THE BEHAVIOUR OF REGIONAL HOUSING MARKETS AND CONSTRUCTION: IMPLICATIONS FOR MODELLING SUB-REGIONAL HOUSING SUPPLY

Chris Leishman[1]

Paper presented to the Cambridge Centre for Housing and Planning Research, 16th-17th September 2010, King's College, Cambridge.

[1] School of Social and Political Sciences, University of Glasgow, 25 Bute Gardens, Glasgow G12 8RS; chris.leishman@glasgow.ac.uk; +44 141 330 5307

THE BEHAVIOUR OF REGIONAL HOUSING MARKETS AND CONSTRUCTION: IMPLICATIONS FOR MODELLING SUB-REGIONAL HOUSING SUPPLY

ABSTRACT

Recent advances in modelling housing investment in the UK and the United States have centred on estimation of price elasticity of supply and on estimating key relationships in the behaviour of housing prices and construction output at regional level. Yet, there are two main limitations evident in existing knowledge. First, the extent to which many operational models reconcile with underlying economic theory is limited. For example, a number of published studies fail to find construction costs or land prices to be significant predictors of new housing investment. Second, the recent focus on national and regional models has had the result that the impact of planning controls on housing investment, and price elasticity of supply in particular, is not generally well understood. Drawing on a recent project funded by the UK Government's National Housing and Planning Advice Unit, this paper compares several approaches to modelling new housing investment at regional level in England. It advances a multi-equation approach to explain new housing construction and the behaviour of house prices. Significantly, the suggested modelling approach includes explicit recognition of the endogeneity of residential development land prices and planning controls.

1. INTRODUCTION

Advances in understanding the drivers and dynamics of new housing supply have not kept apace with developments in modelling housing and labour markets, or demographic processes such as household formation or migration. Since the Barker Review reported its main findings in 2004 (Barker, 2004), the relationships between housing supply and housing prices, hence affordability, have enjoyed a prominent position in the UK. Yet a number of recently published studies, particularly in contexts outwith the UK, demonstrate the potential for explaining outcomes in the housing construction sector more effectively than has been achieved in some previous UK studies.

The aim of this paper is to extend recent developments to the literature on housing supply, the behaviour of house prices and the dynamics of housing construction. One particularly important omission in past studies is considered: the role of the land market and land prices in helping determine construction sector outcomes.

This paper sets out models of housing development land prices and new housing starts. It does not examine the determination of housing price change, labour market outcomes, migration or demographic processes. Instead, by considering land prices as a partial determinant of housing construction the paper is intended to address well recognised limitations inherent in previous studies of housing supply.

The next section reviews previous studies of the housing market and new housing investment focusing initially on the US literature. The section then moves on to consider findings from recent UK studies, with emphases on modelling housing prices and on the role of planning controls in determining the responsiveness of housing supply. Section III sets out a theory of new housing investment accounting for the behaviour of housing prices, land prices and the impact of planning controls. Section IV provides a set of empirical results focusing on models estimated at regional level. A set of simple simulation results, and the implications for modelling sub-regional housing supply, are then considered. Section V provides conclusions and suggestions for further development of the work.

2. REVIEW OF PREVIOUS RESEARCH

US studies of housing supply and elasticity

Most previous studies of housing supply in the US have been concerned either with the price elasticity of supply, or in the development of stock adjustment approaches to modelling the housing stock and housing prices (see Malpezzi and Maclennan, 2001, for a review of studies of price elasticity in particular). Malpezzi and Maclennan's (2001) results indicate a substantial difference between the US and UK experience. Estimating pre-war and post-war price elasticities of housing supply, they find a significant difference between the two periods: rising from between 4 and 10 to between 6 and 13 in the US, and falling from between 1 and 4 to between 0 and 1 in the UK between the two periods they examined. The study represents a unique comparison of US and UK experience using a common methodology. As the authors note, there are few examples of time series approaches to the estimation of price elasticity of supply in the UK with most estimates being derived from cross-sectional studies.

The literature has seen a number of recent studies concerned with structural models of the housing market. Montgomery (1996) defines these as belonging to two distinct groups: those based on models of household formation and housing starts, and those based on stock adjustment approaches. She cites Maisel (1963) as the seminal work, with a reduced form equation for housing starts as follows:

$$starts_t = (\Delta HH_t + R_t) + (\Delta V_t - \Delta I_t)$$

Where R_t refers to net removal from the housing stock such that the first term defines the net change in households and housing stock. The second term describes the net of change in housing units under construction and change in the number of vacant units. Montgomery (1995) refers to the latter as important for explaining the business cycle rather than a long term trend. Meanwhile, Muth's (1960) partial stock adjustment model is rehearsed as follows:

$$i^D{}_t = \mu[H^D t - (1 – \delta)H_{t-1}]$$

Demand for new construction is therefore defined as a function of the difference between the desired housing stock and depreciated current housing stock. Montgomery (1996) notes that the partial adjustment parameter μ can be interpreted as the propensity of households to move and defines a housing investment equation as follows:

$$i^D{}_t = \mu^M[H^M{}_t – (1 - \delta)H_{t-1}] + \mu^I[H^I{}_t – (1 - \delta)H_{t-1}]$$

This innovation distinguishes between investment in improvement and investment in new construction.

