HOUSE PRICE RISK VARIATION BY PROPERTY TYPE

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Abstract

This paper examines the different risk profiles of four different property types in England and Wales, both nationally and by region. Motivated by the ICAPM approach of Scruggs (1998) and using an EGARCH in mean model, we find evidence of a positive risk-return relationship, with particular regard to terraced and semi-detached housing, as well as asymmetric adjustment, suggesting that mid-range housing is the property type most like other risk-based assets. We also find that this relationship differs across property types, as has previously been found across regions.

Keywords: House prices, risk, asset pricing, asymmetric adjustment, EGARCH

JEL Classification: G12, R31

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1. Introduction.

Housing markets in general have important effects on the macro economy, largely through acting as a wealth effect and more specifically through their influence on financial markets. Case *et al.* (2005) concluded that the related issue of housing market volatility and risk has become one of increasing prominence following problems in the US sub-prime mortgage market, and Duca *et al*. (2010: 203) stated that "housing developments are intertwined with – and integral to – the crisis that has gripped financial markets since August 2007". Apart from the appreciation that house price volatility can have detrimental effects on the economy, including negative equity and mortgage foreclosure losses, the safety and integrity of housing investment and associated mortgage lending is an area of generally growing concern given the worldwide repercussions of sub-prime mortgage problems.

While housing investment has historically been viewed as reasonably safe, recent crises suggest a failure by the banking/financial sectors to appropriately price housing risk. It may be posited that risk varies across different property types, as different forms of housing are used for different purposes and attract different types of buyers.

As detailed in the literature review, there have been a number of studies that have found differences in volatility clustering and risk return relationships across regions, countries and across different time periods. We aim to contribute to this literature by examining whether this is also the case across differing property types in England and Wales.

Following the 2007/08 financial crisis greater emphasis has been placed on the need for macroprudential policies to ensure that there aren't similar crises in the future. Given the critical role played by the housing market in the crisis, the risk and return involved appears to be an important consideration for policy makers concerned with macroprudential policies. This is important not only for national economies as a whole but also for regional policy. For instance, in the UK, one of the most important financial institutions to collapse was Northern Rock, which particularly covered the housing market in the north of England, while the Bradford and Bingley bank had an emphasis on the Yorkshire region and the buy-to-let (BTL) market. Such considerations suggest that the riskiness of the UK housing market needs to be assessed on a regional property type as well as on the national level.

Following the literature review there is a description of the model to be estimated and the approach used in the estimation. The data and results are then discussed and finally some conclusions are drawn and policy implications suggested.

2. Literature Review

Since Case and Shiller's (1989) seminal work examining general housing market inefficiency, using a similar approach to that commonly applied to studies of financial market efficiency, there has been a proliferating literature on the asset properties of housing with a number of studies using different methods to model housing risk. These are mostly based on various forms of the GARCH model, and in particular the GARCH-M models, to measure the risk-return relationship. Other types of models have involved the use of EGARCH-M, as extensively used in asset market studies of equities, bonds and foreign exchange, as in Scruggs (1998). This model incorporates an asymmetric adjustment term to account for the fact that different shocks have varying effects on volatility and, therefore, risk.

Many of the early studies on the housing markets found little evidence of volatility clustering using ARCH tests, such as the study by Drake (1993) on the UK housing market. However over time more studies picked up evidence of volatility clustering, such as Miles (2008) for the US as housing markets became more volatile and speculative. One of the first to explicitly model volatility in the US housing market was that of Dolde and Tirtiroglue (1997) using the standard GARCH model to show evidence of a link between house price volatility and the regional economy, whilst Miller and Peng (2006) used GARCH models, with a panel VAR, to analyse interactions between volatility and general economic indicators. The latter study also noted that, with some exceptions, there had been few attempts to explicitly model house price volatility.

However, since the financial crisis the volatility issue has become a more important area of research, as the housing market and its associated risks were central to the financial crisis, especially the sub-prime sector. Most of the studies have concentrated on the US housing market, including Miles (2008), who used the GARCH technique to model risk across the fifty US states, finding evidence of volatility clustering in over half of them. In addition he finds that the GARCH models need to be tailored to the housing markets in the individual states as the nature of the risk differs between them. Miles (2009) further uses the GARCH approach to model housing market uncertainty in the context of housing starts, finding a negative relationship between them.

Further evidence of significant GARCH effects in the US housing market were found by Miles (2011a), with particular regard to the conditional variance displaying substantial persistence or long-memory across many US states. The study also finds that the component-GARCH model is better at forecasting house prices than the standard GARCH models. Karoglou *et al*. (2013) used a component GARCH model to suggest that house prices have similar properties in terms of risk and return to other assets and that this has varied over time. Miao *et al*. (2011) applied a similar approach to determine the transmission of volatility across the US and find that the linkages appear to be more intensive in the run up to the financial crisis compared to earlier eras.

