The Other Side of Eight Mile
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Suburban Population and Housing Supply

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The Other Side of Eight Mile: Suburban Housing Supply

Abstract

This article establishes a linkage between decadal changes in suburban population and the supply of suburban dwelling units. It then estimates an econometric supply and demand model for 317 U.S. suburban areas for the 1970s, 1980s, and 1990s, with the *State of the Cities* database. Suburban supply is more elastic than central city supply, with suburban estimates between +1.26 and +1.42. However, separate estimates by geographic region lead to supply elasticities of +0.89 for the northeastern quadrant of the United States and +1.86 for the remainder of the U.S.

This article addresses issues of population change and housing supply in U.S. suburbs. Central cities often have only limited opportunities for new construction, while surrounding suburbs "beyond Eight Mile Road." may have considerable vacant land to accommodate new employers and new residents.[1] This generalization, of course, oversimplifies. New Rochelle, NY, Evanston, IL, Brookline, MA, Royal Oak, MI, or Lakewood, OH, for example, were developed 100 or more years ago. Many suburbs (Puentes and Orfield, 2002) are fully built up, many have stopped growing or have experienced population losses, and some have problems of blight or poverty similar to central cities.

This article establishes a linkage between decadal changes in suburban population and housing supply, differentiating among central cities, and inner and outer suburban rings. It then estimates an econometric supply and demand model for 317 U.S. suburban areas for the 1970s, 1980s, and 1990s, with the *State of the Cities* database.

With almost all suburban areas characterized by increasing housing stock, and in general more buildable land than the central cities, one would expect suburban supply price elasticities to exceed those of central cities. Using a similar model, Goodman (2004) estimated dwelling unit price elasticities between +0.03 and +0.13 for central cities with declining housing stocks, and between +1.05 and +1.08 for central cities with increasing housing stocks. The expectation of more elastic suburban supply is borne out, with estimates between +1.26 and +1.42. However, separate estimates by geographic region yield a supply elasticity of about +0.89 for the northeastern quadrant of the United States, and +1.86 for the remainder of the U.S., with a weighted mean of +1.42.

Metropolitan Structure and Housing Supply

Over the past 30 years U.S. metropolitan population growth has occurred largely outside

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[1] Eight Mile Road in Detroit is one of the better-known boundaries between central city and suburbs.

the central cities.[2] Most models of urban structure, density, and growth refer to land use and land rents, with capital stocks adjusting to the differing rents. The suburbs are distinguished only by greater distance from the central place, and lower densities. Housing capital stock has only a passive role in such models, with the results differing little from models that examine only land and land rents.

One could argue that housing stock, and particularly new construction, assumes a critical role in characterizing suburban development. Metropolitan population expansions most often occur in suburban areas where empty lots are developed and previously undeveloped tracts are converted into housing developments. Although such development could occur in central cities as well, the costs of "tear-downs and rebuilds" often make it less desirable than building on previously undeveloped land.[3]

Housing stock adjustments generally depend on the flow of new stock. Green and Malpezzi (2003, P. 6) describe a U.S. construction industry with a large number of very small producers, implying close to constant returns to scale for new units and close to an infinitely elastic supply of new units. Using such a theoretical framework, Muth (1968) estimates one of the earliest supply elasticities at approximately +14. DePasquale (1999) surveys the literature and concludes that: (1) New supply appears to be price elastic, with estimates between +3.0 and positive infinity; (2) Higher income households appear more likely to improve their homes than to do nothing, but are more likely to move than to improve their current units; (3) Repair and renovation expenditures are inelastic with result to income and price.

Comparative work between the United States and the United Kingdom shows the UK to

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[2] The United States is not alone. Paris's population, for example, fell from 2,790,091 in 1962 to 2,125,246 in 1999, or by 23.8%. The suburbs of the former Department of the Seine grew by 6.9% although the entire (former) Department decreased by 8.3% during this 37-year interval. See Demographia (2003).

[3] McDonald (1979, Ch. 8) assigns a key role to demolition costs, implying that demolition with replacement is most likely to occur at locations where housing demand increases. He puzzles however over the "long lags observed in some inner city areas between building abandonment, demolition, and replacement," wondering to what extent speculation leads to vacant land for long periods, and what causes the speculation.

have less elastic supply. For the prewar U.S., Malpezzi and Maclennan calculate implied price elasticities of supply from flow models as between +4 and +10, and postwar, between +6 and +13. In contrast, for the prewar United Kingdom, the implied price elasticity from flow models is between +1 and +4; postwar it is between 0 and less than +1.

Bramley (1993a, 1993b) estimates a UK price elasticity of supply of about +0.31. Pryce (1999) uses data provided by Bramley and finds a backward-bending supply curve in the 1988 boom period but not in the slump conditions of 1992. He estimates the price elasticity of supply to be 0.58 in 1988 and 1.03 in 1992.[4]

Mayer and Somerville (MS 2000a, b) examine new construction price elasticities. MS (2000b), for example, characterize housing supply elasticity in terms of the housing stock (rather than new construction), in an empirical model derived from urban growth theory. They describe new housing construction as a function of *changes* in house prices and costs rather than as a function of the levels of those variables, used in previous studies. Their estimates using quarterly panel data (MS 2000b) relate a 10% rise in real prices to a 0.8% increase in the housing stock, which is accomplished by a temporary 60% increase in the annual number of starts, spread over four quarters. With local area supply functions (MS 2000a) they find that the aggregated national data may slightly overestimate price elasticity of new construction and underestimate the time required to respond to price shocks.

Glaeser and Gyourko (GG 2003) argue that an urban area's housing supply is kinked – highly elastic with respect to positive shocks because additional units can be built if desired, but inelastic when shocks are negative because existing homes are quite durable. A positive demand shock is expected to generate more units and people, but only a moderate increase in housing price. A negative demand shock in contrast is expected to cause housing price to fall, but induce

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[4] Green and Malpezzi (2003) provide an updated review of the relevant supply literature and international comparisons. White and Allmendinger (2003) and Barker (2003) focus on European experiences and perspectives.

little change in the housing stock or population. GG do not estimate supply elasticities, but their model suggests asymmetric elasticities close to 0 in the negative direction, but larger in the positive direction. Goodman (2004) provides separate analyses for contracting and expanding central cities and validates the hypothesis that supply is much less elastic in the negative than in the positive direction. Since suburbs are generally expanding, suburban price elasticities would presumably exceed central city elasticities, since the suburbs have access to large tracts of previously undeveloped land that are most often unavailable in central cities.

Suburban Populations and Dwelling Units

This section introduces descriptive analyses using the State of the Cities (SOCDS) data system, which provides Census data for metropolitan statistical areas, metropolitan cities and suburbs for 1970, 1980, 1990 and 2000.[5] The version of the SOCDS here uses the 1990 Standard for Metropolitan Statistical Areas and Primary Metropolitan Statistical Areas (MSAs/PMSAs) as established in June 30, 1999. Suburban data comprise the data for the metropolitan area less the sum of the data for all central/principal cities (if any) in the metropolitan area. For New England states, the analysis uses metropolitan areas as defined by the standard MSA/PMSA definition, rather than the New England County Metropolitan Area (NECMA) definition. This study analyzes 317 suburban areas that provide data for all four years.

(Table 1– Percentage Housing Units Increases for 50 largest Suburban Areas, 1970 – 2000)

Table 1 describes 1970 - 2000 growth patterns for the populations and numbers of dwelling units in the 50 largest suburban areas as ranked by 1970 suburban population. Only Pittsburgh's suburban population fell (by 6.7%), yet *all* areas had at least double-digit percentage increases in numbers of dwelling units, with the Atlanta, Dallas, Houston, Denver, Tampa, and Fort Lauderdale suburbs showing triple-digit increases. Dwelling unit percentage increases

[5] Continuously updated, the SOCDS is located at http://socds.huduser.org/, and was most recently accessed for this work on April 22, 2004.

generally exceeded population percentage increases, often by 20 or more points and only Los Angeles and Riverside, California saw higher unit increases than population increases.

