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Volume effects in the London housing market

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Volume effects in the London housing market

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Abstract

Purpose – This paper aims to extend existing research in relation to both the importance of volume effects within housing markets and the specific behaviour of the London housing market. A detailed borough-level examination is undertaken of the relationships between volume, house prices and house price volatility. Support for alternative housing market theories, the degree of heterogeneity in house price behaviour across boroughs and the extent to which housing displays differing properties to other financial assets are examined.

Design/methodology/approach – Correlation analyses, causality testing and volatility modelling are undertaken in extended forms which synthesise and extend approaches within the housing, economics and finance literatures. The various modelling and testing techniques are supplemented via the use of alternative variable transformations to evaluate housing market behaviour in detail.

Findings – Novel findings are provided concerning both volume effects within housing markets generally and the specific properties of London housing market. Evidence concerning bubbles, the volatility-reducing effects of volume, the importance of geographical and price-related factors underlying the relationship between volume and both house price growth and volatility and the presence of asymmetric adjustment in the London housing market are all provided. The extent and nature of the support available for alternative housing market theories are evaluated.

Originality/value – The volatility-reducing effects of volume within housing markets, along with volume effects and the presence of asymmetric adjustment within the London housing market are examined for the first time. New empirical evidence on the support for alternative housing market theories and the differing empirical characteristics of housing relative to other financial assets are presented.

Keywords Causality, Volume, Housing market analysis, Housing prices, Housing demand, House price volatility

Paper type Research paper

1. Introduction

The analysis of regional house price dynamics within the UK has been the subject of much attention in the housing and economics literatures for many years. At the heart of this research is the examination of the ripple effect hypothesis under which changes in house prices are observed first in London before being observed in other regions (Holmans, 1990; Guissani and Hadjimatheou, 1991; MacDonald and Taylor, 1993; Alexander and Barrow, 1994; Drake, 1995; Ashworth and Parker, 1997; Meen, 1999; Peterson *et al.*, 2002; Cook, 2003, 2005a, 2005b, 2012; Cook and Thomas, 2003; Holmes, 2007; Holmes and Grimes, 2008; Hudson *et al.*, 2018). However, in a recent extension of this literature, Hamnett (2009) and Abbott and De Vita (2012) have examined regional house price behaviour at a higher degree of disaggregation via a borough-level analysis of the London sub-market. In this research, differing house price growth rates and the potential convergence of house prices across boroughs have been explored. It is the examination of this undeniably important sub-market at the heart of the ripple effect that provides the motivation for the present study[1].

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To extend the existing literature, the present analysis provides a detailed examination of the role of transactions, or volume, within the London market. The role of volume has been the subject of much attention within the analysis of financial markets, and its link with market efficiency has been explored (see, *inter alia*, Antoniou *et al.*, 1997). In contrast to the analysis of, for example, stock markets, the analysis of volume in relation to housing permits the analysis of its effects within a relatively thin (or lower volume) market[2]. While the relationship between volume and house price growth has been considered for other housing markets (Clayton *et al.*, 2010; Shi *et al.*, 2010; de Wit *et al.*, 2013), the current analysis extends the existing literature in a number of ways. In particular, research on house price volatility and insights from the finance literature on the volume–returns relationship are synthesised and developed to provide an extended exploration of volume effects in relation to housing. Importantly, the resulting econometric analysis allows the generation of novel empirical findings which permit the extent of empirical evidence consistent with alternative theories concerning the impact of volume effects within the housing market to be gauged. In addition to more general (often conflicting) theories such as those associated with down payments and liquidity constraints (Stein, 1995; Genesove and Mayer, 1997), loss aversion (Genesove and Mayer, 2001) and the role of search or buyer-vendor matching (Wheaton, 1990; Berkovec and Goodman, 1996), the analysis allows consideration of the displaced demand theory proposed by Hamnett (2009) for the London market. Interestingly, in addition to allowing the examination of rival theories, the extended nature of the empirical approach adopted involving modified correlation, causality and conditional volatility analyses provides information on differences in the behaviour of house prices across boroughs, the presence of bubbles in some boroughs and the extent to which volume effects in the housing market possess the volatility-reducing properties observed for other financial assets. On this final issue, the results obtained permit examination of the more general issue of the extent to which the behaviour of house prices differs from that of assets typically considered in financial theory.

To achieve its objectives, this paper proceeds as follows. In Section 2 previous research within the economics, finance and housing literatures relevant to the current analysis are reviewed. Drawing upon and extending themes in these literatures, Section 3 presents the methods employed in the present study along with a discussion of the data examined. Section 4 contains the empirical results derived from the analysis of the housing market data. Concluding remarks are provided in Section 5.

2. Previous research

Analysis of the relationship between housing market transactions (volume) and (the changes in) house prices has been the subject of recent research within the economics/housing literature with the findings arising from this research proving to be mixed. This is illustrated by studies such as de Wit *et al.*'s (2013) where a positive relationship is detected between house price growth and volume in the Dutch housing market, Hort's (2000) where negative relationship is observed in Sweden and the analysis of Clayton *et al.*'s (2010) where a more involved relationship was found for the US market. More specifically, Clayton *et al.* (2010) presented evidence of a complex causal relationship whereby negative, but not positive, changes in house prices impact upon volume, while volume only impacts upon changes in house prices in inelastic markets. These asymmetric and supply-related findings contrast also with the results of Shi *et al.*'s (2010) study which presents a straightforward unidirectional causal relationship from volume to prices within the New Zealand housing market.

