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Exploring developments in Ireland's regional rental markets

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Abstract

The Irish rental market has been characterised by rapid price growth in recent years, particularly in urban areas. This growth has occurred at the same time as the lowest levels of supply since 2006 in many areas. In this *Letter* I present a model in which rents across eight Irish regions between 2006Q1 and 2016Q1 are explained by local unemployment rates, population, house prices, rental supply and an estimate of the vacancy rate. High unemployment, higher numbers of properties supplied and higher vacancy rates are all associated with lower rents, while higher house prices and a larger population are both associated with higher rents. These effects are robust to modelling in levels and lagged growth rates. Finally, I provide estimates of misalignment of rental markets using model residuals, with a focus on the period surrounding the recent introduction of macroprudential mortgage market regulations by the Central Bank of Ireland.

1 Introduction

Despite its role in economic competitiveness, as the income stream in a large investment class, and in quality of life outcomes for a large portion of the population, the rental sector in Ireland is the subject of significantly less research than its counterpart, the house purchase market. From a policy perspective however, developments in Ireland during the period of post-crisis recovery have placed the spotlight firmly on the rental sector. Further, the introduction of macroprudential housing measures (regulations) by the Central Bank of Ireland in February 2015 has led to renewed interest in developments in the rented property sector, given that, firstly, down-payment constraints may lead marginal borrowers to spend longer on the rental market than in the pre-regulations era, thus leading to higher rental demand and , secondly, increases in rents may have direct implications for the ability of potential First Time Buyers (FTB) to accumulate down-payments via savings, as studied in Kelly and McCann (2016).

A number of factors are likely to play an explanatory role in the increase in rental prices experienced in Ireland since 2012. Firstly, the supply of rented properties has decreased sharply in most areas, with particular concerns around supply-demand imbalances raised in the Dublin area. Secondly, the economic recovery has seen a pick-up in wages, as well as significant inflows of workers into urban areas around the country, many of which are likely renters due to their young age

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profile.

The aim of this *Letter* is to present a simple model of the regional rental market in Ireland. Rents are captured using asking prices from the website daft.ie (hereon DAFT) on a quarterly basis from 2006q1 to 2016q1, and are explained by models which incorporate demand-side factors (unemployment and population), supply-side factors (flow of new rental properties per quarter) and regional house prices. The models are run across the eight NUTS 3 regions of Ireland, and allows us to observe whether rents in each region are above or below the level predicted by the model. I extend the analysis to show that not only are rents associated contemporaneously with the explanatory factors, but the growth rates in these factors also explain subsequent rental growth.

The models intuitively find that monthly rents increase in cases where the population is higher, unemployment rates lower, house prices higher, and rental supply lower. In economic terms, the model in levels indicates that all explanatory factors have important effects. A one-standard-deviation increase ("within" each region) in unemployment leads to a lowering of monthly rents by between €26 and €68 (or 3.4 to 9.5 per cent of sample average monthly rents), depending on the model specified. The analogous range for house prices is an increase of between €39 and €65 (or 5.4 to 9.1 per cent of sample average monthly rents); for population the range is €11 to €38 (1.5 to 5.3 per cent); for rental supply €14 to €26 (1.9 to 3.6 per cent); finally a one-standard-deviation increase in the vacancy rate, as calculated by McCartney (2016) is associated with a lowering of monthly rents by €27. Given that the within-region standard deviation of our rental series is €85, in all cases these are sizable effects.

The final analysis plots the residuals from all models through time for each region, with a focus on whether any structural changes in rents beyond those expected by developments in key explanatory factors can be observed in the time period around the introduction of the regulations in early 2015. The analysis for Dublin, and to a lesser extent its bordering counties, finds clear evidence that rents had risen above predicted values as early as late-2013, and that model residuals (the unexplained component of rents) continued to grow through to 2016q1, at which point monthly rents were €100 to €150 above the level expected by some models. This suggests that in Ireland's most expensive rental markets, the introduction of the regulations does not appear to be the sole explanation for price growth, but that disproportionate increases in rents relative to explanatory factors have continued through the period since their introduction. In three of the other six NUTS 3 regions of Ireland however, we do observe some evidence that rents moved above predicted levels at the same time as the introduction of the regulations, with €50 of total rents in 2015 and early 2016 being unexplained by the model in the South-West, West and Midland regions. In the South-East, Mid-West and Border regions, model residuals hover either side of zero, depending on the specification.

The results of this exercise cannot be interpreted as attributing any *causal role* (or lack thereof) to the regulations in driving movements in the rental market. Rather, they should be thought of as providing suggestive evidence that the introduction of the regulations is one of only many factors which may have contributed to increased rents, and that importantly, the price increases beyond model-predicted levels in Dublin had in fact been in place for more than one year before the introduction of regulations. Changing expectations among landlords and tenants around future rental growth, changing demand-side attitudes to leverage in the mortgage market, and changes in the risk appetite of mortgage lenders after the financial crisis are all likely to have played a role in shifting the composition of housing tenure demand, with potential knock-on effects on rental levels themselves.

