The Urban Housing Market: A New Approach for Estimating Demand for Housing by Dwelling Type

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A new approach for estimating urban housing demand by dwelling type is suggested and tested empirically. The approach is based on the assumption that households choose their residential location and dwelling type in a way to maximize the communal utility. The model used is the Dynamic General Linear Expenditure System which allows determination of (1) urban housing demand by dwelling type, and (2) expenditure and own- and cross-price elasticities (compensated and uncompensated).

I. INTRODUCTION

A rapidly growing body of empirical work has attempted to estimate housing demand both in North America and Europe. Many of these studies, which are either national and highly aggregated or local and more disaggregated, focus either on theoretical aspects of the demand function and its determinants or on the signs and magnitude of price and income elasticities. The theoretical formulation of housing demand in general, and urban housing demand in particular, its proper specification, and its empirical verification are in great doubt. Much of the controversy rests on the signs, magnitudes, and derived implications of the various estimated elasticities, and on the theoretical specification of housing demand. The problem becomes more complicated in the case of urban housing demand where externalities, community characteristics, political interference, etc., distort the anticipated function of the housing market.

The purpose of this paper is to suggest and test empirically an alternative approach for estimating housing demand by dwelling type. This approach, based on the family of Linear Expenditure Systems, is considered to be methodologically superior to traditional approaches in that it allows simultaneous determination of housing demand by dwelling type and provides results consistent with consumer theory.

1 This paper was supported by a grant from the University of Waterloo research program.
2 For a brief review, see Paldam [17] and de Leeuw [4].
3 For example, see de Leeuw [4], Morgan [14], Winger [33], Straszheim [25], Uhler [24], Vaughn [30], Oksanen [16], Lee [10], Paldam [17], and Richardson [23, Table IV2].
II. THE THEORETICAL MODEL

The Dynamic General Linear Expenditure System (DGLES) suggested by Gamaletsos [9] is more flexible than the General Linear Expenditure System (GLES) proposed by the same author [7] and estimated by Wales [31] using Canadian data, and Gamaletsos [8] using time-series data for 11 OECD countries, in that it allows (1) the so-called subsistence coefficients, $\gamma_i$'s, to depend on the inflation rate and mortgage costs; and (2) the allocation coefficients, $\beta_i$'s, to depend on prices. In simple mathematical terms, the DGLES can be formulated as follows.

Let the utility function be of a CES type of the form

$$U = \sum_{i=1}^{n} \delta_i^{1-\rho} (x_i - \gamma_i)^\rho, \quad i = 1, \ldots, n$$

s.t.

$$0 < \delta_i < 1, 0 < \rho < 1, \sum_{i=1}^{n} \delta_i = 1, \text{ and } x_i - \gamma_i > 0$$

where $\delta_i$'s, $\gamma_i$'s, and $\rho$ are parametric constants.\(^4\) Maximizing Eq. (1) subject to the expenditure constraint, $\sum_{i=1}^{n} P_i x_i$, yields the following complete set of GLES expenditure equations:

$$E_i = P_i \gamma_i + \delta_i P_i^\tau \left[ \left\{ \sum_{j=1}^{n} \delta_j P_j^\tau \right\}^{-1} \left\{ E - \sum_{j=1}^{n} P_j \gamma_j \right\} \right], \quad i = 1, \ldots, n$$

where $\tau = \rho/(\rho - 1)$ and $\beta_i = \delta_i P_i^\tau (\sum_{j=1}^{n} \delta_j P_j^\tau)^{-1}$.\(^5\) Interpretation of the GLES given by (2) is straightforward. In the present context, it expresses

\[V = \left[ \sum_{i=1}^{n} \delta_i^{(1-\rho)} (x_i - \gamma_i)^{1/\rho} \right]\]  

\(^4\)The utility function given by Eq. (1) is a monotonic transformation of the CES type of utility function of the form

\[v = \left[ \sum_{j=1}^{n} \delta_j^{\rho}(\delta_j^{(1-\rho)} - \rho)^{1/\rho} \right]^{1/\rho}\]

For $\rho \to 0$, (1a) becomes the Geary–Stone [26] utility function. On the other hand, for $\rho \to \infty$, (1a) becomes a homothetic utility function.

