Effect of Local Variations in Public Services on Housing Production at the Fringe of a Growth-Controlled Multi-County Metropolitan Area

Sheku G. Kamara*  

[First received February 1986; in final form September 1986]

Summary. The influence of public services on suburban residential development has been taken for granted until recently when a few scholars have considered their importance in more detail in assessing housing production functions in such small areas as counties. This study examines this issue in more detail at the fringe of a four-county (two-state) SMSA facing the dilemma of centrifugal population movement versus rigid growth-containment policies. It is demonstrated by the results of this investigation that, contrary to some earlier notions, because of the non-restrictive influence of land relative to low density residential development, production functions for housing become largely explained by public services.

Introduction

Prior to the mid-1970s the estimation of housing production functions generally focused on two major inputs: capital and land. Rydell (1976) was one of the earliest to give some thought to this question, and later Neels (1981) included energy in addition to services, land and capital. Not only have some researchers ignored both services and energy contingencies, but others (Habig, 1972) have contended that there exists a differential response by various land use types to public service provision.

The work of Rydell and Neels, useful as it is, was researched in intra-urban locations on non-contiguous units (neighbourhoods, census tracts) and focused only on rental units which are unlikely to be concentrated at the fringe. Thus it is easy to observe that although the additional inputs of energy and services improved the specifications of their models, their potential may not have been fully tapped, hence their diminished importance.

Yet other studies, such as the literature on hedonic prices, either erroneously assume services as given whatever their condition or level of efficiency, or simply assume that other variables are more relevant (Butler, 1982; Brueckner and Colwell, 1983).

At the urban fringe, the constraints which land availability would normally pose for the intra-urban model estimation become of secondary concern especially where rapid growth is taking place, even if the whole system is subjected to rigid growth-containment policies; one argument being the generous land sub-divisions and space advantages therein. As a result, inputs like services would be expected to play an increasingly dominant role in residential housing prediction, especially as suburbanisation in the 1970s was reasonably comparable to the high rates of the 1960s in the metropolitan area under study, albeit that estimates of the latter part of the decade were sceptical (Chalmers and Greenwood, 1980).

The Study Area

The fringe area of the Portland-Vancouver SMSA is the subject of this study. It covers the counties of Clackamas, Multnomah, and Washington in the state of Oregon, and Clark county in the state of...
Washington. The SMSA has grown rapidly within the last two decades, increasing its population by 51 per cent. In 1960 the population was reported at 822,000, increasing to 1,009,129 in 1970, and to 1,242,594 in 1980. Between 1970 and 1980 alone, the increase was 23 per cent, which in absolute terms exceeded that of the preceeding decade by over 46,000 people.

The suburban population increase during the last intercensal period was over 163,000 (Table 1). This was over two-thirds of the metropolitan area-wide increase, which clearly demonstrates the continued preference for rural area residency (Dueker et. al., 1983).

Within the counties, the ratio of the increase in population to residential units constructed during the decade is slightly more than 2:1, the exception being Multnomah county where it is completely the reverse (1:1.8), which shows that there was a very high density of population within that county at the start of the decade probably as a consequence of rapid suburbanisation during the preceeding decade.

This research addresses two issues: first, the role services play among other production inputs in the rural-urban conversion process for residential housing within a constrained system; second, the effect of size differences in service provision mechanisms and local (county-level) disparities on residential development at the Portland fringe.

Methodology and Variable Definition

The fringe areas of the four counties of the SMSA were studied in this research. The central cities as defined in the 1970 census, were excluded and the fringe area was defined by a band of census tracts in the transitional area exhibiting conversion activity during the decade. Residential construction for the period January 1970 to December 1979 was used to represent the quantity of housing produced at the fringe. Variables were generally categorised under capital, land, services, access, network, and social factors. The dependent variable, quantity of residential housing, was represented by housing starts assembled from building permits records acquired from the county assessors’ offices.