In a recent study by Grimes and Aitken (2010), the authors point out that many previous studies have failed to successfully apply the Tobin's (1969) *q* approach to new housing investment. They point to the omission by many studies of land prices as a factor cost and note Mayer and Somerville's (2000) argument[2] that such an omission gives rise to a misspecified model and incompatability with the equilibrium urban growth model (Roback, 1982). They also point out that a stationary variable (housing starts as a proportion of housing stock) cannot be modelled as a function of a set of non-stationary variables unless they constitute a cointegrating vector. This requires the sum of construction and land costs to equal house prices – a condition that cannot be met in the absence of data on housing development land prices.

The unavailability of reliable data on housing land prices on a time series basis is a well recognised problem in the literature, and has affected a number of studies. Glaeser et al (2008) treated land costs as a fixed proportion (20%) of housing prices. DiPasquale and Wheaton (1994) used the price of agricultural land. Neither Poterba (1984) or Topel and Rosen (1988) included land costs with Mayer and Somerville (2000) suggesting that the omission may explain the failure of either study to find a significant relationship between construction costs and housing supply, contrary to the predictions of economic theory. In a detailed review article DiPasquale (1999) points out that house prices and construction costs are generally poor predictors in models of new construction and argues that the apparent importance of inflation and time to sale are difficult to explain theoretically.

One issue that has received relatively little attention to date concerns the potential endogeneity of land prices. DiPasquale and Wheaton (1994) point out that land prices are generated on the basis of developers' expectations of the profitability of constructing housing. Assuming land prices as an exogenous factor cost in the determination of housing investment must therefore be treated with care. Indeed, Malpezzi and Maclennan (2001) point out that although Muth (1960) and Follain (1979) estimated models of housing investment with factor prices on the right hand side, others have argued for sparser specifications (Olsen, 1987; Blackley, 1999).

Planning controls represent a second issue of potentially great importance to the relationship between land prices and new housing supply. Although there is a rich literature concerned with cross-sectional estimation of the impact of planning restraint on housing supply and prices, there are few published studies using time series data. An exception is Glaeser et al (2006) who estimate equations for log population, wages and house prices in non-declining cities. They estimate the effects of an increase in productivity on change in house prices and change in employment and assume that variations in the ratio of these coefficients between areas is the result of variation in local housing supply elasticities. Using 20 years of data for US cities, they show that an increase in labour productivity gives rise to a greater increase in population and lower increase in house prices in cities they describe as having lower housing supply regulation.

UK studies of housing construction in the post Barker era

The post Barker period has seen significant conceptual development of housing market models in the UK (Meen et al, 2005). Prior to this, most published studies of the UK housing market viewed house price growth as the result of short run interactions between supply and demand. Consequently, house price models were, ostensibly, derived from structural supply and demand equations. In practical terms, as Leishman and Bramley (2005) note, reduced form equations for house price determination tended to represent inverted demand functions,

[2] See also Poterba (1984)

primarily because house price change in the UK has historically demonstrated a very weak relationship with housing supply. As a result, many housing models published in the UK literature set out rates of house price growth as a function of lagged values together with real house price levels and real household incomes. The weighting of population towards more housing market active age groups and various formulations of user cost of capital also generally feature as important demand side drivers of house price change.

Recently, econometric models of house prices have become more sophisticated, adopting error correction or cointegration approaches, with a 'stock and adjustment' conceptual framework rather than the notion that prices are the outcome of the interaction of supply and demand and rapid market clearing. Error correction models reflect the predictions of economic theory that long-run relationships exist between key economic variables. A simple example is provided by Malpezzi (1999) who shows that real house price change can be modelled using an error correction model in which price adjustments occur in response to disequilibrium in the ratio of typical house prices to incomes. This natural ratio is estimated based on a restricted sample of near zero price adjustments and an instrumental variables approach. Malpezzi (1999) also found that market adjustments are symmetrical - essentially the same magnitude for positive and negative adjustments - and linear (smaller and larger adjustments to equilibrium have a similar magnitude).

The Meen et al (2005) model adopts a similar concept in relation to the ratio of households to dwellings, but is much more detailed in its specification. For example, it reflects macro-economic drivers of house price change by measuring credit market conditions, nominal and real mortgage rates and inflation. It also includes wealth effects, proxied by the natural log of real FTSE returns) and a set of regional and demographic drivers including the regional share of working population in the 20-39 age group and change in the ratio of working population to housing stock. The ratio of working population to housing stock is an important driver of house prices in the long-run. It acts as a link between the housing market model and the household formation model which, together with models of labour market states and earnings, and household migration, make up the Meen et al (2005) long run simulation model.

In Meen et al (2005), followed by Leishman et al (2008), housing construction is not modelled explicitly. Instead, the ratio of households (or working population) to dwellings is used, in essence, as an error correction term. This conceptual approach assumes that where, or when, this ratio is relatively high, so real house price change will tend to be high, and vice versa. The model specification builds in a combination of short run and long run effects. Changes to individuals' labour market states and earnings and the user cost of capital, for example, have short run effects on house price growth rates. The regional ratios of households to dwellings have long run effects – effectively accelerating or decelerating short-run adjustments in line with this measure of long run disequilibrium. These models reflect the idea that new housing supply affects house prices in an indirect fashion. Within a given region, the future rate of net additions to the housing stock alters the ratio of households to dwellings. This ratio is also affected by the future number of households as predicted by the household formation element of the simulation model. If the rate of net additions exceeds future household formation then the ratio of households to dwellings decreases, and this reduces the long run rate of real house price appreciation.