Demographic Changes and Suburban Housing Supplies

This section links patterns of household formation and household size to numbers of occupied dwelling units. These patterns changed substantially in the last third of the twentieth century, but particularly in the 1970s. From 1970 to 1980 the average number of persons per household in the United States fell from 3.14 to 2.75, a decrease of 12.1%.[6] Sweet (1984) lists six reasons: (1) young people increasingly delayed marriage; (2) rates of separation and divorce increased; (3) remarriage rates began to stabilize and decline, after a period of increase; (4) mortality of the elderly declined; (5) persons of all ages and marital statuses continued their increased propensities to form their own households rather than to share the households of others; and (6) the large baby boom cohorts replaced the very small depression cohorts such that in 1980 there were 39% more 20-34 year olds than in 1970.

By definition, more households mean more dwelling units, even with constant population, but it may be difficult to provide more units in built up areas. For example, a 1,000 square foot unit with one bathroom and one kitchen for a couple cannot be split costlessly into two 500 square foot units (*each* with a bathroom and a kitchen) for two singles; a new unit may be necessary. Alternatively in many older cities or suburban areas, small units with only one bath may no longer be desirable, and the areas might benefit from combining small units, also a costly alternative.

Decomposing population changes into changes in dwelling units, occupancy rates, and average number of people per unit provides useful insights. Begin with total population P, number of dwelling units U, occupancy rate O, and household size per occupied unit, S, at times t and $t+1$,

[6] This compared to drops of 5.7% from 1960 to 1970, 4.7% from 1980 to 1990, and 1.4% from 1990 to 2000. See U.S. Census Bureau (2000).

Population$_t$ = (Dwelling Units)$_t$ (Occupancy Rate)$_t$ (HH Size/Occupied Dwelling Unit)$_t$:

$$P_t = U_t O_t S_t \ ; \tag{1}$$

Population$_{t+1}$ = (Dwelling Units)$_{t+1}$ (Occupancy Rate)$_{t+1}$ (HH Size/Occupied Dwelling Unit)$_{t+1}$

$$P_{t+1} = U_{t+1} O_{t+1} S_{t+1} \tag{1′}$$

Using decennial data, with "bars" indicating mean values, and differencing the two equations:

$$\Delta \text{ Population} = P_{t+1} - P_t = U_{t+1} O_{t+1} S_{t+1} - U_t O_t S_t =$$

$$\overline{U}\overline{O}(S_{t+1} - S_t) + \overline{S}\overline{O}(U_{t+1} - U_t) + \overline{U}\overline{S}(O_{t+1} - O_t) \tag{2}$$

[Absolute Size Effect] [Absolute Housing Effect] [Absolute Occupancy Effect]

One can change (2) to percentage terms by dividing by mean population $\overline{P} = (P_t + P_{t+1})/2$:

$$\text{Percentage } \Delta \text{ in population} = \frac{P_{t+1} - P_t}{\overline{P}} = \frac{S_{t+1} - S_t}{\overline{S}} + \frac{U_{t+1} - U_t}{\overline{U}} + \frac{O_{t+1} - O_t}{\overline{O}}, \text{ or}$$

[Relative Size Effect] [Relative Housing Effect] [Relative Occupancy Effect]

$$\hat{P} = \hat{S} + \hat{U} + \hat{O}, \tag{2′}$$

with "hats" referring to percentage changes, or relative *size* , *housing* and *occupancy* effects respectively. Percentage changes are calculated at mean decadal values, e.g. $\hat{P} = \frac{(P_{t+1} - P_t)}{(P_{t+1} + P_t)/2}$, following Goodman and Thibodeau (1998).

Equations (2) and (2′) provide three insights:

a. The 1970s' substantial household size declines led to central city population declines, because the smaller households were neither offset by increased numbers of units nor occupancy rates.[7] Over time central city housing, generally older than suburban housing, may have endured more economic depreciation and possibly left the market. The use of both occupancy rates and number of units distinguishes between vacant/abandoned (but potentially available) units, and those that have been torn down. Both represent reductions in market-clearing housing supply. Central cities are often geographically constrained from expanding and hence providing increased units, whereas at least some suburbs can generally expand into the surrounding agricultural areas.

[7] Demographers have analyzed household size for the nation as a whole, but only Berry (1980) addressed impacts of household size on urban areas, and his work was more descriptive than analytical.

b. Older suburbs (like central cities) may often have very little new "buildable" land. Population changes generally relate to household size decreases. These changes may be offset, or exacerbated, by what happens to the existing stock, and how much new building occurs.

c. Newer suburbs, with considerable buildable land, experience population increases largely because of the construction of new units. The increased population density involves new (but not necessarily large) households settling into new or more recently built dwelling units.

Central Cities, and Inner and Outer Suburban Rings

The previous section refers to central cities, and their inner and outer suburban rings. It is beyond the scope of this study to delineate inner and outer rings for all 317 suburban areas, because of the inherent subjectivity in defining inner and outer rings, and because for many smaller cities, definition of rings would require delineation at the census tract level.[8] However, this section (through Table 2) examines eight older central cities, (Baltimore, Boston, Chicago, Cleveland, Detroit, Minneapolis-St. Paul, Pittsburgh, and Washington DC), and their larger suburbs to distinguish between the central cities and their inner and outer rings. All of the suburbs examined had 1970 populations that exceeded 10,000 (although some fell below 10,000 in subsequent censuses). In this analysis, drawn from maps, inner ring suburbs physically touched the central city; outer ring suburbs were further away.

(Table 2 – Absolute Household Size and Housing Unit Impacts for Central Cities, Inner, and Outer Suburban Rings for Selected Older American Cities)

In the 1970s, every one of the central cities lost population, and 6 of the 8 lost housing units. Every suburban inner ring also lost population, but these population losses accompanied *increased* numbers of housing units. Six of the 8 outer rings gained population, and these gains were accompanied by even larger increases in numbers of dwelling units than in the inner rings.

Table 2 evaluates equation (2) for absolute household size and housing unit effects.

[8] Zip codes, for example, may cross central city and/or suburban boundaries.

Central City Chicago, for example, lost 357,753 residents in the 1970s. Holding dwelling units and occupancy rates constant, household size decline $\overline{UO}(S_{t+1} - S_t)$ accounted for -234,386, or 65.5% of the population decrease. The number of dwelling units also declined; with constant household size and occupancy rate**,** the population decline, $\overline{SO}(U_{t+1} - U_t)$ would have been 87,872 (or 24.6% of the decrease). The balance of the change (-35,495) came from reduced occupancy rates.

Contrast these central city changes to the inner suburban ring, whose population fell by -45,697. Holding housing units and occupancy rates constant, the population would have fallen by almost three times as much, or 126,462. The positive housing unit effect of +86,692 almost exactly offsets the negative effect in the central city. In a sense, housing units moved from the central city into the inner ring suburbs.

Outer ring suburbs also suffered negative household size effects, particularly in the 1970s and 1980s. Continuing with the 1970s Chicago example, household size effects in the larger outer ring suburbs resulted in population decreases of -259,655. However, because of the construction of new dwelling units (a dwelling unit effect of +482,486), outer ring suburbs grew (in total) by 215,145. Other metropolitan areas provide similar results.

Three points stand out. Inner (older) suburbs lost population like the central cities, but they did not generally lose dwelling units.[9] Second, inner ring population losses generally occurred because decreasing household size was not offset by sufficient construction of new units. Third, outer areas gained population due to large increases in numbers of units built. Separate analyses show that household size fell by larger percentages in the outer suburbs than in the central city or the inner suburbs, but there was substantially more construction (in both absolute

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[9] Goodman (2004) finds that between one-sixth and one-fourth of central cities lost dwelling units in the 1970s, 1980s, or 1990s.

and percentage terms) in the outer ring suburbs.