The two primary inputs of capital and land were operationalised as the median family income of the census tract (FINC), land value ($) per acre (LVL), and the net vacant land (LAND) within the census tract zoned for residential use and devoid of any hazards. The mean household size (HHS) of the census tract was used as a key social variable, whereas measures for services and local network were variously represented in the initial (1970), change (1970–80) and future conditions. For network, these were respectively NET, CNET, and FNET, defined as lane-miles of arterial street network within the census tract and all others contiguous to it. Water and sewer services were combined into a composite variable generally labelled as PINF (initial) and PCIN (change), and operationalised as the percentage area of the census tract covered by these services. In order to isolate the confounding effect of other sewerage facilities (septic tanks, cesspools, etc.), the variables WNS and CWNS were incorporated to measure areas with water and no sewers, but which may however be served by septic tanks and cesspools. These designations refer to the initial condition and changes during the decade respectively. Accessibility was represented by the shortest road distance connecting the centre of the tract with the Portland CBD. These variables were labelled as DIST and DIST2 (distance squared).

Table 1

<table>
<thead>
<tr>
<th>County</th>
<th>Suburban Population Increase</th>
<th>Increase in Residential Development</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SFU</td>
<td>MFU</td>
</tr>
<tr>
<td>Clackamas</td>
<td>39,676</td>
<td>12,590</td>
</tr>
<tr>
<td>Multnomah</td>
<td>12,813</td>
<td>9,869</td>
</tr>
<tr>
<td>Washington</td>
<td>61,698</td>
<td>19,533</td>
</tr>
<tr>
<td>Clark</td>
<td>49,062</td>
<td>18,015</td>
</tr>
<tr>
<td>SMSA</td>
<td>163,249</td>
<td>60,007</td>
</tr>
</tbody>
</table>
Model Specification

The operationalisation of the relationships in this study seeks to specify a model that will adequately address land development concerns as well as constraints at the urban fringe. Thus, whereas inputs specified in the intra-urban models are important, local variations in other conditions at the suburbs are also considered. These include financial opportunities, land suitability including scenic preferences, availability of services, access to major centres, local circulation conditions, the relative degrees of congestion and population density, and social aspects of the neighbourhood. Thus fringe area housing production \((Q_h)\) is expressed in the relationship:

\[
Q_h = f(K_1 \ldots K_m, L_1 \ldots L_p, S_1 \ldots S_q, A_1 \ldots A_r, C_1 \ldots C_t, H_1 \ldots H_u)
\]

where:
- \(K_1 \ldots K_m = \text{capital inputs}\)
- \(L_1 \ldots L_p = \text{land inputs}\)
- \(S_1 \ldots S_q = \text{services}\)
- \(A_1 \ldots A_r = \text{accessibility}\)
- \(C_1 \ldots C_t = \text{local congestion and circulation}\)
- \(H_1 \ldots H_u = \text{local population density}\)

Different combinations of scaled data were used in order to determine the appropriate form of model to estimate the relationship. Four basic criteria were established: (1) the strength of the \(R^2\) of each model, (2) the sensitivity of the coefficients to directional and sign changes, (3) the non-existence of counter-intuitiveness, and (4) the statistical significance of the models and the variables therein. The elasticities of the pecuniary variables especially, unknown as they were, were assumed to vary at the fringe in areas of different county locations even at the same proximity from the CBD. Because of the desire to capture other minute variations which might otherwise be interpreted as constant elasticity functions in the linear measures of the variables, the logarithms of the criterion and predictor variables were used to ascertain a consistent measure across variables, thereby ensuring direct comparability of the elasticities of the models. The only variable which was included in non-logarithmic form, distance, was changed into the square transformation so as to capture the extent of the limit of the Portland fringe.

Appropriate testing was applied during the analysis to investigate the stability of the coefficients and the degree of efficiency of estimation of the variances, to minimise problems due to multicollinearity and autocorrelation. Multicollinearity results in unstable coefficients whereas the underestimation of variances and inefficient prediction are the results of autocorrelation problems. Aside from the pair-wise observation of the correlation coefficients of the predictors to investigate multicollinearity, the correlation matrix was examined along with the eigenvalue spectrum of variables in each model.

