



Master's Degree in Economics and Finance

**“An Investigation into the Dynamics of the Dublin
Housing Market, 2006-2018”**

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ABSTRACT IN ENGLISH (100 words):

After five decades of sustained growth, the Irish housing market experienced a precipitous crash in the aftermath of the Global Financial Crisis in 2007. Our paper examines the short- and long-run dynamics between rental and sale markets from 2006 to 2018. We investigate the role of credit constraints and housing supply in explaining the dynamics in rental and sale prices. Our analysis is the first to study dynamics between sale and rental markets using quality-adjusted time series constructed from microdata. We document a long-run relationship between rental and sale prices. In the short-run, we find that the sale and rental markets became more segmented as a result of the crisis. Our results indicate financial constraints and housing supply are strongly cointegrated with both rental and sale markets in long-run.

ABSTRACT IN CATALAN (100 words)

Després de cinc dècades de creixement sostingut, el mercat irlandès de l'habitatge va patir un accident precipitat després de la crisi financera mundial el 2007. El nostre document examina la dinàmica a curt i llarg termini entre els mercats de lloguer i venda des del 2006 fins al 2018. Investiguem sobre paper de les restriccions de crèdit i l'oferta d'habitatge en explicar la dinàmica dels preus de lloguer i venda. La nostra anàlisi és la primera que estudia la dinàmica entre els mercats de venda i els de lloguer mitjançant sèries temporals ajustades a la qualitat construïdes a partir de microdades. Documentem una relació a llarg termini entre els preus de lloguer i venda. A curt termini, trobem que els mercats de venda i lloguer es van segmentar més arran de la crisi. Els nostres resultats indiquen que les restriccions financeres i l'oferta d'habitatge s'integren fortament amb els mercats de lloguer i venda a llarg termini.

KEYWORDS IN ENGLISH: Housing Market – Time Series – Financial Crises

KEYWORDS IN CATALAN: mercat immobiliari – Sèries Temporals– Crisis Financeres



MASTER PROJECT

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Abstract

After five decades of sustained growth, the Irish housing market experienced a precipitous crash in the aftermath of the Global Financial Crisis in 2007. Our paper examines the short- and long-run dynamics between rental and sale markets from 2006 to 2018. We investigate the role of credit constraints and housing supply in explaining the dynamics in rental and sale prices. Our analysis is the first to study dynamics between sale and rental markets using quality-adjusted time series constructed from microdata. We document a long-run relationship between rental and sale prices. In the short-run, we find that the sale and rental markets became more segmented as a result of the crisis. Our results indicate financial constraints and housing supply are strongly cointegrated with both rental and sale markets in long-run.

1 Introduction

During the boom years of the 1990s and early 2000s in Ireland, often referred to as the "Celtic Tiger", the formation of new housing grew by 150% and prices rose by a cumulative 300% in real terms (Malzubris, 2008). Increases in housing demand were fuelled by rapid increases in property values, the relatively low cost of credit and the extension of mortgages to low income families with relatively loose credit conditions. The availability of credit facilitated consumers' preference to purchase houses over renting (McCarthy and McQuinn, 2017). At the same time, the country experienced 20% growth in domestic population. Specifically, the Greater Dublin Region experienced the biggest population growth nationally with an increase of 8.3% between 2002 and 2006 (Williams and Nedovic-Budic, 2016). Regional differences in demand and supply resulted in the development of commuter towns around Dublin to accommodate the surging housing demand. Williams and Shiels (2002) identified a 'leapfrog effect' in which residential development around Dublin has increasingly moved from traditional suburbs to more remote locations.

The combination of the Global Financial Crisis in 2007 and the Sovereign Debt Crisis greatly reduced the supply of cheap credit. The Irish economy slowed down which resulted in an oversupply of housing in the country at large, a sharp decline in sale prices, and tightening of credit availability. Since 2013, the Dublin housing market has been recovering, though sale prices remain far below their peak. The recovery outside Dublin has, however, been much slower (Lyons, 2018b). In addition, anecdotal evidence suggests that prices in the Dublin rental market are growing at a potentially unsustainable rate, (Lyons, 2018a). Concerned about rapidly rising rental prices, the

government implemented Rent Pressure Zones in the capital in 2016.

There are three principal methods for constructing sale price series in the literature. For long-run analysis, work such as Ambrose et al. (2013) uses raw price data to explore the long-run relation between sale prices in Amsterdam. The repeated sales method, pioneered by Case and Shiller (1989), uses a sample of private rental dwellings that had been bought and sold repeatedly within the analysis period. While it controls for changes in housing quality, this method requires enormous amounts of data and suffers from selection bias (Englund et al., 1999). Lyons (2013) uses hedonic price decomposition to construct a house sale price index for Dublin, finding evidence of relatively consistent nominal housing price growth since the 1940s. This work also shows that listings and prices move together. Keely (2017) analyses the long-term post-war dynamics of the sale and rental markets finding similar trends. Salter (2017) analyses sale dynamics through the housing crisis using a panel approach.

The time series properties of constructed housing prices have been investigated by a number of studies. Lastrapes (2002) used time series data and vector autoregression (VAR) analysis to provide evidence that housing sale prices respond to unanticipated money supply shocks. Similarly, Wolverton et al. (1998) exploit neighbourhood prices time series as a proxy for apartment operating cash flow to study intercity housing portfolio diversification on vacancy and rental prices. Oikarinen (2007) studies cointegrating relationships between sale prices and measures of macroeconomic conditions in metropolitan areas in Finland during a time of significant institutional change. Using a Vector Error Correction Model (VECM), the author investigates how these comovements and long-run relationships differed across regional markets. Further, using sale prices for the UK market over five decades, Holly and Jones (1997) examine how sale prices cointegrated with variables such as real income, demographics and housing stock. They find that equilibrium adjustment is much faster when the variables are above their long-run cointegrating relationship.

Due to the difficulty in building good quality rental indices, only a limited number of studies have analysed the dynamics between the rental and sale markets. Most studies have either omitted an analysis of the rental market, used macro data sources, or applied an ad hoc rental series imputed from a sale price series (*e.g.* Ambrose et al. (2013) or Oikarinen (2007)).

Using a comprehensive database of rental and sale prices, our study analyses the joint dynamics of the rental and sale market in Dublin between 2006 and 2018. Combining the panel approach of Keely (2017) with the time series analysis of Oikarinen (2007), we study the dynamics of the rental and sale markets by constructing a quality-adjusted

sale and rental price series. Our novel contribution is the use of a robust rental price series to investigate the dynamics of the housing market.

Our hypothesis is that households' financial constraints and housing supply may mediate the relationship between sale and rental markets as shown in Figure 1. Standard theory suggests that the level of household borrowing is a function of expected permanent income and desired consumption. As defined by Jappelli (1990), a household is 'credit constrained' if a prospective lender has turned down or not fully granted a household's loan request, or the household did not apply for the credit because they believed they would be turned down (1990). The financial crisis would tighten borrowing constraints reducing the availability of credit and hindering a potential house buyer's capability to obtain a loan. Thus, either delaying or reducing the ability to pay a home purchase deposit. As a result, individuals who would have otherwise chosen to buy will rent until they are able to obtain a loan, suggesting additional pressure in the rental market. Gerlach-Kristen and Merola (2013) study Irish Household Budget Survey data from 2009/10 and find that indebted households start facing credit constraints when the value of housing declined. Duca et al. (2011) found that much of the boom and bust cycle in the U.S. home prices stemmed from easing and tightening of U.S. mortgage standards effecting potential home-buyers. For instance, the combination of low interest rates and expanded credit availability in early 2000s increased the sale prices. Justiniano et al. (2015) showed that mortgage debt and sale prices increased in a parallel trend. Similarly, several studies using household-level data confirmed that credit constraints restrict the consumption of households (Britten-Jones and McKibbin (1989), Zorn (1989)).¹

Given that the supply of housing is inelastic in the short-run, a financial crisis would impact the availability of houses due to the delay of house construction and people's unwillingness or unability to sell their property. In contrast, over the medium to the long-term, the supply of housing is generally thought to be quite elastic (Williams and Shiels, 2002). Kwoun et al. (2013) indicated that housing over-supply results in decreased existing housing prices. As the expected return on capital investment decreases, the demand for housing decreases and vacancy increases. Williams et al. (2010) found evidence of oversupply in regional markets in Ireland. Furthermore, the impact of housing oversupply differs throughout Greater Dublin as some areas recovered more quickly in terms of their demographics, income, employment, and household formation. Most existing research assumes that changes in supply would not affect

¹ Even if borrowing constraints are relaxed, some families might prefer to rent if they are not sufficiently adept at maintaining owner-occupied dwelling or if their house is excessively risky asset (Henderson and Ioannides (1983), Fu (1991)).