Supply and Demand

This section seeks to model the decadal changes in dwelling units discussed in Tables 1 and 2. Whereas most "open city" central place models (e.g., Brueckner, 1987) implicitly assume that all land or dwelling units that are demanded will be supplied, it seems appropriate here to address the issue that the units that are supplied will be demanded. The open city analyses suggest that people migrate among areas, with the resulting land value and wage adjustments equalizing utility. The analysis of the changes in numbers of units uses a structural model of supply of housing stock and demand for housing services. The model implies migration among metropolitan areas, with residents and investors choosing a metropolitan area, and then purchasing or investing in either central city or suburban locations.

The model follows Mills and Hamilton (1994) where market demand for housing units Q^D in a particular location is related to the housing services rental price R, income per capita Y, and metropolitan population N. Market supply of units Q^S is related to the value of housing stock V and other supply shifters G^k, referring to regional factors including factor costs, climate, or degree of labor market unionization, which would usually be characterized with city-, state-, and/or regional binary variables.[10] The use of both R and V does not indicate a tenure choice model, but rather a model in which units could either be owned or rented. Long run equilibrium (5) relates market rents for housing service flows to market values for housing stocks by user cost ρ which includes the effects of foregone interest, asset depreciation, property taxes, and expected capital gains. Product market equilibrium equation (6) equates quantity supplied to quantity demanded.

Demand for Housing Units: $$\ln Q_t^D = \alpha \ln Y_t + \beta \ln R_t + \delta \ln N_t + \varepsilon_t^D \qquad (3)$$

[10] Malpezzi (1996), for example, has developed indices of regulatory stringency, but they are available for only a subset of the 317 areas studied, and not for all three decades.

Supply of Housing Units: $\ln Q_t^S = \gamma \ln V_t + \sum_k \eta_k G_t^k + \varepsilon_t^S$ (4)

Capital Market Equilibrium. $\ln R_t = \ln V_t + \ln \rho_t$ (5)

Product Market Equilibrium $\ln Q_t^S = \ln Q_t^D$ (6)

Price elasticity β is expected to be negative with the other behavioral demand and supply elasticities positive. The signs of shifters η_k are indeterminate.[11]

The model examines long-term changes in housing values and rents. There may be substantial adjustment costs in responding to changes in values and or rents for a non-malleable good like housing, but Table 1 shows substantial quantity responsiveness.[12] To the extent that adjustments are incomplete, parameter estimates will be biased downward.

Solving for *Q* and *V*:

$$\ln V_t = \frac{\alpha}{\gamma - \beta} \ln Y_t + \frac{\beta}{\gamma - \beta} \ln \rho_t + \frac{\delta}{\gamma - \beta} \ln N_t - \sum_k \frac{\eta_k}{\gamma - \beta} G_t^k \quad \text{,or} \tag{7}$$

$$\ln V_t = \vartheta_1 \ln Y_t + \vartheta_2 \ln \rho_t + \vartheta_3 \ln N_t - \sum_k \vartheta_k G_t^k \tag{7′}$$

$$\ln Q_t = \gamma \ln V_t + \sum_k \eta_k G_t^k \ . \tag{8}$$

Equations (7′) and (8) are estimated in difference form to explain the decadal changes.

Differencing the values and the rents provides a "repeat" index for units in the suburban housing stock at the beginning and at the end of the decade and adjusts for systematic differences in unit size or quality across metropolitan areas. It would seem most important, in explaining housing supply responses during the 1970s, that the real suburban Pittsburgh median house values, for example, increased by 28.1% (from \$66,554 in 1970 to \$88,355 in 1980) compared to suburban Chicago where the increase was 23.4% (from \$113,357 in 1970 to \$143,349 in 1980).[13]

Metropolitan population increases *N* imply increased dwelling unit demand both in cities

[11] Malpezzi and Maclennan (2001) develop a model that leads to similar reduced form parameters.

[12] Topel and Rosen (1988) and Mayer and Somerville (2000b) find long and short run investment supply to converge in about a year, which seems unusually fast. DiPasquale and Wheaton (1994) estimate an adjustment rate of 2%, implying 35 years to reach a new equilibrium. DiPasquale (1999) characterizes this adjustment rate as "too slow."

[13] All house value, rent, and income changes are derived from constant (\$2000) dollar measures from the SOCDS by deflating current dollars by the Consumer Price Index. Percentage changes are calculated with the midpoint method.

and suburbs, and increased rents and values in both. Suburban median incomes *Y* or rents *R* that change at the same rate as the central city would not be expected to have differential impacts on demand. Positive (negative) suburban house value appreciation *V* would yield positive (negative) net investment in suburban housing stock.[14]

The G^k vector is characterized by binary variables including city and regional effects that do not change by decade, so differencing equations (7′) and (8) eliminates these fixed effect shifters. In matrix (9) below, "hats" ^ indicate percentage changes in decades 1 (1970s), 2 (1980s) and 3 (1990s). Vectors ϑ and $\boldsymbol{\gamma}$ are parameters for the value and quantity equations, $\mathbf{z}$ represents vectors of explanatory variables, and the dashed lines separate the decades.

$$\begin{bmatrix} \hat{V}_1 \\ \hat{Q}_1 \\ \hdashline \hat{V}_2 \\ \hat{Q}_2 \\ \hdashline \hat{V}_3 \\ \hat{Q}_3 \end{bmatrix} = \begin{bmatrix} \vartheta_1 & 0 & 0 & 0 & 0 & 0 \\ 0 & \boldsymbol{\gamma}_1 & 0 & 0 & 0 & 0 \\ \hdashline 0 & 0 & \vartheta_2 & 0 & 0 & 0 \\ 0 & 0 & 0 & \boldsymbol{\gamma}_2 & 0 & 0 \\ \hdashline 0 & 0 & 0 & 0 & \vartheta_3 & 0 \\ 0 & 0 & 0 & 0 & 0 & \boldsymbol{\gamma}_3 \end{bmatrix} \begin{bmatrix} \hat{\mathbf{z}}_1 \\ \hat{V}_1 \\ \hdashline \hat{\mathbf{z}}_2 \\ \hat{V}_2 \\ \hdashline \hat{\mathbf{z}}_3 \\ \hat{V}_3 \end{bmatrix} + \begin{bmatrix} u_1^V \\ u_1^Q \\ \hdashline u_2^V \\ u_2^Q \\ \hdashline u_3^V \\ u_3^Q \end{bmatrix} \quad (9)$$

Two estimation techniques are used.

1. *Indirect Least Squares* (ILS). A two-stage ILS estimator will first estimate the value change equation $\hat{V}$ in each decade, and then use the fitted value in the quantity change equation $\hat{Q}$. The parameters from equations (7′) and (8) are identified in this procedure.

2. *Three Stage Least Squares* (3SLS). Following Greene (2003, P. 405) a generalized least squares (GLS) method will provide consistent and efficient estimators.[15]

The textbook capital market equilibrium equation (8) implies that the rent/value ratio can serve as ρ. Note that the theoretical derivation of ρ contains *expected* capital gains, which are not

[14] Galster (1998) provides an alternative formulation for 100 cities between 1980 and 1990.

[15] A third method would estimate the entire matrix (9) in block form to allow for decadal error correlation (1970s errors correlated with 1980s or 1990s errors). Attempts to do so, however, (available on request) did not regularly converge to a solution, and are not discussed further.

identical either to current or past house value appreciation, although analysts often use current or recent appreciation as proxies (Green and Malpezzi 2003 [P. 57] note that there is no "generally accepted" way to measure these expectations). In static equilibrium, rent/value ratios and housing values might be jointly determined, but proposed *user cost* measure, $D = Pct.\ \Delta\ \rho_s - Pct.\ \Delta\ \rho_c$, differences the rent/value both within the suburbs and the central city and examines the *suburban changes* relative to the central city. Relative increases in suburban user cost imply higher rents, hence lower quantity demanded, given the same changes in housing values, through equation (3).