One underlying hypothesis of this research is the importance of the spatial element as a primary consideration in establishing the nature of the relationship. Therefore each model or submodel was subjected to the Durbin-Watson test (Durbin and Watson, 1950, 1951, 1971), to determine the extent to which the estimation was limited by autocorrelation of spatial units or time periods.

Analysis

The regression equations adopted for the models assumed the form:

\[
\log Q_{hi} = \log a_i + b_1 \log X_{i1} + b_2 \log X_{i2} + \ldots + b_n \log X_{in} + E_i
\]

where \(a\) represents the intercept, \(b_1 \ldots b_n\) the elasticities of the respective variables \(X_1 \ldots X_n\), and \(E_i\) is the unexplained error disturbance. The \(i\)'s denote the respective area (county or SMSA) for which the model is estimated. Five models are estimated altogether; one for each of the four counties (unrestricted condition), and one for the 83 census tracts of the SMSA fringe (restricted model).

The stepwise option is employed because of the desire to provide equal chances to the wide range of variables used, and thereby consequently ascertain their sequence of importance. Thus, less important ones are isolated in different counties under the prevailing conditions, rather than assuming equal importance for the same variables in all subareas.

Since the variables were transformed into logarithms, their coefficients denote elasticity effects on the predicted housing development pattern, depicting the magnitude of change in fringe area housing production given one per cent change in the respective predictor variable.
Relative Importance of the Inputs at the Regional Level

The model for the SMSA (Table 2) shows the outstanding importance of services and local access to housing production at the fringe. Land and capital inputs, although highly significant as well, remain much less influential in explaining variances in housing production, and together account for less than half the equivalent of the $R^2$-change of services alone.

The importance of channelled services (water and sewer) is even more magnified in the light of the relative insignificance of the effects of septic tanks and cesspools on conversion activity at the Portland fringe. An additional important feature of the model is that congestion (as measured by arterial road network density) negatively but statistically insignificantly influences conversion activity.

Spatial Variations

As the model has a spatio-temporal dimension, it was subjected to further probing first by disaggregating it into the respective counties, each constituting a separate submodel. The results (Table 3) show the relative impacts of the inputs in the subareas, and the spatial variations in the strength of the relationships. With respect to spatial entities, the Washington county submodel is by far the best, with the variables constituting it being practically the same as the SMSA model with the exception of three differences. First, land and network constraints were virtually non-existent in Washington county. Second, household size was mildly positively influential, but relatively insignificant at the regional level. Third, four-fifths (80 per cent) of the explanatory power ($R^2$) was constituted by services alone (LOGPCIN and LOGWNS), whereas at the SMSA level the combined effects of these services was an $R^2$-change of 0.30.

On the contrary, Multnomah county, alleged to suffer from congestion problems, had 0.50 of the $R^2$ constituted by LOGCNET and LOGFNET, with the optimistic note that future changes in network are likely to reduce growth and congestion.

Clackamas and Clark counties which have the largest land reserves showed this variable to be most important in each case. In Clackamas county, it was the only characteristic describing the model, albeit if with an insignificant t-ratio. In Clark county on the other hand, LOGLAND was highly significant, contributing 90 per cent of the $R^2$. Models of all counties except Clackamas were significant at $P_{0.01}$ level.

It is noteworthy that the strength of the Washington county model and its similarity to the regional model is indicative of the fact that events in Washington county such as sewer service planning which covers the whole county tend to dictate the pace of fringe area housing in the Portland-Vancouver SMSA.

Temporal Differences

The relative significance of change variables indicates the importance of investigating the temporal dimension of the model. Further, it could be argued that based on the strength of the association, there is a strong causal link especially between the infrastructure variables and fringe area housing. However, the rigidity and direction of this assertion can only by supported logically by using a time-series analysis and a recursive system approach. Two things could be determined: (1) whether there is any relationship between the planning process and implementation system on the one hand and developers' speculation on the other, and (2) whether leapfrog development of some areas (e.g. Beaverton) in the early 1970s may have resulted in congestion leading to a posteriori road improvements, or whether mushroom growth of other areas (e.g. Tigard, Tualatin, Wilsonville, and Harmony and Sunnyside Roads) was probably the result (rather than the cause) of a priori road improvements.