The other country that has been often analysed is the UK, as along with the US it has an ample supply of good quality data. Some recent applications of the GARCH type models using UK housing data include Miles (2011b) who found evidence of volatility clustering in the majority of UK regions, as well as showing that the nature of these GARCH effects varies across the regions. Other studies include Morley and Thomas (2011), which shows that house prices share some of the properties usually associated with other assets, such as equities, in terms of a positive risk-return relationship and asymmetric adjustment to shocks. Willcocks (2010) investigated conditional variances in regional house prices using time series generating processes commonly employed in financial market research, and Campbell *et al.* (2009) found interesting similarities between housing markets and traditional financial markets, despite differences in form and function. The latter identified the need to seek a greater understanding of the underlying structural links between housing and financial markets as a potentially fruitful area for future research. Other related studies include Stevenson *et al.* (2007) who assessed the interest rate sensitivity of real estate securities to movements in different interest rates, in the context of a GARCH based model, while Tsai *et al.* (2010) have used a switching GARCH model with UK data and found that volatility has been fairly stable over time irrespective of the regime.

Although most extant studies have largely used either US or UK data, there have been a few studies that have examined volatility clustering in other countries. Lee (2009) finds evidence of volatility clustering in some Australian cities although, as with studies in the US and UK, the nature of the effect varies across cities indicating the importance of modelling the effect individually. Lin and Fuerst (2014) have used the

EGARCH model to examine volatility clustering in Canada, with results again showing variation across regions and generally presenting evidence of volatility clustering, positive risk and return relationships and asymmetric adjustments.

While most studies have used aggregate indexes a few have also analysed house prices in terms of different types or tiers of housing. One of the first to analyse this feature was that by Ortalo-Magne and Rady (2006), who found differences in terms of price and volatility between what they term 'starter homes' and the rest of the market. The starter homes were usually bought by first-time buyers and their ability to fund the deposit was often key to this market sector. The study also found that the volatility in the income of first time buyers affected the volatility of house prices and that the higher tier housing had a more volatile transition to the new steady state. More recently Danianov and Escobari (2015) assess the empirical relationship between low and high price tier houses using a vector error correction model and US data from 364 statistical areas. The results provide evidence of a long-run relationship between the different tiers, with low price tiers appreciating more than high price ones during the US housing bubble.

This paper extends the literature by employing disaggregated data to explicitly examine housing risk by UK property type on a regional basis. The dataset is rich and diverse, reflecting advanced and deep housing markets in a developed economy characterised by a high home-ownership ratio.

3. Model and Methodology

The following model is based on the approach of Scruggs (1998), which was used to explain the relationship between return (in excess return or in other words risk premium form) and risk on the stock market, and was also based on the EGARCH in mean model. The main difference with this model is that we have used housing return (excess return) and conditional risk instead of the stock market excess return and conditional risk. If the following model behaves in a similar way with the housing data in terms of risk, return and asymmetric adjustment as with stock price data, then it suggests there is evidence of housing having a similar relationship between risk and excess return as with other financial markets. The Scruggs model in turn has been based on the intertemporal Capital Asset Pricing Model (ICAPM) of Merton (1973). The model assumes a risk averse agent with the following utility of wealth function:

$$J(W(t), F(t), t) \tag{1}$$

where *W(t)* is wealth and *F(t)* is a variable that measures the state of investment opportunities in the economy. The equilibrium expected market risk premium takes the following form:

$$E_{t-1}(r_{Mt}) = \left[\frac{-J_{ww}W}{J_w}\right]\sigma_{Mt}^2 + \left[\frac{-J_{wf}}{J_w}\right]\sigma_{MFt} \tag{2}$$

where $E_{t-1}[\bullet]$ represents the expectations operator, and σ_{Mt}^2 and σ_{MFt} are the market variance and covariance with state variable F respectively; all conditional on information available at time t-1 and where subscripts on J are the partial derivatives. The first term in parentheses is the Arrow-Pratt coefficient of relative risk aversion, implying that $J_w > 0$ and $J_{ww} < 0$. If $\sigma_{MFt} = 0$ or if $J_{wf} = 0$, then the expected market risk premium is not a function of the conditional market covariance with the state variable F.

