Housing Prices, Yields and Credit Conditions in Dublin since 1945

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July 2020

Abstract

Housing is central to the broader economy, as highlighted by the Great Recession of 2007–2009, yet few reliable long-run series exist for sale and rental prices of housing. Using hedonic methods, frequency conversion techniques, and a detailed dataset of over one million sale and rental listings from newspapers and online, we construct new indices of sale and rental prices from 1945 for Dublin, Ireland as a whole and for six sub-markets within the city. Sale prices rose by an average of 8.4% per year between 1945 and 2018, compared to an increase in general consumer prices of 5%. Market rents are estimated to have increase by 6.3% per year, well above prior estimates (4.4%), a finding with implications for accurately measuring living costs and living standards in Ireland since World War II. There is some evidence of rents converging across markets within the city but sale prices have diverged over the same period. Adjusting for inflation, there have been four major housing market cycles since 1945, with peaks in the late 1940s, the early 1970s, the early 1980s and the mid-2000s. The presence of both sale and rental information allows the calculation of the ratio of sale to rental prices for housing, the housing price ratio, a fundamental barometer of housing market health. We identify three phases in the gross yield on Irish housing since 1945, with downward shifts in the yield in the early 1970s and mid-1990s. An error-correction econometric analysis confirms the predictions of economic theory, that credit conditions in the credit market and user cost drive changes in the yield over time.

Keywords: housing price ratio, housing markets, economic history, user cost.

JEL codes: E32; G12; N14; N94; R21; R31.

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1. Introduction

Housing is the dominant asset in household balance sheets and the single largest component of household expenditure. The importance of housing was underscored by its central role in the recent Great Recession – with many high-income countries, such as the US, UK and Spain, experiencing substantial boom-bust cycles in their housing markets. Yet despite the importance of housing in the broader macroeconomy, there exist few reliable time series for housing prices, either sale or rental, extending back before the 1980s, with which the episode of the 1990s and 2000s could be put into a longer-run perspective.[1] This is in part due to the illiquidity of the sales market and the high dimensionality of housing as a good: each dwelling is unique and infrequently traded.

Ireland was home to the world's most extreme housing market cycle of the 1990s and 2000s, with nominal sale prices rising by a factor of four in ten years to 2007, before falling by almost 60% in the following five years. But as with other countries, there remains a paucity of research examining the structural factors at work over the long run that created the conditions for housing to drive a national boom and bust. This paper aims to address that gap, by constructing new housing price indices, both sale and rental, for Dublin, Ireland, from World War II until today. It does this by applying modern hedonic methods of index compilation to newly built datasets of sale and rental listings from Dublin's newspapers and to rich online data for recent years. The calculation of both sale and rental price indices allows the estimation of the ratio of sale to rental prices of housing, the "housing price ratio", a fundamental barometer of conditions in the housing market. In addition to annual series at city level, frequency conversion techniques are used to generate equivalent indices for each of six districts within the city.

The research here connects to a growing literature interested generally in returns to assets over time, e.g. Jordà et al (2019), as well as work specifically on housing and real estate prices over the long run; see, for example, Chambers et al (2018), Eicholtz et al. (2019) and Eicholtz et al. (2020) for specific examples, as well as Knoll et al (2017) for a discussion of sale prices globally since the mid-19th century. It is also related to work on housing returns and user cost, such as Eisfeldt & Demers (2015), who examine total returns for single-family housing in the US in the 2010s, and Himmelberg et al. (2005), who incorporate user cost to reassess the performance of housing prices across U.S. cities in the decade to 2005. Its reliance on real estate listings means it is also part of a growing literature using this rich source type to examine the performance of housing, either as an asset (sales) or as part of the cost of living (rental); see, for example, Kholodilin (2016), Kholodilin et al (2019), and Officer and Williamson (2018).

Given the geographic scope, the work here builds on a literature examining the performance of the Irish housing market. This literature, summarized in the table in Appendix A, is principally interested in sale prices (either nominal or inflation-adjusted), rather than rental prices or the ratio of the two. It can be divided into four phases, the first phase of which dates from the early 1980s; see, for example, Kenneally & McCarthy (1982) and Thom (1983), the latter of which includes a measure of credit conditions. The second phase of research dates from the late 1990s/early 2000s and arose due to the rapid increase in sale prices (e.g. Harmon & Hogan (2000), Kenny (1999)), but ignored non-price credit conditions. Similar theoretical concerns arise when reviewing the third phase, which dates from the mid-2000s and includes

[1] For an overview of existing data series for many countries, including descriptions of their limitations, see Knoll et al (2017).

international reviews of the market, such as IMF (2003) and Rae & van den Noord (2006). After the end of the housing boom in 2008, a fourth phase emerged, placing more emphasis on theoretical foundations and on non-price conditions in the mortgage credit market. Lyons (2018) explicitly examines the housing price ratio since 2000 in a single-stage error-correction framework, finding credit conditions (as measured by first-time buyer loan-to-value and the system-wide credit-deposit ratio) to be central in explaining sale price rises between 2000 and the peak of the market in 2007.

Almost all existing work on Irish housing prices to date has relied at least in part on price series that, while official, do not adjust for the mix of properties traded over time. Sale price series rely on simple averages before the mid-1990s, while rent price series that contribute to official measures of inflation are based on surveys of lettings agents. The lack of mix-adjustment may result in mismeasurement of trends both over longer horizons, when quality drifts may be substantial, and over market cycles, where demand for attributes may be cyclical (Lyons 2015). More recent work, such as Kelly et al. (2018) and Lyons (2018) are notable exceptions, using hedonic methods on substantial datasets.[2] To our knowledge, the latter is also the only published work to examine the housing price ratio, with other work relying on implicit or explicit assumptions on demand and supply drivers of housing.

This paper builds on Lyons (2018) and recent contributions documenting the performance of the Irish economy over the long run. It presents new annual housing price indices from 1945, using modern methods of mix-adjustment, for both sale and rental segments for Dublin and, using frequency conversion techniques, for each of six markets within the city. The collation of sale and rental indices allows the calculation of the ratio of sale to rental prices for housing in Dublin and each of its six sub-markets. In addition to the first consistent series for this ratio for Dublin over the long run, this paper also contributes a theoretically grounded empirical analysis of the determinants of this key metric of housing market health.

Five principal stylised facts emerge regarding the performance of Dublin housing since World War II. Firstly, adjusting for the mix of housing, the nominal sale price of housing rose by an average of 8.4% per year between 1945 and 2018, compared to an average increase in consumer prices of roughly 5%. Secondly, market rents increased by an average of 6.3% per year during the same period, a figure that is well above the existing estimate (4.4%), with implications for measuring the cost and standard of living in the Irish economy since World War II. In this sense, our work speaks to a growing literature that examines how biased measures of housing prices over time have implications for measuring consumer prices over time; see for example Gordon & Van Goethem (2005) and Ambrose *et al* (2015), who – among others – find strong evidence that consumer price indices in the US over the long run have been downward biased due to underestimation of rental price inflation.

Thirdly, we identify three phases in the housing price ratio since 1945, of roughly equal duration: in the range 11%-16% for the first 25 years; in the range 8-11% from the early 1970s to the mid-1990s; and below 8% thereafter, bottoming out at less than 3.5% in the mid-2000s. Fourthly, inflation-adjusted price trends reveal four major housing market cycles since 1945, with peaks in the late 1940s, the early 1970s, the early 1980s, and lastly in 2006 (2001 for rents). Lastly, while

[2] To this may be added Deeter et al. (2017), although their series ends in 1949 and for the twentieth century covers properties that had largely switched from residential to commercial usage.

sale and rental prices typically comove, sale prices move in greater magnitudes, compressing the yield in upswings; the period since 2012 is an exception to this pattern.

The within-city analysis presents additional findings. There is no evidence from the sales segment of the emergence of a single market: the coefficient of variation across districts grew over time, as more expensive areas in the 1940s saw more inflation over the subsequent seven decades. The opposite is true of the rental market, with a falling measure of dispersion as lower-rent areas saw their rental prices grow by more over time. There is some evidence from trends in yields of the re-emergence of urban cores over time. Lastly, the econometric analysis finds that – in line with economic theory and prior work – user cost and credit conditions are central in determining the equilibrium housing price ratio in the housing market.

The rest of the paper is structured as follows. The following section outlines the basic economic theory underpinning the approach adopted here in focusing on the housing price ratio, while Section 3 describes the dataset used, including different newspaper and online sources for housing prices, the method of constructing markets within the city, as well as other sources used in the second-stage regression analysis. The fourth section presents the new sale and rental housing price indices, at city and district levels, and discusses the resulting trends, before presenting an econometric analysis of the city-level figures. The final section concludes with some policy implications and avenues for future research.

2. Theory

The demand for any good depends on its price (p), the income of consumers (y) and other demand shifters (z) such as taste or, in the case of long-lived goods, credit conditions. Applied to housing, the quantity of housing demanded, h, can be approximated linearly by:

$$\ln(h) = -\alpha\ln(hp) + \beta\ln(y) + z,$$

with a t subscript possible to denote the model over time. The fixed supply of housing in the short run allows the demand function to be inverted, so that price is a function of quantity, income and other demand shifters. If income elasticity were unitary, algebraic simplification would leave housing prices as a function of the income to housing ratio and other shifters. This inverted demand approach underpins, often implicitly rather than explicitly, most of the existing research on Irish housing prices, outlined in Appendix A and discussed in Section 1 above.

It is possible to separate demand shifters into those that affect owner-occupied housing and those that affected rental housing. The assumption is that income and housing supply (h, y) affect both segments. Other factors can be added, for example the headship rate as a summary measure of demographics. To the extent that such factors affect both segments, however, 'dividing through' by the rental price of housing will mean that the right-hand side consists of only those factors unique to demand for owner-occupied housing, such as user cost.

The impact of user cost on housing is the subject of a large literature. A seminal paper is Poterba (1984), who uses basic financial theory, in particular the concept of arbitrage, to describe the equilibrium ratio of sale to rental housing prices (hereafter, the housing price ratio, *hpr*). In equilibrium, sale prices should reflect the discounted future stream of rental prices and, if the discount rate matches interest rates, then the simplest version of a housing price ratio equation has *hpr* as a function of interest rates. The interest rates of interest are real, rather than nominal,

and so theory suggests a separation to distinguish between nominal interest rates (after tax, r_t) and expected capital gains (κ_t). To capture the full cost to users of owning housing, other factors that are relevant may include depreciation and maintenance (δ_t), transaction and property tax costs (τ_t), although often these do not vary substantially over time, and any risk premium (π_t):

$$\ln(hpr_t) = f(r_t, \kappa_t, \delta_t, \tau_t, \pi_t),$$

In addition, and especially since the Great Recession, a growing number of papers have outlined the importance of including non-price credit conditions, θ_t – in effect, capturing the distance of the credit supply curve from the origin – in determining the housing price ratio. While no direct measures of credit conditions exist, they have been estimated either using a latent variables approach (Fernandez-Corugedo & Muellbauer, 2006) or using a theoretically motivated proxy, such as the deposit required of the typical first-time buyer (Duca et al., 2011; Lyons, 2018).

As far as we are aware, there is no research on how to calculate the risk premium associated with housing, other than to directly survey market participants. It is for this reason that this important and likely cyclical factor is omitted from studies. In principle, expected capital gains are also unobserved, although – in addition to survey data in some markets – a number of papers have found that, empirically, recent capital gains are typically reliable proxies of current expectations (see, for example Muellbauer, 2007). As noted above, depreciation, maintenance and tax or trading costs of property are more stable over time and thus often also omitted from empirical studies of the housing price ratio.

Therefore, to summarize, economic and financial theory suggest that the housing price ratio will depend not only on nominal interest rates (r), but also on expected capital gains (κ) and credit conditions (θ), as well as typically less volatile factors such as depreciation and property taxation. Theory – and empirical evidence – also suggest that changes, sudden or otherwise, in a component of the user cost such as property taxation will be reflected in the ratio of sale to rental housing prices. In econometric terms, theory suggests the following basic functional form for the equilibrium relation of the log of the housing price ratio, where u_t represents the residual:

$$\ln(hpr_t) = \beta 1.\ r_t + \beta 2.\ \kappa_t + \beta 3.\ \theta_t + u_t,$$

Short-run forces may also play a role, including dynamics such as changes in consumer prices, employment or wages (cf. work by Campbell et al, 2009) or momentum, captured by lagged changes in fundamentals such as rents or credit conditions.

3. Data

This section outlines the datasets of real estate listings used in the analysis carried out, before also outlining the measurement of various series suggested by economic theory as relevant for understanding the housing price ratio.

3.1 Listings overview

The analysis here uses both sale and rental listings for the housing market in Dublin, Ireland. For both segments, two principal sources are used. The first, which covers the period from 2001 on for rental and from 2006 for sale, is an archive of online listings maintained by daft.ie, Ireland's largest property portal, as described in more detail by Lyons (2018). This includes over 250,000 sale and almost 650,000 rental listings meeting size and location criteria. In particular,

listings have information about number of bedrooms and bathrooms, the property type, and its location in the Dublin market, using a set of almost 200 micro-markets that nest within the city's *Eircode* postal district system.