Given the potential simultaneity of ρ and house value, I consider an alternative user cost estimator, based on the premise that rent/value ratios at the beginning of the decade reflect expectations of housing value change through the decade. Equation (10) subscripts c and s refer to the CC and the suburbs respectively, and G_k refers to regional dummy variables: [16]

$$D = Pct.\ \Delta\ \rho_S - Pct.\ \Delta\ \rho_C = \phi_0 + \phi_s \rho_s + \phi_c \rho_c + \sum_k \nu_k G_k\ . \qquad (10)$$

An initially high ρ_s (low suburban value/rent ratio) would be expected to predict a decrease ($\phi_s < 0$) in D. Similarly an initially high central city ρ_c would predict a central city user cost decrease relative to the CC, or a rise ($\phi_c > 0$) through the decade in D. Predicted value $\hat{D}$ from equation (10) is then used as an alternative measure of user cost in the supply-demand regressions.

Estimation Results

This section presents ILS and 3SLS estimates using both the rent/value and the instrumental measures of user cost. Table 3.A shows a mean increase in suburban occupied units of 36.2% in the 1970s, 16.9% in the 1980s and 17.6% in the 1990s.[17] Real owner-occupied values rose by 37.0% in the 1970s, by 1.8% in the 1980s and by 13.1% in the 1990s, outstripping central

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[16] Freddie Mac regional categories are used: *Northeast (N=73)*: NY, NJ, PA, DE, MD, DC, VA, WV, ME, NH, VT, MA, RI, CT; *Southeast (N=64)*: NC, SC, TN, KY, GA, AL, FL, MS; *North Central (N=71)*: OH, IN, IL, MI, WI, MN, IA, ND, SD; *Southwest (N=57)*: TX, LA, NM, OK, AR, MO, KS, CO, NE, WY; *Mountain/West (N=52)*: CA, AZ, NV, OR, WA, UT, ID, MT, HI, AK.

[17] All analyses were also performed with units (net of occupancy rates) rather than occupied units alone. The results (available from the author) are very similar to those presented here.

city increases in each decade (although only marginally in the 1980s).

(Table 3 – Suburban and Central City Values, Rents, and Demand Determinants)

The demand parameters also merit discussion. Suburban real income per household increased relative to the central city by 2.9% in the 1970s, by 3.4% in the 1980s and by 4.6% in the 1990s. The metropolitan populations (central city plus suburbs) increased by 15.8% in the 1970s, and by 10.0% and 10.9% respectively in the 1980s and 1990s. Suburban rent/value ratios fell substantially in the 1970s and 1990s relative to the central city (-9.8 and –15.9% respectively), implying falling relative suburban user costs; they rose, however, by 10.3% in the 1980s.

(Table 4 – Instrumental Estimates for Change in User Cost)

Table 4 estimates user cost instrumental equation (10) by decade. The impacts of initial rent/value ratios ρ_c and ρ_s have expected (and significant) signs, with initial suburban rent/value ratios having larger impacts on subsequent user cost changes than the central city rent/value ratios in all three decades. The regional dummy variables are generally significant, but their effects change by decade. Although regional effects are mixed in the 1970s, the four regions outside the Northeast (the omitted region) show significant relative decreases in user costs in the 1980s, but significant relative increases in the 1990s. Explained variance is substantial in each decade indicating relatively "good" instruments. Subsequent analyses compare these instrumental estimates to those using the raw rent/value user cost.

(Table 5 – Indirect Least Squares Estimates of Value and Supply)

Table 5.A estimates the system of equations (7′) and (8) separately by decade, using ILS methods with the direct user cost measure. For the 1970s, estimated suburban supply elasticity is +1.44, demand price elasticity is -0.24, income elasticity is +0.05, and population elasticity is +1.05. The supply elasticity for the 1980s is +1.13 and for the 1990s, it is +1.34. For the three decades the mean supply is +1.30; the median is slightly higher at +1.34.

Panel 5.B provides comparable ILS estimates of the three decades with the instrumental user cost estimator. For the 1970s, estimated supply elasticity is +1.37, demand price elasticity is -0.67, income elasticity is +0.10 and the population elasticity is +1.13. The supply elasticity for the 1980s is +1.03 and for the 1990s, it is +1.36. For the three decades the mean supply is +1.26; the median is again slightly higher at +1.37.

For perspective, Goodman (2004) estimated 1970-2000 central city supply elasticities for cities with declining stocks (with small expected elasticities), and for cities with increasing stocks (where elasticities are expected to be larger). For the shrinking cities, he finds elasticities between +0.03 and +0.13. For the growing cities he finds elasticities between +1.05 and +1.08. The higher suburban elasticities, between +1.26 and +1.37, can be explained as a combination of the inner ring housing stock, which is quite similar to the central city stock, and the outer ring stock, where one might expect a more elastic response.

(Table 6 – Three Stage Least Squares Estimates of Value and Supply)

Table 6 (Panels A and B) uses iterative 3SLS estimates for improved estimates of the reduced form demand parameters, with coefficient estimates remaining constant for the supply equations. The iterative process converges for all three decades. In Panel A (using the untransformed user cost measures) the three-decade mean price elasticity is –0.02, the income elasticity is +0.10, and the population elasticity is +0.97. In Panel B (using the instrumental user cost measure), the three-decade mean price elasticity is -0.05, the income elasticity is +0.13, and the population elasticity is +0.99.

A comparison of Tables 5 and 6 suggests that the potential simultaneity of current user cost and house value does not have a substantial impact on parameter estimates. In both the ILS and the 3SLS estimates, supply elasticities were similar, between +1.26 and +1.37. Although the demand impacts appeared more elastic when using the instruments in Table 5.B, the 3SLS iterative estimates showed the two estimators (Tables 6.A and 6.B) to provide very similar results.

The Table 5 and 6 results subsume regional indicators G_t^k, but long term employment and population migration patterns may lead to structural regional differences in the elasticities. The next analysis examines regional estimates with the instrumental user cost measure (and using 3SLS estimators), recognizing that measured impacts with the untransformed rent/value ratio (available on request) do not differ significantly. Table 7.A presents the elasticities for the five regions by decade. There is some instability of the estimates owing to relatively small sample sizes, and the Mountain/West region supply elasticity for the 1970s of -11.72 is not plausible. However if the Mountain/West region is omitted, the weighted mean is +1.27, which is very close to the earlier estimates (+1.26) with the instrumental user cost).

(Table 7 – Alternative Regional Elasticity Estimates)

Table 7.B divides the sample into the Northeast/North Central (NNC) quadrant and the South/Southwest/Mountain-West (SSMW) region. Regional binary shift variables distinguish the Northeast and North Central regions in the NNC estimate, and the South, Southwest, and Mountain/West regions in the SSMW. The SSMW supply elasticities are systematically larger, particularly in the 1980s and 1990s, and the three-decade means are +0.89 in NNC and +1.86 in SSMW. The weighted mean supply elasticity is +1.42, or slightly higher than the mean three-decade estimates in Tables 5.B and 6.B of +1.26.

Metropolitan Housing Elasticities

This final section of analysis combines the suburban elasticities in this article with central city elasticities to provide overall metropolitan elasticities at the regional or national level. For metropolitan area *i*, let E_c and E_s refer to central city and suburban elasticity, u_i^c and u_i^s $(u_i = u_i^c + u_i^s)$ to the number of central city and suburban units respectively, with weights w_i^c and

w_i^c defined as $w_i^c = u_i^c / u_i, w_i^s = u_i^s / u_i$. Housing stock supply elasticity E_{si} would be:

$$E_{si} = w_i^c E_c + w_i^s E_s \ . \tag{11a}$$

At the regional or national level, then, metropolitan elasticity E is the weighted sum of the E_{si} over i metropolitan areas or:

$$E = \sum_i z_i E_{si}, \text{where } z_i = \frac{u_i}{\sum_i u_i}. \tag{11b}$$

(Table 8 – Central City, Suburban, and Metropolitan Elasticities)

Table 8 provides calculations at the regional level. Table 8.A displays elasticities estimated separately for central cities with increasing and with declining numbers of occupied units. In all cases the elasticities in the positive direction (increasing numbers of units) are much larger than those with decreasing numbers of units. The estimates for the 1990s at the regional levels were negative, although not significantly so. In their place, values of 0.0 were used.