\(^5\)It should be noted that for $\tau \to 0$, the GLES converges to the Linear Expenditure System (LES). For the formulation and properties of the LES, see Gamaletsos [8], Parks [18], and Lluch and Williams [11].
expenditures on the \( i \)th dwelling type \((E_i, \ldots, E_n)\) as a function of housing selling prices \((P_1, \ldots, P_n)\) and total housing expenditures \((E)\). Furthermore, the GLES suggests that for a given set of housing prices and total housing expenditures the allocation of “supernumerary” expenditures, in the traditional context, \((E - \sum_{i=1}^{n} P_i \gamma_i)\), among alternative dwelling types is determined by the marginal budget shares, \(\beta_i = (\partial E_i)/(\partial E)\), which are functions of housing prices. The \(\gamma_i\)'s in Eq. (2) represent costs of “subsistence housing minima” which in the GLES are assumed constant over time. Location theory, however, suggests that a household’s choice of housing consumption, the residential location, and dwelling type depend upon local housing conditions (such as inflationary housing pressure), employment availability, market accessibility, demographic changes, and the like. To take into account these factors the GLES [Eq. (2)] is modified in two ways.

First, following Gamaletsos [9], the cost of “subsistence-housing minima,” the \(P_i \gamma_i\)'s in Eq. (2), are made functions of last-year’s housing expenditures. This modification takes into account the inflation rate in the housing market. This may be expressed as

\[
P_{it} \gamma_i = P_{it} \gamma_i^* + a_i E_{it-1}
\]

where \(E_{it-1}\) is housing expenditures in period \(t-1\) and the \(\gamma_i\)'s, \(\gamma_i^*\)'s, and \(a_i\)'s are parametric constants. In this way the “habit-formation hypothesis,” adjusted for inflation rates, is incorporated into the GLES.

Second, in order to take into account costs of financing housing expenditures, a further modification is applied on Eq. (3) by making the \(\gamma_i^*\)'s depend upon the mortgage rate, that is,

\[
\gamma_i^* = \gamma_i^{**} + h_i (1/r_m)
\]

We are treating “housing” as a flow variable rather than a stock variable. As Paldam [17, pp. 130–131] argues, “the dwelling is the most durable of all ordinary consumer goods and thus constitutes an important limiting case in the theory of consumption.”

For an analytical interpretation of both the \(\beta_i\)'s and \(\gamma_i\)'s see Section III.

For example, see Muth [15], Reid [22], Maisel [13], Paldam [17], Lee [10], Straszheim [25], de Leeuw [4], and Oksanen [16].

By dividing (3) by \(P_{it}\) and substituting \(E_{it-1} = P_{it-1} x_{it-1}\), Eq. (3) becomes \(\gamma_i = \gamma_i^* + a_i (P_{it-1}/P_{it}) x_{it}\). This indicates that \(\gamma_i\) becomes a function of \(P_{it-1}/P_{it}\) which is the inverse of the inflation rate.

According to Pollack’s interpretation [20], \(P_{it} \gamma_i^*\) represents the “physiological necessary” component of \(P_{it} \gamma_i\) and \(a_i E_{it-1}\) represents the “psychological necessary” component.

Pollak and Wales [21], for example, have introduced “dynamic” elements in the linear expenditure system by allowing the \(\gamma_i\)'s to vary in a linear way with either a time trend or consumption of the \(i\)th commodity lagged 1 year. Parks [18], on the other hand, has tested two dynamic specifications suggested by Stone [27], allowing both the \(\gamma_i\)'s and the \(\beta_i\)'s to depend linearly on time trends. For more detailed analysis, see Parks [18], Pollak and Wales [21], Pollak [20], and Wales [31].
where \( r_m \) is the mortgage rate.\(^{12}\) Substituting the \( \gamma_i^* \) function (3a) into Eq. (3), and the resulting expression into Eq. (2), the DGLES housing expenditure equation system takes the form

\[
E_{it} = P_{it} \left[ \gamma_i^{**} + h_i \left( 1/r_m \right) \right] + \delta_i P_{it}^{-1} \left( \sum_{j=1}^{n} \delta_j P_{jt}^{-1} \right)^{-1} 
\times \left[ E - \sum_{j=1}^{n} \left( \gamma_j^{**} + h_j \left( 1/r_m \right) \right) P_{jt} \right] 
- \delta_i P_{it}^{-1} \left( \sum_{j=1}^{n} \delta_j P_{jt}^{-1} \right)^{-1} \left[ \sum_{j=1}^{n} a_j E_{jt-1} \right] + a_i E_{it-1} + \epsilon_{it}. \tag{4}
\]

For the statistical estimation of the DGLES a stochastic specification term, \( \epsilon_{it} \), is added at the end of Eq. (4).\(^{13}\) The unique features of this model are that (1) it allows the "subsistence-housing minima" expenditures to depend on the inflation rate, mortgage costs, and locational and demographic factors; (2) it permits the housing-expenditure allocation coefficients to depend on housing selling prices; and (3) it sets the ground for estimating both short-run and long-run expenditure and price (own and cross) elasticities.