For the period from 1945 to 2006 (2001 for rental), the analysis relies on a newly compiled dataset of 33,427 listings from three main newspapers: the *Irish Times*, Dublin's newspaper of record, throughout, with additional listings taken from the *Irish Independent* (sales) and *Evening Herald* (rental) from 1996 until the online listings start. To compile this dataset, online archives of each newspaper were consulted. For each year, an initial sample of one set of listings per quarter was collated, with all valid listings on a given date digitized. For a listing to be included in the analysis, it was necessary for it to have information on four key attributes: the date (always available from the newspaper), the property type (in particular house or apartment), its size and its location, both of which are described in more detail below. Information about age, in general terms (as described below) was also recorded where mentioned. Where one set of listings per quarter did not generate sufficient sample size, additional sets of listings within the quarter were consulted. Table 1 outlines the size of the dataset, by period and segment.

Table 1. Newspaper listings dataset, by period

	Five-year totals		Annual averages		Year-area averages	
Period	***Sale***	***Rental***	***Sale***	***Rental***	***Sale***	***Rental***
1945–1949	1,355	291	271	58	45	10
1950–1954	2,437	744	487	149	81	25
1955–1959	2,194	629	439	126	73	21
1960–1964	2,326	533	465	107	78	18
1965–1969	1,184	406	237	81	39	14
1970–1974	1,047	400	209	80	35	13
1975–1979	999	253	200	51	33	8
1980–1984	1,642	584	328	117	55	19
1985–1989	1,252	319	250	64	42	11
1990–1994	664	228	133	46	22	8
1995–1999	2,595	4,469	519	894	87	149
2000–2004	2,815	2,486	563	497	94	83

Note: Cells show total or average number of listings, by segment. Year-area averages show the average number of listings for each of six city areas, as described in the text.

Limitations

Prices included in real estate listings, whether sale or rental, are listed prices, while the true object of interest for each property is the transacted property price. While the listed price for any individual property may vary from its ultimately transacted price, research has found little bias on average in listed prices, once hedonics are used; see, for example, Malpezzi (2003) and Shimuzu et al. (2012). This is found to be the case across market cycles but also within market cycles. As a result, the use of listed prices is well-established in housing economics and related literatures; for example, in the U.S. alone, listed prices are used in the sale segment by Shiller (2005) for the period 1934-53 and in the rental segment during the pre-WW1 period (Margo 1996; Officer & Williamson 2019).

In the Irish housing market, listed prices 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 they are for information only and set after agreement between the seller and their estate agent. Research exploring the relationship between list and transaction prices in Ireland in the sales segment during the 2006-2012 period, when prices were very volatile and thus where any gap between listed and transaction prices might be at its greatest, finds a very strong correlation between the two (Lyons 2019). Nonetheless, the long period covered in this study means that findings based on research covering more recent periods applies with caveats to older periods. The link between listed and transaction prices, both sale and rental, in the period being covered may indeed be weaker than existing research has shown. However, the lack of micro-data on transactions does not allow this assumption to be tested for most of the period; for rental listings 2001-2018, additional controls are included for robustness in Section 4.1.

3.2 Hedonic attributes

In line with internationally agreed best practices for policymakers today, such as those followed by Eurostat (de Haan & Diewert, 2011) and the IMF (Silver 2017), a hedonic approach is used to measure housing prices over time. In each empirical specification, all dimensions of property attributes are treated as (vectors of) categorical variables. In addition to date/time (the coefficients of interest), the four principal dimensions of property attribute used as regressors to control for the property mix are the property's type, age, size and location. The categorical nature of the hedonic specification allows the choice of a control property, whose value is reflected in the regression's constant, as well as the treatment of missing or partially complete information, for example on age or size, as discussed below.

Type

Property type is assigned using two levels. At the top level, a property is assigned either as a house or as an apartment. Underneath this, where possible, a property is further assigned to a sub-type, for example duplex or flat within apartment or semi-detached or terraced within house.

Age

Age is likely to be an important determinant of a dwelling's value to its occupants (and owners). However, it is infrequently included in ads and often, where included, only discussed in general terms, using phrases such as 'interwar' or 'modern'. For that reason, a general three-way categorisation of age was included in regressions. In addition to properties of an unknown age

(coded age = 99), properties were classified into three categories: *new* (including terms such as 'off plans', new build' and 'first letting'), *modern* (the control), and *old* (including terms such as 'period', 'interwar' and 'pre-war').

Size

A number of size metrics were used by housing market participants over the period considered. It is important to note that floor area in square meters/feet was almost never used, especially before the 21st century. Number of bedrooms or, less frequently and typically earlier in the period covered, total number of rooms was used as the main metric of size. Some listings, however, include number of bathrooms and/or number of reception rooms as additional or alternative measures of size.

To maximise the size of the valid dataset in each year, a flexible empirical specification is adopted. Specifically, each size indicator (number of rooms, bedrooms, bathrooms and reception rooms) is treated as a vector of categorical variables, i.e. only taking a value of 0 or 1. This allows non-linear (and indeed non-polynomial) price relationships between size categories as well as the inclusion of a greater number of listings. For example, for bedrooms, a categorical variable is included for each of the dwelling sizes, from one to six bedrooms. Where an otherwise valid listing does not include bedroom number, it is given a value of 99; given the categorical nature in the empirical specification, this has no effect on the estimate of values of size. For a listing to be valid, in addition to property type (house or apartment), it must include at least one of the four size measures.[3] Observations with more than one measure of size, for example the inclusion of both number of bedrooms and number of reception rooms, knit the various size metrics together.

Location

In relation to understanding within-city variation, the long timespan presents challenges, as the city grew significantly during the period analysed. At one end of the spectrum, analysis is possible at the level of city in aggregate and can allow for within-year variation (for example at quarterly frequency) but at the cost of ignoring changes in within-city variation over time. At the other extreme, allowing for heterogeneous within-city trends for each of 200 'micro-markets' within the city requires a sufficient volume of listings for each market in each period.

For the purposes of the analysis here, the dataset is used in two ways. The first is at the level of the city in aggregate. This allows for annual series of sale and rental price indices, while the use of frequency conversion techniques allows for quarterly housing price series. The annual city-level series is analysed using the regressors discussed in Section 3.3 below.

The second approach is to exploit the depth and spatial variety of the dataset, by splitting the city into six markets, each of which is observed throughout the period being analysed. These six markets are based on the city's modern Eircode 'routers' (or subdivisions used by the national postal service). Eircodes are address-specific postcodes, in use since 2015 but, for most of the contiguous city of Dublin, the routers are based on a pre-existing postal district system, originally set up in the nineteenth century. The concentration of roughly 25 Eircode routers

[3] This can be relaxed by including properties with no known size information as a separate category, without affecting the overall results substantively. Unusually large properties (for example, where bedroom number is known to be above six) are treated separately, typically with a coding of 9. Again, these can be excluded without affecting the results substantively.

used in the city currently into six markets is necessary as the volume of listings for certain routers in earlier periods, and especially for the rental segment, is small. The six areas, with corresponding postal districts/Eircode routers, are as follows:

1. North Dublin [ND] – Dublin 1, 3, 5, 7, 9, 11, 13, 15; Malahide [K36], Swords [K67]
2. South inner city [SI] – Dublin 2, 4
3. South suburbs [SS] – Dublin 6, 6W
4. South-west city [SW] – Dublin 8, 10, 12, 14, 16, 20, 22, 24; Lucan [K78], Maynooth [W23]
5. South-east city [SE] – the Blackrock Eircode router [A94; Blackrock, Booterstown, Monkstown, Mount Merrion, Stillorgan]
6. South county/North Wicklow [SC] – Dublin 18, Glenageary [A96; Ballybrack, Dalkey, Dun Laoghaire, Glenageary, Killiney, Sandycove]; Bray [A98], Greystones [A63]

Limitations

The attributes above are designed to capture the principal features of a dwelling, including its type, age, size and location. Nonetheless, these are not a comprehensive list of attributes that affect a dwelling's value and the potential for changes in quality in other ways, unmeasured in this dataset, is real. For example, over the 70 years covered in the dataset, space per room may have changed, with (for example) newer dwellings having larger average room sizes than older dwellings. While categorical age variables may capture some of this potential correlation between time and this particular unmeasured attribute, other examples exist. This includes improvements in sanitation and insulation, for example. A suggestion for future research is to combine price information with modern comprehensive databases on Energy Performance Certificates, which include information on internal floor area, year of construction and insulation, and with databases on planning permissions (which existed in Ireland from 1964) to more explicitly control for these secondary attributes that may be correlated with time.

3.3 Macroeconomic series

Credit Conditions

As outlined in Section 2, two of the principal factors suggested by theory as determining the housing price ratio are price and non-price conditions in the credit market. Price conditions are taken from Stuart's (2017) database on long-run Irish economic aggregates, in particular the short- and long-term interest rate series. Non-price conditions are given by the ratio of credit to deposits, where the level is taken from official statistics and extended backwards using Stuart's (*ibid*.) series for deposits (narrow money) and private sector credit.

User Cost

Section 2 outlined the main elements of user cost aside from nominal interest rates. These include expected capital gains, property taxes, and other holding costs (including depreciation, maintenance and a risk premium). As suggested above, depreciation/maintenance will be ignored, as its largely static nature over time cannot have an influence in a dynamic model. Similarly, no provision will be made for a risk premium – as is standard in the literature – due to the difficulty in its measurement. In line with the existing literature, such as Duca et al (2016) and Muellbauer (2007), one- and four-year annualised changes in nominal sale prices are examined for fit, as proxies for expected capital gains.

There is some additional important variation in user cost over the period. Much of the housing stock in Dublin was, until legislative changes in the 1970s, subject to a ground rent. This ground rent was set in nominal terms, typically for very long lease lengths. Of a sample of almost 1,500 Dublin deed transcriptions examined for the period 1900-1949 (after which the Registry of Deeds is no longer indexed by location), the mean lease length was 543 years, with the median length 460 years. For example, Reuben Street (in Dublin 8) was constructed between 1903 and 1905 and the ground rent for each home was £3.50 for a period of 999 years. With the general cost of living rising substantially in the second half of the twentieth century, this represents a steady fall in the real user cost associated with owner occupancy. This factor is incorporated into the econometric analysis using the general inflation rate.

Real Economic Variables

In addition to price and non-price conditions in the credit market, recent capital gains, and inflation (as a proxy for underlying ground rents), it is possible that conditions in the real economy may affect the ratio of sale to rental housing prices. Unemployment, changes in wages, and changes in real and nominal disposable income for Ireland are taken from Gerlach & Stuart (2015), Gerlach et al (2016) and Stuart (2017). Other real economic conditions, in particular those relating to housing supply and tenure, are captured using (the change in) rental prices as a regressor. In this sense, the housing price ratio can be thought of as a measure reflecting housing as an asset, rather than housing a service, and the analysis examines the response of the capital value of housing to changes in the various factors that affect the value of housing services.

The likely range of values for the coefficient on the change in market rents is between zero and minus one. A coefficient of zero implies that factors such as housing supply affect sale and rental prices equally: an upstream factor lowering rent prices by 10% also lowers sale prices by 10%, leaving the ratio unchanged. Alternatively, if the coefficient were minus one, factors such as housing supply that affected rents are not affecting sale prices: they lower rental prices and this 'passes through' completely into a lower housing price ratio. A coefficient greater than zero would be consistent with home ownership being a luxury good: supply lowers the price of housing as a service, boosting real incomes and demand for ownership, bringing about an offsetting rise in sale prices.

4. Analysis

This section has three subsections, of which the last (Section 4.3) describes the results of an error-correction framework analysis applied to the housing price ratio at city-level and annual frequency, to examine its principal determinants. The first two subsections relate to the compilation of housing price series, at city level (Section 4.1) and for each of the six city areas (Section 4.2). For each of the seven markets (city-level and six areas), there are three series of interest: housing sale prices, housing rental prices, and the housing price ratio.

In all cases, the indices presented for both sale and rental prices are mix-adjusted, through use of hedonics. For both geographic scopes, the frequency of analysis is annual. The annual series for the six sub-city markets stem from frequency conversion techniques applied to underlying staggered quinquennial hedonic price indices. All indices have 1948 as their base, to be

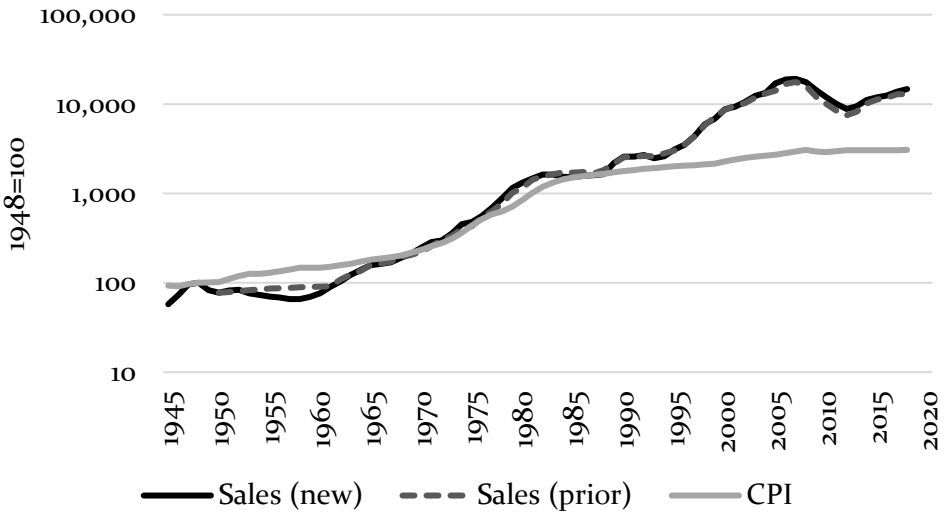
consistent with Irish official statistics; a major revision of its consumer price index was launched that year.[4] All annual indices, and series of the housing yield, are given in Appendix B.