To provide meaningful answers to these ques-
Table 3

County Variations in Fringe Area Housing (1970-1980)

<table>
<thead>
<tr>
<th>County</th>
<th>Variable</th>
<th>b</th>
<th>Beta</th>
<th>R²</th>
<th>t-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multnomah</td>
<td>LOGLAND</td>
<td>0.33</td>
<td>0.32</td>
<td>0.15</td>
<td>3.13**</td>
</tr>
<tr>
<td></td>
<td>LOGFINC</td>
<td>2.63</td>
<td>0.22</td>
<td>0.03</td>
<td>2.12*</td>
</tr>
<tr>
<td></td>
<td>LOGCNET</td>
<td>2.07</td>
<td>0.72</td>
<td>0.46</td>
<td>6.30**</td>
</tr>
<tr>
<td></td>
<td>LOGFNET</td>
<td>−0.64</td>
<td>−0.22</td>
<td>0.04</td>
<td>−2.02*</td>
</tr>
<tr>
<td></td>
<td>LOGHHS</td>
<td>−3.36</td>
<td>−0.18</td>
<td>0.02</td>
<td>−1.72ns</td>
</tr>
<tr>
<td>Washington</td>
<td>LOGFINC</td>
<td>0.98</td>
<td>0.30</td>
<td>0.12</td>
<td>3.48**</td>
</tr>
<tr>
<td></td>
<td>LOGPCIN</td>
<td>0.29</td>
<td>0.88</td>
<td>0.78</td>
<td>9.69**</td>
</tr>
<tr>
<td></td>
<td>LOGCWNS</td>
<td>0.14</td>
<td>0.19</td>
<td>0.02</td>
<td>3.02**</td>
</tr>
<tr>
<td></td>
<td>DIST</td>
<td>−0.02</td>
<td>−0.16</td>
<td>0.01</td>
<td>−1.72ns</td>
</tr>
<tr>
<td></td>
<td>LOGHHS</td>
<td>2.04</td>
<td>0.19</td>
<td>0.02</td>
<td>2.13*</td>
</tr>
<tr>
<td>Clackamas</td>
<td>LOGLAND</td>
<td>0.16</td>
<td>0.48</td>
<td>0.23</td>
<td>1.96ns</td>
</tr>
<tr>
<td>Clark</td>
<td>LOGLAND</td>
<td>1.00</td>
<td>0.85</td>
<td>0.76</td>
<td>3.56**</td>
</tr>
<tr>
<td></td>
<td>LOGFINC</td>
<td>3.72</td>
<td>0.37</td>
<td>0.04</td>
<td>1.85ns</td>
</tr>
<tr>
<td></td>
<td>LOGNET</td>
<td>−0.62</td>
<td>−0.34</td>
<td>0.04</td>
<td>−1.66ns</td>
</tr>
</tbody>
</table>

where:

- \( M_n \) = the criterion variable of the recursive model at condition (period) \( n \).
- \( b_n \), \( a_1, a_2, \ldots, a_{n-1} \), \( X_{n1}, X_{n2}, \ldots, X_{nm} \), \( b_{n1}, b_{n2}, \ldots, b_{nm} \), \( b_0 \), \( E_n \) = the endogenous variables of the recursive model system at period \( n \).
- \( a_1, a_2, \ldots, a_{n-1} \) = coefficients of the endogenous variables.
- \( X_{n1}, X_{n2}, \ldots, X_{nm} \) = the exogenous predictors of the \( n \)th period.
- \( b_{n1}, b_{n2}, \ldots, b_{nm} \) = coefficients of predictors at period \( n \).
- \( b_0 \) = intercept of equation \( M_n \).
- \( E_n \) = error disturbance.

