Risk-return relationships and asymmetric adjustment in the UK housing market

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Abstract

This study employs an EGARCH-M model to determine whether regional house prices in the UK share any of the properties associated with assets such as equities. The results suggest there is some evidence of a positive risk-return relationship as well as evidence of asymmetric adjustment, implying housing should be treated similarly to other assets, with important implications for the pricing of risk by mortgage lenders. However there are differences across the regions, which can be partially explained by using London house prices as a determinant of other regional prices and incorporating interest rates into the model.

Running title: Risk-return relationships and asymmetric adjustment in housing

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I Introduction

This study employs monthly UK regional house price data to investigate whether house prices share similar properties to other assets, such as equities and commodity prices, in terms of a positive risk-return relationship and asymmetric adjustment to shocks. The housing market in general has important effects on the macro economy, largely through acting as a wealth effect (Case *et al*. 2001) and also through its influence on the mortgage markets. In recent years this market has become increasingly influential in the UK as a result of substantial increases in house prices, partially due to a large rise in mortgage lending to the property sector. In general the sector has treated this lending as being reasonably safe, but with the recent problems in the sub-prime housing market in the USA involving the failure to appropriately price housing risks into the mortgage rate, and subsequent global repercussions, there must now be questions regarding the safety of some of this housing investment. The UK regulatory authorities also need to consider whether property lending should be treated in similar ways to lending for other assets, with particular reference to the pricing of the risk inherent in the housing market.

We use the Exponential Generalised Autoregressive Conditional Heteroskedasticity-in-mean (EGARCH–M) model to test for these properties, as extensively used in other asset market studies of equities, bonds, foreign exchange as well as studies on investment (e.g. Scruggs, 1998; Andersen *et al*., 2002; Bo and Lensin, 2005; Smith and Pitts, 2006). In addition the paper also allows for the so-called 'ripple effect' of London prices on other regions, as commonly described in other studies of the UK housing market (Meen and Andrews, 1998; Cook, 2003). The model is finally extended to investigate the presence of a negative interest rate effect, as evidenced in other asset markets (Scruggs, 1998), as well any positive relationship between interest rates and house price volatility.

UK house prices have been extensively researched (e.g. Drake, 1995; Hall *et al.*, 1997; Pain and Westaway, 1998; Andrew and Meen, 2003; Fingleton, 2006) with particular emphasis on the 1980s housing boom and subsequent falls during the 1990s, including studies assessing the importance of speculation (Levin and Wright, 1997) and the role of asymmetric adjustment (Holly and Jones, 1997). In addition there have been studies of the Dublin (Ireland) housing market which has recently displayed similar characteristics to that of the UK, with Roche (2001) providing evidence of speculative bubbles in this market. In addition, speculative bubbles in housing markets have been analysed by Miller and Zhang (2008).

Along with the UK, the US housing market has also received attention, with particular emphasis on the effects of market efficiency and volatility. Case and Shiller's (1989) study identifies general housing market inefficiency using a similar approach to that commonly applied in studies of financial market efficiency. Miller and Peng (2006) note that there have been very few attempts to specifically model house price volatility, although Dolde and Tirtiroglue (1997) use the standard GARCH model to show evidence of a link between house price volatility and the regional economy in the USA, while Miller and Peng (2006) themselves use GARCH models, with a panel VAR, to analyze interactions between volatility and general economic indicators.

The next section discusses the methodology used in the study, and this is followed by a description of the data and the presentation and interpretation of our results. Our concluding remarks suggest some policy implications for the UK housing and financial markets.

II. Methodology

As based on the original ARCH model (Engle, 1982), the EGARCH-M model has proven to be highly popular for testing equities and other assets since its introduction by Nelson (1991). It also has some useful econometric advantages over other GARCH class models, such as not requiring the non-negativity constraint. Although other models were also employed in this study, such as Threshold GARCH (e.g. Glosten *et al.*, 1993) and versions of the model incorporating a long-run time varying component (CGARCH), the EGARCH results proved the most effective in modelling UK regional house prices, with each region being estimated separately. (Results of other approaches can be obtained from the authors on request.)

