Impacts of Land Availability, Housing Supply and Planning Infrastructure on New Zealand House Prices

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Abstract

We summarise and synthesise results from several studies dealing with the impacts of land availability, housing supply and associated planning infrastructure on New Zealand house prices. New house supply is responsive to the ratio of house prices to development costs as predicted by Tobin's q-theory. Development costs, in turn, are influenced by construction costs and land costs. Qualitative evidence indicates that restrictions on land supply around Auckland – partially a result of that city's planning infrastructure – are instrumental in raising land costs for that city, and this is substantiated by econometric analysis of the determinants of Auckland land values. Consenting processes also limit house supply responsiveness in Auckland. Our analysis shows that house supply responsiveness varies across New Zealand. In line with theory and with results of international studies, we show that regions with high supply responsiveness have relatively small price spikes following demand shocks.

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1. Introduction

High house prices are of current policy concern owing to their impacts on housing affordability. House ownership has declined in New Zealand over the past two decades and prospective ownership rates are expected by some to decline still further (DTZ, 2007). The high *level* of house prices are of particular policy concern where the planning infrastructure (e.g. legislative and regulatory restrictions) and related policy actions have themselves placed pressures on housing affordability. House price *dynamics* are also of policy importance. Resources may be misallocated where short run prices diverge from equilibrium. In addition, sharp movements in house prices interact with broader inflation pressures and can complicate the conduct of monetary policy.

Given these concerns, we analyse a number of features of New Zealand's regional housing markets: new house supply determinants, effects of regulation on land prices, and the dynamics of price adjustment. We draw on three recent studies. The first, Grimes and Aitken (GA, 2006), examines the relationship between new housing supply and the dynamics of house price adjustment. It treats land and house supply as fixed in the very short run, so demand shocks are reflected initially in prices rather than in quantities. New house supply reacts to the price of existing houses relative to the cost of developing new houses. Rational agents anticipate these supply responses in their pricing decisions following a demand shock; thus the dynamics of price adjustment are related to anticipated local house supply responsiveness.

We model the determinants of new housing supply. Despite its theoretical and intuitive attractiveness, previous studies have struggled to apply a Tobin's "q" approach to explaining investment in housing.[1] There has even been debate as to whether the standard q-theory approach (in levels) is appropriate for modelling housing starts (Mayer and Somerville, 2000b). We demonstrate that with a suitably specified model, a q-theory specification (in levels) is consistent with the time series properties of the data and does satisfactorily explain intended housing starts. We apply the theory to a panel dataset covering 53 quarters across 73 New Zealand TLAs (3,869 observations).

[1] Harter-Dreiman (2003) notes that a broad consensus about the supply elasticity of housing does not exist.

Our results demonstrate that application of q-theory to housing supply should include not only the house price and construction costs (standard in most prior specifications) but also the cost of land. We find strong, statistically significant, impacts of each relevant variable on new housing supply. We estimate the hypothesised relationship initially with coefficients restricted across regions and subsequently without restrictions. The cross-region restrictions are not accepted, implying that supply elasticities are region-specific, even after accounting for region-specific land prices. This finding is consistent with the existence of regulatory differences across local authorities.

Our second analysis examines the impacts of regulation on Auckland land and house prices. Qualitative (interview-based) data reported in Grimes, Aitken, Mitchell and Smith (GAMS, 2007) indicate that several regulatory issues impede the supply of new housing in the Auckland region. These include consent-related processes as well as zoning restrictions. A separate analysis, Grimes and Liang (GL, 2007) explicitly analyses the impact of Auckland's Metropolitan Urban Limits (MUL) on Auckland land prices, a key piece of planning infrastructure. In accordance with the qualitative evidence, this study finds highly significant (and material) impacts of the MUL on land costs.

Our third area of analysis examines the relationship across New Zealand between supply and price dynamics. The results (from GA) demonstrate that regions with higher supply responsiveness have smaller price spikes following demand shocks. This is consistent with a rational response that limits the jump in house prices in regions that have strong supply responses. In areas with weak supply response, prices jump further since new supply is not forthcoming in the near term to meet the higher demand.

To illustrate the supply results, Figure 1 presents a scatter plot of the relationship between new housing consents (expressed as a percentage of the existing housing stock) versus the logarithm of house prices relative to development costs (devcost).[2] The scatter plot

[2] Development costs are calculated as a logarithmically weighted average of construction costs (2/3) and land costs (1/3) in line with estimates subsequently in the paper.

covers all 3,869 observations using de-meaned data for each region. A clear positive supply relationship can be discerned. The relationship between supply responsiveness and the degree of price adjustment following a demand shock is summarised in a scatter plot for the relevant 73 regional supply and price adjustment parameters in Figure 2. The relationships underlying this plot are discussed further in the paper; for now, the posited negative relationship between the two can be seen.

Section 2 of the paper outlines our application of q-theory to housing investment together with the associated model for house price dynamics and sets out our hypothesis linking supply responsiveness to price dynamics. Section 3 presents estimates of the house price equations, while section 4 presents results for the supply relationship. In each case, we examine the time series properties of the data to ensure appropriate dynamic specifications. Section 5 examines supply issues pertaining particularly to Auckland. We present the supply relationships specifically for local authorities in the Auckland region. In addition, we summarise evidence regarding supply constraints and provide estimates of the impacts of the MUL on Auckland land prices. Section 6 conducts tests of the relationship between supply responsiveness and price dynamics. Concluding remarks are contained in section 7.

2. Housing Supply and Price Dynamics: Theory

We treat housing developers as profit-seeking agents within regional housing markets that are subject to demand shocks. New housing supply is subject to quadratic adjustment costs so new supply does not immediately jump to fulfil increased demand at the pre-existing price. House prices, being asset prices, jump to equilibrate demand and supply at all times. Other prices, particularly land prices, also adjust in response to demand shocks. Over time, the prices, costs and quantities of housing adjust to establish long run spatial equilibrium whereby benefits and costs of living in an area are equated (Roback, 1982).

This framework is isomorphic to the standard firm investment problem addressed by Tobin (1969) [see also Yoshikawa, 1980; Hayashi, 1982] and so yields a supply equation of the standard q-theory form (in levels), together with dynamic price adjustment given by the inverse of the demand function. We use variables relevant to housing in place of the standard capital investment variables for the firm decision.[3]

A developer (with constant returns to scale production function) seeks to build a new house where the expected house sale price (determined, through arbitrage, by the prices of existing houses in the region) exceeds replacement cost (i.e. the full costs of developing and building the house). We assume that a house built in period t is destined for sale in t+1. The expected sale price in t+1, given information at time t, is denoted PH^e_{t+1}. The developer's total costs (TC_t) comprise land costs borne in period t (PL_t), building costs (materials and labour) in period t (PB_t) and financing costs (determined by r_t, where r_t is the nominal interest rate, adjusted for a risk premium, between t and t+1).[4]

The planned rate of change in housing supply between t and t+1 is equal to the rate of new housing consents granted in t (HC_t) relative to the existing housing stock (H_{t-1}).[5] We use housing consents as a measure of planned changes since a new house can be constructed legally only following the granting of a consent by the relevant territorial local authority (TLA), which is the unit of analysis in the study. Expressing the relationship in log-linear form, and allowing the coefficients (γ_{i0}, γ_{i1}) to be potentially region-specific,[6] we hypothesise that new housing supply for each region i is given by the q-theory relationship in equation (1) (in which ε_{it} is an iid error term):

$$HC_{it}/H_{it-1} = \gamma_{i0} + \gamma_{i1}\ln\{PH^e_{it+1}/TC_{it}\} + \varepsilon_{it} \qquad (1)$$