2 Literature

In the residential property market, rents are primarily used as an input into valuation indicators to assess the sustainability of purchase price movements. Case and Shiller (1989) and Gallin (2008), among others, state that the fundamental value of a property may be calculated as the present discounted value of its future rent flows. Rental income is thus viewed in a similar manner to dividends in the calculation of stock prices with the price-to-rent ratio analogous to the dividend-price ratio Leamer (2002). Indeed, as Gallin (2008) highlights, rents tend to be treated as a fundamental determinant of house values and so should not deviate far from prices.

The above theory of rents, which assigns to

them the same role as a price in any asset market, may be incomplete for a number of reasons, the foremost of which is that households derive utility from housing that is different from that associated with other asset markets. Wang et al. (2013) point out that rental prices often follow housing price changes, rather than leading them, as would be expected in an asset pricing framework. They show empirically for Hong Kong that where rental yields move one per cent beyond equilibrium capital market returns across the whole economy, rents respond by increasing by 0.3 per cent.

Models of rents in commercial real estate literature have been more common than in the residential sector due to the importance of forecasting cash flows for real estate investors in that sector. The literature employs a similar approach to that used for residential rents and generally finds that economic fundamentals and the vacancy rate are important drivers of rental adjustment (See Ball et al., 2006 for a full discussion).

More recently in Ireland, Kennedy et al. (2016) show that rents in Ireland have been higher than those expected by long-run trends or by a fundamental-based model since 2014, suggesting as is shown in this paper that the Irish rental market has been experiencing disproportionate price growth since before the introduction of the regulations. A model of regional rents presented in a panel data setting as set out in this *Letter* is rare to my knowledge.

3 Rents in Ireland 2006-2016

Rental data on advertised asking prices are sourced from DAFT. This data source is disaggregated across 54 geographic areas (all Dublin postcodes, all other counties, and a city versus county split in Limerick, Galway, Waterford and Cork). Using weights derived from the number of properties in each region as of the national 2011 census, I collapse these 54 regions' average asking rent into the eight NUTS 3 regions of the Republic of Ireland.[2] This disaggregation is most suitable to the current study given that explanatory information from the Central Statistics Office such as unemployment and population is also available at NUTS 3 level. The figures are hedonically-adjusted average rental values, meaning that they take account of compositional changes in the type of properties being rented over time and across regions to aid comparability.

A caveat must be highlighted when using DAFT data to model rents in Ireland. Given that DAFT is a property search website, rents reported are advertised *asking prices* for rental properties. This makes it likely that the data understate the true agreed rents on new leases during periods of excess demand (given that in a tight market rents may be bid above the asking price) and similarly may overstate the actual price in periods of weak demand, where owners may have to accept rents below those advertised. Despite this weakness, I proceed to use the DAFT rental data given that it provides the longest time series of rental prices at a regional level in the Republic of Ireland. The regional dimension to the data provide distinct advantages relative to an approach using macroeconomic time series for the country as a whole, given the sharp differences in rental markets between the Dublin area and the rest of the country.

Figure 1a plots the average asking rent for each NUTS 3 region in each quarter from 2006q1 to 2016q1. The recession is clearly evident in all rental series, with Dublin rents falling from a peak of €1,400 in 2007q4 to €967 in 2010q4, while the recent recovery to pre-crash levels is also borne out in the DAFT data. The significant geographic bifurcation of the Irish rental market is also clear, with Dublin (and to a lesser extent its commuter belt in the Mid-East region of Meath, Kildare and Wicklow) having average rents that are hundreds of euro in excess of those of most other regions, particularly when the South-West, which includes Cork City, is excluded.

Figure 1b shows that the divide in the Irish rental market between Dublin and the rest of the country is much more striking than that between urban and non-urban areas more generally. When all cities apart from Dublin (Cork, Galway, Waterford and Limerick) are graphed as a distinct group, their average rents are much closer to the rest of the country than they are to Dublin's rents.

4 Explanatory Variables

The aim of this section is to model regional rents using a range of economic explanatory variables X.

[2] The Nomenclature of Territorial Units for Statistics (NUTS) level three classification of Ireland divides the country into the following eight regions: Dublin, Mid-East, South-East, South-West, West, Mid-West, Border, Midland.

What is crucial to the credibility of the estimates is that X contains factors that plausibly represent both the demand for and supply of rental accommodation.

On the demand side, the most direct measure available is the population of each NUTS 3 region. Where the population is higher, *ceteris paribus* there are more potential renters per unit of supply, putting upward pressure on prices. In Ireland, population is only directly measured every five years via a national census. The Central Statistics Office (CSO), however, provide annual estimates on years between each census at both a national and NUTS 3 level. During the sample period, national censuses were carried out in 2006 and 2011. The top left panel of Figure 2 shows that the population of Dublin is estimated to have grown from just under 1.2 million in 2006 to over 1.3 million by 2015, an increase of 10 per cent. The fastest-growing regions in percentage terms over the 2006-2015 period were the Midland and Mid-East regions, with 16 and 15 per cent growth (from 252 to 293 thousand and 479 to 551 thousand, respectively). Estimates for 2016 are unavailable at the time of writing, meaning that empirical models including population estimates must exclude rental data for 2016q1.