As suggested by Scruggs (1998), additional assumptions are required to ensure the model becomes empirically useable. These include the assumption that the conditional second moments are time-varying and also follow the EGARCH type of process. Based on this it is possible to produce conditional versions of the traditional CAPM, if we make a number of further assumptions including that the coefficient of relative risk aversion is an intertemporal constant, the investment opportunity set is static and as above the risk premium doesn't depend on market covariance with the state variable. Scruggs (1998) shows that this produces the following relationship between the excess return or risk premium and conditional variance:

$$r_{M,t} = \delta_o + \delta_1 \sigma_{M,t}^2 + \varepsilon_{M,t} \quad (3)$$

This implies that there should be a simple proportional relationship between the housing market excess return, as measured by the difference between the monthly return on housing and the monthly risk free interest rate, and the conditional housing market variance[1], in a similar way to that hypothesised and subsequently found by Scruggs (1998) in the US stock market. Potential differences in this relationship could be due to varying perceptions to risk and different degrees of risk aversion across regions and property types.

The above model can then be estimated with the standard EGARCH(1,1)-M model of Nelson (1991), which has a number of advantages over the alternative models, such as the GARCH(1,1) model. Our model specification includes a dummy variable in both the mean and variance equations which accounts for the 2007/08 financial crisis. The model has the following form:

$$\Delta \ln hp_t = \alpha_0 + \alpha_1 \sigma_t^2 + \alpha_2 D_t + u_t \quad (4)$$

$$\ln(\sigma_t^2) = \lambda + \phi \ln(\sigma_{t-1}^2) + \gamma \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \beta \left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] + \nu D_t \tag{5}$$

where hp_t are property prices. $\Delta \ln hp_t$ is the continuously compounded yield on property ownership via capital gain minus the return on a risk free bond; D_t is a dummy variable representing the financial crisis beginning in August 2007, taking the value of 0 prior to that and 1 thereafter; u_t is an error term, and σ_t^2 is the conditional variance of the error term. If investors are risk averse, we would expect α_1 to be positive such that higher return is required to compensate for higher risk. If a gearing effect applies then the coefficient on the asymmetric term (γ) should be negative, such that a negative shock increases volatility, as the level of borrowing relative to the property value will rise, increasing the riskiness of the property. A positive sign on γ could be interpreted as indicating a speculative effect, such that a positive shock increases volatility as speculator investment in housing creates a speculative bubble (Koutmos *et al*. 1993). ϕ captures simple persistence in volatility and β measures the ARCH type of effect. Overall the EGARCH model has a number of advantages over other GARCH type models. Firstly it incorporates a term for asymmetric adjustment which is a common feature of asset markets. Secondly it removes the potential problem of the non-negativity constraint, as it is not possible to have a negatively signed variance. We would expect the dummy variable in the mean equation (α_2) to be negative following recent price falls and the dummy variable in the variance equation (υ) to be negative due to the riskier environment following the financial crisis. All models are estimated using Bollerslev-Wooldridge robust standard errors and covariances.

The study data is derived from the Acadametrics House Price Index[2], which is based on property price data collected by the UK Land Registry. The monthly data relates to the English regions, including London as a region, together with Wales as a single region, for the period from January 1995 (as the earliest date available) until April 2011. It covers the four property types of detached, semi-detached and terraced houses and flats/maisonettes. While flats/maisonettes are generally the cheapest and detached houses the most expensive properties across the regions, this is not universally the case. For example, desirable flats/maisonettes in London are commonly more expensive than detached houses elsewhere in England and Wales. The risk free rate is the interest rate on a three month treasury bill obtained from the Bank of England

4. Results

Table 1 contains the mean and standard deviation of each property type[3] by region in £'s, showing that prices are most expensive in London and cheapest in the North of England. In addition in all regions detached houses are most expensive, although the cheapest form of property varies across regions, with flats/maisonettes being the cheapest in London, but terraced houses being the cheapest in the North. The results of the tests for volatility clustering or ARCH effect are contained in Table 2, in this case we have tested for the ARCH(12) effect given the monthly nature of the data and it involves testing for ARCH effects in the residual of the basic price equation with the constant and crisis dummy. Overall there is evidence of the presence of ARCH in the majority of cases, with the main exception being London where there is no evidence of ARCH effects for detached and terraced houses as well as flats/maisonettes. In addition, for Wales there is no evidence of the ARCH effect for detached houses and flats/maisonettes. The main property types that don't generally have the ARCH effect are detached houses and flats/maisonettes, occurring in only three regions. These results are similar to those in other studies, such as Willcocks (2010) and Miles (2011b) that show most regions having an ARCH effect, although not London and the northern regions and in some cases the West Midlands. However we too have found London to be the main outlier in terms of some of the property types and this suggests the London housing market is more complex than that of other regions, with particular regard to the greater international dimension involved. As such, for this region it may be that another approach to modelling volatility clustering is more appropriate, although overall the GARCH approach appears to be a suitable variance data generating process.

