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URBAN DECLINE AND DURABLE HOUSING

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ABSTRACT

People continue to live in many big American cities, because in those cities housing costs less than new construction. While cities may lose their productive edge, their houses remain and population falls only when housing depreciates. This paper presents a simple durable housing model of urban decline with several implications which document: (1) urban growth rates are leptokurtotic -- cities grow more quickly than they decline, (2) city growth rates are highly persistent, especially amount declining cities, (3) positive shocks increase population more than they increase housing prices, (4) negative shocks decrease housing prices more than they decrease population, (5) the relationship between changes in housing prices and changes in population is strongly concave, and (6) declining cities attract individuals with low levels of human capital.

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I. Introduction

In eight of the fifteen largest cities in the U.S. in 1950— Baltimore, Buffalo, Cleveland, Detroit, Philadelphia, Pittsburgh, St. Louis, and Washington, D.C.— population has declined in every subsequent decade. Another three of these top fifteen also have smaller populations now than in 1950. All of these cities are still large, but many have lost more than one-third of their populations. With decline has come poverty and social distress: across cities, the correlation between the poverty rate in 1989 and population growth in the 1980s was -40 percent. While firms try to downsize by firing their least skilled workers, cities appear to downsize by losing their most skilled residents.

Many forces contributed to the decline of these, primarily rustbelt, cities. Improvements in transportation technology eliminated the advantages that these cities once had as ports. As lower transport costs made firms footloose, people and firms fled the harsh climates of the Northeast and Midwest. Manufacturing has declined and de-urbanized. In 1963, Detroit had 338,000 manufacturing jobs, and by 1992, the Motor City had only 62,000 manufacturing jobs. Local policies often exacerbated these declines as some city officials made redistribution a higher priority than keeping businesses. National policies also may have favored sprawl and the sunbelt. While once the rustbelt cities had high wages—reflecting their productivity—now they are generally mired in poverty (e.g. Detroit's median income is 62 percent of the national average), reflecting the fact that they no longer have a productive edge.

Indeed, the key question about these declining cities is not "why aren't they growing?" The key question is "why are they still there are at all?" Quickly growing cities rise at dizzying rates—Las Vegas has grown by more than 50 percent in four out of the last five decades. Why is it that declining cities collapse so slowly? The lowest growth rate in the 1990s among the set of consistently declining cities was -12.5 percent (St. Louis). And why, when these cities decline, do they lose their most skilled workers?

Agglomeration models provide an explanation for why people stay in cities long after those places have lost their comparative advantages. Following Krugman (1991), agglomeration theorists argue that if a critical mass of firms assembles in one place, then workers will stay there because they are either able to earn higher wages, or buy cheaper manufactured goods, or face less unemployment risk. However, these theories tell us little about the continuing existence of Detroit and many other declining cities, as these places have low wages and high unemployment. In addition, American Chamber of Commerce price data tells us that non-housing goods are not materially cheaper in declining cities.[1]

This paper argues that people still live in the blighted cities of America's rustbelt for a far more prosaic reason than agglomeration economies. These places have houses, and houses are very durable. When cities decline, housing prices fall and people continue to live in the houses. To a first approximation, there is a one-to-one correspondence between the number of homes in a city and the number of people in that city. It takes decades, if not centuries, for the housing in cities to disappear, and while the houses remain, the cities remain, attracting residents with homes that cost a fraction of new construction costs. In 1990, over 60 percent of all owned, single unit residences in Philadelphia were priced below the cost of new construction, and 30 percent of all homes in the city were valued at no more than 70 percent of construction costs. In Detroit, 80 percent of the owner-occupied single family housing was valued at least 30 percent below construction costs in 1990.

Figure 1 illustrates our framework. The supply of housing is characterized by a kinked supply curve which is highly elastic with respect to positive shocks and almost completely inelastic with respect to negative shocks in the medium run. The durability of housing is such that it takes decades for a house to become economically unviable and to

[1] See No. 771—Cost of Living Index—Selected Metropolitan Areas, Fourth Quarter 1999 in the *Statistical Abstract of the United States 2000* for more detail. The American Chamber of Commerce computes the cost of a mid-management standard of living in a number of participating metropolitan areas (not cities). While not all of the shrinking cities mentioned above are not tracked in these data, among those which are, purchasing the targeted standard of living costs more than the average in the nation. Thus, there are no meaningful savings found in terms of non-housing goods expenses.

disappear from the market. A negative demand shock, like that illustrated in Figure 1, leads to a large fall in price, but little change in the stock of housing—and, therefore, in population. In growing places, positive demand shocks result primarily in more units with little increase in price.

We incorporate this feature of supply, namely that there is an asymmetry between positive and negative shocks, into a dynamic version of the Alonso-Mills-Muth urban model. In our framework, housing depreciates stochastically and a fixed number of people live in each house. Houses that decay are rebuilt if and only if the value of the unit (including its land value) exceeds its resale price. Thus, city populations decline only when the prices of some of their homes fall below the cost of new construction. If the productivity of a city falls, housing prices will drop immediately as a classic compensating variation for lower wages (see Rosen (1979)), but housing itself decays slowly. Population declines only gradually as the houses disintegrate.

Our simple urban model with durable housing can explain several key features of urban dynamics. First, it can explain some of the remarkable persistence of urban growth rates, especially among declining cities. Almost nine out of ten cities that declined in the 1990s also declined in the 1980s. Nearly eight of ten cities that declined in the 1930s also lost population between 1940 and 1990. Because housing decay is slow, it takes decades for the city housing stock to adjust to a new steady state.

The model also predicts leptokurtotic growth rates. If shocks to urban productivity (or city amenities) are symmetric, then cities will grow more quickly than they decline when housing is durable. As Figure 1 suggests, new construction is readily forthcoming when prices are above construction costs, but units and population disappear only slowly over time. The skewness of city growth rates is ubiquitous throughout the 20th century.

The model also predicts an asymmetric response to positive and negative "exogenous" shocks to cities. Negative shocks will have only a small impact on urban growth, because housing depreciates slowly. Positive shocks will have a large effect, because housing can be built relatively quickly (at least over the decade-long periods we examine). Just as the durable housing view of cities predicts a convexity in the relationship between population growth and exogenous shocks, it predicts concavity in the relationship between price changes and exogenous shocks. Negative shocks impact prices significantly, but positive shocks will show up more in new housing, thereby vitiating some of the increase in prices. Both asymmetries generally are borne out in regression analysis using data on shocks to amenities (weather) and productivity (local labor demand as represented by manufacturing employment).

Next, housing durability implies that the distribution of house prices is an excellent predictor of future population growth—and not merely because high house prices reflect future price growth. Population growth is quite rare in cities with large numbers of homes valued below the cost of new construction. We do not interpret this as a causal connection, but claim that this strong correlation illustrates the role the housing market plays in mediating growth.

The model also explains why declining cities disproportionately attract low human capital residents. As labor demand falls in declining cities, high and low skilled workers lose wages roughly in proportion to their base income. However, the benefits from lower housing prices help the poor more than the rich, because the elasticity of demand for housing structure is far less than one (Glaeser, Kahn and Rappaport, 2000).[2] As such a drop in the price of housing attracts the poor relatively more than it attracts the rich. If housing prices fall to keep a median resident indifferent between a declining city and the rest of America, then a low income resident will strictly prefer the city, and a high income resident will prefer to leave. Those outside the labor force will be particularly attracted to cheap, declining places. For them, there is no wage loss associated with a declining city and they get their housing cheaply. This may help us understand the correlation between urban social problems and declining urban population.

[2] Older estimates with higher income elasticities all look at total spending on housing. The overwhelming component of higher spending on houses by higher income individuals is higher spending on neighborhood, not higher consumption of physical structure.

The next section presents basic facts about housing and cities that will serve to justify the assumptions of the model. Section III presents the model. Section IV looks at facts about city growth. Section V examines city composition and urban dynamics. Section VI investigates more seriously the role that housing costs might play in inducing individuals to stay in declining cities. Section VII concludes.

II. Housing and City Growth—Introductory Facts

This section establishes three basic facts that underpin our bricks and mortar view of urban dynamics. First, we document the powerful connection between housing and population. This connection is critical for our argument that the housing stock determines the size of a city. Second, we establish that there are large portions of urban America where housing costs are substantially below the cost of new construction (even if land is free). This fact justifies our emphasis on declining cities with prices below the cost of new construction. Third, we establish a connection between housing construction and the share of the housing stock that costs less than the price of new construction.

The Connection between Housing Units and City Population

In principle, the connection between the number of homes and the number of people in a city could be weak. Declining cities could see large increases in the vacancy rate, and cities might grow through increases in the number of people per unit. But this is false. The link between the housing stock and city population is extraordinarily tight. Figure 2 shows the relationship between the logarithm of the number of housing units and the logarithm of city population in 1990.[3] The r-squared is 98.6 percent—the elasticity is .996. In 1980, the elasticity is 1.007 and the r-squared of the relationship is 99.0 percent. In 1970, the elasticity is 1.017 and the r-squared in 99.0 percent. Across cities, at any given point in time, the link between the number of people and the number of homes is almost perfect.

[3] All of the data in this section come from the 1970, 1980 and 1990 censuses. We consider all cities with more than 30,000 people in each decade for the levels regressions and all cities with more than 30,000 people in the initial time period for the change regressions.

The relationship between changes in housing units and changes in population is more important for our model. Figure 3 shows this connection for the 1970s. The elasticity estimated is essentially one (1.007) and the r-squared is 91.0 percent. The fit is less good in the 1980s, as the elasticity from a regression of change in housing units on change in population is only 0.82, and the r-squared is 81 percent. Closer examination of the data from that decade finds the mismatch between housing and population to be almost entirely due to fast growing California cities in which housing growth did not keep up with population growth. Perhaps, this was because immigrants crowded into homes or perhaps because of constraints on new construction.[4] If we exclude California cities, the r-squared in the 1980's rises to 87 percent and the estimated elasticity increases to 0.96. Importantly, the mismatch between changes in population and changes in housing units occurs almost exclusively in rapidly growing cities. The connection between people and homes continues to be extremely tight in declining cities.[5]

The Distribution of Housing Prices and Construction Costs

This paper is primarily concerned with cities that lie on the vertical part of the housing supply curve in Figure 1. For our durable housing model to explain the persistence of Philadelphia or Detroit, it must be cheaper to live there than to build a comparable house on the edges of the sunbelt, where land is essentially free. Thus, we compare the distribution of the value of the housing stock with the cost of new construction, and compute the distribution of houses priced above and below construction costs for 123 cities in 1980 and 93 cities in 1990.

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[4] We suspect that building constraints are a more important factor, as immigrant inflows are also quite large in very fast growing cities in Arizona, Florida, and Texas. Growth in units outpaces growth in population in cities in those states, leading us to believe restrictions on development are relevant. However, that is a separate issue for future research.

[5] An important reason the relationship between growth in units and growth in population still is so tight is that, while vacancy rates are higher in declining cities, they are only slightly more so. For example, in 1990 the vacancy rate was 7.8 percent among cities that grew in the 1980s, and 9.3 percent among cities that declined in population. If California cities are excluded, the mean vacancy rate among growing cities is 8.5 percent, further narrowing the difference in vacancies between declining and expanding cities.

Housing unit values are obtained from the *Integrated Public Use Microdata Series* (*IPUMS*) maintained by the Minnesota Population Center at the University of Minnesota and from the *American Housing Survey* (*AHS*). The *IPUMS* and *AHS* series contain micro data on individuals and housing units, with self-reported values. In each, we focus exclusively on observations of single unit residences that are owner occupied in order to better facilitate a comparison with construction costs. We use construction cost data from the R.S. Means Company (hereafter, the Means data). [6] This firm computes construction costs per square foot of living area for single family homes in a wide variety of American and Canadian cities. The Means data on construction costs include material costs, labor costs, and equipment costs for four different qualities of single unit residences. No land costs are included so their data are for the physical structure itself.[7]

We adjust the data to account for the depreciation that occurs on older homes, to account for general inflation when making comparisons across different years, to account for the fact that research shows owners overestimate the value of their homes, and to account for regional variation in the presence of key house attributes that have a major impact on value. The data appendix discusses these and other data construction issues in detail.

Tables in the appendix report summary statistics on the distribution of house value to construction costs for each city in 1980 and 1990. Figure 4 highlights the extensive heterogeneity across cities in the share of single family housing that was priced below construction costs in 1980. Many cities in California (and Hawaii) have almost no housing priced below the cost of new construction, while many of the older cities in the

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[6] Two publications are particularly relevant for greater detail on the underlying data: *Residential Cost Data*, 19th annual edition, (2000) and *Square Foot Costs*, 21st annual edition (2000), both published by the R.S. Means Company.

[7] It is noteworthy that the Means data contain information on four qualities of homes—economy, average, custom, and luxury. The series are broken down further by the size of living area (ranging from $600ft^2$ to $3200ft^2$), the number of stories in the unit, and a few other differentiators. We developed cost series for a one story, economy house, with an unfinished basement, with the mean cost associated with four possible types of siding and building frame, and that could be of small ($<1550ft^2$), medium ($1550ft^2$-$1850ft^2$), or large ($1850ft^2$-$2500ft^2$) size in terms of living area. Generally, our choices reflect low to modest construction costs. This conservative strategy is appropriate given our purposes. Because we are particularly interested in accounting for why people continue to live in relatively unattractive areas, we could easily bias the findings toward a 'cheap housing' explanation by choosing a high quality house for

colder regions of the country (the Midwest especially), are filled with cheap housing. These data alone should raise questions about urban models that suggest land generally is worth a great deal.

Nationally, 41 percent of single unit housing in cities in 1980 are valued below the cost of new construction. In 1980, nearly 60 percent of all owned, single unit, attached and detached residences in the central cities of the northeast and midwest were valued below the cost of new construction. One-third of the stock in these regions was worth no more than 80 percent of construction costs. Conversely, in the west only 5 percent of homes were priced more than 20 percent below new construction costs, and nearly three-quarters were valued in excess of 120 percent of construction costs. These regional patterns persist in 1990 despite a general rise in housing values. By 1990, the midwest still had a large amount of very cheap housing relative to construction costs; the west still had plenty of land that is worth a great deal, and the south and northeast were somewhere in between these two extremes.[8]

Changes in Units and Housing Prices below Construction Costs

The third building block of our model is that existing cheap housing is a substitute for new construction. For this to be true, it should be the case that cities with large amounts of cheap housing do not have new construction. If old housing were not a close substitute for new housing, then abundance of old, cheap housing would not deter new construction.

Table 1 reports some basic findings for the relation between growth and the extent to which a city's housing is valued at less than the cost of new construction. To illustrate the relationship, we split our sample of cities into three groups based on housing values in

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which construction costs are high. Existing homes, especially those in declining areas, are more likely to look cheap compared to that alternative. By choosing a modest home, we guard against that possibility.

[8] We also examined the 1989 and 1991 *AHS* to provide a comparison to the census data. Reported house prices tend to be a bit higher, so fewer units are estimated to be valued below construction costs. However, the basic patterns discussed above are clearly evident in these data. In addition, investigation of the 1999 *AHS* indicates similar regional patterns persisted throughout the 1990s.

1990: (a) cities with abundant cheap housing, i.e. those with over one-half of their housing stock priced below the cost of new construction and with over 30 percent of the total stock valued at least 20 percent below the cost of new construction; (b) cities with little cheap housing, i.e. those with less than 25 percent of their stock priced below the cost of new construction and with less than 10 percent of their stock priced at least 20 percent below the cost of new construction; and (c) cities in the middle, which are the remaining cities.

Table 1 shows that cities with expensive housing do not necessarily grow, but cities with cheap housing are almost uniformly shrinking. Of the 15 cities with abundant cheap housing in 1990, 14 lost population in the 1980s, with mean and median growth rates of about –9 percent. Of the 20 cities in the middle group, 11 had positive growth in the 1980s, while 9 had negative growth. The 45 cities with little cheap housing relative to construction costs grew at much higher rates on average. The overall statistical relationship between growth and the share of the housing stock that is priced below the cost of new construction is quite strong: the correlation coefficient is –0.55 for the 1980s. These results confirm that new homes are not built, and population does not come, to cities with abundant cheap housing.

III. Theory and Evidence on Skewness and Persistence

In this section, we introduce our model of durable housing and urban decline.
We consider an "open city" model where workers will continue to migrate to the city until the utility in the city equals an outside reservation utility (denoted $\underline{U}$). Thus, utility for urban residents must equal $\underline{U}$ at every point. Wages and amenities are assumed to be exogenous, independent of city population and variable over time. The annual flow of utility for workers in the city from wages equals W and from amenities equals A.