The identification and measurement of any risk-return relationship requires the incorporation of the conditional standard deviation, which measures the risk in the mean equation of the model. An alternative approach to modelling the mean could have involved an ARIMA model, but we have adopted the inclusion of the constant and conditional standard deviation only, as much of the literature on equities has followed this method (such as Scruggs, 1998). Additionally, and again in line with most equity-based studies, we only include the capital gain from owning a house as the return, and not any benefit from living in or renting out the property. The test for any asymmetry is accounted for by the following EGARCH-M model specification:

$$\Delta \ln hp_t = \mu + \delta\sigma_t + u_t \quad N(0, \sigma_t^2) \tag{1}$$

$$\ln(\sigma_t^2) = \gamma_0 + \gamma_1 \left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] + \gamma_2 \frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \gamma_3 \ln(\sigma_{t-1}^2) \tag{2}$$

In the present context $\Delta\ln hp_t$ is the first-difference of the logarithm of the regional house price, which is in effect the return or capital gain on owning the house. It is assumed that $\delta > 0$ if investors are risk averse, such that an increase in return is required to compensate for increased risk. The coefficient γ_3 measures the degree of persistence of the volatility; the closer to unity, the longer the volatility persists. It is assumed that $\gamma_2 < 0$ if the leverage effect applies such that bad news increases volatility. The leverage effect in this case being that a fall in house prices causes the debt to housing equity ratio of home owners to rise, increasing the risk associated with owning a house.

As with some other asset market studies we do not rule out the possibility of a positive sign on the asymmetry term. For example, Koutmos *et al*. (1993) suggested that the positive relationship for the Athens stock market could possibly be explained by investors perceiving excessive rises in asset prices as evidence of a speculative bubble, facilitating a rise in uncertainty and an associated increase in volatility. Apergis and Eleptheriou (2001) and Kassimatis (2002) confirm these results for the Athens market among others and also suggest that the nature of developing asset markets, which are often more speculative in nature, contributes to a positive relationship. As such, a positive sign on the asymmetry term in a housing market model could also reflect a speculative bubble, as identified by Roche (2001) in the Dublin market, using a different methodology. Supporting evidence of speculative behaviour in the UK housing market may be provided by the sharp expansion in the buy-to-let sector of the market recently. For instance, the Council of Mortgage Lenders reports that while in 2000 a total of 48,400 gross advances for mortgages to the letting sector were reported, worth £3,900 million, these numbers had risen to 330,300 gross advances totalling £38,400 million by 2006. (www.cml.org.uk/cml/statistics).

To determine the importance of London house prices in affecting other regions, the return on London's house prices, $\Delta \ln Lonhp_{t-1}$, is included in both the mean and conditional variance equations:

$$\Delta \ln hp_t = \mu + \delta\sigma_t + \phi\Delta \ln Lonhp_{t-1} + u_t \quad N(0,\sigma_t^2) \tag{3}$$

$$\ln(\sigma_t^2) = \gamma_0 + \gamma_1\left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right] + \gamma_2\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \gamma_3\ln(\sigma_{t-1}^2) + \gamma_4\Delta \ln Lonhp_{t-1} \tag{4}$$

London's house prices are lagged to reflect the belief that they move before those in the rest of the country (Cook 2003), and it is assumed that both φ and γ_4 are positively signed.

The final model specification incorporates an interest rate in both the mean and conditional variance equations, as used by Scruggs (1998) (among others) who also discusses the theoretical reasons for this form of specification when testing equity markets. Following the literature on asset markets in general, we have included the interest rate separate to the London house prices, so that the results can be more directly comparable. This produces the following model:

$$\Delta \ln hp_t = \mu + \delta\sigma_t + \eta i_t + u_t \quad N(0,\sigma_t^2) \tag{5}$$

$$\ln(\sigma_t^2) = \gamma_0 + \gamma_1\left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right] + \gamma_2\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \gamma_3\ln(\sigma_{t-1}^2) + \gamma_4 i_t \tag{6}$$

where i_t is the nominal interest rate. While the expectation that a negative relationship between house price returns and interest rates in the mean equation reflects results generally found in equity market studies, Scruggs (1998) explains that there are potential situations in which it could be positive. However, it may be anticipated that any negative relationship in the housing market should be strengthened to the extent that higher interest rates directly reduce the affordability of mortgages and the demand for housing. As with asset market studies using stock price data, we assume there is a positive relationship between housing market volatility and the nominal interest rate, as reported in Glosten *et al*. (1993) and Scruggs (1998).

III. Data and Results

The study employs the monthly regional Financial Times house price data running from February 1995 (the earliest available) to July 2008 for English regions and Wales, with quarterly data from 1972 to quarter 2 of 2008 used for the final set of tests. The Financial Times house price index is the only UK house price index based on every residential property transaction as recorded at the Land Registry, including properties transacted for cash and using the final transaction price, with the data smoothed and both seasonally and mix adjusted. To produce a return measure, the data is logged and differenced in the standard way. Given the study's emphasis on examining the asset properties of housing, rather than a specific attempt to model house prices, the chosen interest rate employed is the mortgage equivalent form presented by the 3 month London Interbank Offer Rate (LIBOR) as taken from *International Financial Statistics*.

