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DEMOGRAPHIC FACTORS  
AND REAL HOUSE PRICES

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ABSTRACT

Real house prices are directly determined by the willingness of households to pay for (and willingness of builders to supply) a constant-quality house. Changes in the quantity of housing demanded will affect real prices only to the extent that the long-run housing supply schedule is positively sloped. In this paper we use 1980 census data to measure the impact of the age structure and real income per household on the willingness of households to pay for a constant quality house. Extrapolating these variables forward to 2010, we conclude that evolving demographic forces are likely to raise real house prices, not lower them.

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## DEMOGRAPHIC FACTORS AND REAL HOUSE PRICES

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The roughly 20 percent increase in real house prices in the 1970s and the recent forecast of plunging real house prices in the 1990s (Mankiw-Weil, 1989) has generated substantial research on the movement in and determinants of real house prices. There are two broad strands to the research on determinants. The first is the structural model approach, where multiple equations are specified and estimated, with house prices being simultaneously determined with housing production and future house prices depending on forecasts of multiple relationships [Topel and Rosen (1988) and DiPasquale and Wheaton (1990)]. The second is a reduced-form single equation approach, where supply and demand factors together explain prices [Abraham and Hendershott (1992), Peek and Wilcox (1991) and Poterba (1991)].

Mankiw and Weil's particular innovation was to link demand directly to demographic factors (age) by first estimating a cross-section demand equation on data from the 1970 census. They then constructed a time series age-demand variable to use in the explanation of real house prices. In contrast to the other single-equation models, Mankiw and Weil do not allow for separate influences of real income, real construction costs, and the rental or user cost of housing.

We follow Mankiw and Weil in the micro-based single-equation tradition, using 1980 census data to explain housing demand. Our analysis differs from theirs in three ways. First, we link demand to numerous economic and demographic variables, rather than just age. Second, we allow for supply influences by estimating a hedonic function, while Mankiw and Weil work solely with the demand equation. Third, we focus on a constant quality house. If real prices are to rise in response to an increase in real income or an aging of the population, people must be willing to pay more for a constant-quality house (or builders must be willing to supply new units only at higher prices). A general increase in the quantity of housing demanded per household would cause the prices of higher quality houses to rise relative to prices of lower quality house, but the increase will not necessarily raise constant-quality prices, on average.

The differences in analyses seem to matter a great deal.<sup>1</sup> While Mankiw and Weil find age, and thus "demographics," to be a major determinant of real house

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<sup>1</sup> In fact, the differences probably don't matter that much. Hendershott (1992) shows that the Mankiw-Weil equation doesn't explain real prices in the 1970s and 1980s and that the negative time trend in the M-W equation, not the age-demand construct, is the variable responsible for the large forecasted drop in real prices.

prices and forecast plunging real house prices in the 1990s, we find only a modest impact of demographic factors and a barely perceptible one of age. Mankiw and Weil have hugely exaggerated the impact of demographic factors.

Our paper begins with a statement of our general framework and its implementation. The cross-sectional results for 1980 are then reported and the sensitivity of housing demand to demographic factors and real income is discussed. We conclude that changes in demographic factors did not contribute to the rise in real house prices during the 1970s and are unlikely to cause significant changes over the next two decades.

### I. The General Framework

Rosen's (1974) well-known model relates the demand for housing characteristics to (among other things) demographic factors. The model requires three steps. First, we establish a relationship between the real flow of (real expenditures on) housing services provided by a house and the characteristics of the house

$$q = f(Z) \tag{1}$$

where  $q$  is the flow of housing services consumed (the "user cost" times the asset price) and  $Z$  is a vector of  $n$  hedonic characteristics of the house,  $z_1, z_2, \dots, z_n$ . Second, we obtain

the real marginal implicit price of each hedonic characteristic by taking derivatives of (1):

$$q_i = \frac{\partial f}{\partial z_i}(Z) \quad (2)$$

Third, we relate these marginal prices to: the hedonic characteristics of the house, the demographic characteristics of the household, and the household's real income ( $Y$ )

$$q_i = g_i(Z, A, X, Y) \quad (3)$$

where  $Z$  and the  $q_i$  are as before,  $A$  is the household's age and  $X$  is a vector of  $m$  other demographic characteristics,  $x_1, x_2, \dots, x_m$ .