While these recent studies provide important evidence concerning the presence and nature of the relationship between changes in prices and volume in housing markets, the empirical finance literature has a longer history of research into the relationship between returns (price changes) and volume. Following the seminal studies of Osborne (1959) and Granger and Morgenstern (1963), the volume–returns relationship for financial assets has been the subject of repeated analysis. Indeed, the literature includes a variety of measures of returns in addition to price changes (first differences), including squared prices (Harris, 1986; Clark, 1973), the variance of prices (Epps and Epps, 1976), contemporaneous absolute price changes (Crouch, 1970) and lagged relationships (Rogalski, 1978; Cornell, 1981). This wealth of research into the volume–returns relationship led to the extensive survey of Karpoff (1987) and subsequent empirical examinations of causality such as Smirlock and Starks (1988) and Hiemstra and Jones (1994). Research within these related housing and finance literatures is drawn upon for the first element of the current empirical analysis in which correlation and causality between volume and alternative measures of returns are considered for the London market. Using the finance literature, the alternative measures of returns used are absolute returns which allow exploration of the impact of volatility and positive/negative returns to consider asymmetric effects via potential differing behaviour in rising and falling housing markets. This extends previous analysis of asymmetric causal effects within housing markets such as Clayton *et al.* (2010) as possible asymmetric effects of not just returns, but also volume are considered. The analysis of causality between volume and returns, and an underlying potential asymmetry in its nature, allows the evaluation of alternative housing market theories. Considering the theories of Stein (1995) and Genesove and Mayer (1997), house price changes are viewed as driving transactions via their impact on required down payments and liquidity. In a similar fashion to these down payment or liquidity constraint theories, the loss aversion model of Genesove and Mayer (2001), where price changes impact on transactions as a result of psychological factors linked to potential financial losses, provides a further example of theoretical prediction of returns causing volume. However, in contrast to this, search and buyer-vendor matching theories (Wheaton, 1990; Berkovec and Goodman, 1996) view causality running in the opposite direction with potential transactions influencing the reserve prices of sellers. Consequently, examination of the nature of causality in the volume–returns relationship has a clear link to the evaluation of alternative economic theories.

The second element of the current empirical analysis introduces volatility into the analysis of housing market volume. The importance of volatility is noted by, *inter alia*, Miles (2011) and Barros *et al.* (2015), where the role of housing markets in the recent financial crisis and the implications of their volatility for mortgage defaults and pre-payment, investment trusts, portfolio management, property taxation revenues and the pricing of mortgage-backed securities (Crawford and Rosenblatt, 1995; Foster and Van Order, 1984; LaCour-Little *et al.*, 2002; Miles, 2008) are discussed[3]. To examine volatility clustering in house prices, much use has been made of tests for, and models of, autoregressive conditional heteroskedasticity (ARCH), with a variety of results obtained. For example, while studies such as of Dolde and Tirtiroglu (1997), Crawford and Fratantoni (2003) and Lin and Fuerst (2014) find evidence of volatility clustering in the US metropolitan statistical agency (MSA), the US state level and Canadian provincial data, respectively, the results of Miller and Peng (2006) for MSA data are less supportive with generalised ARCH (GARCH) detected in approximately only 12 per cent of the series examined. This research has been extended to consider potential asymmetric volatility with Miles (2008, 2011) and Lin and Fuerst (2014) using the threshold GARCH (TGARCH) model of Glosten *et al.* (1993) and the exponential GARCH (EGARCH) model of Nelson (1991), respectively, to consider the Canadian, the US and the UK housing markets. This analysis permits consideration of the possibility of house price volatility responding differently to positive and negative shocks. While the results obtained indicated little asymmetry in the regional data examined for the US market and no asymmetry for the UK, widespread evidence of asymmetric volatility was detected for the Canadian market[4]. The present analysis extends this volatility literature in two ways. First, an initial analysis of asymmetric volatility within disaggregated London data is provided via application of the EGARCH model of Nelson (1991). Second, the potential volatility-reducing effect of volume is examined within the London housing market. Noting that volatility can arise as a proxy for the information flows which volume captures, the potential volatility-reducing effects of volume were proposed by Lamoureux and Lastrapes (1990) and have been explored subsequently in numerous studies within the finance literature (see, *inter alia*, Lamoureux and Lastrapes, 1994; Gallo and Pacini, 2000; Carroll and Kearney, 2012). However, to our knowledge, the volatility-reducing potential of volume has not yet been considered in relation to housing markets.

3. Data and methodology

3.1 Data

The data examined in the present study are average monthly house prices and total house sale volumes for the 32 boroughs of London over the period January 1995 to December 2015, along with the aggregate London price and volume series[5]. As the house price series are provided in nominal terms, the consumer price index is used as a deflator to create a real price series[6]. In contrast to the seasonally adjusted house price data, the volume series are provided in a seasonally unadjusted form. To avoid spurious inferences, the volume series are seasonally adjusted via application of the Census X-13 method[7]. Denoting natural logarithms of the house price series and volume as p_t and V_t, respectively, "standard" house price returns are calculated as the difference $r_t = \Delta p_t$[8]. To provide information on the nature of the series considered, the volume and real house price series for the 32 boroughs are presented in Figures 1 to 4. In light of the number of series considered, Table I provides summary statistics on the price and volume series to ease understanding of their properties. Interestingly, it can be seen that the financial crisis caused a more pronounced change (fall) in volume that prices. However, despite this, the level of volume remained relatively healthy with the minimum number of transactions per month over the sample being 49 for Barking and Dagenham in February 2009, whereas other boroughs retained far higher levels.