The housing structure of the city is the simplest form of the classic Alonso-Muth-Mills model with only one source of heterogeneity within the city—proximity to the downtown. Following Solow (1973), our city is a line through the central business district (CBD). Each resident works in the CBD, and pays annual commuting costs equal to T times the distance to the city center. Each worker must consume one unit of housing that must sit on one unit of land. The notation N refers to the number of homes, the number of people in the city, and the total amount of land being used in the city. Since the city is a line through a point, the distance between the CBD and the edge of the city equals N/2. Thus, for the consumer at the edge of the city (which is N/2 units of land from city center) the costs of commuting equal TN/2.

Housing prices within the city must in equilibrium make consumers indifferent between living at the center and paying no commuting costs versus living elsewhere in the city. Hence, if R(d) refers to the annual rent at distance d from the CBD, then $R(d)+Td=R(0)$, where R(0) is the rent for a house at the city center. There is no non-urban use for the land, so land is free at the edge of the city. Within the city, the price of land is determined by the demand for proximity.

The reservation utility that must be realized at every distance d from the city center at which people live can be defined as wages plus amenities minus rent minus travel costs, or W+A-R(d)-Td. To simplify our notation, we use X to denote $W+A-\underline{U}$. Thus, the open city assumption of the model gives us $X=R(d)+Td$, which implies that the combined rental and commuting costs of living in the city must equal wages plus amenities minus the reservation utility.

So far, we have described a completely standard urban model. However, our focus is on the role of housing supply and, in particular, on housing durability. While there is an existing literature on durable housing that is well reviewed in Brueckner (2000), we differ from most of this literature because our primary interest is in cities in decline, not growing cities. Our basic housing supply assumption is that homes can always be built with one unit of land at a cost of C. This cost, C, is meant to correspond with the physical costs of construction reported in the Means data.

In addition, during each time period, a fraction of houses, δ, collapse. These houses must be completely rebuilt at cost C if they are to be used. Houses collapse randomly, and there is no decay of non-collapsing homes. In reality, housing decay is much more continuous. Moving to continuous depreciation would not change the basic results of the model, as the basic durability of housing would remain. However, continuous depreciation makes the model much less tractable.[9]

New construction, or renovation, occurs when the expected rental flows from the property equal the cost of new construction. We assume that developers discount future rent payments with a discount rate, r, and of course, there also is the probability of collapse which further reduces the value of the flow of housing. Thus, if we let R(d, t+j) denote the rent at distance d from the city at time t+j, for the marginal piece of new construction it must be the case that:

$$C = E_t\left(\sum_{j\geq 0}\frac{(1-\delta)^j R(d,t+j)}{(1+r)^j}\right) \tag{1}$$

As $R(d,t+j) = X(t+j) - Td$, if we assume that $E_t(X(t+j)) = X(t)$, then equation (1) can be rewritten as $C = (1+r)(X(t)-Td)/(\delta+r)$.[10] This equation tells us that homes will be built, or renovated, at distances from the CBD that are less than $X(t)/T-(\delta+r)C/(1+r)$. At distances further than this, it will not pay to build new homes and it will not pay to renovate collapsed homes.

In a static model where X is constant over time, the distance from the city center to the edge will equal $X/T-(\delta+r)C/(1+r)$ and the population level will equal two times this

[9] And, as the filtering literature has stressed, if the poor demand less housing quality, then a continuously decaying housing stock will create an additional reason why the poor will live in declining cities.

[10] The random walk assumption will be problematic in some places. For example, the persistence of growth rates implies an explosive process for X. A more general formulation might assume that $E_t(X(t+j)) = \overline{X} + \theta^j(X(t)-\overline{X})$, which (as long as $1+r>\theta$) would imply $P(d,t) = (\overline{X}-Td)/r + (X(t)-\overline{X})/(1+r)(1+r-\theta)$, but we will not treat this more general case. Our view is that this does not raise a problem within the relevant range of the data.

amount. In the static model, undeveloped land will be priced at zero, so we can also determine housing prices because the price of a home at the edge of the city will equal C.[11] At all other points in the city, the price of housing must satisfy the following difference equation: $P = R - \delta C + \frac{P}{1+r}$, which implies that price this period equals the discounted value of price next period plus expected revenues minus expected costs, or $P(d) = (1+r)(X - Td - \delta C)/r$. The average housing cost in the city then equals $(1+r)X/2r + (r(1-\delta)-\delta)C/2r$. Average housing prices do not rise one-for-one with construction costs because these costs also restrict the size of the city and lead to a reduction in average commuting costs. The basic structure of this urban model is illustrated in Figure 5, with house prices being single peaked at the CBD and city size being bounded by prices on the edge that equal construction costs.

We now consider an unexpected permanent shock to the city, so that there is a new value of X, denoted X', where $X' = X + \varepsilon$. For simplicity, we assume that this is the only shock that is expected to occur. If $\varepsilon > 0$, then new construction will occur and there will be an increase in housing units (and population) equal to $2\varepsilon/T$.

When $\varepsilon < 0$, new construction will not occur. The new boundary point for construction will be $X'/T - (\delta + r)C/(1+r)$. Renovation will occur on homes that are closer to the CBD than this point. However, homes that collapse which are further from the CBD than this point will not be rebuilt. As of the first time period, there are $2\varepsilon/T$ homes that lie between the old city boundary and the new point that determines efficient renovation. Exactly $2\delta\varepsilon/T$ homes will, therefore, collapse in this region between the first period and the second period, and this will create the only change in population. Over a longer time period, between time t and time t+j the number of homes that will collapse in this region will equal $2(1-(1-\delta)^j)\varepsilon/T$. As j goes to infinity, the effect of a negative shock will approach $2\varepsilon/T$, which is the effect of a positive shock. This is illustrated in Figure 6.

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[11] Because there is option value to land in a stochastic model, even the undeveloped land at the edge of the city will have a positive value, as there is some chance that this land may be worth a positive amount in the future.

One of the most well known stylized facts about urban growth is that the growth rate is orthogonal to the initial population level (Eaton and Eckstein, 1997; Glaeser et al., 1995). For this to be the case, we will assume that $\varepsilon = \mu * Population$, where the mean and variance of μ is independent of city size. This formulation justifies our focus on growth rates rather than raw population growth and leads to the first proposition (proofs are in the appendix):

Proposition 1: If there is a shock at time t denoted $\varepsilon = \mu * Population$ that is unexpected, and there are no further shocks, then the distribution of population changes between time t and t+j is leptokurtotic, in that the mean is greater than the median. The gap between the median and the mean of the distribution diminishes as j gets larger. Furthermore, the rate of depreciation satisfies

$$1-(1-\delta)^{j} = \frac{E\left(\frac{N_t - N_{t+j}}{N_t} \middle| N_{t+j} < N_t\right)}{E\left(\frac{N_{t+j}-N_t}{N_t} \middle| \frac{N_{t+j}-N_t}{N_t} > 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}\right) - 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}},$$

when the median growth rate is positive and

$$1-(1-\delta)^{j} = \frac{E\left(\frac{N_t - N_{t+j}}{N_t} \middle| \left(\frac{N_{t+j}-N_t}{N_t}\right) < 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}\right) + 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}}{E\left(\frac{N_{t+j}-N_t}{N_t} \middle| N_{t+j} > N_t\right)},$$

when the median growth rate is negative.

The skewness in city population growth rates predicted by Proposition 1 is ubiquitous throughout the 20th century as Table 2 documents. The first column reports the skewness coefficients for urban growth rates in each decade from 1920 to 2000. In every decade, the distribution is quite skewed. Figure 7 highlights this visually for the 1980s, a decade in which growth rates were not abnormally skewed. Even in the 1990s, which has the lowest skewness coefficient by far, we can still conclude that growth rates are skewed at standard confidence levels (97 percent in this case). The bottom panel of Table 2 reports the same information for growth rates over increasingly longer time periods. As the model suggests, skewness becomes less severe over longer periods, but symmetry in the distribution of urban growth rates can still be rejected over these longer intervals.

The last column in Table 2 reports the value of δ that was defined in Proposition 1. On a decadal basis, housing depreciation tends to have averaged from 2.5-3.5 percent per annum until the 1960s. The data then suggest a systematic increase in the rate of depreciation from the 1960s onward—which empirically reflects a more symmetric path of urban growth. There are two plausible explanations for this higher depreciation. First, increasing social problems in declining cities may have led to actions (e.g. more arson) that increased the rate of depreciation. Second, the model may be somewhat faulty, and the distribution of city-level shocks might have changed in the 1980s and 1990s. There are fewer extremely quickly growing cities (relative to the median). The analogous figures for multiple decade periods reported in the bottom panel of Table 2 show a similar trend of faster depreciation in recent decades. However, the implied rates are lower and seem more sensible to us.

Our second proposition concerns the persistence of growth rates. Here, we again assume that there is a single unexpected shock at time t that is proportional to initial city size.

Proposition 2: Growth rates will be positively correlated over time. The current growth rate will be increasing in the lagged growth rate when the lagged growth rate is negative and will be independent of the lagged growth rate when the lagged growth rate is positive.

The positive relationship between current and lagged growth rates occurs because population does not instantaneously adjust when there is a negative shock, as the rate of decline is determined by the depreciation rate of housing. There is no persistence of positive shocks in this case because new housing is built to accommodate positive shocks. With only one shock, the second period growth rate is zero if the first period growth rate is positive.

The persistence of growth rates predicted by Proposition 2 is one of the most striking features of urban growth rates. Table 3 documents the effect of regressing current growth on lagged growth for decades in the post-World War II era. As suggested by the model, we use a spline at zero and test if the impact of past growth on current growth is greater when past growth is negative.[12] In all decades, the coefficient on past growth is higher when past growth is negative. In three of four cases, we can reject the equality of the two coefficients.

Of course, as Table 3 makes clear, one aspect of the model is clearly counterfactual. While persistence is very strong among declining cities, there also is significant serial correlation among cities that had positive growth. One explanation for this is that there is serial correlation in the city-specific shocks.[13] Alternatively, it could take time to build new houses and positive shocks to cities might only be accommodated over decades. Nevertheless, the greater elasticity of current growth with past growth when past growth is negative provides support for the importance of bricks and mortar in urban dynamics.

IV. Theory and Evidence on Shocks and City Growth

We now return to the model and consider the connection between population growth, housing price growth and exogenous shocks. As discussed above, a population response to a positive shock will equal $2\varepsilon / T$, and the population response to a negative shock equals $2\delta\varepsilon / T$. This difference makes the relationship between population movements and ε convex.

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[12] In each decade, we include all cities with a population level greater than 30,000 in the initial decade of each time period. Data from two series are used. One is the sample of cities with consistent population figures dating back to 1920. The other is a much larger sample that dates back only to 1970. This series will be used extensively below. The notes to the table provide the details.

[13] Building this serial correlation into the model would not affect the qualitative results of the model, but would lead to significant increases in tractability.

As discussed above, the median housing price in the city before a shock will equal $(1+r)X/2r+(r(1-\delta)-\delta)C/2r$, and prices at each distance from the city center, d, equal $(1+r)(X-Td-\delta C)/r$. After a positive shock, prices at all distances from the city center will equal $(1+r)(X'-Td-\delta C)/r$. The median housing price will equal $(1+r)X'/2r+(r(1-\delta)-\delta)C/2r$, and the growth in median prices will equal $(1+r)\varepsilon/2r$. The growth in prices for any given house will equal $(1+r)\varepsilon/r$. The growth in median prices equals one-half of the price growth for any given house because as the city grows, it adds cheap housing on the fringe of the city.

When there is a negative shock, the price at each point in space equals $(1+r)(X'-Td-\delta C)/r$, with the price change for any given house equal to $(1+r)\varepsilon/r$. However, because the supply response to urban decline is limited by housing durability, the change in the median price will not be symmetric. For example, if housing were completely durable, then the median house after the shock would be exactly as far from the city center as the median house before the shock, and the price of this house would drop by $(1+r)\varepsilon/r$. Thus, the median housing price will have declined by twice as much in a downturn as it rises during an upturn in this case.

When housing is not completely durable, some housing far from the center collapses and is not rebuilt. After this collapse, the median house becomes the home that is $\delta\varepsilon/2T$ land units closer to the city center (because $\delta\varepsilon/T$ units of housing have collapsed on the edge of the city).[14] Thus, the median house price declines by $(1+r)\varepsilon/r$ units because the city has become less attractive and increases in value by $-(1+r)\delta\varepsilon/2r$ units because the median home is now closer to the city. The overall change in median housing prices equals $(1+r)(2-\delta)\varepsilon/2r$. In sum, when all housing collapses each period, the impact of shocks on prices is symmetric and when all housing is perfectly durable, the impact of positive shocks is one-half of the size of the impact of negative shocks. This reasoning leads to the following proposition:

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[14] This requires that the median home is itself worth renovating after the shock, which we assume to be the case.

Proposition 3:

a. The effect of an exogenous shock on population will be convex around zero. More specifically, the slope of population growth with respect to positive shocks will equal $1/\delta$ times the slope of population growth with respect to negative shocks.

b. The effect of exogenous shocks on median housing price growth will be concave around zero.

c. The relationship between average housing price growth and population growth will be concave around zero.

Evidence on Asymmetric Responses to Exogenous Shocks

We start with the concavity of the relationship between population growth and average housing price growth. There is no exogenous variable in this relationship, and this regression is not meant to suggest causality, as both variables are being moved by unmeasured exogenous shocks to urban productivity and urban amenities. Instead, the regression results reported in Table 4 test an important implication of our durable housing stock model.

By using the log change in median house price as the dependent variable in these regressions, we are ignoring potential changes in housing quality. We could only estimate reliable hedonic prices for constant quality units in 77 cities across 1980 and 1990.[15] As this is a small number of cities for our purposes, and as the correlation between adjusted and unadjusted housing prices is quite high (63 percent), to increase our sample size, we use the unadjusted housing prices for our regressions.[16]

[15] In terms of micro data, census data from the *IPUMS* are superior, as the *AHS* samples of housing units tend to be very small for all but the largest cities, making it difficult to adequately control for quality differences in many cities. Fewer cities were identified in the 1990 *IPUMS*, reducing the number for which consistent data could be obtained across years.

[16] Since this is the dependent variable, it is not clear that there will be any bias associated with not controlling for quality. The case we thought most worrisome potentially was the one in which housing quality declines in shrinking cities and grows in rising cities. We investigated this possibility by analyzing whether the difference between unadjusted housing price changes (i.e., in the median price) and adjusted housing prices changes (estimated via hedonic techniques using micro data) is higher in growing or declining cities. This difference should reflect housing quality changes. This difference is not significantly

Table 4 documents the relationship between housing price changes and population changes for our larger sample of cities that we track from 1970. The first and second columns report regression results for the basic spline of population during the 1970s and 1980s. There is an economically and statistically significant difference between growing and declining cities in the relationship between population and prices in both decades. Figure 8's plot illustrates the strong concavity in the relationship between price and population changes in the raw data for the 1980s.[17] Among cities with shrinking populations in this decade, a one percent higher rate of population decline is associated with two percent lower prices. Among growing cities, price change and population change are uncorrelated.[18]

A similar pattern holds for the 1970s (column 2). Finally, Proposition 3 also applies to rental properties, so the change in median rental prices over the 1980s is examined in the final column. The strong asymmetry again is apparent. Overall, the results from Table 4 indicate that the concave relationship between changes in prices and changes in population is a robust fact that corroborates the model.

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higher in declining cities. Also, there is no significant correlation between population growth and the difference between adjusted and unadjusted price changes.

[17] Somewhat surprising to us is the coefficient on the spline for positive population growth, which is small and not significantly different from zero for positive growth cities in the 1980s. In principle, this might be explained by changing housing quality for growing cities, but the evidence regarding quality growth in this group of cities suggests this is not the case. It seems more likely that the lack of any positive real price growth among these cities reflects a housing supply that is quite elastic for many of these growing cities—at least over decade-long periods.

[18] While the proposition does not indicate that we should control for exogenous variables that drive city growth, we did investigate whether the relationship documented in Table 4 and Figure 8 is robust to inclusion of a variety of common city-level controls. A strong and significant asymmetry remains in an expanded specification that includes values for the following variables as of the beginning of the relevant decade: the fraction of single unit structures in the city, the log of city population, the family poverty rate, and the log of median family income; 30 year weather averages for mean January temperature, mean July temperature, and annual rainfall; and census region dummy variables.