To estimate (1), we use Christensen, Jorgensen, and Lau's (1975) Translog function:

$$\ln q = \alpha_0 + \sum_{i=1}^n \alpha_i \ln z_i + 0.5 \sum_{i=1}^n \sum_{j=1}^n B_{ij} \ln z_i \ln z_j + \epsilon \quad (1')$$

where  $\epsilon$  is independently and normally distributed. We use the Translog because it will approximate any arbitrary functional form and imposes fewer restrictions than many

other functional forms that are homogeneous of degree one.<sup>2</sup> We impose homogeneity and symmetry upon the translog through the following restrictions:

$$\sum_{i=1}^R \alpha_i = 1 \quad (4)$$

$$\sum_{i=1}^R B_{ij} = 0 \quad (5)$$

$$B_{ij} = B_{ji} \quad (6)$$

That is, we estimate (1') subject to (4)-(6). By restricting (1) to be homogenous of degree one, Euler's Theorem allows us to compute the aggregate quantity of housing services from a specific house as:

$$q = \sum_{i=1}^R q_i z_i \quad (7)$$

We obtain the  $q_i$  by taking partial derivatives of  $q$  with respect to the  $z_i$  in the estimated (1'):

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<sup>2</sup> For example, while a linear functional form is homogeneous of degree 1, it imposes for each hedonic characteristic a common price for each household. This would defeat our ability to derive a relationship between a household's demographic characteristics and its demand for housing.

$$q_i = \frac{\partial q}{\partial z_i} = (\alpha_i + \sum_{j=1}^n \beta_{ij} \ln z_j) \frac{q}{z_i} \quad (2')$$

The form of the inverse demand functions for housing characteristics is not specified by theory. Ideally we would estimate the effect of every characteristic on every implicit price. As a practical matter, we haven't sufficient instrumental variables to do so. We therefore regress the  $q_i$  on only their corresponding characteristic and on the demographic and economic variables:

$$q_i = a_0 + a_i z_i + \sum_{a=1}^{17} a_a A_a + \Psi X + \sum_{a=1}^{17} a_{ya} Y A_a + \mu_i \quad (3')$$

where the  $A_a$  are 0-1 dummies for each five-year age class running from 0-5 to 81-85,  $Y$  is the income of the household head, the  $a$ 's are individual coefficients,  $\Psi$  is a coefficient vector for the other demographic variables denoted by  $X$ , and  $\mu$  is independently and normally distributed. We anticipate that the  $a_i$  will be negative for characteristics yielding positive utility (e.g., the number of rooms) and positive for characteristics with negative utility (e.g., age of house).



## II. Implementation and Results

We estimate equation (1') for the 1980 census year. The hedonic characteristics are house age, numbers of bedrooms, of bathrooms, and of other rooms, whether the house has central air, gas heat, sewer and water hookup, whether it is a condominium or is in an urban area, and which of nine census regions it is in. All data come from the public use micro-data series. Because we do not have a direct estimate of either the quality or quantity of land, we include a variable for whether the household is an owner as a crude proxy for the land attribute.

For renters,  $q$  is gross rent as reported by renters to the census. For owner-occupiers,  $q$  is the product of a user cost measure and the house price as reported by owner-occupiers to the census. We estimate the user cost of housing capital in period  $t$  for each owner from

$$uc_t = r_t(1-m_t) + \rho + \tau_t(1-m_t) + \delta - g_t \quad (8)$$

where  $r_t$  is the nominal interest rate,  $\rho$  is a risk premium,  $\tau_t$  is the property tax rate,  $m_t$  is the marginal tax rate,  $\delta$  is the rate of depreciation and/or maintenance, and  $g_t$  is the expected capital gain. We set  $r$  equal to the 1980 ten-year Treasury rate (0.1146) and set  $\rho = 0.04$ ,  $\delta = 0.03$  and  $g = 0.06$ . We determine the marginal tax rate for each household

by calculating a taxable income based on total income, marital status and number of dependents as reported to the census and then associating with that taxable income a marginal tax rate as based upon 1980 tax law.<sup>3</sup> We take property taxes as reported to the 1980 census.

Using ordinary least squares to explain the service flow provided by 65,622 houses, we obtain an R-squared of 0.40. In Table 1 we report the own-quantity coefficients on the 18 characteristics, their standard errors, and the partial derivatives with respect to the own quantity. As can be seen, 15 of the 18 own coefficients are statistically different from zero at the 5 percent level, and all partial derivatives, with the possible exception of gas heat, have the expected sign. Of the 139 coefficients on the interactive terms, 95 are statistically different from zero at the 5 percent level, none with unexpected signs.

We then estimate (3') for each of the 18 characteristics using two-stage least squares as prescribed in Bartik (1987). For the demographic vector, we include the relevant 0-1 age-dummy for each household member (and therefore implicitly, each household's size), the household head's marital status, the race, gender, and educational attainment (one of five

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<sup>3</sup> The data are not sufficiently complete to allow us to be precisely sure of each household's taxable income.

categories ranging from no high school to post college) of the household's highest earner.