The short-run expenditure and price elasticities implied by (4) are summarized below.\(^{14}\)

\[
H_{yi} = \left( \frac{\partial X_i}{\partial E} \right) = \beta_i/W_i \tag{5}
\]

s.t.

\[
H_{yi} > 0, \quad \text{for} \quad \beta_i > 0, \quad i = 1, \ldots, n
\]

\[
H_{ii} = \left[ \left( \frac{\partial X_i}{\partial P_i} \right) \div \left( \frac{\partial X_i}{\partial P_i} \right) \right]
= \left( \beta_i (\tau - 1) E_{it}^{-1} - \eta \beta_i^2 E_{it}^{-1} \right) \left( E - \sum_{j=1}^{n} P_j \gamma_j^* \right) - \beta_i \gamma_i^* X_i^{-1} - a_i E_{it-1} E_{it-1}^{-1} \tag{6}
\]

\(^{12}\)Even though our formulation has not explicitly introduced the locational and demographic factors on the subsistence-housing minima, \( \gamma_i^* \)'s, they are taken into account by the intercept of the \( \gamma_i^* \) function.

\(^{13}\)The specification of the error structure in a system of demand (expenditure) equations is the most controversial issue in the literature. It is usually assumed that the errors for different observations are uncorrelated and the \( P_i \)'s are assumed to be nonstochastic, or if stochastic, independent of \( \epsilon_i \). Nevertheless, our estimation routine provides correction for a first-order autocorrelation scheme. For alternative specification of the error structure see Lluch and Williams [11].

\(^{14}\)The housing-unit demand equations upon which estimation of price elasticities is based can be derived from Eq. (4) by dividing through by \( P_{it} \).
s.t.
\[-\infty < H_{ii} < 0, \quad \text{for } 0 < \beta_i < 1, \chi_i > \gamma_i^*, \quad \text{and } \tau < 1, i = j\]
\[H_{ii} < 0, \quad \text{for } 0 < \beta_i < 1, \chi_i < \gamma_i^*, \quad \text{and } \tau > 1, i = j\]
\[H_{ij} = \left[\left(\partial \chi_i / \partial P_j\right) + \left(\partial \chi_i / \partial P_j\right)\right] = -\beta_i \tau \beta_j E_{it}^{-1} \left( E - \sum_{j=1}^{n} P_j \gamma_j^* - \sum_{j=1}^{n} a_j E_{jt} \right) - \beta_i P_j \gamma_j E_{it}^{-1} \quad (7)\]
\[s.t.
\[-\infty < H_{ii} < 0, \quad \text{for } 0 < \beta_i < 1, \chi_i > \gamma_i^*, \quad \text{and } -\infty < \tau < 1, i \neq j\]
\[-\infty < H_{ij} < 0, \quad \text{for } 0 < \beta_i < 1, \chi_i < \gamma_i^*, \quad \text{and } 1 < \tau < \infty, i \neq j\]
\[\overline{H}_{ii} = \left[\left(\partial \chi_i / \partial P_j\right) + \left(\partial \chi_i / \partial P_j\right)\right] = H_{ii} + H_{yi} W_i \quad (8)\]
\[s.t.
\[-\infty < \overline{H}_{ii} < 0, \quad \text{for } H_{ii} < 0, \quad \text{and } 0 < H_{yi} W_i < H_{ii}, i = j\]
\[\overline{H}_{ij} = \left[\left(\partial \chi_i / \partial P_j\right) + \left(\partial \chi_i / \partial P_j\right)\right] = H_{ij} + H_{yi} W_j \quad (9)\]
\[s.t.
\[\overline{H}_{ij} > 0, \quad \text{for } H_{ij} < 0, \quad \text{and } H_{yi} W_j > H_{ij} < 0, i \neq j\]

where \( W_i = E_{it} / E \), \( W_j = (P_{ij} \gamma_j^*) / (\sum_{j=1}^{n} P_j \gamma_j^*) \), \( H_{yi} \) are expenditure elasticities, \( H_{ii} \) and \( H_{ij} \) are uncompensated (Cournot's case) own- and cross-price elasticities, and \( \overline{H}_{ii} \) and \( \overline{H}_{ij} \) are compensated (Slutsky's) own- and cross-price elasticities, respectively.\(^{15}\)