Finally, we also estimated similar models on the much smaller sample of 77 cities for which we could compute the growth in constant quality prices. While statistically significant results are not forthcoming from the full specification, the qualitative nature of the findings still holds. That is, the coefficient on the negative spline of growth is relatively large and positive, while that on the negative spline of growth is relatively small and negative. And, if the region dummies are omitted, the quantitative results are very similar to those reported in the first column of Table 4, with the coefficient on the spline for positive growth being significant at the 8 percent level (t=1.8).

We now proceed to tests using a more "exogenous" shock to the city population. We experiment with two sources of such shocks: the weather and industry structure. The weather is one of the most reliable determinants of population growth at the city and state level. Over the past fifty years, warm places have grown and cold places have declined. The simple correlation between mean January temperature and city growth has ranged from 0.47 to 0.73 in the three decades since 1970 (see Glaeser and Shapiro, 2001, for more discussion).

Obviously, the weather of cities is not changing. Instead, it is the demand for weather that is changing. Rising incomes, or improving air conditioner technology, have increased the relative importance of the weather as an urban amenity. In the context of the model, this could be formalized by assuming that A=z*V, where z is the taste for the weather and V is the weather. The shock to X, comes through a change in z, not a change in V. Using this formulation, the value of ε should be thought of as $(z(t+1)-z(t))V$, or the city's basic climatic quality times the change in the value that is placed on climate. Of course, the variation associated with the weather can reflect other shocks (including political ones), but for our purposes, the key is that the weather provides exogenous variation, not that any estimated impacts only reflect a change in the value of good weather.[19]

While the weather seems to be a reasonable source of exogenous variation, it not easy to guess at the level at which weather increases population (versus decreasing it). To address this issue, we use the model which tells us that the share of cities with negative population changes will equal the share of the distribution of exogenous factors which predict negative growth. As 30.3 percent of our sample of cities declined in population during the 1990s, we will assume that the lowest 30.3 percent of mean January temperatures can be thought of as reflecting a negative population shock from the weather. This implies that all cities with mean January temperatures above 26.7 degrees

[19] For example, if the older and colder cities of the north systematically suffered more negative political shocks (i.e., had more costly corruption or engaged in more intense efforts at local redistribution that mobile firms and workers could avoid), the underlying causal force influencing population change would be different from that just described.

will be thought of as having a positive shock and cities with temperature levels below that quantity will be thought of as having a negative shock. For the 1980s, this value changes slightly (as 33.5 percent of cities declined in the 1980s) and the cut-off becomes 28.4 degrees. Fully 45 percent of cities suffered population declines in the 1970s, so the spline is set at 31.8 degrees for that decade.

Table 5 shows the response of population levels to this 'weather shock'.[20] The predicted convexity of population change and weather shocks is evident in all three decades, as cities with good weather grew quite rapidly, while cities with bad weather either grew more slowly (1970s) or shrank slowly (1980s and 1990s). It also is the case that the relevant coefficients are significantly different from one another.[21] Figure 9 graphs the results for the 1980s, with population growth plotted against the weather and the solid line showing the predicted values from the regression. While some aspects of our procedure may seem subjective, these results are extremely robust to alternative definitions of the positive-negative cutoff point.[22]

In Table 6, we look at the response of prices to weather shocks. The regression results in the first column show the response of median housing prices in the 1980s. Figure 10 plots the results. As the model predicts, there is a strong impact of weather on prices when the shock is negative, but only a weak effect when the shock is positive. The next column shows the analogous results for the 1970s. Note that the predicted asymmetry

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[20] Because population figures from the 2000 census are available, we also include regressions for changes over the 1990s in this table. We also estimated a specification that takes more seriously the assumption that it is only a change in the demand for weather quality that is captured in the weather variable. In that case, we controlled for the fact that temperate climates are desirable and made adjustments for the fact that very hot places (those with mean January temperatures in excess of 60 degrees Fahrenheit, more specifically) were less desirable. The economic and statistical nature of the findings is largely unchanged.

[21] We also estimated specifications that included other local controls as of the beginning of the relevant decade. These included the fraction of single unit residences and beginning of period population, poverty rate, and median family income. Adding these controls has very little impact, statistically or economically, on the estimated impacts of bad and good weather. Because region controls are so strongly correlated with the weather, we do not think they should be included. However, as further check on robustness, we also performed the estimation with them included. The basic asymmetry still is evident with region controls, but the results are less precise so that we no longer can conclude that there is any significant difference in the two relevant coefficients in this case.

[22] Furthermore, since the proposition technically deals only with previously growing cities, we have checked that our results still hold for cities that only grew during the previous decade.

does not hold here.[23] The final column reports results for the 1980s using median rental prices. Once again, the basic asymmetry exists, with prices responding more strongly to negative shocks. Hence, the data from the 1980s, but not the 1970s, confirm this part of Proposition 3.[24]

We now proceed to a similar analysis using an industry structure variable in the 1980s. Here we use the initial share of manufacturing employment in the city as a source of exogenous urban variation. This is defined as the sum of each city's employment share in durables and non-durables goods manufacturing. The de-urbanization of manufacturing that has occurred suggests that cities with large initial shares of employment in manufacturing have suffered negative shocks. Consistent with our approach above, we presume that 33.5 percent of cities suffered negative shocks (i.e., the number of cities receiving negative shocks equals the number of cities that declined during the period). Transforming the variable into one minus the employment share in manufacturing (so that lower values represent 'negative shocks' to be consistent with the weather variable above) leads us to spline the data at 74.6 percent. This implies that cities with manufacturing employment shares above 25.4 percent are presumed to have negative shocks.

Table 7 reports our results. The point estimates in column one still exhibit the asymmetry predicted by the model, with positive shocks having a stronger impact on population growth.[25] In the next regression, we look at the price response to these industry level shocks. Here the results do not match the model. Increases in demand tend to be related to lower prices, especially when demand shocks are negative. Not only is this incompatible with a model of durable housing, it is also incompatible with any model in which housing supply is positively sloped.

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[23] Real house price growth was quite strong if there was a positive or negative weather shock during that decade. For example, real median house price appreciation in our cities was 24.3 percent during the 1970s versus only 7.5 percent in the 1980s. Moreover, the housing price change distribution changed radically between the decades. The variance about the mean was a relatively low 4.5 percent in the 1970s versus 9.5 percent in the 1980s. The distribution was much more skewed in the 1980s, with its skewness coefficient being 0.78 versus 0.003 for the 1970s.

[24] As with the results in Table 5 on population changes and weather, adding common local controls does not change the findings in any important way—for the 1970s and the 1980s.

A close examination of the data reveals the observations that are driving this particular finding. In the 1980s, there are a number of one-time manufacturing cities near New York City and Boston that had substantial price increases because they switched from being centers of production to being more suburban-like residential centers. These cities are predicted to decline but in fact experience significant housing price increases.[26] If we exclude these cities in the New York-Northern New Jersey and Boston-Lawrence-Salem CMSAs (other than New York City and Boston) and the Providence Metropolitan Statistical Area, this perverse result goes away. However, even excluding those cities does not allow us to recover the any meaningful asymmetry between positive and negative shocks that we saw in Table 6 with respect to the weather.

VI. Housing Prices and Urban Decline

At this point, we return to our empirical work connecting the abundance of below cost housing with urban decline. Naturally, we do not suggest that this connection is causal—indeed the model explicitly argues that cheap housing will be the result of past negative shocks. Instead, our goal is to document the predictive power of housing market prices.

We turn again to the model and consider the growth rates of cities one period after a shock. In period one, there is an unexpected shock to urban productivity or amenities. There will immediately be a price response to that shock. If the shock is positive, then none of the housing that currently exists will cost less than the price of new construction. If the shock is negative then all houses beyond $X'/T-(\delta+r)C/(1+r)$ units of distance from the city center will be priced less than the cost of new construction. There will be $-2\varepsilon/T$ such houses. The total share of housing that costs less than the price of new construction will thus equal: $-\varepsilon/\left(X-T(\delta+r)C/(1+r)\right)$, which we denote as "S". The

[25] The pattern still holds after controlling for a variety of local controls.
[26] Because of this problem, the overall connection between this variable and price change is not even positive, rendering it an ineffective demand shift instrument.

change in population equals $2\delta\varepsilon / T$, or $-2\delta\big(X - T(\delta + r)C/(1+r)\big)S/T$, which implies the following proposition:

Proposition 4: Expected population growth is declining in the share of the housing stock with prices below the cost of new construction.

At first blush, it would seem that a connection between housing prices and population growth is not surprising. After all, housing prices should reflect expectations about future growth so that one might expect higher price areas to grow more. We have two ways of addressing this concern. First, we can control for median housing prices in the regression analysis. Second, we can also show that there is no meaningful relationship between our housing price measure—the share of the city's housing stock that is priced below the cost of new construction—and the growth of real house prices over the next ten years. The simple correlation between the two variables is 0.06 and the adjusted R-square from regressing real price appreciation over the 1980s on the fraction of stock priced below construction costs in 1980 is –0.002. It seems unlikely that this variable is actually capturing expectations, perhaps because long-run housing prices are just too unpredictable.

Empirical Results

Table 8 shows our first results on the connection between urban growth and the share of the housing stock priced below the cost of new construction. The construction of this variable was discussed above and is described in detail in the appendix. The results in the first two columns illustrate the connection between our variable and population growth in the 1980s. The first specification includes only the fraction of the city's housing stock that is valued below the cost of new construction. The coefficient of -0.32 implies that for every 10 percent more of the housing stock that is priced below the cost of new construction, the growth rate of population is reduced by just over 3 percent. The r-squared of the regression is 38 percent, corresponding to over a 60 percent correlation coefficient between this variable and growth over the next 10 years. Apart from lagged growth, this construction cost and price variable is the best we have for predicting cities' future growth.

The second specification includes a rich set of other controls. These include the median housing price at the beginning of the decade, as well as a variable capturing the share of the housing stock that sells for at least a 30 percent premium to construction costs. Interestingly, these other housing price variables do not predict positive growth. In fact, cities with lots of expensive housing tend to have lower growth in the 1980s, possibly because they are facing supply constraints. The median value of housing has no predictive content for growth in the 1980s once we have controlled for the other variables. The coefficient on the share price below construction costs is almost unchanged from the first model.[27]

The final two specifications in Table 8 include findings for the 1990s. The results are less stable, but the fraction of housing stock valued below construction cost variable has a significantly negative coefficient unless lagged growth is included. While the percentage of the stock valued at least 1.3 times construction costs is not independently significant in the 1990s, it is its inclusion which is associated with the doubling of the coefficient on the fraction of the stock priced below construction costs.[28] While the impressive connection between cheap housing and future decline cannot be considered surprising as the underlying economics could not be more straightforward, the power of the variable suggests that the housing market really does mediate urban growth.[29]

[27] For completeness, we also estimated a specification that included the lagged population growth rate from the 1970s. In the model, the share of housing that is priced below construction costs is capturing urban decline and as such, we do not necessarily expect much of an impact of this variable once we control for lagged population growth. Yet, the fraction of the housing stock priced below construction costs at the beginning of the decade still matters. The coefficient drops by about one-quarter, but it remains significant. Places with much housing priced below the cost of new construction just do not grow.

[28] By 1990, there is a very strong regional concentration in the west of cities with substantial fractions of their housing stocks priced well above construction costs. If the region controls are dropped, the coefficient on the fraction of stock priced at least 30 percent above construction cost rises substantially in absolute value (the coefficient becomes negative in this case) and is highly statistically significant.

[29] It is noteworthy that the alternative measure of housing price based on the constant quality price series discussed above confirms the findings in this section. When that measure of housing price premium

VII. Human Capital and Urban Decline

In this section, we address the connection between human capital, the housing stock and urban decline. At this point, we assume that there are high human capital types and low human capital types. Otherwise, the model is unchanged. Low human capital types receive wages of W, pay transport costs of T, and have a reservation utility outside of the city that is equal to $\underline{U}$. High human capital types have wages equal to $(\phi+1)W$, travel costs equal to $(\phi+1)T$, and reservation utility equal to $\overline{U}$. The fact that travel costs and wages scale by the same amount is meant to capture the time costs of travel. The crucial aspect of the model is not that transport costs and wages scale identically, but that the high human capital types have both higher wages and higher commuting costs. Significantly, high and low human capital types are assumed to receive the same utility flow from amenities.

At this point, we address empirically our assumption that human capital acts to multiply city level productivity. We examined mean hourly wage rates in 1990 for full-time (or nearly full-time) workers of various skill groupings for samples of growing and declining cities.[30] We split the sample into cities which gained population over the 1980s and cities that lost population over the 1990s. On average, workers in the growing cities indeed earned more than workers in the declining cities. If there are different levels of "W" in those two samples, then our model requires that the higher levels of W in growing cities impact all workers in proportion to their base wages.

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relative to construction costs is used as the dependent variable, it, too, strongly predicts future growth. Those results are available upon request.

[30] The figures discussed below are unweighted means of the city means. The underlying figures themselves reflect averages across workers in each city that were computed using 1990 census data from the IPUMs. The samples were restricted to city residents who reported substantial labor market and work activity in 1989. More specifically, the individual worked at least 40 weeks during the year and typically worked at least 20 hours per week. The range of ages was restricted to between 19 and 59. Hourly wages were computed by dividing reported wage and salary income by total hours worked during 1989. Total hours worked was computed as the multiple of weeks worked and usual hours worked per week. We experimented with different treatments for outliers (e.g., individuals who worked 80 hours per week, 52 weeks per year), but the results are not sensitive how we dealt with them. The wage rates reported just below presume that everyone took at least two weeks of vacation, that nobody typically worked more than 60 hours per week, and that nobody working at least 800 hours (the minimum required to be in our sample) earned less than $1,000.

To examine this hypothesis, we divided workers into four skill groups based on their educational achievement: high school dropouts (i.e. those with less than 12 years of schooling), high school graduates (those with exactly 12 years of schooling), people with some college (those with more than 12 and less than 16 years of schooling), and college graduates (those with more than 16 years of schooling). The difference in average wages across growing versus shrinking cities then was computed for each group. The wage gap was –1.3 percent for the dropouts (i.e., they earned slightly less in growing cities), 5.4 percent for the high school graduates, 7.5 percent for those with some college and 4.5 percent for college graduates. These numbers are just mean percentage differences, but controlling for other factors makes little difference.[31]

For the three highest groups, the assumption of proportionately seems basically correct. However, high school dropouts actually earn slightly more in declining cities. This may be because of omitted human capital controls, or because improving city level productivity impacts the skilled more than the less skilled. While this does not support our assumption exactly, it makes the empirical relationship between decline and poverty even more understandable. If we were to assume that negative shocks lower wages for high human capital people even more than for low human capital people, our basic theoretical result— population declines are associated with a greater population share for the less skilled—would follow even more easily.

However, we stick with our proportionately assumption and given this assumption, people with high levels of human capital will live closer to the city center.[32] The

[31] Because the underlying sample sizes of workers are small in some cities for certain skill groups (especially for dropouts), we computed the analogous figures for more aggregated groupings. For example, dividing workers into two skill categories, with the low skill group having 12 or fewer years of schooling, finds that wages for this group are 2.8 percent lower on average in declining cities; wages for the high skill group (i.e., those with at least some college training) are 5.5 percent lower on average in declining cities. Finally, we also examined wage differences by occupation. Very small sample sizes for individual occupations in most cities forced us to aggregate across many occupations. However, it proved possible to compute mean wages for groups of pretty clearly defined skill groups (e.g., engineers and scientists versus various low level service personnel). Those results are consistent with those for those just discussed.

[32] Of course, this is counter-factual in some cases.), this is true. A richer model (see Glaeser, Kahn and Rappaport, 2000), with better predictions about where the poor and rich live, would still find that the poor would live disproportionately in declining cities.

equilibrium population of the city will be characterized by two key equations. The first is the furthest point where it pays to construct new housing or renovate old housing. Since the low human capital types live at the edge of the city, this point is determined by their parameter values. The edge of construction will equal $(W + A - \underline{U})/T - (\delta + r)C/(1+r)$, just as before, and we denote this distance $\overline{d}$. In the completely static city, the population will again equal two times this amount.