Table 1 contains some summary statistics on regional house prices, showing that London has the highest prices, whereas the North has the lowest. Wales has the most volatile house prices, with respect to the coefficient of variation, whilst the South East has the most stable. All estimations of the EGARCH-M models were carried out using the Bollerslev-Wooldridge robust standard errors and covariances, with conditionally normal errors employed.

The results of the basic EGARCH-M model are presented in Table 2 and suggest that for the UK aggregate index, there is only marginal evidence of the positive risk-return relationship occurring. However when testing for individual regions, there is strong evidence of this relationship holding with the exception of the South East, East Anglia, West Midlands and the South West. With regard to the conditional variance equation, there appears to be little evidence of asymmetry in the aggregated data as a whole, but again there is evidence of positive asymmetry in all the regions except the South East, East Anglia, West Midlands and the South West. A possible explanation for the failure of both tests in these adjacent regions is that their house prices are dominated by London house prices, arising from a strong 'commuter' effect. The volatility persistence measures across regions vary from 0.58 to almost 0.95, suggesting that the degree of persistence is in general not particularly high.

Although the positive nature of the asymmetry suggests that it is not a leverage effect, as generally identified for equity markets in western economies, a positive asymmetry has been identified in EGARCH models applied to developing equity markets in terms of speculative behaviour (Apergis *et al*., 2001; Koutmos *et al*.,1993). As applied to the housing market a speculative bubble may be identified and interpreted in terms of a rise in house prices, following a positive shock such as fall in interest rates, encouraging speculators to join the market on top of ordinary homeowners and creating excessive levels of volatility. As noted by Levin and Wright (1997), there are a number of channels through which speculative opportunities can occur in the housing market.

Table 3 contains results from the second EGARCH-M model, where lagged London house price returns are included in the mean and conditional variance equations, to test for any evidence of the 'ripple effect'. The results indicate that for many regions London house prices have a significant effect in both equations and are positively signed, suggesting that a rise in London house prices not only increases house prices around the country but also, in many regions, increases their volatility. This provides some support for those studies, such as Meen and Andrew (1998) which suggest that London house prices lead the rest of the UK.

By including London house prices the models for the South West and to an extent the South-East improve, with the risk factor and asymmetry terms becoming significant and positively signed as for other regions. However London house prices have only marginal effects, if any, on East Anglia, Yorkshire, the North and Wales. Overall the results indicate that the closer to London, the more influential are London house prices. The one exception is the North West of England, where London house prices are particularly influential. Despite its distance from London, the North West shares the distinctive characteristic of high levels of buy-to-let properties and consequent mortgages, often used for speculative purposes. Taylor (2008) reports that the North West comes third behind London and the South East for buy-to-let mortgages approved between 2004 and 2006, with the buy-to-let sector generally having a significant effect on house prices across the UK.

Table 4 contains the results of the EGARCH-M model with the LIBOR interest rate included in both the mean and variance components. In terms of the mean, the LIBOR interest rate is significant and negative in all the regions except most of the South. In contrast the interest rate is significant in the Midlands and Wales and highly significant in the North West and North. It is also significant, and as expected positive, in the variance equations of the northern regions as well as some in the South and Midlands. In three regions – the North West, Wales and the South West - adding the interest rate produces negative signs on the volatility and asymmetric terms; which, although unexpected, does reflect a phenomenon sometimes observed in equity markets, as shown by Scruggs (1998), who produces both positive and negative values for the volatility term in the mean equation depending on the specification.

In general, the regional differences in terms of the interest rate reflect the importance of the LIBOR interest rate to the northern regions, whereas the wholesale money markets, which use this rate, are of less importance to the southern regions. The negative relationship between the return and the interest rate has been observed in the literature on equity markets, although in addition the interest rate is often significant when incorporated into the conditional variance equation of these equity market studies (Scruggs, 1998). As such the inclusion of the interest rate only offers partial support for house prices acting in a similar way to assets in the UK[1].

For completeness, tests were also carried out on quarterly data running from 1972 to quarter 2 of 2008, also covering Scotland, Northern Ireland and outer London. These produced similar results to the monthly data, as reported in Table 5, including positive asymmetry, although the effects are generally less significant.