As is standard with hedonic regressions used to produce price indices, standard errors are largely uninformative: the focus is on conditional averages, rather than the extent to which those averages are precisely estimated. Similarly, where the time span covers sufficiently large general price inflation, the R-squared will be uninformative: the year variables, almost by construction, will account for most of the variation, resulting in very large R-squared statistics. (The root mean square error is more informative as a measure of fit.) For that reason, results are presented graphically rather than in tabular form in Sections 4.1 and 4.2 below, although for completeness, Appendix C outlines regression output for sale and rental segments at city level and annual frequency, for the period 1945-2001.

4.1 City-level series

As outlined in Section 3.2, the core empirical specification across the datasets examines the (log of) the listed price, either sale or rental, as a function of property type, age and size (as measured by number of bedrooms, bathrooms, reception rooms, and/or total rooms), area in the city, and period. For rental properties, the frequency of payment is also controlled for. Online rental listings (from 2001) have some additional property features, such as lease length and the presence of white goods and utilities, which are also controlled for.

Figure 1. Sale prices indices for Dublin housing (1948=100)



Note: This figure shows the new index of the sale price of housing (solid black), compared to a spliced index reflecting previous estimates (dashed grey) and the consumer price index (solid grey). All have 1948 as the base of 100.

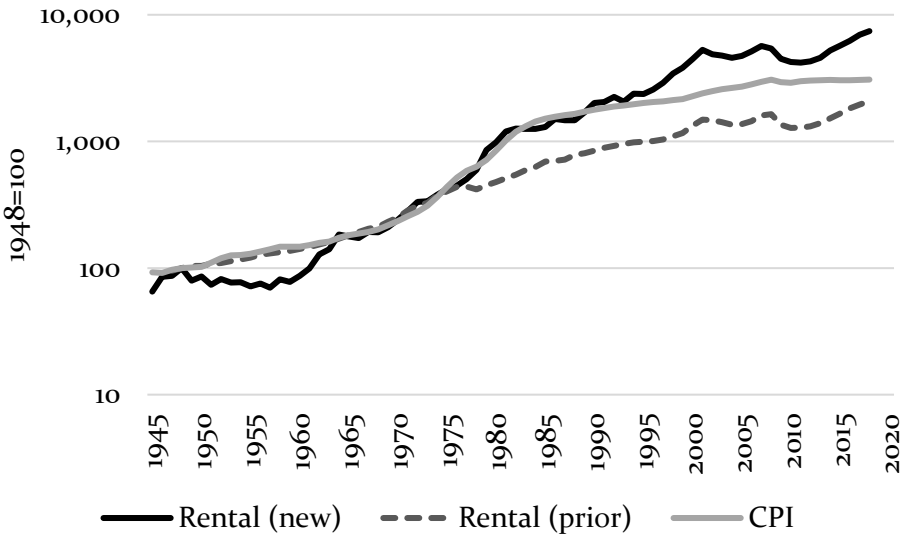
Figures 1 and 2 show new annual housing price indices for Dublin, sale and rental, compared to the official consumer price index (CPI) and to the best estimates of price inflation in each segment before the publication of these series. The best prior estimates of sale price inflation

[4] The same techniques can also applied to the annual city-level analysis to produce indices at quarterly frequency; these results may be useful for those conducting macroeconomic analysis at quarterly frequency and are available from the authors on request.

for Dublin come from a simple average produced by the Department of the Environment, starting in 1970, and figures from the Valuation Office and sporadic surveys prior to this. The first hedonic index for Irish sale prices dates from 1996 and was based on mortgages issued by one lender (Irish Permanent, later permanent-tsb). The official Central Statistics Office index of sale prices, based on comprehensive administrative data on transactions, starts in January 2005; it and an index of listed prices published by daft.ie are extremely highly correlated. The best prior estimates of rental price inflation are from the private market rent sub-index of the Consumer Price Index, published by the Central Statistics Office. Unfortunately, the methodology underpinning the construction of this sub-index is not explained. However, discussions with officials at the CSO indicate that it is likely this took the form of a written or telephone survey of lettings agents. Therefore, it is unlikely that any formal mix adjustment was undertaken.

Between 1945 and 2018, the general price level in Ireland increased by a factor of roughly 33. The new sale price index – similar to existing evidence – suggests much greater inflation in housing. The hedonic index suggests that sale prices rose by a factor of more than 250 between 1945 and 2018, or a rate of almost 8% per year on average. This compares with an AGR of just under 5% in general prices. As shown in Figure 1, this difference between general prices and housing prices would be somewhat more accentuated if the start date was 1960, rather than 1950. Notwithstanding that, much of the gap between trends in housing and general prices stems from the post-1985 period: between 1950 and 1985, the increase in general prices was very similar to that in the sale price of housing (roughly by a factor of 15 in both). With one or two small differences, the new index of sale prices shows very similar increases in housing prices to existing evidence, which is based on numerous sources spliced together: an AGR of 8.0% since 1950 compared to 7.8% in the prior index.

Figure 2. Rental prices indices for Dublin housing (1948=100)



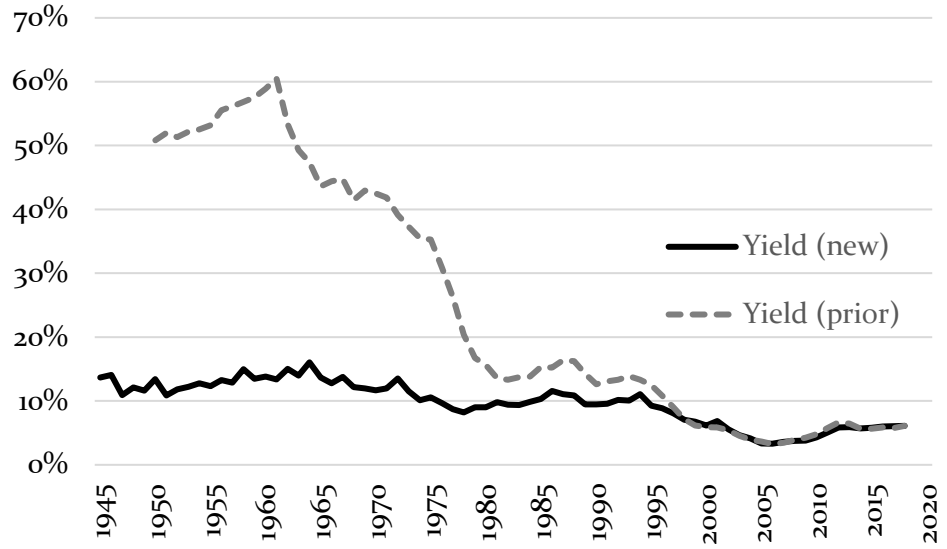
Note: This figure shows the new index of the rental price of housing (solid black), compared to the prior estimates (dashed grey) and the consumer price index (solid grey). All have 1948 as the base of 100.

While the new sale indices are broadly in line with existing estimates of overall inflation in the post-war period, the new rental index – shown in Figure 2 – suggests significantly greater price

inflation than previously understood. The existing CSO sub-index on private market rents suggests they increased by a factor of just 13 between 1948 and 2000, compared to an increase in general consumer prices of 23. In contrast, the mix-adjusted method here suggests private market rents increased on a like-by-like basis by twice as much as general prices (a factor of 45). While the spatial composition of the two series differs – the new index here focuses on Dublin, while the CSO index is designed to cover the entire country – this is unlikely to drive the discrepancy. Throughout the time period, given its large share of the population, Dublin dominated the private rental market. In the early 21st century, for example, it accounted for roughly 40% of the private rental market by tenancies (and more by market value). Given its nominal AGR of 7.6% during the second half of the 20th century, this means that nominal rents in the rest of the country would have had to be significantly *lower* in 2000 than in 1945, to generate a national nominal AGR of less than 5%.

For the period 2001-2011, it is possible to examine the possible effect of missing dwelling attributes. For consistency, the same hedonic specification is used throughout; from 2001 on, however, online listings contain significant further information about location (and thus the presence of location-specific amenities) and dwelling attributes (such as utilities and white goods). However, the addition either separately or jointly of (1) a vector of 120 micro-markets within Dublin, (2) controls for lease length, and (3) ten dwelling attributes including parking, central heating, a dishwasher and cable TV has almost no effect on the resulting hedonic indices. Comparing 2018 to 2001, rental prices increase by 40.6% in the baseline and by 40.7% in the full hedonic specification with additional location and dwelling controls. This both eases concerns that omitted dwelling characteristics are driving time trends observed in hedonic indices and allays any fear that the discrepancy between the trend observed and the existing trends for market rents is driven by such omissions.

Figure 3. Gross annual yields for Dublin housing (percent)



Note: This figure compares new (black) and prior (dashed grey) estimates of the gross annual yield on residential real estate. In both cases, the estimated gross annual yield for 2018 is used as a starting point, with annual changes in both sale and rental prices used to extend the series back.

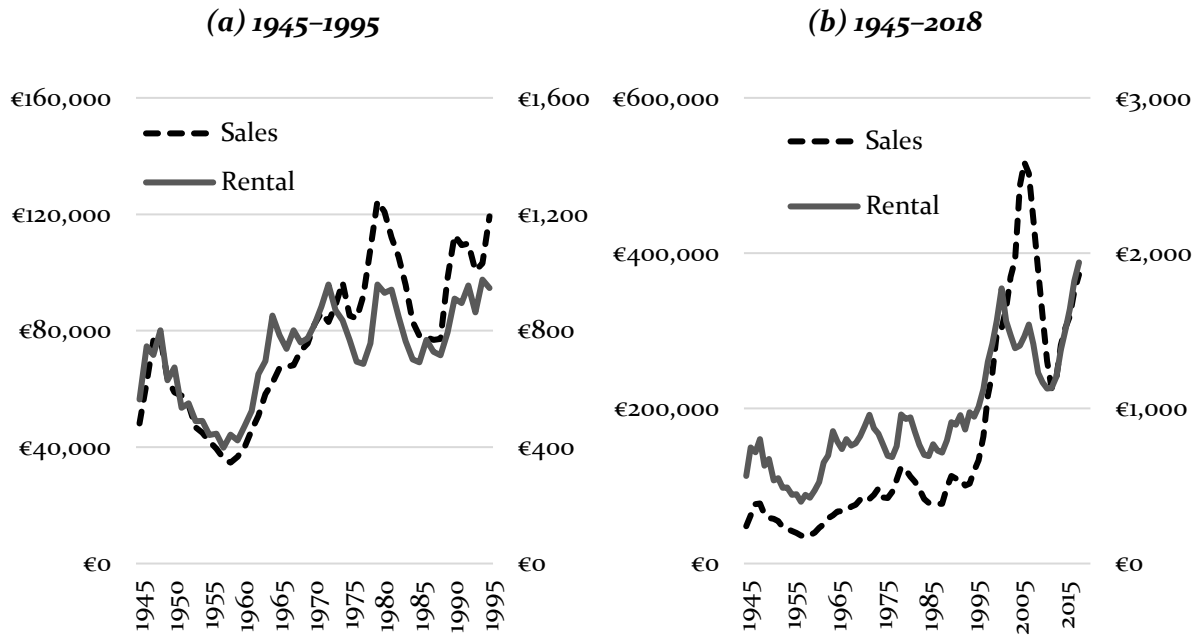
The second reason to doubt existing rental price series comes from evidence in relation to yields on housing. The housing price ratio, when expressed as the annual rent relative to the capital

value of the dwelling, gives a percentage annual return, known as the gross yield. Figure 3 presents two series for the gross yield on residential property in Dublin. The first is based on existing series, including the CPI rent component, while the second is based on the listings dataset, regression analysis, and resulting hedonic indices described above. For both prior and new series, the level of the index is set to 6.1% in 2018, which is the weighted average gross yield for Dublin residential property for 2018. (This choice affects the level but not trend for either series.) Gross yields for Dublin housing are calculated for earlier years by combining the estimated year-on-year changes in both sale and rental housing.

While both new and prior series suggest very similar yields after 1980, the two series diverge considerably before this. In particular, prior series imply implausibly high gross yields on housing earlier in the period, with an annual yield over 50% during the 1950s. By contrast, while the yield according to the new series is at its highest between 1945 and 1965, its peak is 16% (housing sold for six times its annual rent), rather than 50% (housing sold for twice its annual rent). This much lower level of yields is supported by individual property listings from the period: in the Ballsbridge area of Dublin, a number of three-bedroom houses were advertised around 1960 for a rent of £500 per year, while during the same period, similar properties were listed for sale for prices between £2,000 and £3,000.