There is also a distance which marks the furthest point at which high human capital types will live, which is denoted d*. This is the point at which low and high human capital types are willing to pay equal rents. The rental payments in the high human capital region of the city equal $R(0) - (1+\phi)Td$, and, the open city assumption tells us that $R(0) = (1+\phi)W + A - \overline{U}$. The rental payments in the low human capital region of the city equal $R(\overline{d}) + T(\overline{d} - d)$ and the open city assumption requires that $R(\overline{d}) = W + A - \underline{U} - T\overline{d}$. Solving these equations tells us $d^* = (R(0) - R(\overline{d}) - T\overline{d})/\phi T$, or $d^* = W/T - (\overline{U} - \underline{U})/\phi T$. In a static city, the share of the city that is high human capital equals the ratio of d* to $\overline{d}: (W - (\overline{U} - \underline{U})/\phi)/(W + A - \underline{U} - T(\delta + r)C/(1+r))$.

We assume that this is less than one. Differentiation reveals that the skill level of the city will be (a) rising with W, (b) falling with A, (c) rising with C, (d) rising with $\underline{U}$, and (e) falling with $\overline{U}$. Thus, growing cities will tend to increase their skill quantity if the growth is the result of W and decrease their skill quantity if the growth is the result of A.

As we have observed throughout this paper, the durability of housing will mute the population losses at far distances from the city center. This means that declining cities will tend to lose fewer low human capital individuals than they would if housing depreciated instantaneously. More precisely, consider a city with an innovation to both wages and amenities (denoted Δ_W and Δ_A respectively). If these innovations are positive, the increase in population will equal $2(\Delta_W + \Delta_A)/T$. The change in the skill level will be positive if the change in wages dominates and negative if the change in amenities dominates.

However, when the city shrinks, assuming that the decline is sufficiently modest so that it still pays to maintain the housing of the high human capital types, decreases in population will equal $-2\delta(\Delta_W + \Delta_A)/T$, and the change in the skill level will differ, because the housing on the edge of the city decays only slowly.

Declining amenity levels generally will lead to increasing skill levels, but the effect will be smaller than the impact of rising amenities on skill levels (by roughly the ratio 1/δ). Decreasing wages will have a greater impact on decreasing skill levels than increasing wages will have on increasing skill levels. This asymmetry occurs because there are large amounts of low cost housing that disproportionately attract the poor remain in the city. The following statement formalizes this intuition.

Proposition 5: If $\Delta_W = z\Delta_A$, and z is such that population increases are skill neutral, then population decreases will be associated with declining levels of human capital.

Since we do not know whether rising population levels are coming from amenities or wages, we do not know whether increases in population will cause increased skills or not. However, we do know that the decreases in population will be much more likely to be associated with declining skill levels, even when the co-movement of amenities and wages is symmetric.

Empirical Results

Tables 9-12 report empirical results on the connection between city growth and human capital levels. We begin with two conventional measures of education: the share of college graduates (Table 9) and the share of high school dropouts (Table 10).
The first regression in Table 9, for the 1980s, shows the relationship between the share of the city's population that has a college degree and city growth. The primary independent

variable is the growth rate of population and we use a spline at zero. The results indicate that greater population decline is associated with sharply falling skill levels when city population growth is negative. However, when cities grow they actually face a decrease in the share of the population that are college graduates (although the effect is not statistically significant). This pattern is compatible with amenities being more important to city growth than wages. This could create a situation where both increases and decreases in population lead to declines in the skill level.

In the second specification, we include a rich set of controls including region dummies and a host of initial controls. We also control for the change in the share of the population that is Hispanic. This control is important because many of the growing cities of the west grow because of increasing Hispanic populations. When we include these controls, there is still an asymmetry whereby less sharp decline leads to more college graduates as a share of population when population growth is negative, while it has no significant impact when population growth is positive.

In the third regression, we add a control for the log of the median value of housing at the end of the time period. The model suggests that poor people come to declining cities primarily because of the availability of cheap housing. If this is the case, then controlling for housing prices should eliminate the connection between city growth and increasing human capital levels for declining cities. We see that this is indeed the case. The housing price control, and no other local variable, has the effect of eliminating the connection. This supports our contention that housing markets enable us to understand why there is a strong connection between declining cities and declining skill levels.

Because our explanation of the connection between urban decline and urban deskilling rests on the poor and less-skilled losing relatively less from lower wages and gaining relatively more from lower house prices in declining cities, it is useful to know more about the magnitudes of wage and housing prices declines in shrinking cities. The differences in wage outcomes in growing versus declining cities pale in comparison to the differences in mean house prices. For cities that lost population in the 1980s, the mean house price (of the means for the 31 declining cities in the sample for which we were able to compute mean wages by skill category) was $61,342. This is 49 percent below the mean of $119,177 for the 65 cities that gained population in the 1980s. The abundance of relatively cheap housing in declining cities combined with the fact that wages for lower skilled workers are not lower in declining cities (especially compared to the situation for higher skilled workers) bolsters the case for our hypothesis that these places are relatively attractive to this group.

Regressions (4)-(6) of Table 9 repeat regressions (1)-(3) for the 1970s. The results are similar. Lower population growth is associated with falling human capital levels when population growth is negative, but not when population growth is positive. Here, we really seem to be close to the situation described in the proposal where city-level shocks are neutral on the upside but strongly decrease skill levels on the downside. Once again, including a rich set of local controls leaves the results virtually unchanged (column 5), but controlling for the logarithm of the median value of housing at the end of the period again eliminates the connection between population decline and declining skills during this time period.

Table 10 repeats this exercise using the share of adults over 25 years of age in the city with less than 12 years of schooling as the dependent variable. In this case, local controls—the change in Hispanic population share especially—are needed for the results to support the model.[33] In the absence of those controls, the first column shows that rising population generally is associated with rising dropout rates in the 1980s. As suggested by the findings from the second specification, this is due to the fact that many high growth cities in the west and southwest had increasing Hispanic populations which tend not to be highly educated. When this factor is controlled for, less negative growth in declining cities strongly decreases the share of the population that dropped out of high school. For growing cities, the point estimate is less than half that for declining cities. The specification in the third column includes the housing price variable, but it has little effect on the findings in this case.

[33] We find similar results to those in column 2 if we exclude cities with large Hispanic populations.

The final three specifications examine dropouts in the 1970s. The pattern of results is very similar to that for the 1980s. This time, including the housing price variable makes the population-dropout relationship statistically insignificant among declining cities, providing further evidence that housing prices explain why the poor come to declining cities.

Tables 11 and 12 look at income-based measures of human capital: median family income and the poverty rate. These variables are problematic because if rising population levels are caused by rising wages, then we should expect to see a positive relationship even if the housing market factors that dominate our model are not important. Nonetheless, since these measures may be better measures of human capital than educational degrees, we repeat the analysis using them.

The first regression in Table 11 shows that population growth and rising income are closely linked when population growth is negative but not when population growth is positive. This again supports the model. While a general connection between rising growth and rising wages should occur whenever rising labor demand drives growth, the asymmetry in the results makes this seem less likely to be causing the relationship, as it requires a complicated story whereby labor demand drives declining cities but labor supply drives growing cities. Among declining cities, a one percent decline in growth in the 1980s is associated with a 1.14 percent decrease in real income. Including the standard set of local controls does not change the basic result (column 2). However, controlling for the end of period median housing price does eliminate much of the connection between income growth and population growth among declining cities. We have repeated these regressions for the 1970s and found extremely similar results. In the 1970s, there is no relationship between income growth and population growth, once we control for the end-of-period price of housing.

Table 12 then presents results using the change in the poverty rate as the dependent variable. The asymmetry shows up in this variable as well. Greater population losses strongly increase the poverty rate for declining cities, but not for growing cities. Our other controls do not affect the result, but controlling for the end period housing price does materially reduce the impact. We find similar results using poverty rates in the 1970s.

Tables 9-12 have documented a strong connection between falling population and decreasing skills (and incomes) among declining cities, but little connection among growing cities. The tendency of declining cities to disproportionately attract the poor is particularly important if concentrations of poverty then further deter growth. If low skill cities have lower rates of innovation or have social problems that then repel future residents, the tendency of cheap housing to attract the poor can create a vicious cycle. A preliminary urban decline can cause the skill composition of the city to shift. Then, this lower skill composition can drive out future residents and further depress the growth of the city. These dynamic considerations are a pressing topic for future research.

VIII. Conclusion

Heretofore, the urban growth literature has not considered the physical nature of cities as an important factor in explaining urban dynamics. While the durability of housing may not be a crucial element of urban dynamics for growing cities, it is the key to understanding the nature of urban decline, and we are in an era of decline for many our major cities. Consequently, we develop a dynamic version of the Mills-Muth-Alonso model in which housing is durable and can explain five key features of urban change.

First, city growth rates are leptokurtotic. The durability of the housing stock can explain why cities grow much faster than they decline. Second, the persistence of city growth is particularly striking. The degree of persistence is strongest among declining cities—as predicted by our bricks and mortar model of urban dynamics. Third, exogenous shocks lead to (different) asymmetric responses of population and house prices. Negative shocks have a relatively small impact on population growth, especially among declining cities, as the durability of housing leads to declines in demand being reflected more in prices than in people. Conversely, the ability to build means that positive shocks have greater impact on growth because new supply dampens the effect on prices. Both asymmetries are borne out in the data. Fourth, the distribution of house prices is an excellent predictor of future population growth. In particular, the data show that growth is quite rare in cities with large fractions of their housing stock valued below the cost of new construction. This link is not causal, but rather illustrates the role the housing market plays in mediating growth. Fifth, the model helps explain why cities in greater decline tend to have lower levels of human capital, as cheap housing is relatively more attractive to the poor. This is confirmed in the data in terms of the share of college graduates, the share of high school drop outs, real income growth, and changes in poverty rates. This finding may help us understand the correlation between urban decline and urban social problems.

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Appendix 1: Construction of the House Value/Construction Cost Ratio

A number of adjustments are made to the underlying house price data in the comparison of prices to construction costs. These include imputation of the square footage of living area for observations from the *IPUMS* for the 1980 and 1990 census years. Following that, we make three adjustments to the house price data to account for the depreciation that occurs on older homes, to account for general inflation when comparing across years, and to account for the fact that research shows owners tend to overestimate the value of their homes. Finally, we make an adjustment to construction costs in order to account for the wide regional variation in the presence of basements. The remainder of this Appendix provides the details.

First, the square footage of living area must be imputed for each observation in 1980 and 1990 from the *IPUMS*. Because the *AHS* contains square footage information, we begin by estimating square footage in that data set, using housing traits that are common to the *AHS* and *IPUMS* data. This set includes the age of the building (AGE and its square), whether there is a full kitchen (KITFULL), the number of bedrooms (BEDROOMS), the number of bathrooms (BATHROOMS), the number of other rooms (OTHROOMS), a dummy variable for the presence of central air conditioning (AIRCON), controls for the type of home heating system (HEAT, with controls for the following types: gas, oil, electric, no heat), a dummy variable for detached housing unit status (DETACHED), dummy variables for each metropolitan area (MSA), and dummy variables for the U.S. census regions (REGION).

Thus, the linear specification estimated is of the following form:

$$\text{SQUARE FOOTAGE}_i = f\{\text{AGE}_i, \text{AGE}^2_i, \text{BEDROOMS}_i, \text{BATHROOMS}_i, \text{KITFULL}_i, \text{OTHROOMS}_i, \text{AIRCON}_i, \text{HEAT}_i, \text{DETACHED}_i, \text{MSA}_i, \text{REGION}_i\}$$ [34],

[34] Data frequently was missing for the presence of air conditioning (AIRCON) and the number of other rooms (OTHROOMS). So as not to substantially reduce the number of available observations, we coded in the mean for these variables when the true value was missing. Special dummies were included in the specification estimated to provide separate effects of the true versus assigned data.

The subscript i indexes the house observations and separate regressions are run using the 1985 and 1989 *AHS* data. Our samples include only single unit, owned residences in central cities (which can be attached or detached).[35] The overall fits are reasonably good, with the adjusted R-squares being .391 in the 1985 data and .306 in the 1989 data.

The 1985 coefficients are then used to impute the square footage of the observations from the 1980 *IPUMS*, and the 1989 coefficients are used analogously for the 1990 *IPUMS* sample. Once house value is put into price per square foot form, it can be compared to the construction cost per square foot data from the R.S. Means Company.

However, we make other adjustments before actually making that comparison. One adjustment takes into account the fact that research shows owners tend to overestimate the value of their homes. Following the survey and recent estimation by Goodman & Ittner, 1992, we presume that owners typically overvalue their homes by 6 percent.[36]

A second, and empirically more important, adjustment takes into account the fact that the vast majority of our homes are not new and have experienced real depreciation. Depreciation factors are estimated using the *AHS* and then applied to the *IPUMS* data. More specifically, we regress house value per square foot (scaled down by the Goodman & Ittner, 1992, correction) in the relevant year (1985 or 1989) on a series of age controls and metropolitan area dummies. The age data is in interval form so that we can tell if a house is from 0-5 years old, from 6-10 years old, from 11-25 years old, from 25-36 years old, and more than 45 years old.[37] The coefficients on the age controls are each negative as expected and represent the extent to which houses of different ages have depreciated in value on a per square foot basis.

Because the regressions use nominal data, we make a further adjustment for the fact that general price inflation occurred between 1980-1985 and 1989-1990. In the case of

[35] We excluded observations with extreme square footage values, deleting those with less than 500 square feet and more than 5,000 square feet of living area (4,000 square feet in the 1989 survey is the top code).
[36] This effect turns out to be relatively minor in terms of its quantitative impact on the results.
[37] Slightly different intervals are reported in the AHS and IPUMS. We experimented with transformations based on each surveys intervals. The different matching produce very similar results.

applying the 1985 results to the 1980 *IPUMS* data, we scale down the implied depreciation factor by the percentage change in the rental cost component of the Consumer Price Index between 1980 and 1985. In the case of applying the 1989 results to the 1990 IPUMS observations, we scale up the implied depreciation factor in an analogous fashion.[38]

Finally, we make an adjustment for the fact that there is substantial regional and cross-metropolitan area variation in the presence of basements. Having a basement adds materially to construction costs according to the Means data. Units with unfinished basements have about 10 percent higher construction costs depending on the size of the unit. Units with finished basements have up to 30 percent higher construction costs, again depending on the size of the unit. Our procedure effectively assumes that units with a basement in the *AHS* have unfinished basements, so that we underestimate construction costs for units with finished basements. Unfortunately, the *IPUMS* data in 1980 and 1990 do not report whether the housing units have a basement. However, using the *AHS* data we can calculate the probability that a housing unit in a specific U.S. census division has a basement. The divisional differences are extremely large, ranging from 1.3 percent in the West South Central census division to 94.9 percent in the Middle Atlantic census division. Thus, in the West South Central census division we assume that each unit has 0.013 basements, and that each unit in the Middle Atlantic division has 0.949 basements. Because of the very large gross differences in the propensity to have basements, this adjustment almost certainly reduces measurement error relative to assuming all units have basements or that none have basements.

After these adjustments, house value is then compared to construction costs to produce the distributions reported in the main text.

[38] The depreciation factors themselves are relatively large. After making the inflation and Goodman-Ittner correction, the results for 1980 suggest that a house that was 6-11 years old was worth $3.17 per square foot less than a new home. Very old homes (i.e., 46+ years) were estimated to be worth $11.94 per square foot less than a new home that year.

Appendix 2: Proofs of Propositions

Proposition 1: If there is a shock at time t denoted $\varepsilon = \mu * Population$ that is unexpected, and there are no further shocks, then the distribution of population changes between time t and t+j is leptokurtotic, in that the mean is greater than the median. The gap between the median and the mean of the distribution diminishes as j gets larger. Furthermore, the rate of depreciation satisfies

$$1-(1-\delta)^j = \frac{E\left(\frac{N_t - N_{t+j}}{N_t} \middle| N_{t+j} < N_t\right)}{E\left(\frac{N_{t+j}-N_t}{N_t} \middle| \frac{N_{t+j}-N_t}{N_t} > 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}\right) - 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}},$$

when the median growth rate is positive and

$$1-(1-\delta)^j = \frac{E\left(\frac{N_t - N_{t+j}}{N_t} \middle| \left(\frac{N_{t+j}-N_t}{N_t}\right) < 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}\right) + 2\left(\frac{N_{t+j}-N_t}{N_t}\right)_{Med}}{E\left(\frac{N_{t+j}-N_t}{N_t} \middle| N_{t+j} > N_t\right)},$$

when the median growth rate is negative.