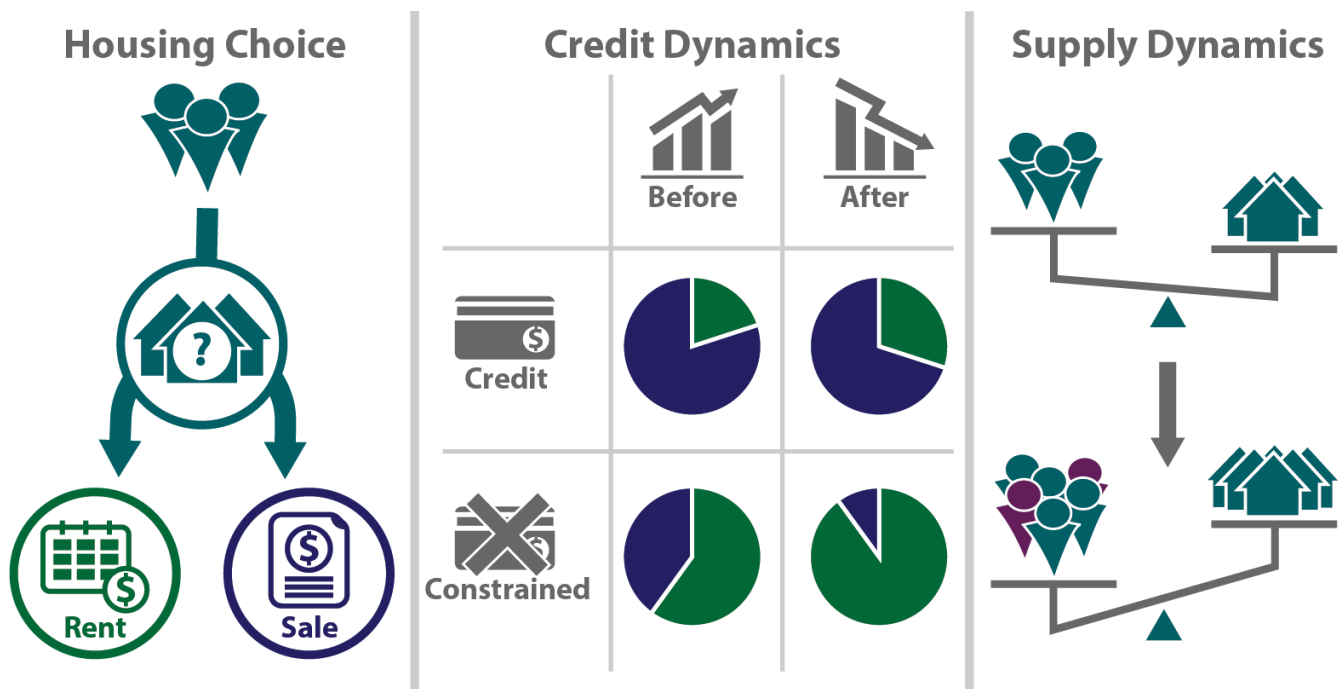


Figure 1: Overview of Principal Mechanisms

the long-run dynamics of housing prices. This assumption is based on the difficulty of constructing suitable proxies for housing supply to integrate into time series analysis. However, as we will demonstrate, our data indicates that housing supply increased significantly over the sample period. As such, we would argue that housing supply is an important mechanism for explaining price dynamics in the housing market.

In our report, we document that during the crises house sale prices experienced a substantially larger drop than rental prices. During the subsequent recovery, rental prices recovered their value faster than sale prices. Our main empirical investigation is conducted in two stages. First, we use hedonic panel regressions to construct a quality-adjusted price series for the sale and rental markets. Using our estimation, we generate a macro time series for sale and rental prices. Then, we investigate the co-movement of generated sale and rental time series with proxies for credit constraints and housing supply using cointegration and VAR. Our report is structured as follows; we provide an overview of the data, the methodology and the analysis before detailing our conclusions.

2 Data

2.1 Micro Data Sources

Our sale and rental price listings data are sourced from [daft.ie], the dominant player in the housing market ² and covers the years 2006 to 2018. In addition to the listed price, the database contains a number of characteristics of the property including the number of bedrooms (used as an indicator of size), the address and additional housing quality indicators.

For the purposes of the panel analysis, we have constructed a set of intermediate districts using local electoral divisions. While our preference would be to use an exogenously determined spatial measure to classify our data, the available districts were either not compact, not cohesive or too granular.

The size of our dataset and variety of our sources meant that the building of our dataset was a complicated process, involving spatial analysis and big data techniques. A comprehensive discussion of the construction process can be found in Appendix A.1.

2.2 Macro Data Sources

For our time series analysis, we have included a number of macroeconomic time series data in our analysis.³ These macroeconomic indicators were used to investigate the two main mechanisms we posit as mediating the dynamics between the rental and sale markets: financial constraints and housing supply. Financial constraints are measured by availability of *Total Loans Advanced For House Purchase*, which were constructed from reports from all credit institutions resident in Ireland.⁴

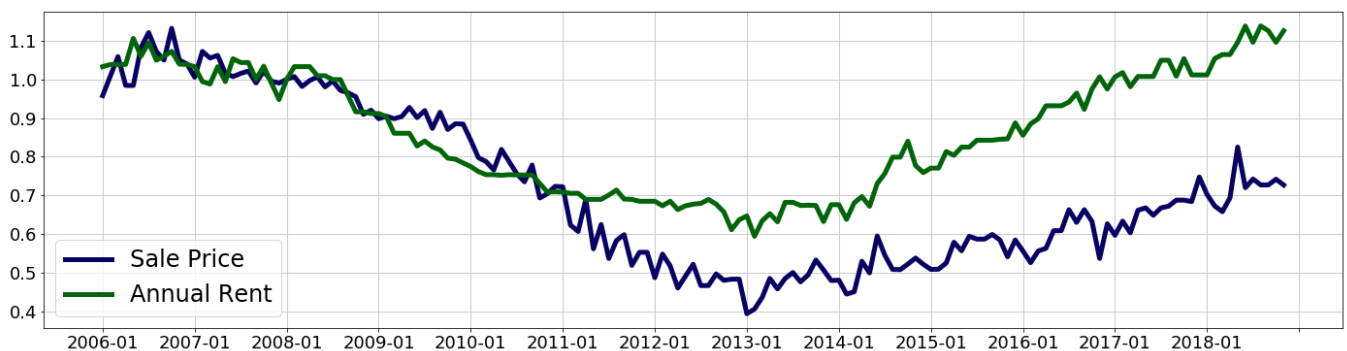


Figure 2: Indexed Real Price, rel. to 2007/12

²Daft scrapes the websites of their competitors in the sale market.

³These sources are summarised in the appendices in Table 2.

⁴The series is constructed based on licensed banks, building societies, and credit unions.

The housing supply is measured by the *Total Housing Stock*. This series is constructed by assuming a given rate of obsolescence and adding a measure of newly completed houses to the existing housing stock from the previous year. Our macroeconomic series may be unreliable due to methodological inconsistencies and other discrepancies with the available series.

2.3 Descriptive Statistics

Figure 2 presents indexed monthly non-quality-adjusted median sale and rental prices in real terms. Our data shows both sale and rental prices increased through the end of 2007 before decreasing until 2011 (rental) and 2013 (sale). Rental prices stabilise some months earlier than the sale and appear to have recovered much faster than sale prices. While the sale prices has not recovered to its 2007 value, the rental price has exceeded its 2007 value, showing that there is strong pressure in the rental market. Figure 3 shows the price-to-rent ratio, the ratio of the purchase price of a house divided by the annual rent of a similar home. It remains steady until 2010. Between 2010 and 2013, the ratio declines as rental prices recover more quickly than sale prices. As discussed above, Keely (2017) builds long-term price-to-rent ratios for Dublin from the 1950s to the 1990s using a newspaper dataset. Although this previous work finds a lower level of the price-to-rent ratio, an increase in the level is in line with the more general longer-term findings of Ambrose et al. (2013) given the strong GDP growth between the periods considered.