The final figure in this sub-section, Figure 4, presents both sale and rental prices of Dublin housing in real terms, expressed in 2018 euro, over two time periods. To do this, it uses the weighted average price of Dublin housing in 2018, published in the Daft.ie Reports, to anchor the series and applies the year-on-year changes in housing and general price indices to extend the two series back to 1945. The left-hand panel covers the period to 1995 only and is included given the dramatic increase in sale prices that occurred after this period, which hides market cycles before this date and is shown in the right-hand panel.

Figure 4. Inflation-adjusted sale and monthly rental prices for Dublin housing (2018€)



Note: This figure shows average real (i.e. inflation-adjusted) housing prices for sale (dashed black; left-hand axis) and rental (solid grey; right-hand axis) segments. The left-hand panel runs from 1945 to 1995, while

the right-hand panel runs to 2018. The axes are set so that where the lines overlap, the gross annual yield is 12% in the left-hand panel and 6% in the right-hand panel.

The real (i.e. inflation-adjusted) series are shown, as stripping out general price inflation makes it simpler to assess market cycles, as well as to compare values over time. The left-hand panel shows the overall synchronicity of sale and rental prices before 1995: having risen sharply in the immediate post-war period, both fell during the 1950s, a time of economic hardship – with the series bottoming out in 1957 and 1958, just before Ireland ended its policy of protectionism. Thereafter, both sale and rental prices grew strongly until the early 1970s – with a local peak in rents in 1964, a year of rapid wage increases. The falls seen in the mid-1970s were undone with a boom in the late 1970s, itself undone with real housing prices falls during the economic crises of the mid-1980s. The right-hand panel adds the dramatic increase in real housing prices, both sale and rental, after 1995, with different peaks for the two segments – 2001 for rents and 2006 for sale prices, but with both bottoming out in 2012.

Table 2. Change in inflation-adjusted sale and rental prices (percent) and in gross yield (percentage points) of Dublin housing, by market cycle

	SALE	RENTAL	YIELD
1948–1958	-55%	-45%	+2.9%
1958–1979	+259%	+116%	-5.9%
1979–1987	-38%	-24%	+2.1%
1987–1995	+55%	+30%	-1.8%
1995–2006	+333%	+54%	-6.0%
2006–2012	-56%	-23%	-2.6%
2012–2018	+65%	+72%	-0.2%

Note: This table shows the overall change in inflation-adjusted sale and rental prices, in percent, and the gross annual yield, in percentage points, by market cycle from 1948 to 2018.

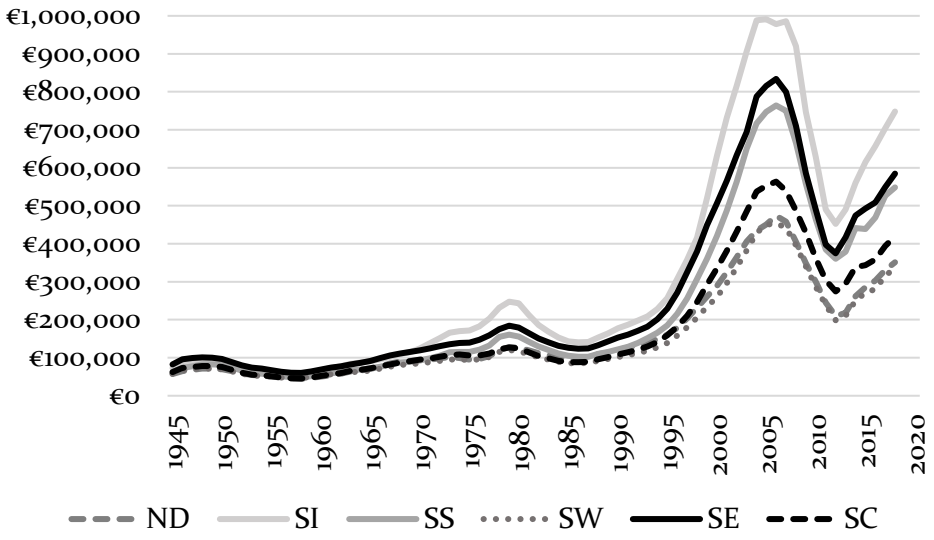
A summary of the movement in real sale and rental housing prices, together with the percentage point change in the gross yield, is given in Table 2. The extent of the real prices falls (in the 1950s) and rises (in the 1960s and 1970s) is immediately apparent: while in reverse order, they are of similar magnitude to the later Celtic Tiger boom/bust cycle. Three other features are of note. Firstly, sale and rental prices comove, but with greater volatility in the sale segment. This means that, in line with theoretical expectations, the yield on housing (as measured by annual rents) is negatively correlated with the housing market cycles. Lastly, the most recent housing market upturn is an important exception to this general trend: despite a 65% real increase in the price of housing 2012-2018, the yield if anything increased slightly during this period.

This analysis at city-level presents five stylised facts.

1. When measured on a like-for-like basis, the sale price of housing rose by an average of 8.4% per year, in nominal terms, between 1945 and 2018, compared to an average increase in consumer prices over the same period of roughly 5%.

2. Market rents increased by an average of 6.3% per year during the same period. Given this is well above the prior estimate of 4.4%, this substantially revises our understanding of the path of rental prices for Dublin, with implications for measuring the cost and standard of living in the Irish economy since World War II.
3. There have been three phases in gross yields since 1945, of roughly equal duration: averaging 13% (and in the range 11%-16%) for the first 25 years, to the early 1970s; averaging 10% (and in the range 8-11%) for the next 25, ending in the late 1990s; and yields below 8% thereafter, bottoming out at less than 3.5% in the mid-2000s.
4. Trends from real series of housing prices reveal roughly four major housing market cycles since 1945. Inflation-adjusted sale and rental prices peaked in the late 1940s, again in the early 1970s and the early 1980s, and lastly in 2006 (2001 for rents). Market troughs occurred in the late 1950s, the mid-1970s, the mid/late 1980s, and lastly in 2012.
5. While sale and rental prices typically comove, sale prices move in greater magnitudes, meaning the yield compresses during market upswings (such as 1958-1979 and 1995-2006) and grows during price busts (such as 1948-1958 and 2006-2012). The period since 2012 is a notable exception to this pattern.

Figure 5. Mix-adjusted average sale price of Dublin housing, by city market (2018 euro)



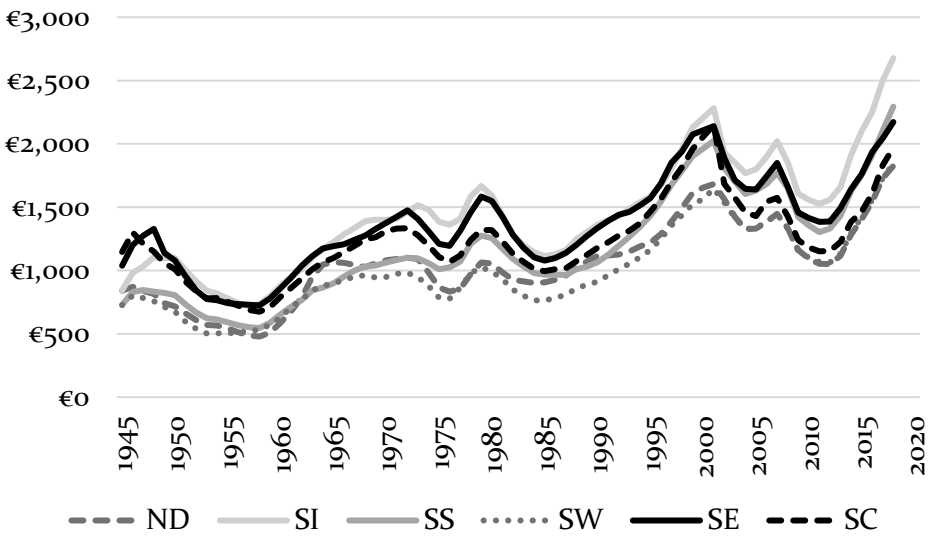
Note: This figure shows the average inflation-adjusted sale price of housing, by Dublin sub-market and year, from 1945 to 2018. Abbreviations are as per Section 3.2.

4.2 Within-city variation

This section presents the results of the within-city analysis, for the six consistent markets within the city over the period analysed. To generate indices of annual frequency, frequency conversion methods are applied to the newspaper dataset. (Sample sizes are sufficiently large, for each area, in the datasets of online listings.) Specifically, a set of regressions is performed separately for each of the six city markets. For each of the six markets, five staggered regression analyses are undertaken, using quinquennial (five-year) categorical variables. Once the full set of regressions is performed for each city market, an average for each year is calculated, giving an annual index for each.

Figures 5 and 6 present inflation-adjusted graphs of sale and rental prices, at annual frequency, for each of the six markets described in Section 3.2, using the same hedonic method as the city-level analysis. As with the city-level analysis, the post-1995 boom/bust cycle dominates in the sales market. Stripping out general inflation, the overall scale of change in the seven decades to 2018 ranges from just under a factor of 5 in North and South-West Dublin to almost 8 in the South Inner City. By contrast, increases in inflation-adjusted rents were significantly smaller in scale: the areas with the smallest changes 1948-2018 saw rents increase by less than 75%, while the largest increase of 175% was seen in the south suburbs.

Figure 6. Mix-adjusted average monthly rental price of Dublin housing, by city market (2018 euro)



Note: This figure shows the average inflation-adjusted monthly rental price of housing, by Dublin sub-market and year, from 1945 to 2018. Abbreviations are as per Section 3.2.

Table 3. Summary statistics for changes in housing prices by city market, 1948–2018

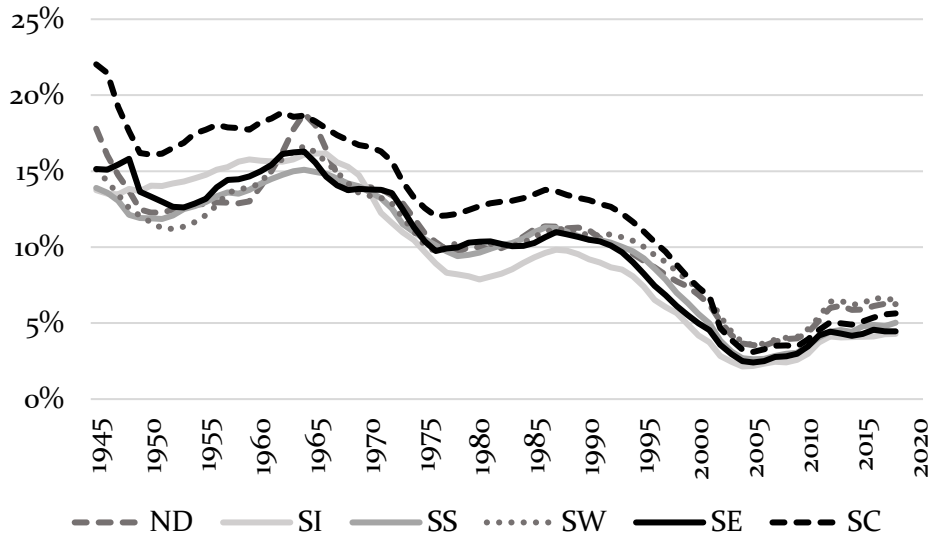
	NORTH DUBLIN	SOUTH INNER	SOUTH SUBURBS	SOUTH WEST	SOUTH EAST	SOUTH COUNTY
SALE PRICE, 1948 (IN 2018€)	€71,388	€95,832	€82,541	€72,157	€100,851	€78,261
SALE PRICE CHANGE	4.9	7.8	6.6	4.7	5.8	5.4
RENT PRICE CHANGE	2.2	2.4	2.8	2.4	1.6	1.7
YIELD CHANGE	-7.5%	-9.5%	-7.1%	-6.0%	-11.4%	-12.0%

Note: This table summarizes overall changes in housing prices (ratios) and yields (percentage points), by city market, from 1948 to 2018, adjusting for inflation.

An overview of the start-to-end changes is given in Table 3. There is a strong correlation between initial sale price and subsequent change in sale prices: albeit with a small sample size (six areas), the correlation coefficient is +0.46. The final row of Table 2 shows the compression in yields on housing in Dublin over the same period. In South County Dublin, for example, yields fell by 12 percentage points, from an estimated 18% in the late 1940s to 6% in the late 2010s.

Figure 7 presents annual estimates of the yield, by city market, for the period under consideration. The dominant trend is one of yield compression, over roughly three phases – as suggested by the city-level analysis discussed above. Nonetheless, the ranking of city markets changes. The South-West market – comprising even postal districts from Dublin 8 up (excluding Dublin 18) – had the lowest gross yields in the early 1950s but the highest yields by the end of the period. Conversely, the South Inner City (Dublin 2 and Dublin 4) went from second-highest yields of the six areas analysed to the lowest. This change had already occurred by the early 1970s. It is suggestive of the re-emergence of attraction of urban cores, a trend that has gained international attention in the 21st century.