There have been several attempts to model new-build housing supply directly, with reference to construction cost, macro economic, planning and land supply, and demographic variables. Leishman and Bramley (2005) modelled house prices, rates of household migration between sub-regions and new-build housing supply simultaneously. They reported price elasticity of supply estimates ranging from 0.2 to 0.5. However, they also report a poor empirical performance for their supply equation, noting that new-build housing completions are driven by planning and land availability and demand side variables (such as house prices and change). Construction costs and interest rates are not particularly important in their model. A more complex version of their model estimated at sub-regional level in England (Bramley and Leishman, 2005) demonstrates stronger empirical performance. However, these results also suggest that new housing output at sub-regional level is driven primarily by the flow of land, planning permissions, house prices and area effects (proxied by spatial lag terms).

At the macro level, the conclusions may be quite different. For example, Tsoukis and Westaway (1994) found that the volume of housing construction is affected significantly and negatively by nominal interests rates and, to a lesser extent, positively by contemporaneous and future house price levels. They show that construction costs are relatively unimportant in terms of driving new supply. However, developers generally view interest rates as an important 'cost' factor. The Tsoukis and Westaway (1994) results suggest that interest rates affect construction in two ways: negatively in the long run, and positively in the short run. These findings are consistent with expectations since higher levels of interest rates should lower construction, given the importance of development finance to this form of investment. A rise in interest rates alters the relationship between housing starts and completions, reflecting developers' ability to speed up construction to avoid the higher opportunity cost of higher interest rates.

In a more detailed review of models of housing starts (and completions), Meen (1996) notes that most studies find that credit market conditions or borrowing constraints are found to be insignificant, but that house prices, construction costs and interest rates generally have the expected effects. He suggests that an early consensus model might include these variables together with land prices and credit availability (though, as noted, these proxies are generally not significant). A particularly important finding set out by Meen (1996) is of very stable construction equation coefficients at regional level. This is in contrast to house prices and earnings, the results for which suggest a strong degree of spatial dependence.

Interestingly, Meen (1996) points out that land costs or availability are generally not significant, though he points out that land availability may 'become' significant at smaller spatial units. For example, Bramley (1993) and Bramley and Leishman (2005) find, as noted earlier, that land supply and the flow of land with planning permissions are significant determinants of construction output at local or sub-regional levels. Perhaps more significantly, Bramley and Leishman (2005) find some evidence that coefficients vary between areas of low, high and 'mainstream' housing demand, although this hypothesis is not tested exhaustively. However, their suggestion accords with the 'backward bending' supply curve hypothesis suggested by Meen (1996) and Pryce (1999) and mirrors theoretical predictions made by Aura and Davidoff (2007). The latter predict that a rise in land supply in the context of a single U.S. local housing market would have relatively little impact on house prices, but that a significant price effect would result in response to a co-ordinated policy of land supply increase across many such markets. Leishman and Bramley (2005) show empirical evidence that higher rates of house building output in a single sub-regional area have relatively limited impact on price, but that higher rates of household inward migration may result instead. Concerted increases in land supply across a series of adjacent subregions would have a more significant effect on prices.

More recently, Fingleton (2008) has suggested that the effects of a rise in housing construction are not necessarily as readily predictable at sub-regional level as at regional or national level. He argues that higher rates of new housing supply may have important labour market effects – effectively increasing sub-regional household incomes and wealth with the possibility of increasing housing demand.

Many unanswered questions therefore remain in the context of housing and land markets. It is not clear why planning and the supply of land should be apparently unimportant at larger spatial scales while seemingly becoming important predictors of construction output at smaller scales. Similarly, the 'backward bending supply curve' hypothesis, while intuitively appealing, has not been subject to comprehensive empirical test. Yet, if the behaviour of the construction sector in response to housing market change varies spatially then this is at least suggestive that an important aspect of the housing system is not currently well understood. The next section picks up the argument from earlier in this one – that land prices should be of importance in partly determining construction activity, and that they are endogenous in the housing system.

3. DETERMINANTS OF HOUSING CONSTRUCTION AND LAND PRICES

Theoretical approach

The price of land suitable for housing construction is not exogenous, but is determined partly through the expectations of developers. Assuming that developers have perfect foresight and the market is sufficiently competitive to ensure normal profits, the price of development land should be the discounted residual of revenue generated from completed housing sales over development costs (see Leishman et al, 2000). Hence, developers expectations concerning the path of construction costs, housing prices and the short term rate of finance during the development period combine to determine their maximum land bids.