Ahead of undertaking the empirical analysis of correlation, causality and volatility, the orders of integration of the r_t and V_t series are examined. Using Im *et al.*'s (2003) test, the unit root null is rejected for all series with a p-value of 0.00 per cent obtained. Consequently, the returns and volumes series are treated as stationary for the subsequent analysis[9].

3.2 Methodology

The methods recounted in the above review of previous research shape the nature of the subsequent examination of the London returns and volume data. From inspection of the literature, it is clear that correlation, causality and GARCH-based analyses feature prominently as methods of analysis. However, in addition to consideration of a standard application of these methods, the references to asymmetric adjustment in previous research are recognised to extend the use of these approaches. Consequently, the analysis of correlation involves consideration of volume in relation to returns, absolute returns, positive returns and negative returns. These series are denoted as r_t, $|r_t|$, r_t^+ and r_t^-, respectively, where:

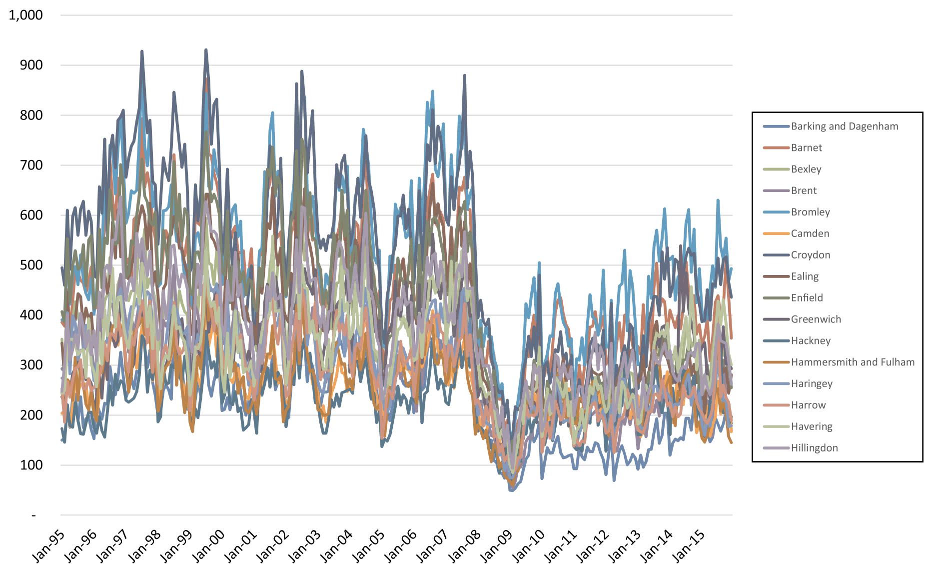

Figure 1.
Volume data for boroughs

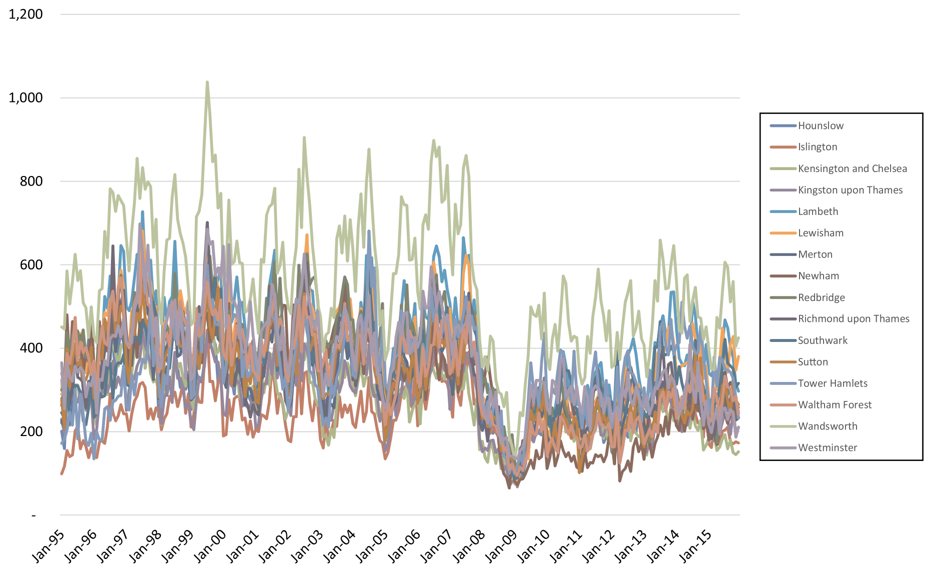

Figure 2.
Volume data for boroughs

$$r_t^+ = \begin{cases} r_t & \text{if } r_t \geq 0 \\ 0 & \textit{otherwise} \end{cases} \tag{1}$$

$$r_t^- = \begin{cases} r_t & \text{if } r_t < 0 \\ 0 & \textit{otherwise} \end{cases} \tag{2}$$