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[3] Fettig, 1996 notes that Tobin suggested use of this relationship for studies of housing investment.
[4] For related approaches see Follain (1979), Poterba (1984), Topel and Rosen (1988), Capozza and Helsey (1989), DiPasquale (1999), Blackley (1999), Meen (2000), Tsoukis and Westaway (1994), Mayer and Somerville (1996, 2000a, 2000b) and Jud and Winkler (2003). However virtually all of these approaches omit the price of residential land or, as in DiPasquale and Wheaton (1994), use farmland prices as a (possibly inappropriate) proxy for the price of residential land.
[5] Note that $HC_t/H_{t-1} \cong \Delta\ln H_t$ provided all consents in period t are converted into new houses and there is no scrapping of existing houses. In practice, there is some scrapping and some consents are not actioned; these effects are minor and are catered for with time and region fixed effects in the estimated equations (where effects are consistent over time and/or over regions) and in the error term (where effects are random).
[6] Subsequently, we treat the term γ_{i0} as a nationwide constant, γ_0, plus a vector of area fixed effects.

We model expected house prices, PH^{e}_{it+1}, as a function of existing house prices in region i at period t, together with a region-specific growth factor (proxied by a vector of region-fixed effects, FE_i, with associated coefficient vector, λ_i) and a nationwide time-specific growth factor (proxied by time fixed effects, FE_t, with associated coefficient vector, λ_t). Thus for region i, we postulate:

$$\ln(PH^{e}_{it+1}) = \ln(PH_{it}) + \lambda_i FE_i + \lambda_t FE_t \qquad (2)$$

Total costs are modelled as a divisia index of land and building costs; both land and building costs are relevant to the developer in deciding whether to purchase a plot of land plus construction materials and labour for a specific housing development. In addition, we include financial costs, reflecting the costs of borrowing to cover construction materials, labour and land from t until sale of the house in t+1:

$$TC_{it} = [e^{\alpha i} PL_{it}^{\beta i} PB_{it}^{1-\beta i}](1+r_t) \qquad (3)$$

Combining equations (1) to (3) we obtain the q-theory equation, (4), for housing supply:

$$HC_{it}/H_{it-1} = \lambda'_0 + \gamma_{i1}\ln\{PH_{it}/PB_{it}\} + \mu_i \ln\{PB_{it}/PL_{it}\} + \lambda'_i FE_i + \lambda'_t FE_t + \varepsilon_{it} \qquad (4)$$

where $\mu_i = \gamma_{i1}\beta_i$, the λ'_t incorporate the impact of r_t plus any time-specific risk premia plus other time fixed effects, the λ'_i incorporate all region-specific fixed effects from equations (1) to (3), and λ'_0 is the overall constant term excluding time and area fixed effects.

Mayer and Somerville (2000b) criticise use of the levels q-theory specification since they find that the housing investment rate and the price and cost explanatory variables are integrated of different orders, so housing investment cannot be a function of the (log) levels of prices and costs. As demonstrated in section 4, our data also indicate that the housing investment rate is stationary (across the panel) while each of the house price and cost variables is non-stationary. However, the relevant comparison is with the ratio of house prices to total development costs, where the latter includes land costs and where development costs are weighted regionally according to the respective contributions of land and construction costs in each region. Once these factors are accounted for, the levels q-theory specification is accepted econometrically.

House prices are a jump variable, equating short run housing demand with fixed short run supply. Accordingly, house prices can be modelled as an inverse demand function, taking supply as given in the short run. Pain and Westaway (1996) demonstrate that a standard consumer optimisation problem over current and future housing and non-housing consumption goods yields the inverted demand curve in period t:

$$\ln(p^h_t/p^c_t) = (1-\delta)\ln(\theta) - \delta\ln(h_t/pop_t) + \delta\ln(cx_t) - \ln(uc_t) \qquad (5)$$

where p^h_t is the price of housing; p^c_t is the price of non-housing consumption goods; δ is the coefficient of relative risk aversion (within a representative constant relative risk aversion utility function); θ is the (constant) ratio of housing services to the housing stock, h_t; pop_t is population; cx_t is per capita non-housing consumption; and uc_t is the real user cost of capital. Empirical application of this approach takes the stock of houses, h, as contemporaneously fixed (so can be treated as exogenous in the price equation). Prices adjust after a demand shock towards the equilibrium value based on the current stock of houses; however, the nature of price adjustment will differ depending on the nature of the short term supply response.[7]

The importance of housing supply responsiveness for price dynamics following a demand shock can be seen from the demand and supply graph in Figure 3. House prices and quantities (P and Q respectively) are depicted on the axes; the line marked D is the demand curve for houses; the line marked S^L is the long run supply curve for houses. Equilibrium is initially at prices and quantities (P_0, Q_0). Housing demand then shifts

[7] See Capozza et al (2002) for a related approach in the United States, and Grimes and Aitken (2004) for application of this approach to New Zealand.

permanently upwards (to the line marked D').[8] In (5), this will be reflected through an increase in cx. In the long run, the price and quantity of housing settles at (P_L, Q_L).

In the short run, house supply does not respond fully. Consider the perfectly inelastic short run supply curve, S^S. Prices initially jump to the short run equilibrium at P_1. Price P_1 can be derived directly from (5) using the new value for cx, holding all other variables constant, including h (since supply is assumed perfectly inelastic).

Now consider a case with more responsive short run housing supply, given by short run supply curve, S'^S. The new short run equilibrium price will be at P_2. Denote P_1-P_0 as ΔP_1 and P_2-P_0 as ΔP_2 . From Figure 3, $\Delta P_2 = \eta\Delta P_1$, where $0<\eta<1$, and where $\partial\eta/\partial\gamma_{i1}<0$ (recalling that γ_{i1} is the short run elasticity of housing supply). If we were to calculate the short run equilibrium price, P*, as P_1 (i.e. derived on the assumption of a zero short run supply elasticity) and estimate a short run adjustment equation such as (6), we would expect that the adjustment coefficient, η_i, will be close to 1 (respectively 0) where short run supply is inelastic (elastic):[9]

$$\Delta \ln P_{it} = \eta_i(\ln P^*_{it-1} - \ln P_{it-1}) \qquad (6)$$

Glaeser and Gyourko (2005) emphasise the importance of house supply in determining house prices and mediating urban dynamics. When supply expands quickly in response to demand pressures the housing stock and population can grow quickly with little pressure on house prices. Recent evidence indicates that regulation plays an important role in affecting the elasticity of new housing supply; see, for example: Mayer and Somerville (2000a), Glaeser and Gyourko (2002, 2003), Glaeser et al (2005a, 2005b, 2005c), Green et al (2005) and Quigley and Raphael (2005). Glaeser et al (2005b) point out that new construction has fallen and housing prices have risen dramatically in a small, but increasing number of places. They argue that this is primarily due to increasing

[8] This may occur, for instance, due to a permanent positive employment increase for a given population within the region.
[9] This specification assumes that short run adjustment responds to demand shocks in the previous quarter; other adjustment dynamics can be catered for through slightly different dynamic specifications.

regulatory barriers to large-scale residential development. Green el al (2005) estimate supply elasticities for 44 U.S. metropolitan areas following a model based on Capozza and Helsey (1989). Using survey data on land regulation they estimate supply elasticities and find that areas that are heavily regulated exhibit lower elasticities.