Differences in Housing Development Among the Time-Series

The general outcome of the variables in the submodel \( M_1 \) (Table 4) is similar to the decade pattern in Table 2 with the following differences:

1. available land suitable for residential development and the speculative influence of planned road network improvements were not major considerations during this sub-period.
2. Subarea differences in land value had a negative influence on development during the early part of the decade. However, this effect was not statistically significant.
Table 4

Recursive Models of Fringe Area Housing Production in Metropolitan Portland

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>b</th>
<th>Beta</th>
<th>$R^2$</th>
<th>$t$-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>LOGLAND</td>
<td>0.11</td>
<td>0.14</td>
<td>0.03</td>
<td>1.50ns</td>
</tr>
<tr>
<td></td>
<td>LOGLV</td>
<td>-0.07</td>
<td>-0.05</td>
<td>0.07</td>
<td>-0.39ns</td>
</tr>
<tr>
<td></td>
<td>LOGFINC</td>
<td>2.31</td>
<td>0.31</td>
<td>0.05</td>
<td>3.35**</td>
</tr>
<tr>
<td></td>
<td>LOGPCIN</td>
<td>0.15</td>
<td>0.29</td>
<td>0.21</td>
<td>3.27**</td>
</tr>
<tr>
<td></td>
<td>LOGWNS</td>
<td>0.17</td>
<td>0.19</td>
<td>0.02</td>
<td>2.10*</td>
</tr>
<tr>
<td></td>
<td>DIST2</td>
<td>0.05</td>
<td>0.36</td>
<td>0.02</td>
<td>2.60**</td>
</tr>
<tr>
<td></td>
<td>LOGNET</td>
<td>0.50</td>
<td>0.15</td>
<td>0.02</td>
<td>1.58ns</td>
</tr>
<tr>
<td></td>
<td>LOGCNET</td>
<td>0.97</td>
<td>0.34</td>
<td>0.11</td>
<td>3.17**</td>
</tr>
<tr>
<td></td>
<td>LOGFNET</td>
<td>-0.48</td>
<td>-0.20</td>
<td>0.05</td>
<td>-1.82ns</td>
</tr>
<tr>
<td>M2</td>
<td>Y1</td>
<td>0.58</td>
<td>0.54</td>
<td>0.58</td>
<td>6.48**</td>
</tr>
<tr>
<td></td>
<td>LOGLV</td>
<td>-0.31</td>
<td>-0.21</td>
<td>0.05</td>
<td>-2.78**</td>
</tr>
<tr>
<td></td>
<td>LOGPCIN</td>
<td>0.08</td>
<td>0.18</td>
<td>0.02</td>
<td>2.30*</td>
</tr>
<tr>
<td></td>
<td>LOGCNET</td>
<td>0.37</td>
<td>0.12</td>
<td>0.01</td>
<td>1.67ns</td>
</tr>
<tr>
<td>M3</td>
<td>Y2</td>
<td>0.44</td>
<td>0.53</td>
<td>0.76</td>
<td>8.19**</td>
</tr>
<tr>
<td></td>
<td>Y1</td>
<td>0.25</td>
<td>0.28</td>
<td>0.03</td>
<td>4.55**</td>
</tr>
<tr>
<td></td>
<td>LOGPCIN</td>
<td>0.08</td>
<td>0.20</td>
<td>0.06</td>
<td>3.88**</td>
</tr>
<tr>
<td></td>
<td>LOGCWNS</td>
<td>0.11</td>
<td>0.08</td>
<td>0.01</td>
<td>1.92ns</td>
</tr>
<tr>
<td></td>
<td>LOGFNET</td>
<td>0.36</td>
<td>0.17</td>
<td>0.03</td>
<td>4.02**</td>
</tr>
</tbody>
</table>

During the second recursive period, the M2 model included additional exogenous variables improving on the model of the previous sub-period. Land value showed significant effects during this period.