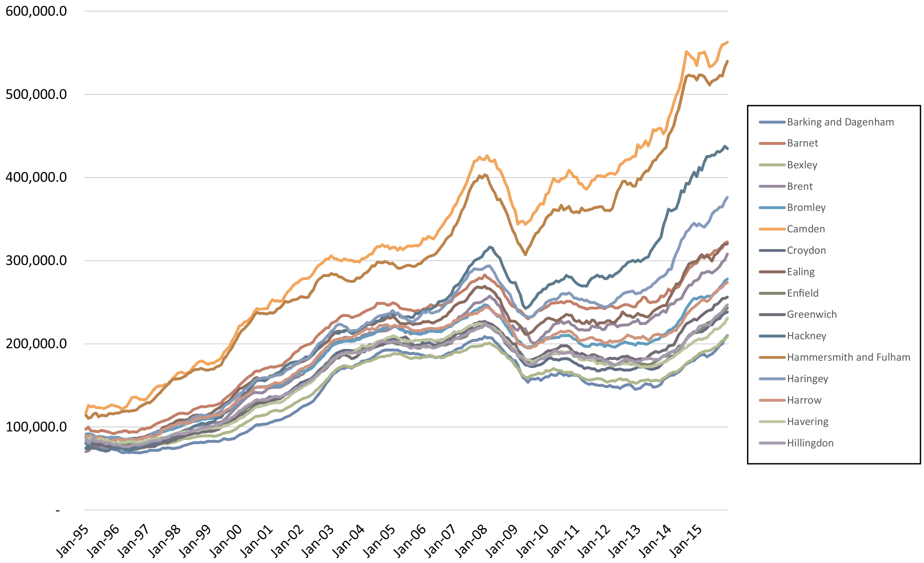

Figure 3.
Price data for boroughs

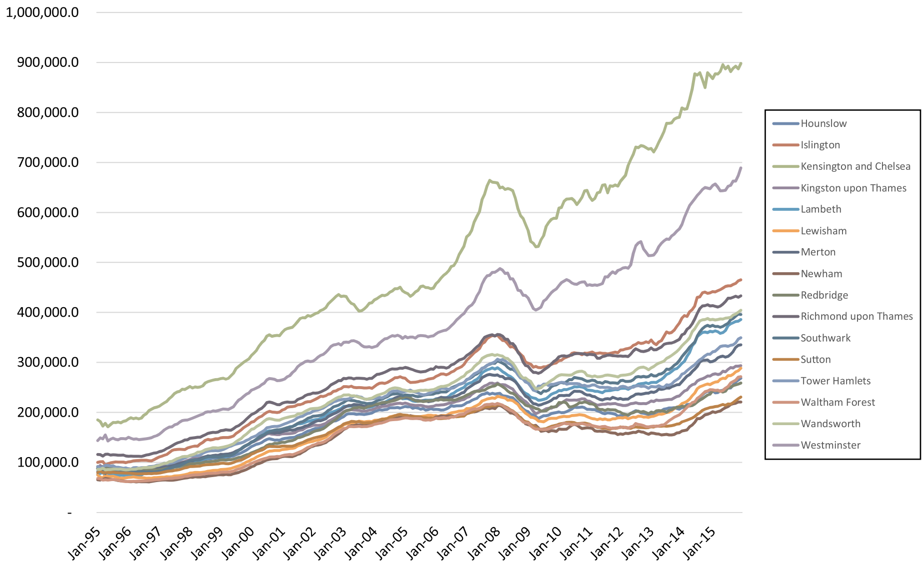

Figure 4.
Price data for boroughs

In a similar fashion to the correlation analysis, examination of potential causality between returns and volume is extended to consider r_t, $|r_t|$, r_t^+ and r_t^-. In addition, volume (V_t) is partitioned into positive and negative components $\{V_t^+, V_t^-\}$ where "positive" and "negative" are again defined relative to rising and falling markets as below:

Borough	Price			Volume		
	min	*md*	*max*	*min*	*md*	*max*
Barking	68,753	153,899	209,879	49	221	428
Barnet	91,790	240,860	322,526	138	464	873
Bexley	73,949	158,420	208,914	81	358	625
Brent	70,233	213,262	307,875	54	302	534
Bromley	85,034	200,338	277,869	155	518	895
Camden	116,707	317,589	562,726	86	257	433
City of Westminster	142,639	352,676	689,014	135	360	698
Croydon	75,193	173,069	238,225	143	534	931
Ealing	81,794	224,026	320,146	92	391	664
Enfield	78,782	180,426	243,076	87	449	767
Greenwich	72,877	184,594	256,119	70	320	569
Hackney	70,750	234,789	437,569	74	226	397
Hammersmith and Fulham	110,297	296,733	539,705	60	254	497
Haringey	82,145	233,688	376,111	75	297	507
Harrow	82,439	205,681	273,723	86	277	475
Havering	80,059	179,117	230,762	85	334	558
Hillingdon	76,139	181,865	246,700	94	364	637
Hounslow	78,192	197,389	268,357	88	303	554
Islington	94,646	267,819	465,164	91	236	447
Kensington and Chelsea	171,107	448,003	897,977	75	266	497
Kingston upon Thames	85,443	211,981	293,481	68	269	450
Lambeth	72,329	225,461	385,826	91	406	727
Lewisham	68,315	187,195	288,419	77	402	681
Merton	82,580	222,794	335,080	96	302	540
Newham	60,824	161,728	220,746	65	347	565
Redbridge	84,290	205,177	258,680	103	388	626
Richmond upon Thames	111,737	285,280	433,183	104	326	701
Southwark	77,584	235,985	396,547	87	348	585
Sutton	76,993	172,096	230,682	102	323	563
Tower Hamlets	86,558	242,195	349,333	99	348	681
Waltham Forest	61,531	171,610	271,545	95	353	632
Wandsworth	84,991	245,326	404,237	136	560	1038