Our model estimations are reported in tables 3 to 8. Table 3 presents the results for the whole of England and Wales by property type, and tables 4-8 show the results of our five regional models. Table 4 presents the results for all property types combined by region and tables 5-8 display the results for each property type. The results in Table 3 are fairly uniform regarding the mean equation, with all property types having a positive and significant risk premium, with higher risk requiring higher return to compensate for the extra risk. The conditional variance is used in the mean equation, hence the large values for the coefficients on this variable. The financial crisis dummy is negative and significant, again as expected as the return on property ownership fell post 2007. In the variance equation all asymmetry terms are positive and significant suggesting that, as originally noted by Koutmos *et al.*'s (1993) testing of stock prices, the fact that a positive shock increases volatility is indicative of speculative behaviour. There is also strong evidence of significant volatility persistence, although only some 38-50% of the volatility persists month-by-month across the different property types.

The financial crisis dummy in the variance equation is uniformly positive and significant, confirming that volatility has increased after 2007.

When the data is disaggregated by region the results become much more varied, as detailed in tables 4 to 8. The models generally work best, in terms of correct signs and significant variables, for semi-detached and terraced housing sectors in terms of the risk/return relationship and asymmetric adjustment, but worst for flats/maisonettes. This appears to hold across the regions, but particularly so in southern parts of England. The risk-return relationship is generally positive as expected, although in some cases that for detached housing and flats/maisonettes is either insignificant – suggesting risk neutrality where investors are not concerned by risk, in terms of making a short-term capital loss - or negative and significant, indicating aspects of risk taking behaviour, where greater volatility and possibility of making a short-term capital gain, attracts investors.

The findings relating to the risk premium in real estate in general have been found to vary across different studies, for instance Stevenson *et al*. (2007) suggest that a lack of homogeneity across the assets included in the analysis may produce insignificant results, as different sectors could produce differently signed risk premium, which cancel each other out. The results from this disaggregated dataset seem to confirm this and suggest a different relationship exists across the different types.

The result that the sign on the risk premium varies across regions is common to many studies, although Miles (2011b) finds more negative signs for the UK, whereas this study finds more positive signs, possibly due to a different time span for the estimation. Other studies have also found a mix of signs for this model, some showing a predominance of positive signs such as Willcocks (2010) and in a majority of cases in Canada (Lin and Fuerst, 2014). Also in common with the Willcocks (2010) study is the finding that both asymmetric adjustment and volatility persistence varies across regions producing distinct regional markets, while this study also indicates distinctive markets in terms of different property types.

The regional results indicate that asymmetry is mostly significant but again generally positive, reflecting the speculative nature of housing during the recent past although, as with the risk-return relationship, the southern regions in England display some significant negative relationships. In most cases the financial crisis dummy has reduced return and increased volatility, especially in southern regions, while in midland and northern regions volatility has fallen for some property types. There remains strong evidence of volatility persistence, although the parameter values display considerable variation across regions and property types. Overall the speculative nature of prices is most apparent in the middle range of property types. This may reflect the fact that most of the more speculative BTL market is featured in the terraced and semi-detached sectors[4], with investors purchasing these types of housing and then letting to either families or groups of individuals such as students, whereas detached housing and to an extent flats/maisonettes tend to be bought more as a home.

5. Conclusions

Aggregated house price data hides sectoral demand patterns and different risk perceptions and assessments. On a policy basis our results indicate the need for greater understanding of the market dynamics for different property types and their spatial/geographic variability, if the financial sector is to be better able to manage the risk/return situation and policymakers are to be better informed to oversee the financial sector. The results specifically indicate that using the EGARCH in mean model is appropriate for modelling house price risks and return in the UK regions and across different property types and complements the theoretical and empirical approach to EGARCH modelling of equity markets as noted initially by Scruggs (1998); indicating clear similarities between housing and stock markets in terms of significant risk/return relationships, which differ across models in terms of whether they are positively or negatively signed. In addition the EGARCH specification on the whole appears appropriate for modelling the volatility clustering found in both markets.

This study suggests that the most financial market-like sectors of the housing market are in the mid-range properties, comprising terraced and semi-detached housing, where there is evidence across the regions of a positive relationship between risk and return as well as asymmetric adjustment. Our results indicate that the latter effect is a speculative one, rather than the gearing effect found in some asset markets, with a positive shock increasing speculation and house price volatility. The effects of the financial crisis suggest risk has increased since the crisis in the southern parts of England, but not elsewhere, across all property types.

Our findings regarding variability in house price volatility across property types as well as regions, which has already been established in previous studies, indicate the need for more extensive research into particular market sectors across regions, enabling identification of the key characteristics that make for greater volatility and meaningful assessment of their impact. The associated risk-return issues are important in understanding price fluctuations, and their implications for the banking/financial sectors, and for informing government policy. The importance of housing finance risk also has major implications for the way in which the banking sector is supervised, with particular regard to capital adequacy regulation and the way in which credit risk is treated at the consumer level in terms of default probability and the correlation of risks with those in other sectors.