Proof: When $\varepsilon_t > 0$, then $\frac{N_{t+j}-N_t}{N_t} = \frac{2}{T}\frac{\varepsilon_t}{N_t} = \frac{2\mu_t}{T}$. When $\varepsilon_t < 0$,

$\frac{N_{t+j}-N_t}{N_t} = \frac{2}{T}\frac{(1-(1-\delta)^j)\varepsilon_t}{N_t} = \frac{2(1-(1-\delta)^j)\mu_t}{T}$. We use the notation

$\Delta N_j = \frac{N_{t+j}-N_t}{N_t}$ and ΔN_j^{Med} is the median growth rate. Skewness means that the mean of the variable is greater than the median. The average value of ΔN_j is

$\frac{2}{T}\left(E(\mu) - (1-\delta)^j \int_{\mu<0} \mu f(\mu) d\mu\right)$. We have assumed that μ is symmetrically distributed around a constant, which must be $E(\mu)$, so the median growth rate is either equal to

$\frac{2}{T}E(\mu)$ if $E(\mu) > 0$ or $\frac{2(1-(1-\delta)^j)}{T}E(\mu)$ if $E(\mu) < 0$. In the case where $E(\mu) > 0$ is positive, it is obvious that the mean is above the median. The gap equals

$\frac{2}{T}\left((1-\delta)^j \int_{\mu<0} \mu f(\mu) d\mu\right)$ which goes to zero as j gets large. In the case where $E(\mu) < 0$, the gap equals $\frac{2(1-\delta)^j}{T}\left(E(\mu) - \int_{\mu<0} \mu f(\mu) d\mu\right)$ which is positive, but also goes to zero as j gets large.

For the second part of the theorem, we define $e = \mu - \hat{\mu}$, where $\hat{\mu}$ is the median and mean of μ, and e is then a variable that is symmetrically distributed around zero. Using the symmetry of e, we know that for any number "z", $E(e|e < z) = -E(e|e > z)$, which implies

(A1) $E(\mu|\mu < 0) = E(\hat{\mu} + e|\hat{\mu} + e < 0) = E(e|e < -\hat{\mu}) + \hat{\mu} = \hat{\mu} - E(e|e > \hat{\mu})$.

This further implies that:

(A2) $E(-\Delta N_j|\Delta N_j < 0) = \frac{2}{T}(1-(1-\delta)^j)(-E(\mu|\mu < 0)) = \frac{2}{T}(1-(1-\delta)^j)(E(e|e > \hat{\mu}) - \hat{\mu})$,

and

(A3) $E(\Delta N_j - 2\Delta N_j^{Med}|\Delta N_j > 2\Delta N_j^{Med}) = \frac{2}{T}((E(e|e > \hat{\mu}) + \hat{\mu}) - \frac{4\hat{\mu}}{T} = \frac{2}{T}((E(e|e > \hat{\mu}) - \hat{\mu})$,

and the first formula follows. For the second formula, we use the following:

(A4) $E(-\mu|\mu < 2\hat{\mu}) = E(-\hat{\mu} - e|e < \hat{\mu}) = E(-e|e < \hat{\mu}) - \hat{\mu} = -\hat{\mu} + E(e|e > -\hat{\mu})$.

When $\hat{\mu} < 0$, then $\Delta N_j^{med} = \frac{2}{T}(1-(1-\delta)^j)\hat{\mu}$, and

$E(\Delta N_j|\Delta N_j > 0) = \frac{2}{T}((E(e|e > -\hat{\mu}) + \hat{\mu})$, and thus

(A5) $E(-\Delta N_j|\Delta N_j < -2\Delta N_j^{Med}) = \frac{2(1-(1-\delta)^j)}{T}((E(e|e > \hat{\mu}) - \hat{\mu})$,

and the second formula follows.

Proposition 2: Growth rates will be positively correlated over time. The current growth rate will be increasing in the lagged growth rate when the lagged growth rate is negative and will be independent of the lagged growth rate when the lagged growth rate is positive.

Proof: In the first period, if there is a positive shock the city immediately adjusts and there is no further growth—thus there is no correlation between first period growth and second period growth. If during the first period, there is a negative shock, then growth rate in the first period will equal $\Delta N = 2\delta\mu / T$, and growth during the second period equals $2(1-\delta)\delta\mu / T$, which is obviously correlated with first period growth positively (perfectly in fact). If there was a second period shock, the first and second period growth rates would still be orthogonal, if the first period growth was positive (since, after a period of a positive shock) the city is basically starting afresh. If there is a negative shock, then in the second period, there will still be a positive correlation because of the tendency of the housing stock priced below the cost of new construction to decay and not be replaced.

Proposition 3:

a. The effect of exogenous on population will be convex around zero, and mores specifically, the slope of population growth with respect to positive shocks will equal $1/\delta$ times the slope of population growth with respect to negative shocks.

b. The effect of exogenous shocks on median housing price growth will be concave around zero.

c. The relationship between average housing price growth and population growth will be concave around zero.

Proof: For (a), in the case of a positive shock, $\Delta N = 2\varepsilon / T$; in the case of a negative shock, $\Delta N = 2\delta\varepsilon / T$. If the size of μ, is identified, then the ratio of the slopes holds.

For (b), in the text we argued that a negative shock leads to a total change of $(1+r)(2-\delta)\varepsilon / 2r$ in housing prices and a positive shock leads to a total change of $(1+r)\varepsilon / 2r$. It is again obvious that the slope with respect to the exogenous shock is greater when the exogenous shock is positive than when the shock is negative, and thus the relationship is piecewise linear in the shock and convex around zero.

For (c), the slope of housing price growth (in percentage terms) on percentage changes in population will equal $\frac{T(1+r)}{4r}\frac{\text{Initial Population}}{\text{Initial Price}}$ when population growth is positve and $\frac{T(1+r)(2-\delta)}{4\delta r}\frac{\text{Initial Population}}{\text{Initial Price}}$ when population is negative. As $\frac{2-\delta}{\delta}>1$, it follows that slope is concave with a kink at zero.

Proposition 4: Expected population growth is declining in the share of the housing stock with prices below the cost of new construction.

Proof: The change in population equals $2\delta\varepsilon / T$, or $-2\delta\left(X - T(\delta + r)C/(1+r)\right)S/T$, so the population change will be declining in S—the share of the housing stock that costs less than the price of new construction.

Proposition 5: If $\Delta_W = z\Delta_A$, and z equals $\frac{\phi W - \overline{U} + \underline{U}}{\phi A + \overline{U} - (1+\phi)\underline{U} - \phi rC}$ so that population increases are skill neutral, then population decreases will be associated with declining levels of human capital.

Proof: For population changes to be skill neutral, it must be the case the ratio of high skill people to total population is equal before and after the shock, i.e.:

$$\text{(A6)}\quad \frac{W - (\overline{U} - \underline{U})/\phi}{W + A - \underline{U} - T(\delta + r)C/(1+r)} = \frac{W + \Delta_W - (\overline{U} - \underline{U})/\phi}{W + \Delta_W + A + \Delta_A - \underline{U} - T(\delta + r)C/(1+r)}.$$

This implies

(A7) $$\Delta_A = \left(\frac{1}{H} - 1\right)\Delta_W,$$

where H refers to the initial skill level, $(W - (\overline{U} - \underline{U})/\phi)/(W + A - \underline{U} - T(\delta + r)C/(1+r))$. After a negative shock, the value of d* becomes $(W + \Delta_W)/T - (\overline{U} - \underline{U})/\phi T$ and the population of high human capital individuals is twice this amount.

The total population of the city $2(W + A - \underline{U})/T - 2(\delta + r)C/(1+r))$ is reduced by $2\delta(\Delta_W + \Delta_A)/T$ after a negative shock. This means that the ratio of high skill to total population after a negative shock equals:

(A8) $$\frac{W + \Delta_W - (\overline{U} - \underline{U})/\phi}{W + \delta\Delta_W + A + \delta\Delta_A - \underline{U} - T(\delta + r)C/(1+r)},$$

which is less than $(W - (\overline{U} - \underline{U})/\phi)/(W + A - \underline{U} - T(\delta + r)C/(1+r))$, as long as

(A9) $$\Delta_A > \left(\frac{1}{\delta H} - 1\right)\Delta_W,$$

which must always hold, as long as (A7) holds (recall that both shocks are negative).

Appendix 3--Table 1: House Price/Construction Cost Distribution, Summary Statistics, 1980 (cities listed in ascending order of % homes below 100% of construction costs--middle column)

City	State	%houses valued at least 20% below construction costs (0.5=50%)	%houses valued below 100% of construction costs (0.5=50%)	%houses valued at least 20% above construction costs(0.5=50%)
Honolulu city	HI	0.003	0.009	0.983
Anaheim city	CA	0.007	0.012	0.967
San Diego city	CA	0.018	0.031	0.936
San Francisco city	CA	0.020	0.033	0.913
Oxnard city	CA	0.015	0.040	0.874
Las Vegas city	NV	0.023	0.053	0.763
Riverside city	CA	0.019	0.059	0.772
Denver city	CO	0.011	0.071	0.862
Los Angeles city	CA	0.032	0.071	0.884
Washington city	DC	0.018	0.077	0.825
Fort Lauderdale city	FL	0.045	0.079	0.771
Vallejo city	CA	0.037	0.087	0.746
Madison city	WI	0.008	0.088	0.630
Santa Barbara city	CA	0.038	0.093	0.765
Salt Lake City city	UT	0.043	0.104	0.682
Bridgeport city	CT	0.062	0.110	0.646
Ann Arbor city	MI	0.022	0.118	0.687
Albuquerque city	NM	0.059	0.131	0.672
New Orleans city	LA	0.038	0.133	0.744
Fresno city	CA	0.072	0.153	0.622
Seattle city	WA	0.060	0.155	0.677
Minneapolis city	MN	0.041	0.180	0.466
Newport News city	VA	0.049	0.181	0.562
Colorado Springs city	CO	0.044	0.186	0.506
Raleigh city	NC	0.088	0.189	0.666
Bakersfield city	CA	0.069	0.193	0.538
Portland city	OR	0.051	0.202	0.573
Charleston city	SC	0.091	0.203	0.603
Eugene city	OR	0.050	0.204	0.485
Miami city	FL	0.089	0.224	0.586
New Haven city	CT	0.075	0.229	0.492
Charlotte city	NC	0.092	0.242	0.565
Tulsa city	OK	0.114	0.242	0.562
Columbia city	SC	0.096	0.254	0.611
Tucson city	AZ	0.111	0.255	0.526
Huntsville city	AL	0.097	0.257	0.528
Phoenix city	AZ	0.108	0.259	0.509
Greensboro city	NC	0.108	0.261	0.494
Austin city	TX	0.117	0.262	0.558
Norfolk city	VA	0.061	0.262	0.473

Appendix 3, Table 1 (cont.d)

Nashville-Davidson city	TN	0.123	0.263	0.496
Oklahoma City city	OK	0.123	0.274	0.512
Lexington-Fayette city	KY	0.096	0.286	0.448
Little Rock city	AR	0.116	0.291	0.522
Stockton city	CA	0.137	0.306	0.456
Winston-Salem city	NC	0.146	0.306	0.527
Orlando city	FL	0.163	0.320	0.423
Richmond city	VA	0.124	0.323	0.423
Jackson city	MS	0.175	0.326	0.430
Davenport city	IA	0.111	0.329	0.397
Sacramento city	CA	0.148	0.332	0.481
Knoxville city	TN	0.184	0.339	0.419
Houston city	TX	0.184	0.340	0.494
Shreveport city	LA	0.201	0.352	0.474
Albany city	NY	0.167	0.356	0.292
El Paso city	TX	0.140	0.356	0.410
Milwaukee city	WI	0.129	0.358	0.281
Baton Rouge city	LA	0.218	0.365	0.461
Tacoma city	WA	0.136	0.370	0.321
New York city	NY	0.086	0.376	0.311
Roanoke city	VA	0.121	0.383	0.316
Dallas city	TX	0.231	0.387	0.482
Wichita city	KS	0.179	0.406	0.355
Peoria city	IL	0.204	0.418	0.307
Mobile city	AL	0.215	0.430	0.360
Memphis city	TN	0.207	0.433	0.346
Durham city	NC	0.176	0.441	0.369
Lorain city	OH	0.142	0.446	0.230
Cincinnati city	OH	0.198	0.450	0.301
Chattanooga city	TN	0.208	0.460	0.304
Chicago city	IL	0.219	0.465	0.307
Tampa city	FL	0.250	0.471	0.327
Birmingham city	AL	0.206	0.477	0.285
Fort Wayne city	IN	0.263	0.480	0.227
Providence city	RI	0.163	0.484	0.338
Baltimore city	MD	0.237	0.502	0.228
Fort Worth city	TX	0.347	0.505	0.339
Columbus city	OH	0.211	0.515	0.234
Spokane city	WA	0.171	0.520	0.211
Des Moines city	IA	0.220	0.525	0.210
Hartford city	CT	0.230	0.526	0.199
Rockford city	IL	0.236	0.533	0.205
Topeka city	KS	0.262	0.536	0.172
Waterbury city	CT	0.206	0.549	0.163
Kalamazoo city	MI	0.316	0.556	0.198
Toledo city	OH	0.259	0.558	0.224
San Antonio city	TX	0.346	0.563	0.265

Appendix 3, Table 1 (cont'd.)

Indianapolis city	IN	0.349	0.571	0.254
Atlanta city	GA	0.322	0.572	0.299
Erie city	PA	0.211	0.576	0.136
Jacksonville city	FL	0.310	0.577	0.231
Beaumont city	TX	0.356	0.578	0.258
Macon city	GA	0.280	0.583	0.235
Lawrence city	MA	0.162	0.599	0.076
Kansas City city	MO	0.363	0.601	0.210
Louisville city	KY	0.406	0.611	0.228
Newark city	NJ	0.327	0.637	0.112
Duluth city	MN	0.221	0.642	0.133
Omaha city	NE	0.336	0.644	0.187
Jersey City city	NJ	0.295	0.645	0.112
Grand Rapids city	MI	0.307	0.651	0.129
Evansville city	IN	0.340	0.659	0.169
Allentown city	PA	0.227	0.670	0.144
Lansing city	MI	0.315	0.678	0.163
Syracuse city	NY	0.291	0.686	0.132
St. Louis city	MO	0.450	0.700	0.131
Utica city	NY	0.361	0.707	0.123
Pittsburgh city	PA	0.390	0.720	0.107
Dayton city	OH	0.332	0.721	0.076
Cleveland city	OH	0.383	0.736	0.057
Boston city	MA	0.435	0.750	0.108
Akron city	OH	0.454	0.767	0.130
Philadelphia city	PA	0.503	0.773	0.098
South Bend city	IN	0.430	0.791	0.101
Worcester city	MA	0.376	0.804	0.070
Springfield city	MA	0.471	0.829	0.072
Rochester city	NY	0.495	0.834	0.060
Youngstown city	OH	0.507	0.835	0.047
Buffalo city	NY	0.549	0.840	0.079
Scranton city	PA	0.445	0.845	0.042
Gary city	IN	0.599	0.853	0.064
Flint city	MI	0.651	0.905	0.057
Detroit city	MI	0.822	0.937	0.022

Appendix 3--Table 2: House Price/Construction Cost Distribution, Summary Statistics, 1990

City	State	%houses valued at least 20% below construction costs (0.5=50%)	%houses valued below 100% of construction costs (0.5=50%)	%houses valued at least 20% above construction costs (0.5=50%)
Oxnard city	CA	0.000	0.005	0.989
Honolulu city	HI	0.010	0.010	0.987
Anaheim city	CA	0.010	0.010	0.987
New Haven city	CT	0.000	0.011	0.989
San Diego city	CA	0.007	0.016	0.958
Los Angeles city	CA	0.011	0.020	0.958
Lowell city	MA	0.000	0.020	0.931
Washington city	DC	0.008	0.021	0.921
Bridgeport city	CT	0.000	0.023	0.969
Lawrence city	MA	0.015	0.030	0.962
Hartford city	CT	0.017	0.034	0.881
San Francisco city	CA	0.034	0.035	0.954
Vallejo city	CA	0.027	0.036	0.920
Waterbury city	CT	0.019	0.037	0.932
Reno city	NV	0.000	0.038	0.880
Boston city	MA	0.018	0.040	0.880
Riverside city	CA	0.024	0.045	0.886
Seattle city	WA	0.008	0.046	0.856
Albany city	NY	0.037	0.046	0.889
Springfield city	MA	0.011	0.059	0.855
Providence city	RI	0.024	0.065	0.878
Ann Arbor city	MI	0.031	0.069	0.779
Worcester city	MA	0.019	0.077	0.812
Jersey City city	NJ	0.034	0.079	0.910
New York city	NY	0.039	0.079	0.857
Greensboro city	NC	0.027	0.080	0.800
Miami city	FL	0.033	0.110	0.756
Paterson city	NJ	0.070	0.116	0.791
Fort Lauderdale city	FL	0.027	0.117	0.680
Las Vegas city	NV	0.014	0.121	0.603
Colorado Springs city	CO	0.020	0.124	0.611
Nashville-Davidson city	TN	0.040	0.128	0.685
Sacramento city	CA	0.042	0.128	0.735
Denver city	CO	0.022	0.129	0.659
Newark city	NJ	0.079	0.145	0.789
New Orleans city	LA	0.055	0.153	0.673
Lexington-Fayette city	KY	0.049	0.156	0.611
Stockton city	CA	0.066	0.159	0.713
Baton Rouge city	LA	0.090	0.163	0.701
Bakersfield city	CA	0.022	0.179	0.585
Austin city	TX	0.055	0.184	0.634

Appendix 3, Table 2 (cont'd.)