The interpretation of these elasticities and derived implications, in the context of traditional consumer theory, is straightforward. Since \( H_{yi} \) and \( \beta_i \)'s are postulated to be positive, the DGLES is restricted, as are its competitors (i.e., LES, ELES, GLES, HLES, etc.) to normal commodities (i.e., no saturation). The fact that the own-price elasticities (\( H_{ii} \)) and the uncompensated cross-elasticities (\( H_{ij} \)) are negative suggests that the

\(^{15}\)The long-run price elasticities can be derived, as the short-run elasticities, by utilizing the long-run DGLES. The long-run DGLES can be derived from Eq. (4) by assuming that \( E_{it} = E_{it-1} = E_i \). The long-run DGLES takes the form

\[E_i = P_i \left[ (\gamma_i^*) (1 - a_i) \right]^{-1} + \left[ \delta_i P_i^* (1 - a_i)^{-1} \right] / \left( \sum_{j=1}^{n} \delta_j P_j^* (1 - a_j)^{-1} \right) \]
\[\times \left[ E - \sum_{j=1}^{n} P_j \gamma_j^* (1 - a_i)^{-1} \right]. \quad (4a)\]

where \( 1/(1 - a_i) \) are long-run expenditure multipliers. For the derivation see Gamaletsos [9].
commodities are "gross complements." Finally, the assumed positive compensated cross elasticities indicate that all commodities are "net" substitutes. In the present context, we interpret expenditure elasticities in an analogous manner. Negative cross elasticities \( H_{ij} \), for example, suggest substitution between housing types. Positive cross elasticities \( H_{ij} \), however, imply that the income (expenditure) effect swamps the substitution effect.

Even though the model developed here is pertinent in analyzing consumer expenditure patterns in the traditional sense, it retains sufficient realism for applications regarding housing demand. Undoubtedly the approach taken here will enable us to describe patterns of housing demand and most important, to suggest, on the basis of the estimates, policy measures related to the future "housing market" structure.

III. EMPIRICAL ESTIMATION OF THE MODEL

A. Data and Method of Estimation

The DGLES was estimated for Metropolitan Toronto, Canada, using monthly housing data covering the period 1974–1980. The Metropolitan Toronto housing market was broken down into three dwelling types: apartments, townhouses, and single-family dwellings including semidetached. The analysis excludes duplexes, triplexes, and other multiples. Thus the dependent variables, \( E_i \)'s, used in this study are expenditures on those three dwelling types. We have not attempted to include aggregate expenditures on nonhousing commodities due to the unavailability of comparable data.

Three sets of data are utilized in this paper: (1) monthly time series on single-family dwellings and semis, condominium apartment and townhouse units sold, and their respective average selling price; (2) dollar volume of units sold; and (3) nominal mortgage rates. The data for the first two sets of data come from the Toronto Real Estate Board [28]. Nominal mortgage rates come from the Bank of Canada Review [2].

The method used to estimate the DGLES is nonlinear in terms of the coefficients but linear in terms of prices and housing expenditures. The

\[ \text{Data on single-family dwellings and semis are not readily available. They were estimated as residual from total residential figures minus figures for condominium apartments and townhouses.} \]

\[ \text{It is well known that nonlinear estimation may converge to a local situation, if at all. Thus the initial values of coefficients are of paramount importance. For this study initial } \beta \text{'s were set equal to the mean value of expenditure shares and } y \text{'s were set equal to one half of minimum housing quantities. Experimentation suggested that the estimates are not overly sensitive to starting values in a plausible range. For the properties of the nonlinear estimation see Maddala [12, pp. 171–181] and Pindyck and Rubinfeld [19, pp. 225–234].} \]
estimation uses the full-information maximum-likelihood routine contained in the TROLL [29] software package.

B. Statistical Results and Model Evaluation

a. Statistical Results

Three sets of criteria are set forth in evaluating the performance of the model: (1) theoretical plausibility of the model including signs and magnitudes of the "housing allocation," $\beta_i$'s, and "housing-subsistence-minima" coefficients, $\gamma_i^*$'s; (2) signs and magnitude of expenditure and price elasticities; and (3) conformity of our estimates with other studies of this nature.