Another measure of the demand for rental property is the unemployment rate. While a change in the unemployment rate does not necessarily indicate that there are more individuals searching for a rented property, it does provide a proxy for disposable income and economic dynamism, improvements in which should lead to higher euro amounts being spent on rented properties as individuals are likely to search for higher-value and higher-quality properties, as well as to loosen their willingness to pay for a given property. Decreases in the unemployment rate and the associated improvements in income may also be associated with increases in the share of the population that choose to live outside the family home, thereby increasing rental demand for a fixed population level.

Given that rented properties are an investment asset class, with monthly rent being the yield on the investment, it is inevitable that rental prices and house purchase prices are closely linked and that causality is likely to run in both directions. Any breakdown in the relationship, with rental growth outstripping house price growth, is likely to be exploited and arbitraged by Buy-to-Let investors seeking yield, therefore pushing house purchase demand and prices upward. Similarly, if house prices outstrip rents, affordability of purchased housing is eroded, which may increase effective rental demand as more households choose to remain outside the owner-occupier segment due to affordability concerns, thereby causing rents to rise. For these reasons, house purchase asking prices are included in the model with the expectation that when house prices are higher, rents are also likely to be higher.

A direct measure of rental market supply is included. DAFT data on the number of properties made available to rent per month is used. This includes *all properties* that were on the website for rent at any point over the three month period, and is a more accurate representation of rental supply than a "stock" measure which would capture the number of properties available for rent at a point in time. The bottom right hand panel shows that quarterly rental supply has fallen sharply in all regions, with the number of properties available in Dublin falling from roughly 19,000 in late 2008 to under 7,000 in 2016q1.[3] Similar trends are observed in all regions, with the fall-off being particularly visible in the South-West and Mid-East regions.

A related measure is the vacancy rate on rented housing, calculated by McCartney (2016). This estimates the share of the rental stock that is unoccupied on a quarterly basis using information from DAFT, the national Census and the Quarterly National Household Survey. In essence it gives the rental supply variable outlined above additional context by measuring it in percentage terms relative to all properties in the market. The disadvantage of this measure is that it is calculated by McCartney (2016) only for Dublin and the rest of the country. Consistent with the measure of supply in the previous chart, the chart shows that vacancy rates in the Dublin and non-Dublin rental markets have fallen sharply since the crisis, to the point where under two per cent of properties were estimated to be vacant in early 2016.

[3] The most recent monthly observation for Dublin at the time of writing was April 2016, during which there were 2,097 properties available for rent in Dublin.

5 Empirical Model

The model applied is a panel data model with NUTS 3 regional fixed effects (a model of "within variation" in each region) where factors reflecting both the demand for and supply of rental properties mentioned in the previous section are incorporated directly.

It must be acknowledged up front that econometric endogeneity concerns surround a number of the X variables included in these models. As noted in Section 4, house prices may respond to rental developments in the case where property developers and Buy-to-Let investors increase their demand to build and purchase housing for rent in response to increasing yields (rents as a ratio to house prices). Similarly, the use of a measure of rental supply on the right hand side of the model is subject to the same criticism, given that more properties may be made available to rent in times where rents are increasing. Finally, it may even be argued that population suffers from an endogeneity problem, given that rising rents may make a region unattractive for both internal and external migrants given the impact of eroding housing affordability on quality of life. Methodologically, a *causal effect* of X on rents can only be inferred if the researcher has satisfactorily dealt with these issues. The nature of the data to hand renders this extremely difficult, and for this reason the coefficients estimated in this study are best understood as associations between X and rents.

Table 1 reports the results of the empirical model. I begin with a model that includes local unemployment rates, house prices, population and rental supply information. In Column (2) I remove the house price term from the model, given that in many modelling approaches rents are seen as a fundamental driver of house prices. In Column (3), due to the annual rather than quarterly nature of the population estimates, I exclude population from the model along with house prices. In model (4) I include house prices in the specification of model (3). Finally, I run a model where rents are explained only by the vacancy rate, similar in nature to that run by McCartney (2016).

Model (1) suggests that a one percentage point fall in the regional unemployment rate is associated with a €7 increase in that region's average rent. Columns (2) to (4) suggest that, depending on the accompanying set of controls, this effect ranges between €6 and €16. Column (1) also suggests that when local house prices are higher, local rents are also higher, with a €10,000 increase in house prices associated with a €9 increase in monthly rents. This effect falls to €5.40 in Column (3) The parameter estimates for population suggest that when the local population is ten thousand people higher, average monthly rents are increased by €20. This effect falls to €0.69 in Column (2). Finally, consistent with theoretical priors, Columns (1) to (4) estimate a negative relationship between supply and rents. When there are one thousand additional properties made available to rent in a region in a given quarter, rents are lower by €8.80 to €16.40. Column (5) suggests that, where the vacancy rate is 1 percentage point higher, rents are lower by €9.79.