IV. Conclusion

Regional house prices in the UK appear to share some of the properties usually associated with equities and other equity type assets, with a significant positive relationship between risk and return. There is also evidence of asymmetric adjustment to shocks, although this is positive rather than the more usual negative asymmetry associated with the leverage effect in equity markets. However, studies using equity data from developing markets have also found positive asymmetry and given the recent nature of the UK housing market, with growth rates far above the long-run rates, the positive sign on this variable could also be interpreted as being due to the speculative nature of the UK housing market, which was enhanced by the large interest rate cuts in 2001. To the extent that the study also picks up the importance of London house prices leading other regions, by influencing the mean and volatility of the market, this may reflect the possibility of comparing the London market 'ripple effect' with that of a large multinational share price driving other share prices in the market.

While the study results show that the UK housing market displays the commonly identified negative relationship between interest rates and asset returns, there is no evidence of any interest rate effect on volatility. Employing LIBOR as the interest rate shows a particularly strong effect in the northern regions of England. This finding has a particularly interesting currency given the problems in 2007 experienced by the North East based Northern Rock building society, which had been predominantly active in that area as a mortgage lender raising much of its resources from the wholesale markets.

In general, the policy implications of our results suggest a need to view housing more like other assets. This is particularly relevant for mortgage lenders who, in recent years, have increasingly treated housing equity as an investment which possibly does not have the level of risk suitably priced. As with other assets, houses have the potential for considerable future price adjustment back to long-run levels, which has further implications for lenders as well as homeowners. In addition to recognising that house price volatility can have detrimental effects on the economy, including negative equity and mortgage foreclosure losses (Pennington-Cross, 2003), there is a growing concern regarding the safety, and integrity, of housing investment and associated mortgage lending; an issue of major concern given the current housing market crisis**.** 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 retail sectors.

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Table 1. Summary Statistics

Region	Mean (£)	SD	Coefficient of variation (%)	Min (£)	Max (£)
London (L)	213313	87374	41.0	93044	375976
East Anglia (EA)	122995	54306	44.2	57795	211913
East Midlands(EM)	105975	45328	42.8	54582	177360
North (N)	90065	39110	43.4	49722	160575
North West (NW)	96410	42895	44.5	50338	168662
South East (SE)	165599	66530	40.2	78231	277616
South West (SW)	139915	60978	43.6	64822	238903
Wales (W)	96360	43099	44.7	50391	170286
West Midlands(WM)	113171	46573	41.2	58539	186228
Yorkshire (Y)	97296	42594	43.8	53610	170740
UK	135709	56639	40.2	66018	231857

Note: 162 observations.

Table 2. EGARCH –M Model Results

	Mean		Variance (EGARCH)			
Region	constant	δ (s.d.)	γ_0	γ_1	γ_2	γ_3
London	-0.014	3.766*	-3.216*	-0.062	0.305*	0.687*
	(1.319)	(2.126)	(4.033)	(1.190)	(2.503)	(9.035)
East Anglia	-0.081	10.644	-0.507*	0.025	0.047	0.949*
	(1.295)	(1.429)	(1.314)	(1.008)	(1.375)	(23.384)
East Midlands	-0.018**	4.239*	-2.085*	-0.043	0.197*	0.797*
	(1.914)	(2.816)	(2.975)	(0.660)	(2.672)	(11.920)
North	-0.029	4.708**	-4.141*	0.010	0.227*	0.578*
	(1.372)	(1.816)	(3.988)	(0.217)	(2.014)	(5.367)
North West	-0.013*	3.295*	-1.756*	-0.099*	0.277*	0.826*
	(2.481)	(4.021)	(3.575)	(2.069)	(4.828)	(17.226)
South East	0.005*	0.580*	-3.211*	0.859*	0.146	0.764*
	(3.766)	(2.203)	(2.794)	(6.676)	(1.463)	(6.804)
South West	0.041*	-5.591*	-0.995**	0.032	-0.133	0.905*
	(7.689)	(8.491)	(1.711)	(0.829)	(4.704)	(15.706)
Wales	-0.018**	3.500*	-1.708*	-0.037	0.214*	0.827*
	(2.314)	(3.208)	(3.208)	(0.808)	(3.681)	(15.228)
West Midlands	0.004**	0.463*	-2.607*	0.766*	0.144	0.810*
	(4.867)	(2.445)	(3.861)	(5.334)	(1.532)	(13.001)
Yorkshire	-0.023	4.619	-4.312*	0.048	0.267**	0.580*
	(1.169)	(1.538)	(3.175)	(0.710)	(1.734)	(4.216)
UK	0.008*	0.052	-3.616*	1.173	0.028	0.763*
	(22.240)	(0.406)	(3.526)	(7.323)	(0.204)	(8.853)

Note: All estimations used the Bollerslev-Wooldridge adjusted standard errors and covariances. See equation 1. and 2. for explanation of coefficients. The z-statistics are in parentheses, where * (**) indicates significance at the 5% (10%) level of significance.