I. HOUSING ALLOCATION COEFFICIENTS ($\beta_i$'s). Table 1 reports the $\beta_i$'s and $\delta_i$'s for the DGLES estimated by the "iterative" maximum-likelihood approach. These coefficients were found to be consistent with our prior expectations ($\beta_i$'s > 0, and $\delta_i$'s > 0) and statistically significant at the 1% probability level. We interpret these estimates to mean that housing expenditures above the "supernumery" expenditures, $E - \Sigma_{j=1}^{n} P_j \gamma_j^*$, are allocated, at a constant percentage, among dwelling types. For example, our estimates show that 89.1% of expenditures over supernumerary expenditures goes to single-family dwellings and semis, 4.7% to condominium apartments, and 6.2% to townhouses. These findings suggest that the Metropolitan Toronto community tends to allocate more housing expenditures on single-family dwellings and significantly less on condominium apartments and townhouses. A further support of this argument is the fact that even though the average selling price for single-family dwellings has risen by 47.1% between 1974 and 1980, total units sold have risen by 46.4%. In contrast, the price-change effect has had a pronounced effect on purchases of townhouses where the small change in average selling price has resulted in a 92.04% increase in purchases. Condominium apartments follow the same pattern as that of single-family dwellings and semis, that is, an average increase in selling price by 33.5% has been matched by a similar increase in condominium apartment units (i.e., by 35.9%). However, since the average share for single-family dwellings and semis, $E_i/E$, accounts for 88.97% of total housing expenditure, the effect of prices on the marginal budget share, $\beta_i = \partial E_i/\partial E$, is on the average negligible. This is also indicated by the fact that $\tau$ has been found statistically insignificant (Table 1).

II. HOUSING SUBSISTENCE MINIMA ($\gamma_i^*$'s). The housing "subsistence minima" are reported in Table 1. Since the DGLES was derived on the assumption that households will choose dwelling type in a given location in such a way as to maximize to communal utility derived from the purchases, the housing subsistence minima, $\gamma^*$'s, or alternatively, the cost of the
TABLE 1

<table>
<thead>
<tr>
<th>No.</th>
<th>Housing type</th>
<th>Allocation coefficients</th>
<th>Subsistence coefficients</th>
<th>Statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$\delta_i$</td>
<td>%</td>
<td>$\beta_i$</td>
</tr>
<tr>
<td>1</td>
<td>Single-family dwellings/sems (31.79)</td>
<td>0.919</td>
<td>91.9</td>
<td>0.891</td>
</tr>
<tr>
<td>2</td>
<td>Apartments (2.11)</td>
<td>0.032</td>
<td>3.2</td>
<td>0.047</td>
</tr>
<tr>
<td>3</td>
<td>Townhouses (4.87)</td>
<td>0.049</td>
<td>4.9</td>
<td>0.062</td>
</tr>
<tr>
<td></td>
<td>Totals</td>
<td>1.000</td>
<td>1.000</td>
<td>1.000</td>
</tr>
</tbody>
</table>

R² – 0.585 (10.43) 0.700 (10.48) 0.695 (10.13) -0.799 (0.91)
housing subsistence minima, \( P_{i} y_{i}^{*} \), indicate, on the basis of inflationary housing pressure and mortgage costs, how the urban community will choose dwelling type. For example, the "subsistence minima" housing quantities will go 77.45% to single-family dwellings and semis, 11.71% to condominium apartments, and 10.84% to townhouses. These estimates further indicate the urban community's preference for single-family dwellings and semis. It is important, however, to emphasize the way in which subsistence housing quantities are affected by the inflation rate in the housing market and the cost of financing housing purchases. First, cost of financing, as measured by mortgage rates, has a negative effect on subsistence housing quantities. On the basis of Eq. (3a) and the figures in Table 1, an increase in mortgage rates will reduce subsistence housing quantities in the single-family dwellings and semis sector and increase subsistence quantities in the condominium apartment sector and townhouse sector.\(^{18}\) These findings suggest that high mortgage rates observed in Canada have shifted demand from the single-family and semis sector with the highest average selling price to the other sectors with relatively lower selling prices. Second, inflation in the housing market has, as one would expect, a negative effect on the subsistence minimum quantities. This effect appears to be stronger in the condominium apartment \((a = 0.700)\) and townhouse sector \((a = 0.695)\) than in the single family and semis sector \((a = 0.585)\).\(^{19}\) These findings confirm again the theory that price and mortgage rates have negative effects on community housing demand. Briefly, our \( y^{*} \) estimates are consistent with restrictions imposed by the DGLES and in line with hypothesized relationships.