Changes in sewer services during the middle part of the decade and the effects of speculations on planned transportation improvements for the latter part of the decade had mild and relatively less significant influences on the volume of housing construction that was taking place during the middle part of the decade. However, the corresponding measures of these variables in the subsequent recursive model were the only important predictors of the model in addition to the endogenous variables. The variable LOGCWNS which was significant at $P_{0.05}$ in the M1 model, made an insignificant contribution to the M3 model.

In all models of both spatial and temporal dimensions, the importance of infrastructure is over-emphasised in so far as fringe area housing is concerned. Their immense contribution to $M_1$ is a major attribute to the consistent performances of $Y_1$ and $Y_2$ in the respective successive recursive analyses, improving the strength of the models over each successive stage.

Multicollinearity and Autocorrelation

In this study, just like many other similar ones designed on the same basis and principles, a certain amount of variable intercorrelation and collinearity is to be expected. Because of some interdependence among the predictors, the issue is addressed not from the point of view of the existence of these problems, but the degree to which they were minimised so as not to detract from the predictive power of the models, and also to ensure stability of the coefficients without underestimating variances.

During various stages of the pre-analysis, the behaviour of variables exhibiting correlation coefficients of 0.70 or better was observed. In the analysis, either the weaker of two collinear variables was dropped or both were combined in a composite variable, whichever option resulted in the stability of the coefficients. For example, infrastructure is a combination of water and sewer. Further, Farrar and Glauber's (1967) heuristic test was applied to see how much variable intercorrelation occurs among the variables of each model. Although this test has faced criticism (Maddala, 1977), its soundness and practical applicability to an empirical
situation necessitated its use as a basic tool to ensure that not only that multicollinearity was not a prediction problem, but it was not a serious problem in estimating the coefficients. In this test, the eigenvalue spectrum of the correlation matrix was evaluated and the ratio of the largest to the smallest noted, i.e.:

$$\frac{V_1}{V_n}$$

where: $V_1 =$ eigenvalue of variable 1, and $V_n =$ eigenvalue of variable n.

The spectrum was considered large if $\frac{V_1}{V_n}$ exceeded n in each model, where n represents the number of variables defining the model. Further, the minimax index (MMI), basically defined as the sum of the squares of the inverse of the eigenvalue ratio, was computed as follows:

$$\text{MMI} = \sum_i \left( \frac{1}{V_i^2} / \frac{1}{V_n^2} \right)$$

A small MMI (less than two) indicated the presence of severe multicollinearity. The results of the examination of the eigenvalue spectrum was that the observed indices were greater than two, implying minimal multicollinearity problems occurring in the study.

For each spatial or recursive model, the Durbin-Watson statistic ($d$) was computed as an index of autocorrelation (Tables 2, 3, and 4). As a basic test, this observed statistic may be compared with the tabulated upper and lower limits at both 5 per cent and 1 per cent probability levels. The observed ($d$) values for the spatial entities are at reasonably significant levels at the respective degrees of freedom. In the main metropolitan model, the ($d$) statistic was significant at the 5 per cent level, but barely falls outside of the upper level of the per cent range.

With respect to the individual counties, there is reasonable evidence of spatial autocorrelation in Multnomah county ($d = 2.02$), where, as noted earlier, census tracts were generally small in size, and appear in this case not to exhibit much spatial variation in their attributes. The rest of the counties showed little evidence of limitation due to autocorrelation even at the 1 per cent level of significance.

The recursive models, based on their very structure, were expected to show some amount of autocorrelation in the time-series, with the exception of the first time-period. Thus, the $M_1$ model is significant at 1 per cent level. But as one succeeding model is designed to be fed by the previous model as an endogenous variable as well as the respective corresponding exogenous variables, models $M_2$ and $M_3$ showed some amount of autocorrelation, which nonetheless did not limit the analysis.

### Structural Differences in the Spatio-Temporal Systems

Disaggregating the model into spatial subunits and time subperiods raises the question whether the submodels are any different from the parent model, i.e., whether it was necessary to estimate individual submodels to capture differential effects of the predictors in subareas and sub-periods. In short, is it arguable that different parameter estimates exist for the four counties and time intervals from the metropolitan pattern for the decade? To satisfy these concerns, the equations were subjected to appropriate forms of the Chow test (Chow, 1960; Maddala, 1977).