Notes

1. See Scruggs (1998) for a more complete discussion of the model. The excess return on housing is used so as to follow the Scruggs approach. However the results are not materially different to just having the pure housing return on its own, as the return on housing as with other assets is much larger than the monthly risk free return. The results are not included for the pure housing return without the risk free rate but are available from the authors on request. In the mean equation, the conditional variance rather than the standard deviation are used, although it produces similar levels of significance, it means the coefficients are much larger than for the standard deviation case.

2. We are grateful to LSL Property Services for releasing the data for use in this study.

3. The property type equivalents in the US may be identified as: single detached dwelling/separate house (detached), duplex house, with two-family side-by-side residences (semi-detached), row house (terraced), apartment (flat), apartment on two levels (maisonette).

4. According to a report by the Council of Mortgage Lenders (CML) on 'Property Investment Funds for the UK: Potential Impact on the private sector' by Ball and Glascock (2005, p. 24), "the clients for BTL properties in general prefer individual units in semi-detached or terrace houses as opposed to flats/maisonettes in medium to-large complexes".

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Table 1. Summary statistics for regional property prices

Region	All	Semi-Detached	Detached	Terrace	Flats/ Maisonettes
East Anglia	134,888.7	116,420.8	185,870.9	101,143.1	88,946.7
	(54,838)	(49,436.6)	(73,741.0)	(44,498.3)	(39,839.6)
East Midland	113,462.9	95,051.9	166,508.7	78,348.5	80,348.5
	(44,349.8)	(39,629.7)	(64,273.8)	(34,624.8)	(32,860.5)
London	243,443.7	269,018.2	486,828.6	254,521.2	208,299.4
	(103,246.0)	(111,967.2)	(204,419.7)	(115,272.9)	(86,465.2)
North	97,792.8	94,189.1	169,517.1	72,030.5	76,943.4
	(39,373.1)	(38,928.9)	(67,633.1)	(31,957.7)	(33,027.5)
North West	105,020.5	104,418.3	194,395.9	69,123.0	93,853.1
	(41,606.0)	(43,865.8)	(77,269.8)	(31,449.5)	(36,145.0)
South East	180,718.3	167,000.0	297,994.2	137,305.7	113,344.0
	(69,581.1)	(65,896.0)	(113,451.0)	(55,896.0)	(47,298.7)
South West	151,596.2	136,529.5	224,632.1	118,002.6	109,438.9
	(61,702.3)	(57,625.4)	(90,408.2)	(52,398.0)	(45,056.6)
Wales	104,429.8	94,579.6	155,146.2	74,339.0	90,331.5
	(43,319.1)	(40,418.4)	(63,718.7)	(32,455.6)	(38,002.2)
West Midland	120,866.0	107,527.2	200,249.0	86,470.0	87,357.9
	(45,428.4)	(42,792.8)	(75,152.9)	(36,359.8)	(34,805.7)
Yorkshire	104,988.8	96,826.3	176,060.0	74,328.1	90,891.2
	(42,632.5)	(40,760.7)	(71,786.5)	(33,856.1)	(35,721.0)
Observations	196	196	196	196	196

Notes: Mean price of a particular type of property expressed in £'s with standard deviation in parentheses.

Table 2. Tests for ARCH Effect

Region	All	Semi-Detached	Detached	Terrace	Flats/ Maisonettes
East Anglia	29.818*	11.228	44.059*	28.589*	42.649*
East Midland	36.966*	36.514*	23.317**	29.620*	16.627
London	34.440*	38.686*	11.887	17.154	13.503
North	38.625*	38.188	21.063**	35.688*	46.638*
North West	52.258*	72.518*	12.072	54.334*	35.004*
South East	39.403*	48.250*	58.615*	56.860*	31.346*
South West	44.528*	40.329*	35.173*	48.106*	43.583*
Wales	29.468*	27.900*	17.783	30.276*	8.828
West Midland	37.097*	40.394*	63.813*	28.625*	21.442**
Yorkshire	58.617*	69.335*	46.543*	51.984*	38.165*

Notes: The statistics are chi-square(12), 21.026 (5%) and 26.217(1%). *(**) indicates significance at the 1% (5%) levels.