Notes: The above figures are minimum (*min*), median (*md*) and maximum (*max*) house prices and volume for the 32 boroughs of London over the sample period

Table I.
House price and volume summary statistics

$$V_t^+ = \begin{cases} V_t & \text{if } r_t \geq 0 \\ 0 & \text{otherwise} \end{cases} \quad (3)$$

$$V_t^- = \begin{cases} V_t & \text{if } r_t < 0 \\ 0 & \text{otherwise} \end{cases} \quad (4)$$

That is, the partitioning of volume is based upon whether returns are positive or negative. As a consequence of the various original and modified returns and volumes series available, a number of alternative Granger (1969) testing equations are used to consider returns–volume causality. However, to extend the analysis of causality beyond the bivariate setting often considered for the returns–volume relationship (Smirlock and Starks, 1988), the natural logarithm of the Bank of England base rate (b_t) is included in the testing equations. The base rate is used to capture mortgage rate effects which might otherwise generate spurious findings of causality between returns and volume if omitted, and it is an obvious choice given its stated importance in works such as de Wit *et al.* (2013). However, while the impact of the *omission* of variables has long been recognised, the more recent research of Triacca (2017) shows potential spurious findings concerning causality can result from the inclusion of *additional* variables. Consequently, restricting and extending causality equations can potentially generate spurious results. In recognition of these contrasting effects, the testing equations used initially are as below:

$$V_t = \phi_0 + \sum_{i=1}^{m} \phi_i V_{t-i} + \sum_{i=1}^{m} \lambda_i r_{t-i} + \sum_{i=1}^{m} \psi_i b_{t-i} + \xi_t \tag{5}$$

$$r_t = \delta_0 + \sum_{i=1}^{m} \delta_i r_{t-i} + \sum_{i=1}^{m} \theta_i V_{t-i} + \sum_{i=1}^{m} \gamma_i b_{t-i} + \eta_t \tag{6}$$

with nulls of no causality $H_0 : r_t \nrightarrow V_t$ and $H_0 : V_t \nrightarrow r_t$ examined via H_0: $\lambda_i = 0\ \forall i$ and H_0: $\theta_i = 0\ \forall i$, respectively. To overcome potential problems resulting from autocorrelation and heteroskedasticity, the Newey and West's (1987) corrected variance-covariance matrix estimator is used.

Further, potential causal relationships are considered. First, replacing r_t in equations (5)-(6) above with $|r_t|$ allows consideration of the potential absolute returns and volume causality. Second, asymmetric causal relationships are considered by modifying the above testing equations of equations (5)-(6) as below:

$$V_t = \phi_0 + \sum_{i=1}^{m} \phi_i V_{t-i} + \sum_{i=1}^{m} \lambda_i^+ r_{t-i}^+ + \sum_{i=1}^{m} \lambda_i^- r_{t-i}^- + \sum_{i=1}^{m} \psi_i b_{t-i} + \xi_t \tag{7}$$

$$r_t = \delta_0 + \sum_{i=1}^{m} \delta_i r_{t-i} + \sum_{i=1}^{m} \theta_i^+ V_{t-i}^+ + \sum_{i=1}^{m} \theta_i^- V_{t-i}^- + \sum_{i=1}^{m} \gamma_i b_{t-i} + \eta_t \tag{8}$$

where the respective nulls of no causality considered are $H_0 : r_t^+ \nrightarrow V_t$, $H_0 : r_t^- \nrightarrow V_t$, $H_0 : V_t^+ \nrightarrow r_t$ and $H_0 : V_t^- \nrightarrow r_t$, with these examined via $H_0 : \lambda_i^+ = 0\ \forall i$, $H_0 : \lambda_i^- = 0\ \forall i$, $H_0 : \theta_i^+ = 0\ \forall i$ and $H_0 : \theta_i^- = 0\ \forall i$, respectively. These equations allow consideration of potential asymmetries or asymmetric causality whereby positive and negative terms have differing effects which would be masked by consideration of the total measures.

To explore both the potential volatility-reducing effects of volume and asymmetric volatility, EGARCH-based analysis is undertaken. In addition to permitting the examination of these alternative effects, the EGARCH model is selected, as it has further attractive features. More precisely, while removing the restriction of having to satisfy non-negativity constraints associated with GARCH models, this specification also simplifies the analysis of volatility persistence via the need to consider a single coefficient. Given the decision to use the EGARCH specification, the models estimated for the returns series are therefore given as follows[10]:

$$r_t = \mu + \sum_{i=1}^{k} \varphi_i r_{t-i} + u_t \qquad \mathrm{u_t} \sim \left(0, \sigma_{\mathrm{t}}^2\right) \tag{9}$$

$$\log\left(\sigma_t^2\right) = \gamma_0 + \alpha_1 \left|\frac{u_{t-1}}{\sigma_{t-1}}\right| + \alpha_2 \left(\frac{u_{t-1}}{\sigma_{t-1}}\right) + \beta \log\left(\sigma_{\mathrm{t-1}}^2\right) + \pi \mathrm{V_t} \tag{10}$$