As alluded to above, the coefficients of Table 1 can be interpreted only as estimates of the contemporaneous association between X and rents, rather than an estimate of the *causal effect* of X. In order to ascertain whether the relationships in Table 1 contain information on how developments in X are likely to translate into one-period ahead changes in rents, I run the models of Table 1 in first differences, where the first difference of rents is regressed against the first lagged first difference of each X. In all cases, the coefficient signs and statistical significance levels on unemployment, house prices, population, rental supply and vacancy rates in Table 2 match those of the contemporaneous model in levels from Table 1. The only exception is the decrease in the statistical significance of the population measure, which is to be expected given that the model is in first-differences at a quarterly frequency whereas the measure of population only varies on an annual basis. It is safe to conclude from the table not only that rents are associated with unemployment, population, house prices and supply, but also that growth rates in these explanatory variables are also associated with subsequent rental growth. Due to the possibility of serial correlation across the variables of interest, these lagged-first-difference are still not interpretable as causal effects of changes in X on changes in Y.

6 Estimates of misalignment

The final empirical step in this paper is to calculate residuals from the empirical models of Table 1. Figure 3 contains eight panels, one for each NUTS 3 region. Within each panel I present four lines:

residuals from each of the empirical models (1) to (4) of Table 1. A horizontal solid line represents that point at which the region-quarter's residual is zero, indicating that actual rents exactly equal that predicted by the empirical model. Any point above the solid black line is a period in which rents exceed that predicted by explanatory values. Given current debates about the possible role of recent macroprudential housing measures (regulations) in stimulating excessive rental demand, I include a dashed green line at 2015q1, indicating the date of the introduction of the regulations.

Panel (A) reports rents and residuals for Dublin. The chart exhibits clearly that in the models, residuals moved above zero in late-2013, over one year before the introduction of the regulations, suggesting that there were features of the Dublin market beyond unemployment, house prices, supply and population that were relating to rental developments at that time. The model also indicates that the magnitude of the residual rent has continued to rise since the introduction of the regulations, with between €100 and €150 of the city's rental levels of €1,405 in early 2016 being unexplained by levels of the aforementioned explanatory factors.

Given its proximity to Dublin, and the large share of the population that works in Dublin while living in the region, the rental and housing market of the Mid-East region (Meath, Wicklow and Kildare) has also been the subject of much attention since the introduction of the regulations. Panel (B) of Figure 3 shows that rents exceeded those predicted by the model in early 2014 according to the no-population model (red line), but according to other estimates, residuals have grown from close to zero in early 2015 to approach €100 by early 2016. This delay in the growth of rental values beyond expected levels appears intuitive if one believes that these areas act as a spillover region for the Dublin housing market, with demand pressures only increasing once affordability has been eroded in Dublin and more renters select relatively lower-cost rental properties further from the city.

Panels (C) to (H) report rents and residuals for the South-West, South-East, Border, Midland, West and Mid-West regions, respectively. Relative to the Dublin region, rental markets in these regions do not suffer from the same demand-supply imbalances, with the exception of certain cities. In striking contrast to Dublin and the Mid-East, the rental markets of these areas did not experience collapses in rents beyond those expected given the deterioration in the economy in the 2008-2013 period: in most models and most regions, residual estimates hovered close to or above zero throughout the financial crisis. Another contrast relative to the greater Dublin area is evident in the late-2013 to late-2014 period: in the majority of models and regions in Panels (C) to (H), through late-2013 and 2014 while rents in the capital grew disproportionately to growth in explanatory factors, residual values in the rest of the country remained close to or just slightly above zero, suggesting that rental increases experienced during that period were in line with those expected as a result of improvements in the local economy, demographics and changes in supply.

Finally, a shift towards positive residuals in all six of the regions (C) to (H) is apparent in some of the models in the period to the right of the dashed green line in Figure 3. This suggests that, outside of Dublin and its commuter belt, the introduction of the regulations coincided with increases in rents beyond those expected by the improving economy in some models. Depending on the model chosen and the region, these positive residuals range from just above zero to roughly €50 in average monthly rent, smaller than increases experienced in Dublin and the Mid-East. These residuals may incorporate the role that the regulations have had in transferring demand from the purchase to rental market, but may also include other factors not included directly in the empirical models of Table 1.

In the Border, South-East and Mid-West regions the findings in the post-Regulation period are even less conclusive given that two models suggest positive residuals while two models suggest continued existence of below-expected rental levels in these areas. Given that these are regions where house prices are at a level that would imply that most prospective FTB purchasers will have a required LTV of 90 (rather than LTVs sliding towards 80 where prices are further above €220,000), the regulations are likely to have less of an effect on delayed entry to the purchase market.

Our final empirical exercise involves fitting rental values using the coefficients of the models of Table 2. Due to the fact that these models are in first differences, the predicted values $\hat{Y}$ from each model will give predicted changes in rents rather than predicted levels. To compare observed rents to predicted rents in this setting I must there-

fore choose a starting point rental level, and apply predicted first-differences of rent based on lagged first-differences of the X variables to sequentially calculate predicted rental levels. As a starting point I choose quarter three of 2012, which is assumed in McCartney (2016) to be the last point at which the national rental market was in equilibrium. The differences between predicted rents as per this method and those observed in the data are plotted in Figure 4. The levels of the residuals are not comparable to those in Figure 3 given that I begin with rents as observed in reality in 2012q2 and only allow deviations based on growth rates from that point on, whereas in Figure 3 deviations from model-expected values can accumulate over the whole period 2006-2016.

