal disutility of a longer trip just offsets the savings achieved for land consumed.

2.2 Hedonic Markets and Implicit Prices

There is an important caveat to the von Thunen set of theories, namely that all models assume that cities are monocentric and indeed that these centres are exogenous. Work such as that by Dubin & Sung (1987) suggests that there are limitations to models that focus on one particular amenity, i.e. proximity to employment, and that impose a particular distribution of that amenity, i.e. entirely within a set central business district. There are a large number of potential considerations beyond employment that may affect a household's choice of residence, from market depth to environmental. Allowing an n-dimensional amenity vector and relaxing the restrictions on the location of amenities across the city space suggests that a more complicated bid function for given levels of utility and income is required.

Rosen's (1974) model contains a market for good z comprising $i = 1, \ldots, n$ attributes (or amenities), where $p(z_1, \ldots, z_n)$ is increasing in all its arguments and has second derivatives. Due to indivisibilities in the good directly traded, its package of amenities cannot be "untied" and therefore there cannot be the arbitrage required to make $p(z)$ linear. The value function $\theta(z_1, \ldots, z_n; u, y)$ represents the expenditure a consumer is willing to pay for different alternative values of z, for a given utility index and income level and is the multi-dimensional counterpart to Alonso's bid-rent function.

In practical terms, this means that the value of an amenity should be reflected in the price. A suitable empirical strategy will be able to highlight the marginal willingness to pay for access to that amenity by holding other factors constant and varying access to the amenity. This is the approach used here.

2.3 Amenity valuation by tenure

It is possible that, controlling for household characteristics, renters and buyers care about different sets of amenities. In particular, two mechanisms suggest that buyers will factor in a wider range of amenities than renters.

The first is that there are factors, such as indivisibilities related to search costs, that restrict renters' willingness to pay for amenities. The market for accommodation is one where matching is important, as both occupants and properties have idiosyncratic attributes. Suppose that search costs (s) in the property market, whether renting or

buying, involve indivisibilities: finding somewhere to live cannot be done without a certain minimum amount of time spent online and visiting properties (κ), in addition to any tenure-specific search costs and/or searcher intensities. Suppose also that prospective buyers and tenants have maximum thresholds (t) to their search costs that are roughly proportional to the value of the transaction (λV, where V denotes the value of the transaction): in practical terms, those buying their home for the next twenty years might be prepared to spend six months searching for the right property, but those renting for the next two years might not.

In such a market, there would be a disproportionality in the $s(\kappa) : t(\lambda)$ ratios for the same household buying or renting: renters are likely to hit their thresholds of search costs sooner. For example, while both buyers and renters may prefer properties closer to the coast or with a southerly orientation, only buyers may hold out and reward these amenities. Thus, one may expect certain amenities, particularly those that could be regarded as secondary, will not be rewarded to the same extent in the lettings market as in the sales market.

An alternative theory is that there are factors that encourage buyers to "over-capitalize" amenities. One obvious candidate is the frenzy of the bubble, where, due to the fixed supply of amenities, buyers are concerned about securing access to amenities (for example having schools nearby). In particular, buyers may worry about the cost of accessing amenities in the future, leading to a greater valuation by buyers than renters. Alternatively, transaction costs, such as legal fees and transaction-based taxes, may be significant for buyers (but unimportant for renters), restricting buyer mobility and thus encouraging them to lock in supply of particular amenities.[1]

Hypothesis 1 The first hypothesis to be tested empirically is, therefore, that the price effect of amenities is, in relative terms, greater than the rent effect.

2.4 Valuation of amenities over the market cycle

One theory suggests that higher price housing should be more volatile over the market cycle, due to the presence of down-payments and the fact that the typical household holds most of their private net wealth in housing (Stein 1995). Consider a negative shock to house prices: this hinders movers from making their next down-payment, depressing demand. If high-priced homes are purchased primarily by buyers trading up (rather than

[1]Note also that even if the buyer does not value a particular amenity, if they believe that the amenity will contribute to future capital gains, they will be prepared to pay for it now, unlike a tenant, who has no financial gain for an amenity they do not derive utility from directly. Using U.S. data on expenditure on education, Hilber & Mayer (2009) extend this argument to willingness-to-pay for new amenities by households that will only benefit through the capitalization of the amenity in house prices.

first-time buyers), then their prices should have a greater variance over the real estate cycle. The prior expectation, according to this liquidity constraint model, is that houses with higher prices would both rise and fall more dramatically than those with lower prices. As houses with higher prices are those in locations with greater amenities, this liquidity constraint model suggests procyclical amenity prices: that the price of amenities would rise in the bubble and then fall in the crash.

Alternatively, lower segments of the housing market may experience more volatile swings in prices. Costello (2000) suggests that more affordable properties are more liquid and thus these segments will be more competitive, rising more in boom markets and falling more in down markets. In lay terms, this can be thought of as a "property ladder" effect. In such a situation, greater importance is attached by buyers to having any property, even one with poor amenities, than at other points in the cycle, as (expected) capital gains will facilitate trading up in the future. Consequently, demand for low-quality (low-amenity) properties shifts up. With relatively less importance attached to amenities in the bubble than at other points in the market cycle, countercyclical amenity prices would be evidence of "property ladder" effects.

Hypothesis 2 The second hypothesis to be tested empirically is, therefore, whether the price effect of amenities is pro-cyclical or counter-cyclical.

2.5 Categories of amenities

It is possible to think of a multitude of location-specific characteristics that may impact on a property's desirability. A natural ordering of these amenities is by permanence or mobility. At one end of the spectrum are first-nature endowments of geography and environment. At the other end are population-specific, rather than location-specific amenities, such as market depth or social capital. Such amenities are hypothetically mobile, although taken as given by any individual actor as a point in time.[2] For the purposes of this analysis, six categories of amenities are considered. Roughly in order from least mobile to most, they are: environmental amenities; transport facilities; educational amenities; the labour market; neighbourhood quality; and agglomeration or market depth:

1. Environmental factors, such as proximity to coastline, lakes, rivers, forests or urban green space

2. Transport facilities, such as primary and secondary roads, train stations or light rail services

[2]The categorizaton presented is merely for ease of exposition and does not affect the conclusions reached.

3. Education facilities, including primary and post-primary schools and higher education institutes; the latter may be particularly important for renters (due to demographic reasons)

4. Labour market amenities, including the unemployment rate, the length of commuting to work and the diversity of general employment opportunities

5. Neighbourhood quality, measured through either incidents (crime rates) or inhabitants (for example the proportion with a third-level degree)

6. Agglomeration amenities, those of von Thunen and Alonso recast: proximity to centres of economic activity and distance from borders

While the focus here is on the amenities listed above as reflecting the primary location-specific factors, a large number of other amenities may affect house prices, including polluting facilities, national monuments, facilities such as prisons and stadiums. In addition, location-specific housing supply variables may affect property values, for example proximity to "ghost estates" or zoned land.

3 Literature

3.1 Hedonic pricing of amenities

Since Rosen's (1974) seminal paper, a large empirical literature has developed, estimating the implicit price of a wide range of amenities.[3] Much of the early literature was focused on environmental public goods, such as air and water quality – reviews are given by Smith & Huang (1995) on air quality, Boyle & Kiel (2001) on water quality and Kuminoff et al. (2010) on environmental amenities. There is also a large literature on the effect of transport facilities on property values, although the hedonic method is just one of a number of methods used here (Debrezion et al. 2007, RICS Policy Unit 2002, Wrigley et al. 2001).

A good overview of the hedonic valuation of amenities method and of the findings from recent research on the value of education, transport and safety amenities, is given by Gibbons & Machin (2008). They stress the use of quasi-experimental approaches that exploit variations in the supply of amenities, although recent theoretical research has highlighted the limits to reliance on supply shocks (Coate 2013). Literature on other amenities – in particular social capital but also market-depth – is much less developed at this stage, most likely as the bulk of empirical work is at city- or county-level and thus

[3]There are over 5,600 papers citing Rosen (1974), according to Google Scholar (Harzing 2007).

there is significantly less variation in population-specific characteristics than at country-level.