Winston-Salem city	NC	0.028	0.197	0.631
Orlando city	FL	0.057	0.199	0.521
Dallas city	TX	0.084	0.206	0.644
Atlanta city	GA	0.065	0.207	0.642
Tulsa city	OK	0.096	0.263	0.547
Anchorage city	AK	0.091	0.269	0.436
Corpus Christi city	TX	0.100	0.282	0.419
Eugene city	OR	0.102	0.284	0.503
Syracuse city	NY	0.090	0.290	0.421
El Paso city	TX	0.068	0.301	0.474
Memphis city	TN	0.118	0.303	0.470
Rochester city	NY	0.104	0.306	0.309
Fresno city	CA	0.105	0.316	0.404
Jackson city	MS	0.123	0.318	0.429
Fort Worth city	TX	0.143	0.319	0.469
Tampa city	FL	0.138	0.345	0.448
Shreveport city	LA	0.187	0.356	0.479
Allentown city	PA	0.094	0.363	0.316
Chicago city	IL	0.137	0.364	0.414
San Antonio city	TX	0.158	0.374	0.421
Oklahoma City city	OK	0.181	0.375	0.427
Baltimore city	MD	0.148	0.378	0.339
Mobile city	AL	0.164	0.383	0.438
Houston city	TX	0.202	0.406	0.418
Chattanooga city	TN	0.164	0.431	0.352
Grand Rapids city	MI	0.125	0.434	0.270
Minneapolis city	MN	0.079	0.440	0.230
Lubbock city	TX	0.158	0.457	0.310
Portland city	OR	0.185	0.465	0.285
Louisville city	KY	0.231	0.490	0.306
Jacksonville city	FL	0.259	0.539	0.237
Fort Wayne city	IN	0.262	0.554	0.187
Springfield city	MO	0.255	0.563	0.221
Lorain city	OH	0.216	0.581	0.186
Buffalo city	NY	0.347	0.607	0.226
Philadelphia city	PA	0.403	0.621	0.204
St. Louis city	MO	0.314	0.630	0.142
Beaumont city	TX	0.369	0.644	0.210
Peoria city	IL	0.389	0.654	0.185
Kansas City city	MO	0.453	0.667	0.187
Milwaukee city	WI	0.256	0.677	0.096
Erie city	PA	0.389	0.678	0.122
South Bend city	IN	0.421	0.686	0.153
Spokane city	WA	0.368	0.706	0.130
Des Moines city	IA	0.296	0.718	0.086
Toledo city	OH	0.435	0.719	0.147
Davenport city	IA	0.299	0.735	0.143

Appendix 3, Table 2 (cont'd.)

Pittsburgh city	PA	0.468	0.793	0.119
Cleveland city	OH	0.493	0.853	0.039
Gary city	IN	0.696	0.901	0.033
Flint city	MI	0.683	0.908	0.037
Detroit city	MI	0.885	0.963	0.018

Table 1: Population Growth and the Share of Housing Below Construction Costs in 1990			
	Cities with Abundant Cheap Housing (50%+ of Single Family Housing Below Construction Costs and 30%+ at Least 20% Below Construction Costs)	*Cities with Moderate Amounts of Cheap Housing* (Between 25% and 50% of Single Family Housing Below Construction Costs and between 10% and 30% at Least 20% Below Construction Costs)	*Cities with Little Cheap Housing* (<25% of Single Family Housing Below Construction Costs and Less than 10% at Least 20% Below Construction Costs)
# of Cities	15	20	45
# of Cities in Group with Positive Population Growth	1	11	36
Mean Population Growth, 1980-1990	-9.3%	4.3%	10.8%
Median Population Growth, 1980-1990	-9.0%	2.6%	5.4%

Notes:

1. Sample consists of 93 cities with sufficient micro housing data in the 1990 *IPUMS* and construction cost data from the R.S. Means Company. See Appendix 3 for the full list of cities.
2. See Appendix 1 for the details for the calculation of house values relative to construction costs.

Table 2: The Skewness of Urban Growth and the Implied Depreciation Rate of Housing			
Decadal Periods			
	Skewness		Implied δ
1920-30	1.66		0.034
1930-40	1.93		0.025
1940-50	2.18		0.020
1950-60	1.82		0.031
1960-70	1.89		0.045
1970-80	0.90		0.048
1980-90	1.00		0.062
1990-2000	0.49		0.133
Multiple Decade Periods			
1920-2000	0.54		0.016
1930-2000	0.62		0.013
1940-2000	0.66		0.018
1950-2000	0.79		0.018
1960-2000	0.78		0.018
1970-2000	0.75		0.039
1980-2000	0.83		0.035

Notes:

1. Data are for sample of 114 cities with continuous population data from 1920-2000. Each city was the equivalent of a census-designated place in 1920 and had a population of at least 10,000 in that year.
2. Implied δ is the implied depreciation rate based on the formula in Proposition 1. See the text for details.

Table 3: Summary Statistics on the Persistence of Growth, Evidence from the Post-WWII Era				
	Dependent Variables			
Independent Variables	Log Change in Population, 1960-1970	Log Change in Population, 1970-1980	Log Change in Population, 1980-1990	Log Change in Population, 1990-2000
Spline for negative growth in previous decade	0.870 (0.465)*	1.112 (0.273)**	0.804 (0.103)**	0.814 (0.119)**
Spline for positive growth in previous decade	0.256 (0.072)**	0.416 (0.074)**	0.506 (0.041)**	0.533 (0.039)
Intercept	0.055 (0.030)	-0.004 (0.020)	0.065 (0.009)**	0.043 (0.007)**
Adj. R-square	0.19	0.41	0.53	0.53
F-statistic for equality of spline coefficients	1.49	4.98	5.50	4.07
Prob>F:	0.22	0.03	0.02	0.04
# of Observations	114	114	322	322

Notes:

1. All cities had a population of at least 30,000 in the initial period pertaining to the relevant regression analysis.
2. The 114 city sample used to estimate the specifications reported in the first two columns is drawn from the long time series on city population dating back to 1920.
3. The 322 city sample used to estimate the specifications reported in the final two columns are drawn from a shorter time series running from 1970-2000.
4. Standard errors of coefficients are in parentheses. A single * indicates significance at the 10% level; a double ** indicates significance at the 5% level.

Table 4: Price Changes and Population Changes			
Independent Variables	Log Change Med. House Price, 1980-90	Log Change Med. House Price, 1970-1980	Log Change Median Rent, 1980-90
Spline for negative growth in decade	2.135 (0.424)**	1.349 (0.159)**	0.890 (0.202)**
Spline for positive growth in decade	-0.171 (0.138)	0.495 (0.064)**	0.018 (0.075)
Intercept	0.141 (0.026)**	0.252 (0.014)**	0.149 (0.012)**
Adjusted R-square	0.07	0.42	0.07
F-statistic for equality of spline coefficients (Prob>F)	21.62 (0.00)	19.13 (0.00)	12.98 (0.00)

Notes:

1. Data are drawn from large city sample dating to 1970. All cities used had populations of at least 30,000 in 1970.
2. Robust standard errors in parentheses. Clustering occurs because of identical weather data for some cities located within the same metropolitan area. For the first four specifications using the log change in median house price as the dependent variable, data from 322 cities is used in the analysis, with 215 unique clusters observed in the sample. For the final two specifications using the log change in median rent as the dependent variable, data from 284 cities is used in the analysis, with 204 unique clusters observed in the sample.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level or better.

Table 5: Population Changes and Weather			
	Dependent Variables		
Independent Variables	Log Change Population, 1990-2000	Log Change Population, 1980-1990	Log Change Population, 1970-1980
Spline for negative shock	-0.0025 (0.0016)*	-0.0009 (0.0018)	0.0025 (0.0018)
Spline for positive shock	0.0034 (0.0007)**	0.0061 (0.001)**	0.088 (0.0014)**
Intercept	0.098 (0.038)**	0.044 (0.043)	-0.084 (0.045)*
# of observations	284	322	321
Adjusted R-square	0.09	0.18	0.17
F-statistic for equality of spline coefficients (Prob>F)	8.77 (0.00)	8.95 (0.00)	5.04 (0.00)

Notes:

1. Data are drawn from the large city sample dating to 1970. All cities had populations of at least 30,000 in 1970.
2. Robust standard errors of the coefficients are in parentheses. Clustering occurs because of identical weather data for some cities located within the same metropolitan area. For the first two regressions using population changes in the 1990s, 203 unique clusters are observed. For the middle two regressions using population changes in the 1980s, 214 unique clusters are observed. For the final two regressions using population changes from the 1970s, 214 unique clusters are observed.
3. A single * denotes significance at the 10% level; a double ** indicates significance at or better than the 5% level.

Table 6: House Price Changes and Weather			
	Dependent Variables		
Independent Variables	Log Change Med. House Price, 1980-1990	Log Change Med. House Price, 1970-1980	Log Change Median Rent 1980-1990
Spline for negative shock	0.0212 (0.0039)**	0.0023 (0.0026)	0.0066 (0.0020)**
Spline for positive shock	-0.0001 (0.0021)	0.0104 (0.0014)**	-0.0004 (0.001)
Intercept	-0.483 (0.083)**	0.093 (0.068)*	-0.041 (0.047)
# of observations	322	321	287
Adjusted R-square	0.08	0.18	0.03
F-statistic for equality of spline coefficients (Prob>F)	15.09 (0.00)	5.05 (0.03)	7.07 (0.01)

Notes:

1. Data are drawn from the large city sample dating to 1970. All cities had populations of at least 30,000 in 1970.
2. Robust standard errors of the coefficients are in parentheses. Clustering occurs because of identical weather data from some cities located within the same metropolitan area. For the first two regressions using house price changes in the 1980s, 214 unique clusters are observed. For the middle two regressions using house price changes in the 1970s, 214 unique clusters are observed. For the final two regressions using rent changes in the 1980s, 203 unique clusters are observed.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level.

Table 7: Population and Price Changes and Manufacturing Employment Share		
	Dependent Variables	
Independent Variables	Log Change Population, 1980-1990	Log Change Med. House Price, 1980-1990
Spline for negative shock	0.1857 (0.15825)	-0.8367 (0.5103)
Spline for positive shock	0.5599 (0.1474)**	-0.6593 (0.2955)**
Intercept	-0.092 (0.158)	0.7279 (0.3618)**
# of observations	322	322
Adjusted R-square	0.07	0.05
F-statistic for equality of spline coefficients (Prob>F)	1.93 (0.17)	0.06 (0.80)

Notes:

1. Data are drawn from large city sample dating to 1970. All cities had populations of at least 30,000 in 1970.
2. Standard errors of the coefficients are reported in parentheses.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level.

Table 8: Home Prices, Construction Costs, and Future Growth

	Dependent Variables			
	(1)	(2)	(4)	(5)
Independent Variables	Log Change Population, 1980-1990	Log Change Population, 1980-1990	Log Change Population, 1990-2000	Log Change Population, 1990-2000
%Homes Priced Below Construction Costs, Beginning of Decade	-0.324 (0.046)**	-0.315 (0.122)**	-0.151 (0.038)**	-0.267 (0.100)**
%Homes Priced 1.3x Construction Costs, Beginning of Decade		-0.357 (0.115)**		0.046 (0.090)
% Single Units		-0.0007 (0.001)		-0.003 (0.001)**
East Region		0.056 (0.026)**		-0.059 (0.025)**
West Region		0.047 (0.047)		0.094 (0.035)**
South Region		0.101 (0.043)**		0.051 (0.036)
Log Population, Beginning of Decade		-0.013 (0.010)		0.005 (0.010)
Family Poverty Rate Beginning of Decade		-0.009 (0.003)**		-0.010 (0.002)**
Mean January Temperature		0.004 (0.002)**		0.001 (0.001)
Mean July Temperature		0.0002 (0.001)		-0.001 (0.002)
Mean Annual Rainfall		-0.006 (0.001)**		-0.003 (0.001)**
Log Median House Price, Beginning of Decade		0.006 (0.087)		-0.238 (0.067)**
Intercept	0.179 (0.026)**	0.510 (1.032)	0.108 (0.020)**	3.156 (0.817)**
Observations	123	123	93	93
R-squared	0.38	0.60	0.11	0.65

Notes:

1. Sample of cities drawn from those with construction cost estimates from the Means data. All possible cities used. All cities had populations in excess of 30,000 as of 1970.
2. Standard errors in parentheses. No clustering of cities in the same metropolitan area occurs in this sample.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level.

Table 9: Human Capital and City Growth, The Share of College Graduates in the 1970s and 1980s						
	(1)	(2)	(3)	(4)	(5)	(6)
	Δ College Grad Share, 1980-90	Δ College Grad Share, 1980-90	Δ College Grad Share, 1980-90	Δ College Grad Share, 1970-80	Δ College Grad Share, 1970-80	Δ College Grad Share, 1970-80
Spline for negative growth	12.224 (2.687)**	6.727 (2.789)**	0.457 (2.501)	5.652 (2.397)**	6.642 (2.812)**	-1.228 (2.913)
Spline for positive growth	-0.968 (1.157)	1.651 (1.393)	1.404 (1.264)	1.413 (1.564)	3.057 (1.665)*	1.246 (1.416)
% Single Units, Beginning of Decade		-0.019 (0.013)	0.023 (0.013)		-0.029 (0.013)**	0.008 (0.012)
East Region		1.987 (0.443)**	1.100 (0.333)**		-0.447 (0.820)	0.069 (0.716)
West Region		0.060 (0.648)	-0.867 (0.478)*		2.834 (0.725)**	1.523 (0.631)**
South Region		0.414 (0.521)	0.780 (0.445)		1.926 (0.560)**	1.915 (0.564)**
Log Population Beginning of Decade		0.434 (0.141)**	0.361 (0.118)**		0.924 (0.169)**	0.785 (0.142)**
Family Poverty Rate, Beginning of Decade		-0.066 (0.031)*	0.026 (0.027)		0.006 (0.039)	0.087 (0.044)*
Mean January Temperature		0.016 (0.017)	-0.044 (0.014)**		-0.084 (0.025)**	-0.107 (0.024)**
Mean July Temperature		-0.022 (0.022)	0.016 (0.010)		-0.014 (0.014)	0.008 (0.011)
Mean Annual Rainfall		0.005 (0.016)	0.009 (0.011)		0.045 (0.018)**	0.048 (0.017)**
% College Grads, Beginning of Decade		0.088 (0.021)**	0.051 (0.020)**		0.053 (0.049)	0.009 (0.048)
Δ Hispanic Population Share		-0.182 (0.043)**	-0.224 (0.041)**		-0.198 (0.063)**	-0.176 (0.063)**
Log Median House Price, End of Decade			3.493 (0.318)**			4.603 (0.773)**
Intercept	4.139 (0.199)**	-0.163 (2.648)	-41.952 (4.286)**	5.494 (0.292)**	-2.756 (2.506)	-55.906 (9.193)**
Observations	324	323	323	276	276	276
R-squared	0.03	0.28	0.46	0.02	0.23	0.33
F test, equality of spline coefficients (Prob>F)	15.91 (0.00)	2.42 (0.12)	0.10 (0.75)	1.51 (0.22)	1.06 (0.31)	0.48 (0.49)

Notes:

1. Data are drawn from large city sample dating to 1970. All cities had populations in excess of 30,000 in 1970.
2. Robust standard errors are in parentheses. For the first three regressions using college share changes in the 1980s, 216 unique clusters are observed. For the final three regressions using college share changes in the 1970s, 199 unique clusters are observed.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level or better.