where equations (9)-(10) are referred to herein as the EGARCH model without volume included (π = 0 imposed), and the EGARCH-V model with volume incorporated (π = 0 not imposed). Therefore, π is the coefficient attached to the volume regressor which appears in the volume incorporated EGARCH-V specification but is not included in the EGARCH model. However, as the persistence of volatility is captured by the β coefficient, it is the comparison of the estimated values of this coefficient within the EGARCH and EGARCH-V models that provides evidence on the volatility-reducing effect of volume. In short, if $\hat{\beta}$ takes a lower value in the EGARCH-V model than in the EGARCH model, an inference of a reduction in volatility following the inclusion of volume is drawn. Consequently, the level of volatility as indicated by $\hat{\beta}$ is noted and compared across the two specifications. In addition, the properties of the EGARCH and EGARCH-V models are examined via application of the ARCH test (Engle, 1982) and the Q^2-test using squared standardised residuals (McLeod and Li, 1983). Application of these tests allows both examination of the robustness of the estimated models and, importantly in the present context, the extent to which the inclusion or exclusion of volume impacts upon the removal of volatility.

Further to allowing examination of potential volatility-reducing effects of volume, the EGARCH and EGARCH-V models allow analysis of the presence of asymmetric volatility whereby price shocks have differential effects according to their sign. This is examined via the significance of the asymmetry parameter α_2. Typically, it is anticipated that $\alpha_2 < 0$ with shocks having a greater effect when they are negative rather than positive. However, when considering housing, a positive sign might arise as a result of the presence of a bubble reflecting increased prices generating increased uncertainty. This possibility is explored for the London housing market in the following section.

4. Empirical results

4.1 Correlation

The results for volume–returns correlations using alternative measures of returns are provided in Table II. For ease of exposition, the results for the 32 boroughs are summarised

Series	ρ^{mn}	ρ^{md}	$c_{.05}$	*Lon* ρ *[p. v.]*
r_t, V_t	44.90	44.76	32	48.43 [0.00]
$\lvert r_t \rvert, V_t$	0.57	0.87	2	–2.52 [69.03]
r_t^+, V_t	18.43	17.30	21	7.46 [32.35]
r_t^-, V_t	37.67	37.63	27	46.68 [0.00]

Notes: ρ^{mn}/ρ^{md} denote the mean/median calculated correlation coefficients for the stated {returns, volume} pairings across the 32 boroughs of London. $c_{.05}$ denotes the number of boroughs for which the null H_0: $\rho = 0$ is rejected at the 5% level of significance. *Lon* ρ [*p. v.*] denotes calculated correlation coefficients and *p*-values for the test of H_0: $\rho = 0$ for the aggregate London series

Table II.
Return-volume correlations

using mean and median values of the correlation coefficient across the boroughs along with the number of these which are statistically significant at the 5 per cent level. The results obtained show an overwhelming degree of correlation between returns and volume with all boroughs and the aggregate measure providing significant results. Interestingly, the analogous results for absolute returns are in stark contrast to this with no significant correlations detected. This finding contrasts also with a number of findings in the finance literature in which significant correlations between absolute returns and volume have been detected[11]. Finally, the partitioned series indicate the presence of an underlying asymmetry with correlation being markedly more significance for the negative returns series (r_t^-) relative to the negative returns. This supports findings such as those of Clayton *et al.* (2010) in which a stronger link between returns and volume has been detected in falling markets.

4.2 Causality

The results from application of causality tests are presented in Table III[12]. The most prominent feature of the results for the total measures (r_t, V_t) is that of overwhelming unidirectional causality from volume to returns. Comparing these results with those in the finance literature for other assets, the present results are very convincing. For example, while Smirlock and Starks (1988) report figures in the range 13-16 per cent for the instances of significant causality, the analogous figures herein exceed this dramatically with 94 per cent (30 of 32) of boroughs exhibiting a significant causal relationship from volume to returns, while the aggregated measure also exhibits significant causality from volume to returns with a *p*-value of 0.00 per cent reported. The two boroughs which fail to reject the no causality null hypothesis from volume to returns are the East London boroughs of Barking and Dagenham and Redbridge. The differing properties of these boroughs represent an interesting finding which is discussed later in connection with further results obtained for asymmetric causality. This widespread rejection of non-causality from volume to returns is consistent with search-based theories (Wheaton, 1990; Berkovec and Goodman, 1996) whereby transactions drive price changes. While a number of significant results are present in the other direction from returns to volume, these findings are limited. Similarly, the results for absolute returns, evidence of causality is far weaker. This is also in contrast to results in the finance literature where absolute returns are found to be causally related to

Statistic	Null hypotheses			
	$H_0 : V_t \nrightarrow r_t$	$H_0 : r_t \nrightarrow V_t$	$H_0 : V_t \nrightarrow \lvert r_t \rvert$	$H_0 : \lvert r_t \rvert \nrightarrow V_t$
mn	1.61	38.14	26.66	19.72
md	0.00	35.43	18.47	7.64
$c_{0.05}$	30	4	10	9
Lon	0.00	11.68	30.61	32.42
	$H_0 : V_t^+ \nrightarrow r_t$	$H_0 : V_t^- \nrightarrow r_t$	$H_0 : r_t^+ \nrightarrow V_t$	$H_0 : r_t^- \nrightarrow V_t$
mn	2.47	2.31	38.17	10.88
md	0.02	0.01	38.05	1.30
$c_{0.05}$	28	27	5	22
Lon	0.00	0.00	10.51	1.85

Notes: *mn* and *md* denote mean and median *p*-values across the 32 boroughs of London associated with for causality tests of the stated null hypotheses. *Lon* denotes analogous results for the aggregate London series. $c_{.05}$ denotes the number of boroughs for which the relevant null is rejected at the 5% level of significance

Table III. Return-volume causality for real house prices volume and provide a further example of the differing behaviour of house price relative to other financial assets.