The literature on the hedonic pricing of amenities in the Irish property market is somewhat more limited. Mayor et al. (2009) and Mayor et al. (2008) examine amenities in the Dublin housing market during the final stages of the bubble (2001-2006). They find evidence that both urban green space and transport access are valued in house prices: increasing by 10% the proportion of urban green space within two kilometres of a house was associated with an increase of at least 7% in the house price. The effect of being less than 2km from a light rail station (Green Luas line) was of a similar magnitude. Another amenity they report is proximity to the coast, associated with a premium of 12%-22% premium for being within a kilometer of the coast (the closer to the coast, the larger the premium). The effect of various amenities is not broken down by phase in the market cycle, however, most likely due to sample size constraints.

Two comments on the literature are worthwhile. The first is that, by and large, well-specified studies – especially those that both control for omitted variables and exploit supply-side variation – do find that a wide range of amenities is factored into the cost of accommodation with the expected sign, although there is often little agreement across researchers on the magnitude. This may be understandable given that the studies vary hugely in terms of regions (and time periods) analyzed, as well as sample sizes and exact specification.

The second is that the established literature has a number of limitations. As is pointed out by Kuminoff et al. (2010), there is no reason to assume that amenities have time-constant prices, yet this is overwhelmingly the strategy adopted in the literature to date, more than likely due to sample size limitations. Likewise, there is very little information on the valuation of amenities in the lettings segment of the residential property market, again more than likely due to limitations of data.

One glimpse into the relationship between amenities and the housing market cycle is given by Case & Mayer (1996). Their study is of 135,000 repeat sales in 168 towns in Eastern Massachusetts over the period 1981-1994, when real house prices rose by 116% (1983-1988) before falling by 27% (1988-1991). Case & Mayer's (1996) model relates relative house prices changes over boom and bust to seven sets of variables, including amenities (employment, proximity to Boston, demographics, crime and schooling), shocks to the supply of land/housing, immigration, and local taxes.

They find that amenities such as employment, education and low crime shifted the distribution of prices during the boom, but far less so if at all during the bust. For example, towns with a larger share of residents working in the declining manufacturing sector witnessed smaller increases in house prices over the boom-bust cycle, while house prices

appreciated faster in towns with a larger percentage in 1980 of middle-aged residents, a sign of age-specific amenities. With school enrolment falling rapidly in the period, the premium attached to homes in high-quality school districts fell during the boom.

Nonetheless, despite the impact of amenities during the boom, Case & Mayer (1996) do not find evidence in favour of Stein's (1995) hypothesis, in relation to liquidity constraints, that the spread of house price is procyclical. Controlling for amenities, low-priced towns saw faster house price growth to 1988 and then greater falls after that. Also, distance to Boston mattered both in the boom and the bust: over the period as a whole, for a town one standard deviation closer to Boston than the average (15 miles compared to 32), house prices grew 5% faster, reflecting either Boston's high-income employment mix or the amenities it offers to nearby residents.

3.2 Structure of house prices

The paper by Case & Mayer (1996) is part of a broader literature on the structure of prices in the housing market, much of which is based on the U.S. market from the 1970s to the 1990s. For example, in their analysis of Houston, Texas, over the 1970s and 1980s, Smith & Tesarek (1991) find evidence in favour of Stein's (1995) hypothesis of a procyclical spread in house prices. Over a broader time frame, though, vacancy was key with higher-end properties recovering faster.

Case & Shiller (1994) explore two other 1980s boom-bust cycles in U.S. cities, those of Boston and Los Angeles and their results run somewhat counter to the liquidity constraint model presented above. In Boston, there is evidence of a shift in house price inflation to the lower tier after other tiers had stabilised (1987-9), giving that part of the market the greatest boom in prices. Similar to Houston, once prices started to fall, the higher tier bottomed out earlier. In LA, there was very similar appreciation across high, medium and low tiers of housing. Price falls, which had not finished by the time of publication, differed noticeably across segments, with higher tier housing seeing significantly larger falls.

Using data for the city of Perth, Western Australia, during the period 1988-1996, Costello (2000) finds that repeat sales were biased towards lower price quartiles, suggesting greater liquidity in cheaper segments. He also finds that the top quartile in particular exhibited significantly less real house price inflation than other segments. For two major Japanese cities, Tokyo and Osaka, Hirayama (2005) outlines the extent of 1990-2002 price falls by property type. While the price of new single-family dwellings fell by 10%, second-hand condominiums fell by 30% in Osaka and 40% in Tokyo. The biggest price falls (60%) were concentrated in bubble-era condominiums, either "super-luxury condominiums" in central districts, whose price had risen most dramatically in the boom years,

or "suburban bubble condominiums", which faced competition from steady streams of fresh supply.

In relation to the recent bubble and crash in Ireland, Lyons (2013*a*) finds that, once the overall fall in prices is accounted for, there is a marked increase in the spread of property prices by type. For example, controlling for location, the differential between a four-bedroom property and a two-bedroom property increased from 54% to 70% – a similar effect exists for type (switching from terraced to detached). This is in contrast to the lettings market, where there was marked compression in the spread of rents over the same period, and suggests that for property-specific attributes, there are countercyclical relative prices and thus "property ladder" effects dominate. Is the same true for location-specific amenities?

4 Data

The principal dataset used is provided by the online accommodation portal, Daft.ie, which provides price (rent) information as well as property attributes, including location. In addition to information on listed purchase or rental price (outlined below), there are seven further dimensions along which the data are segmented: segment; size; type; time; location; property attributes; and location amenities. For time (in particular phase of the market, whether bubble or crash), but also for segment (sales or lettings) and for certain variables type and location, interactions between dimensions are included.

The sales component of the full dataset includes 416,899 properties listed for sale between 2006 and 2012.[4] As is outlined in Table 1, almost three-quarters of properties listed were three-bedroom or four-bedroom in size. In terms of regional distribution, two-fifths of the listings were in Ireland's five cities (almost 30% alone in Dublin). Roughly one third of properties were from the Leinster province, large parts of which act as commuter areas for Dublin. After excluding properties whose location is not known to sufficient accuracy, the lettings component of the dataset comprises just over 825,000 ads. Compared to the sales dataset, there are a greater proportion of smaller properties and Dublin properties: the most common property size is two-bedroom, while Dublin properties comprise almost half of all ads. Summary stats for both components of the dataset are given in Table 1.

There are three distinguishing features about this dataset. The first is its size (well

[4]The vast majority of listings in the dataset refer to ads posted on the Daft.ie site. Roughly 34,000 refer to the small fraction of online listings in Ireland that were not advertised on the Daft.ie portal, most of which date from 2006-2007. Where the list price was changed, the revised ad was treated as a new observation, reflecting the fact that the focus here is on price relativities within a given period of time and general market trends are controlled for.

Category	Cohort	Sales		Lettings	
		Count	Percent	Count	Percent
Size	One-bedroom	11,459	2.7%	83,954	10.2%
	Two-bedroom	67,124	16.1%	314,140	38.1%
	Three-bedroom	190,076	45.6%	267,530	32.4%
	Four-bedroom	121,050	29.0%	133,886	16.2%
	Five-bedroom	27,190	6.5%	25,589	3.1%
Region	Dublin	119,898	28.8%	394,376	47.8%
	Other cities	53,069	12.7%	128,806	15.6%
	Leinster	125,467	30.1%	189,041	22.9%
	Munster	69,396	16.6%	69,837	8.5%
	Connacht-Ulster	49,069	11.8%	43,039	5.2%
Total		416,899	100.0%	825,099	100.0%

Table 1: *Dataset size, by cohort*

over a million observations), not only relative to the size of Ireland's housing market – the country had in Census 2011 just over two million households – but also in absolute terms, compared to studies from other countries. In their review of 69 hedonic studies of willingness to pay for environmental amenities in the two decades to 2006, Kuminoff et al. (2010) find that only about one in five (22%) contains more than 10,000 observations. The second is the fact that the dataset covers an entire country. Only about one in ten hedonic studies (9%) has been at the national level (Kuminoff et al. 2010). The third distinguishing feature is the fact that both sales and lettings markets are included: this is the first study of this type known to the author that has comparable data for both.