To simplify, assume that developers are myopic and that the land market clears within a single year. Developers' demand for land suitable for development can then be defined very simply:

$$D_L = \alpha_0 + \alpha_1 Ph_t - \alpha_2 C_t - \alpha_3 Si_t - \alpha_4 Pl_t \qquad (1)$$

Where,

Ph	Per unit price of housing
C	Per unit cost of new construction
Si	Short term rate of finance
Pl	Price of land suitable for development

An urban economics approach would define supply in relation to the profitability of a competing land use (agricultural rent) and the potential significance of supply constraints would not be accounted for. If we acknowledge that the supply of land suitable for development is derived from the stock either with planning permission or with strong potential for acquiring it then we can define the supply of developable land as:

$$S_L = \beta_0 + \beta_1 Pl_t + \beta_2 (1-\lambda) Sp_{t-1} \qquad (2)$$

Where Sp_{t-1} represents previous period stock of land with planning permission and λ represents the propensity of developers or land speculators to stockpile land with planning permission rather than offer for immediate supply. Rearranging and solving for Pl we obtain:

$$Pl_t = \mu_0 + \mu_1 Sp_{t-1} + \mu_2 Ph_t + \mu_3 C_t + \mu_4 Si_t \quad (3)$$

Where μ_1 represents a combination of the propensity of developers to stockpile land and the resultant price effect, and all other parameters represent non-identifiable combinations of parameters from (1) and (2), i.e:

$$Pl_t = \frac{\beta_0 - \alpha_0}{\beta_1 + \alpha_4} + \frac{\beta_2}{\beta_1 + \alpha_4}(1-\lambda)Sp_{t-1} - \frac{\alpha_1}{\beta_1 + \alpha_4} Ph_t + \frac{\alpha_2}{\beta_1 + \alpha_4} C_t + \frac{\alpha_3}{\beta_1 + \alpha_4} Si_t \quad (3a)$$

Construction starts may be taken as determined within a partial stock adjustment framework as set out by Muth (1960) and DiPasquale & Wheaton (1994). Year on year change to the housing stock depends on an adjustment parameter and the difference between a required or desirable equilibrium stock level and depreciated previous period housing stock:

$$\Delta HS = \gamma\left[HS_t^*(Ph_t, C_t, Si_t, Pl_t) - (1-\delta)HS_{t-1}\right] \quad (4)$$

Where,

γ Adjustment parameter
HS^* Desirable or equilibrium level of housing stock
δ Rate of depreciation of the existing housing stock

As noted in the previous section, empirical studies in the stock adjustment tradition do not generally find factor costs to be significant, and few studies have successfully included an appropriate measure of land prices, let alone found them to be important in determining construction starts. Interestingly, Meen (1996) also notes this point but suggests that the price of land may ‘become’ significant at smaller spatial scales.

From a theoretical standpoint, the definition of a desired or equilbrium housing stock on the basis of factor prices and costs is difficult to reconcile with the urban spatial economic model (Alonso, 1964; Muth, 1969). The desired level of housing stock is more logically a function of a city’s population, population density, household incomes and housing prices. Factor costs (and supply constraints) more logically affect the rate of adjustment of the housing stock to the desired level:

$$\Delta HS = \gamma(C_t, Si_t Pl_t)\left[HS_t^*(Pt_t, Pd_t, Y_t, Ph_t) - (1-\delta)HS_{t-1}\right] \quad (5)$$

Data and estimation approach

The remainder of this paper sets out estimation results drawing on data collected during a project funded by the UK Government’s National Housing and Planning Advice Unit (NHPAU). The project was designed to test the feasibility of modelling housing and labour markets, labour market migration and housing construction at sub-regional level in England. However, this paper concentrates on regional level models and a 1994-2007 study period. The results for sub-regional model of new housing supply, as well as housing prices, labour market status, labour market earnings and labour market migration are reported elsewhere (primarily in Andrew et al, 2010).

Results for two main models, both regional in scope, are reported:

i) The determination of the price of land suitable for housing construction;
ii) Determination of housing construction starts.

The land price model is closely related to equation (3). The model defines land prices as a function of the previous period stock of land with outline planning permission for housing development. Contemporaneous new housing prices, short term interest rates and an index of construction costs act as demand and cost shifters. The land price data is, in fact, a measure of mean valuations of housing development land rather than transaction price data. This variable, together with the mix-adjusted measure of new-build housing prices, was sourced from the UK Government's department of Communities and Local Government. The short term interest rate variable is the annual mean of the three month interbank interest rate. The construction cost index is a national measure derived from the Building Cost Information Service (BCIS) of the Royal Institution of Chartered Surveyors.

Two alternative approaches are taken to operationalise the model of construction starts. The first flows directly from equation (4). Construction starts are assumed to be a function of contemporaneous new-build housing prices, a construction cost index, the price of land suitable for housing development, short-term interest rates and lagged housing stock. The latter is designed to act as an error correction term, capturing the assumed tendency of construction activity to be partly related to disparity between the actual and a desirable level of housing stock.

The second approach modifies the way in which new housing prices, construction costs and short-term interest rates combine to determine construction activity. Specifically, the analysis tests whether a Q approach is appropriate (Tobin, 1969). In this context, the Q approach to modelling investment assumes that construction activity occurs when the price of new housing exceeds the costs of construction. To test this hypothesis, housing prices should enter the equation only when the ratio of an index of prices to an index of construction costs exceeds one, and are set to zero otherwise. However, a slightly different empirical approach is taken in this paper reflecting the fact that while housing price and construction cost change can be measured, it is not possible to predict per unit profitability of housing development with any accuracy.

4. EMPIRICAL ANALYSIS

As noted in the previous section, the model estimations are based on a dataset of 9 regions (government office regions) in England, measured over a 1994-2007 study period. The estimations employ a panel econometric approach, primarily to optimise the available but limited dataset. A disadvantage of this approach is that coefficients are, by definition, assumed to be constant across spatial units. However, some justification for this assumption has been reported by others in the context of the construction industry (see for example Meen, 1996). The main advantage is pragmatic: good quality data on the price or value of housing development land are not readily available prior to 1994.