Building on these insights, we seek to determine whether local authorities that have relatively high short run supply responsiveness have less volatile price dynamics following demand shocks. In contrast to the cited studies, we have data that enable us both to estimate supply elasticities explicitly, and to estimate the dynamics of price adjustment. We estimate supply responsiveness (γ_{i1}) in section 4. In order to estimate price dynamics (section 3), we estimate a standard cointegrating regression for house prices (to determine P^*_i), and then estimate a version of (6) to estimate the dynamic adjustment coefficient, η_i. Our hypothesis is that areas with high values of γ_{i1} will have low values of η_i; thus the relationship between γ_{i1} and η_i will be significantly negative.

3. House Price Dynamics: Estimation

We base our specification of P*, the short run equilibrium price (given h_{t-1}), on Grimes and Aitken (2004) that used a cointegration approach to modelling prices. The log of real house prices [i.e. $\ln(PH_{it}/PC_t)$ where PC_t is the economy-wide consumers price index] is regressed against the log of dwelling density [lnDD; i.e. $\ln(h_t/pop_t)$ in (5)], the real user cost of capital [UC; i.e. uc_t in (5)],[10] plus two variables proxying determinants of per capita non-housing consumption, cx_t in (5), being: lnXPROD (the log of per capita regional production) and lnXEMP (the log of employment as a ratio of population of working age).

Table 1 presents panel unit root tests of each of these variables under the null hypothesis of a unit root. The Levin, Lin and Chu (LLC) test assumes common unit root processes across the panel, while the Im, Pesaran and Shin (IPS) and Augmented Dickey-Fuller (ADF) tests assume individual unit root processes; we include an individual time trend

[10] We enter uc, multiplied by a freely estimated coefficient, rather than log(uc) since uc is negative in some quarters for some areas. As in Grimes and Aitken (2004) we proxy real capital gains expectations within the uc term as the last three years' annual rate of real capital gain within the area.

and intercept in each case.[11] With the exception of the dwelling density variable, $lnDD_{it}$, no test rejects a unit root for any of these variables; for $lnDD_{it}$, the IPS and ADF tests do not reject a unit root. We therefore treat each of these variables as being non-stationary. In addition, the table presents unit root tests on a variable included in the dynamic equation of Grimes and Aitken (2004) - the ratio of house sales to the housing stock (S_{it}). Each of the tests rejects a unit root for this variable and so it is omitted from the cointegrating equation.

In estimating the cointegrating equation, we restrict the long run coefficients on the variables to be identical across regions reflecting shared underlying preferences. Area fixed effects are included; time fixed effects are replaced by inclusion of an area-specific time trend for each TLA to account for long run (deterministic) trends in tastes towards different regions (e.g. towards climate or coastal proximity). The resulting equation is estimated using pooled least squares (PLS) since all variables are non-stationary making PLS estimates super-consistent. The results are presented as (7):

$$\ln(PH_{it}/PC_t) = \underset{\substack{(0.0710)\\ [0.0000]}}{0.4514}\ln XPROD_{it} + \underset{\substack{(0.1780)\\ [0.0000]}}{0.9484}\ln XEMP_{it} - \underset{\substack{(0.2616)\\ [0.0000]}}{2.9811}\ln DD_{it} - \underset{\substack{(0.0007)\\ [0.0000]}}{0.0138}UC_{it} \qquad (7)$$

$Adj.R^2 = 0.972$; s.e. = 0.0738; n=3,942 (1991q1-2004q2)

Constant, area FEs and area-specific time trends included but not reported; White period standard errors in round brackets; p-values in square brackets; mean of dependent variable = 4.6355 (std dev = 0.4416).

The residual from (7) is stationary: the null of a unit root is rejected at p=0.0000 for each of the LLC, IPS and ADF tests. Equation (7) therefore represents a valid cointegration relationship. For the purposes of our study, it is the dynamic response of house prices to a demand shock - i.e. to the explanatory variables in (7) - that is of major interest. We

[11] The results are robust to inclusion or exclusion of a time trend. Further tests indicate that first differences of the variables are each stationary, and so these results are not reported.

estimate an adjustment equation, standard in the cointegration approach[12] and consistent with (6), as shown in (8):

$$\Delta\ln(PH_{it}/PC_t) = \eta_0 + \eta_{i1}[\ln(PH_{it-1}/PC_{t-1})^* - \ln(PH_{it-1}/PC_{t-1})] + \eta_2 S_{it-2} + \zeta_{it} \quad (8)$$

where ζ_{it} is an iid error term, and S_{it-2} is the ratio of house sales to housing stock in region i in period t-2. We include this variable since earlier research (Grimes and Aitken, 2004) indicates that prior sales strongly influence price dynamics. The coefficient on the disequlibrium term, η_{i1}, is the responsiveness of house prices in period t to a demand shock in period t-1 in region i. Initially we estimate (8) with η_{i1} restricted to be identical across regions and then estimate the panel with η_{i1} unrestricted.[13] Results of estimating (8), with η_{i1} restricted, using PLS are shown as (9):[14]

$$\Delta\ln(PH_{it}/PC_t) = \underset{\substack{(0.0034)\\ [0.0000]}}{-0.0170} + \underset{\substack{(0.0309)\\ [0.0000]}}{0.5816}[\ln(PH_{it-1}/PC_{t-1})^* - \ln(PH_{it-1}/PC_{t-1})] + \underset{\substack{(0.2202)\\ [0.0000]}}{1.6807}S_{it-2} \quad (9)$$

Adj.R^2 = 0.287; s.e. = 0.0671; n=3,869 (1991q2-2004q2)
White period standard errors in round brackets; p-values in square brackets.

When re-estimated with η_{i1} unrestricted, the estimates of η_{i1} vary across regions with a mean of 0.50 and standard deviation of 0.22. The standard deviation indicates that substantial variation in adjustment dynamics across regions is apparent. In section 6, we examine whether the variation in adjustment dynamics across regions is related to regional house supply responsiveness.

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[12] Engle and Granger (1987). We have reversed the order of variables within the adjustment term compared with the usual ordering to aid interpretation without any change to methodology.
[13] The equation does not include area fixed effects; when added, they are jointly insignificant and other coefficients remain virtually unchanged.
[14] PLS is appropriate since all explanatory variables are lagged. There is little evidence of autocorrelation (DW=2.08) but since the Durbin-Watson statistic is not appropriate in the presence of a lagged dependent variable, we report (robust) White period standard errors. Equation estimates are unweighted; estimates are virtually unchanged using GLS with period weights; when cross-section weights are used the estimate of η_1 and η_2 fall a little to 0.4710 and 1.5027 respectively. Population-weighted estimates are similar, as are estimates weighted by housing stock and also by house sales.