4.1 Price data

Price information included in the dataset is listed, or asking, price. An obvious concern is that the list price may not reflect the transaction price, if it exists. List prices in Ireland are not in any way legally privileged. A seller may state that they require offers "in excess of" or "in the region of" the list price, but typically the list prices are for information only and set after agreement between the seller and their estate agent. There is considerable precedent for using list prices where no dataset of transaction prices exists, as is the case with Ireland as the bubble ended. Some of the earliest contributions to housing economics use owner estimates of property values, for example in the Annual/American Housing Survey (e.g. Linneman 1980). Estimates of U.S. house prices during the 1890-1934 are based on homeowner recollection and current assessments (Grebler et al. 1956), while estimates for the period 1934-53 are based on newspaper listings (Shiller 2005). It has also been pointed out that listings data may more comprehensively capture relative values than sales data, which will be in some sense truncated samples of the full housing

stock (DiPasquale & Somerville 1995, Gatzlaff & Haurin 1998).

Nonetheless, there are differing views as to the accuracy of owner- or agent-assessed values. The general finding appears to be that homeowners tend to overstate the value of their homes (Banzhaf & Farooque 2012, Goodman & Ittner 1992), although this would not present an issue here if this bias did not vary systematically by market segment. Also, prices here are typically based on expert valuations, which are more accurate than owner assessments (Banzhaf & Farooque 2012). Kiel & Zabel (1999) find little difference in appreciation rates between self-reported values and transaction values, while Malpezzi (2003) concludes that hedonic models based on owner assessments would be "reasonably reliable". Research exploring the relationship between list and transaction prices in Ireland during this period finds a strong correlation between the two at an aggregate level, both over time and across space (Lyons 2013*b*). So while it is possible that particular effects may exist, such as greater negative equity among larger properties affecting list price, the current dataset offers a unique window into a market in flux.

4.2 Segment

Regressions are pooled across sales and lettings segments, in order to assess whether differences between price and rent effects are statisically signficant. For this, a categorical variable *let* is included, which takes a value of 1 for lettings ads. Interactions are also included between this variable and all other dimensions of the data, i.e. size, type, time, location, attributes and amenities. For example, in relation to size, examples of interacted variables include $beds2\_let$ and $beds2\_let\_cr$, which capture respectively (1) the difference in differential between 2- and 3-bed properties across sales and lettings segments, and (2) how that differential changed in the crash period (defined below). Similar variables are included for type, while interactions between *let* and property attributes, quarterly dummies and location dummies (explained below) are also included.

4.3 Size

Size in square metres is not a widely used metric by consumers in Ireland and consequently, the majority of sales listings (and all lettings listings) do not include this information. To capture a property's size, indicator variables are included for number of bedrooms (one to five) and then number of bathrooms relative to number of bedrooms.[5] For lettings properties, the occupancy of each bedroom is also known and this is measured by number of single bedrooms out of the total number of bedrooms. Interactions between segment and size are included, as described above.

[5]For example, $bb41$ refers to properties with four bedrooms and one bathroom.

4.4 Type

The most fundamental distinction by type is between apartments and houses. Within apartments, there are additional variables for duplexes (in sales) and "flats" (in lettings; referring to parts of houses that have been subdivided for lettings accommodation). For houses, there is additional information in the sales segment: terraced, semi-detached, detached and bungalow. These are all captured with categorical variables.

4.5 Time

Categorical variables by quarter are included to reflect the trend in property prices over time. Additional variables (e.g. $2010q1\_let$) allow the trend in rents (which fell 25% between 2007 and 2012) to differ from the trend in list prices (which fell more than 50%). As noted by Conniffe & Duffy (1999), a frequently absent feature of hedonic models was investigating the extent to which time and other attributes interact. Thus, the model includes interactions between different phases of the market and other dimensions of the data. Phases are defined as follows: the bubble (2006-2007, prices rising) and the crash (2010-2012, prices down by at least one third), with the intermediate period 2008-2009 is used as a control where relevant.

4.6 Location

Three dimensions of a property's location are used in this research: its regional market, to enable accurate pricing of different property types; its local market, to capture factors not included in the analysis; and its exact physical location, used to calculate distance to amenities.

4.6.1 Regional markets

Five broad regions in the Irish property market are defined. The first is Dublin city, while the second regional market contains the four other cities in Ireland combined (Cork, Galway, Limerick and Waterford), whose populations vary from 50,000 to 275,000. These are not contiguous but may share marginal price effects due to their status as regional cities. The other three regional markets are based on Ireland's provinces, but excluding the city areas: Leinster, Munster and Connacht-Ulster.

4.6.2 Local markets

At a more granular level, areas are grouped into one of about 400 local markets. These are fixed effects, designed to capture the impact on price of locality-specific factors that are

not included in a given specification, including location-specific and population-specific attributes or indeed any pure label effects. Ireland lacks a postcode system, so these markets were manually configured for each part of the country, according to a combination of the volume of listings, geographic coherence and market logic. Each is interacted with the *let* categorical variable, allowing the fixed effect for each local market to vary between sales and lettings segments.

4.6.3 Exact location

The final locational attribute used is the property's physical coordinates. The addresses of each property advertised is converted at the time of listing into xy coordinates. Also given is a level of accuracy with which these are coordinates are known. Both are products of addresses being applied to the Geodirectory service, run jointly by Ireland's official mapping and postal services (OSI and *An Post*). This accuracy can vary from area-level through townland, village and street-level to building-level. Only observations known to building or street level were included, given the focus of the study on amenity valuation using distance based on xy coordinates.[6]

4.7 Property attributes

A range of property-specific attributes can be measured from the data. A number, particularly for lettings listings, are included as separate fields in listings; these include white goods (the presence of a washing machine, dryer, dishwasher or microwave), utilities (cable TV, internet, an alarm or central heating), and whether the property has parking, is suitable for pets, wheelchair-accessible, furnished, or available to those on rent allowance. Information is also available on the lease length. For sales properties, there is information on whether the property is part of a new development, whether it is a re-listing at a different price, and whether the property is being sold by the owner or through an agent. For both sales and lettings listings, there is information on whether the property has a garden.

In addition, it is possible to reflect other potentially important property-specific features, using the text of the ad. This process generates an indicator variable capturing a particular attribute, when one of a number of key phrases that reflect the presence of that attibute occurs in the text of an ad. These variables include a property's aspect (south, west or south-west facing), its age (period, Edwardian, Victorian or Georgian), condition (whether the property has been recently refurbished or renovated), views, whether the

[6]This restriction involved the exclusion of an additional 264,975 sales listings and 322,809 rental listings over the period 2006-2012.

property is in a cul-de-sac (no through road), various types of rooms (utility room, conservatory, granny-flat, walk-in wardrobe, wetroom), features related to energy efficiency (underfloor heating, fireplace solar panels, double-glazing) and other features (balcony, bay windows, jacuzzi, fitted wardrobes, ensuite, garage, French doors, high or corniced ceilings, and branded kitchen appliances).

All property attributes are set up as categorical variables, with interactions for segment and for bubble and crash periods. An overview of the property-specific attributes included is given in Table 2 in Section 5.2.

4.8 Location amenities

The focus of this research is on location-specific amenities. A total of 25 location-specific characteritics were included. As explained in more detail in Section 5.2, the relationship between many of these characteristics and real estate is defined by distance, while for others (such as nearby crime or the local unemployment rate) the relationship will be a value, rather than a distance. The data are described below, by broad category of amenity.

4.8.1 Environmental amenities

Five environmental amenities were included: coastline, rivers, lakes, urban green space and forests. For data on the location of Ireland's coastline, lakes and rivers, the source for the data is Ireland's Environmental Protection Agency (EPA). For both lakes and rivers, controls are included for scale. Data on urban green spaces come from the European Urban Atlas and on Ireland's forests come from the 2006 CORINE Land Cover project (Environmental Protection Agency 2013*a*, European Environment Agency 2013); for both, controls for size are included, as described in Appendix A.

4.8.2 Transport facilities

Six amenities reflecting transport services were included. Four relate to the rail network: stations for commuter/intercity traffic, for DART (suburban) trains, and for Dublin's Luas Red and Luas Green light rail networks. Information on the location of stations is from Railway Procurement Agency (2012). Information is also included on the primary and secondary road network, from a complete dataset of the road network on the island of Ireland, produced by NavTeq (2012) and courtesy of National Institute of Regional & Spatial Analysis (NIRSA) at NUI Maynooth. Controls are included for speed limit that applies on the nearest stretch of road; see Appendix A.