Table 3. EGARCH-M Models including London house prices

	Mean			Variance				
Region	constant	s.d	$Lnhp_{t-1}$	γ_0	γ_1	γ_2	γ_3	γ_4
EA	0.025*	-3.241*	0.364*	-0.002	-.099**	0.003	0.988*	-4.423*
	(6.733)	(4.733)	(5.827)	(0.054)	(1.796)	(0.140)	(6251719	(2.461)
EM	-0.020*	4.126*	0.346*	-0.271	-0.034	0.080*	0.980*	3.272**
	(2.748)	(3.767)	(4.959)	(1.186)	(0.762)	(2.395)	(41.199)	(1.725)
N	-0.028*	4.306*	0.406*	-3.207*	-0.044	0.233*	0.667*	-8.590**
	(2.178)	(2.849)	(2.270)	(3.541)	(0.872)	(2.831)	(7.105)	(1.731)
NW	-0.013*	3.048*	0.287*	-0.465	-0.041	0.155*	0.957*	3.270
	(2.967)	(4.300)	(4.641)	(1.617)	(0.874)	(3.380)	(34.917)	(1.524)
SE	-0.026	7.113	0.237*	-1.910*	-0.048	0.107*	0.828*	7.066
	(1.075)	(1.395)	(3.252)	(3.088)	(1.082)	(1.483)	(14.637))	(1.442)
SW	-0.025**	5.343*	0.121	-2.776*	-0.073	0.143*	0.734*	10.350*
	(1.954)	(2.586)	(0.807)	(3.209)	(1.685)	(2.552)	(8.897)	(2.500)
W	-0.021*	3.805*	0.284*	-1.284*	-0.033	0.167*	0.871*	0.868
	(2.811)	(3.568)	(2.803)	(2.570)	(0.704)	(3.343)	(17.214)	(0.778)
WM	-0.016*	3.882*	0.272*	-0.836*	0.080*	0.123*	0.930*	3.429
	(2.238)	(3.014)	(3.532)	(2.079)	(1.542)	(2.418)	(25.521)	(1.107)
Y	-0.023**	4.619*	0.162	-2.811*	0.088	0.248*	0.739*	7.902
	(1.682)	(2.261)	(0.987)	(3.529)	(1.220)	(2.671)	(9.302)	(1.381)

Note: See Table 2 and equations 3 and 4 for explanation of coefficients. The fourth and final columns contain the coefficients and z-statistics for the London house price variable.

Table 4. EGARCH-M Models including interest rates

	Mean			Variance				
Region	const	s.d	i	γ_0	γ_1	γ_2	γ_3	γ_4
L	-0.000	3.791*	-0.251	-3.284*	-0.073	0.303*	0.704*	0.046
	(0.013)	(2.414)	(1.525)	(3.970)	(1.330)	(2.831)	(9.692)	(1.091)
EA	-0.001	8.019*	-0.809*	-3.179*	0.027	0.104*	0.722*	0.066*
	(0.054))	(2.075)	(2.936)	(3.034)	(0.807)	(2.238)	(7.909)	(2.016)
EM	-0.010	6.902*	-0.384*	-1.130*	-0.037	0.105*	0.889*	-0.001
	(0.172)	(2.701)	(3.575)	(2.183)	(0.839)	(2.306)	(17.723)	(0.141)
N	0.016	7.949*	-1.088*	-6.001*	-0.008	0.109*	0.474*	0.122*
	(1.337)	(4.456)	(4.361)	(3.412)	(0.243)	(3.644)	(3.200)	(2.028)
NW	0.058*	-7.242*	-0.239*	-2.089**	0.031	-0.106*	0.813*	0.017
	(7.445)	(6.519)	(1.991)	(1.675)	(1.061)	(4.209)	(7.199)	(0.990)
SE	0.013*	0.238**	-0.114*	-3.899*	1.019*	0.080	0.745*	0.062
	(11.043)	(1.703)	(4.404)	(4.102)	(9.371)	(0.697)	(10.241)	(1.132)
SW	0.042*	-7.842*	0.191	-1.558*	0.022	-0.104*	0.868*	0.030*
	(4.412)	(10.701)	(1.187)	(2.794)	(0.817)	(5.313)	(17.261)	(2.032)
W	0.051*	-5.635*	-0.147	-2.886*	-0.016	-0.136*	0.740*	0.045**
	(5.813)	(4.295)	(0.927)	(3.247)	(0.402)	(3.993)	(9.287)	(1.782)
WM	-0.008	7.252*	-0.459*	-1.516*	-0.014	0.114*	0.858*	0.008
	(0.495)	(2.132)	(2.968)	(2.164)	(0.463)	(2.180)	(13.261)	(0.660)
Y	0.029	6.590**	-1.094*	-7.000*	0.020	0.169**	0.430*	0.194*
	(3.357)	(1.789)	(2.782)	(5.019)	(0.363)	(1.918)	(3.880)	(3.051)
UK	0.019*	-0.629	-0.147*	-3.018**	0.883*	-0.248*	0.793*	-0.004
	(19.000)	(3.813)	(8.925)	(3.841)	(7.172)	(2.719)	(11.254)	(0.104)