4. Housing Supply: Estimation

We estimate housing supply elasticities, based on equation (4), using four separate approaches. Initially, we estimate the equation by pooled least squares (PLS), firstly with coefficients restricted to be identical across regions (other than the regional fixed effects) and secondly with unrestricted coefficients. We test the validity of the restrictions across regions. Subsequently, we estimate the equation using instrumental variables (IV). We do so: (a) because of the potential simultaneity between building consents in period t and the price and cost terms in period t, and (b) because of potential errors in variables problems. We estimate the IV equations in both restricted and unrestricted forms. The instruments comprise the set of variables appearing in the house price equation reported in section 3.[15] Because of the likely simultaneity in the system, the IV results are our preferred estimates. In all cases, we report standard errors using White period standard errors that are robust to arbitrary within cross-section residual autocorrelation.

Prior to estimating (4), we address the issue raised by Mayer and Somerville relating to the order of integration of the relevant variables. Table 2 presents the equivalent unit root tests to those in Table 1 for the variables included directly and indirectly in the housing investment equation, (4). In some cases, inclusion or exclusion of individual time trends alters the results substantially, so we include both sets of tests.[16]

Consistent with Mayer and Somerville, we can reject non-stationarity of the dependent variable (i.e. the rate of planned housing investment) according to all six test statistics. The results for the ratio of house prices to construction costs [$\ln(PH_{it}/PB_{it})$] depend on the test and on whether a time trend is included or not, while the results for the ratio of construction costs to land prices [$\ln(PB_{it}/PL_{it})$] generally do not reject a unit root. Tests on the individual price and cost variables also do not clearly reject a unit root. Together, these results appear consistent with the findings of Mayer and Somerville that the

[15] Thus the set of instruments is: $\ln XPROD_{it-1}$, $\ln XEMP_{it-1}$, $\ln DD_{it-1}$, UC_{it-1}, S_{it-2}. We have also estimated the supply equation using the fourth lag of each instrument to test robustness in case of serial correlation in the instruments. The IV estimates are virtually unchanged, as is the equation's explanatory power.

[16] All levels variables that have a unit root are stationary in first differences.

housing investment rate (i.e. the dependent variable) is stationary while the explanatory variables that are derived from the levels specification of the q-theory are non-stationary.

These tests, however, are inadequate in the case where a linearly weighted combination of explanatory variables is itself stationary. The penultimate variable tested in Table 2 is the variable depicted on the horizontal axis of Figure 1, being (the log of) the ratio of the house price to development costs [$\ln(PH_{it}/DEVCOST_{it})$] where the latter is determined using a ratio of two-thirds construction costs and one-third land costs for each region. In this case, we can reject a unit root for three of the six tests, but not for the other three.

A further complication arises where the proportion of land to construction costs in total development costs differs across regions. Our data cover local authorities for the entire country; different land and construction cost weights should be expected for urban relative to rural areas (and for dense urban areas relative to less dense urban areas). Our estimates of (4), reported below, indicate that we cannot restrict these proportions to be identical across regions; we must therefore weight the costs by region-specific weights to determine regional development costs. The (de-meaned) ratio of house prices to regionally-weighted development costs is, in effect, given by the estimated equation error term, ε_{it}. Tests of this residual[17] are presented in the final two rows of Table 2.

As is the case for the dependent variable, each of these six test statistics rejects a unit root. Thus once land and construction costs are weighted using regionally appropriate weights, the ratio of house prices to development costs is a stationary variable despite non-stationarity of the underlying price and cost variables. This result depends: (a) on including land costs as well as construction costs in the specification, and (b) allowing weights to vary regionally. Both of these characteristics are in keeping with 'real world' observations, but differ from prior applications of q-theory to housing investment.

Estimation results based on (4) are reported in Table 3; all equations include both region and time fixed effects. The key parameter determining responsiveness of new housing

[17] The residuals are obtained from our preferred results reported below in column 4 of Table 3.

supply to demand shocks (reflected in house prices) is γ_{i1}. In the restricted PLS equation, γ_{i1} is significant at the 1% level [p=0.0000]. The size of γ_{i1} indicates that building consents rise by approximately 0.5% in response to a 1% increase in house prices (relative to costs). The restricted IV equation indicates higher responsiveness, with building consents rising by approximately 1.1% in response to a 1% increase in house prices (relative to costs). The difference between the two estimates suggests that prices and/or costs are themselves influenced by the supply response, consistent with our theoretical priors. We treat the IV results as our preferred estimates.

The two restricted estimates find that land prices comprise a material portion of total development costs; the implied β_i (=μ_i/γ_{i1}) is estimated at 35% in the IV estimate. In each case, the estimate of μ_i is significant at the 1% level; thus omission of land costs (as in most prior studies) will lead to omitted variables bias.

Columns 2 and 4 of Table 3 present the unrestricted PLS and IV estimates respectively. We do not present all 146 γ_{i1} and μ_i coefficients, but instead report their means (together with the mean of the implied β_i). An F-test for joint significance of each of γ_{i1} and μ_i is significant at the 1% level in each case. Thus when the specification is estimated at a disaggregated regional level, we find that the q-theory relationship continues to hold and that land remains an important element of development costs. A Wald test for the null hypothesis of equality of γ_{i1} $\forall i$ is rejected [p = 0.0000] indicating that supply responsiveness differs across TLAs. Without further information, we cannot determine whether the supply elasticities differ because of regulatory factors or because of geographical factors (e.g. mountainous land) or for other reasons.

5. Auckland Supply Issues

We gain some insights into differential supply dynamics by comparing the supply responsiveness of TLAs within Auckland. The city comprises five 'core' TLAs.[18] McShane (1996) prepared an assessment of the impact of regulation on the 'housing and construction' components of the Consumers Price Index, using Auckland case studies.

[18] North Shore, Waitakere, Auckland City, Manukau City, Papakura.

His interpretation of the local authorities' district plans rated Papakura local authority as the most development-friendly authority within the city. Papakura had also experienced lower increases in regulatory costs than had the three other local authorities included in his study. These case study observations on regulatory impacts can be compared with our econometric findings regarding supply responsiveness. We test the null hypothesis that γ_{i1} is equal for the five core TLAs. A Wald test for the null hypothesis of equality is rejected [p=0.0000].[19] We present the γ_{i1} (instrumental variables) estimates in Table 4 for the five core TLAs. Consistent with McShane's observations, Papakura has the highest supply responsiveness, followed by Manukau (which was not covered in McShane's comparison). The supply responsiveness in these two TLAs is 50% higher than in Auckland City and is more than twice the responsiveness estimated in North Shore and Waitakere. The second column of Table 4 reports the estimated region fixed effect for each TLA, which may also reflect underlying regulatory differences. Consistent with the supply response parameters, Papakura has the highest regional fixed effect of the five core TLAs. Our q-theory estimates are therefore consistent with prior case study findings.

GAMS (2007) supplied further contextual material surrounding Auckland's housing supply responsiveness. It examined constraints to expansion of Auckland's housing supply since 2000 at a time when positive net immigration, higher incomes, higher employment and easy credit were increasing housing demand. A number of factors have constrained supply. One has been a limited supply of land. Another contributor has been difficulties in the consents process, especially its time consuming nature.

