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The Other Side of Eight Mile: Suburban Population and Housing Supply

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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 using 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 United States.

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; and Lakewood, OH, for example, were developed 100 or more years go. 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 between 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 using 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

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

+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 United States, 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 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 "teardowns 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. DiPasquale (1999) surveys the literature and concludes that (i) new supply appears to be price elastic, with estimates between

[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 (2001).

[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 increase. He puzzles, however, over the "long lags observed in some inner city areas among building abandonment, demolition, and replacement," wondering to what extent speculation leads to vacant land for long periods, and what causes the speculation.

+3.0 and positive infinity, (ii) higher income households appear more likely to improve their homes than to do nothing, but they are more likely to move than to improve their current units, and (iii) repair and renovation expenditures are inelastic with result to income and price.

Comparative work between the United States and the United Kingdom shows the United Kingdom to have less elastic supply. For the prewar United States, Malpezzi and Maclennan (2001) calculate implied price elasticity of supply from flow models as between +4 and +10, and for postwar, it is between +6 and +13. In contrast, for the prewar United Kingdom, the implied price elasticity from flow models is between +1 and +4, and for postwar, it is between 0 and less than +1.

Bramley (1993a, 1993b) estimates a U.K. price elasticity of supply of about +0.31. Pryce (1999) uses the 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 (2000a, 2000b) examine new construction price elasticities. Mayer and Somerville (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 the previous studies. Their estimates using quarterly panel data (Mayer and Somerville 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 (Mayer and Somerville 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 (2005) 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. In contrast, a negative demand shock is expected to cause housing price to fall, but induce

[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. Glaeser and Gyourko (2005) 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. As suburbs are generally expanding, suburban price elasticities would presumably exceed central city elasticities, as 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 data system (SOCDS), which provides census data for metropolitan statistical areas (MSAs), metropolitan cities, and suburbs for the years 1970, 1980, 1990, and 2000.[5] The version of the SOCDS here uses the 1990 standard for MSAs and primary metropolitan statistical areas (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 definition. This study analyzes 317 suburban areas that provide data for all the four years.

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 increase in numbers of dwelling units, with the Atlanta, Dallas, Houston, Denver, Tampa, and Fort Lauderdale suburbs showing triple-digit increase. Dwelling unit percentage increase generally exceeded population percentage increase, often by 20 or more points, and only Los Angeles and Riverside, California, saw higher unit increase than population increase.

Demographic Changes and Suburban Housing Supplies

This section links patterns of household formation and household size to the numbers of occupied dwelling units. These patterns changed substantially in the last third of the 20th century, particularly in the 1970s. From 1970 to 1980,

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

Table 1 ■ Percentage changes in population and occupied housing units, 1970–2000, in the 50 largest suburban areas by 1970 suburban population.

		%Δ Population	%Δ Occupied Units
<u>Los Angeles</u>	<u>CA</u>	<u>31.60</u>	<u>27.89</u>
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
<u>Riverside</u>	<u>CA</u>	<u>101.28</u>	<u>94.28</u>
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

Notes: Bolded items indicate a decrease in population, and underlined items indicate that the % change in population exceeds the % change in units.

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 for this: (i) young people increasingly delayed marriage, (ii) rates of separation and divorce increased, (iii) remarriage rates began to stabilize and decline, after a period of increase, (iv) mortality of the elderly declined, (v) 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 (vi) 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 feet unit with one bathroom and one kitchen for a couple cannot be split costlessly into two 500 square feet 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 $t+1$,

$$\begin{aligned}(\text{Population})_t &= (\text{Dwelling Units})_t(\text{Occupancy Rate})_t \\ &\quad \times (\text{HH Size/Occupied Dwelling Unit})_t \\ P_t &= U_t O_t S_t \qquad (1)\end{aligned}$$

$$\begin{aligned}(\text{Population})_{t+1} &= (\text{Dwelling Units})_{t+1}(\text{Occupancy Rate})_{t+1} \\ &\quad \times (\text{HH Size/Occupied Dwelling Unit})_{t+1} \\ P_{t+1} &= U_{t+1} O_{t+1} S_{t+1} \qquad (1')\end{aligned}$$

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

$$\begin{aligned}\Delta\,\text{Population} &= P_{t+1} - P_t = U_{t+1}O_{t+1}S_{t+1} - U_t O_t S_t \\ &= \overline{UO}(S_{t+1} - S_t) + \overline{SO}(U_{t+1} - U_t) + \overline{US}(O_{t+1} - O_t), \qquad (2)\end{aligned}$$

[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).

where $\overline{UO}(S_{t+1} - S_t)$ denotes the absolute size effect, $\overline{SO}(U_{t+1} - U_t)$ the absolute housing effect, and $\overline{US}(O_{t+1} - O_t)$ the absolute occupancy effect.