The results for the partitioned "positive" and "negative" volume series suggest little evidence of asymmetry; in that, extensive causality from volume to returns is detected irrespective of whether V_t^+ or V_t^- is considered[13]. However, the interesting finding here concerns the location of the limited number of boroughs where causality is not detected. Considering V_t^+, the four boroughs failing to reject the null are Barking and Dagenham, Newham, Redbridge and Tower Hamlets. These four boroughs are joined by Hackney to produce five regions not rejecting the null for V_t^-. These (contiguous) boroughs are all located in East London. That returns in these boroughs display a lower degree of sensitivity to volume than other regions can be related to the displaced demand theory introduced by Hamnett (2009) to explain the high degree of house price growth experienced in these areas with prices changing irrespective of particular conditions concerning volume. The analysis of partitioned returns series $\left(r_t^+, r_t^-\right)$ produces two interesting results. First, marked asymmetry is detected in the form of more pronounced causality for r_t^- than r_t^+. This shows the limited evidence of significant causality for (total) returns (r_t) masks an interesting underlying variation across rising and falling markets. Second, the findings presented are consistent with down payment and loss aversion theories (Stein, 1995; Genesove and Mayer, 2001) associated with returns impacting upon transactions during downturns.

4.3 Volatility modelling

Before applying the EGARCH models to the returns series, an initial prior assessment of the degree of volatility present in the London housing market was performed via the examination of residuals from fitted autoregressive models. In all instances, fourth order ARCH and Q^2-tests applied to residuals from estimated AR(12) models detected significant volatility at the 5 per cent level. Turning to the results presented in Table IV obtained from estimation of the EGARCH models, a number of interesting issues arise. First, it can be seen that the volatility-reducing impact of volume associated with Lamoureux and Lastrapes (1990) is supported with the mean and median estimates of persistence $\left(\hat{\beta}\right)$ lower when

(a) Boroughs

Model	$\hat{\beta}$ *mn*	*md*	$c_{.05}$	$\hat{\alpha}_2$ *mn*	*md*	$c^-_{.05}$	$c^+_{.05}$	$arch_{.05}$	$Q^2_{.05}$
EGARCH	0.732	0.868	25	–0.054	–0.059	11	0	1	1
EGARCH-V	0.404	0.356	15	0.036	0.004	1	3	0	0

(b) London

Model	$\hat{\beta}$ [*p. v.*]	$\hat{\alpha}_2$[*p. v.*]	*arch*	Q^2
EGARCH	0.543 [1.22]	–0.003 [97.48]	85.9	76.8
EGARCH-V	0.305 [34.77]	0.053 [53.22]	86.9	81.7

Notes: Figures under the heading $\hat{\beta}$ denote mean (*mn*) and median (*md*) values of $\hat{\beta}$ across the 32 boroughs of London, with $c_{.05}$ denoting the number of boroughs rejecting H_0: $\beta = 0$ at the 5% level. Figures under the heading $\hat{\alpha}_2$ denote mean (*mn*) and median (*md*) values of $\hat{\alpha}_2$ across the 32 boroughs of London, with $c^-_{.05}/c^+_{.05}$ denoting the number of boroughs with significant negative/positive values of $\hat{\alpha}_2$ at the 5% level. $\hat{\beta}$ [*p. v.*] and $\hat{\alpha}_2$ [*p. v.*] denote estimated values of β and α_2 along with associated p-values of their significance in percentage terms for the aggregate London series. $arch_{.05}$ and $Q^2_{.05}$ denote the number of boroughs rejecting the null for the *ARCH* and Q^2 tests at the 5% level for the estimated EGARCH(-V) models. *arch* and Q^2 denote analogous percentage p-values for the *ARCH* and Q^2 tests for the aggregate London series

Table IV. EGARCH and EGARCH-V modelling volume is included as a regressor. In addition, the number of boroughs possessing significant persistence is seen to fall from 25 to 15 when moving from the EGARCH to the EGARCH-V model and none of the fitted models indicate any evidence of residual volatility in the form of significant ARCH or Q^2 statistics. Analysis of the aggregate London series produces similar results with $\hat{\beta}$ lowered following the inclusion of volume and the null of insignificance no longer rejected (the p-value for the test of H_0: $\beta = 0$ changing from 1.22 to 34.77 per cent). Turning to the results for asymmetric volatility as captured by α_2, the aggregate series does not detect significant asymmetry with or without a volume regressor. However, the results for the disaggregated series are interesting, as the inclusion of volume dramatically reduces the number of boroughs exhibiting asymmetric volatility, with falling from 11 to 4. A further interesting issue arising from these results is that that three of the four instances relate to detection of a positive asymmetry coefficient. While a negative coefficient is typically anticipated for the asymmetric volatility parameter when considering typical financial assets, the positive values observed here can be interpreted as resulting from the presence of a bubble in the series under examination with positive price shocks increasing price uncertainty. When considering the three particular series for which a positive value is observed, this argument has merit, as the boroughs concerned are Camden, Hammersmith and Fulham and Richmond upon Thames which have average ranks of third, fourth and fifth in terms of house prices across the sample period used. While it might be argued that the two highest priced boroughs (Kensington and Chelsea; City of Westminster) should be expected to generate similar results, these boroughs are effectively outliers given the exceptionally high house prices in these areas and the impact of additional factors such as international demand.