There are in all five areas (four counties and the SMSA), resulting in five equations for the decade. In addition, three other models are recursive for subperiods within the decade. The units of observations for all counties sum up to the SMSA total ($n = 83$). The number of variables in each of the five models for the decade is the same as in $M_1$ model, but those of $M_2$ and $M_3$ had one more variable each than the previous period. These restrictions limit the number of tests to two comparisons as follows:

**Test 1.** The unrestricted county models for the decade against the restricted SMSA decade model.

**Test 2.** The unrestricted county submodels against the restricted SMSA model ($M_1$).

The general form of the Chow formula applicable to these situations was:

$$F = \frac{(URSS/(n - 2k)) - 1 ((RRSS - URSS)/k)}$$

where: $RRSS$ is the residual sums of squares for the respective restricted equation at k degrees of freedom, and $URSS$ is the summed residual sums of squares for the respective unrestricted equations at k and n - 2k degrees of freedom.

The results of these analyses were F-ratios of 4.46.
and 2.52 respectively, both significant at \( P < 0.01 \). This indicates that the differences between the spatial entities are not just due to chance, but there was indeed a real difference in parameter estimates between the equations of the individual counties and the SMSA, among the decade-long equations, and between them on the one hand and the metropolitan pattern for the first third of the decade. From these results and the fact that the recursive models cannot be directly compared because of the variation in the numbers of variables, it may be inferred that differences abound between the time-periods, especially as later models were improvements on those of earlier time-periods.

**Summary**

In sum, infrastructural services constitute the most important input variables influencing housing construction at the Portland fringe. This outcome is largely attributable to the stable and reliable sewer service system in Washington county, where during the decade, a large proportion of the nearly countywide district was serviced. Septic tanks and cesspools exerted little influence, but in some cases, a decline in the size of these areas over time correlated with increased housing. This perhaps indicates the reality of the influence of sewers which in effect replaced the non-channelled services.

Accessibility and network changes were the second major influence. In Clackamas and Clark counties these effects were shown by a tendency towards increased development near sub-centres, whereas in Washington county fringe area housing favoured areas away from sub-centres (Kamara, 1984).

Land attributes were of moderate importance and posed few constraints of diminishing importance over the decade. Land values generally exhibited increasing negative influence, implying the interaction effects of price, demand, speculation, and growth containment policy enforcements.

Income elasticities were significantly important as positive correlates of housing at the Portland fringe \( (P < 0.01) \), Washington county \( (P < 0.01) \), and Multnomah county \( (P = 0.05) \).

The lag effects of residential developments during the preceding periods all generally had positive influences.

**Conclusion**

Aside from the overwhelming performance of services, the derived models and tests confirm the existence of different parameter estimates for most of the major inputs in the different counties. Secondly, the variables showed high differential responses in the constituent counties resulting in a different set of predictors in each area, albeit if similar.

Although it may be tempting to overstate causal inferences especially when the response of some input is overwhelming (Blalock, 1961), it may be inferred from the results in Washington county that a single service district has more significant influence on fringe area growth and suburbanisation than a number of fragmentary ones. This probably further suggests that the larger the area served by one district the more economical the service to the consumer (Bruggink, 1979). Logical though this might seem, it cannot be inferred for the region as a whole.

The emphasised theoretical importance of physical facilities and infrastructure to residential development (Hawley, 1950; Kaserda, 1972) corroborated by empirical studies in Ohio (Habig, 1972; Corsi, 1974) is generally supported by the results of this investigation. Specifically, however, they make additional clarification on the positive effects of services especially on residential land-use as opposed to what is contended in some other studies (Habig, 1972). Further, the combined effects of public facilities and access on fringe area housing is consistent with other significant findings in other parts of the country (Morrill, 1965; Lee, 1977; Bourne, 1974; Gleeson, 1979).

**REFERENCES**


THE INFLUENCE OF PUBLIC SERVICES