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

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

where $(S_{t+1} - S_t)/\bar{S}$ denotes relative size effect, $(U_{t+1} - U_t)/U$ the relative housing effect, and $(O_{t+1} - O_t)/\bar{O}$ the relative occupancy effect; or

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

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

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

1. The 1970s' substantial household size declines led to central city population declines, because the smaller households were offset neither by increased numbers of units nor by 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.
2. 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.

[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.

3. Newer suburbs, with considerable buildable land, experience population increase 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.

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

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

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

Table 2 ■ Absolute household size and occupied housing unit impacts for central cities and inner and outer suburban rings in selected older American cities.

Metropolitan Area	1970s Δ Population	1970s HH Size Effect	1970s Occupied Unit Effect	1980s Δ Population	1980s HH Size Effect	1980s Occupied Unit Effect	1990s Δ Population	1990s HH Size Effect	1990s Occupied Unit Effect
Baltimore									
City center	−118,984	−96,479	−7,301	−50,761	−37,308	2,515	−84,860	−37,013	−10,167
Inner ring	−68,504	−76,129	6,490	−9,353	−29,230	24,833	8,112	−6,833	14,615
Outer ring	−1,549	−26,197	24,360	1,481	−11,395	13,221	7,209	−5,286	13,037
Boston									
City center	−78,059	−80,402	22,700	11,289	−14,182	20,137	14,858	−12,208	756
Inner ring	−65,227	−131,053	68,952	−10,607	−54,312	49,838	19,312	−17,139	27,196
Outer ring	109,418	−275,026	384,666	104,889	−152,730	269,114	155,524	−50,256	173,863
Chicago									
City center	−357,753	−234,386	−87,872	−221,346	−34,926	−108,298	112,290	12,682	43,433
Inner ring	−45,679	−126,462	86,692	−26,349	−26,843	3,209	52,098	26,742	23,288
Outer ring	215,145	−259,655	482,486	182,437	−91,318	262,227	248,784	12,717	223,090
Cleveland									
City center	−177,224	−92,073	−64,684	−68,206	−20,448	−35,622	−27,213	−4,535	−20,214
Inner ring	−46,170	−85,457	41,961	−24,209	−31,781	11,118	−19,239	−19,927	2,564
Outer ring	45,686	−87,380	136,027	7,559	−49,253	56,042	39,831	−26,714	66,480

Table 2 ■ continued.

Metropolitan Area	1970s Δ Population	1970s HH Size Effect	1970s Occupied Unit Effect	1980s Δ Population	1980s HH Size Effect	1980s Occupied Unit Effect	1990s Δ Population	1990s HH Size Effect	1990s Occupied Unit Effect
Detroit									
City center	−307,997	−121,169	−156,242	−175,365	−11,210	−155,346	−76,704	32,474	−89,326
Inner ring	−124,790	−293,312	172,192	−94,888	−133,557	45,185	−36,696	−63,939	24,877
Outer ring	39,837	−40,865	78,828	−1,311	−27,571	27,321	386	−17,860	17,294
Minneapolis/St Paul									
City center	−103,140	−110,660	12,351	−563	−7,961	23,020	29,151	20,013	−14,849
Inner ring	−3,059	−133,001	130,217	18,610	−61,716	82,040	11,146	−17,700	21,105
Outer ring	64,670	−71,533	135,042	85,944	−31,209	120,230	62,029	−18,008	71,052
Pittsburgh									
City center	−96,229	−63,501	−27,204	−54,059	−22,826	−21,342	−35,316	−12,970	−15,389
Inner ring	−26,787	−45,476	24,181	−24,993	−27,664	4,122	−13,214	−7,696	−4,342
Outer ring	−31,219	−51,817	20,580	−32,270	−22,904	−2,794	−8,712	−10,010	3,666
Washington[a]									
City center	−118,177	−92,792	−3,854	−31,433	−22,743	−556	−34,841	−31,877	−8,526
Inner ring	−26,502	−53,151	29,781	2,548	−11,199	13,447	−2,834	7,883	−12,063
Outer ring	22,560	−65,961	89,566	25,148	−14,898	40,288	28,198	3,859	23,208

[a]Maryland suburbs.