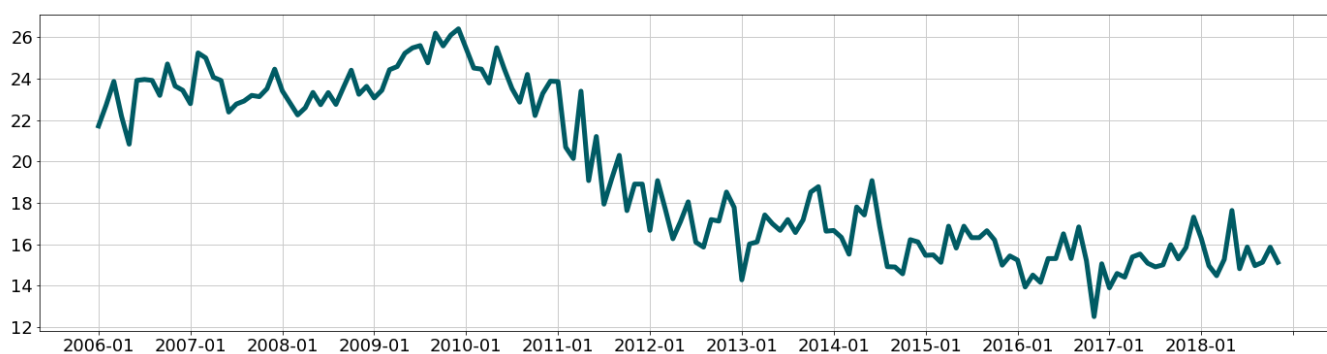


Figure 3: Price-to-Rent Ratio, Median Real Price

3 Methodology

Our empirical analysis is conducted in two stages. First, we control for changes in the composition of rental and sale using a panel econometric analysis. Using results from the econometric analysis, we then construct a time series for rental and sale prices. Second, we test for co-movement between the series using the series in order to iden-

tify the short- and long-run dynamics between sale and rental prices.

3.1 Panel Analysis

To construct housing price series, the standard approach for statistical agencies is to use median sale and rental prices. However, this may be biased since the average quality of dwellings transacted may differ substantially over time. For this reason, following Meese and Wallace (2003) and Hort (1998), the first stage of our analysis uses a hedonic regression approach to control for changes in hedonic characteristics over time:

$$\ln y_{price} = \alpha + \beta X_{qual.} + \gamma Z_{amen.} + \delta W_{spat.} + \phi Y_{time} + \varepsilon$$

where $X_{qual.}$ are house quality measures such as the size of the house, number of rooms etc.; $Z_{amen.}$ are measures for amenities which are proximate to the house, $W_{spat.}$ are area-level controls and Y_{time} are time fixed effects.

Hedonic regressions allow us to decompose the price of a composite good into different features. Imputing the price of a base unit allows for a comparison of similar units over time. Following Ambrose et al. (2013), we then generate a time series index using the monthly time fixed-effects.

Our main analysis is conducted on sale and rental prices of houses. A house is defined as a unit which occupies the entirety of a building. We are solely focusing on houses due to data limitations as only 10% of properties sold are apartments. Thus, conducting the analysis on all types of properties may lead to an omitted variable bias.

The baseline regressions were constructed following a bottom-up approach. Standard errors were clustered at the district level to control for spatial correlation in residuals. We also conducted robustness checks to test for multicollinearity and the sensitivity of coefficients to the inclusion and removal of variables as well as addition of amenity controls.

3.2 Time Series Analysis

The first step of our time series analysis was to conduct a Vector Auto Regression (VAR) model between rental and sale prices (Case and Shiller, 1989).⁵ The VAR approach is appropriate as it captures the dependence of current prices on lagged prices as well as the lag values of other variables.

In addition, it provides insight into both short- and long-run interdependencies be-

⁵While our rental and sale data is of high quality, the macroeconomic variables sourced from statistical agencies may be affected by the frequency and quality of these series.

tween markets, allowing us to explain the impact of credit and housing supply factor into the observed price dynamics. We performed a number of standard tests on the data:

- The Portmanteau test for serial correlation was used to ensure that our VAR had sufficient lags to fully capture the intertemporal dependence of our variables.
- The Akaike Information Criterion (AIC) was used to determine the required number of lags.
- The Augmented Dickey-Fuller (ADF) test was used to test for stationarity and the order of integration of series.

These tests indicated our data was non-stationary, but we decided to continue without differencing our series as it preserves more information and allows for cointegration analysis.

To further understand the dynamics, we investigated the Impulse Responses Functions (IRF) between the sale and rental price series. This provides information on how a shock to any of the variables in the VAR impacts sale and rental prices. Using these estimated IRFs, we can then construct a Forecast Error Variance Decomposition (FEVD) for each variable to determine the proportion of the variance of the forecast error attributable to each series.

Finally, we test for cointegration using a Johansen test (Johansen, 1991) and use this information to construct a Vector Error Correction Model (VECM). A VECM takes into account the adjustment towards the long-run relationship between our cointegrated variables while still preserving the short-run dynamics. The presence of a cointegrating relation suggests the existence of a long-run relationship between our variables of interest. If one of the variables deviates from the long-run relationship, at least one of the other cointegrated variables has to change for the long-run relation to be preserved. Thus cointegration implies Granger causality between our variables in at least one direction. This adjustment process between the variables is measured by the error correction term in the VECM. By accounting for this adjustment process, the VECM produces superior forecasts to the VAR.⁶

We performed the analysis twice; including and excluding the macroeconomic variables.⁷ A summary of the variables included is provided in Section 2.2. While our rental and sale series are computed at a monthly frequency, our macro indicators were only

⁶For example, housing prices adjusting to supply. See (Engle and Granger, 1987) for one of the earliest formalisations of the concept.

⁷As the quality of macroeconomic indicators is inferior to our constructed price indices.

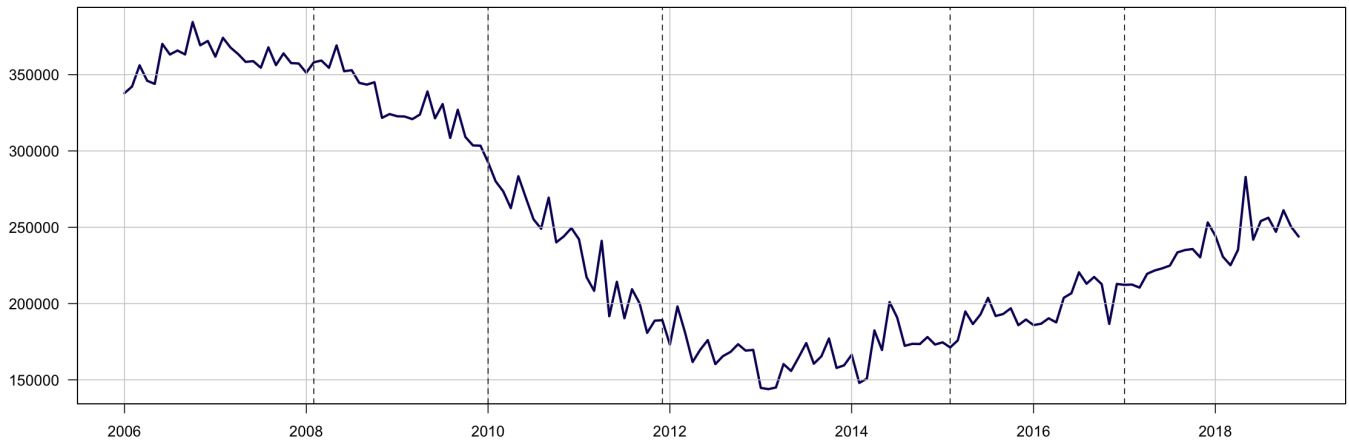


Figure 4: Structural Breaks, Sale Prices

available at yearly and quarterly frequencies. For this reason, we temporally decomposed the low frequency series to a monthly series using a cubic spline interpolation (Reber et al., 2014).⁸

While our sale, rental and housing supply measures are $I(1)$, our loan data is $I(2)$. Therefore, we differenced our loans to households measure so that all of our series were $I(1)$.⁹ A crucial assumption for the cointegration analysis is that there is at most a single structural break in the data. We find evidence of five structural breaks in the data.¹⁰ Structural breaks are shown in Figure 4 below.¹¹

In the housing literature, it is not uncommon to ignore the presence of breaks and perform cointegration analysis. This is justified given that a structural break is more likely to lead to false rejection of cointegration (Oikarinen, 2007). We ran our baseline specification over the entire sample. As structural breaks indicate a change in the underlying trend in a series, it is reasonable to conclude that examining the whole series without taking into account structural breaks would miss the changing dynamics between the markets. As such, we also conduct analysis by subdividing our sample into four sub-samples (Juselius, 2001).¹² The identified windows are as follows:

- Window 1: January 2006 - June 2009

⁸Alternatively we could have used the Chow-Lin procedure instead. However, this method requires the identification of suitable high frequency indicator series.