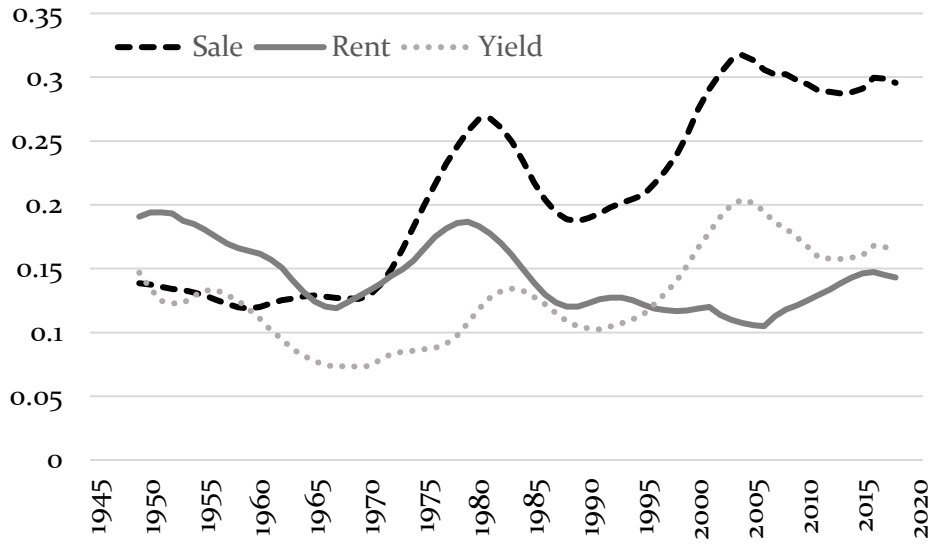
Figure 7. Gross annual yields for Dublin housing, by city market (percent)



Note: This figure shows the gross annual yield on housing by city market and year, from 1948 to 2018.

The final two pieces of analysis draw together the trends from the various different city market series. Figure 8 presents the coefficients of variation for each of the three housing price series – sale, rental and yield – across the six city markets, calculated at five-year moving averages. What is striking is that there is no obvious trend towards a more integrated city-level housing market, at least in the sale segment. There, the coefficient of variation across the six city markets grew from less than 15% before 1970 to approximately 30% since 2000. If anything, the opposite trend has taken place in the rental market: at the start of the period, rental prices were more dispersed than sale prices, across the six markets, but converged, particularly after the late 1970s. Since 2005, there has been a slight increase in rent dispersion but the spread remained in 2018 roughly half what it was in the sales market.

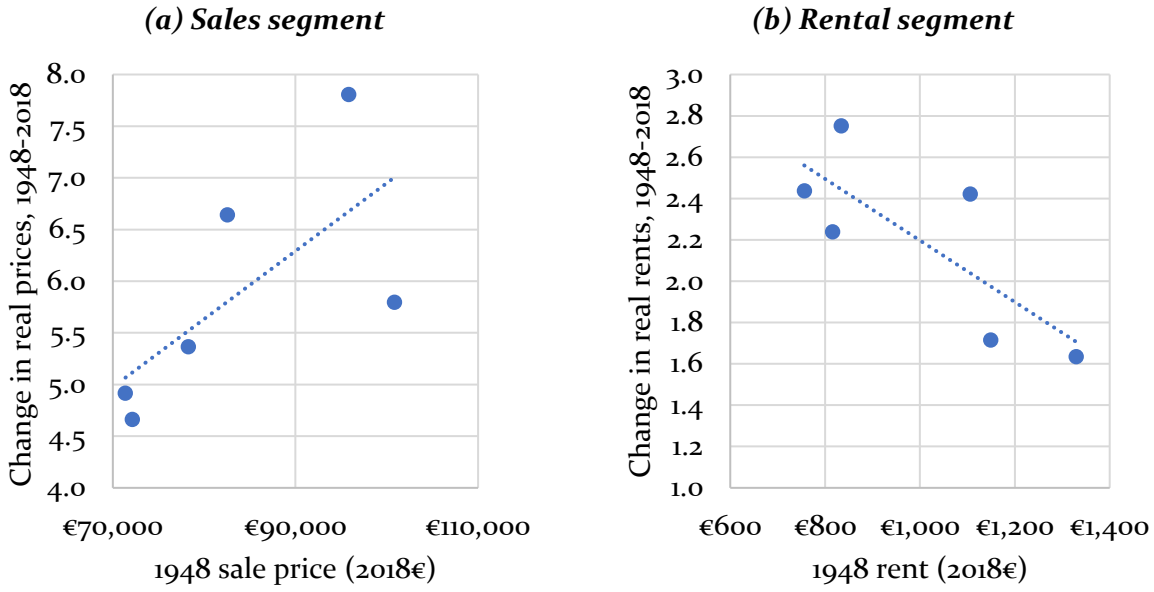
Figure 8. Five-year moving average coefficients of variation, by housing market series



Note: This table shows the five-year moving average of the coefficient of variation of the level of housing prices across the six city markets, for both sale and rental prices and for gross annual yields.

Figure 9 presents in two panels the correlation between initial sale and rental prices (1948 values, expressed in 2018 euro) and subsequent changes in those prices. What is striking is the opposite correlations across segments. There is a strong positive correlation between initial (late 1940s) sale price and the level of subsequent inflation over the following seven decades. However, in the rental segment, initial rents are negatively correlated with the extent of rent increases between 1948 and 2018. While trends in rental prices across Dublin suggest the emergence of a single rental market, trends in the sales segment suggest the opposite.

Figure 9. Scatterplots of initial sale and rental prices and subsequent changes



Note: This figure shows scatter-plots of the initial housing price in sale and rental markets and the overall change, 1948-2018, in prices.

4.3 Determinants of the housing price ratio

This sub-section presents the results of an exploratory parsimonious analysis of the determinants of the housing price ratio, as suggested by economic theory as outlined in Section 2. In particular, it examines the applicability over a longer time period of the findings of Lyons (2018), who documents that for 2000–2016 non-price conditions in the mortgage credit market in Ireland were central in determining the housing price ratio. The exercise is meant to be exploratory, rather than definitive, in nature. Significant additional value remains in the use of other, complementary, approaches – such as that in Ambrose et al (2013), who examine whether rental or sale prices adjust more to changes in fundamentals such as the interest rate.

The outcome of interest is the change in the Dublin housing price ratio, at annual frequency. This is the inverse of the yield presented earlier. At low yields, small absolute changes may represent large relative changes: for example, at a yield of 3%, a change to 2% is a fall in the yield of a half, unlike a fall from 13% to 12%. Thus, for statistical analysis, as distinct from the preceding graphical representation, the log of the ratio of sale to rental prices is preferred to the ratio of rental to sale prices. In levels, this housing price ratio – the multiple of annual rent needed to buy property – varies from 6 to almost 30 in the dataset. In log form, it varies from 1.8 to 3.4. Its annual changes have an average of just below +0.1, consistent with yields falling over time, but are quite volatile, ranging from -0.17 to +0.21.

As in Lyons (2018), the method used for analysing the changes is a single-step error correction procedure, following Johansen (1988), rather than an Engle-Grainger two-step procedure. The latter can introduce spurious long-run relationships while also imposing restrictions on the cointegration space. An alternative approach would be that used by Campbell et al. (2009). However, applying this method to the Dublin market involves the use of a risk-free rate, in their case a ten-year government bond yield. It is unclear what the equivalent rate in Ireland would be: while data on an Irish ten-year government bond is available, to the extent that capital is internationally mobile, this may not represent the appropriate return. Moreover, the mobility of capital to/from Ireland varied hugely over the period being analysed.

As outlined in Section 2, the three principal determinants of the level of the housing price ratio, as suggested by economic theory, are the nominal interest rate, expected capital gain (as proxied by lagged price appreciation), and non-price conditions in the credit market (as proxied by the ratio of credit to deposits). In order to use an error-correction set-up, it is required that there is cointegration, i.e. while individual variables are non-stationary, there exists a linear combination of them that is stationary. Augmented Dickey-Fuller tests, using one lag, clearly reject the null hypothesis of a unit root for the sale and rental housing price indices for Dublin, and for CPI. This is also the case for the housing price ratio, the ratio of credit to deposits, expected capital gains, and interest rates, although the statistical significance of the latter is arguably marginal (a p-value of 0.043; in all other cases it is less than 0.002).

In addition to these long-run determinants, a variety of short-run dynamics were also examined. As in Lyons (2018), changes in rents and changes in credit conditions are significant, while changes in wages and in unemployment are also important, similar to Campbell et al. (2009). The final factor included in the analysis is the annual inflation rate. While this could be interpreted as a dynamic factor, it may also be capturing the gradual erosion of the ground rent element of user cost, as discussed in Section 3.3.

Table 4. Regression results for model of the change in the housing price ratio

	Full span		Up to 2000		From 1985		To 1985	
	Coeff	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**	**Coeff**	**t-stat**
Equilibrium relation								
Lagged log of hpr	-0.272	-3.91	-0.338	-4.42	-0.593	-4.91	-0.391	-3.61
Lagged credit deposit ratio	0.318	4.26	0.27	3.8	0.66	4.35	0.289	1.47
Lagged rate of interest	-0.792	-2.75	-0.427	-1.35	-2.561	-4.14	0.001	0
Lagged changed in sale prices	0.245	2.95	0.285	3.11	0.26	2.67	0.281	2.31
Dynamic factors								
CPI inflation	0.721	2.93	0.831	3.32	-0.527	-0.82	0.641	2.19
Change in rents	-0.69	-7.75	-0.651	-7.59	-0.53	-2.99	-0.663	-6.72
Change in credit deposit ratio	0.341	2.23	0.299	1.12	0.529	3.31	0.015	0.04
Change in unempl't	-0.024	-3.6	-0.035	-4.63	-0.006	-0.42	-0.032	-3.84
Change in wages	0.433	2.53	0.354	2.18	0.633	2.73	0.308	1.35
Constant	0.46	3.6	0.588	4.13	1.096	4.61	0.689	3.54
Adjusted R2	0.654		0.682		0.772		0.699	
Root MSE	0.0604		0.0546		0.0511		0.0552	
Sample size	68		53		29		39	

The main results are shown in the first columns of Table 4. The first empirical specification, labelled 'Full span', explains changes in the housing price ratio as a function of the variables listed above. In an error correction framework, the coefficient on the lagged level of the dependent variable can be interpreted as the speed of adjustment of the outcome of interest to its long-run relation, given in lagged levels. The speed of adjustment is here is relatively swift: almost 30% of the gap between the current and implied equilibrium levels is closed in a twelve-month period.

All three coefficients on fundamentals suggested by theory have the expected sign and are statistically significant at conventional levels. In the equilibrium relation, the ratio of sale to rental housing prices rises (i.e. yields fall) by approximately 3% when the credit/deposit ratio increases by 10%. Yields rise (i.e. sale prices fall relative to rents) when interest rates increase:

this effect is close to unit-elastic in the full dataset (0.8% fall when interest rates rise 1%). And when expected capital gains, measured here as the recent inflation rate in sale prices, increase, so too does the ratio of sale to rental prices: a 10% increase in past inflation increases the yield by roughly 2.5%.

The second half of the regression output table shows dynamic factors. While equilibrium factors are, as per the error correction method, included in lagged levels, dynamic factors are contemporaneous and reflect short-run factors that can affect the housing price ratio. Changes in rents are included to capture factors relating to fundamental underlying demand for housing, in particular housing supply, given that contemporaneous changes in unemployment and wages are directly controlled for. Changes in the credit-deposit ratio are included to reflect well-known momentum effects in credit cycles (cf. Bracke 2013), while the change in the price level could, as discussed in Section 3.3, be thought of either as a dynamic factor or, given the period, a gradual erosion in the ground rent element of the user cost associated with housing.

The remaining three empirical specifications examine, albeit informally, parameter stability over regimes. One concern might be that the period after 2000, captured in Lyons's (2018) model, is driving either the overall model fit or the result relating to credit conditions. This is not the case, however. As measured by root mean square error, the fit of the same model actually improves when the post-2000 period is omitted. The final two specifications examine whether the model changes between periods of higher and lower inflation. This does appear to be the case, with the coefficient on CPI inflation not significant (and with a changed signed) for the period from 1985.

This error-correction set-up, while exploratory, offers at least three important insights. Firstly, the results from the overall sample and the subsample specifications reinforce the finding from the post-2000 period that non-price credit conditions are important in determining the ratio of sale to rental prices in Ireland's housing market. This was not, therefore, a new phenomenon, rather the episode in the 2000s was simply a significantly more extreme episode of earlier tightening and loosening of credit affecting the housing market. Secondly, the difference in results between earlier and later subsamples support the interpretation of the inclusion of general consumer inflation as reflecting ground rents (and thus user cost), prevalent until the late 1970s, rather than for example more general erosion of debt liabilities, which could be expected to have an effect in all periods. Lastly, given the presence of the change in rents as a dynamic factor, the statistical significance of unemployment and wages suggests ownership is not income-neutral. In both cases, when labour market conditions are improving, sale prices rise more than rental prices, something consistent with ownership and income being positively related.

5. Conclusion

This paper presented new housing prices indices for Dublin, Ireland, for the period since World War II. It did this by applying modern methods of index construction, in particular hedonic price regressions but also frequency conversion techniques, to a purpose-built dataset of over 30,000 newspaper listings, together with a substantial archive of more recent online listings. The resulting indices suggest a number of stylised facts that have implications both for understanding Ireland's path to economic development and for other countries.