Table 3. England and Wales property types

Property Type	All	Detached	Semi-Detached	Terraced	Flats/ Maisonettes
α_0	-0.017*	-0.018**	-0.014*	-0.019*	-0.011
	(3.147)	(2.173)	(5.818)	(3.774)	(1.788)
α_1	198.419*	182.263**	215.980*	200.036*	163.725**
	(3.429)	(2.438)	(8.004)	(4.064)	(2.174)
α_2	-0.022*	-0.028*	-0.018*	-0.018*	-0.028**
	(3.220)	(2.655)	(4.227)	(3.243)	(2.308)
λ	-4.454*	-5.500*	-4.850*	-4.930*	-5.254*
	(6.120)	(4.869)	(5.411)	(6.947)	(5.386)
β	-0.125	-0.075	-0.116**	-0.145**	-0.051
	(1.412)	(0.981)	(2.300)	(2.112)	(0.690)
γ	0.280*	0.209*	0.310*	0.309*	0.218**
	(3.294)	(2.601)	(6.284)	(4.153)	(2.506)
ϕ	0.508*	0.387*	0.479*	0.448*	0.437*
	(6.374)	(3.032)	(5.058)	(5.640)	(4.204)
υ	0.323*	0.442*	0.288**	0.230**	0.617*
	(3.135)	(2.668)	(2.330)	(2.204)	(4.020)

Notes: Parameter symbols as contained in equations (4) and (5). All models estimated using Bollerslev-Wooldridge robust standard errors and covariances. z-statistics are in parentheses, critical value is 1.96 (2.58) at the 5% (1%) level of significance. * (**) indicates significance at the 1% (5%) levels.

Table 4. Regional Model 1: All property prices by region.

Property Type: All	London	South East	South West	East Anglia	East Midlands	West Midlands	North West	North	Yorkshire	Wales
α_0	-0.020*	-0.016*	-0.014*	-0.019*	-0.046*	-0.038*	-0.048*	-0.119*	-0.121*	-0.174
	(2.031)	(3.047)	(3.930)	(2.362)	(2.052)	(2.452)	(4.628)	(5.423)	(6.639)	(1.567)
α_1	153.199*	170.215*	189.814*	157.948*	370.855*	324.460*	4.635*	712.138*	847.436*	1038.7
	(2.290)	(3.496)	(3.815)	(2.652)	(2.528)	(3.190)	(5.363)	(5.987)	(6.892)	(1.549)
α_2	-0.032*	-0.024*	-0.016*	-0.020*	0.003	-0.012	-0.010**	-0.002	0.004	-0.004
	(2.240)	(3.240)	(3.179)	(2.825)	(0.356)	(1.626)	(1.802)	(0.204)	(0.406)	(0.460)
λ	-5.794*	-3.588*	-4.195*	-4.318*	-3.750*	-3.469*	-2.682*	-3.353*	-3.223*	-3.329*
	(4.451)	(3.964)	(3.853)	(4.648)	(3.756)	(3.561)	(3.257)	(25.952)	(23.185)	(26.130)
β	-0.093	-0.073	-0.149	0.025	0.027	0.050	0.283*	0.034**	0.029**	0.017
	(1.367)	(0.894)	(1.635)	(0.408)	(0.845)	(1.458)	(5.335)	(2.566)	(2.446)	(1.238)
γ	0.206**	0.269*	0.331*	0.238*	0.117**	0.132*	0.186*	0.038*	0.054*	0.028
	(2.208)	(3.614)	(3.662)	(2.841)	(2.119)	(2.687)	(5.504)	(3.537)	(4.718)	(0.510)
ϕ	0.334**	0.603*	0.540*	0.518*	0.583*	0.619*	0.726*	0.617*	0.638*	0.618*
	(2.245)	(6.063)	(4.593)	(4.986)	(5.053)	(5.617)	(7.838)	(41.786)	(39.391)	(41.473)
υ	0.539*	0.298*	0.197**	0.216	-0.105	0.042	0.044	-0.010	-0.035	-0.009
	(2.806)	(3.285)	(2.247)	(1.761)	(1.075)	(0.452)	(0.541)	(0.223)	(0.816)	(0.403)

Notes: See notes to Table 3. z-statistics are in parentheses, critical value is 1.96 (2.58) at the 5% (1%) level of significance.

Table 5. Regional Model 2: Detached house prices by region.