4.8.3 Educational amenities

Proximity to primary and post-primary schools and higher education institutes is included in this research. The coordinates of all primary and secondary schools were provided directly to the author by the Department of Education and Skills in Ireland, who maintain an annual census of all schools in Ireland (Department of Education 2013). Information on the number and size of classes in each primary school is available from the same source, while information on the proportion of students progressing to higher education from post-primary schools was provided to the author by Grainne Faller, author of the Irish Times ranking of secondary schools. As outlined in Appendix A, controls were included for large and small primary schools (as measured by number of classes) and also for large and small average class sizes.

4.8.4 Labour market

Three labour market amenities are included. Information is available from the April 2011 Census on the neighbourhood ("Small Area") unemployment rate, on the average commute in minutes, and the contemporaneous sectoral allocation of the labour force (Central Statistics Office 2013).[7] The proportion of people employed in agriculture is used as a simple reduced form index of employment opportunity for an area. These three indicators give different measures of the local labour market amenity: unemployment, commuting, and opportunity. These can be best thought of as area-level fixed effects, as they are not time-varying and labour market conditions changed substantially over the period under consideration. Information from the 2011 Census, rather than the 2006 Census, is included due to the introduction of "Small Areas" in the later census, allowing a much more granular treatment of neighbourhood-specific labour market conditions.

4.8.5 Neighbourhood

Factors such as class, educational attainment, diversity or sense of community in an area may have an impact on property prices. However, without a more rigorous treatment, many of these factors belong in a second-stage analysis that attempts to describe the underlying demand curve. Much of the literature already includes local unemployment rates, to capture some index of neighbourhood quality. Here, unemployment is treated as part of the labour market amenity. Instead, for neighbourhood quality, the focus is

[7]The 2011 Census in Ireland was the first to launch administrative units below the level of Electoral Divisions (of which there are 3,409). Almost 18,500 "Small Areas" were used as the basis for enumeration in Census 2011. Each "Small Area" has a population of between 50 and 200 dwellings. They were created by NIRSA to be the lowest level of geography for the compilation of statistics in line with data protection and generally comprise either complete or partial townlands or neighbourhoods.

on attributes related to social capital that are, in a relative sense, more exogenous or difficult to change.

Five neighbourhood amenities were included that will be relatively fixed, at least in the short run. These include the percentage of residents with a degree and the neighbourhood's population density. As with the labour market amenities, these are the equivalent of cardinal fixed effects, based on a property's "Small Area" district in Central Statistics Office (2013). Three crime-related variables were included, based on station-level statistics for three types of crime over the period 2004-2010: burglary, murders, and drug-related offences. Each property was assigned a unique value for each category crime, based on an interpolated map of crime incidents. The resulting figure gives an indication of the number of incidents in the nearby area. As with Census-based values, these represent an ordering of areas, rather than reflecting innovations in crime rates over the period under investigation, which is left for future research.

4.8.6 Agglomeration

Lastly, three more general market depth or agglomeration amenities are included. The first two comprise distance from the "national CBD" (central Dublin) and, where relevant, distance from the nearest CBD, which may be across the border in Northern Ireland. The third is distance from the border with Northern Ireland.

4.8.7 Additional controls

To aid exposition, the treatment focuses primarily on these 25 location-specific characteristics. However, other factors may matter in determining the cost of accommodation. In addition to amenity-specific controls (as outlined above), and micro-market fixed effects, a further 45 location features are included as controls. In brief, they include distance from bathing facilities (mostly coast-side beaches), existing and proposed National Heritage Areas, elevation, sports & leisure facilities, rail track, and sea- and airports. They also include 17 different categories of facilities, eleven polluting facilities, so-termed under the system of Integrated Pollution Prevention Control (IPPC) Licensing, and a further six categories of waste facilities, which require a permit to operate and are available from the same source. Also included are the location of mobile phone masts, prisons, stadiums, hospitals, supermarkets, convenience stores and disused mines.

In relation to neighbourhood quality, the following controls were included: an area's maturity and spaciousness, as captured by the proportion of pre-1914 buildings and the average building size (in rooms), the proportion in State-provided housing, whether the property is in (or close to) an Irish-speaking *Gaeltacht* area. Six prominent categories

of national monument were also included: castles, church monuments, historic houses, ring-forts, holy wells, and stone monuments (such as standing crosses or Ogham stones). Controls are also included for whether the property lies within the boundaries of a town and, if so, what size of town (by population; seven categories).

Two further controls are included, reflecting housing supply conditions. The first is proximity to officially designated "ghost estates", of which almost 2,900 were recorded by the Department of the Environment in 2011 (Department of the Environment, Community & Local Government 2013*b*). The location of each is known (as a point rather than a polygon), as are a number of other details, including the size of the proposed development and its state of completion. Information is available on standardized zoning of land around the country, and in particular whether or not the property is on or near land zoned for residential development (Department of the Environment, Community & Local Government 2013*a*).

5 Model

5.1 General specification

The price of each property in the database can be represented as the sum of the estimated value of its constituent components as well as an error term, ϵ, reflecting the gap between the predicted value and the actual value; in simplified equation form:

$$log(price_i) = \alpha + \beta_0 let_i + X'_{1i}\beta_1 + X'_{2i}\beta_2 + X'_{3i}\beta_3 + X'_{4i}\beta_4 + \epsilon_i \quad (1)$$

where: let_i refers to whether the property is for sale or to let, X'_{1i} refers to property-specific characteristics, including size and type and interactions outlined earlier, X'_{2i} refers to the time period (quarterly fixed effects); and X'_{3i} refers to local market fixed effects, and X'_{4i} refers to a vector of location-specific amenities.

5.2 Amenity variables

For each amenity, five core sets of variables are included: the base effect (e.g. distance from the coast), the lettings effect (distance from coast interacted with *let*), effects by phase (interactions with indicators variables *bubble* and *crash*, reflecting the 2006-2007 and 2009-2012 periods) and lettings effects by phase (distance interacted with both *let* and one of *bubble* or *crash*). For each amenity, there may also be controls, reflecting amenity type, size and region, as described above. Regional controls may reflect a difference in the nature or supply of the amenity or alternatively income elasticities. Size and type

controls are included where possible to ensure that like-for-like comparisons are being made for different instances of what are classed as the same amenity.

How the base effect is captured affects the treatment of the other effects and controls. For most amenities, the treatment of distance is the use of log-distance with a second-order polynomial, to capture orders of magnitude and diminishing marginal effects. For certain amenities, this will impose an overly restrictive relationship between space and price, particularly where larger distances may matter. Thus, for distance from central Dublin, other CBDs and the border, a combination of log-distance and buffer variables was used, allowing the relationship between distance and price to vary over the following ranges 0-250m, 250m-1600m, 1600m-5000m and beyond.[8]

For the typical distance-based amenity, regression output will be in the form of a number of distance variables: log distance and its square, and similar variables that apply to all lettings only, all listings during the bubble, all listings during the crash, lettings listings during the bubble, and lettings listings during the crash. For other amenity-related variables, in particular controls for type, size or region, one additional interacted variable was included. The final treatment of amenity relates to "score" variables, rather than distance variables (such as the local unemployment rate or the incidence of burglaries nearby). As with distance, it is possible to interact these with indicator variables for *let*, *bubble*, *crash*, *let_bubble* and *let_crash*, as well as regions.

An overview of the treatment of amenities and location specific controls is given in Table 2. Numbers after each refer to the treatment of distance, where 1 refers to log distance with a second-order polynomial, 2 refers to buffer variables (controls only), while 3 refers to a combination log-buffer treatment, as described above, and 4 refers to a "score" variable. Letters refer to the source of the data, where *a* refers to Environmental Protection Agency (2013*a*), *b* Natural Earth Project (2013), *c* European Environment Agency (2013), *d* National Parks & Wildlife Service (2013), *e* Environmental Protection Agency (2013*b*), *f* Commission for Communications Regulation (2013), *g* Railway Procurement Agency (2012), *h* Geofabrik.de (2013), *i* NavTeq (2012), *j* Department of Education (2013), *k* Faller (2011), *m* Central Statistics Office (2013), *n* Office of the Garda Commissioner (2011), *o* National Monuments Service (2013), *p* the Competition Authority, *q* Department of the Environment, Community & Local Government (2013*b*), *r* Department of the Environment, Community & Local Government (2013*a*) and *z* refers to manual calculations by the author.