The clearest parallel between Figures 3 and 4 is that in the majority of the first-differenced models, I continue to find that rents in Dublin grew to above-expected levels in 2013, well in advance of the introduction of the regulations. The patterns are noisier in this setting due to the first-differenced nature of the data, with a particular spike for one period in late 2014 due to a sharp one-period change in the number of properties supplied in Dublin in the preceding periods. However, in its totality the four models of Figure 4 predominantly support the proposition that Dublin rental values have been higher than predicted by the models since 2013.

These models again suggest that in the Mid-East (Dublin commuter belt) region, much of the post-2013 period has been associated with above-fundamental rent, with there being less suggestion from these models that there has been a discernible shift in rent relative to fundamentals since the introduction of the regulations. In all other regions, residuals are much closer to zero through the period under observation, with some weak evidence that some regions' rental levels have moved beyond fundamentals in the post 2015q1 period. Overall for these six regions the first-differenced models broadly suggest that rent has grown in line with growth in fundamentals since mid-2012.

7 Conclusion

In this *Letter* I explain rents across the eight NUTS 3 regions of Ireland using regional panel data collated from the website www.daft.ie from 2006q1 to 2016q1. The models show that the higher the population and the level of house prices in a region, the higher are contemporaneous rents, while the higher the unemployment rate, the number of rental properties supplied and the vacancy rate, the lower the level of rent. These effects are all shown to hold up in a lagged-first-differenced model of rents, i.e. the growth rate in each explanatory factor in the preceding period is shown to have an effect on subsequent rental growth.

Using coefficients from these models I calculate whether actual rent levels in each region are above or below those predicted by the levels of the aforementioned explanatory factors. This residual analysis shows that rents in Dublin were significantly below those explained by the model in the 2009 to 2013 period, but since late 2013 have continued to move further away from predicted levels. As of 2016q1, Dublin rents are €100 to €150 above model-predicted levels, depending on the specification. A similar pattern, but less precisely estimated, is observed in the Mid-East region which contains many towns which house commuters to the Dublin labour market. Importantly from the point of view of recent debates around the potential side effects of Central Bank regulations on Loan to Value and Loan to Income limits, the model suggests that rental markets around the capital were over-heating more than one year in advance of the introduction of the regulations, while also showing that the extent of this over-heating has continued to grow since their introduction.

Outside of the broad Dublin area, model estimates are less precise, with evidence that in the South-West region, which includes Cork City, rents have moved beyond expected levels in the period of the introduction of the regulations. In other regions, some models provide suggestive evidence of small rental increases beyond those expected by the model, while other models suggest that these findings are not conclusive.

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Tables

Table 1: Fixed effects model. Dependent variable: Rent (varying by region and quarter)

	(1) Rent	(2) Rent	(3) Rent	(4) Rent	(5) Rent
Unemployment Rate	-7.169***	-16.11***	-14.14***	-6.311***	
	(0.793)	(0.918)	(0.733)	(1.000)	
House Prices (Thousand)	0.896***			0.537***	
	(0.0481)			(0.0529)	
Population (Thousand)	2.261***	0.686***			
	(0.169)	(0.213)			
Rental Supply	-0.0160***	-0.00880***	-0.0109***	-0.0164***	
	(0.00138)	(0.00193)	(0.00192)	(0.00176)	
Vacancy Rate					-9.791***
					(1.750)
Constant	-1726.3***	549.7**	1422.2***	1234.2***	1198.6***
	(219.9)	(266.1)	(22.69)	(27.05)	(15.80)
Observations	320	320	328	328	296
R^2	0.973	0.942	0.940	0.955	0.837

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Table 2: Fixed effects model in first differences. Dependent variable: One-quarter change in rent (varying by region and quarter)

	(1) D.Rent	(2) D.Rent	(3) D.Rent	(4) D.Rent	(5) D.Rent
LD.Unemployment Rate	-2.282***	-6.342***	-6.177***	-2.176***	
	(0.690)	(0.924)	(0.923)	(0.686)	
LD.House Prices (Thousand)	1.462***			1.470***	
	(0.0833)			(0.0832)	
LD.Population (Thousand)	0.197	0.393*			
	(0.149)	(0.211)			
LD.Rental Supply	-0.00629***	-0.00440***	-0.00409***	-0.00614***	
	(0.000798)	(0.00112)	(0.00112)	(0.000791)	
LD.Vacancy Rate					-6.953***
					(1.249)
Constant	9.579***	4.214	5.462**	10.23***	1.241
	(1.976)	(2.774)	(2.703)	(1.915)	(2.928)
Observations	312	312	312	312	280
R^2	0.615	0.220	0.211	0.613	0.107