Property Type: Detached	London	South East	South West	East Anglia	East Midlands	West Midlands	North West	North	Yorkshire	Wales
α_0	0.004*	0.044*	0.037*	-0.015**	-0.020**	-0.014**	-0.016	-0.016	-0.016*	-0.022
	(2.776)	(4.648)	(4.930)	(2.376)	(2.378)	(2.194)	(1.435)	(1.951)	(2.657)	(1.278)
α_1	-1.884	-333.51*	-339.14*	140.084*	220.129*	155.164*	134.667	134.12**	173.393*	200.620
	(1.199)	(7.034)	(4.371)	(2.823)	(2.803)	(2.642)	(1.695)	(2.452)	(2.834)	(1.377)
α_2	0.002	0.010	0.003	-0.042*	-0.013**	-0.027*	-0.019	-0.025**	-0.011*	-0.021
	(0.403)	(0.813)	(0.306)	(2.778)	(2.102)	(3.099)	(1.901)	(2.551)	(2.963)	(1.877)
λ	-0.203**	-4.180*	-3.730*	-5.353*	-3.668*	-4.459*	-5.385*	-5.787*	-4.849*	-7.160*
	(2.351)	(4.681)	(3.611)	(4.585)	(3.717)	(3.868)	(3.390)	(5.402)	(4.522)	(6.338)
β	-0.177	0.033	-0.059	-0.018	0.014	0.026	-0.058	-0.095	0.040	-0.083
	(1.471)	(1.027)	(1.312)	(0.305)	(0.242)	(0.306)	(0.608)	(1.248)	(0.632)	(0.967)
γ	0.162*	-0.131*	-0.163*	0.223*	0.182*	0.235**	0.166	0.230**	0.270*	0.164
	(3.351)	(4.971)	(3.853)	(3.125)	(2.604)	(2.473)	(1.567)	(2.568)	(3.112)	(1.406)
ϕ	0.954*	0.541*	0.594*	0.404*	0.603*	0.515*	0.390**	0.342*	0.477*	0.198
	(146.833)	(5.348)	(5.354)	(3.120)	(5.565)	(4.130)	(2.192)	(2.821)	(4.090)	(1.570)
υ	0.092*	0.164	0.141	0.672*	0.097	0.383	0.341	0.473**	0.124	0.315
	(3.336)	(1.560)	(1.376)	(3.716)	(1.067)	(1.956)	(1.940)	(2.449)	(1.004)	(1.925)

Notes: See notes to Table 3. z-statistics are in parentheses, critical value is 1.96 (2.58) at the 5% (1%) level of significance.

Table 6. Regional Model 3: Semi-detached house prices by region.

Property Type: Semi-detached	London	South East	South West	East Anglia	East Midlands	West Midlands	North West	North	Yorkshire	Wales
α_0	-0.021*	-0.011**	-0.009*	-0.015	-0.016*	-0.015*	-0.013*	-0.025**	-0.014*	-0.015*
	(2.758)	(2.452)	(2.703)	(1.204)	(2.597)	(3.860)	(3.684)	(2.494)	(4.138)	(3.212)
α_1	124.796*	219.127*	164.517*	159.671	209.468*	278.512*	196.08*	253.76*	199.05*	136.61*
	(3.099)	(2.883)	(3.320)	(1.577)	(2.912)	(4.886)	(3.964)	(3.022)	(3.778)	(3.410)
α_2	-0.045*	-0.019*	-0.018*	-0.018*	-0.015*	-0.013*	-0.012**	-0.019**	-0.015**	-0.010**
	(3.238)	(3.427)	(4.143)	(2.821)	(2.722)	(2.943)	(1.998)	(2.092)	(2.452)	(2.188)
λ	-5.023*	-3.737*	-3.129*	-4.662*	-2.938*	-3.792*	-2.800*	-3.915*	-3.761*	-3.038*
	(5.313)	(4.191)	(3.969)	(4.497)	(3.126)	(3.986)	(3.251)	(5.679)	(4.903)	(3.095)
β	-0.093	0.050	-0.033	-0.022	0.064	-0.055	0.133**	0.098**	-0.044	0.043
	(1.829)	(1.113)	(0.504)	(0.400)	(1.060)	(0.923)	(2.476)	(2.194)	(0.452)	(0.748)
γ	0.211*	0.260*	0.298*	0.200	0.187*	0.242*	0.254*	0.150*	0.334*	0.243*
	(3.181)	(3.721)	(4.258)	(1.738)	(3.290)	(4.790)	(4.496)	(2.820)	(3.549)	(3.827)
ϕ	0.403*	0.618*	0.672*	0.484*	0.692*	0.605*	0.715*	0.582*	0.602*	0.667*
	(2.626)	(6.617)	(8.041)	(4.248)	(6.695)	(6.202)	(7.828)	(7.766)	(7.243)	(6.105)
υ	0.583*	0.259**	0.231*	0.229	0.126	0.134	0.094	0.206	0.218	0.061
	(3.806)	(2.577)	(2.691)	(1.739)	(1.633)	(1.453)	(0.984)	(1.757)	(1.522)	(0.673)

Notes: See notes to Table 3. z-statistics are in parentheses, critical value is 1.96 (2.58) at the 5% (1%) level of significance.

Table 7. Regional Model 4: Terraced house prices by region.