Auckland's Regional Growth Strategy (RGS), adopted in 1999, sets the overarching strategy for urban development. It promotes a compact city capable of accommodating at least 2 million people by 2050. Intensification of dwellings and population is sought around growth nodes situated around town centres and transport links. The RGS adopts Metropolitan Urban Limits (MUL) that set a boundary within which residential, business and other 'urban activities' are to occur. TLA District Plans are each influenced by the

[19] Our results are obtained after controlling for land prices. To the extent that regulatory factors are responsible for the estimated supply responses, those factors must therefore be influencing the rate of construction of new dwellings rather than acting through land constraints reflected in land prices.

RGS. However zoning changes since 1999 have generally been minor other than near the city's periphery (e.g. through rezoning of land near Long Bay, Hobsonville, Flat Bush, Takanini and Hingaia).[20] Comparatively little has been done to promote intensification in growth nodes; in some cases, regulatory changes have further limited the ability to intensify within the heart of the city (e.g. heritage type restrictions in Auckland City and North Shore).

House consents exceeded apartment consents across the region. This is consistent with feedback from developers and other housing stakeholders that, in aggregate, there is a continuing consumer preference for stand-alone houses over apartments. However there have been some moves towards intensification, with considerable apartment consent activity around the CBD, the Albany area and in the western part of the isthmus (e.g. New Lynn and Henderson). Apart from in the CBD, however, GAMS found little evidence of a relative increase in overall development in the growth nodes over and above what was occurring already prior to adoption of the RGS.

Vacant section prices doubled or more than doubled in the five years to 2005 in Auckland City, Waitakere and Franklin. Over the decade to 2005, the median vacant section price across TLAs rose from a 'low' of 108% in Manukau to highs of 334%, 329% and 315% in Auckland City, Franklin and Rodney respectively. The correlation coefficient between ten year rates of increase in median house prices and median section prices across the TLAs is 0.88. In other words, house price inflation is linked very strongly with land price inflation. By contrast, construction price inflation was moderate over this period.

Greenfield land prices reflect the value of the option to develop a site for residential and/or business purposes. They will therefore be influenced by the MUL boundary since the option to develop is different within and outside the MUL. Rural land values within the boundary tend to be considerably higher than values well outside the MUL, despite both being zoned for rural use. The former are likely to be converted to residential use.

[20] Relative to the existing stock of dwellings, Franklin and Rodney have had the strongest dwelling consents while, within the other five TLAs, considerable activity occurred near MUL boundaries. These developments indicate pressures for continued outward expansion of the city.

Rural land just outside the MUL tends to be priced to reflect some probability of the MUL being shifted outwards. This indicates that the current MUL boundaries are seen to be unsustainable over coming years.

Further evidence on this matter is contained in GL (2007). That study examined whether Auckland's MUL affects land prices in the city. At a descriptive level, the study found that Auckland regional land values rose by almost 60% relative to Hamilton and Wellington urban land values over 1992-2003. The study modelled land prices across the greater Auckland region and tested whether land prices exhibit a boundary effect at the limits prescribed by the MUL boundary. If the MUL constitutes a binding constraint on land supply for the city, we would expect a step change in land values with land just inside the boundary being valued more highly than land just outside. Furthermore, land just outside the boundary may build in some option value relating to possible limited expansion of the MUL over time.

GL estimated a model (using QVNZ data from 1992-2004) designed to capture the highly divergent values of land across urban and rural uses in the region. It captures approximately 80% of the variation in per hectare land values of around 8,000 'meshblock' observations in each year. Estimated (non-regulatory) determinants of land values across the region accord with theoretical priors. Specifically: (i) land is highly valued near the city centre, declining (non-linearly) as distance from the CBD increases; (ii) the ratio of CBD land values to outer land values has increased virtually monotonically over time, consistent with greater agglomeration economies since the early 1990s; (iii) land is generally more highly valued near other local nodes than in areas more distant from them; and (iv) land is valued more highly near the coast than in areas more distant from coastal locations.

In order to capture the impact of the MUL boundary on land prices, the study adopts six variables that identify land which is: (i) well inside the MUL boundary,(ii) just within the boundary, (iii) sitting astride the boundary, (iv) sitting just outside the boundary, (v) sitting just beyond the previous areas of land, and (vi) sitting well beyond the boundary.

Table 5 presents summary statistics for relative land values in each of these areas over the sample period.

The model is specified and estimated in a number of different ways to test robustness of results. All estimates of the boundary effect (other than one method[21]) find a boundary land value ratio of between 7.9 and 13.2, with the lower estimates coming earlier in the sample period when the growth boundary was a less binding constraint. These estimates variously control for distance effects (from the CBD, local nodes and the coast), TLA effects (reflecting different amenities and property taxes by local authority), rural land-use, social and population factors (population density, incomes and relative deprivation status), spatial lags and spatial errors. The boundary effects near the end of the sample are almost always stronger than the beginning of the sample, albeit with some slight drop-off between 2001 and 2003.

Our data indicate that Auckland house prices as a whole have risen substantially relative to other urban (Hamilton and Wellington) prices in the North Island. This rise in relative values is likely to reflect, at least in part, the increasingly binding impact of the MUL over time. Further, the data indicate that the largest relative land price increases between 1992 and 2003 occurred for land located just outside the urban boundary. This could reflect increasing option value being placed on this land for future development.

GAMS provides further information regarding views of developers and other stakeholders on factors affecting land values and development constraints (see Table 6 for a summary of the major findings). In interviewing private sector stakeholders, the study identified two key themes concerning Auckland house supply constraints: land-related constraints and council-related issues pertaining to consent processes and infrastructure. Three land issues were seen as posing major constraints to development: land availability, land ownership, and cost of land. Land availability and cost reflect the existence of urban growth controls (the MUL). Land ownership reflects two separate

[21] The remaining estimation method, which involves inclusion of area unit fixed effects, results in a 2003 boundary effect approximately half that indicated by other methods. For reasons summarised in GL, this estimate is considered to be an under-statement of the true effect.

concerns. Ownership of greenfields land within the MUL was seen as concentrated in the hands of a few 'land-bankers'. The MUL results in limited land supply for greenfields development, giving the landowners strong bargaining power when selling to developers.

The problem is the opposite for intensification. Ownership of sites within the metropolitan area is fragmented, especially where prior infill development has occurred. This makes it difficult for developers to purchase a sizeable block to make medium/high density development feasible. A single 'hold-out' can block development. There is no legal avenue in New Zealand to force amalgamation or sale of sites to enable more intensive development to occur. High land prices promote intensification by incentivising apartment living over stand-alone dwellings. This has acted to the benefit of CBD developers. However others note that where land prices (and other costs) become too high, any kind of development becomes unprofitable and so does not proceed.

Officials also see land as a constraining factor, but place a higher weighting on land ownership issues (land-banking and fragmented ownership), and a lower weighting on land availability and cost issues than do private sector participants. Most private sector participants feel that MUL expansion provides one way to mitigate land supply issues. Some officials share this view, but others consider that MUL expansion would not reduce land price pressures and believe that greater restrictions on expansion are required to force increased intensification.

Council planning procedures and consent processing times are the subject of huge dissatisfaction amongst private stakeholders. Over 80% of respondents see these two features as major development constraints. Consent approval processes tend to proceed iteratively within councils, each item having to be 'solved' before the next officer becomes involved. This leads to a prolonged process. Delays are most extensive (and expensive) where a development is notifiable, opening up the potential for objections and lengthy hearings. Developers seek to avoid notification at all costs. This frequently means they settle for 'lowest common denominator' developments that meet all District Plan requirements, rather than including innovative features that might make the development notifiable. Poor quality development raises the potential for community objection, which is seen as problematic by two-thirds of private sector respondents and by 90% of officials.[22] The differing views of private stakeholders and of officials may reflect their respective roles, and the incentives and constraints acting upon them.