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 increase in the 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 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,

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

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.

$$\text{Demand for housing units: } \ln Q_t^{\mathrm{D}} = \alpha \ln Y_t + \beta \ln R_t + \delta \ln N_t + \varepsilon_t^{\mathrm{D}}, \tag{3}$$

$$\text{Supply of housing units: } \ln Q_t^{\mathrm{S}} = \gamma \ln V_t + \sum_k \eta_k G_t^k + \varepsilon_t^{\mathrm{S}}, \tag{4}$$

$$\text{Capital market equilibrium: } \ln R_t = \ln V_t + \ln \rho_t, \tag{5}$$

$$\text{Product market equilibrium: } \ln Q_t^{\mathrm{S}} = \ln Q_t^{\mathrm{D}}. \tag{6}$$

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 nonmalleable 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:

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

or

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

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

[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.

[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."

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 increase, N, implies increased dwelling unit demand both in cities 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; hence, differencing Equations (7′) and (8) eliminates these fixed-effect shifters. In matrix (9), "hats", indicate percentage changes in decades 1 (1970s), 2 (1980s), and 3 (1990s). Vectors $\boldsymbol{\vartheta}$ 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.

$$\begin{bmatrix} \hat{V}_1 \\ \hat{Q}_1 \\ \hat{V}_2 \\ \hat{Q}_2 \\ \hat{V}_3 \\ \hat{Q}_3 \end{bmatrix} = \begin{bmatrix} \boldsymbol{\vartheta_1} & 0 & 0 & 0 & 0 & 0 \\ 0 & \boldsymbol{\gamma_1} & 0 & 0 & 0 & 0 \\ 0 & 0 & \boldsymbol{\vartheta_2} & 0 & 0 & 0 \\ 0 & 0 & 0 & \boldsymbol{\gamma_2} & 0 & 0 \\ 0 & 0 & 0 & 0 & \boldsymbol{\vartheta_3} & 0 \\ 0 & 0 & 0 & 0 & 0 & \boldsymbol{\gamma_3} \end{bmatrix} \begin{bmatrix} \hat{\mathbf{z}}_1 \\ \hat{V}_1 \\ \hat{\mathbf{z}}_2 \\ \hat{V}_2 \\ \hat{\mathbf{z}}_3 \\ \hat{V}_3 \end{bmatrix} + \begin{bmatrix} u_1^V \\ u_1^Q \\ u_2^V \\ u_2^Q \\ u_3^V \\ u_3^Q \end{bmatrix} \tag{9}$$

Two estimation techniques are used.

[13] All house value, rent, and income changes are derived from constant ($2,000) dollar measures from the SOCDS by deflating current dollars by the Consumer Price Index. Percentage changes are calculated with the midpoint method.

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

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 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 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 increase in suburban user cost implies 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. The subscripts "c" and "s" in Equation (10) refer to the city center and the suburbs, respectively, and G_k refers to regional dummy variables:[16]

$$D = Pct.\,\Delta\rho_{\mathrm{s}} - Pct.\Delta\rho_{\mathrm{c}} = \phi_0 + \phi_{\mathrm{s}}\rho_{\mathrm{s}} + \phi_{\mathrm{c}}\rho_{\mathrm{c}} + \sum_k \nu_k G_k. \tag{10}$$

An initially high ρ_{s} (low suburban value/rent ratio) would be expected to predict a decrease ($\phi_{\mathrm{s}} < 0$) in D. Similarly, an initially high central city ρ_{c} would predict a central city user cost decrease relative to the city center, or a rise ($\phi_{\mathrm{c}} > 0$)

[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 (available on request), however, did not regularly converge to a solution and are not discussed further.