⁹We can only run standard cointegration tests on variables which are the same order of integration.

¹⁰Using the Bayesian-Information-Criterion.

¹¹There are minor differences between the sale and rental structural breaks but our results are robust to both sets of breaks.

¹²We conduct our analysis over four periods rather than six due to the limited number of data points in our sample. The BIC provides a very similar likelihood value for three and five break points, justifying the windows used. All the aforementioned steps and tests were conducted on each individual analysis windows.

- Window 2: April 2009 - May 2011
- Window 3: May 2011 - June 2016
- Window 4: June 2016 - December 2018

4 Analysis

Our analysis is conducted in two stages. First, we construct quality-adjusted series for sale and rental prices. Second, we investigate the short- and long-run dynamics of these series.

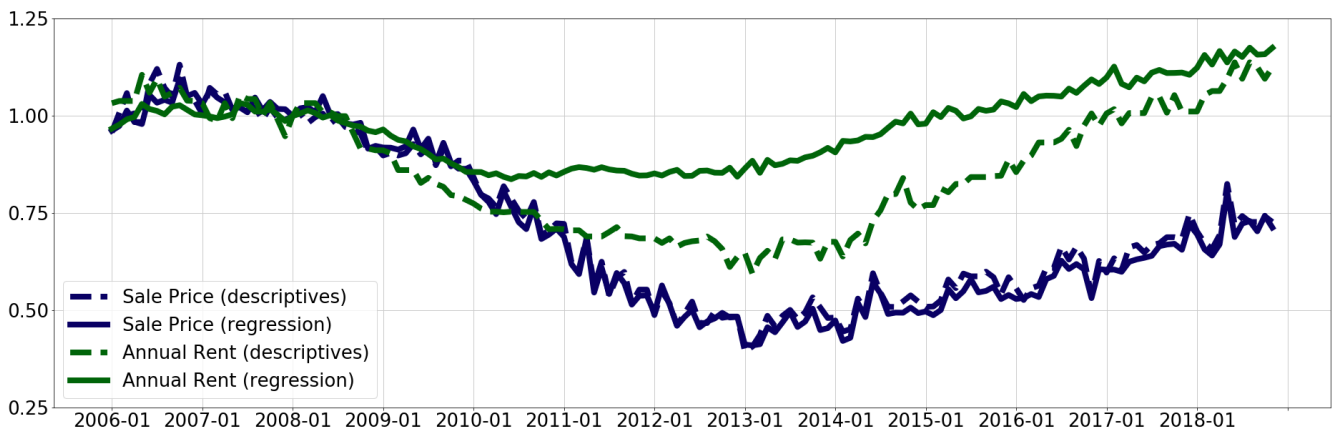


Figure 5: Indexed Real Price, rel. to 2007/12

4.1 Panel Analysis

The quality-adjusted indexed rental and sale series constructed from our panel analysis are presented in Figure 5. Housing sale prices experienced a sharp drop and subsequent slow recovery, whereas rental experienced a smaller drop with a subsequently stronger recovery.

We find that while controlling for composition has a minor effect in sale, the effect in rental is more pronounced. This is likely due to the exclusion of apartments from the sample. Otherwise, as shown by Table 1, the hedonic characteristics associated with rental and sale purchases are broadly comparable. Estimated coefficients are also broadly stable across specifications.¹³

Figure 6 presents the quality-adjusted price-to-rent ratio. The ratio remains broadly stable during the Great Recession and experiences a gradual drop between 2010 and

¹³A number of controls were available for the rental data but not sale data which indicate they are important for rental decisions but not sale decisions.

Table 1: Panel Time-Series Results

	Log of real sale price	Log of real sale price	Log of real sale price	Log of real rental price	Log of real rental price	Log of real rental price
1 bedroom		-0.372*** (0.0170)	-0.372*** (0.0171)		-0.285*** (0.00334)	-0.284*** (0.00334)
2 bedrooms		-0.206*** (0.00412)	-0.206*** (0.00412)		-0.140*** (0.00236)	-0.140*** (0.00237)
4 bedrooms		0.336*** (0.00243)	0.336*** (0.00243)		0.0186** (0.00889)	0.0186** (0.00888)
5 bedrooms		0.660*** (0.00507)	0.660*** (0.00507)		0.0986*** (0.0185)	0.0985*** (0.0185)
Garden		0.131*** (0.00252)	0.131*** (0.00253)		0.0288*** (0.00132)	0.0288*** (0.00132)
Washing machine					0.0416*** (0.00159)	0.0416*** (0.00159)
Dishwasher					0.0689*** (0.00124)	0.0689*** (0.00125)
House alarm					0.0123*** (0.00151)	0.0123*** (0.00151)
Parking					-0.00967*** (0.00158)	-0.00965*** (0.00158)
Constant	12.79*** (0.0146)	12.61*** (0.0123)	12.61*** (0.0129)	9.625*** (0.00878)	9.704*** (0.00835)	9.705*** (0.00812)
Observations	308,795	307,639	307,639	257,895	257,815	257,815
R-squared	0.169	0.334	0.334	0.129	0.246	0.246
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes
Amenities	No	No	Yes	No	No	Yes

Robust standard errors in parentheses
 *** p<0.01, ** p<0.05, * p<0.1

2013 before stabilising at a lower level. This suggests that rental and sale prices diverged in the period between 2010 and 2013. As per the indexed price series, control for housing quality has had an effect on the relative ratio.

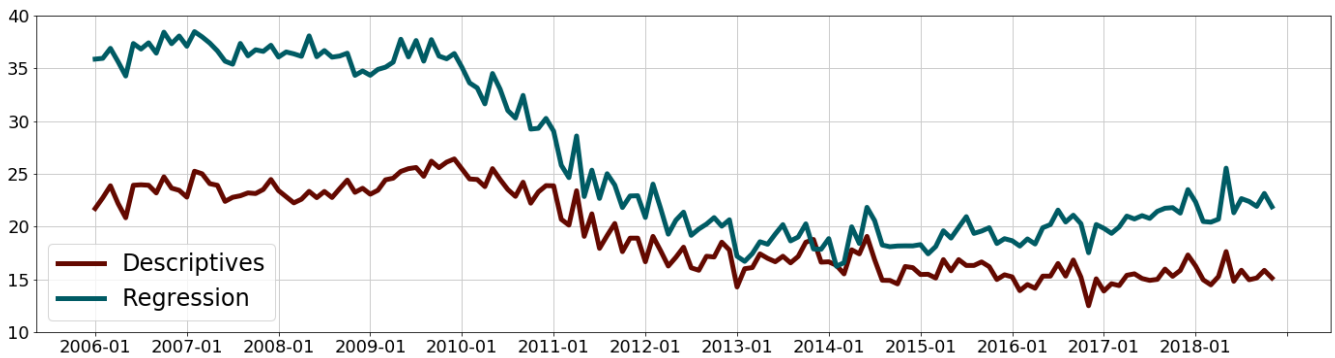


Figure 6: Price-to-Rent Ratio, Quality-Adjusted

4.2 Time Series Analysis

Adjustment Dynamics Between Sale and Rental Prices

The first step of our analysis was to estimate a VAR with rental prices, sale prices, and GNP as an exogenous control. As described in Section 3.2, we present our analysis for the four windows separately. The results indicate that the dynamics change significantly across the analysis period.