Property Type: Terraced	London	South East	South West	East Anglia	East Midlands	West Midlands	North West	North	Yorkshire	Wales
α_0	-0.030	-0.013**	-0.012**	-0.001	-0.027	-0.034*	-0.033*	-0.067	-0.019*	-0.025**
	(1.781)	(2.208)	(2.426)	(0.400)	(1.769)	(4.165)	(2.865)	(1.388)	(3.388)	(2.466)
α_1	103.373	275.038*	237.246*	31.061**	241.791**	312.797*	282.15*	287.652	157.218*	186.396*
	(1.910)	(2.876)	(3.695)	(2.431)	(2.164)	(7.252)	(3.760)	(1.550)	(4.546)	(3.398)
α_2	-0.043	-0.023*	-0.018*	-0.012*	-0.020**	-0.003	-0.015	-0.004	-0.024*	-0.012
	(1.843)	(2.814)	(2.764)	(4.406)	(2.105)	(0.497)	(1.797)	(0.387)	(2.979)	(1.755)
λ	-4.551*	-4.564*	-2.680*	-1.933**	-1.951*	-1.623*	-2.761*	-3.660*	-2.441*	-3.608*
	(2.946)	(5.091)	(3.843)	(2.386)	(3.147)	(19.234)	(27.535)	(7.580)	(3.232)	(3.544)
β	-0.008	0.002	0.024	0.433*	0.099	0.201*	0.179*	0.083	0.157*	0.071
	(0.213)	(0.041)	(0.497)	(3.665)	(1.868)	(5.129)	(3.412)	(1.590)	(2.949)	(1.374)
γ	0.172**	0.212*	0.228*	0.120**	0.085**	0.059*	0.062*	0.072	0.161*	0.178*
	(2.001)	(3.109)	(4.125)	(2.130)	(2.091)	(2.824)	(2.804)	(1.513)	(3.689)	(3.097)
ϕ	0.433**	0.533*	0.725*	0.821*	0.792*	0.837*	0.707*	0.569*	0.740*	0.598*
	(2.283)	(5.722)	(10.080)	(9.003)	(11.400)	(87.904)	(48.420)	(9.355)	(8.859)	(5.245)
υ	0.476**	0.360*	0.183**	0.168	0.074	-0.043	0.032	-0.014	0.153	0.082
	(2.253)	(2.825)	(2.205)	(1.920)	(0.984)	(0.983)	(0.406)	(0.187)	(1.405)	(0.694)

Notes: See notes to Table 3. z-statistics are in parentheses, critical value is 1.96 (2.58) at the 5% (1%) level of significance.

Table. 8. Regional Model 5: Flat/Maisonette prices by region.

Property Type: Flats/ Mais	London	South East	South West	East Anglia	East Midlands	West Midlands	North West	North	Yorkshire	Wales
α_0	-0.020	0.045*	0.154*	0.051*	0.052	0.152*	-0.007	-0.124	0.192	-0.018
	(1.433)	(4.029)	(4.229)	(2.658)	(0.643)	(3.004)	(1.995)	(1.559)	(1.069)	(0.998)
α_1	186.537	-464.50*	-302.43*	-51.874	-73.068	-596.78*	36.909*	232.577	-478.556	86.169
	(1.651)	(5.335)	(4.987)	(1.855)	(0.587)	(3.396)	(2.919)	(1.430)	(0.922)	(1.054)
α_2	-0.024	-0.004	0.007	-0.028*	-0.023	0.057	-0.018*	0.059	-0.071	0.018
	(1.416)	(0.579)	(0.648)	(2.650)	(0.887)	(1.762)	(4.865)	(1.539)	(1.313)	(0.594)
λ	-6.252*	-4.528*	-5.087*	-5.635	-6.345	-5.448*	-5.532*	-6.020*	-6.479*	-6.573*
	(5.572)	(4.419)	(4.554)	(1.049)	(1.689)	(6.645)	(2.919)	(3.166)	(8.585)	(3.709)
β	-0.075	-0.004	-0.047	-0.254	-0.081	-0.005	0.533*	0.044	-0.014	-0.098
	(0.887)	(0.126)	(1.396)	(1.105)	(0.590)	(0.495)	(4.348)	(1.257)	(0.673)	(1.033)
γ	0.164	-0.121*	-0.138*	-0.151	-0.047	-0.026*	0.038	0.024	-0.023	0.104
	(1.603)	(3.672)	(4.083)	(1.587)	(0.596)	(2.776)	(0.553)	(1.156)	(0.877)	(1.225)
ϕ	0.297**	0.516*	0.414*	0.179	0.126	0.343*	0.383	0.203	0.172	0.064
	(2.380)	(4.720)	(3.261)	(0.228)	(0.245)	(3.475)	(1.687)	(0.810)	(1.795)	(0.249)
υ	0.475*	0.028	0.151	-0.372	-0.318	0.242**	0.232	-0.599*	-0.339	-0.411
	(2.667)	(0.306)	(1.348)	(0.824)	(1.126)	(2.054)	(1.259)	(2.828)	(1.587)	(1.319)

Notes: See notes to Table 3. z-statistics are in parentheses, critical value is 1.96 (2.58) at the 5% (1%) level of significance.