[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.

Table 3 ■ Suburban and central city values and rents, three decades.

$N = 317$				
Variable	Mean	SD	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
Suburban – Central city value 1970–1980	0.1402	0.1229	−0.2785	0.6048
Suburban – Central city value 1980–1990	0.0018	0.0859	−0.2802	0.2395
Suburban – 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

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. Tables 3 and 4 show 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 city increase in each decade (although only marginally in the 1980s).

[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.

Table 4 ■ Demand determinants, three decades.

Variable	Mean	SD	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 population 1970–1980	0.1585	0.1430	−0.0923	0.7730
% Δ Metro population 1980–1990	0.1000	0.1221	−0.1598	0.5555
% Δ Metro population 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.

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 5 estimates user cost instrumental Equation (10) by decade. The impacts of initial rent/value ratios ρ_c andρ_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 increase 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 6A 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

Table 5 ■ Instrumental estimates for change in user cost.

	1970s	1980s	1990s
Dep. Var.: $D = \text{Pct.}\Delta\rho_s - \text{Pct.}\Delta\rho_c$			
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 are expressed in bold and standard errors are in regular type.

the three decades the mean supply is +1.30; the median is slightly higher at +1.34.

Panel 6B 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 7 (Panels A and B) uses iterative 3SLS estimates for improved estimates of the reduced form demand parameters, with coefficient estimates remaining

Table 6 ■ Indirect least squares estimates of value and supply.

A. Indirect Least Squares—Direct User Cost				B. Indirect Least Squares—Instrumental User Cost			
Variable	Coefficient	Standard Error	*t*-Ratio	Variable	Coefficient	Stdandard Error	*t*-Ratio
1970–1980				*1970–1980*			
Pct. Δ Sub Value				Pct. Δ Sub Value			
Constant	**0.2496**	0.0142	17.52	Constant	**0.2303**	0.0161	14.27
% Δ Sub ρ	**−0.1426**	0.0571	−2.50	% Δ Sub ρ	**−0.3279**	0.0939	−3.49
% Δ Sub income	**0.0300**	0.0366	0.82	% Δ Sub income	**0.0512**	0.0349	1.47
% Δ Metro population	**0.6639**	0.0597	11.12	% Δ Metro population	**0.6674**	0.0590	11.31
Standard error	0.1493			Standard error	0.1092		
1970–1980				*1970–1980*			
Pct. Δ Sub Supply				Pct. Δ Sub Supply			
Constant	**−0.1713**	0.0237	−7.24	Constant	**−0.1424**	0.0244	−5.84
Pct. Δ Sub value	**1.4442**	0.0620	23.28	Pct. Δ Sub value	**1.3662**	0.0639	21.37
Standard error	0.1036			Standard error	0.1092		
Elasticities				Elasticities			
Supply	1.4442			Supply	1.3662		
Demand price	−0.2403			Demand price	−0.6665		
Demand income	0.0506			Demand income	0.1041		
Demand population	1.0536			Demand population	1.1307		

1980–1990				*1980–1990*			
Pct. Δ Sub Value				Pct. Δ Sub Value			
Constant	**−0.0595**	0.0216	−2.75	Constant	**−0.0646**	0.0219	−2.95
% Δ Sub ρ	**0.1944**	0.0596	3.26	% Δ Sub ρ	**0.2394**	0.0686	3.49
% Δ Sub income	**−0.2474**	0.1952	−1.27	% Δ Sub income	**−0.2616**	0.1950	−1.34
% Δ Metro population	**0.6551**	0.1227	5.34	% Δ Metro population	**0.6653**	0.1227	5.42
Standard error	**0.2608**			Standard error	**0.2601**		
1980–1990				*1980–1990*			
Pct. Δ Sub Supply				Pct. Δ Sub Supply			
Constant	**0.1494**	0.0051	29.11	Constant	**0.1512**	0.0055	27.31
Pct. Δ Sub value	**1.1301**	0.0579	19.52	Pct. Δ Sub value	**1.0282**	0.0612	16.80
Standard error	**0.0896**			Standard error	**0.0967**		
Elasticities				Elasticities			
Supply	1.1301			Supply	1.0282		
Demand price	0.1839			Demand price	0.1986		
Demand income	−0.2341			Demand income	−0.2170		
Demand population	0.6130			Demand population	0.5248		

Table 6 ■ continued.