**III. EXPENDITURES AND PRICE ELASTICITIES.** Housing-demand expenditure elasticities [Eq. (5)], reported in Table 2, are as expected positive for all types of dwellings. This suggests that all types of dwellings are normal "commodities." Expenditure elasticities for single-family dwellings, semis, and townhouses were found to be greater than one and that of condominium apartments less than one. As argued by Paldam [17, p. 131], income elasticities of a value greater than one do not imply that the dwelling is a luxury commodity. They merely imply that "Schwabe's law" does not apply to dwellings. High housing-expenditure elasticities for single-family dwellings, semis, and condominium apartments are further indicated by high marginal shares \((\beta_{i}^{'}s, \text{Table 1})\) for these two dwelling types. It should be emphasized, however, that a confident evaluation of expenditure elastic-

\(^{18}\) Notice that the \( h_{i}^{'}s \) [Eq. (3a)] for condominium apartments and townhouses have been found to be negative.

\(^{19}\) One further support of this argument would be provided by calculating the price multipliers, \( 1/(1 - a_{i}) \), in Eq. (4a). They are 2.4, 3.3, and 3.3 for single-family and semis, condominium apartments, and townhouses, respectively.
TABLE 2
Estimates of the Dynamic General Linear Expenditure System: Expenditures and Price Elasticities

<table>
<thead>
<tr>
<th>Housing type</th>
<th>Singles/semis</th>
<th>Price elasticities</th>
<th>Townhouses</th>
<th>Expenditure elasticities ((H_{xy}))</th>
<th>Average expenditure ((E_x/E))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singles/semis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0018</td>
<td>0.8897</td>
</tr>
<tr>
<td>compensated</td>
<td>-0.2979</td>
<td>0.3825</td>
<td>0.3201</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>uncompensated</td>
<td>-1.1892</td>
<td>-0.4852</td>
<td>-0.6481</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Apartments</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.9753</td>
<td>0.0519</td>
</tr>
<tr>
<td>compensated</td>
<td>0.0252</td>
<td>-0.6615</td>
<td>0.0276</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>uncompensated</td>
<td>-0.0267</td>
<td>-0.7122</td>
<td>-0.0289</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Townhouses</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.0882</td>
<td>0.0853</td>
</tr>
<tr>
<td>compensated</td>
<td>0.0267</td>
<td>0.0266</td>
<td>-0.6848</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>uncompensated</td>
<td>-0.0318</td>
<td>-0.0302</td>
<td>-0.7483</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Estimates requires a comparison of our estimates with other related studies. This comparison is not always possible because of different methodological approaches, different sets of data (cross-section vs time-series data), estimation techniques, and definitional approaches (stock variables vs flow variables). Nevertheless, our expenditure elasticities are in very close agreement with those obtained by de Leeuw [4], Winger [33], Clark and Jones [3], Whithead [32], Erickson and Rietz [6], Muth [15], Lee [10], Uhler [24], and Maisel [13].

"Housing-demand" price elasticities are also reported in Table 2. Own-price elasticities (compensated and uncompensated) are given by the diagonal elements of the table. Cross-elasticities are given by the off-diagonal elements. All uncompensated elasticities (Cournot’s case) are consistent with prior expectations, that is, negative and within the limits implied by the model. As one would expect, the highest uncompensated own-price elasticity is observed for single-family dwellings and semis \((H_{ii} = -1.1892)\), followed by that of townhouses \((H_{ii} = -0.7483)\) and condominium apartments \((H_{ii} = -0.7122)\). These elasticities fall within the limits of those estimated by Reid [22], de Leeuw [4], Maisel [13], and Paldam [17]. Compensated own-price elasticities \((\bar{H}_{ii})\), on the other hand, indicate (Table 2) that demand for single-family dwellings and semis is most inelastic \((\bar{H}_{ii} = -0.2979)\) and that of condominium apartments least inelastic \((\bar{H}_{ii})\).