We expect the coefficient on the own housing characteristic ("z") to have a sign opposite the average "q<sub>i</sub>" of the characteristic (see Table 1). That is, we expect normal goods to have downward-sloping demand curves. As indicated in the first column of Table 2, with two exceptions, the coefficient on the own housing characteristic is statistically significant at the 1 percent level with the expected sign. The exceptions are the age of the house and region 2, and the magnitudes of these average prices are quite small.

Also shown in Table 2 are coefficients on selected other variables. To conserve space, we report coefficients on only two of our 17 age-class dummy variables, 21-25 and 41-45; one of our 17 age-income variables, (31-35)\*income; and the single and black identifiers. These coefficients begin to provide a sense about how various income and demographic characteristics affect the demand for housing. Note, for example, that between ages 21-25 and 41-45 the willingness to pay rises for all housing characteristics except sewer hook-up and central air conditioning. Moreover, the willingness to pay for "newness," other rooms, and home-ownership (land?) rises significantly with income (the age 36-40 interaction with

income is fairly typical. The one mystery is the decreasing preference for bathrooms as income rises.

Singles value new houses and more rooms of all types less than do married couples. They also value urban settings and homeownership (land) less and condominiums more. These results seem sensible. Finally, black preferences are quite mixed when compared with others. The willingness of blacks to pay for bedrooms, bathrooms, unbanness, and condos is less than the willingness of others, but blacks pay more for other rooms.

Precise estimates of how the willingness to pay varies with age, income, household type and race are obtained by selecting a housing quality mix (specifying  $Z$ ), computing the implicit prices from (3') and solving equation (7).<sup>4</sup> Figure 1 shows how this willingness to pay for our constant-quality house varied with age in 1980, from two perspectives. In the first, all the average characteristics (education, income, etc.) associated with age are varied with age. That is, the plotted age relationship is a total derivative. The second holds real

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<sup>4</sup> Our constant-quality house is 20 years old and owner-occupied, has three bedrooms, one and one-half bathrooms, three other rooms, central air conditioning, and central heat. Our house is hooked up to city sewer and water, and is in an urban area in Region 9, the Pacific Division of the United States.

income and all nonage demographic variables constant. That is, we show the partial derivative with respect to age. We do the calculations for a white married couple who have attended college and had a real 1980 income of \$25,000.

Both curves rise sharply from the early 20s to the late 30s, when children are leaving the parental home. The total derivative is then basically flat. The partial age derivative, in contrast, jumps in the 60s by a little over 10 percent. All else being equal, older households are willing to pay a premium for housing; in spite of empty nests and lower income, many retirees do not leave the homestead.

Figure 2 shows the large effect of marital status and race on the willingness of owning households with \$25,000 real income to pay for the constant-quality house. The effects are large: blacks are willing to pay only half as much for housing as whites and singles half as much as marrieds. (Single males and females of the same race pay similar amounts.) The explanation for these differences is conjectural.<sup>5</sup> We know that singles and blacks are more apt to live in central cities than married couples and whites. Because land is more expensive in central cities than in suburbia, singles and blacks

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<sup>5</sup> Married couples will have slightly more after-tax income than singles, but they must spend more of their income on food, clothing, medical expenses and so on.

may be acting as a proxy for a hedonic attribute -- land quality or "neighborhood amenities" -- not in our data set [Brown and Rosen (1982)]. While we attempted to "instrument out" this problem by performing two-stage least squares on our demand for amenities equations, we may not have been completely successful. Another possible explanation for the black differential is racial discrimination: if blacks are constrained to live in less desirable neighborhoods than whites, it will appear that blacks are unwilling to pay as much as whites for the "same" quality house. In any event, households in the central city consuming less land and poorer quality housing is in the spirit of Alonzo (1960).

### III. The Importance of Age and Other Demographic Characteristics

A controversial question is what impact have population growth and changes in its age distribution since 1970 had on real house prices in the 1980s and 1990s? A further question is what impact might further growth and changes be expected to have in the next two decades? According to Mankiw and Weil (1989), population growth and changes in age structure in the 1970s contributed significantly to the observed 20 percent increase in real prices, and

expected population evolution in the next two decades will almost halve real prices.

Comparing our Figure 1 with their Figure 2 suggests a strong likelihood that we will answer these questions differently than they did. The age-"demand" relationships for the two studies are similar through age 40, but differ markedly thereafter. For 1980 data, Mankiw and Weil have a monotonic demand decline after age 40 that cumulates to 50 percent by age 90. When only age is varied, we have about a 15 percent increase after age 40; when all variables related to age are also varied, demand is basically flat after age 40. The baby-boomer bulge is now aged 30 to 45. According to Mankiw and Weil, the shift to ages 50 to 65 will significantly lower housing demand and cause a collapse in real house prices. By our estimates, demand (willingness to pay) and real prices will be either flat or increase in response to that shift.