Standard errors in parentheses
* $p < .1$, ** $p < .05$, *** $p < .01$

Figures

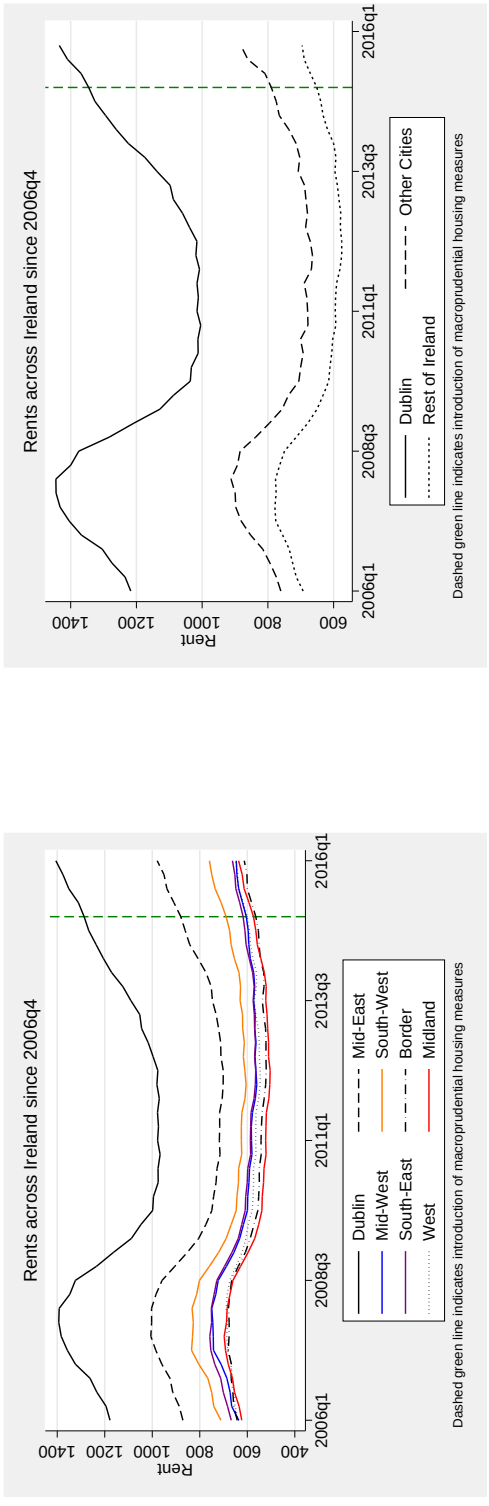


Figure 1: Rents across the country, 2006q1 to 2016q1

(a) Average rent per NUTS 3 region

(b) Average rent in Dublin, other cities and rest of country

Figure 2: Explanatory variables, 2006q1 to 2016q1

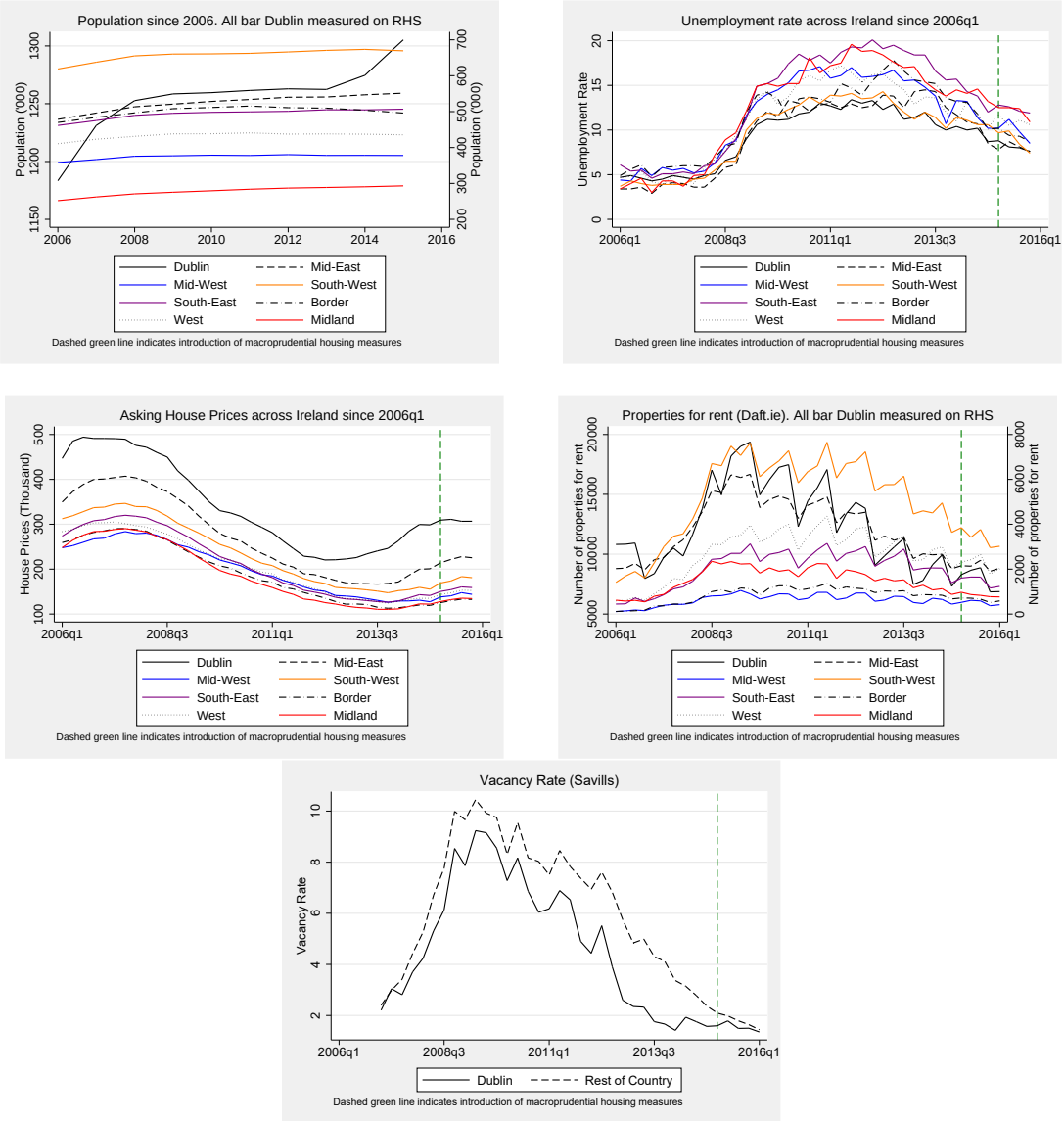


Figure 3: Rent and model residuals for each NUTS 3 region, 2006q1 to 2016q1