Table 10: Human Capital and City Growth, The Share of High School Dropouts in the 1970s and 1980s						
	(1)	(2)	(3)	(4)	(5)	(6)
	Δ Non-HS Grad Share, 1980-90	Δ Non-HS Grad Share, 1980-90	Δ Non-HS Grad Share, 1980-90	Δ Non-HS Grad Share, 1970-80	Δ Non-HS Grad Share, 1970-80	Δ Non-HS Grad Share, 1970-80
Spline for negative growth	10.439 (3.745)**	-10.285 (3.307)**	-9.742 (3.356)**	11.107 (3.172)**	-11.054 (5.545)**	-6.088 (5.494)
Spline for positive growth	8.320 (2.172)**	-4.385 (1.548)**	-4.378 (1.547)**	0.822 (2.524)	-4.464 (1.961)**	-3.747 (1.893)**
% Single Units, Beginning of Decade		0.007 (0.017)	0.004 (0.020)		0.002 (0.020)	-0.025 (0.022)
East Region		-1.717 (0.540)**	-1.652 (0.521)**		1.492 (0.960)	1.154 (0.882)
West Region		0.111 (0.699)	0.180 (0.699)		-3.507 (0.856)**	-2.270 (0.751)**
South Region		-2.056 (0.496)**	-2.072 (0.499)**		-0.744 (0.780)	0.742 (0.770)
Log Population Beginning of Decade		-0.126 (0.183)	-0.122 (0.182)		-0.824 (0.216)**	-0.748 (0.205)**
Family Poverty Rate, Beginning of Decade		0.108 (0.059)*	0.102 (0.060)*		0.235 (0.058)**	0.180 (0.061)*
Mean January Temperature		0.076 (0.019)**	0.080 (0.022)**		0.084 (0.023)**	0.111 (0.028)**
Mean July Temperature		0.021 (0.029)	0.018 (0.030)		0.009 (0.015)	-0.013 (0.015)
Mean Annual Rainfall		-0.010 (0.019)	-0.010 (0.020)		-0.070 (0.018)**	-0.075 (0.018)**
% Non-High School Graduates, Beginning of Decade		-0.220 (0.037)**	-0.222 (0.038)**		-0.317 (0.057)**	-0.350 (0.060)**
Δ Hispanic Population Share		0.574 (0.072)**	0.577 (0.073)**		0.391 (0.081)**	0.388 (0.083)**
Log Median House Price, End of Decade			-0.266 (0.480)			-3.444 (1.137)**
Intercept	-7.985 (0.326)**	-4.697 (3.213)	-1.360 (7.104)	-11.563 (0.434)**	7.950 (3.347)	50.114 (15.660)**
Observations	324	323	323	324	322	322
R-squared	0.10	0.62	0.62	0.03	0.43	0.45
F test, equality of spline coefficients (Prob>F)	0.17 (0.68)	2.53 (0.11)	2.09 (0.15)	4.06 (0.05)	1.08 (0.30)	0.14 (0.71)

Notes:

1. Data are drawn from large city sample dating to 1970. All cities had populations in excess of 30,000 in 1970.
2. Robust standard errors are in parentheses. For the first three regressions using college share changes in the 1980s, 216 unique clusters are observed. For the final three regressions using college share changes in the 1970s, 215 unique clusters are observed.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level or better.

Table 11: Human Capital and City Growth, Real Income Growth in the 1970s and 1980s						
	(1)	(2)	(3)	(4)	(5)	(6)
	Log Change Real Income, 1980-90	Log Change Real Income, 1980-90	Log Change Real Income, 1980-90	Log Change Real Income, 1970-80	Log Change Real Income, 1970-80	Log Change Real Income, 1970-80
Spline for negative growth	1.142 (0.175)**	1.022 (0.161)**	0.412 (0.103)**	0.534 (0.069)**	0.428 (0.074)**	0.100 (0.068)
Spline for positive growth	0.095 (0.050)*	0.213 (0.050)**	0.169 (0.036)**	0.126 (0.028)**	0.093 (0.026)**	0.053 (0.026)**
% Single Units, Beginning of Decade		-0.002 (0.001)**	0.002 (0.001)*		0.001 (0.0003)**	0.003 (0.0003)**
East Region		0.104 (0.021)**	0.043 (0.013)**		-0.003 (0.014)	0.018 (0.013)
West Region		0.037 (0.027)	-0.050 (0.016)**		-0.026 (0.019)	-0.084 (0.016)**
South Region		0.001 (0.018)	-0.008 (0.011)		0.043 (0.015)**	0.023 (0.013)*
Log Population Beginning of Decade		-0.003 (0.006)	0.005 (0.004)		0.000 (0.004)	0.005 (0.004)
Family Poverty Rate, Beginning of Decade		-0.0002 (0.003)	-0.006 (0.002)**		0.001 (0.001)	-0.001 (0.001)
Mean January Temperature		0.002 (0.001)**	-0.002 (0.001)**		-0.0006 (0.0005)	-0.002 (0.0005)**
Mean July Temperature		-0.002 (0.001)*	0.001 (0.0003)**		-0.0001 (0.0001)	0.001 (0.0003)**
Mean Annual Rainfall		0.001 (0.001)	0.001 (0.0004)**		-0.0013 (0.0005)**	-0.0008 (0.0005)*
Log Real Family Income, Beginning of Decade		0.030 (0.066)	-0.414 (0.052)**		-0.024 (0.048)	-0.302 (0.054)**
Δ Hispanic Population Share		-0.005 (0.002)**	-0.006 (0.001)**		-0.005 (0.001)**	-0.004 (0.001)**
Log Median House Price, End of Decade			0.244 (0.014)**			0.190 (0.019)**
Intercept	0.019 (0.010)	-0.138 (0.691)	1.448 (0.461)	0.020 (0.007)**	0.253 (0.507)	0.841 (0.469)*
Observations	322	321	321	321	321	321
R-squared	0.22	0.49	0.76	0.28	0.43	0.68
F test, equality of spline coefficients (Prob>F)	27.62 (0.00)	20.16 (0.00)	4.63 (0.03)	23.86 (0.01)	18.14 (0.00)	0.38 (0.54)

Notes:

1. Data are drawn from large city sample dating to 1970. All cities had populations in excess of 30,000 in 1970.
2. Robust standard errors are in parentheses. For the first three regressions using college share changes in the 1980s, 215 unique clusters are observed. For the final three regressions using college share changes in the 1970s, 215 unique clusters also are observed.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level.

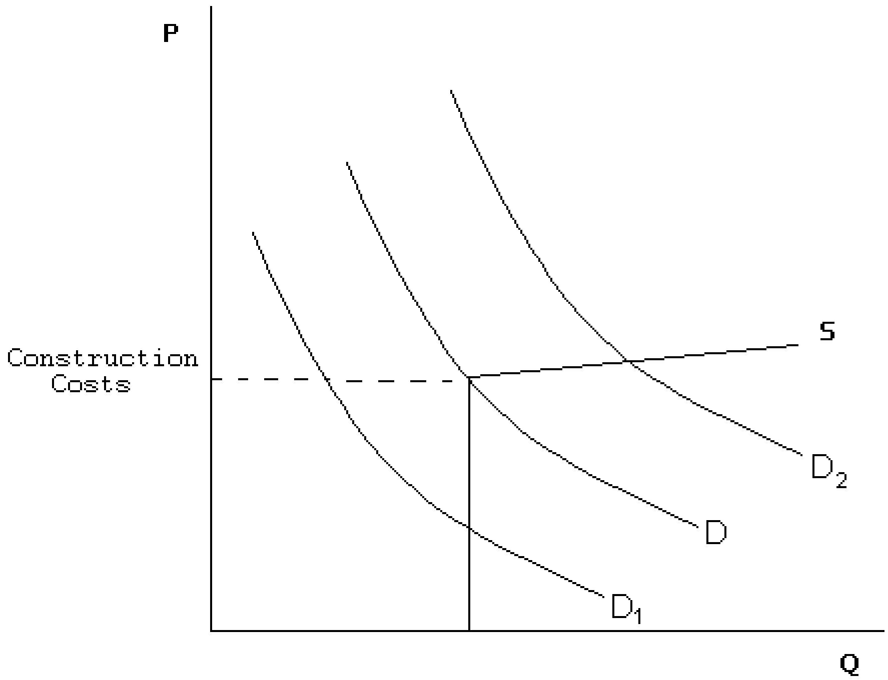
Table 12: Human Capital and City Growth,
Poverty Rate Change in the 1970s and 1980s

	Δ Poverty Rate, 1980-90	Δ Poverty Rate, 1980-90	Δ Poverty Rate, 1980-90	Δ Poverty Rate, 1980-90	Δ Poverty Rate, 1980-90	Δ Poverty Rate, 1980-90
Spline for negative growth	-26.777 (4.97)**	-26.762 (4.745)**	-15.133 (4.347)**	-20.246 (2.663)**	-15.105 (2.645)**	-7.805 (2.411)**
Spline for positive growth	-1.754 (1.162)	-5.388 (1.350)**	-4.559 (1.133)**	-4.124 (1.172)**	-2.052 (0.755)**	-1.162 (0.730)
% Single Units, Beginning of Decade		0.034 (0.019)*	0.039 (0.018)**		-0.037 (0.011)**	-0.078 (0.012)**
East Region		-2.155 (0.575)**	-0.981 (0.541)*		0.079 (0.478)	-0.403 (0.439)
West Region		-1.470 (0.727)**	0.206 (0.579)		0.100 (0.511)	1.379 (0.506)**
South Region		-0.008 (0.469)	0.158 (0.386)		-1.504 (0.448)**	-1.058 (0.395)**
Log Population Beginning of Decade		0.020 (0.214)	-0.136 (0.192)		0.362 (0.133)**	0.256 (0.116)**
Family Poverty Rate, Beginning of Decade		-0.062 (0.090)	0.045 (0.079)		-0.272 (0.058)**	-0.219 (0.057)**
Mean January Temperature		-0.014 (0.019)	0.050 (0.024)**		0.015 (0.014)	0.037 (0.014)**
Mean July Temperature		-0.003 (0.033)	-0.053 (0.033)		0.010 (0.012)	-0.010 (0.013)
Mean Annual Rainfall		-0.047 (0.022)**	-0.047 (0.016)**		0.029 (0.014)**	0.017 (0.014)
Log Real Family Income, Beginning of Decade		-3.062 (1.879)*	5.414 (2.082)**		-1.828 (1.603)	4.374 (1.823)**
Δ Hispanic Population Share		0.213 (0.059)**	0.227 (0.053)**		0.235 (0.039)**	0.205 (0.041)**
Log Median House Price, End of Decade			-4.646 (0.613)**			-4.233 (0.520)**
Intercept	1.670 (0.239)**	34.910 (20.055)*	4.657 (18.110)	0.069 (0.242)	17.897 (17.111)	4.802 (17.721)
Observations	324	321	321	323	320	320
R-squared	0.18	0.34	0.49	0.28	0.67	0.73
F test, equality of spline coefficients (Prob>F)	21.06 (0.00)	16.62 (0.00)	5.24 (0.02)	24.97 (0.00)	20.77 (0.00)	6.19 (0.01)

Notes:

1. Data are drawn from large city sample dating to 1970. All cities had populations in excess of 30,000 in 1970.
2. Robust standard errors are in parentheses. For the first three regressions using college share changes in the 1980s, 215 unique clusters are observed. For the final three regressions using college share changes in the 1970s, 215 unique clusters also are observed.
3. A single * denotes significance at the 10% level; a double ** denotes significance at the 5% level or better.