6. Housing Supply and Price Dynamics: Relationships

We turn now to the issue of whether there is any systematic relationship between the estimated dynamic price adjustment parameters (η_{i1}) and the estimated supply elasticities (γ_{i1}). Figure 2 presents a scatter plot of the estimated price adjustment parameters (η_{i1}) against the estimated (IV) supply adjustment parameters (γ_{i1}). While the match is far from perfect, a negative relationship between the two, as shown by the estimated linear regression line and as predicted by theory, is apparent.

The significance of this relationship is explored in Table 7 in which we conduct a cross-section regression of the estimated η_{i1} on the estimated γ_{i1}. We hypothesize that there will be a negative relationship between η_{i1} (the degree of price adjustment following a demand shock) and γ_{i1} (supply elasticity). We also test two other related hypotheses. First, it is possible that areas with strong supply growth, irrespective of price elasticity of supply, may have different price dynamics compared with regions with slower supply growth. To examine this possibility, we test whether η_{i1} is related to the area fixed effects (AFE_i) estimated in the housing supply equation.

Second, we hypothesize that areas with high land price growth may be subject to stricter planning regulations than areas with lower land price growth. The intensity of land-use regulation across regions may be positively correlated with the strictness of planning controls affecting new construction. If so, we hypothesize that areas with high land price increases will tend to have higher price spikes in response to demand shocks. These impacts may already be fully summarized by the estimated γ_{i1} coefficients. To examine

[22] Infrastructure and drainage issues are seen as important by both private stakeholders and officials. Officials are primarily concerned with infrastructure availability and drainage requirements; private stakeholders are more concerned with infrastructure and development contributions.

whether there is any additional effect, we test whether η_{i1} is related (positively) to the rate of residential land price increase (PLI_i) over the full sample period.

Columns 1 and 2 of Table 7 report the cross-section regression of η_{i1} on a constant plus the PLS and IV estimates of γ_{i1} respectively. In each case, the coefficient on γ_{i1} is negative and significant at the 1% level.[23] This result is consistent with the hypothesis that local authorities having low supply elasticities also tend to have high price responses to demand shocks. Since land prices (which *inter alia* reflect geographical conditions) are already included in the supply equation, the difference in supply elasticity is more likely to be related to regulatory differences across local authorities than to land availability.

We extend the equations in Table 7 to test the two additional hypotheses. Column 3 adds the area fixed effects from the PLS supply equation and also adds the rate of increase of residential land prices for each area over the sample period. Column 4 presents the corresponding results based on the IV supply equation. The coefficient on γ_{i1} stays negative and significant at the 5% level in each equation. The coefficient on residential land price increases is positive (as expected if regulatory factors that constrain both land availability and construction are positively correlated); they are significant at the 10% level using the PLS-based estimates and at 11% using the IV-based estimates. The area fixed effects are not significantly different from zero in either equation (p=0.89 and p=0.77 respectively) indicating that price dynamics are not related to the underlying housing supply growth within an area.

Columns 5 and 6 drop the area fixed effects from the equation. The resulting estimates of the effects of γ_{i1} and of land price increases are little changed, although the former are now significant at 1% in each case. The results indicate that local authorities with low

[23] The explanatory variable (γ_{i1}) is stochastic so its p-value in this and subsequent regressions may be under-stated. The η_{i1} and γ_{i1} estimates are obtained within a systems context since the (lagged) determinants of house prices are included as the instruments in the supply equation, so reducing the potential for the error term within γ_{i1} to be correlated with that for η_{i1}.

supply elasticities (and, more tentatively, high land price increases) face more volatile price adjustment in response to demand shocks.[24]

7. Conclusions

Housing supply and house price dynamics are inextricably inter-related. We find that an increase in house prices (relative to total development costs) raises new house supply with an elasticity of between 0.5% and 1.1%, the upper estimate corresponding to our (preferred) instrumental variables estimate.

Our estimated supply responsiveness coefficient is inversely related to the estimated coefficient determining price dynamics. Prices react more strongly to a demand change in local authorities where housing supply responsiveness is low compared with those in which supply responsiveness is high. A 1% increase in equilibrium prices (calculated on the basis of the existing housing stock) leads to an immediate 0.56% jump in house prices in an authority with lower quartile supply responsiveness, compared with a 0.45% jump in an authority with upper quartile supply responsiveness. Since responsiveness is faster in the latter case, the length of time that prices are raised above their long run equilibrium is also shorter in the more responsive than the less responsive region. Thus the impact on resource (mis)allocation is more pronounced in the less responsive authority and lasts for longer than if it were more responsive.

Our results for Auckland local authorities are consistent with the case study findings of McShane (1996) and with subsequent findings reported in GAMS. In addition, the fact that we have controlled for land prices in these estimates implies that geographical factors are most likely not the 'culprit' in determining supply responsiveness.

Land prices themselves have a strong impact on new house construction. A 1% increase in land prices is estimated to lift total development costs by 0.33% (using the restricted

[24] While there is a positive short run relationship between house prices (relative to costs) and new house supply (as shown in Figure 1 and in our supply estimates), the cross-sectional long run correlation coefficient between the two is slightly negative, at -0.17. This result is consistent with Figure 3, in which a more responsive supply schedule reduces the long run price increase consequent on an increase in demand.

IV estimate), in turn reducing house supply by an estimated 0.37%. Thus regulations, such as zoning restrictions, that impact on the availability and price of residential land induce lower house supply and raise house prices in affected authorities. Land prices just within Auckland's MUL are approximately 10 times those of neighbouring properties just outside the MUL (i.e. a ratio of 1,000%). Given our supply estimates, this regulatory-induced cost is almost certainly having a major negative impact on new housing supply, and hence house prices, within the Auckland region.

These findings are consistent with those of recent studies in the United States on links between the planning infrastructure (including growth boundaries), housing supply and house price dynamics. A key contribution of the GA analysis is to highlight explicitly the role of residential land prices in determining supply responses and thence price dynamics. Coupled with the qualitative evidence in McShane (1996) and GAMS (2007) and with the empirical findings in GL on the effects of Auckland's MUL on land prices, there is reason to investigate whether regulatory changes can be made that reduce the cost of purchasing land and increase the responsiveness of new housing supply, so improving housing affordability.

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Table 1: Price Equation Variables, Unit Root Tests

Variable	Panel Unit Root Test		
	LLC	IPS	ADF
$\ln(PH_{it}/PC_t)$	1.0000	1.0000	1.0000
$\ln XPROD_{it}$	1.0000	1.0000	0.9992
$\ln XEMP_{it}$	0.8992	1.0000	1.0000
$\ln DD_{it}$	0.0000	1.0000	0.9944
UC_{it}	0.9997	1.0000	1.0000
S_{it}	0.0000	0.0000	0.0000

The figure presented for each test is the p-value for the statistic under the null hypothesis of a unit root. LLC is the Levin, Lin and Chu test; IPS is the Im, Pesaran and Shin test; ADF is the augmented Dickey-Fuller test. Each statistic is for the level of the variable, and includes an individual trend and intercept.