As shown by Figure 7, the percentage of forecast error variance in sale prices that may

be attributed to rental prices declines significantly in the aftermath of the financial crisis. One possible explanation is that it was more difficult to buy property after the crash. Thus, due to greater market segmentation, sale prices did not need to compete with rental prices.

Conversely, in the initial period sale prices explain a similar proportion of the forecast error variance in rent prices relative to rent prices in sale. This effect increasing significantly over the analysis period. This is also shown in Figure 7. This would seem to contradict our above interpretation of the sale FEVD. However, it is possible that, due to credit constraints, the limited number of people who are able to buy is driving sale prices to compete more aggressively against the rental market.

IRFs based on our VAR coefficients are also presented in Figure 8 for Windows 1 and 3. The patterns from IRFs are somewhat different to those observed in the FEVD. The IRFs suggest that rental and sale prices remain more connected to each other than our FEVDs would suggest.

IRFs in both the pre-crisis and post-crisis periods show that sale prices react strongly to a shock in rental prices. This appears to contradict the results from the FEVD analysis. A plausible explanation for this difference is that IRFs measure the absolute effect of an orthogonal shock of one variable on another. Whereas, the FEVD presents the relative impact of a shock compared to the impact of the dynamics of other variables. We also observe that the response to a shock changes from a monotonic impact to a more complex dynamics. This may be indicative of the market being in disequilibrium in the aftermath of the financial crisis. A structural model would be required to fully investigate these dynamics.

Cointegration between Sale and Rental Prices

Using the VAR with only sale and rental prices, we found evidence of cointegration between both series.¹⁴ The result is robust to considering our entire sample and the four windows separately. This demonstrates there is a long-run relationship between rental and sale prices together even if, as shown in the previous section, we find evidence for short-run segmentation.

¹⁴Sale and rental prices were included as endogenous variables.

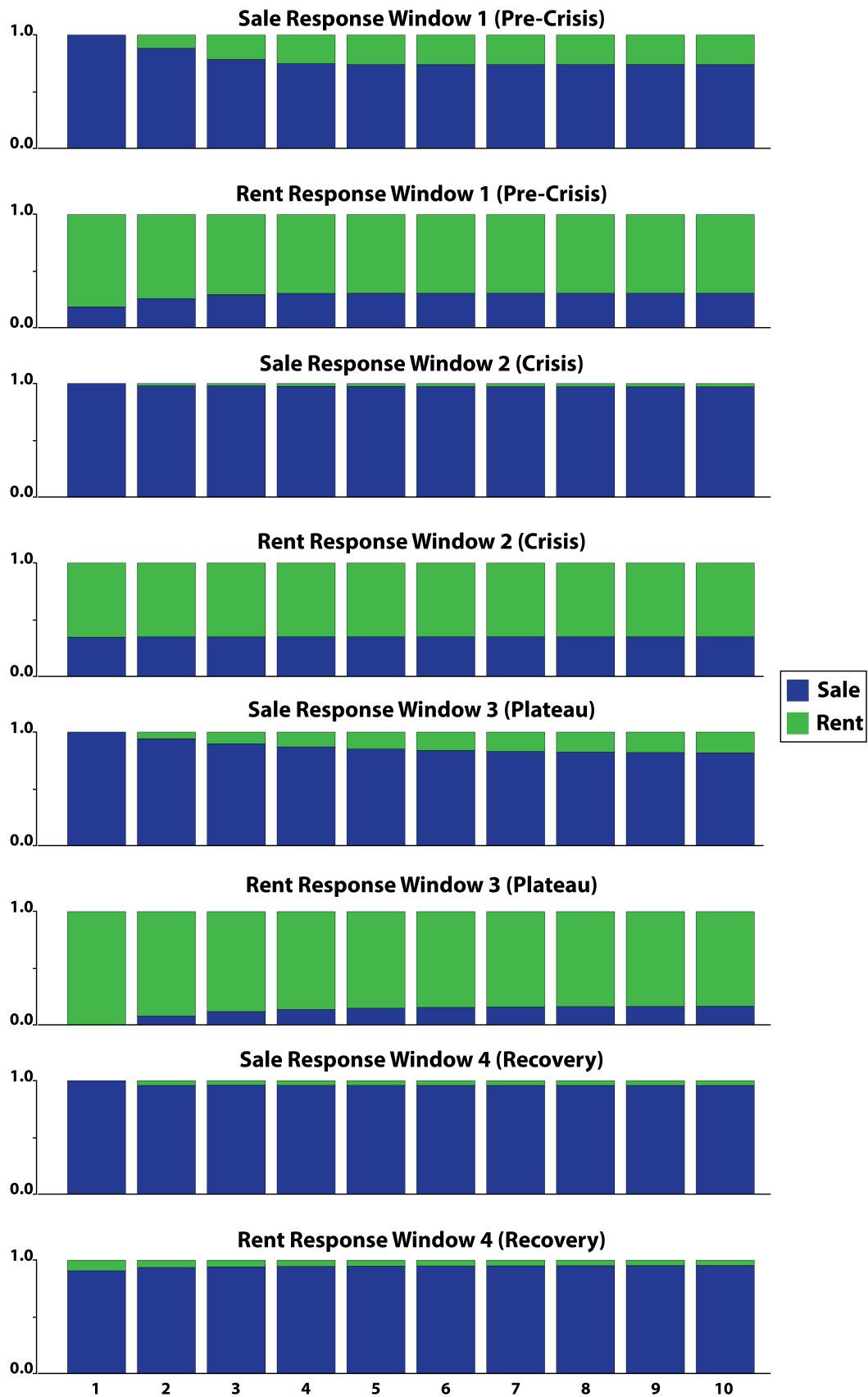


Figure 7: Forecast Error Variance Decomposition of Rental and Sale Prices

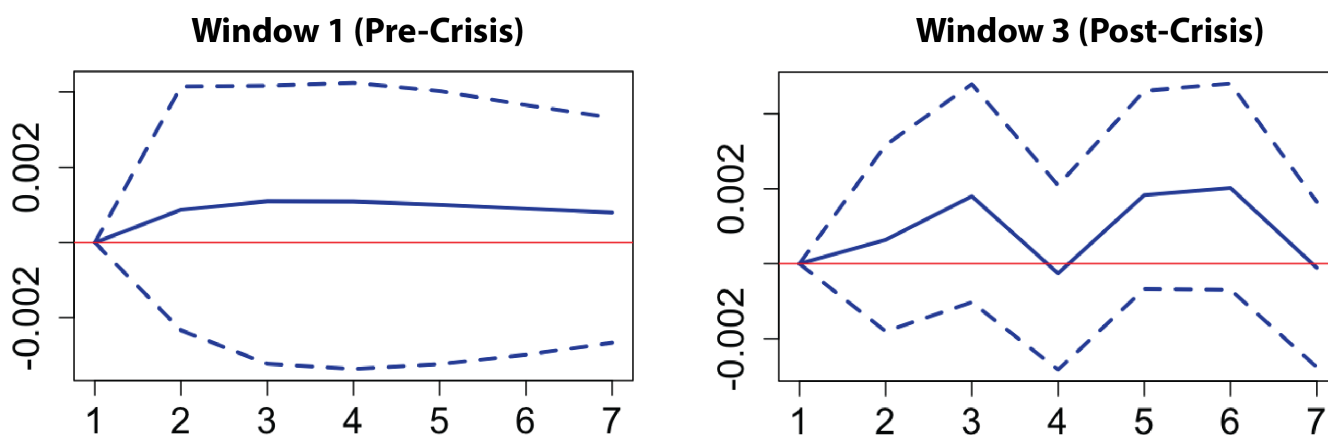


Figure 8: Impulse Response Functions, Response of Sale Price to a Rental shock

Relationship between Sale and Rental Prices and Other Macroeconomic Variables

Adjustment Dynamics between Sale, Rental Prices and Other Macroeconomic Variables

We estimated VARs with housing stock, loan supply, and rental and sale prices as endogenous variables.¹⁵ For this analysis, we restrict our attention to Window 1 (June 2006-May 2009) and 3 (May 2011-May 2016). We do not focus on the crisis window (Window 2) as it is relatively short and displays a high degree of volatility that is predominantly explained by movements in GNP in that period. We focus on Windows 1 and 3 as the core periods of considerable economic interest. Window 1 shows the lead-up to the crisis with the economy experiencing significant growth in all sectors, whereas Window 3 covers the initial recovery from the recession.