Table 8.B shows the metropolitan elasticities by decade by region. By decade, the mean elasticity decreased from +1.59 in the 1970s to +1.11 in the 1980s, and then increased to +1.24 in the 1990s. By region, the Northeast (+0.62) and the Midwest (+1.01) had substantively lower elasticities than the other three regions, all of which ranged between +1.60 and +1.70.

What can explain the differences across decades? With large increases in real value during the 1970s, the housing investment rate of return was attractive compared to depressed equities markets, leading to more capital moving into the housing market. Increased returns to equities as competing investments in the 1980s and 1990s help explain the decreased housing elasticity. Further, increased investment in the latter two decades occurred on relatively inelastically supplied urban land, again restricting elasticities.

Regional differences also have two major causes. The Northeast and Midwest regions contained almost all of those central cities with declining numbers of occupied units, with their very low elasticities, and the lower central city elasticities pushed down the weighted measure. Second, although there are some number of coastal areas in the Mountain/West, for example, with growth restrictions, there are far more areas in the interior which exhibited considerable central city and suburban growth. Combining these two led to the relatively high regional elasticities.

How do these metropolitan supply elasticities compare with those reviewed earlier? Most of the flow models, as noted by DiPasquale and by Malpezzi and Maclennan, find U.S. elasticities of +3.0 or higher. Mayer and Somerville (2000b) relate a 10% rise in real prices to a 0.8% increase in the housing stock for a stock elasticity of +0.08. The estimates here, between +0.62 and +1.70 among different regions, are essentially "in the middle."

Conclusions

This study has examined housing supply elasticities in 317 U.S. suburban areas for the final three decades of the twentieth century. Both central cities and suburbs experienced substantial decreases in household sizes in the 1970s. In many central cities, numbers of housing units decreased, and in many others, unchanged housing supplies accompanied population declines of 10 to 15%. Household size stabilized in the 1980s and 1990s, but in older central cities, housing supplies often remained stagnant, or even decreased.

The suburbs in all regions showed increasing numbers of housing units in all three decades. In many inner suburbs, numbers of units did not increase enough to offset decreasing household sizes. In growing outer suburbs, numbers of units grew by double and sometimes triple digit percentages, outstripping the household size declines, and leading to increased outer ring populations. There were relatively few decreases in numbers of suburban units compared to the central cities.[18]

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[18] In the 1970s only 3 of the 317 suburban areas experienced declines in numbers of units. These numbers rose to 18 in the 1980s and 20 in the 1990s

The supply/demand model provides supply elasticity estimates between +1.25 and +1.42. Supply elasticities in the 1980s were slightly lower than the other two decades. These may have reflected the increase in suburban user costs relative to the central cities, implying that other uses for investment capital were more attractive. In addition, housing supplies were more elastically (+1.86) provided in the South and West than in the North and East (elasticity of +0.89).

This study has limitations. Census data contain errors relating to population undercounts, although these problems would seem more acute in central cities than in suburban areas. Nonetheless, analysts must be cautious about interpreting one or two percentage point changes from decade to decade as more than random errors. One must also consider errors in owner estimates of house values. Pollakowski (1995) discusses the literature, and notes that most studies find owner-occupants overestimating their house values, but that owners who sell their dwellings do not perceive value changes over time differently from those who do not sell. Ihlanfeldt and Martinez-Vazquez (1986) and Goodman and Ittner (1992) provide further discussion.

This is a "units" model and it does not account explicitly for either depreciation or improvement in existing stock. Assuming that existing housing maintains constant size and quality, if the size (quality) of new construction increases (improves) over a decade, then measuring the number of units almost certainly provides a lower bound on the supply response. The variation of size or quality is probably greater over time than across areas, but the database used will not provide information that can be used to make an adjustment.

Further, Census "snapshots" from 1970, 1980, 1990, and 2000 (with incomes from 1969, 1979, 1989, and 1999) imply that those particular years represented similar points in the respective economic cycles, and that housing stock changes in intervening years are appropriately described by the end-of-decade measures of value and user cost. 1980 for example provided a historically high inflation rate of 13.5%, and a high unemployment rate of 7.2% relative to the other three years.[19] Pryce (1999) suggests evidence of lower flow supply elasticities during booms due to skilled labor shortages, but it is difficult using the data at hand to link the particular characteristics of 1980 to either the higher supply elasticities of the 1970s or the lower ones of the 1980s.

Finally, housing supply can grow *in situ* through teardowns, rebuilds, remodeling and addition of space. Montgomery (1992) finds probability of remodeling to be positively related to: (1) the age of the housing stock, and; (2) current v. historical population growth rates, which vary across MSAs. To the extent that these effects impact vacancy or abandonment, they are subsumed within the model. However, to the extent that they impact units that have remained in the housing supply, both effects suggest that the supply elasticities measured here may be downward biased. With the "age of stock" effect more likely to occur in older areas (Northeast and North Central) and the "population growth effect" more likely to occur in the other three regions, the differential regional impacts of these biases is not clear.

Measuring Montgomery's effects in a "units model" is may be difficult, but an alternative approach might compare some central cities with considerable abandonment, to their (inner and outer) suburban rings with different vintages of housing and with differing levels of abandonment. This analysis would attempt to decompose decadal changes in value into increases in price per unit, and increases in housing per unit, to sharpen estimates of housing supply and supply elasticity.

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[19] Inflation rates for 1970, 1990, and 2000 were 5.8%, 5.4%, and 3.4% respectively; unemployment rates for 1970, 1990, and 2000 were 5.0%, 5.6%, and 4.0% respectively.

References

Barker, K., Review of Housing Supply: Securing our Future Housing Needs, http://www.hm-treasury.gov.uk/consultations_and_legislation/barker/consult_barker_background.cfm, accessed March 8, 2005.

Berry, B. J. L. 1980. Inner City Futures: An American Dilemma Revisited, *Transactions of the Institute of British Geographers*, New Series 5: 1-28.

Bramley, G. 1993a. Land-use planning and the housing market in Britain: the impact on house-building and house prices, *Environment and Planning* A, 25: 1021–1051.

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

Brueckner, J. K. 1987. The Structure of Urban Equilibria: A Unified Treatment of the Muth-Mills Model, *Handbook of Regional and Urban Economics*, Volume II, Edwin S. Mills Ed.: 821-845.

Demographia, Paris Urban Area & Former Department of the Seine: 1962-1999, source: http://www.demographia.com/db-paris-seine.htm, accessed June 3, 2003.

DiPasquale, D. 1999. Why Don't We Know More About Housing Supply? *Journal of Real Estate Finance and Economics*, 18: 9-23.

DiPasquale, D. and W. C. Wheaton. 1994. Housing Market Dynamics and the Future of Housing Prices, *Journal of Urban Economics* 35: 1-27.

Galster, G. C., An econometric model of the urban opportunity structure, Washington: FannieMae Foundation Research Report, 1998.

Glaeser, E. L. and J. Gyourko. 2003. Urban Decline and Durable Housing, forthcoming in *Journal of Political Economy*.

Goodman, A. C. and T. G. Thibodeau. 1998. Housing Market Segmentation, *Journal of Housing Economics* 7: 121-143.

Goodman, A. C. 2004. Central Cities and Housing Supply: Growth and Decline in U.S. Cities, Wayne State University.

Goodman, J. L. and J. B. Ittner. 1992. The Accuracy of Home Owners' Estimates of Value, *Journal of Housing Economics* 2 (4): 339-357.

Green, R. K. and S. Malpezzi. 2003. *A Primer on U.S. housing markets and Housing Policy*, Washington DC: Urban Institute Press.