[8]All properties and many amenities are indicated on the map as points, whereas in reality they are polygons. Thus, one other modification, to prevent small distances (and any measurement error at small distances) skewing the results was to set the minimum log-distance from an amenity to 3 (20 metres), or 4 (55 metres) where the property's location is known only to street level.

Category	Amenity (treatment of distance, source)
Environmental	Coastline (1,a); Lakes (1,a); Rivers (1,a); Urban green space (1,c); Forest (1,c)
Transport	Train stations [including Luas and DART] (1,g); Primary roads (1,i); Secondary roads (1,i)
Education	Primary schools (1,j); Post-primary schools (1,jk); Higher education institutes (1,z)
Labour market	Unemployment (4,m); Commute length (4,m); % in agriculture (4,m)
Neighbourhood	Education levels (4,m); Population density (4,m); Burglary (4,n); Murders (4,n); Drugs-related crime (4,n)
Market Depth	Dublin CBD (3,z); nearest CBD (3,z); border (3,b)
Other Controls	IPPC & waste facilities (2/3, e); Prisons (1,z); Mobile phone masts (1,f); Historical Mines (1,a); Stadiums (1,z); Bathing facilities (1,a); Elevation (4,b); Hospitals (1,z); Sports facilities (1,c); National Heritage Areas (2,d); National monuments (2,o); Train track (1,h); Sea port (2,c); Airport (1,c); Area maturity (4,m); Area spaciousness (4,m); Irish-speaking Gaeltacht area (2,m); Local authority housing (4,m); Garda station (1,n); Town size (2,m); Supermarket location (1,p); Convenience store location (1,p); % single (4,m); Ghost estates (1,q); Zoned land (2,r)

Table 2: *Summary of location-specific variables used – for legend, see text*

6 Results

Table 5 presents regression output, both coefficient size and the associated p-values, for each of the 25 location-specific amenities being considered. Values shown for the DART, Luas Green and Luas Red amenities are the net effects, i.e. capturing the difference relative to standard train stations. Amenities marked with a diamond($^\diamond$) represent those measured with combined log-buffer variables, rather than a second-order polynomial in log distance; the second coefficient shown in each case represents the outermost effect (all those properties less than 5km). Those marked with a dagger (†) are score-based, rather than distance-based amenities.

The pattern of p-values indicates that for amenities there is a statistically significant relationship with the cost of accommodation. Of 25 amenities, the core effect was statistically significant at the 5% for 23, the exceptions being proximity to a primary road and the percentage involved in agriculture in an area. The majority of base effects for the lettings segment are also statistically significant (18 of 25 at the 5% level), indicating that different price gradients with respect to distance applied during the period across sales and lettings segments. Similarly, for the bulk of amenities, the bubble and crash base effects are statistically significant (17 of 25 at the 5% level for both).

Due to the necessarily detailed treatment of distance, the actual effect in a given phase or segment may be different to the simple sign on the coefficient. For that reason,

results are presented in Table 3 for the following thought experiment: the estimated effect on the price (or rent) of moving a property from 1km to 100m from a particular amenity or facility. For those amenities and facilities marked with a diamond ($^{\diamond}$), the results shows moving a property from 5km to 1km away. Those marked with a dagger (†) are not distance-based amenities and the percentage figures shown represent a one-standard-devation change in the variable. Where the effect is not statistically significant at the 5% level, the percentage is shown in italics, signifying for price effects that it is not statistically significantly different from zero and for other effects that one cannot reject the null hypothesis that the particular effect is no different from the price effect.

The second and third columns show the expected sign and the outcome. The vast majority are in agreement. The positive association between property prices and burglaries appears to be in line with research suggesting that the causality runs in the opposite direction, i.e. burglaries are more likely to occur in valuable areas (Gibbons & Machin 2008). Similarly, the negative relationship between proximity to rivers and property prices may reflect the dominance of flood risk concerns over natural amenity value. Costs of congestion may explain the result in relation to primary schools, particularly given that the vast majority of properties in the sample are within walking distance (1.5km) of a primary school.

More difficult to explain are negative effects associated with green space (particularly given the results in Mayor et al. 2009), higher education institutes and distance from the border. These results are largely robust to specification and are worthy of more detailed future research.

6.1 Comparing Price & Rent Effects

The fourth and fifth columns compare the price and rent effects. Evidence in favour of the first core hypothesis, i.e. where the price effect (P) is greater than the rent effect (R) is summarized in the second last column. For all 25 amenities, there is evidence from 18 of an attenuated rent effect, compared to the price effect. In other words, there is overwhelming evidence that a mechanism similar in effect to either the search thresholds or buyer lock-in effects described above is at work in the Irish property market. The principal exceptions relate to distance from the centre (either Dublin or other CBD). In surveys, those active in the property market emphasise access to employment as among the most important factors when choosing a place to live (Daft.ie 2012). This indicates that renter search thresholds, rather than buyer lock-in effects, are more likely to explain the difference for secondary amenities. Also worth noting is the difference between segments in relation to higher education institutes, with an almost complete absence of the negative price effect possible evidence of countervailing effects valued by renters who are in large part third-

Amenity	**Exp**	**Out**	**Price**	**Rent**	**Bubble**	**Crash**	**Hyp(1)**	**Hyp(2)**
Coastline	+	+	4.7%	2.1%	3.4%	4.4%	P>R	C>B
Lakes	+	+	2.0%	3.1%	*1.8%*	2.8%		C>B
Rivers	+/-	-	-2.0%	*-0.8%*	-2.4%	-1.8%	P>R	
Green space	+	-	-1.5%	-0.2%	-1.9%	-1.3%	P>R	
Forest	+	+	2.7%	0.7%	2.7%	*1.8%*	P>R	
Train station	+	+	3.2%	-0.5%	1.0%	*3.5%*	P>R	C>B
DART station	+	+	5.0%	*0.6%*	*3.3%*	7.7%	P>R	C>B
Luas Green station	+	+	4.9%	1.6%	*4.8%*	*5.4%*	P>R	C>B
Luas Red station	+	+	0.8%	1.2%	*-2.2%*	*1.6%*		C>B
Primary roads	+	+	*0.2%*	-1.2%	*0.8%*	0.8%	P>R	
Secondary roads	+	+	0.7%	-0.1%	1.1%	*0.3%*	P>R	
Primary school	+	-	-2.2%	-0.2%	-2.6%	-2.4%	P>R	
Secondary school	+	+	0.7%	-1.3%	1.6%	-0.7%	P>R	
Higher education$^{\diamond}$	+	-	-4.7%	-0.3%	*-7.8%*	-5.9%	P>R	
Unemployment†	-	-	-1.3%	-0.1%	-1.6%	-3.2%	P>R	C>B
Commute time†	-	-	-0.9%	-0.1%	-0.2%	-1.5%	P>R	C>B
Agriculture†	-	+	*0.1%*	0.1%	-0.2%	-0.3%		C>B
Education levels†	+	+	6.0%	0.6%	5.5%	7.2%	P>R	C>B
Crime: Burglary†	+/-	+	9.7%	8.4%	11.9%	9.0%	P>R	
Crime: Murder†	-	-	-6.3%	-6.3%	*-6.9%*	*-6.1%*		
Crime: Drugs†	-	-	-1.2%	-1.0%	-1.9%	*-1.1%*	P>R	
Population density†	-	-	-2.6%	-1.4%	-3.2%	*-2.8%*	P>R	
Border$^{\diamond}$	-	+	2.3%	*3.6%*	8.0%	-0.8%		
Central Dublin$^{\diamond}$	+	+	7.1%	8.1%	7.4%	8.2%		C>B
Nearest CBD$^{\diamond}$	+	+	5.6%	*6.5%*	*7.2%*	7.5%		C>B

Table 3: *Effect of moving a property from 1km to 100m away from an amenity; for exceptions (†, ⋄), see text*

level students, and conversely secondary schools, which exhibit a positive price effect but a negative rent effect.