Figure 9 displays the FEVD for Window 1. The forecast error of the sale prices were largely dependent on themselves in the early part of the forecast horizon. As the forecast horizon expands, the variance of the forecast error is increasingly explained by changes predominantly in housing supply and to a lesser extent loan supply. This suggests that supply constraints are driving up sale prices, a pattern common in OECD countries (Hilber and Vermeulen, 2016).¹⁶ During this period, housing stock itself was rapidly increasing, but did not appear to respond sufficiently to increases in demand. Consistent with our previous findings, the figure also shows that the variance of the forecast error for rental markets is largely independent of sale prices. This demon-

¹⁵Our results were also robust to making these variables exogenous.

¹⁶Graphs of the loan and housing supply series are shown in Figures 17 and 16 in the Appendix.

strates the relative unimportance of sale prices, in comparison with the loan and housing supply, in explaining the rental dynamics.

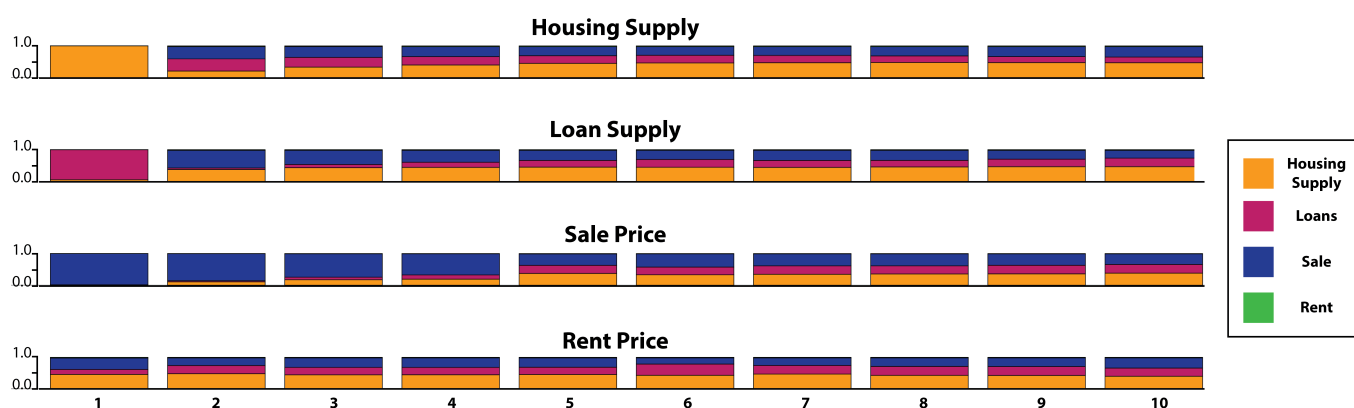


Figure 9: Forecast Error Variance Decomposition of the Rental and Sale Prices, 2006-2018 Window 1



Figure 10: Forecast Error Variance Decomposition of Rental and Sale Prices, Window 3

The FEVD for Window 3 covering the period between May 2011 - May 2016 is given by Figure 10 below. We see a remarkable change in the underlying dynamics between these variables. In contrast with the pre-crisis period, sale prices are largely driven by only themselves throughout the forecast horizon. Prices are not particularly dependent on overall structural conditions such as the availability of loans or on the supply of houses. Rental prices exhibit similar dynamics; although still largely independent of movements in sale prices, the forecast error is now less dependent on the availability of loans and housing supply.

The results suggest that rental and sale markets become more segmented and less dependent on loan and housing supply as a result of the crisis. One explanation for the lack of dependence in the post-crisis period may be reflecting sale and rental prices adjusting to a new long-run equilibrium, with our results for Window 1 driven by rapid

growth in the pre-crisis period which tends to amplify the dependence between segments of the economy. Although, it should also be noted that there is a marked slow-down in growth in housing supply following the crisis.¹⁷ In turn, the variances of forecast errors for sale prices may be less dependent on the housing supply in the post-crisis due to its muted growth in the latter period.

The IRFs of sale prices to loan supply between the two windows are presented in Figure 11. The figure demonstrates that a loan supply shock has a persistent effect on sale prices in both windows. Though in the post crisis period, this effect is more muted and there is a slower response in the short-term. This might be explained by the particular dynamics in the pre-crisis period where fewer households are credit constrained and increased availability of loans translates quickly to increased demand for houses.

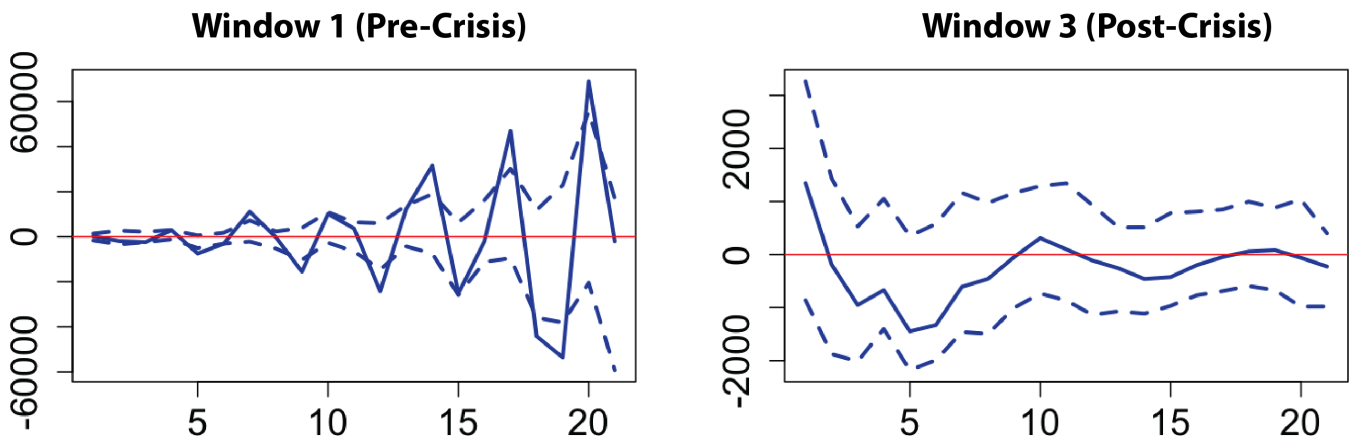


Figure 11: Impulse Response of Sale Prices to a Shock in Loan Supply

Cointegration between Sale and Rental Prices and other Macroeconomic Variables

We then test for cointegration between rental, sale, house supply and the first difference of loan supply where the latter variable can be seen as a proxy for loan growth.¹⁸ Furthermore, our loan supply data is I(2) requiring differencing once to make the series I(1). The Johansen cointegration can only be run on series which are the same order of cointegration. We find there is a long-run relation between the variables: rental prices, sale prices, loan supply growth are cointegrated of order 3.¹⁹ Repeating our analysis using the windows, we find the order of cointegration remains the same across all windows as in the aggregate series.

¹⁷The housing supply series can be found in the Appendix. Housing supply itself seems less dependent on both sale prices and loan supply compared to the previous window.

¹⁸Both our sale, rental and housing supply time series are integrated of order 1 (I(1)) indicating first differences are stationary.

¹⁹This means there are 3 vectors which span the space of all cointegrating vectors. Linear combinations of these vectors allow for the creation of an overall stationary series.

The existence of cointegration between these variables is a significant result given our use of a robust quality-adjusted rental price series. Our results align with evidence of the importance of credit market conditions to the rental and sale market dynamics found in other papers including Oikarinen (2007).