Greene, W. H. 2003. *Econometric Analysis* 5th Ed., Upper Saddle River NJ: Prentice Hall, 404-407.

Ihlanfeldt, K. R. and J. Martinez-Vazquez. 1986. Alternative Value Estimates of Owner-Occupied Housing: Evidence of Sample Selection Bias and Systematic Errors, *Journal of Urban Economics* 20 (3): 356-369.

Malpezzi, S. 1996. Housing Prices, Externalities, and Regulation in U.S. Metropolitan Areas, *Journal of Housing Research* 7 (2): 209-241.

Malpezzi, S. and D. Maclennan. 2001. The Long-Run Price Elasticity of Supply of New Construction in the United States and the United Kingdom, *Journal of Housing Economics* 10: 278-306.

Mayer, C. J. and C. T. Somerville. 2000a. Land Use Regulation and New Construction, *Regional Science and Urban Economics* 30: 639–662.

Mayer, C. J. and C. T. Somerville. 2000b. Residential Construction: Using the Urban Growth Model to Estimate Housing Supply, *Journal of Urban Economics* 48: 85-109.

McDonald J. F. 1979. *Economic Analysis of an Urban Housing Market*, New York: Academic Press, Chapter 8.

Mills, E. S. and B. W. Hamilton. 1994. *Urban Economics*, 5th Edition, Harper Collins, Chapter 10.

Montgomery, C. 1992. Explaining Home Investment in the Context of Household Investment in Residential Housing, *Journal of Urban Economics* 32: 326-350.

Muth, R. F. 1968. Urban Residential Land and Housing Markets, *Issues in Urban Economics*, Harvey S. Perloff and Lowden Wingo, Jr., editors, Baltimore: Johns Hopkins University Press: 285-333.

Pollakowski, H. O. 1995. Data Sources for Measuring House Price Changes, *Journal of Housing Research* 6 (3): 377-387

Pryce, G. 1999. Construction Elasticities and Land Availability: A Two Stage Least Squares Model of Housing Supply Using the Variable Elasticity Approach, *Urban Studies* 36: 2283-2304.

Puentes, R. and M. Orfield. 2002. Valuing America's First Suburbs, Brookings Institution.

Sweet, J. A. 1984. Components of Change in the Number of Households: 1970 – 1980, *Demography* 21: 129-140.

Topel, R. H. and S. Rosen. 1988. Housing Investment in the United States, *Journal of Political Economy*, 96: 718-740.

U.S. Census Bureau, Current Population Reports, P20-515, and unpublished data, 2000.

White M. and P. Allmendinger, *2003.* Land-use Planning and the Housing Market: A Comparative Review of the UK and the USA, *Urban Studies* 40: 953–972.

Table 1 – Percentage Changes in Population and Occupied Housing Units, 1970 – 2000, 50 Largest Suburban Areas by 1970 Suburban Population

		% Δ Pop	% Δ Occupied Units
Los Angeles	CA	31.60	27.89
Chicago	IL	36.74	56.44
Philadelphia	PA	21.37	46.00
Detroit	MI	17.84	33.52
Boston	MA	9.63	34.38
Washington	DC	58.66	76.36
Pittsburgh	PA	**-6.66**	23.85
St. Louis	MO	24.22	48.32
Newark	NJ	7.80	23.69
Cleveland	OH	7.02	35.02
Minneapolis	MN	56.77	83.09
Atlanta	GA	97.90	111.41
Baltimore	MD	47.17	71.56
New York	NY	10.26	24.89
Anaheim	CA	59.94	69.23
Oakland	CA	50.73	63.61
Cincinnati	OH	28.47	54.31
Fall River	MA	13.46	33.74
Hartford	CT	16.04	41.87
Riverside	CA	101.28	94.28
Miami	FL	72.28	78.08
Seattle	WA	69.08	84.47
Buffalo	NY	2.60	33.89
San Francisco	CA	22.39	32.55
Rochester	NY	19.27	45.01
Kansas City	MO	45.73	67.03
Portland	OR	62.29	78.36
Dallas	TX	104.10	112.53
Milwaukee	WI	25.94	57.25
Dayton	OH	11.07	41.52
Houston	TX	110.10	117.11
San Diego	CA	81.19	91.38
Denver	CO	90.04	110.31
Tampa	FL	102.40	112.82
Providence	RI	23.05	48.25
New Orleans	LA	43.03	69.51
Albany	NY	19.78	45.21
Columbus	OH	37.43	59.45
Louisville	KY	36.66	66.25
Sacramento	CA	84.09	94.69
Grand Rapids	MI	48.97	71.50
Scranton	PA	3.41	28.72
Greenville	SC	54.26	76.49
Syracuse	NY	14.28	43.51
Fort Lauderdale	FL	101.49	108.19
Charlotte	NC	47.17	69.62
Greensboro	NC	42.45	67.05
Youngstown	OH	5.46	34.53
Birmingham	AL	43.24	68.01
Indianapolis	IN	55.55	74.14

Bold – Population decrease; underline – % change in population exceeds % change in units.

Table 2 – Absolute Household Size and Occupied Housing Unit Impacts for Central Cities, Inner, and Outer Suburban Rings
Selected Older American Cities

Metropolitan Area		1970s Δ Pop	1970s HH Size Effect	1970s Occ. Unit Effect	1980s Δ Pop	1980s HH Size Effect	1980s Occ. Unit Effect	1990s Δ Pop	1990s HH Size Effect	1990s Occ. Unit Effect
Baltimore	**CC**	**-118984**	**-96479**	**-7301**	**-50761**	**-37308**	**2515**	**-84860**	**-37013**	**-10167**
	Inner Ring	-68504	-76129	6490	-9353	-29230	24833	8112	-6833	14615
	Outer Ring	-1549	-26197	24360	1481	-11395	13221	7209	-5286	13037
Boston	**CC**	**-78059**	**-80402**	**22700**	**11289**	**-14182**	**20137**	**14858**	**-12208**	**756**
	Inner Ring	-65227	-131053	68952	-10607	-54312	49838	19312	-17139	27196
	Outer Ring	109418	-275026	384666	104889	-152730	269114	155524	-50256	173863
Chicago	**CC**	**-357753**	**-234386**	**-87872**	**-221346**	**-34926**	**-108298**	**112290**	**12682**	**43433**
	Inner Ring	-45679	-126462	86692	-26349	-26843	3209	52098	26742	23288
	Outer Ring	215145	-259655	482486	182437	-91318	262227	248784	12717	223090
Cleveland	**CC**	**-177224**	**-92073**	**-64684**	**-68206**	**-20448**	**-35622**	**-27213**	**-4535**	**-20214**
	Inner Ring	-46170	-85457	41961	-24209	-31781	11118	-19239	-19927	2564
	Outer Ring	45686	-87380	136027	7559	-49253	56042	39831	-26714	66480
Detroit	**CC**	**-307997**	**-121169**	**-156242**	**-175365**	**-11210**	**-155346**	**-76704**	**32474**	**-89326**
	Inner Ring	-124790	-293312	172192	-94888	-133557	45185	-36696	-63939	24877
	Outer Ring	39837	-40865	78828	-1311	-27571	27321	386	-17860	17294
Mpls - St. Paul	**CC**	**-103140**	**-110660**	**12351**	**-563**	**-7961**	**23020**	**29151**	**20013**	**-14849**
	Inner Ring	-3059	-133001	130217	18610	-61716	82040	11146	-17700	21105
	Outer Ring	64670	-71533	135042	85944	-31209	120230	62029	-18008	71052
Pittsburgh	**CC**	**-96229**	**-63501**	**-27204**	**-54059**	**-22826**	**-21342**	**-35316**	**-12970**	**-15389**
	Inner Ring	-26787	-45476	24181	-24993	-27664	4122	-13214	-7696	-4342
	Outer Ring	-31219	-51817	20580	-32270	-22904	-2794	-8712	-10010	3666
Washington[a]	**CC**	**-118177**	**-92792**	**-3854**	**-31433**	**-22743**	**-556**	**-34841**	**-31877**	**-8526**
	Inner Ring	-26502	-53151	29781	2548	-11199	13447	-2834	7883	-12063
	Outer Ring	22560	-65961	89566	25148	-14898	40288	28198	3859	23208