A. Indirect Least Squares—Direct User Cost				B. Indirect Least Squares—Instrumental User Cost			
Variable	Coefficient	Standard Error	t-Ratio	Variable	Coefficient	Stdandard Error	t-Ratio
1990–2000				*1990–2000*			
Pct. Δ Sub Value				Pct. Δ Sub Value			
Constant	**0.0987**	0.0225	4.38	Constant	**0.0793**	0.0254	3.13
% Δ Sub ρ	**0.0248**	0.0438	0.57	% Δ Sub ρ	**−0.0422**	0.0574	−0.74
% Δ Sub income	**−0.3446**	0.1553	−2.22	% Δ Sub income	**−0.3138**	0.1598	−1.96
% Δ Metro population	**0.4757**	0.1353	3.52	% Δ Metro population	**0.5430**	0.1383	3.93
Standard error	0.1870			Standard Error	0.1869		
Constant	**0.0012**	0.0132	0.09	Constant	**−0.0048**	0.0128	−0.37
Pct. Δ Sub value	**1.3355**	0.0950	14.05	Pct. Δ Sub value	**1.3812**	0.0921	14.99
Standard error	**0.0816**			Standard Error	0.0795		
Elasticities				Elasticities			
Supply	1.3355			Supply	1.3812		
Demand price	0.0323			Demand price	−0.0609		
Demand income	−0.4490			Demand income	−0.4525		
Demand population	0.6235			Demand population	0.7730		
Three Decades				Three Decades			
	Mean	Median			Mean	Median	
Supply	1.3033	1.3355		Supply	1.2585	1.3662	
Demand price	−0.0080	0.0323		Demand price	−0.1763	−0.0609	
Demand income	−0.2108	−0.2341		Demand income	−0.1885	−0.2170	
Demand population	0.7634	0.6235		Demand population	0.8095	0.7730	

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 6 and 7 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 6B, the 3SLS iterative estimates showed the two estimators (Table 7A and 7B) to provide very similar results.

Tables 6 and 7 result 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 8A 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 8B 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 6B and 7B 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} ($u_i = u_i^{\mathrm{c}} + u_i^{\mathrm{s}}$) to the number of central

Table 7 ■ 3SLS estimates of value and supply

A. 3SLS—Direct User Cost				B. 3SLS—Instrumental User Costs			
Variable	Coefficient	Standard Error	t-Ratio	Variable	Coefficient	Standard Error	t-Ratio
1970–1980				1970–1980			
Pct. Δ Sub Value				Pct. Δ Sub Value			
Constant	**0.2554**	0.0137	18.64	Constant	**0.2488**	0.0151	16.53
% Δ Sub ρ	**−0.0769**	0.0271	−2.84	% Δ Sub ρ	**−0.0961**	0.0499	−1.93
% Δ Sub income	**0.0061**	0.0159	0.39	% Δ Sub income	**0.0200**	0.0165	1.21
% Δ Metro population	**0.6720**	0.0593	11.34	% Δ Metro population	**0.6993**	0.0584	11.97
Standard error	0.1489			Standard error	0.1488		
1970–1980				*1970–1980*			
Pct. Δ Sub Supply				Pct. Δ Sub Supply			
Constant	**−0.1713**	0.0534	−3.21	Constant	**−0.1424**	0.0500	−2.85
Pct. Δ Sub Value	**1.4442**	0.1401	10.31	Pct. Δ Sub Value	**1.3662**	0.1310	10.43
Standard error	0.1036			Standard error	0.2238		
Elasticities				Elasticities			
Supply	1.4442			Supply	1.3662		
Demand price	−0.1203			Demand price	−0.1453		
Demand income	0.0096			Demand income	0.0302		
Demand population	1.0223			Demand population	1.0225		