To indicate the impact of demographic changes implied by our estimates, we have computed the average service flow provided by a constant-quality house in 1970, 1980, and 1990. To do this, we use equation (3') to measure the implicit price of the  $i$ th characteristic for a household in the  $j$ th age class

$$q_{ij} = a_0 + a_i z_i + \sum_{a=1}^{17} a_a A_{ja} + \psi X + \sum_{a=1}^{17} a_{ya} Y_j A_{ja}^{(3)}$$

and then sum over the age classes and then the housing characteristics

$$Q = \sum_{i=1}^{17} \sum_{j=1}^n w_j q_{ij} \quad (13)$$

where  $w_j$  is the proportion of households in the  $j$ th age class. Table 3 provides the age-class weights, and Table 4 presents the annual average demographic and real income characteristics for 1970, 1980 and 1990. Demographic and real income data are from the U.S. Department of Commerce, Population Reports, Series P-20, P-25, and P-60.

We first compute the service flow for 1970 data and then repeat the calculation twice for 1980 data and again for 1990 data. In the first repetition, we vary only the age class weights. The result is a 3.6 percent decline in the 1970s and a 1.7 percent rebound in the 1980s, leaving real demand (willingness to pay) 1.9 percent lower in 1990 than in 1970. Looking forward, the aging of the baby-boomers should raise real demand by 3 percent between 1990 and 2010. Allowing for all the changes accompanying the variation in age (calculating the total derivative), willingness to pay fell by almost 7 percent in the 1970s, predominantly due to the shift



from married to single households, and was flat in the 1980s. Looking forward, willingness to pay should rise by about 2.5 percent between now and 2010.

We do not mean to emphasize our exact estimates of demographic effects. Rather, we feature two of their general characteristics. First, both the age shifts and the reduced tendency to marry in the 1970s lowered, not raised, the willingness to pay for constant-quality housing.<sup>6</sup> While an increased quantity demanded may have raised prices by shifting the economy along a rising supply curve, the direct demand effect was negative. Second, the aging of the baby boomers between now and 2010 will increase both the willingness to pay for housing and the quantity demanded. Both increases will raise real house prices, not lower them. While demographic forces undoubtedly affect real house prices, the effect is both more complicated -- the prices of houses at different quality levels will be affected differently -- and weaker in the aggregate than some recent research has suggested. And, of course, real prices will be affected by changes in willingness to supply as well as willingness to demand.

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<sup>6</sup> Peek and Wilcox (1991) attribute the rise to increases in real construction costs and declines in real after-tax interest rates.

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Figure 1  
Willingness to Pay for Housing Services

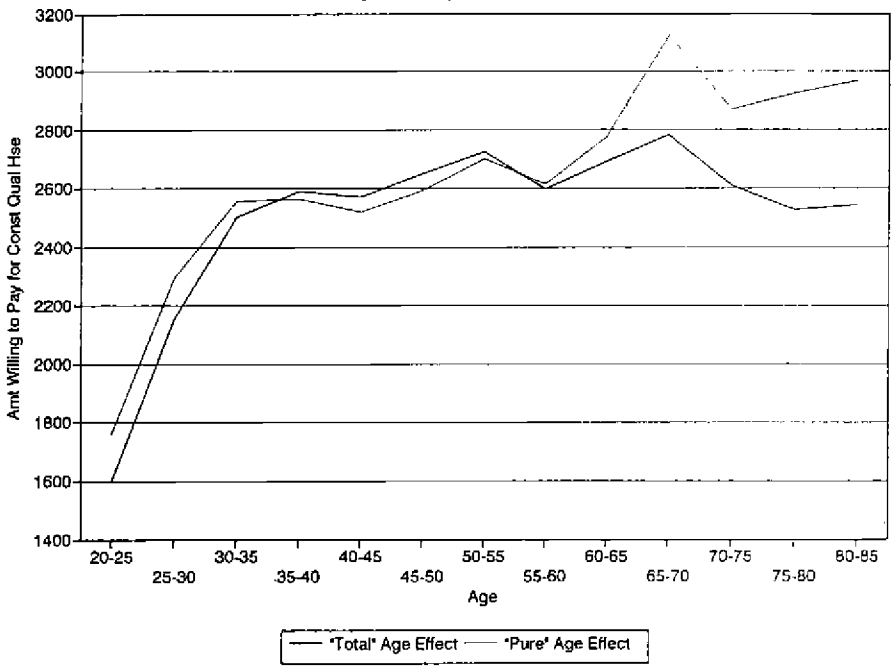


Figure 2  
 "Demand" by Age, Race, and Mar. Status