We estimated a VECM to account for our cointegrating relationship. Figures 12 and 13 show a set of FEVDs for Windows 1 and 3 using estimates from the VECM. The results are similar to our previous findings. Following the crash, we observe that the main determinants of the FEVD of each variable is the variable itself. This provides further evidence that the financial crisis led to increased market segmentation.

In contrast to the FEVDs derived from the VAR, these FEVDs indicate that housing supply accounts for the largest proportion of the forecasted error variance in both sale and rental prices prior to the crisis. This suggests the combination of high housing demand and inelastic supply drove a significant supply crises during the period.

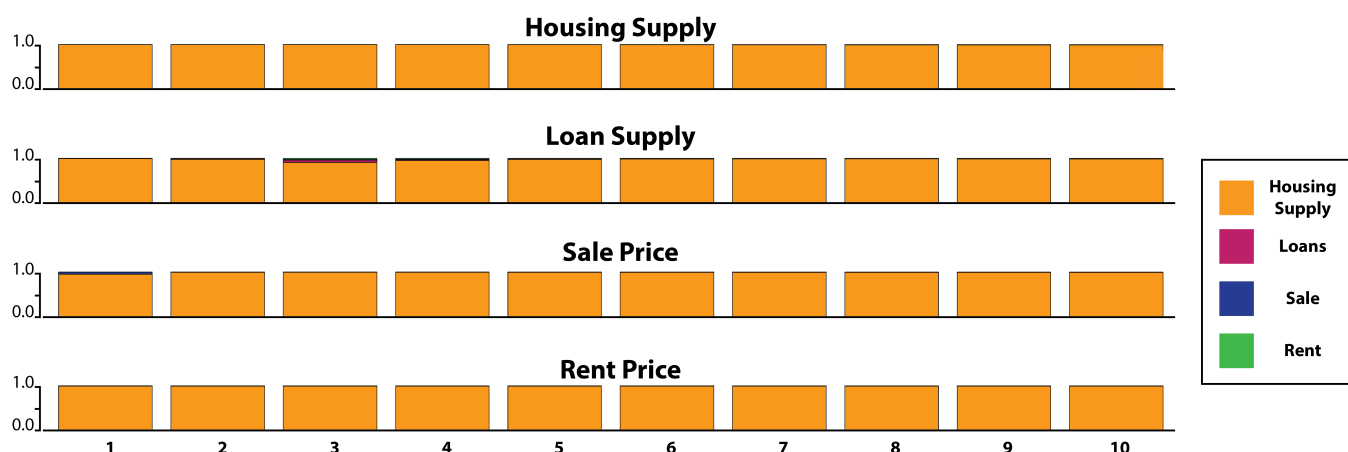


Figure 12: FEVD of the Rental and Sale Prices 2006-2018, Accounting for Cointegration Window 1

5 Conclusion

Our novel contribution is to analyse the joint short- and long-run dynamics of the rental and sale market using high-quality listings data. Much of the existing literature has not been able to robustly quantify the role of the rental market in overall housing dynamics given the relative paucity of available rental data. It is also among the first to study time series dynamics of prices in the rental market using a quality-adjusted robust time series for rental prices.

Our analysis demonstrates that there is a long-run relationship between sale and rental prices. Examining the relationship between these two series independently of macroe-

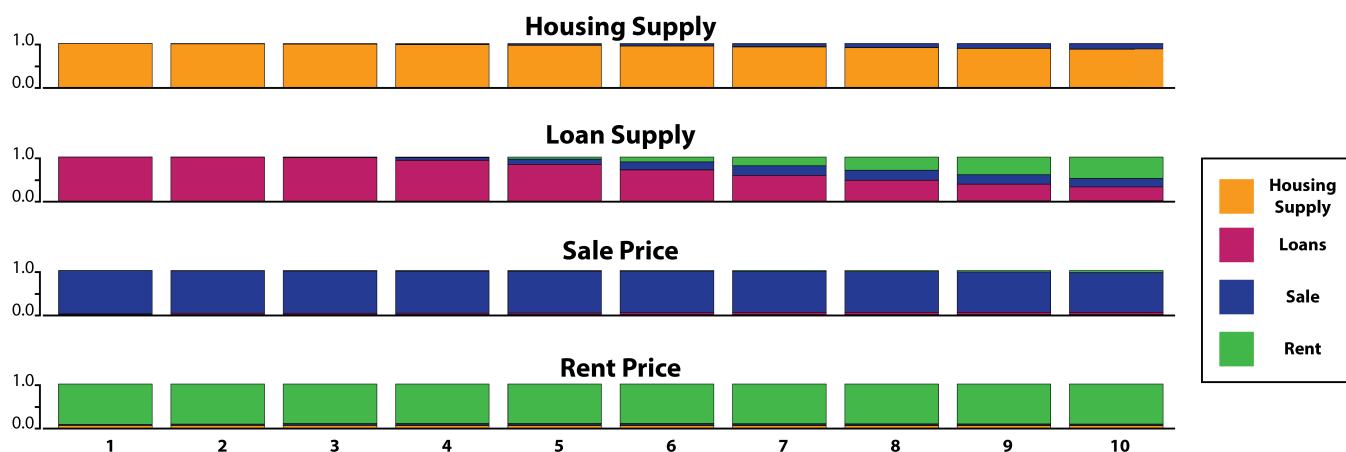


Figure 13: FEVD of the Rental and Sale Prices 2006-2018, Accounting for Cointegration Window 3

conomic indicators, we observe that the relationship between the two markets fluctuates substantially over the period of analysis. Following the crisis, sale prices become less dependant on rental prices whereas the opposite is true for rental prices. The dependence of rental prices on sale prices increased significantly as a result of the crisis. Our analysis demonstrates that the financial crisis led to greater segmentation of these markets.

Incorporating macroeconomic indicators into our analysis, we also find that financial constraints and housing supply are strongly cointegrated with both rental and sale markets. Accounting for the cointegrating relationship using a VECM provides evidence of a housing supply shortage in the pre-crisis period. These findings are consistent with the theoretical and empirical literature demonstrating the importance of these macroeconomic variables for the housing market. In line with our results excluding macroeconomic indicators, we see greater segmentation between the rental and sale markets than might be expected. However, a significant concern for our analysis is that the quality of macroeconomic indicators may be poor. Further research should investigate this relationship with better quality data.

There are a large number of possible extensions to the present research. Housing and rental prices are likely to display heterogeneous trends across different markets. One extension would be to study how dynamics have differed across population districts within Dublin city and its surrounding area. Another potential avenue is to integrate micro wage data²⁰ with the sale and rental prices, allowing a fuller view of the market to be constructed.

²⁰Using the Survey of Income and Living Conditions data.

A further extension would be to study how dynamics differed within the housing market across different types of house purchases. Finally, the Great Recession affected not only the value of housing sold but also the speed at which housing was bought and rented. Additional analysis could study volatility and duration effects within the Irish housing market.

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A Appendices

A.1 Districts

In order to control for spatial heterogeneity in the Dublin housing market, we have investigated the feasibility of using a number of different spatial districts as observational units of analysis. This is viewed as an advantage of the hedonic regression method over the repeated sale method advocated by Case and Shiller (1989). By using a large number of units distributed spatially and temporally, we are better able to capture the dynamics of the market. For our purposes, the Irish LAU1 (formerly NUTS4),