1980–1990				*1980–1990*			
Pct. Δ Sub Value				Pct. Δ Sub Value			
Constant	**−0.0744**	0.0198	−3.75	Constant	**−0.0795**	0.0204	−3.90
% Δ Sub ρ	**0.0737**	0.0352	2.09	% Δ Sub ρ	**0.0520**	0.0430	1.21
% Δ Sub income	**0.1013**	0.0630	1.61	% Δ Sub income	**0.1309**	0.0686	1.91
% Δ Metro population	**0.8105**	0.1119	7.24	% Δ Metro population	**0.8737**	0.1123	7.78
Standard error	0.2626			Standard error	0.2643		
1980–1990				*1980–1990*			
Pct. Δ Sub Supply				Pct. Δ Sub Supply			
Constant	**0.1494**	0.0172	8.67	Constant	**0.1512**	0.0158	9.57
Pct. Δ Sub Value	**1.1301**	0.1944	5.81	Pct. Δ Sub Value	**1.0282**	0.1746	5.89
Standard error	0.3009			Standard error	0.2760		
Elasticities				Elasticities			
Supply	1.1301			Supply	1.0282		
Demand price	0.0775			Demand price	0.0508		
Demand income	0.1067			Demand income	0.1280		
Demand population	0.8563			Demand population	0.8529		

Table 7 ■ continued.

A. 3SLS—Direct User Cost				B. 3SLS—Instrumental User Costs			
Variable	Coefficient	Standard Error	*t*-Ratio	Variable	Coefficient	Standard Error	*t*-Ratio
1990–2000				*1990–2000*			
Pct. Δ Sub Value				Pct. Δ Sub Value			
Constant	**0.0369**	0.0136	2.72	Constant	**0.0321**	0.0162	1.98
% Δ Sub ρ	**−0.0233**	0.0120	−1.95	% Δ Sub ρ	**−0.0480**	0.0162	−2.97
% Δ Sub income	**0.1367**	0.0831	1.65	% Δ Sub income	**0.1621**	0.0767	2.11
% Δ Metro population	**0.7672**	0.1073	7.15	% Δ Metro population	**0.7644**	0.1202	6.36
Standard error	0.1899			Standard error	0.1893		
Constant	**0.0012**	0.0407	0.03	Constant	**−0.0048**	0.0418	−0.12
Pct. Δ Sub value	**1.3355**	0.2921	4.57	Pct. Δ Sub value	**1.3812**	0.2999	4.61
Standard error	0.2509			Standard error	0.2589		
Elasticities				Elasticities			
Supply	1.3355			Supply	1.3812		
Demand price	−0.0318			Demand price	−0.0697		
Demand income	0.1869			Demand income	0.2352		
Demand population	1.0424			Demand population	1.0926		
Three Decades				Three Decades			
	Mean	Median			Mean	Median	
Supply	1.3033	1.3355		Supply	1.2585	1.3662	
Demand price	−0.0249	−0.0318		Demand price	−0.0547	−0.0697	
Demand income	0.1011	0.1067		Demand income	0.1311	0.1280	
Demand population	0.9737	1.0223		Demand population	0.9893	1.0225	

Table 8 ■ 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						
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 are expressed in bold and standard errors are in regular type.

Table 9 ■ 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 8B and 9A)

	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	

city and suburban units respectively, with weights w_i^{c} and w_i^{s} defined as $w_i^{\mathrm{c}} = u_i^{\mathrm{c}}/u_i$ and $w_i^{\mathrm{s}} = u_i^{\mathrm{s}}/u_i$. Housing stock supply elasticity $E_{\mathrm{s}i}$ would be:

$$E_{\mathrm{s}i} = w_i^{\mathrm{c}} E_{\mathrm{c}} + w_i^{\mathrm{s}} E_{\mathrm{s}}. \tag{11a}$$

At the regional or national level, then, metropolitan elasticity E is the weighted sum of the $E_{\mathrm{s}i}$ over i metropolitan areas or

$$E = \sum_i z_i E_{\mathrm{s}i}, \quad \text{where } z_i = \frac{u_i}{\sum_i u_i}. \tag{11b}$$

Table 9 provides calculations at the regional level. Table 9A 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 9B 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 increase 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 (1999) and by Malpezzi and Maclennan (2001), 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 20th 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 10–15%. 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]

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, noting 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

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

of value and user cost. For example, 1980 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 (i) the age of the housing stock, and (ii) current versus 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 to increase in price per unit and to increase in housing per unit, to sharpen estimates of housing supply-and-supply elasticity.

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