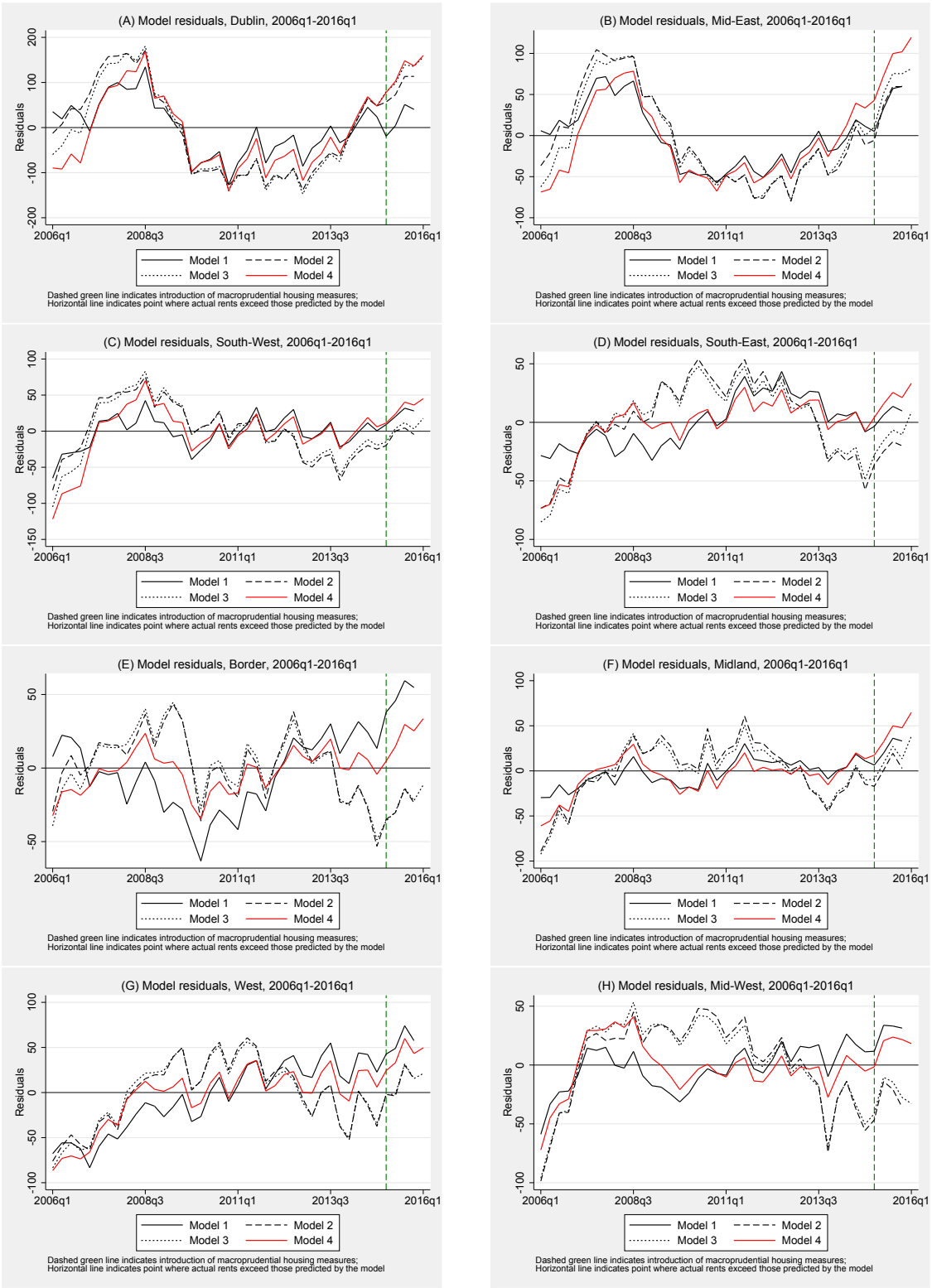
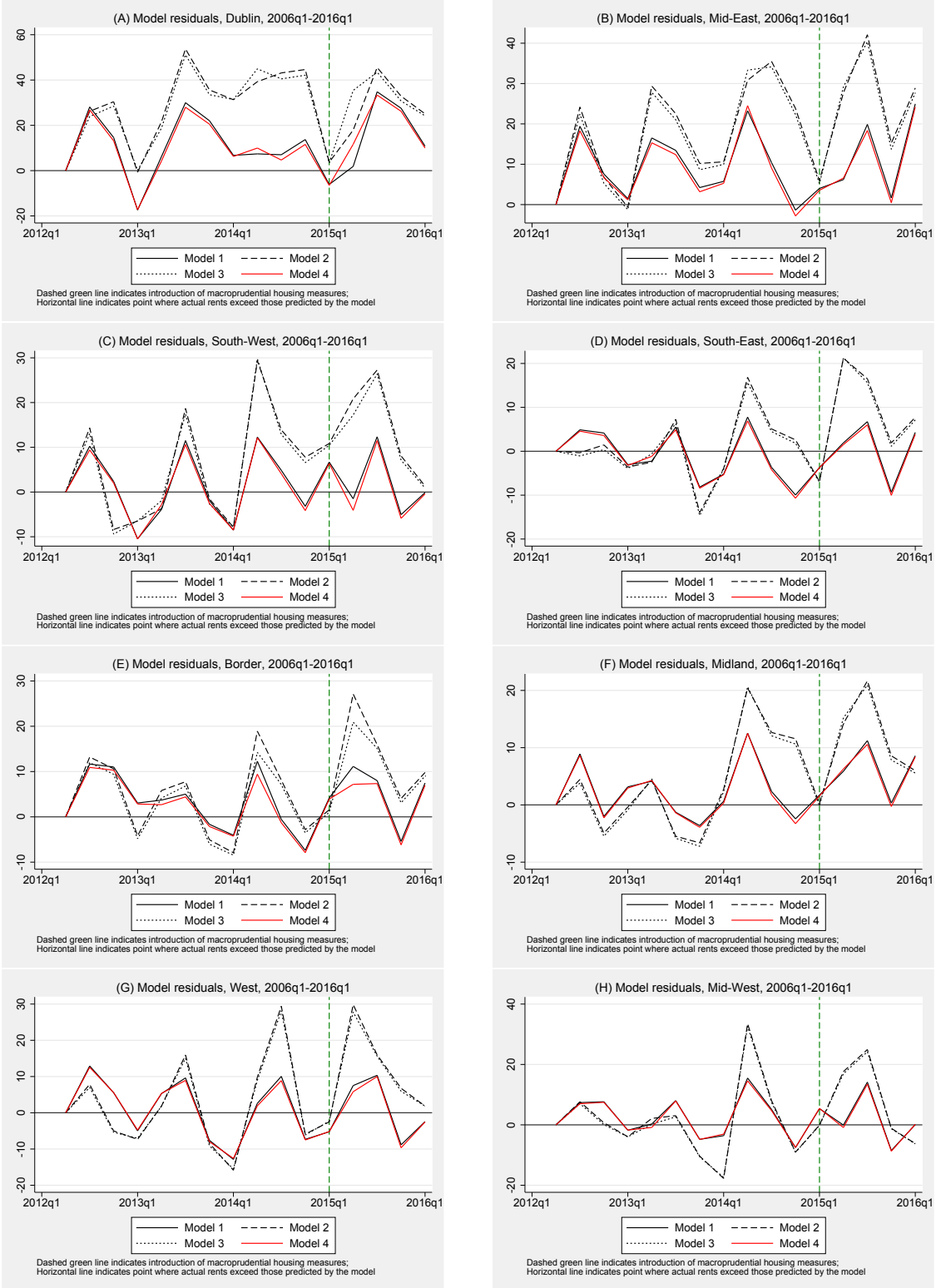


Figure 4: Rent and model residuals from models in lagged differences, 2006q1 to 2016q1



Note: In all cases the model of Table 2 is run to 2012q2, which is the point at which the Irish rental market was in equilibrium as per McCartney (2016). Coefficients on the growth rate in X are then applied to the growth rate in X in every period to calculate a fitted value for rental growth in every period from 2012q2 onwards. These fitted value growth rates are applied sequentially, beginning with the actual level of rents in 2012q2, to calculate predicted rent levels based on the models of Table 2. Residuals plotted here are the differences between these rents implied from the first-differenced model and those actually observed.