Table 1 reports the results of three estimations that closely follow the specification set out by equation (4). Model 2 differs from model 1 in the inclusion of the new flow of land with outline planning permission, rather than the outstanding stock of land with permission. Model 3 includes both variables.

Table 1 Land price model initial estimation results

Variable	Model 1		Model 2		Model 3	
Constant	-7.447	***	-5.701	***	-5.719	***
l_Phn	2.016	***	1.922	***	1.912	***
l_Si	0.409	***	0.361	***	0.37	***
l_cind_r	-0.344	**	-0.258	*	-0.243	
l_plfh/st(-1)			0.275	***	0.293	***
l_plsh/st(-1)	0.175	***			-0.03	
sigma_u	0.293		0.272		0.28	
sigma_e	0.145		0.132		0.133	
rho	0.803		0.808		0.816	
R-sq: within	0.942		0.952		0.952	
R-sq: between	0.827		0.847		0.85	
R-sq: overall	0.871		0.88		0.882	
Wald / F	1731.92	***	2088.14	***	2079.17	***
Groups	9		9		9	
N	117		117		117	

Note: Dependent variable is l_Pl (natural log of real land price); *** significant at 1%; ** significant at 5%; * significant at 10%

The results are somewhat disappointing, with a number of 'incorrectly' signed coefficients. In particular, while new-build housing prices are positive and significant in each of the models, the index of real construction costs is significant only in models 1 and 2, though is correctly signed. Most concerning is the fact that the previous period stock or flow of land with outline planning permission is positively signed in each of the models. This is clearly not in accordance with a priori expectations and the overall conclusion must be that none of the initial models can be regarded as acceptable. Further experimentation with specification led to an alternative model as summarised in table 2.

Table 2 Revised land price model estimation results

Variable	AR and FE		AR		FE		no AR or FE	
Constant	2.634	***	-1.463		-2.27	*	-3.102	**
l_Phn	0.918	***	1.244	***	1.248	***	1.341	***
l_plsh/st(-3)	-0.25	**	-0.281	***	-0.391	***	-0.338	***
l_c_si(-2)	-0.357	***	-0.372	***	-0.358	***	-0.316	***
rho_ar	0.695		0.695					
sigma_u	0.365		0.241		0.301		0.236	
sigma_e	0.125		0.126		0.156		0.156	
rho_fov	0.896		0.784		0.788		0.695	
theta			0.6					
R-sq: within	0.516		0.92		0.921		0.921	
R-sq: between	0.813		0.821		0.794		0.812	
R-sq: overall	0.821		0.841		0.834		0.843	
Wald / F	27.69	***	353.9	***	337.42	***	1005.09	***

Groups	9	9	9	9
N	99	99	99	99

Note: Dependent variable is l_Pl (natural log of real land price); *** significant at 1%; ** significant at 5%; * significant at 10%

The revised land price model combines the construction cost index and short-term interest rates into a single variable. Experimentation revealed several specifications in which either of these original variables was revealed as negatively signed and statistically significant, but no specification in which both were simultaneously. Given that the cost of development is a combination of construction costs and the cost of short-term development finance, the combination of these variables in a single measure is justifiable, as well as empirically desirable in this case. The choice of lag for this variable is more difficult to justify: while contemporaneous new-build housing prices provide higher explanatory power than any other choice of lag, the interaction of construction cost index and short-term interest rates is significant only at two lags. This may suggest that developers respond more rapidly to housing prices than development costs in formulating their bids for development land.

The choice of appropriate lag for the planning variable is equally a combination of empirical and theoretical criteria. As noted earlier in the section, at one lag the stock of land with outline planning permission is statistically significant but correctly signed. The variable is not significant at two lags, but is significant and negatively signed at three lags. This somewhat strange set of results may be the result of endogeneity with respect to the stock or flow of land with planning permission and the supply of land actually entering the development process. Earlier in the paper it was argued that the supply of land for housing development should be at least a partial derivation from the stock of land with planning permission. Clearly, there are also feedback effects at work: on one hand, a rise in construction activity will deplete the stock of land with planning permission; on the other hand, the quantity of land taken by developers through the planning process is likely to be related to the level of construction activity and the rate at which the stock of land with permission is consumed by construction.

Table 2 reports a number of model variants: with and without fixed effects, and both with and without a first order autoregressive term. The justification for the latter is based on the instability of the coefficient on the stock of land with planning permission with respect to choice of lag. The results show some evidence of coefficient stability for this variable, and for new-build housing prices. However, all four estimations summarised in table 2 include a positive coefficient for housing prices and negative for both the construction cost / short-term interest rate variable and the lagged stock of land with planning permission (expressed as a proportion of annual construction starts). All three variables are statistically significant in each case.

The estimation results for the construction model are summarised in table 3. The dependent variable is the natural log of new housing starts, and all explanatory variables are also measured in natural logs. The models broadly follow the specification suggested by equation (4), but with several important differences. In particular, including lagged housing stock produced surprising results, as shown in the column summarising model 3. In this simple model with no fixed effects or autoregressive term, the coefficient on lagged housing stock is large and positive contrary to prior expectations of a small and negative coefficient. In fact, the coefficient is very unstable, as indicated by the substantial differences between the four estimation approaches in addition to change in sign. In a further attempt to capture the behaviour of construction activity as part of an adjustment process in establishing an equilibrium housing stock, the ratio of households to dwellings was included in the specification. This variable (with three lags) is significant only in the specification of model 1, which includes a first order autoregressive term but no fixed effects.