The 'discovery' of four major cycles, three different phases of housing yield, and substantially greater inflation in private market rents than previously thought will be of relevance to Irish policymakers and researchers interested in understanding that country's economic performance. In line with Jordà et al (2019), we find high returns on what is, relative to equities, a low-volatility asset. The contribution to researchers elsewhere comes in part from the empirical findings, which confirm the predictions of economic and financial theory relating to housing, but perhaps at least as much from the methodology. As outlined in Knoll et al (2017), very few countries have reliable measures of housing prices indices extending back before the 1980s. This means that in many countries, such as the U.S., housing costs and thus general costs of living may be mis-measured over longer periods of time.

Ultimately, housing is central to modern economies and to individual households' welfare. The case of Dublin highlights the importance of credit conditions, as well as real economic conditions, in understanding apparent shifts in the housing market, for example from a high-yield equilibrium to a low-yield one. It also underscores the importance of within-city dynamics, and how these might differ by segment, with evidence of rental price convergence across areas of the city at the same that sale prices have diverged. What drives these trends is a topic worthy of future research.

References

Addison-Smyth, D., McQuinn, K. & O'Reilly, G. (2009). Modelling credit in the Irish mortgage market. *Economic and Social Review*, 40(4), 371.

Ambrose, B. W., Coulson, N. E., & Yoshida, J. (2015). The repeat rent index. *Review of Economics and Statistics*, 97(5), 939-950.

Ambrose, B. W., Eichholtz, P., & Lindenthal, T. (2013). House prices and fundamentals: 355 years of evidence. *Journal of Money, Credit and Banking*, 45(2-3), 477-491.

Bracke, P. (2013). How long do housing cycles last? A duration analysis for 19 OECD countries. *Journal of Housing Economics*, 22(3), 213-230.

Browne, F., Conefrey, T. & Kennedy, G. (2013). Understanding Irish house price movements – a user cost of capital approach. Research Technical Paper 04RT13, Central Bank of Ireland.

Campbell, S. D., Davis, M. A., Gallin, J., & Martin, R. F. (2009). What moves housing markets: A variance decomposition of the rent–price ratio. *Journal of Urban Economics*, 66(2), 90-102.

Chambers, D., Spaenjers, C., & Steiner, E. (2019). The rate of return on real estate: Long-run micro-level evidence. Available at SSRN: http://dx.doi.org/10.2139/ssrn.3407236.

Deeter, K., Quinn, F., & Duffy, D. (2017). Dublin House Prices: A History of Booms and Busts from 1708-1949. *Journal of the Statistical and Social Inquiry Society of Ireland*, 46, 1-18.

de Haan, J., & Diewert, W. E. (2011). Handbook on residential property price indexes. Luxembourg: Eurostat.

Duca, J. V., Muellbauer, J., & Murphy, A. (2011). House prices and credit constraints: Making sense of the US experience. *The Economic Journal*, 121(552), 533-551.

Eichholtz, P., Korevaar, M., & Lindenthal, T. (2019). 500 Years of Housing Rents, Quality and Affordability. Available at SSRN: http://dx.doi.org/10.2139/ssrn.3418495.

Eichholtz, P., Korevaar, M., Lindenthal, T., & Tallec, R. (2020). The total return and risk to residential real estate. Available at SSRN: http://dx.doi.org/10.2139/ssrn.3549278.

Eisfeldt, A., & Demers, A. (2015). Total Returns to Single Family Rentals. National Bureau of Economic Research Working Paper #21804.

Fernandez-Corugedo, E., & Muellbauer, J. (2006). Consumer credit conditions in the United Kingdom. Working Paper, available at RePEc.

Gerlach, S. and Stuart, R. (2015). Money, Interest Rates and Prices in Ireland, 1933-2012. *Irish Economic and Social History*, 42(1), 1-32.

Gerlach, S., Lydon, R. and Stuart, R. (2016). Unemployment and inflation in Ireland: 1926-2012. *Cliometrica*, 10(3), 345-364.

Gordon, R. J., & Van Goethem, T. (2004). A Century of Downward Bias in the Most Important Component of the CPI: The Case of Rental Shelter, 1914-2003. *Hard-to-Measure Goods and Services: Essays in Memory of Zvi Griliches, Studies in Income and Wealth*, 67.

Harmon, C. & Hogan, V. (2000). Econometric Analysis of the Housing Market and Projections of Future Developments, in P. Bacon & F. MacCabe, eds, *The Housing Market in Ireland: An Economic Evaluation of Trends & Prospects*, Government of Ireland Publications.

Himmelberg, C., Mayer, C., & Sinai, T. (2005). Assessing high house prices: Bubbles, fundamentals and misperceptions. *Journal of Economic Perspectives*, 19(4), 67-92.

Kenneally, M. F. & McCarthy, J. V. (1982), A Preliminary Econometric Investigation of the Irish Housing Market, *Economic and Social Review* 14(1), 41-69.

IMF (2003). *Ireland: 2003 Article IV Consultation – Staff Report; Staff Supplement; and Public Information Notice on the Executive Board Discussion for Ireland*. Country Report 03/242, International Monetary Fund.

Johansen, S. (1988). Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control*, 12(2-3), 231-254.

Jordà, Ò., Knoll, K., Kuvshinov, D., Schularick, M., & Taylor, A. M. (2019). The rate of return on everything, 1870–2015. *Quarterly Journal of Economics*, 134(3), 1225-1298.

Kelly, R., McCann, F. & O'Toole, C. (2018). Credit conditions, macroprudential policy and house prices. *Journal of Housing Economics*, 41, 153-167.

Kennedy, G. & McQuinn, K. (2011). Scenarios for Irish House Prices, *Economic Letters*, 2011:2, Central Bank of Ireland.

Kenny, G. (1999). Modelling the demand and supply sides of the housing market: evidence from Ireland. *Economic Modelling* 16(3), 389-409.

Kholodilin, K. A. (2016). War, housing rents, and free market: Berlin's rental housing during World War I. *European Review of Economic History*, 20(3), 322-344.

Kholodilin, K. A., Limonov, L. E., & Waltl, S. R. (2019). Housing rent dynamics and rent regulation in St. Petersburg (1880-1917). DIW Discussion Papers No. 1780.

Knoll, K., Schularick, M., & Steger, T. (2017). No price like home: Global house prices, 1870-2012. *American Economic Review*, 107(2), 331-53.

Lyons, R. C. (2015). East, west, boom and bust: the spread of house prices and rents in Ireland, 2007–2012. *Journal of Property Research*, 32(1), 77-101.

Lyons, R. C. (2018). Credit conditions and the housing price ratio: evidence from Ireland's boom and bust. *Journal of Housing Economics*, 42, 84-96.

Lyons, R. C. (2019). Can list prices accurately capture housing price trends? Insights from extreme markets conditions. *Finance Research Letters*, 30, 228-232.

Malpezzi, S. (2003). 'Hedonic pricing models: a selective and applied review' in Tony O'Sullivan, Kenneth Gibb (eds.), *Housing Economics and Public Policy: Essays in honour of Duncan Maclennan* (2003), pp. 67-89.

McQuinn, K. (2004). A Model of the Irish Housing Sector. *Research Technical Papers* 1/RT/04, Central Bank of Ireland.

McQuinn, K. & O'Reilly, G. (2008). Assessing the role of income and interest rates in determining house prices. *Economic modelling* 25(3), 377-390.

Muellbauer, J. (2007). Housing, credit and consumer expenditure. *Proceedings - Economic Policy Symposium - Jackson Hole*, Federal Reserve Bank of Kansas City, pp. 267-334.

Murphy, A. (1998). Econometric Modelling of the Irish Housing Market, in P. Bacon, F. MacCabe & A. Murphy, eds, *An Economic Assessment of Recent House Price Developments*, Government of Ireland Publications.

Murphy, A. (2005). Modelling Irish House Prices: A Review and Some New Results. Working Papers, Nuffield College, Oxford.

Murphy, A. & Brereton, F. (2001). Modeling Irish House Prices: A Review. *Irish Economic Association 2001 Annual Conference*.

Offer, A. (2014). Narrow banking, real estate, and financial stability in the UK, c. 1870-2010. *British Financial Crises since 1825*, pp.158-173.

Officer, L. H., & Williamson, S. (2018). The annual consumer price index for the United States, 1774-2017. *MeasuringWorth. com*.

Poterba, J. M. (1992). Taxation and Housing: Old Questions, New Answers. *American Economic Review*, 82(2), 237-242.

Shiller, R.J., 2005. *Irrational Exuberance*. Princeton: Princeton University Press.

Shimizu, C., Nishimura, K. G., & Watanabe, T. (2012). 'House prices from magazines, realtors, and the Land Registry' in Bank for International Settlements (ed.), *Property markets and financial stability* (2012), pp. 29-38.

Silver, M. S. (2016). How to better measure hedonic residential property price indexes. International Monetary Fund.

Stuart, Rebecca, (2017), '70 years of personal disposable income and consumption in Ireland', *Journal of the Statistical and Social Inquiry Society of Ireland*.

Rae, D. & van den Noord, P. (2006). 'Ireland's Housing Boom: What has Driven it and Have Prices Overshot?', OECD Economics Department Working Papers.

Roche, M. (2004). Will there be a Crash in Irish House Prices? *Quarterly Economic Commentary* 2003(4), 1-16.

Stevenson, S. (2003). Economic, demographic & fiscal influences on housing market dynamics, UCD Centre for Real Estate Research Working Paper Series, University College Dublin School of Economics.

Stevenson, S. (2008). Modeling housing market fundamentals: Empirical evidence of extreme market conditions, *Real Estate Economics* 36(1), 1-29.

Thom, D. R. (1983). *House prices, inflation and the mortgage market*. Economic and Social Review 15(1), 57-68.

Appendix A

The table below summarizes the relevant literature analysing price outcomes in the Irish housing market.

AUTHOR(S)	PERIOD	METHOD	FUNDAMENTALS	COMMENT
KENNEALLY & MCCARTHY (1982)	1969IV-1976III	Quasi-inverted demand; 6-equation system	Y, S, rr, demog, q mort, rhp-1	Levels not logs, lack of statistical significance; unsuccessful inclusion of credit rationing
THOM (1983)	1971I-1980IV	Inverted D; quasi-ECM	Y, S, rr, demog, CCI, repayment, T	Coeff on Y 1.68, coeff on CCI 0.69
MURPHY (1998)	1974-1997	Inverted D	Y, S, rr, pop2534, dY	Coeffs on Y, r 1.4 and -0.35 respectively
KENNY (1999)	1975I-1997I	Inverted D; VECM	Y, S, rn	Unit elasticities imposed; Y measured by agg GNP (no demographics)
HARMON & HOGAN (2000)	1972-1999	Inverted D	Y, S, rn, pop2534	Only Y significant; prices in 2000 above LR prediction
MURPHY & BRERETON (2001)	1974-1999	Inverted D	Y, S, rr, pop2534, dY	LR equation unstable in period 1997-9; demand higher than predicted
IMF (2003)	1976-2002	Inverted D; ECM	Y, rr, pop2534	1976-97 model suggests 50% overvalued in 2002; no stock measure; SOA=0.31
STEVENSON (2003)	1978-2001	Ad hoc, based on inverted D	Y, S, rr, pop, conf, empl, rhp-1	Interpretation unclear; model without lagged DV performs poorly
ROCHE (2004)	1979I-2003I	Regime-switching; ad hoc	Y, rr, av mort, migr, c build, c land	Good fit, but likely due to endogeneity issues (incl of land values)
MCQUINN (2004)	1980I-2002IV	Inverted D; ECM in 3-eq system	Y, S, rr, av mort, migr, uc	User cost term dropped; LR coefficient on income very low (<0.2), SOA<0.14

MURPHY (2005)	1974-2004	Inverted D; two-stage ECM	Y, S, uc, rr, pop2534	Lower coeff on Y than S; dummies for financial liberalization; SOA=0.44
RAE & VAN DEN NOORD (2006)	1977I-2004I	Inverted D; two-stage ECM	Y, S, r, pop2534	2nd-hand: coeff on Y and S similar (1.69, -1.68), SOA=0.34; new: only Y, S included
STEVENSON (2008)	1978I-2003I	Inverted D; two-stage ECM	Y, S, rr, pop2534	Large LR coefficients on Y (3.3), S (11); SOA= 0.08 (t-stat of 2); 18% overvaluation by 2003
MCQUINN & O'REILLY (2008)	1980I-2005IV	Inverted D; two-stage ECM	Y + rn (specific functional form), S	LR coeff on Y,r term 0.8; SOA=0.05; report that LTV when included not significant
ADDISON ET AL (2009)	1982IV-2009I	Inverted D; 2-eq system ECM	Y + rn (specific functional form), S	SOA=0.17; coefficient on joint Y,r term close to 1
KENNEDY & MCQUINN (2011)	1982I-2010IV	Inverted D; 2-eq system ECM	Y + rn (specific functional form), S	Detailed results not reported; DOE price data replaced with hedonic price data post-1996
BROWNE ET AL (2013)	1980I-2012IV	User cost	N/A	Real user cost of capital negative 1980-4 and 1998-2008
LYONS (2018)	2000I-2016IV	Housing price ratio; one-stage ECM	hpr, rn, uc, past appreciation, ltv, CCI	Rapid adjustment to implied equilibrium relation; 10pp increase in first-time buyer LTV associated with 9% rise in sale prices
KELLY ET AL (2018)	2003-2010	Property-level model	Credit, Y, deposits, dwelling attributes	Elasticity of house prices wrt credit availability approximately 0.15

Note on abbreviations: within 'Period', I-IV refer to quarters of the year. 'Inverted D' refers to inverted demand method of modelling housing prices; (V)ECM refers to (vector) error-correction method. Within fundamentals, Y, S and uc refer to income, supply and user cost respectively, while r, rn and rr refer to rate of interest (unadjusted, nominal and real, respectively); CCI refers to credit conditions index. Within 'Comments', SOA refers to 'speed of adjustment' (in error correction methods), while LR and SR refer to long- and short-run respectively.