20It should be emphasized, however, that a meaningful comparison of our estimates with other studies is not feasible due to the entirely different methodological approach followed by this study and the different sets of data utilized in various studies.
This suggests that the high transaction activity observed in the single-family dwelling and semis housing sector is dominated by family-income structure rather than by selling prices. The price effect is more important for condominium apartments and townhouses.

Uncompensated cross-price elasticities \( H_{ij} \) given by off-diagonal elements of Table 2 are also negative, indicating the "housing types" are, for the urban community as a whole, "gross" complements. Note the manner (Table 2) in which the cross-price effect operates in the home-ownership market. An increase in the selling price of the single-family dwellings and semis, for example, will have negligible effect on both the condominium apartment sector \( (H_{ij} = -0.0267) \) and townhouse sector \( (H_{ij} = -0.0318) \). On the other hand, an increase in the selling price of condominium apartments and/or townhouses will influence demand for single-family dwellings more than for the other housing types. For instance, an increase in the price of townhouses by 10% will reduce, given total housing expenditures, the demand for single-family dwellings by 6.5% \( (H_{ij} = -0.6481) \) and that of apartments by 0.29% \( (H_{ij} = -0.0289) \).

Turning to the compensated \( H_{ij} \) cross-price elasticities, we find all of them positive, indicating that housing types are "net" substitutes. The important features demonstrated by these elasticities are that (1) an increase in price for single-family dwellings and semis, after compensation takes place, will increase only slightly demand for condominium apartments \( (H_{ij} = 0.0257) \) and townhouses \( (H_{ij} = 0.0267) \), and (2) an increase in the selling price for townhouses and condominium apartments will tend to increase demand for single-family dwellings to a larger extent than demand for the other two types of dwellings (Table 2).

Due to the aggregate nature of our data, factors such as housing age, qualities, travel times, and neighborhood characteristics are assumed to be captured by the subsistence minima coefficients \( \gamma_i 's \). Since these parameters enter the formulae for the price elasticities, the estimated values of the elasticities might well have been altered if we had been able to make the \( \gamma_i 's \) explicitly dependent on such items in a manner similar to the treatment of mortgage rates in this study.

One may argue the estimates of elasticities (both expenditure and price elasticities) provided by the DGLES have some rather significant implications regarding housing income policies (such as cash grants, mortgage grants, etc.) aiming to enforce housing demand of a designated type of dwelling.

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\(^{21}\) One should expect that additional factors such as income distribution, family size, location characteristics, etc., would affect our estimates. However, there is no way of knowing how these factors would affect the performance of our model.
b. Statistical Evaluation of the Model

In addition to the theoretical plausibility of the DGLES, three other criteria were used to evaluate the performance of the model: (1) the significance of the estimates (t values or standard errors); (2) the goodness of fit of housing expenditure equations; and (3) the Durbin–Watson [5], $d$, statistics. On the basis of the first criterion, the model performs extremely well, since all the estimates have been found statistically significant at the 1% probability level. On the basis of the second criterion, the model performs equally well ($0.811 \leq R^2 < 0.998$). The third criterion, the Durbin–Watson statistic, indicates that the DGLES specification is free of autocorrelation across housing expenditure equations since the D–W statistic, $d$, is very close to the critical value of two ($1.989 \leq d \leq 2.230$).

On the basis of the findings one would infer two major economic implications. First, there is a good deal of evidence that the Dynamic General Linear Expenditure System is a useful tool in explaining housing demand patterns and allocating housing expenditures among different dwelling types. This implication results from the fact that the DGLES model allows the simultaneous determination of not only housing allocation, $\beta$, 's, and subsistence coefficients, $\gamma$, 's, but, and most important, simultaneous determination of expenditure and price elasticities (compensated/ uncompensated) by dwelling type. Second, the analysis suggests that the model can be used in predicting future housing expenditure for different dwelling types.

IV. SUMMARY

The main purpose of this paper has been to suggest and test empirically an alternative approach for estimating urban housing demand by dwelling type. By assuming that households will choose individual residential location and type of dwelling in a way that they maximize the communal utility, we have demonstrated that (1) the DGLES provides not only estimates that conform with other related studies, but and most important, the model is more general in nature in that it allows the simultaneous determination of expenditures, own- and cross-price elasticities; and (2) our approach provides additional information concerning the allocation of housing expenditures among dwelling types, in contrast to the traditional practice of estimating housing demand. It is our belief that our approach might prove useful to other investigators in the area of housing demand.

REFERENCES