Table 3 Housing construction starts: initial estimation results

Variable	Model 1: with AR term		Model 2: AR & FE		Model 3: no AR / FE		Model 4: with fixed effects	
Constant	3.494	***	22.736	***	3.219	***	27.197	***
l_Phn	0.179	*	0.355	***	0.173	*	0.278	***
l_Pl	-0.102	*	0.07		-0.091	*	0.111	*
l_c_si(-2)	-0.145	**	-0.15	***	-0.154	***	-0.169	***
l_occst(-1)	0.816	***	-2.5	**	0.82	***	-3.042	***
l_hhst(-3)	-0.824	***	1.044		-0.315		0.649	
rho_ar	0.054		0.054					
sigma_u	0.057		1.193		0.098		1.365	
sigma_e	0.085		0.067		0.073		0.073	
rho_fov	0.314		0.997		0.642		0.997	
theta	0.576							
R-sq: within	0.312		0.544		0.34		0.503	
R-sq: between	0.957		0.93		0.928		0.908	
R-sq: overall	0.903		0.817		0.878		0.804	
Wald / F	244.47	***	18.11	***	109.93	***	17.21	***
Groups	9		9		9		9	
N	90		90		90		90	

Note: Dependent variable is l_ST (natural log of annual construction starts); *** significant at 1%; ** significant at 5%; * significant at 10%

The results also suggest some instability in terms of the land price variable. This is weakly significant in three of the four estimations (at the 10% level). New housing prices and the composite construction cost / short-term interest rate variable are positive/negative and statistically significant in all four models.

The final estimation results are shown in table 4. These concern the revised construction starts model specification and differ from those shown in table 3 in terms of the way housing prices and construction costs are treated in the model. Rather than including house prices together with a composite measure of construction costs and interest rates, the variable "ip/ic" represents the index of real new housing prices relative to the index of real construction costs. Short-term interest rates enter the model in two ways: "l_Si" is the log of short-term interest rates, and "dev_si" represents the deviation between short-term interest rates and the mean level observed over the 1994-2007 study period.

Table 4 Housing construction starts: Q specification results

l_ST	Model 1		Model 2		Model 3		Model 4	
Constant	5.175	***	5.343	***	4.931	***	4.9	***
l_Pl	-0.094	***	-0.11	***	-0.07	*	-0.068	***
ip/ic	0.013							
ip/ic(-1)			0.045					
ip/ic(-2)					-0.035			
ip/ic(-3)							-0.039	
l_Si(-2)	-0.251	***	-0.227	***	-0.262	***	-0.255	***
dev_si(-3)	-0.023	***	-0.022	***	-0.027	***	-0.028	***

l_occst(-1)	0.874	***	0.871	***	0.875	***	0.873	***
l_hhst(-3)	-0.772	***	-0.784	***	-0.787	***	-0.781	***
rho_ar	0.11		0.176		0.132		0.143	
sigma_u	0.058		0.057		0.058		0.058	
sigma_e	0.079		0.078		0.078		0.078	
rho_fov	0.35		0.351		0.357		0.355	
theta	0.584		0.561		0.582		0.577	
R-sq: within	0.425		0.423		0.43		0.43	
R-sq: between	0.953		0.954		0.952		0.952	
R-sq: overall	0.909		0.91		0.909		0.909	
Wald / F	261.32	***	252.88	***	255.16	***	255.95	***
Groups	9		9		9		9	
N	90		90		90		90	

As table 4 shows, the index of prices relative to costs is not statistically significant either contemporaneously or on a lagged basis. Extensive experimentation with the specification, excluding or including the other explanatory variables each in turn, did not yield any model in which the Q variable proved significant. However, as discussed earlier in the paper, a properly defined Q variable would measure the profitability of housing development for positive values only, and would be set to zero otherwise. Given the difficulty in defining the time periods in which residual values are positive or negative, the modelling approach adopted here is necessarily practical but suffers from limitations as a result.

5. SIMULATION RESULTS

Before summarising the results and providing concluding remarks, this paper now turns to a simple simulation exercise. The primary motivation for the paper was to consider the endogenous nature of the price of land suitable for housing development. Recent studies of housing construction in the UK have assumed that planning controls have a direct effect on construction activity (see for example Bramley and Leishman, 2005; Leishman and Bramley, 2005), or have assumed that land prices or land availability have little or no direct impact on construction. Studies based on the U.S. experience similarly suffer from poor availability of adequate land price data as discussed earlier in the paper.

Work focused on housing supply and affordability in England (Meen et al, 2005; Fingleton, 2008) and Scotland (Leishman et al, 2008) is concerned primarily with the question of housing affordability in the context of the supply of owner occupied housing. It seems appropriate in this context to provide simulation results drawing together the models of land prices and construction activity set out in this paper.

Tables 5 and 6 summarise the results. The simulation begins with an assumed 10% rise in the stock of land with outline planning permission. The simulated impact on construction activity occurs when the rise in the stock of land with development potential reduces, ceterus paribus, the price of land. This causes a rise in construction activity.