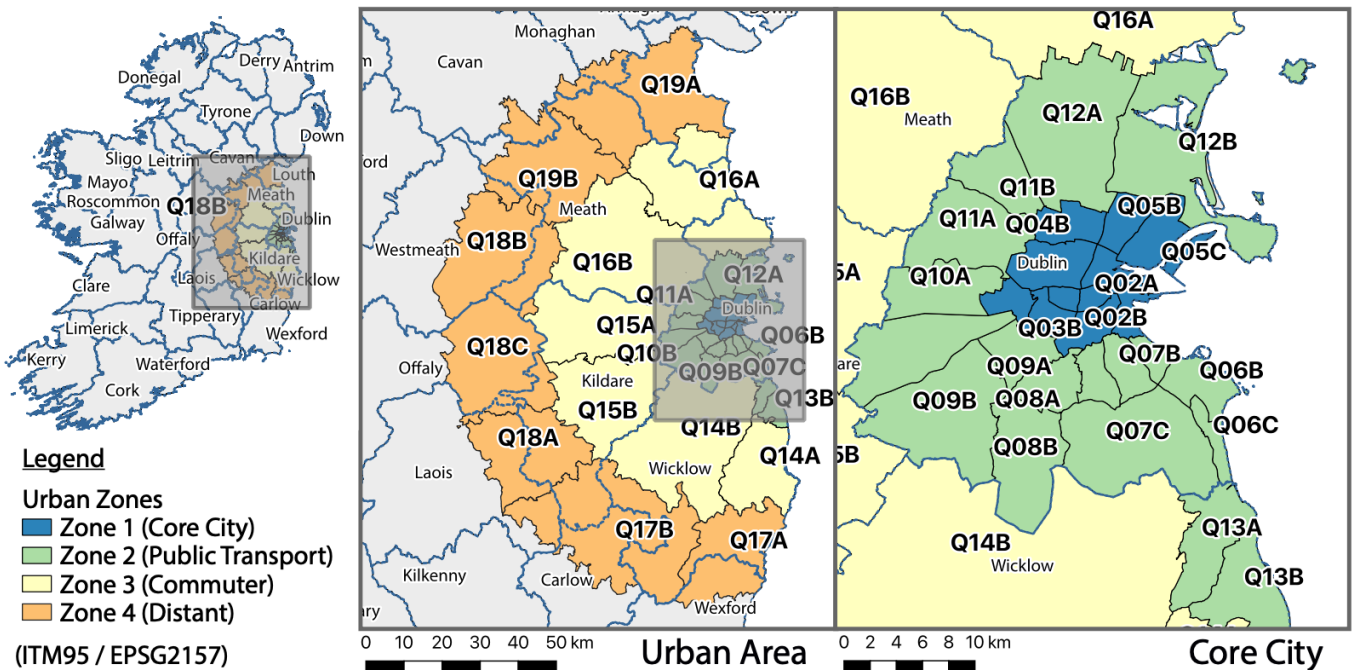


Figure 14: Constructed Districts

the administrative county, is too coarse a division and the LAU2 (formerly NUTS5), the district electoral division is too fine a division. As such we have investigated a number of alternatives such as Local Electoral Areas, Eircode²¹ and Baronies. Because none of the existing districts were cohesive and compact, we constructed districts in line with the work of Buitleir (de Buitleir, 2013), respecting the natural boundaries and evidence within the electoral divisions of previous aggregation. The three levels of aggregation used are visible in Figure 14.

²¹The Irish postcode system.

A.2 Dataset Construction

All stages of the dataset construction were performed using Python 3 Jupyter notebooks. An overview of the process can be seen in Figure 15. First, due to the large number of listings, we split the raw data for both databases into quarterly files, allowing for faster manipulation of the data. Next we dropped duplicate and invalid listings before performing spatial merges that coded the listings data with all of our districts.



Figure 15: Data Process

After creating the base database, we performed our panel analysis and then generated time series from our regressions using a custom Stata ado file, adapted from one developed by Keely (2017) which allowed us to output the entire regression table in a machine readable format that was used to construct a time series from a panel regression table.

A.3 Overview of Data Sources

Table 2: Summary of Variables

Variable	Coverage	Source
GNI* ²²	2003-2018	Central Statistics Office
Total Housing Stock	1991-2017	Central Statistics Office
Total Loans Advanced* for House Purchase	2003-2018	Irish Central Bank
Daft Listings	2006-2018	Daft.ie
Amenities	2018	Open Street Map
Census data	2016, 2011, 2006	Central Statistics Office

This table summarises the data sources used in this project. The macro series tagged with (*) are integrated of order 2. All other series used are I(1).

Sale and rental listings were aggregated at a monthly level. Housing stock was only available yearly and census data for the three stated years. All other series are quarterly.

Although the housing listings and spatial districts are the predominant micro sources used for this analysis, we have also merged our database of listings with a number of other micro data sources including census population estimates by electoral division, which allowed for the construction of secondary measures such as population density at different periods. In addition, we have merged the data with a census derived index of deprivation (Haase and Pratschke, 2012). Finally, we have scraped information on a number of different amenities such as schools, transport etc. and performed a nearest neighbour analysis to the listings. We have used our micro data primarily for checking the robustness of our regressions.

A.4 Graphs of Macro Indicators

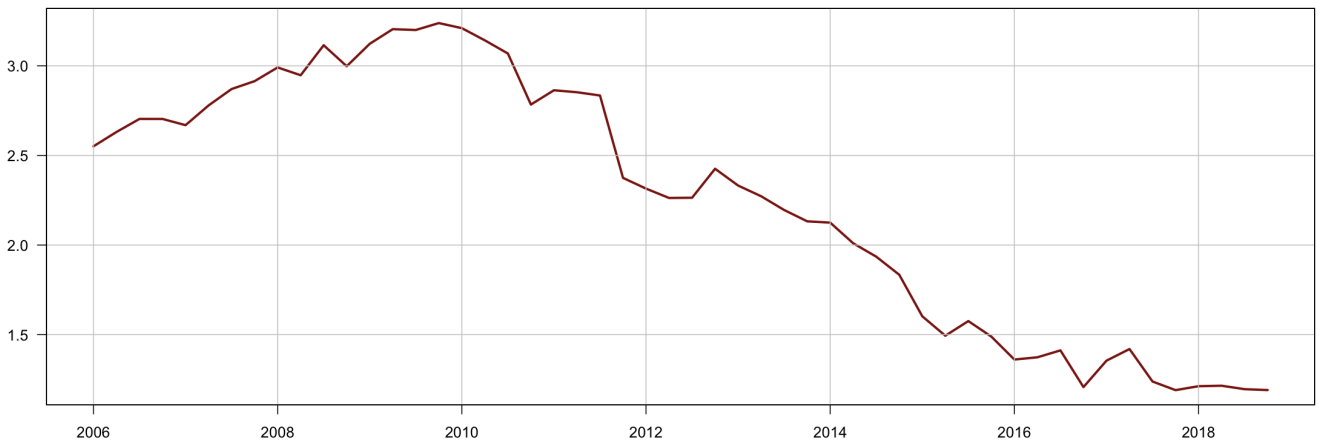


Figure 16: Total Loans Advanced for House Purchase (GNP adjusted), ICB

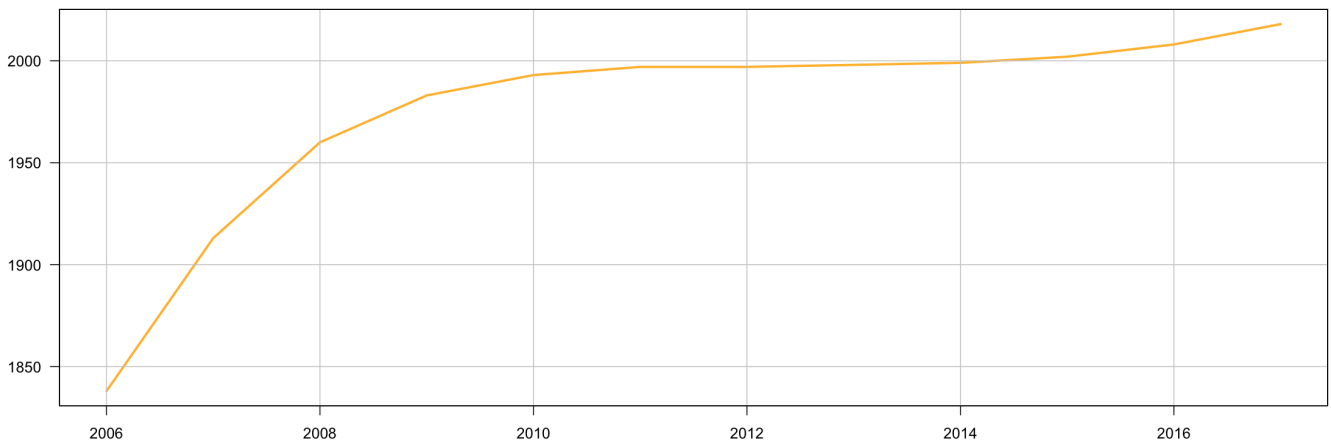


Figure 17: Total Housing Stock ('000s), Central Statistics Office