5. Conclusion

The above analysis has sought to draw upon and develop themes within the economics, housing and finance literatures to provide a broad examination of the returns–volume relationship for the London housing market. The extended nature of the econometric approach adopted proved to generate a number of interesting and novel results. Using a more standard approach, evidence of unidirectional causality from volume causing returns was detected, thus supporting the search-based or buyer-vendor matching theories proposed by Wheaton (1990) and Berkovec and Goodman (1996). However, an extension of the approach to consider potential asymmetry generated evidence consistent with the down payment, liquidity constraint and loss aversion theories associated with Stein (1995) and Genesove and Mayer (1997, 2001) within falling, but not rising, markets. The incorporation of potential asymmetric adjustment in the econometric methods adopted therefore resulted in the observation of support for theories which would have remained undetected under a standard approach. In addition, the partitioning of volume across rising and falling markets led to the detection of differing behaviour for East London boroughs. The marked difference of these boroughs compared to other areas was related to the displaced demand theory of Hamnett (2009) which was prompted by the differing nature of house price growth in East London.

Further analysis using volatility models produced additional interesting findings with the first results in the literature for the volatility-reducing effects of volume noted within housing markets. In addition, the analysis of asymmetric volatility using EGARCH models provided evidence of bubbles within higher priced boroughs. Consequently, the analysis showed the existence of a variation in housing market behaviour across boroughs which is dependent upon both geographical factors and price levels. Beyond these more specific results, the analysis showed differences in the properties of housing relative other financial assets. This was apparent in both terms of the increased degree of causality detected relative to standard financial assets (Smirlock and Starks, 1988) and lack of importance of absolute returns (Karpoff, 1987).

The present paper has provided a first examination of volume effects within the London housing market and via the detailed nature of the analysis undertaken has produced some novel results. As a consequence, alternative theories have been evaluated, initial findings concerning the volume and volatility have been derived and the differing behaviour across boroughs has been observed. One interesting future line of research involves the extension of the current analysis to consider other regions of the UK to gauge the extent to which the findings for this unique market are apparent elsewhere.

Notes

1. The importance of the London market can be illustrated by the value of its housing stock. In 2015, the combined value of the housing stock in Northern Ireland, Scotland and Wales amounted to under 38 per cent of the value of the London housing stock (see www.savills.co.uk/blog/article/198459/residential-property/uk-housing-value-tops-6-trillion.aspx).
2. We are grateful to an anonymous referee for the observation that housing is a relatively thin market. However, as later analysis shows, volume retains perhaps surprisingly strong levels even during the financial crisis within the sample considered herein.
3. With regard to the causes of volatility clustering in house prices, it has been argued that this can arise due to the inertia which has been detected in housing markets (Case and Shiller, 1988, 1989, 1990).
4. It should be noted that these findings may be in part due to differences in data frequency, with Miles (2008, 2011) employing quarterly data for the US and UK, while Lin and Fuerst (2014) considered monthly data their analysis of the Canadian market. As discussed below, the current study considers higher frequency monthly data which are more suited to the analysis of both volatility and causality.
5. The 32 boroughs of London are: Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Camden, City of Westminster, Croydon, Ealing, Enfield, Greenwich, Hackney, Hammersmith and Fulham, Haringey, Harrow, Havering, Hillingdon, Hounslow, Islington, Kensington and Chelsea, Kingston upon Thames, Lambeth, Lewisham, Merton, Newham, Redbridge, Richmond upon Thames, Southwark, Sutton, Tower Hamlets, Waltham Forest and Wandsworth. The price data are not mix-adjusted, which follows previous research (Abbott and De Vita, 2012; Hamnett, 2009).
6. The CPI series was obtained from the Office of National Statistics (www.ons.gov.uk/).
7. Further details of the seasonal adjustment process are available upon request.
8. To avoid the introduction of additional, complicating notation, r_t is used to refer to all returns series considered herein irrespective of the borough/aggregate distinction. The exact returns series under examination at different stages of the analysis will be made clear in the text and the tabulated results.
9. Further details on the unit root testing are available upon request.
10. The models for the returns series are estimated using the Berndt *et al.* (1974) BHHH algorithm and Bollerslev and Wooldridge (1992) corrected standard errors. With regard to dynamic specification of (9), the orders of the autoregression of the mean equation is determined via minimisation of the Akaike Information Criterion (AIC) from a maximum value of $k = 12$ down to static model.
11. Numerous examples of such research are provided in the survey of Karpoff (1987).

12. In recognition of the frequency of the data examined, a lag length of 12 (m = 12) is employed for the causality tests.

13. The use of quotes for "positive" and "negative" reflects the issue that the partitioning does not relate to the sign of volume but rather the sign of returns.

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