Note: See Table 2. The fourth and final columns contain the coefficients and z-statistics for the interest rate variable.

Table 5. EGARCH-M Models using quarterly regional data

	Mean		Variance (EGARCH)			
Region	constant	δ (s.d.)	γ_0	γ_1	γ_2	γ_3
London	-0.156*	6.617*	-1.121*	0.030	0.130*	0.849*
	(2.197)	(2.785)	(2.378)	(0.799)	(2.424)	(13.206)
Outer London	0.023*	-0.080	-4.368*	1.241*	-0.072	0.553*
	(6.794)	(0.517)	(3.950)	(8.413)	(0.045)	(3.768)
South East	0.022*	-0.180	-2.898*	1.132*	-0.039	0.730*
	(7.277)	(1.158)	(4.503)	(6.494)	(0.271)	(9.458)
South West	-0.102*	5.914*	-1.921*	0.014	0.213*	0.755*
	(2.709)	(4.026)	(2.948)	(0.287)	(3.046)	(8.980)
East Anglia	0.010*	0.236**	-2.019*	0.984*	0.127	0.824*
	(4.861)	(1.821)	(3.838)	(4.693)	(0.868)	(13.355)
Wales	-0.010	0.932	-2.961*	0.416*	0.221*	0.626*
	(0.667)	(1.719)	(2.232)	(3.713)	(2.209)	(3.487)
West Midlands	-0.036**	2.305*	-2.373*	0.402*	0.231*	0.726*
	(1.958)	(2.592)	(4.687)	(4.687)	(2.606)	(9.476)
East Midlands	-0.148	6.747**	-1.328**	-0.001	0.127	0.821*
	(1.502)	(1.869)	(1.803)	(0.033)	(1.432)	(8.192)
North West	-0.073**	4.514*	-1.342*	0.070	0.199*	0.836*
	(1.969)	(2.814)	(2.715)	(1.422)	(2.746)	(13.579)
Yorkshire	0.016*	0.126	-3.237*	0.893*	0.069	0.649*
	(3.879)	(0.709)	(4.664)	(5.501)	(0.527)	(6.942)
North	-0.005	0.846*	-3.062*	0.744*	0.098	0.652*
	(0.726)	(3.213)	(3.532)	(5.167)	(1.035)	(5.528)
Scotland	-0.011	1.511*	-2.367*	0.078	0.381*	0.706*
	(0.958)	(2.230)	(2.538)	(1.065)	(3.273)	(5.992)
Northern Ireland	0.020	0.060	-5.246*	1.127*	0.029	0.386*
	(3.776)	(0.314)	(3.876)	(4.691)	(0.188)	(2.068)
UK	-0.072*	5.378*	-2.008*	-0.026	0.293*	0.755*
	(3.178)	(4.380)	(2.950)	(0.437)	(4.192)	(9.080)

Note: See Tables 1 and 2.

End Notes

[1] Other interest rates were also used, such as the yield on long-term Government bonds, which is usually associated with mortgage interest rates in the UK. These produced contrasting results to the LIBOR models, as those for London and the South East were significant and negative respectively, whereas those for northern regions were insignificant. In addition, a model that incorporated the return on equities and a separate model including the exchange rate produced results that were only significant in the South East and London, suggesting the housing markets in these regions are more internationally traded than other parts of the UK. Results are available from the authors on request.