6.2 Comparing Bubble & Crash Effects

The sixth and seventh columns of Table 3 compare the price effect of proximity to amenities across bubble and crashes phases of the market. The final column summarizes evidence in relation to the second core hypothesis, with C>B noted for instances where the price effect in the crash period is greater than in the bubble period. For 12 amenities, this is the case, in particular relating to transport amenities (all four categories of train station) and distance from the CBD. The premium associated with moving from 1km to 100m away from the coastline increased from 3.4% to 4.4% in the crash, while the equivalent effect for a suburban DART train station increased from 3.3% to 7.7%.

Particularly noteworthy is the finding that a 30-minute longer commute, *ceteris paribus*, was associated with a 1% lower house price during the bubble but an 8.4% lower price during the crash. This suggests that during the bubble, households were prepared to pay the opportunity and resource costs of longer commutes, as these were offset by capital gains. However, in the crash, no such capital gains appear to have strengthened forces of agglomeration in Ireland.

There are a number of amenities where the percentage price effect during the bubble is greater than in the crash, something that would suggest a pro-cyclical "buyer lock-in" effect (similar to the Stein hypothesis), rather than a counter-cyclical "property ladder" effect (similar to the Costello hypothesis). This is clearest for the crime-related amenities, where although not dramatic there was a fall in the discount associated with higher murder and drugs-related crime in the crash.

7 Concluding Thoughts

Understanding housing markets and their cycles is key to understanding economic fluctuations, due to the importance of housing as a good and an asset. This paper has explored the relationship between the economics of location-specific amenities and housing market cycles. Following in the footsteps of a long literature, it traced the impact of amenities on property prices but also on rents, a less common feature of the literature. Of twenty-five location-specific characteristics, almost all were reflected in the housing market with a sign in line with expectations or the existing literature. For example, moving a property from 1km from the coast to 100m away was associated with a 4.7% increase in price.

This paper exploited the dataset's large size, its coverage of both sales and lettings

segments and huge variations in market conditions over the period covered to test whether the valuation of amenities is greater in the sales segment than in the lettings segment, reflecting either tenants' search costs or buyers' desire to lock in supply of the amenity. This was typically found to be the case – there is evidence of an attenuated rental effect for 18 of the 25 amenities. For example, the rental premium for a coastline property was 2.1%, less than half the 4.7% price effect.

To distinguish between tenant search costs and buyer lock-in concerns, Ireland's violent property market cycle was exploited. A sign of "lock-in" effects would be if relative amenity prices were procyclical, rising in the bubble and falling in the crash: during the frenzy of a bubble, people pay over the odds to secure access to amenities which are by their very nature fixed in supply. However, if the price of amenities increased in the crash, this would suggest that "property ladder" concerns dominated: normally people prefer to reward access to amenities, but in the bubble, the principal concern is not having any property, pushing up the relative price of low-amenity properties.

There was evidence of counter-cyclical amenity pricing, i.e. the relative price rising in the crash, for the majority of amenities for which sensible and statistically significant results emerged, including prominent housing market amenities such as commute time, distance to CBD and proximity to train stations and the coastline. For example, the premium enjoyed by a property 100m from the coast compared to one 1km away increased from 3.4% to 4.4% between bubble and crash. Similarly, moving a property from 5km from the CBD to 1km away was associated with an increase in price of 7.4% in the bubble and 8.2% in the crash.

It is left to future work to examine income elasticities, using county-level information on incomes, and to exploit supply-side innovations, such as the opening of new motorways, by-passes and train stations, and the opening and closure of schools and hospitals. If micro-level datasets of transaction prices become available, a comparison of asking price and transaction price effects could reveal important differences between the expectations of market participants and final outcomes.

Ultimately, with information on both sales and lettings segments, it will be worthwhile to understand the return on real estate, as expressed by the rent-house price ratio. Much of the focus on this ratio has been over time; there are few explanations in the literature as to why this ratio would vary over space. Incorporating the search costs and lock-in/property ladder effects outlined earlier in a model with micro-foundations would be a significant step in that direction.

References

Alonso, W. (1964), *Location and land use: toward a general theory of land rent*, Vol. 204, Harvard University Press Cambridge, MA.

Bank of Ireland (2007), Wealth of the Nation Report. Available at: http://www.boi.ie/html/gws/includes/about_us/pdfs/wealth_nation_3007.pdf.

Banzhaf, H. S. & Farooque, O. (2012), Interjurisdictional housing prices and spatial amenities: Which measures of housing prices reflect local public goods?, Working Paper 17809, National Bureau of Economic Research.
URL: *http://www.nber.org/papers/w17809*

Boyle, M. & Kiel, K. (2001), 'A survey of house price hedonic studies of the impact of environmental externalities', *Journal of Real Estate Literature* **9**(2), 117–144.

Case, K. & Mayer, C. (1996), 'Housing price dynamics within a metropolitan area', *Regional Science and Urban Economics* **26**(3-4), 387–407.

Case, K. & Shiller, R. (1994), 'A decade of boom and bust in the prices of single-family homes: Boston and Los Angeles, 1983 to 1993', *New England Economic Review* pp. 40–40.

Central Statistics Office (2013), 'Census 2011 reports'. http://www.cso.ie/en/census/census2011boundaryfiles/ (accessed February 19, 2013).

Coate, S. (2013), Evaluating durable public good provision using housing prices, NBER Working Paper Series WP18767, National Bureau of Economic Research.

Commission for Communications Regulation (2013), 'Comreg siteviewer'. http://www.askcomreg.ie/mobile/siteviewer.273.LE.asp (accessed February 15, 2013).

Conniffe, D. & Duffy, D. (1999), 'Irish house price indices: Methodological issues', *Economic and Social Review* **30**(4), 403–424.

Costello, G. J. (2000), 'Pricing size effects in housing markets', *Journal of Property Research* **17**(3), 203–219.

Daft.ie (2012), 2012 Consumer Attitudes Survey, Technical report, Daft.ie.
URL:
http://blog.daft.ie/2012/02/daft-ie-release-inaugural-consumer-attitudes-survey/

Debrezion, G., Pels, E. & Rietveld, P. (2007), 'The impact of railway stations on residential and commercial property value: A meta-analysis', *The Journal of Real Estate Finance and Economics* **35**, 161–180.
URL: *http://dx.doi.org/10.1007/s11146-007-9032-z*

Department of Education (2013), 'Search for a school'. http://www.education.ie/home/home.jsp?pcategory=10917&ecategory=12016&language=EN (accessed February 15, 2013).

Department of the Environment, Community & Local Government (2013*a*), 'myplan.ie'. http://www.myplan.ie/en/index.html (accessed February 15, 2013).

Department of the Environment, Community & Local Government (2013*b*), 'National housing development survey, 2011'. http://www.environ.ie/en/DevelopmentHousing/Housing/UnfinishedHousingDevelopments/ (accessed February 15, 2013).

DiPasquale, D. & Somerville, C. (1995), 'Do house price indices based on transacting units represent the entire stock? evidence from the american housing survey', *Journal of Housing Economics* **4**(3), 195–229.

Dubin, R. & Sung, C. (1987), 'Spatial variation in the price of housing: rent gradients in non-monocentric cities', *Urban Studies* **24**(3), 193–204.

Duca, J., Muellbauer, J., Murata, K. & Murphy, A. (2010), Credit, Housing Collateral and Consumption: Evidence from the UK, Japan and the US, Technical Report 1002, Federal Reserve Bank of Dallas.

Eichholtz, P., Straetmans, S. & Theebe, M. (2012), 'The Amsterdam Rent Index: The Housing Market and the Economy, 1550-1850', *Journal of Housing Economics* **21**(4), 269–282.

Environmental Protection Agency (2013*a*), 'Corine land cover data'. http://www.epa.ie/downloads/data/corinedata/ (accessed February 15, 2013).

Environmental Protection Agency (2013*b*), 'Licensing & permitting'. http://www.epa.ie/whatwedo/licensing/files/ (accessed February 15, 2013).

European Environment Agency (2013), 'Gmes urban atlas'. http://www.eea.europa.eu/data-and-maps/data/urban-atlas (accessed February 15, 2013).

Faller, G. (2011), 'Feeder schools in the republic of ireland'. Provided via email correspondence.

Gatzlaff, D. & Haurin, D. (1998), 'Sample selection and biases in local house value indices', *Journal of Urban Economics* **43**(2), 199–222.