Appendix B

B.1 Hedonic housing price indices for Dublin (Ireland), sale and rental (annual; 1948=100)

Year	Sale	Rent	Yield	Year	Sale	Rent	Yield
1945	57.6	65.2	13.7%	**1982**	1624	1264	9.4%
1946	73.4	85.2	14.1%	**1983**	1628	1256	9.3%
1947	95.8	86.5	10.9%	**1984**	1536	1252	9.9%
1948	100.0	100.0	12.1%	**1985**	1525	1302	10.3%
1949	82.8	79.4	11.6%	**1986**	1574	1502	11.6%
1950	77.4	85.8	13.4%	**1987**	1603	1468	11.1%
1951	82.0	73.5	10.9%	**1988**	1642	1473	10.9%
1952	83.7	81.9	11.8%	**1989**	2174	1702	9.5%
1953	76.1	76.9	12.2%	**1990**	2584	2017	9.5%
1954	73.3	77.2	12.8%	**1991**	2586	2044	9.6%
1955	70.3	71.5	12.3%	**1992**	2680	2252	10.2%
1956	68.7	75.3	13.3%	**1993**	2486	2062	10.0%
1957	65.7	69.9	12.9%	**1994**	2607	2386	11.1%
1958	65.8	81.3	15.0%	**1995**	3094	2373	9.3%
1959	69.7	77.6	13.5%	**1996**	3513	2572	8.9%
1960	76.3	87.0	13.8%	**1997**	4371	2903	8.0%
1961	89.7	99.2	13.4%	**1998**	5930	3445	7.0%
1962	103.5	128.3	15.0%	**1999**	6831	3812	6.8%
1963	121.9	140.7	14.0%	**2000**	8732	4455	6.2%
1964	138.7	183.9	16.1%	**2001**	9336	5284	6.9%
1965	157.3	178.0	13.7%	**2002**	10613	4875	5.6%
1966	163.3	172.1	12.8%	**2003**	12334	4749	4.7%
1967	169.7	192.9	13.8%	**2004**	13351	4577	4.2%
1968	190.7	191.7	12.2%	**2005**	17024	4741	3.4%
1969	211.9	209.8	12.0%	**2006**	18775	5136	3.3%
1970	248.9	240.2	11.7%	**2007**	19147	5671	3.6%
1971	284.9	282.0	12.0%	**2008**	17591	5417	3.7%
1972	297.5	332.5	13.5%	**2009**	14297	4496	3.8%
1973	354.5	336.6	11.5%	**2010**	11954	4228	4.3%
1974	451.7	377.9	10.1%	**2011**	10039	4195	5.1%
1975	481.1	419.7	10.6%	**2012**	8833	4277	5.9%
1976	561.1	447.3	9.7%	**2013**	9408	4579	5.9%
1977	697.1	502.4	8.7%	**2014**	11091	5241	5.7%
1978	881.2	596.7	8.2%	**2015**	11917	5704	5.8%
1979	1150	856.3	9.0%	**2016**	12512	6220	6.0%
1980	1319	982.0	9.0%	**2017**	13822	6938	6.1%
1981	1473	1197	9.8%	**2018**	14747	7429	6.1%

B.2 Hedonic housing price indices for area within Dublin, sale (1948=100; area definition explained in the text)

Year	ND	SI	SS	SW	SE	SC
1945	73.7	71.2	70.7	74.3	75.6	74.0
1946	83.3	83.3	81.3	85.2	86.7	85.1
1947	92.6	92.9	91.2	93.7	95.2	93.4
1948	100.0	100.0	100.0	100.0	100.0	100.0
1949	100.8	101.5	101.3	99.1	100.3	101.2
1950	100.2	99.9	100.4	98.3	98.1	98.3
1951	99.5	98.6	98.7	97.0	96.4	95.3
1952	98.0	96.1	95.8	95.4	94.5	92.6
1953	95.8	92.6	91.4	92.9	92.2	89.4
1954	93.8	89.1	88.8	91.2	89.3	86.7
1955	91.8	85.7	86.0	90.1	86.9	84.4
1956	90.0	83.2	83.7	89.8	84.8	83.0
1957	89.2	83.0	83.0	90.2	84.8	83.0
1958	91.9	86.6	86.2	94.2	87.7	85.3
1959	96.8	93.2	91.3	100.9	93.2	90.5
1960	104.4	103.7	99.1	108.6	100.8	98.6
1961	115.2	115.5	108.9	118.3	110.7	108.7
1962	128.9	128.3	119.6	128.4	121.2	120.4
1963	145.8	141.9	132.5	139.9	132.4	135.2
1964	162.0	157.5	144.5	151.9	148.5	151.5
1965	180.8	172.3	159.0	166.9	165.6	167.7
1966	203.1	186.7	174.5	184.5	183.7	184.5
1967	228.9	207.3	193.0	204.6	202.9	203.5
1968	254.2	230.1	213.4	227.4	223.2	226.8
1969	278.1	258.5	234.8	251.7	248.2	251.4
1970	306.4	304.5	266.5	277.5	279.1	284.6
1971	340.1	369.2	305.0	313.0	315.6	320.5
1972	383.3	438.8	354.6	352.1	359.7	363.2
1973	441.3	536.9	428.4	408.9	415.7	424.5
1974	503.7	642.4	506.3	479.9	500.4	501.3
1975	584.8	784.1	610.8	565.9	607.7	591.2
1976	699.7	987.3	760.7	689.8	754.4	702.7
1977	859.6	1242.4	940.3	829.2	925.1	832.3
1978	1068.2	1527.2	1183.6	1009.3	1100.0	987.9
1979	1280.2	1846.5	1397.4	1191.1	1309.7	1165.0
1980	1501.1	2146.0	1600.7	1376.5	1507.1	1346.7
1981	1707.9	2267.1	1755.6	1545.6	1665.4	1489.2
1982	1868.6	2318.7	1870.0	1665.6	1780.6	1593.1
1983	1980.4	2318.1	1924.0	1736.3	1836.9	1654.1
1984	2029.4	2287.3	1929.5	1769.3	1865.7	1682.5
1985	2061.7	2257.5	1931.3	1789.4	1884.9	1711.9
1986	2149.8	2298.4	1952.3	1851.5	1922.1	1764.2
1987	2294.7	2389.0	2014.2	1943.9	1993.6	1842.7
1988	2527.7	2638.9	2203.6	2103.8	2177.2	2024.3
1989	2741.7	2946.0	2400.8	2298.5	2438.1	2235.5
1990	2992.5	3293.5	2618.6	2505.1	2694.2	2453.1

1991	3255.8	3567.2	2860.8	2713.6	2925.4	2670.6
1992	3496.0	3904.0	3181.3	2930.8	3203.2	2919.6
1993	3748.2	4179.3	3522.9	3151.5	3448.6	3163.3
1994	4097.2	4673.4	3937.0	3449.9	3919.4	3540.0
1995	4537.0	5385.0	4518.1	3873.7	4561.3	4087.8
1996	5104.8	6564.8	5347.6	4485.6	5503.5	4746.9
1997	5910.3	7745.6	6422.9	5184.2	6682.9	5568.5
1998	6884.4	9219.8	7905.6	6048.1	8005.1	6691.9
1999	7894.7	11715.7	9438.1	6991.8	9617.8	8056.2
2000	9221.3	15010.8	11602.2	8191.5	11449.4	9773.4
2001	10873.4	18249.7	14114.4	9825.5	13409.9	11657.1
2002	12790.9	21305.9	17066.1	11720.4	15700.6	13817.8
2003	14709.4	24481.3	20385.1	13707.5	17823.6	16045.8
2004	16098.9	27265.8	22971.9	15708.7	20654.2	18170.5
2005	17094.8	28014.4	24537.1	16901.7	21910.0	19140.2
2006	18684.8	28743.6	26066.7	17715.3	23283.4	20277.4
2007	18959.6	30374.8	26815.2	18112.9	23399.5	20329.0
2008	17449.7	29491.2	24760.0	16869.6	21649.0	19120.4
2009	14339.6	22866.6	19839.0	13844.3	17040.0	16086.5
2010	12193.1	19040.0	16347.3	11540.0	14105.1	13411.1
2011	10229.9	15268.8	13902.8	9849.3	11765.3	11576.7
2012	8920.7	14322.0	13245.2	8339.8	11260.1	10635.6
2013	9299.6	15600.0	13993.9	8882.9	12598.0	11492.6
2014	11215.9	17852.3	16336.9	10586.9	14366.2	13226.2
2015	12186.8	19531.7	16184.4	11450.2	14875.8	13370.3
2016	12917.2	20868.2	17314.0	11834.4	15370.5	13974.9
2017	14177.8	22460.5	19503.8	13385.1	16637.8	15406.6
2018	15091.4	23966.7	20392.6	14309.5	17796.0	16469.8

B.3 Hedonic housing price indices for area within Dublin, rental (1948=100)

Year	ND	SI	SS	SW	SE	SC
1945	95.7	70.7	81.0	89.3	72.4	92.5
1946	97.6	81.4	91.1	97.1	82.7	103.6
1947	99.5	90.4	98.3	100.3	92.9	102.0
1948	100.0	100.0	100.0	100.0	100.0	100.0
1949	91.8	100.4	99.6	95.1	86.5	93.1
1950	89.7	101.3	98.5	91.1	82.7	89.7
1951	89.1	99.9	96.5	86.7	79.2	87.4
1952	89.0	98.5	95.6	85.0	75.7	86.9
1953	87.9	95.7	94.4	83.9	73.5	85.6
1954	87.6	93.5	92.9	84.4	72.7	86.0
1955	86.0	91.4	92.0	86.7	72.5	85.0
1956	85.0	90.8	92.1	91.1	74.8	85.1
1957	84.1	91.5	93.1	97.2	77.4	84.3
1958	86.3	97.7	96.1	103.5	80.2	86.3
1959	91.8	106.2	103.8	111.6	86.3	91.1
1960	106.5	117.5	115.9	122.7	95.6	101.9
1961	126.0	130.6	130.1	142.6	107.9	113.9
1962	152.6	144.8	145.7	161.3	123.6	129.0
1963	188.6	161.7	163.8	180.9	135.9	142.6
1964	222.1	183.2	179.8	201.1	153.0	160.5
1965	237.6	201.2	196.0	215.9	163.0	173.9
1966	243.2	217.8	213.5	228.8	170.1	186.7
1967	246.9	233.3	231.1	243.0	180.5	200.6
1968	254.8	254.1	249.9	257.2	194.2	219.3
1969	280.7	275.2	271.1	271.5	217.3	238.6
1970	311.4	297.6	299.6	295.0	243.5	268.1
1971	342.4	326.9	332.7	329.8	274.7	296.7
1972	375.0	368.0	367.0	360.7	308.4	322.6
1973	414.5	425.1	406.9	388.1	328.3	344.8
1974	437.0	485.7	459.3	421.0	357.5	377.7
1975	464.9	548.9	529.9	454.7	398.6	421.5
1976	527.8	636.4	635.7	532.0	464.9	480.4
1977	616.9	747.0	753.5	670.4	580.3	571.4
1978	753.2	906.6	918.3	819.4	694.5	683.5
1979	933.7	1078.9	1093.7	969.5	853.3	822.9
1980	1094.6	1219.3	1273.7	1110.0	986.7	971.2
1981	1228.7	1319.8	1432.9	1255.7	1092.5	1089.8
1982	1354.5	1382.8	1561.5	1339.6	1150.0	1174.2
1983	1477.8	1430.5	1631.8	1395.6	1169.3	1225.8
1984	1583.3	1480.6	1680.5	1447.1	1190.1	1262.9
1985	1679.5	1521.9	1750.4	1519.9	1223.6	1308.8
1986	1780.8	1598.6	1815.8	1624.9	1294.4	1378.1
1987	1898.6	1697.7	1870.1	1729.3	1384.8	1431.1
1988	2071.3	1863.5	2001.2	1872.0	1492.0	1543.7
1989	2257.3	2031.2	2124.6	2019.8	1646.8	1681.0
1990	2426.5	2186.6	2270.0	2140.8	1785.8	1823.5
1991	2513.6	2315.7	2468.0	2329.1	1920.0	1948.3