Table 5 Simulated impact on land values from an increase in land with planning permission

Region	Land values (£000)

	2008 (baseline)	2008 (after 10% rise in land with planning)	2012 (after 5 * 10% rises in land with planning)	Difference from baseline (%)
North East	1,655	1,602	1,409	-14.88
North West	2,015	1,951	1,715	-14.88
Yorkshire & Humberside	1,816	1,758	1,546	-14.88
East Midlands	1,926	1,864	1,639	-14.88
West Midlands	2,120	2,053	1,805	-14.88
East	2,878	2,787	2,450	-14.88
South West	2,454	2,376	2,089	-14.88
South East	3,810	3,690	3,243	-14.88
London	3,884	3,761	3,306	-14.88

Table 6 Simulated impact on construction starts from an increase in land with planning permission

Region	Construction starts			
	2008 (baseline)	2008 (after 10% rise in land with planning)	2012 (after 5 * 10% rises in land with planning)	Difference from baseline (%)
North East	7,646	7,903	8,008	4.74
North West	19,534	19,925	20,189	3.35
Yorkshire & Humberside	14,548	15,040	15,239	4.75
East Midlands	14,682	14,696	14,890	1.42
West Midlands	16,039	16,195	16,409	2.31
East	17,491	17,908	18,145	3.74
South West	16,843	17,084	17,310	2.77
South East	24,035	24,225	24,546	2.12
London	13,246	14,610	14,804	11.76

The simulation predicts a 14.88% decrease in land values per hectare resulting from five successive 10% annual increases in the stock of land with outline planning permission (table 5). The results do not vary by region. However, the predicted impact on construction starts do differ regionally. These are shown in table 6. The drop in real housing land values leads to a rise in construction starts ranging from 1.42% (East Midlands) to 11.76% (London). The predicted effect in London is significantly larger than in any other region. In general, the predicted impact on construction starts is muted in southern regions (particularly the South East, South West) compared with northern regions.

6. CONCLUSIONS

The overarching aim of this paper has been to integrate the economics of the land market and implications of planning controls in a housing construction modelling framework. Many previous studies have either failed to include data on housing land prices, or have not found this information to be significant to the determination of housing construction activity. Ignoring land prices, or failing to explain their determination adequately, omits an important aspect of the planning, land and housing system. Land prices are at least partly determined through the bids that developers make for the acquisition of land. In turn, these are influenced by developers' expectations about key development variables including new-build housing prices, construction costs and short-term interest rates.

The analysis presented in this paper suggests that the lagged stock of land with planning permission for development is a partial determinant of the current price of land suitable for housing development. By establishing this indirect link between the supply of land procured by the planning system, the supply of land for housing development and land prices, this study contributes to our understanding of the planning, land and housing system. Unlike recent studies that have assumed a direct impact of planning on construction activity, this paper has assumed the impacts to be intermediated through the land market.

The analysis of housing construction starts produced plausible (negative) and statistically significant coefficients for land prices. Together, the regional land price and regional construction starts models suggest that a reduction in the stock of land with planning permission gives rise to an increase in the price of land. This feeds through to cause a reduction in construction activity. However, although they are statistically significant, the magnitude of these effects is small. This reinforces findings from earlier studies, particularly those with a local or sub-regional focus, that a significant stimulus to total construction output in the housing sector would require a substantial increase in the quantity of land brought forward for housing development by the planning system.

There are a number of areas in which the analysis presented in this paper could be developed further. For example, the treatment of developers' expectations has been simplistic. The land price model reported here assumes that developers are concerned with current or recent past housing prices, construction costs and interest rates. Other studies have suggested that developers' methods of forecasting the future path of key development variables makes a difference to housing market outcomes (see for example Antwi & Henneberry, 1995; Leishman et al, 1999; Tsoukis & Westaway, 1994).

In addition, the study period considered in this paper is relatively short: 1994-2007. To permit the estimation of the models set out in this paper, a panel econometric approach has been adopted. While there is evidence presented elsewhere that housing construction may behave like a national market, rather than a set of regional markets, this assumption has not been tested directly in this paper.

Extending the modelling approach set out here to consider sub-regional markets is a particular challenge for future research. The results reported for regional level markets suggest that land prices are an important part of the dynamics of housing and construction markets. Yet, reliable and appropriate data on housing land prices are not available below regional level in the UK. As several other studies have suggested, ignoring the endogeneity of land market outcomes in models of housing prices and construction activity omits an important aspect of the housing system, with the resultant risk of misleading empirical results.

REFERENCES

Alonso, W. (1964) *Location and Land Use: Toward a General Theory of Land Rent*, Cambridge (Mass): Harvard University Press

Andrew, M., Bramley, G., Leishman, C., Watkins, D. and White, M. (2010) *Subregional market modelling feasibility: main report on model testing and feasibility*, London: National Housing and Planning Advice Unit

Antwi, A. and Henneberry, J. (1995) Developers, non-linearity and asymmetry in the development cycle, *Journal of Property Research*, Vol. 12, No. 3, 217-239

Aura, S. and Davidoff, T. (2007) Supply constraints and housing prices, *Economic Letters* 99(2), 275-277

Blackley, D.M. (1999) The long run elasticity of new housing supply in the United States: empirical evidence for 1950 to 1994, *Journal of Real Estate Finance and Economics* 18(1), 25-42