Table 2: Housing Supply Equation Variables, Unit Root Tests

Variable	Time Trend Included	Panel Unit Root Test		
		LLC	IPS	ADF
HC_{it}/H_{it-1})	No	0.0000	0.0000	0.0000
	Yes	0.0000	0.0000	0.0000
$\ln(PH_{it}/PB_{it})$	No	0.9999	0.9569	0.0003
	Yes	0.0004	0.0000	0.0000
$\ln(PB_{it}/PL_{it})$	No	0.9999	1.0000	0.0288
	Yes	0.9822	1.0000	0.9973
$\ln(PH_{it})$	No	1.0000	1.0000	0.4090
	Yes	0.9648	0.0001	0.0000
$\ln(PB_{it})$	No	0.0000	0.9993	1.0000
	Yes	0.0274	0.1529	0.5610
$\ln(PL_{it})$	No	0.0000	0.9902	0.0004
	Yes	1.0000	0.0039	0.0000
$\ln(PH_{it}/DEVCOST_{it})$	No	0.4091	0.0000	0.0000
	Yes	0.9953	0.6962	0.0000
ε_{it}	No	0.0000	0.0000	0.0000
	Yes	0.0000	0.0000	0.0000

The figure presented for each test is the p-value for the statistic under the null hypothesis of a unit root. LLC is the Levin, Lin and Chu test; IPS is the Im, Pesaran and Shin test; ADF is the augmented Dickey-Fuller test. Each statistic is for the level of the variable, and includes an intercept. Inclusion or exclusion of a time trend is indicated in column 2.

Table 3: House Supply Responsiveness

	PLS Restricted	PLS Unrestricted	IV Restricted	IV Unrestricted
γ_{i1}	0.0048 (0.0010) [0.0000]	Mean=0.0048 [<0.01]	0.0112 (0.0023) [0.0000]	Mean=0.0070 [<0.01]
μ_i	0.0009 (0.0003) [0.0032]	Mean=0.0017 [<0.01]	0.0035 (0.0013) [0.0080]	Mean=0.0020 [<0.01]
β_i (Implied)	0.1795	0.3465	0.3094	0.2780
Adj.R^2	0.778	0.833	0.727	0.822
s.e.	0.0015	0.0013	0.0017	0.0014
n	3,869	3,869	3,869	3,869

Notes:

Estimated equation: $HC_{it}/H_{it-1} = \lambda'_0 + \gamma_{i1}\ln\{PH_{it}/PB_{it}\} + \mu_i\ln\{PB_{it}/PL_{it}\} + \lambda'_iFE_i + \lambda'_tFE_t + \varepsilon_{it}$
where implied $\beta_i=\mu_i/\gamma_{i1}$ (calculated at means of μ_i and γ_{i1} for unrestricted estimates).
White period standard errors in round brackets; p-values in square brackets.
PLS is pooled (ordinary) least squares estimation; IV is instrumental variables estimation.
All equations estimated over 1991q2 - 2004q2.
Mean (standard deviation) of dependent variable = 0.0038 (0.0032).
Constant, region fixed effects and time fixed effects included but not reported.
Adj.R^2 is the adjusted R^2; s.e. is the equation standard error.
n is number of observations (all equations cover 73 regions for 53 quarters).
Individual coefficients not reported in unrestricted equations (means of coefficients are reported); p-values in unrestricted equations refer to F-test for significance of all 73 regional coefficients.
IV instruments: $\ln XPROD_{it-1}$, $\ln XEMP_{it-1}$, $\ln DD_{it-1}$, UC_{it-1}, S_{it-2}, $TIME_t$, constant); see section 3 and Appendix for descriptions.

Table 4: Auckland Core TLA Supply Parameter Estimates

TLA	Supply Responsiveness (γ_{i1})	Region Fixed Effect (λ'_i)
North Shore	0.63%	-0.16%
Waitakere	0.73%	0.78%
Auckland City	1.05%	0.81%
Manukau	1.56%	1.37%
Papakura	1.58%	1.91%

Notes:
Parameters are instrumental variables estimates consistent with Table 3, corresponding to equation (4); thus a 1% rise in house prices relative to costs increases quarterly housing consents relative to the housing stock by 0.63% in North Shore.

Table 5: Average Real Per Ha Land Value Relative to Hamilton/Wellington

Area	Year					% change: 1992-2003
	1992	1995	1998	2001	2003	
Well within MUL	3.93	3.58	4.71	5.16	6.27	59%
Just inside MUL	1.78	1.80	2.34	2.18	2.52	41%
Astride MUL	0.92	0.92	1.27	1.21	1.41	53%
Just outside MUL	0.13	0.13	0.16	0.17	0.22	73%
Further outside MUL	0.13	0.13	0.16	0.15	0.18	39%
Well outside MUL	0.43	0.43	0.57	0.57	0.60	37%
Total	3.33	3.04	4.00	4.36	5.28	59%

Table 6: Stakeholder Views on Key Constraints to Auckland Housing Development[a]

ISSUE	Private (%)	Govt (%)
Cost of building materials	58	30
Cost of land	84	70
Land availability	79	60
Land ownership	74	90
Consent processing times	89	50
Planning procedures	84	30
Development contributions	84	50
Community opposition	68	90

[a] Share of respondents reporting the issue as a major constraint to development.

Table 7: Relationship of Price Adjustment (η_{i1}) to Supply Responsiveness (γ_{i1})

	Supply Equation (Estimation Method)					
	PLS	**IV**	**PLS**	**IV**	**PLS**	**IV**
Constant	0.5800 (0.0319) [0.0000]	0.5756 (0.0329) [0.0000]	0.5428 (0.0416) [0.0000]	0.5339 (0.0445) [0.0000]	0.5409 (0.0390) [0.0000]	0.5369 (0.0403) [0.0000]
γ_{i1}	-15.7699 (4.4138) [0.0006]	-10.1839 (3.1753) [0.0020]	-15.7958 (5.1194) [0.0029]	-9.4402 (4.0430) [0.0225]	-15.4430 (4.3599) [0.0007]	-9.8550 (3.1457) [0.0025]
AFE_i	-	-	0.3327 (2.4818) [0.8938]	-0.4006 (2.4264) [0.8693]	-	-
PLI_i	-	-	0.0137 (0.0081) [0.0965]	0.0134 (0.0083) [0.1100]	0.0138 (0.0081) [0.0926]	0.0134 (0.0082) [0.1084]
Adj.R^2	0.140	0.114	0.151	0.122	0.163	0.134
s.e.	0.203	0.206	0.202	0.206	0.201	0.204
N	73	73	73	73	73	73

Notes:

Estimated equation: $\eta_{i1} = c_0 + c_1 * \gamma_{i1} + c_2 * AFE_i + c_3 * PLI_i + \xi_i$

where η_{i1} is the estimated unrestricted price adjustment parameter from (8); γ_{i1} is the estimated unrestricted supply elasticity from the PLS and IV supply equation respectively; AFE_i are the area fixed effects from the PLS and IV supply equations; PLI_i is the rate of residential land price increase over the sample period; ξ_i is an iid error term; c_0, c_1, c_2 and c_3 are estimated coefficients from a cross-section regression.