[a] Maryland Suburbs

Table 3.A – Suburban and Central City Values and Rents, Three Decades

N = 317

Variable	Mean	Std.Dev.	Minimum	Maximum
% Δ Suburban Occupied Units 1970-1980	0.3624	0.1707	-0.0814	0.9622
% Δ Suburban Occupied Units 1980-1990	0.1693	0.1330	-0.2661	0.6574
% Δ Suburban Occupied Units 1990-2000	0.1756	0.1040	-0.0526	0.5688
% Δ Suburban Value 1970-1980	0.3696	0.1758	-0.0547	1.0874
% Δ Suburban Value 1980-1990	0.0176	0.2737	-0.7218	0.7578
% Δ Suburban Value 1990-2000	0.1306	0.1923	-0.3896	0.6026
% Δ Central City Value 1970-1980	0.2294	0.1996	-0.5099	0.8451
% Δ Central City Value 1980-1990	0.0158	0.2959	-0.7187	0.9484
% Δ Central City Value 1990-2000	0.0802	0.2146	-0.6064	0.6695
Sub – Central City Value 1970-1980	0.1402	0.1229	-0.2785	0.6048
Sub – Central City Value 1980-1990	0.0018	0.0859	-0.2802	0.2395
Sub – Central City Value 1990-2000	0.0504	0.0837	-0.2622	0.3013
% Δ Suburban Rent 1970-1980	0.1116	0.1467	-0.5611	0.5695
% Δ Suburban Rent 1980-1990	0.0985	0.1501	-0.5407	0.6962
% Δ Suburban Rent 1990-2000	0.0233	0.0874	-0.2491	0.3151
% Δ Central City Rent 1970-1980	0.0669	0.1260	-0.4926	0.5105
% Δ Central City Rent 1980-1990	0.1123	0.1455	-0.5444	0.4544
% Δ Central City Rent 1990-2000	0.0152	0.0832	-0.2317	0.2895
Suburban – Central City Rent 1970-1980	0.0447	0.1275	-0.5910	0.8729
Suburban – Central City Rent 1980-1990	-0.0139	0.0836	-0.5821	0.6131
Suburban – Central City Rent 1990-2000	0.0082	0.0525	-0.1693	0.2442

Table 3.B – Demand Determinants, Three Decades

Variable	Mean	Std.Dev.	Minimum	Maximum
% Δ Suburban Income 1970-1980[a]	0.0287	0.2406	-0.9640	0.7048
% Δ Suburban Income 1980-1990	0.0339	0.0770	-0.1569	0.5416
% Δ Suburban Income 1990-2000	0.0465	0.0678	-0.3425	0.2253
% Δ Metro Pop 1970-1980	0.1585	0.1430	-0.0923	0.7730
% Δ Metro Pop 1980-1990	0.1000	0.1221	-0.1598	0.5555
% Δ Metro Pop 1990-2000	0.1090	0.0829	-0.0797	0.4545
% Δ Suburban user cost ρ 1970-1980[b]	-0.0976	0.1546	-0.7095	0.6445
% Δ Suburban user cost ρ 1980-1990	0.1028	0.2556	-0.7200	1.0311
% Δ Suburban user cost ρ 1990-2000	-0.1591	0.2561	-0.9760	0.9670

a. % change in suburban income less % change in central city income

b. % change in suburban user cost less % change in central city user cost. Rent/value is used to model user cost.

Table 4 – Instrumental Estimates for Change in User Cost

	1970s	1980s	1990s
Dep. Var: $D = Pct.\ \Delta\ \rho_s - Pct.\ \Delta\ \rho_c$			
Constant	**-0.0629**	**0.2471**	**0.0764**
	0.0520	0.0499	0.0370
Initial Suburban ρ_s	**-61.4445**	**-209.9906**	**-156.9625**
	7.3276	9.8411	10.7593
Initial Central City ρ_c	**36.8553**	**179.6729**	**110.7284**
	6.4661	6.5060	14.1687
South	**0.0492**	**-0.0679**	**0.1622**
	0.0224	0.0223	0.0276
Midwest	**-0.0342**	**-0.0770**	**0.1117**
	0.0220	0.0212	0.0289
Southwest	**-0.0320**	**-0.0763**	**0.1468**
	0.0245	0.0225	0.0289
Mountain/West	**0.0885**	**-0.1092**	**0.1267**
	0.0232	0.0269	0.0290
SER	0.1275	0.1266	0.1554
R^2	0.3330	0.7593	0.6387

Coefficients in **bold**
Standard errors in roman type

Table 5 – Indirect Least Squares Estimates of Value and Supply

A. Indirect Least Squares - Direct User Cost

1970-1980
Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.2496**	0.0142	17.52
% Δ Sub ρ	**-0.1426**	0.0571	-2.50
% Δ Sub Income	**0.0300**	0.0366	0.82
% Δ Metro Pop	**0.6639**	0.0597	11.12
Std. Error	0.1493		

1970-1980
Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.1713**	0.0237	-7.24
Pct. Δ Sub Value	**1.4442**	0.0620	23.28
Std. Error	0.1036		

Elasticities	
Supply	1.4442
Demand Price	-0.2403
Demand Income	0.0506
Demand Pop	1.0536

1980-1990
Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.0595**	0.0216	-2.75
% Δ Sub ρ	**0.1944**	0.0596	3.26
% Δ Sub Income	**-0.2474**	0.1952	-1.27
% Δ Metro Pop	**0.6551**	0.1227	5.34
Std. Error	**0.2608**		

1980-1990
Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.1494**	0.0051	29.11
Pct. Δ Sub Value	**1.1301**	0.0579	19.52
Std. Error	**0.0896**		

Elasticities	
Supply	1.1301
Demand Price	0.1839
Demand Income	-0.2341
Demand Pop	0.6130

B. Indirect Least Squares - Instrumental User Cost

1970-1980
Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.2303**	0.0161	14.27
% Δ Sub ρ	**-0.3279**	0.0939	-3.49
% Δ Sub Income	**0.0512**	0.0349	1.47
% Δ Metro Pop	**0.6674**	0.0590	11.31
Std. Error	0.1092		

1970-1980
Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.1424**	0.0244	-5.84
Pct. Δ Sub Value	**1.3662**	0.0639	21.37
Std. Error	0.1092		

Elasticities	
Supply	1.3662
Demand Price	-0.6665
Demand Income	0.1041
Demand Pop	1.1307

1980-1990
Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.0646**	0.0219	-2.95
% Δ Sub ρ	**0.2394**	0.0686	3.49
% Δ Sub Income	**-0.2616**	0.1950	-1.34
% Δ Metro Pop	**0.6653**	0.1227	5.42
Std. Error	**0.2601**		

1980-1990
Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.1512**	0.0055	27.31
Pct. Δ Sub Value	**1.0282**	0.0612	16.80
Std. Error	**0.0967**		

Elasticities	
Supply	1.0282
Demand Price	0.1986
Demand Income	-0.2170
Demand Pop	0.5248

1990-2000
Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.0987**	0.0225	4.38
% Δ Sub ρ	**0.0248**	0.0438	0.57
% Δ Sub Income	**-0.3446**	0.1553	-2.22
% Δ Metro Pop	**0.4757**	0.1353	3.52
Std. Error	0.1870		

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.0012**	0.0132	0.09
Pct. Δ Sub Value	**1.3355**	0.0950	14.05
Std. Error	**0.0816**		

Elasticities	
Supply	1.3355
Demand Price	0.0323
Demand Income	-0.4490
Demand Pop	0.6235