Bramley, G. (1993) The impact of land use planning and tax subsidies on the supply and price of housing in Britain, *Urban Studies* 30(1), 5-30

Bramley, G. and Leishman, C. (2005) Planning and housing supply in two-speed Britain: modelling local market outcomes, *Urban Studies* 42(12), 2213-2244

DiPasquale, D. (1999) Why don't we know more about housing supply? *Journal of Real Estate Finance and Economics* 18(1), 9-23

DiPasquale, D. and Wheaton, W.C. (1994) Housing market dynamics and the future of housing prices, *Journal of Urban Economics* 35(1), 1-27

Fingleton, B. (2008) Housing supply, demand and affordability, *Urban Studies* 45(8), 1545-1563

Follain, J.R. (1979) The price elasticity of the long-run supply of new housing construction, *Land Economics* 55(2), 190-199

Glaeser, E., Gyourko, J. and Saks, R.E. (2006) Urban growth and housing supply, *Journal of Economic Geography* 6, 71-89

Glaeser, E., Gyourko, J. and Saiz, A. (2008) Housing supply and housing bubbles, *Journal of Urban Economics* 64(2), 198-217

Grimes, A. and Aitken, A. (2010) Housing supply, land costs and price adjustment, *Real Estate Economics* 38(2), 325-353

Leishman, C. and Bramley, G. (2005) A local housing market model with spatial interaction and land use planning controls, *Environment and Planning A* 37(9), 1637-1649

Leishman, C., Gibb, K., Meen, G., O'Sullivan, T., Young, G., Chen, Y., Orr, A. and Wright, R. (2008) *Scottish model of housing supply and affordability: final report*, Edinburgh: Scottish Government

Leishman, C., Jones, C. and Fraser, W.D. (2000) The influence of uncertainty on house builder behaviour and residential land values, *Journal of Property Research*, Vol. 17, No. 2, 147-168

Leishman, C. and Bramley, G. (2005) A local housing market model with spatial interaction and land use planning controls, *Environment and Planning A*, Vol. 37, No. 9, 1637-1649

Leishman, C., Gibb, K., Meen, G., O'Sullivan, A., Young, Y., Chen, Y., Orr, A. and Wright, R.E. (2008) *Scottish model of housing supply and affordability*, Edinburgh: Scottish Government

Maisel, S.J. (1963) A theory of fluctuations in residential construction starts, *American Economic Review* 53(3), 359-383

Malpezzi, S. (1999) A simple error correction model of house prices, *Journal of Housing Economics* 8(1), 27-62

Mayer, C.J. and Somerville, C.T. (2000) Residential construction: using the urban growth model to estimate housing supply, *Journal of Urban Economics* 48(1), 85-109

Meen, G. (1996) Spatial aggregation, spatial dependence and predictability in the UK housing market, *Housing Studies* 11(3), 345-373

Meen, G. et al (2005) *Affordability targets: implications for housing supply*, London: Office of the Deputy Prime Minister

Meen, G. (2000) Housing cycles and efficiency, *Scottish Journal of Political Economy* 47(2), 114-140

Montgomery, C.A. (1996) A structural model of the US housing market: improvement and new construction, *Journal of Housing Economics* 5(2), 166-192

Muth, R.T. (1960) "The demand for non-farm housing", in *The demand for durable goods*, (A.C. Harberger, Ed.), pp 27-96, Chicago: University of Chicago Press

Muth, R.F. (1969), *Cities and Housing*, Chicago University Press

Olsen, E.O. (1987) "The demand and supply of housing services: a critical review of the empirical literature," in *Handbook of regional and urban economics*, (E.S. Mills, Ed), Vol. 2, Amsterdam: Elsevier

Poterba, J.M. (1984) Tax subsidies to owner occupied housing: an asset market approach, *Quarterly Journal of Economics* 99(4), 729-752

Pryce, G. (1999) Construction elasticities and land availability: a two-stage least squares model of housing supply using the variable elasticity approach, *Urban Studies* 36(13), 2283-2304

Roback, J. (1982) Wages, rents and the quality of life, *Journal of Political Economy* 90(6), 1257-1278

Tobin, J. (1969) A general equilibrium approach to monetary theory, *Journal of Money, Credit and Banking* 1(1), 15-29

Topel, R. and Rosen, S. (1988) Housing investment in the United States, *Journal of Political Economy* 96(4), 718-40

Tsoukis, C. and Westaway, P. (1994) A forward looking model of housing construction in the UK, *Economic Modelling* 11(2), 266 - 279

Appendix - Variable sources and definitions

l_Phn	Natural log of real new-build housing prices (sourced from Communities and Local Government live tables)
l_Pl	Natural log of real housing development land values expressed per hectare (sourced from Communities and Local Government live tables)
l_c_si	Natural log of real construction cost index multiplied by the short-term cost of borrowing (3 month interbank rate)
l_occst	Natural log of the owner occupied housing stock
l_hhst	Natural log of the ratio of total households to owner occupied housing stock
l_plsh/st	Natural log of the regional stock of land with planning permission, expressed as a proportion of annual construction starts
st	Natural log of private housing starts (sourced from Communities and Local Government live tables / NHBC statistics)
ip/ic	Ratio of the real new-build housing price index to real construction cost index
dev_si	Deviation of the short-term cost of borrowing from the study period mean