Standard errors are in round brackets; p-values in square brackets.

Figure 1: New House Supply versus House Prices / Development Costs

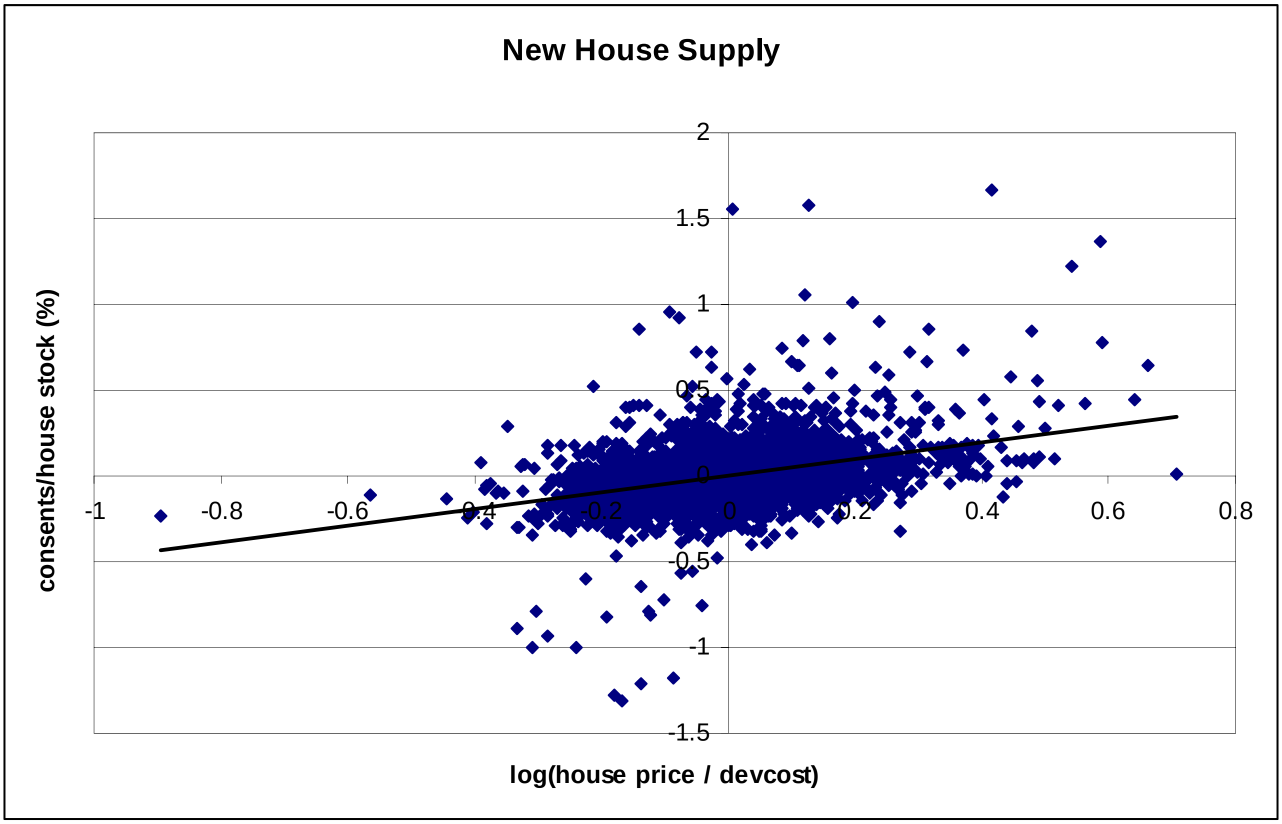

Figure 2: Estimated IV Price and Supply Adjustment Parameters (η_{i1} and γ_{i1})

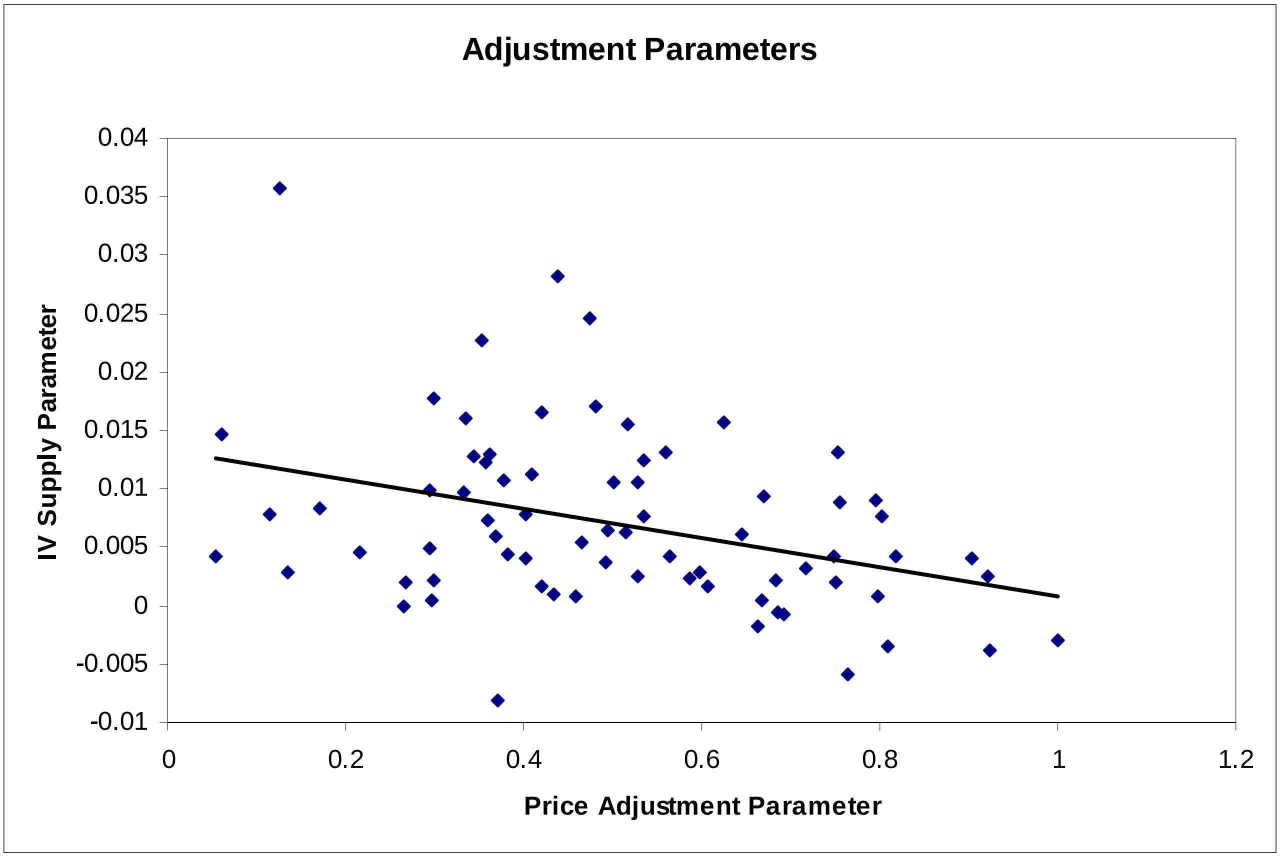

Figure 3: House Price Adjustment Dynamics