1992	2606.6	2445.2	2703.7	2525.7	2046.5	2096.3
1993	2697.8	2575.1	2909.5	2670.3	2109.5	2191.4
1994	2856.6	2727.5	3156.6	2861.5	2234.3	2342.3
1995	3007.6	2881.4	3449.7	3085.4	2377.4	2561.1
1996	3224.9	3092.0	3783.3	3377.5	2594.6	2786.2
1997	3525.0	3392.8	4169.2	3720.0	2887.9	3069.3
1998	3893.3	3768.8	4552.4	4037.1	3101.9	3356.4
1999	4266.4	4160.4	4925.1	4346.5	3370.4	3678.5
2000	4619.9	4548.9	5361.8	4710.6	3612.5	4077.1
2001	4932.8	4933.1	5800.6	5207.7	3848.2	4467.3
2002	4791.0	4367.7	5425.4	5088.4	3555.8	3669.0
2003	4520.4	4334.1	5280.9	4848.5	3336.5	3545.9
2004	4295.8	4233.0	5084.4	4645.4	3271.1	3359.1
2005	4422.1	4405.3	5298.6	4787.6	3339.9	3373.3
2006	4780.6	4835.9	5683.8	5153.2	3690.6	3781.6
2007	5237.4	5396.6	6270.9	5641.1	4109.4	4042.8
2008	5034.7	5151.6	6086.3	5422.6	3846.2	3824.0
2009	4183.3	4267.4	5001.2	4483.3	3217.3	3168.6
2010	3895.5	4095.6	4727.2	4234.8	3094.1	2989.0
2011	3851.5	4116.0	4661.0	4211.7	3106.3	2989.6
2012	3901.3	4273.0	4841.3	4261.1	3163.2	3044.8
2013	4173.9	4578.1	5235.2	4564.8	3426.3	3250.5
2014	4798.9	5273.4	5953.6	5230.5	3773.7	3681.4
2015	5244.2	5785.1	6403.8	5728.9	4036.5	3885.9
2016	5759.9	6204.2	6969.9	6279.2	4431.5	4255.4
2017	6475.7	6911.5	7713.0	6997.9	4700.5	4873.9
2018	6873.2	7436.2	8445.2	7480.1	5019.0	5267.7

B.4 Gross yield on housing, for area within Dublin, annual in percent

Year	ND	SI	SS	SW	SE	SC
1945	17.8%	13.8%	13.9%	15.1%	15.1%	22.0%
1946	16.1%	13.5%	13.6%	14.3%	15.1%	21.5%
1947	14.7%	13.5%	13.1%	13.5%	15.4%	19.2%
1948	13.7%	13.8%	12.1%	12.6%	15.8%	17.6%
1949	12.5%	13.7%	11.9%	12.1%	13.6%	16.2%
1950	12.3%	14.0%	11.9%	11.6%	13.3%	16.1%
1951	12.3%	14.0%	11.9%	11.2%	13.0%	16.2%
1952	12.5%	14.2%	12.1%	11.2%	12.7%	16.5%
1953	12.6%	14.3%	12.5%	11.4%	12.6%	16.9%
1954	12.8%	14.5%	12.7%	11.6%	12.9%	17.5%
1955	12.8%	14.8%	13.0%	12.1%	13.2%	17.7%
1956	12.9%	15.1%	13.3%	12.8%	13.9%	18.1%
1957	12.9%	15.3%	13.6%	13.6%	14.4%	17.9%
1958	12.9%	15.6%	13.5%	13.8%	14.5%	17.8%
1959	13.0%	15.8%	13.8%	13.9%	14.6%	17.7%
1960	14.0%	15.7%	14.2%	14.2%	15.0%	18.2%
1961	15.0%	15.7%	14.5%	15.2%	15.4%	18.5%
1962	16.2%	15.6%	14.8%	15.8%	16.1%	18.9%
1963	17.7%	15.8%	15.0%	16.3%	16.2%	18.6%
1964	18.8%	16.1%	15.1%	16.6%	16.3%	18.7%
1965	18.0%	16.2%	14.9%	16.3%	15.6%	18.3%
1966	16.4%	16.1%	14.8%	15.6%	14.6%	17.8%
1967	14.8%	15.6%	14.5%	14.9%	14.1%	17.4%
1968	13.7%	15.3%	14.2%	14.2%	13.8%	17.0%
1969	13.8%	14.7%	14.0%	13.6%	13.8%	16.7%
1970	13.9%	13.5%	13.6%	13.4%	13.8%	16.6%
1971	13.8%	12.3%	13.2%	13.2%	13.8%	16.3%
1972	13.4%	11.6%	12.5%	12.9%	13.6%	15.6%
1973	12.9%	11.0%	11.5%	11.9%	12.5%	14.3%
1974	11.9%	10.5%	11.0%	11.0%	11.3%	13.3%
1975	10.9%	9.7%	10.5%	10.1%	10.4%	12.6%
1976	10.3%	8.9%	10.1%	9.7%	9.7%	12.0%
1977	9.8%	8.3%	9.7%	10.2%	9.9%	12.1%
1978	9.7%	8.2%	9.4%	10.2%	10.0%	12.2%
1979	10.0%	8.1%	9.5%	10.2%	10.3%	12.4%
1980	10.0%	7.9%	9.6%	10.1%	10.4%	12.7%
1981	9.9%	8.1%	9.9%	10.2%	10.4%	12.9%
1982	9.9%	8.3%	10.1%	10.1%	10.2%	13.0%
1983	10.2%	8.5%	10.3%	10.1%	10.1%	13.1%
1984	10.7%	9.0%	10.6%	10.3%	10.1%	13.2%
1985	11.2%	9.3%	11.0%	10.7%	10.3%	13.5%
1986	11.4%	9.6%	11.3%	11.0%	10.6%	13.8%
1987	11.3%	9.8%	11.3%	11.2%	11.0%	13.7%
1988	11.2%	9.8%	11.0%	11.2%	10.8%	13.4%
1989	11.3%	9.5%	10.7%	11.0%	10.7%	13.2%
1990	11.1%	9.2%	10.5%	10.7%	10.5%	13.1%
1991	10.6%	9.0%	10.5%	10.8%	10.4%	12.9%

1992	10.2%	8.7%	10.3%	10.8%	10.1%	12.6%
1993	9.9%	8.5%	10.0%	10.7%	9.7%	12.2%
1994	9.6%	8.1%	9.7%	10.4%	9.0%	11.7%
1995	9.1%	7.4%	9.3%	10.0%	8.2%	11.0%
1996	8.7%	6.5%	8.6%	9.5%	7.5%	10.3%
1997	8.2%	6.1%	7.9%	9.0%	6.8%	9.7%
1998	7.8%	5.7%	7.0%	8.4%	6.1%	8.8%
1999	7.4%	4.9%	6.3%	7.8%	5.5%	8.0%
2000	6.9%	4.2%	5.6%	7.2%	5.0%	7.3%
2001	6.2%	3.7%	5.0%	6.7%	4.5%	6.8%
2002	5.1%	2.8%	3.9%	5.5%	3.6%	4.7%
2003	4.2%	2.5%	3.1%	4.4%	3.0%	3.9%
2004	3.7%	2.1%	2.7%	3.7%	2.5%	3.3%
2005	3.5%	2.2%	2.6%	3.6%	2.4%	3.1%
2006	3.5%	2.3%	2.6%	3.7%	2.5%	3.3%
2007	3.8%	2.5%	2.8%	3.9%	2.8%	3.5%
2008	4.0%	2.4%	3.0%	4.0%	2.8%	3.5%
2009	4.0%	2.6%	3.1%	4.1%	3.0%	3.5%
2010	4.4%	3.0%	3.5%	4.6%	3.5%	3.9%
2011	5.2%	3.7%	4.1%	5.4%	4.2%	4.5%
2012	6.0%	4.1%	4.4%	6.4%	4.4%	5.0%
2013	6.2%	4.1%	4.5%	6.5%	4.3%	5.0%
2014	5.9%	4.1%	4.4%	6.2%	4.2%	4.9%
2015	5.9%	4.1%	4.8%	6.3%	4.3%	5.1%
2016	6.1%	4.1%	4.9%	6.7%	4.6%	5.4%
2017	6.3%	4.3%	4.8%	6.6%	4.5%	5.6%
2018	6.2%	4.3%	5.0%	6.6%	4.5%	5.6%

Appendix C

Sample regression output

	Sales				Rental			
	Coeff	S.E.	t-stat	p-value	Coeff	S.E.	t-stat	p-value
1945.year	-0.552	0.04	-13.66	0	-0.433	0.107	-4.05	0
1946.year	-0.311	0.04	-7.86	0	-0.157	0.106	-1.48	0.139
1947.year	-0.045	0.038	-1.18	0.237	-0.142	0.079	-1.81	0.071
1948.year	0	.	.	.	0	.	.	.
1949.year	-0.19	0.02	-9.54	0	-0.236	0.038	-6.18	0
1950.year	-0.257	0.021	-12	0	-0.148	0.038	-3.88	0
1951.year	-0.199	0.022	-9.1	0	-0.307	0.039	-7.91	0
1952.year	-0.177	0.022	-8.22	0	-0.188	0.04	-4.73	0
1953.year	-0.273	0.021	-12.89	0	-0.263	0.039	-6.8	0
1954.year	-0.311	0.02	-15.44	0	-0.259	0.039	-6.71	0
1955.year	-0.354	0.021	-16.91	0	-0.322	0.041	-7.81	0
1956.year	-0.376	0.021	-17.6	0	-0.282	0.041	-6.94	0
1957.year	-0.421	0.021	-20.26	0	-0.356	0.039	-9.11	0
1958.year	-0.42	0.023	-18.46	0	-0.206	0.042	-4.9	0
1959.year	-0.362	0.022	-16.49	0	-0.254	0.039	-6.47	0
1960.year	-0.272	0.022	-12.38	0	-0.126	0.042	-2.96	0.003
1961.year	-0.11	0.021	-5.21	0	-0.007	0.044	-0.16	0.872
1962.year	0.034	0.019	1.77	0.077	0.247	0.041	6.1	0
1963.year	0.197	0.02	9.88	0	0.346	0.039	8.96	0
1964.year	0.326	0.024	13.67	0	0.61	0.045	13.64	0
1965.year	0.452	0.023	19.34	0	0.586	0.044	13.27	0
1966.year	0.489	0.024	20.07	0	0.546	0.042	12.91	0
1967.year	0.528	0.025	21.19	0	0.66	0.041	16.02	0
1968.year	0.645	0.024	26.36	0	0.652	0.043	15.34	0
1969.year	0.75	0.025	29.69	0	0.747	0.041	18.15	0
1970.year	0.911	0.025	35.91	0	0.878	0.046	19.16	0
1971.year	1.046	0.024	44.23	0	1.042	0.043	24.39	0
1972.year	1.087	0.024	44.9	0	1.203	0.04	29.89	0
1973.year	1.265	0.029	44.34	0	1.214	0.044	27.89	0
1974.year	1.507	0.027	56.36	0	1.329	0.045	29.31	0
1975.year	1.57	0.026	59.5	0	1.436	0.048	30.08	0
1976.year	1.724	0.025	69.5	0	1.5	0.044	34.14	0
1977.year	1.941	0.025	78.31	0	1.615	0.049	33	0
1978.year	2.175	0.025	87.51	0	1.786	0.054	33.13	0
1979.year	2.44	0.028	88.68	0	2.148	0.049	44.09	0
1980.year	2.58	0.023	112.28	0	2.281	0.04	56.93	0
1981.year	2.69	0.024	111	0	2.477	0.042	59.11	0
1982.year	2.788	0.022	127.98	0	2.539	0.039	65.82	0
1983.year	2.79	0.022	127.19	0	2.531	0.038	66.73	0
1984.year	2.732	0.021	131.68	0	2.527	0.039	64.04	0
1985.year	2.725	0.021	128.47	0	2.566	0.041	62.93	0
1986.year	2.756	0.023	121.5	0	2.709	0.044	60.96	0
1987.year	2.774	0.021	129.55	0	2.685	0.04	67.22	0
1988.year	2.799	0.034	83.28	0	2.689	0.069	38.78	0
1989.year	3.064	0.041	73.83	0	2.865	0.051	56.26	0

1990.year	3.252	0.027	121.38	0	3.004	0.043	70.37	0
1991.year	3.253	0.029	111.18	0	3.017	0.055	55.33	0
1992.year	3.288	0.027	120.35	0	3.114	0.045	69.89	0
1993.year	3.214	0.028	114.23	0	3.028	0.051	58.97	0
1994.year	3.261	0.03	108.26	0	3.171	0.051	62	0
1995.year	3.432	0.024	143.23	0	3.166	0.035	90.17	0
1996.year	3.59	0.019	186.15	0	3.246	0.035	92.36	0
1997.year	3.778	0.02	187.13	0	3.367	0.035	95.67	0
1998.year	4.084	0.019	214.42	0	3.538	0.035	101.76	0
1999.year	4.226	0.019	224.03	0	3.639	0.035	105	0
2000.year	4.471	0.019	239.79	0	3.795	0.035	108.71	0
2001.year	4.537	0.019	239.12	0	3.966	0.035	113.68	0
Type	YES				YES			
Age	YES				YES			
Size	YES				YES			
Location	YES				YES			
Frequency	NO				YES			
Constant	7.547	0.048	156.05	0	3.492	0.079	44.26	0
R-squared	0.98				0.977			
RMSE	0.267				0.226			
Sample	18,693				9,830			