Geofabrik.de (2013), 'Openstreetmap'. http://www.openstreetmap.org/ (accessed February 15, 2013).

Gibbons, S. & Machin, S. (2008), 'Valuing school quality, better transport, and lower crime: evidence from house prices', *Oxford Review of Economic Policy* **24**(1), 99.

Goodman, J. L. & Ittner, J. B. (1992), 'The accuracy of home owners' estimates of house value', *Journal of Housing Economics* **2**(4), 339–357.

Grebler, L., Blank, D. M. & Winnick, L. (1956), *Capital Formation in Residential Real Estate: Trends and Prospects*, Princeton University Press.

Harzing, A. (2007), 'Publish or perish'. http://www.harzing.com/pop.htm (accessed February 15, 2012).

Hilber, C. & Mayer, C. (2009), 'Why do households without children support local public schools? Linking house price capitalization to school spending', *Journal of Urban Economics* **65**(1), 74–90.

Hirayama, Y. (2005), 'Running hot and cold in the urban home-ownership market: the experience of japans major cities', *Journal of Housing and the Built Environment* **20**(1), 1–20.

Holly, S. & Jones, N. (1997), 'House prices since the 1940s: Cointegration, demography and asymmetries', *Economic Modelling* **14**(4), 549 – 565.

Kiel, K. A. & Zabel, J. E. (1999), 'The accuracy of owner-provided house values: The 1978–1991 american housing survey', *Real Estate Economics* **27**(2), 263–298.

Kuminoff, N., Parmeter, C. & Pope, J. (2010), 'Which hedonic models can we trust to recover the marginal willingness to pay for environmental amenities?', *Journal of Environmental Economics and Management* **60**, 145–160.

Leamer, E. E. (2007), Housing IS the Business Cycle, NBER Working Papers 13428, National Bureau of Economic Research, Inc.

Linneman, P. (1980), 'Some empirical results on the nature of the hedonic price function for the urban housing market', *Journal of Urban Economics* **8**(1), 47–68.

Luckett, S. (2001), Did You Know? Homes Account for 44 Percent of All Wealth - Findings from the SIPP, Report, U.S. Department of Commerce.

Lyons, R. C. (2013*a*), East, West, Boom & Bust: The Spread of House Prices and Rents in Ireland, 2006-2012, Working Paper 2015276, Social Sciences Research Network.

Lyons, R. C. (2013*b*), Price signals in an illiquid market: The case of residential property in Ireland, 2006-2012, Working Paper 2205742, Social Sciences Research Network.

Malpezzi, S. (2003), Hedonic pricing models: A selective and applied review, *in* T. OSullivan & K. Gibb, eds, 'Housing Economics and Public Policy: Essays in honour of Duncan Maclennan', Blackwell Science, pp. 67–89.

Mayor, K., Lyons, S., Duffy, D. & Tol, R. (2008), A Hedonic Analysis of the Value of Rail Transport in the Greater Dublin Area, Technical Report 264, Economic & Social Research Institute.

Mayor, K., Lyons, S., Duffy, D. & Tol, R. (2009), A Hedonic Analysis of the Value of Parks and Green Spaces in the Dublin Area, Technical Report 331, Economic & Social Research Institute.

Muellbauer, J. (2012), When is a housing market overheated enough to threaten stability?, *in* A. Heath, F. Packer & C. Windsor, eds, 'Property Markets and Financial Stability', Reserve Bank of Australia and the Bank for International Settlements, pp. 73–105.

National Monuments Service (2013), 'Archaeological survey database'. http://www.archaeology.ie/ArchaeologicalSurveyDatabase/ (accessed February 15, 2013).

National Parks & Wildlife Service (2013), 'Npws maps and data'. http://www.npws.ie/mapsanddata/ (accessed February 15, 2013).

Natural Earth Project (2013), 'Natural earth data'. http://www.naturalearthdata.com/downloads/10m-raster-data/10m-cross-blend-hypso/ (accessed February 15, 2013).

NavTeq (2012), 'Irish road network data'. Accessed in capacity as Visiting Researcher at the National Institute for Regional & Spatial Analysis, NUI Maynooth. http://www.navteq.com/ (accessed February 15, 2013).

Office of the Garda Commissioner (2011), 'Location of police stations in ireland'. Provided via email correspondence.

O'Rourke, K. H. & Polak, B. (1991), Property transactions in Ireland, 1708-1988: an introduction, UCD Centre for Economic Research Working Paper Series WP92/12, University College Dublin School of Economics.

Railway Procurement Agency (2012), 'Irish rail network data'. http://www.rpa.ie/en/Pages/default.aspx (accessed February 15, 2013).

RICS Policy Unit (2002), Land Value and Public Transport: Stage 1 – Summary of Findings, *in* 'Paper presented at RICS Cutting Edge Conference', Vol. 5, p. 7.

Rosen, S. (1974), 'Hedonic prices and implicit markets: product differentiation in pure competition', *The Journal of Political Economy* **82**(1), 34–55.

Shiller, R. (2005), *Irrational Exuberance*, Princeton University Press.

Smith, B. & Tesarek, W. (1991), 'House prices and regional real estate cycles: Market adjustments in Houston', *Real Estate Economics* **19**(3), 396–416.

Smith, V. & Huang, J. (1995), 'Can markets value air quality? A meta-analysis of hedonic property value models', *Journal of political Economy* **103**(1), 209–227.

Stein, J. (1995), 'Prices and trading volume in the housing market: A model with down-payment effects', *Quarterly Journal of Economics* **110**(2), 379.

Straszheim, M. (1987), 'The theory of urban residential location', *Handbook of regional and urban economics* **2**, 717–757.

Von Thünen, J. (1863), *Isolated state*, Pergamon Press.

Wrigley, M., Wyatt, P. & Lane, C. (2001), Transport policy and property values, *in* 'Paper presented at RICS Cutting Edge Conference', Vol. 5, p. 7.

Amenity	Type	Regions
Coastline	None	Regions
Lakes	Size (hectares: 0.1, 1, 20, 1000)	Regions
Rivers	Size (order: 1-7)	Regions
Green space	Size (hectares: 3, 10, 50, 100)	-
Forest	Size (hectares: 30, 50, 100, 200)	None
Train station	Type (suburban / N. Ireland rail)	Regions
DART station	None	None
Luas Green station	None	None
Luas Red station	None	None
Primary roads	Speed limit (km/h: 60, 90)	Regions
Secondary roads	Speed limit (km/h: 60, 90)	Regions
Primary school	Number of classes (5, 10); average class size (16, 27)	Regions
Secondary school	School size (1-3); fee-paying (0/1); % progressing to university (15, 25, 35, 50)	Regions
Higher Ed*	Size (number of students: 3,000, 15,000) / university status	Dublin (0/1)
Unemployment†	None	Regions
Commute time†	None	Regions
Agriculture†	None	Regions (rural only)
Education levels†	None	Regions
Burglary†	None	Regions
Murders†	None	Regions
Drugs†	None	Regions
Density†	None	Regions
Border*	None	None
Central Dublin*	None	None
Nearest CBD*	Cross-border	None

Table 4: *Type and region controls for primary amenities*

A Amenity controls

Where possible, controls are included for the class of a particular amenity. For example, the effect on prices of proximity to a lake may be different for small lakes and large lakes, while the effect of proximity to post-primary schools may vary with the proportion of students at those schools that progresses to higher education. Table 4 describes the type controls that apply to various amenities analysed and also describes any region controls. Numbers refer to cut-offs with the control being the middle category; for example, with forests, the control is forests of 50-100 hectares, with variables (indicator variables interacted with any relevant measures of distance) for less than 30, 30-50, 100-200 and more than 200.

The table also outlines regional controls. For most variables to which this apply, they are based on the five broad regions described in Section 4.6. For urban green space, they refer to a more refined set of regional markets: six regions within Dublin (central, north city, south city, north county, south county and west); each of the other four cities (Cork, Galway, Limerick and Waterford); Dublin's commuter counties; and all other parts of Ireland.

B Regression output

On the following pages is an overview of the regression output underlying the results presented above. For each amenity, coefficients and p-values are shown for a range of variables. Four categories of coefficient are reported: the core price effect, the lettings effect, and the price and rent effects in both bubble and crash periods. The figures given are the net effects, so p-values indicate whether that effect is statistically significant from the core price effect and any other segment-relevant effects. For further details, see the text discussing the results.