Figure 1: The Nature of Housing Supply and Construction Costs



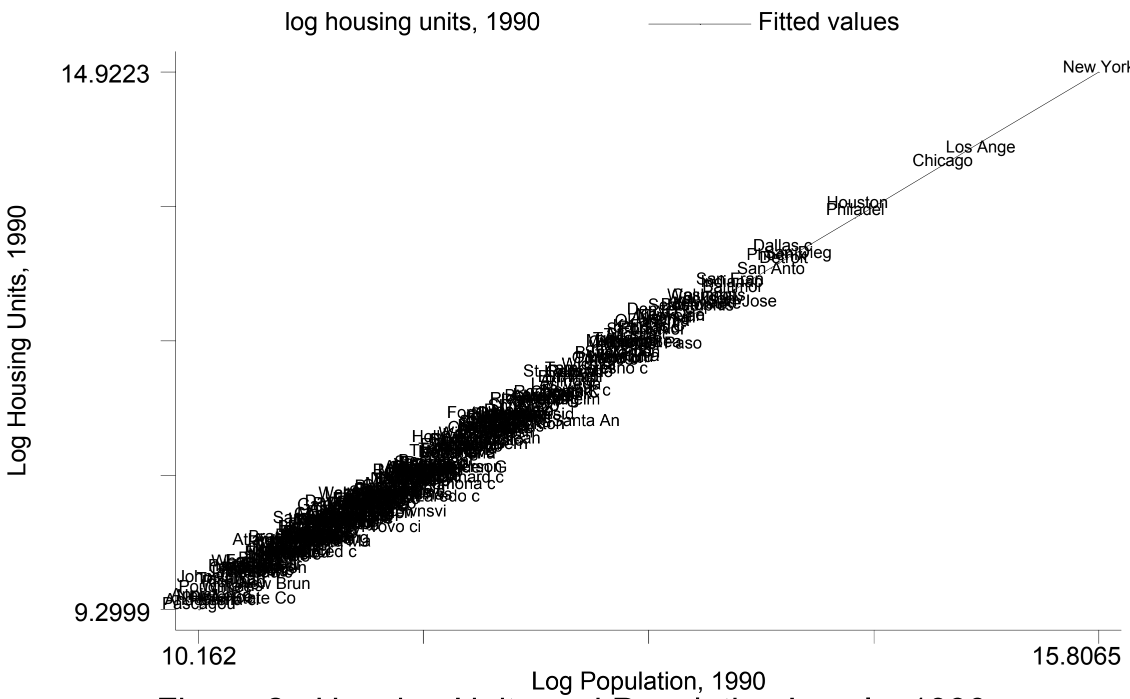


Figure 2: Housing Units and Population Levels, 1990

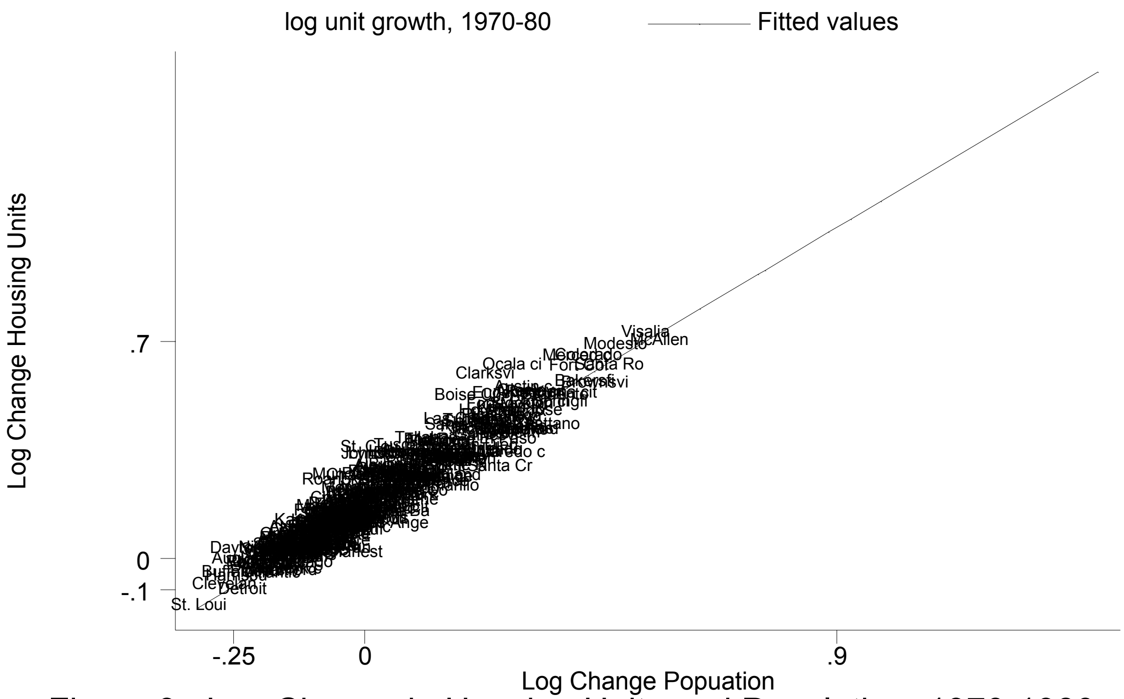


Figure 3: Log Change in Housing Units and Population, 1970-1980

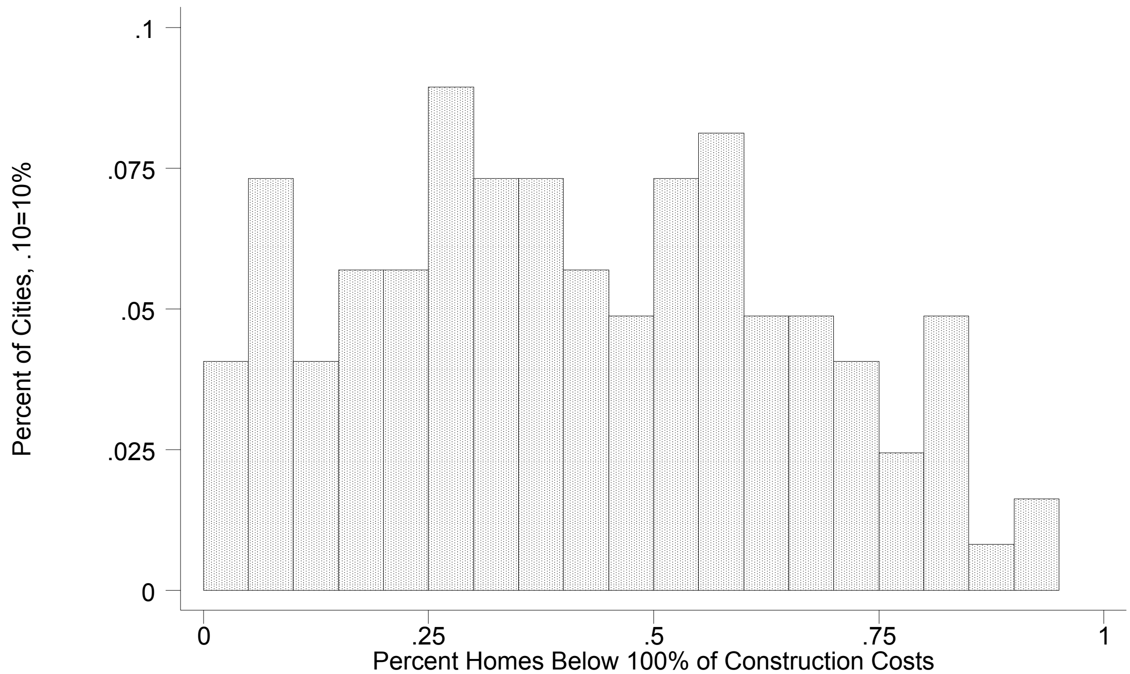


Figure 4: Distribution of Cities for Share Below Construction Costs

Figure 5: Solow's Linear City With A Single Amenity (the central business district (CBD))

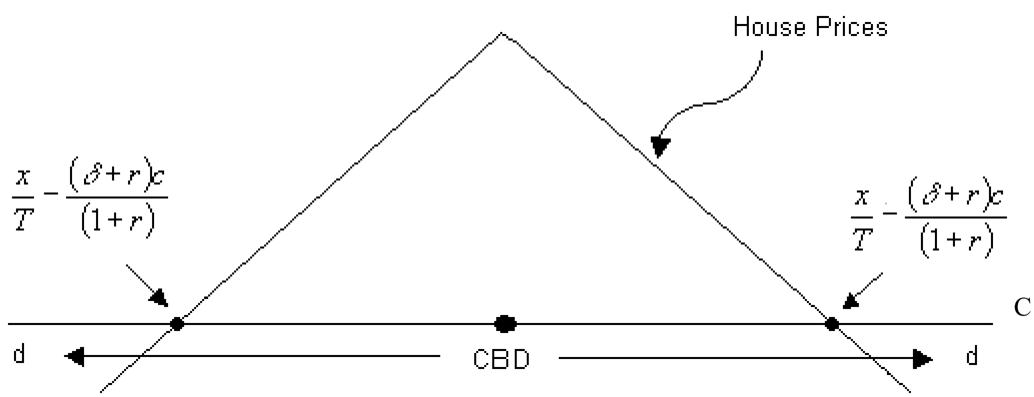
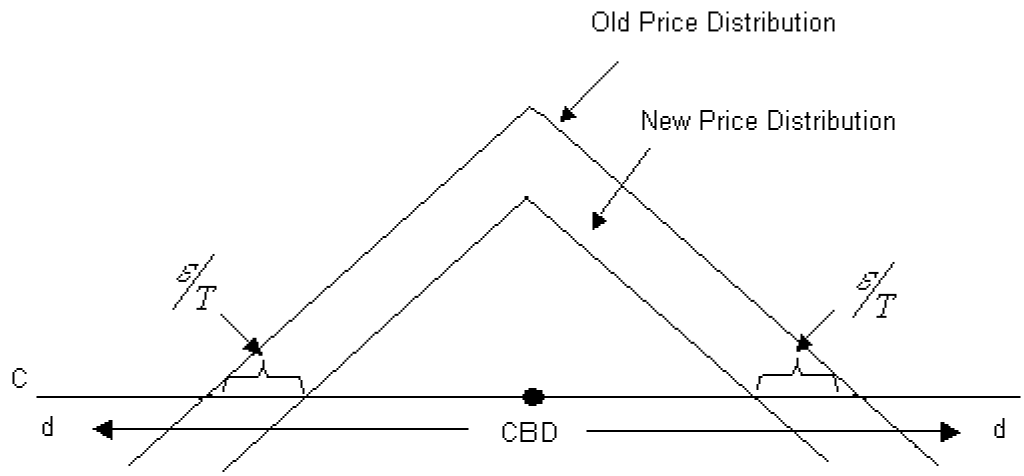


Figure 6: Short-Run and Long-Run Changes in City Size from a Negative Demand Shock



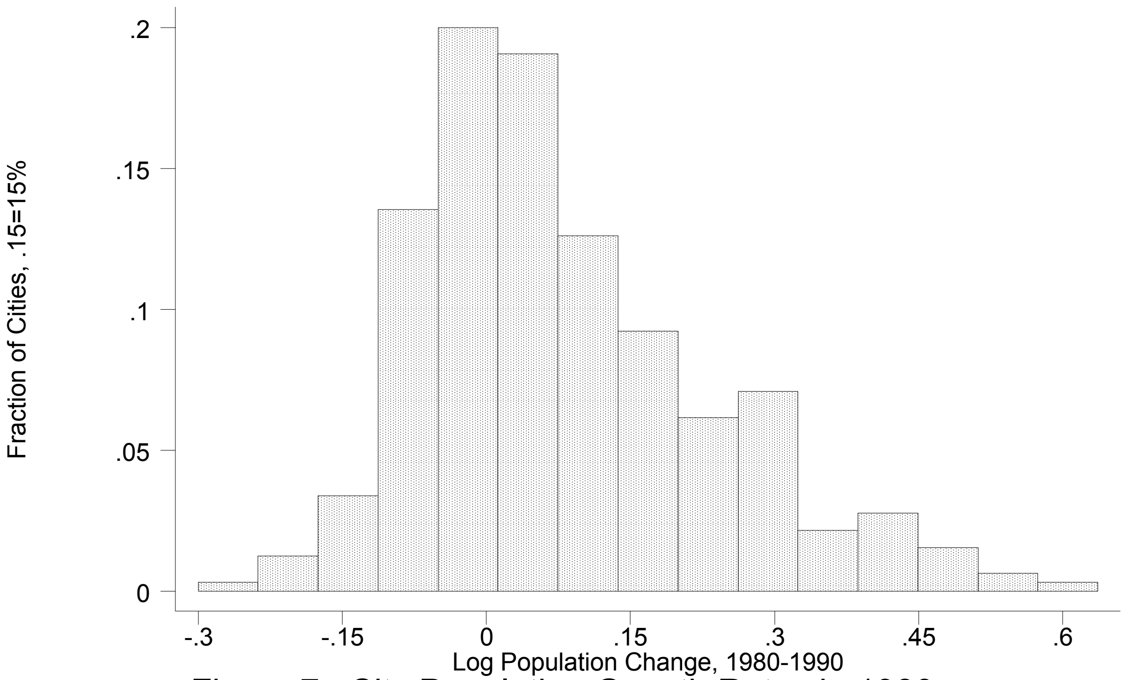


Figure 7: City Population Growth Rates in 1980s

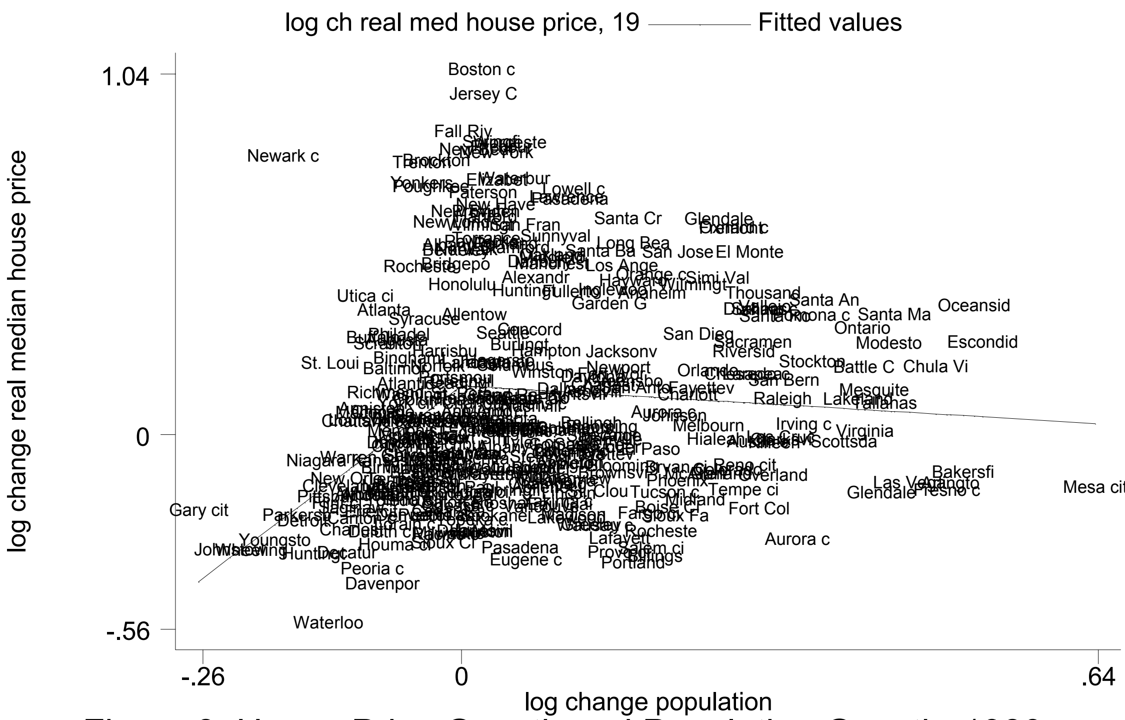


Figure 8: House Price Growth and Population Growth, 1980s

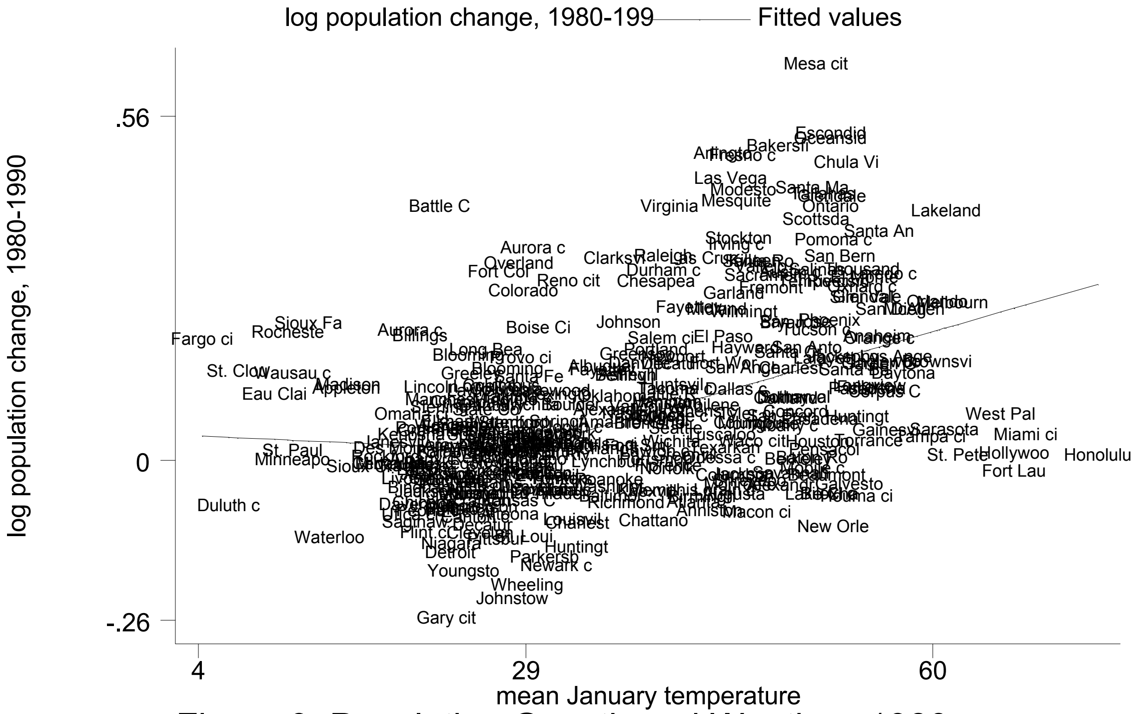


Figure 9: Population Growth and Weather, 1980s

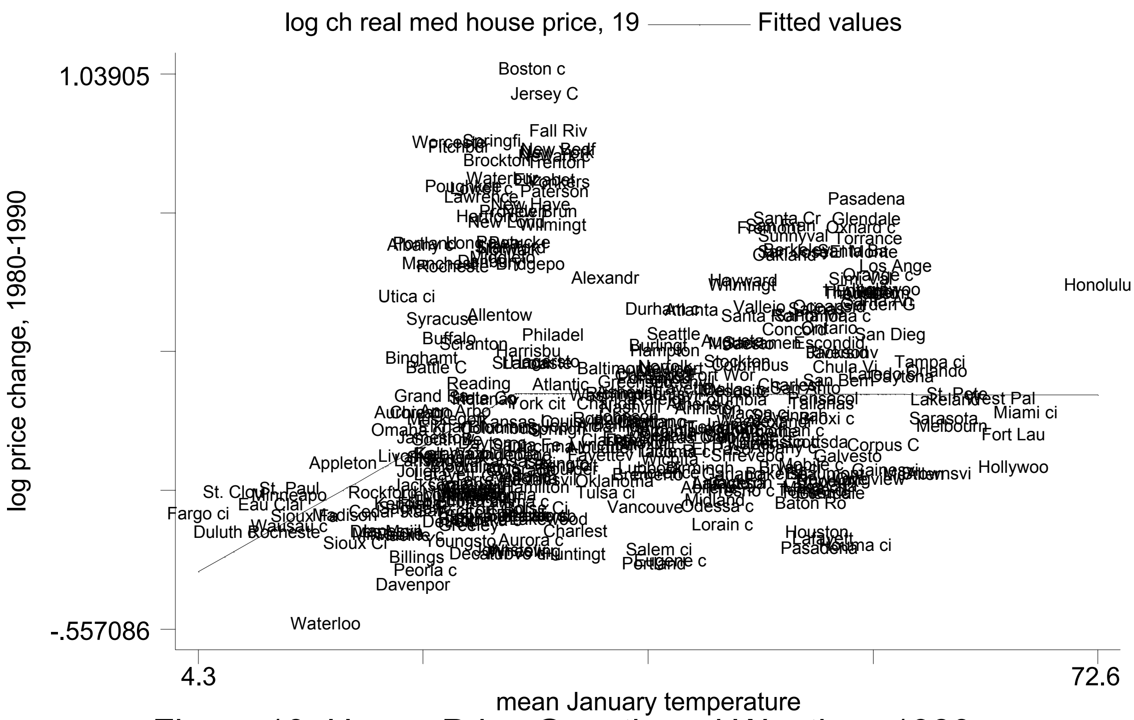


Figure 10: House Price Growth and Weather, 1980s