1990-2000
Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.0793**	0.0254	3.13
% Δ Sub ρ	**-0.0422**	0.0574	-0.74
% Δ Sub Income	**-0.3138**	0.1598	-1.96
% Δ Metro Pop	**0.5430**	0.1383	3.93
Std. Error	0.1869		

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.0048**	0.0128	-0.37
Pct. Δ Sub Value	**1.3812**	0.0921	14.99
Std. Error	0.0795		

Elasticities	
Supply	1.3812
Demand Price	-0.0609
Demand Income	-0.4525
Demand Pop	0.7730

Three Decades

	Mean	Median
Supply	1.3033	1.3355
Demand Price	-0.0080	0.0323
Demand Income	-0.2108	-0.2341
Demand Pop	0.7634	0.6235

Three Decades

	Mean	Median
Supply	1.2585	1.3662
Demand Price	-0.1763	-0.0609
Demand Income	-0.1885	-0.2170
Demand Pop	0.8095	0.7730

Table 6 – 3SLS Estimates of Value and Supply

A. 3SLS – Direct User Cost

1970-1980

Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.2554**	0.0137	18.64
% Δ Sub ρ	**-0.0769**	0.0271	-2.84
% Δ Sub Income	**0.0061**	0.0159	0.39
% Δ Metro Pop	**0.6720**	0.0593	11.34
Std. Error	0.1489		

1970-1980

Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.1713**	0.0534	-3.21
Pct. Δ Sub Value	**1.4442**	0.1401	10.31
Std. Error	0.1036		

Elasticities	
Supply	1.4442
Demand Price	-0.1203
Demand Income	0.0096
Demand Pop	1.0223

1980-1990

Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.0744**	0.0198	-3.75
% Δ Sub ρ	**0.0737**	0.0352	2.09
% Δ Sub Income	**0.1013**	0.0630	1.61
% Δ Metro Pop	**0.8105**	0.1119	7.24
Std. Error	0.2626		

1980-1990

Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.1494**	0.0172	8.67
Pct. Δ Sub Value	**1.1301**	0.1944	5.81
Std. Error	0.3009		

Elasticities	
Supply	1.1301
Demand Price	0.0775
Demand Income	0.1067
Demand Pop	0.8563

B. 3SLS – Instrumental User Costs

1970-1980

Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.2488**	0.0151	16.53
% Δ Sub ρ	**-0.0961**	0.0499	-1.93
% Δ Sub Income	**0.0200**	0.0165	1.21
% Δ Metro Pop	**0.6993**	0.0584	11.97
Std. Error	0.1488		

1970-1980

Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.1424**	0.0500	-2.85
Pct. Δ Sub Value	**1.3662**	0.1310	10.43
Std. Error	0.2238		

Elasticities	
Supply	1.3662
Demand Price	-0.1453
Demand Income	0.0302
Demand Pop	1.0225

1980-1990

Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.0795**	0.0204	-3.90
% Δ Sub ρ	**0.0520**	0.0430	1.21
% Δ Sub Income	**0.1309**	0.0686	1.91
% Δ Metro Pop	**0.8737**	0.1123	7.78
Std. Error	0.2643		

1980-1990

Pct. Δ Sub Supply

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.1512**	0.0158	9.57
Pct. Δ Sub Value	**1.0282**	0.1746	5.89
Std. Error	0.2760		

Elasticities	
Supply	1.0282
Demand Price	0.0508
Demand Income	0.1280
Demand Pop	0.8529

1990-2000

Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.0369**	0.0136	2.72
% Δ Sub ρ	**-0.0233**	0.0120	-1.95
% Δ Sub Income	**0.1367**	0.0831	1.65
% Δ Metro Pop	**0.7672**	0.1073	7.15
Std. Error	0.1899		

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.0012**	0.0407	0.03
Pct. Δ Sub Value	**1.3355**	0.2921	4.57
Std. Error	0.2509		

Elasticities	
Supply	1.3355
Demand Price	-0.0318
Demand Income	0.1869
Demand Pop	1.0424

Three Decades

	Mean	Median
Supply	1.3033	1.3355
Demand Price	-0.0249	-0.0318
Demand Income	0.1011	0.1067
Demand Pop	0.9737	1.0223

1990-2000

Pct. Δ Sub Value

Variable	Coefficient	Std. Error.	t-ratio
Constant	**0.0321**	0.0162	1.98
% Δ Sub ρ	**-0.0480**	0.0162	-2.97
% Δ Sub Income	**0.1621**	0.0767	2.11
% Δ Metro Pop	**0.7644**	0.1202	6.36
Std. Error	0.1893		

Variable	Coefficient	Std. Error.	t-ratio
Constant	**-0.0048**	0.0418	-0.12
Pct. Δ Sub Value	**1.3812**	0.2999	4.61
Std. Error	0.2589		

Elasticities	
Supply	1.3812
Demand Price	-0.0697
Demand Income	0.2352
Demand Pop	1.0926

Three Decades

	Mean	Median
Supply	1.2585	1.3662
Demand Price	-0.0547	-0.0697
Demand Income	0.1311	0.1280
Demand Pop	0.9893	1.0225

Table 7 - Regional Supply Elasticities - With Instruments
3SLS Estimators

	Number	1970-1980	1980-1990	1990-2000	Row Mean	Row Median
A. Separate Regions						
Northeast	73	**2.3769**	**0.5213**	**-0.1700**	0.9094	0.5213
		0.8241	0.1186	0.1685		
South	64	**2.7680**	**2.9538**	**-0.1853**	1.8455	2.7680
		0.8387	0.7056	0.3757		
North Central	71	**0.5279**	**0.7153**	**2.0762**	1.1065	0.7153
		0.1835	0.1601	0.7959		
Southwest	57	**0.8094**	**1.5636**	**1.5434**	1.3055	1.5434
		0.1983	0.3688	0.4937		
Mountain/West (M/W)	52	**-11.7151**	**0.7258**	**0.5409**	-3.4828	0.5409
		2.0000	0.2128	0.1728		
Column Weighted Mean		-0.5517	1.2768	0.7547	0.4933	1.2053
(omitting M/W Region)		1.6388	1.3849	0.7967	1.2735	1.3357

B. Regions with Shift Terms

	Number	1970-1980	1980-1990	1990-2000	Row Mean	Row Median
Northeast/North Central	144	**1.5983**	**0.6252**	**0.4468**	0.8901	0.6252
		0.3572	0.1113	0.2651		
South/Southwest/MW	173	**1.7872**	**1.5352**	**2.2663**	1.8629	1.7872
		0.3645	0.2863	0.7083		
Column Weighted Mean		1.7014	1.1218	1.4398	1.4210	1.2594

Estimates in **bold**
Standard errors in roman

Table 8 - Central City, Suburban, and Metropolitan Elasticities

A. Central City Supply Elasticities

	1970s	1980s	1990s
Northeast			
Increasing # of Units	0.4363	0.2502	0.5474
Decreasing # of Units	0.1048	0.1030	0.0000
South			
Increasing # of Units	1.3142	0.6703	1.4218
Decreasing # of Units	0.1004	0.0849	0.0000
Midwest			
Increasing # of Units	2.1955	1.0612	0.3467
Decreasing # of Units	0.2538	0.0780	0.0000
Southwest			
Increasing # of Units	2.3563	1.3134	1.1422
Decreasing # of Units	0.1004	0.0849	0.0000
Mountain/West			
Increasing # of Units	2.0460	0.9330	0.7940
Decreasing # of Units	0.1004	0.0849	0.0000

B. Metropolitan Elasticities Calculated from Central City and Suburban Elasticities
(Parameters from Tables 7.B and 8.A.)

	1970s	1980s	1990s	**Row Mean**
Northeast	1.0009	0.4652	0.4090	**0.6250**
South	1.6225	1.2276	2.0005	**1.6169**
Midwest	1.4306	1.2276	0.3725	**1.0102**
Southwest	1.9832	1.3284	1.7062	**1.6726**
Mountain/West	1.8954	1.2938	1.7053	**1.6315**
Column Mean	**1.5865**	**1.1085**	**1.2387**	