Table 5: *Selected regression output: coefficients on amenities (and associated p-values in brackets below)*

Amenity	Core	Square	Let	Let_sq	Bubble	Bu_sq	Crash	Cr_sq	Let_bu	Let_bu_sq	Let_cr	Let_cr_sq
Coastline	−0.1093	0.0069	0.1003	−0.0069	0.0189	−0.0008	0.0182	−0.0013	−0.0201	0.0009	−0.0198	0.0017
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0008)	(0.0243)	(0.0002)	(0.0000)	(0.0042)	(0.0627)	(0.0003)	(0.0000)
Lakes	0.0238	−0.0028	−0.0477	0.0035	−0.0078	0.0007	−0.0398	0.003	−0.0057	0.0003	0.034	−0.0026
	(0.0067)	(0.0000)	(0.0000)	(0.0000)	(0.5082)	(0.385)	(0.0001)	(0.0000)	(0.737)	(0.7881)	(0.007)	(0.0038)
Rivers	−0.0133	0.0019	0.0107	−0.0014	−0.0223	0.0022	−0.0231	0.002	0.0359	−0.0032	0.0251	−0.0023
	(0.0139)	(0.0001)	(0.1256)	(0.0262)	(0.0021)	(0.001)	(0.0005)	(0.0008)	(0.0011)	(0.0012)	(0.0022)	(0.002)
Green space	0.0092	−0.0003	−0.0086	0.0003	0.0132	−0.001	−0.0109	0.0009	−0.0053	0.0003	0.0024	−0.0001
	(0.0015)	(0.2827)	(0.016)	(0.3279)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.2231)	(0.3963)	(0.4697)	(0.5873)
Forest	−0.0498	0.0031	0.0326	−0.0019	0.019	−0.0016	−0.0029	0.0007	−0.0411	0.0035	0.0071	−0.0011
	(0.0000)	(0.0000)	(0.0004)	(0.0039)	(0.0296)	(0.0087)	(0.706)	(0.1933)	(0.0024)	(0.0002)	(0.4664)	(0.0955)
Station	−0.0472	0.0027	0.0575	−0.0034	0.0333	−0.0018	0.0075	−0.0007	−0.0601	0.0038	−0.018	0.0012
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0005)	(0.3428)	(0.1242)	(0.0000)	(0.0000)	(0.0419)	(0.0263)
DART	0.0198	−0.0025	−0.0116	0.0014	−0.0026	0.0001	0.0199	−0.0027	−0.0036	0.0009	−0.0176	0.0024
	(0.0003)	(0.0009)	(0.063)	(0.1158)	(0.7197)	(0.9267)	(0.0015)	(0.002)	(0.6926)	(0.4877)	(0.0136)	(0.0153)
Luas G	0.0379	−0.0039	−0.0201	0.0016	0.0127	−0.0019	0.0011	−0.0002	−0.0298	0.0042	−0.0263	0.0036
	(0.0000)	(0.0000)	(0.0017)	(0.0643)	(0.0606)	(0.0423)	(0.8408)	(0.8017)	(0.0001)	(0.0001)	(0.0000)	(0.0000)
Luas R	−0.0245	0.0032	0.0295	−0.0043	−0.0052	0.0007	0.0034	−0.0006	0.0065	−0.0007	−0.0088	0.0013
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.2796)	(0.3165)	(0.4446)	(0.3618)	(0.2573)	(0.3783)	(0.0738)	(0.0612)
Primary Rd	−0.0045	0.0003	0.0143	−0.0007	−0.0057	0.0003	−0.0127	0.0008	0.0044	−0.0003	0.0076	−0.0006
	(0.2891)	(0.2892)	(0.0061)	(0.052)	(0.2384)	(0.4412)	(0.0038)	(0.0049)	(0.5093)	(0.5366)	(0.1397)	(0.0761)
Second Rd	−0.0088	0.0005	0.0259	−0.0019	−0.0097	0.0007	−0.0025	0.0004	−0.0042	0.0005	−0.0092	0.0003
	(0.0235)	(0.104)	(0.0000)	(0.0000)	(0.033)	(0.0297)	(0.549)	(0.1862)	(0.502)	(0.2472)	(0.0538)	(0.2822)
Prim School	−0.0861	0.0085	0.0412	−0.0045	0.0323	−0.0027	0.0443	−0.0039	−0.0364	0.003	0.0038	−0.0001
	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0071)	(0.0059)	(0.0000)	(0.0000)	(0.039)	(0.0427)	(0.7678)	(0.9246)
Sec School	−0.0377	0.003	0.0476	−0.0034	−0.0277	0.002	0.0317	−0.0022	0.0041	−0.0002	−0.0284	0.002
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0032)	(0.0036)	(0.0003)	(0.0005)	(0.7657)	(0.8583)	(0.0069)	(0.0078)
3rd Level	0.0846	−0.0042	−0.0407	0.0015	0.0132	−0.0002	0.0825	−0.0054	−0.0124	0.0003	−0.1316	0.0081
	(0.0000)	(0.0000)	(0.0034)	(0.0973)	(0.2755)	(0.7794)	(0.0000)	(0.0000)	(0.4396)	(0.7378)	(0.0000)	(0.0000)
Unemployment	−0.2021		0.1901		−0.0398		−0.29		0.1138		0.1842	
	(0.0000)		(0.0000)		(0.0388)		(0.0000)		(0.0000)		(0.0000)	
Commute time	−0.0016		0.0015		0.0013		−0.0011		0.0007		0	
	(0.0000)		(0.0000)		(0.0000)		(0.0000)		(0.0425)		(0.9151)	

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Amenity	Core	Square	Let	Let_sq	Bubble	Bu_sq	Crash	Cr_sq	Let_bu	Let_bu_sq	Let_cr	Let_cr_sq
Agriculture	0.04		−0.0078		−0.0819		−0.1274		0.3686		0.1445	
	(0.1373)		(0.821)		(0.0182)		(0.0000)		(0.0000)		(0.0002)	
Edu levels	0.3449		−0.3104		−0.0281		0.0683		0.017		0.0249	
	(0.0000)		(0.0000)		(0.0015)		(0.0000)		(0.1212)		(0.0065)	
Burglary	0.0853		−0.0115		0.0191		−0.0062		−0.0143		0.0163	
	(0.0000)		(0.0017)		(0.0000)		(0.0235)		(0.0008)		(0.0000)	
Murder	−0.0616		−0.0005		−0.0057		0.0015		−0.0015		−0.0067	
	(0.0000)		(0.8749)		(0.0513)		(0.5731)		(0.7361)		(0.042)	
Drugs	−0.0084		0.001		−0.0055		0.0008		0.0069		−0.0024	
	(0.0129)		(0.6763)		(0.0037)		(0.6345)		(0.0155)		(0.2594)	
Density	−0.0162		0.0071		−0.0039		−0.0015		0.0056		0.0009	
	(0.0000)		(0.0000)		(0.0000)		(0.0721)		(0.0000)		(0.3451)	
Border	−0.0082	0.0012	0.007	−0.0056	−0.0266	−0.002	0.0137	−0.0012	0.0138	−0.0017	−0.0109	0.0058
	(0.0331)	(0.1466)	(0.2685)	(0.0000)	(0.0000)	(0.0215)	(0.0000)	(0.1392)	(0.0007)	(0.2237)	(0.0003)	(0.0000)
Central Dub	−0.0685	0.002	0.0304	−0.0038	0.0172	−0.0001	0.0157	0.0013	−0.0155	−0.0017	−0.0092	0.0015
	(0.0000)	(0.052)	(0.0000)	(0.0019)	(0.0000)	(0.9242)	(0.0000)	(0.02)	(0.0001)	(0.0227)	(0.0033)	(0.0167)
Other CBD	0.0023	0.0028	−0.0008	−0.0014	−0.0005	−0.0023	−0.0009	−0.0038	0.0008	−0.0006	0.0015	0.004
	(0.0000)	(0.0000)	(0.2249)	(0.0888)	(0.2751)	(0.0001)	(0.0365)	(0.0000)	(0.2446)	(0.5345)	(0.0025)	(0.0000)

End of Table