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Urban Decline and Durable Housing

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Urban decline is not the mirror image of growth, and durable housing is the primary reason the nature of decline is so different. This paper presents a model of urban decline with durable housing and verifies these implications of the model: (1) city growth rates are skewed so that cities grow more quickly than they decline; (2) urban decline is highly persistent; (3) positive shocks increase population more than they increase housing prices; (4) negative shocks decrease housing prices more than they decrease population; (5) if housing prices are below construction costs, then the city declines; and (6) the combination of cheap housing and weak labor demand attracts individuals with low levels of human capital to declining cities.

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I. Introduction

Across space and over time, the population of a city is almost perfectly correlated with the size of its housing stock. Regressing the logarithm of the number of housing units on the logarithm of population in any of the last four census years always yields estimated elasticities and R^2's very near one. In every decade since the 1960s, the correlation coefficient between log changes in housing units and population is above 0.9.

Despite the tight link between the housing sector and population change, the modern literature on urban dynamics (e.g., Glaeser et al. 1992; Eaton and Eckstein 1997; Black and Henderson 1999) typically ignores housing and the physical side of cities altogether. An implicit assumption of this research is that new housing is elastically supplied and that housing quickly disappears in cities with declining productivity levels. Even if new housing can be elastically supplied, old housing does not disappear quickly. Housing may be the quintessential durable good, since homes often are decades, if not a century, old.

Because homes can be built quickly, but disappear slowly, urban decline is not the mirror image of growth. Understanding the impact of durable housing is critical to comprehending the urban decline that is prevalent among many of our larger cities. Eleven of the 15 largest cities in 1950 lost population over the ensuing 50 years; eight of them—Baltimore, Buffalo, Cleveland, Detroit, Philadelphia, Pittsburgh, St. Louis, and Washington, DC—lost population in each decade.

In this paper, we present a simple model of urban decline and durable housing and test the implications of that model. Figure 1 illustrates our framework. The housing market is characterized by a kinked supply curve that is highly elastic when prices are at or above construction costs and highly inelastic otherwise. Because housing is durable, a negative demand shock like that drawn from D to D_1 leads to a large fall in price but little change in quantity. Given the extremely tight relationship between housing units and population, declining cities initially suffer price declines, not population losses. As long as housing is elastically supplied, a positive demand shock, shown by the shift from D to D_2, will cause new housing units to be supplied at roughly constant cost so that there will be an increase in population accompanied by little change in price.

This asymmetric response to positive and negative demand shocks that arises from the durable nature of housing is consistent with all the key stylized facts about urban growth and decline. For example, housing durability can explain the highly skewed nature of urban growth one sees in the data, where expansion can be extremely rapid (Las Vegas's population grew by 61.6 percent in the 1990s) but decline much less so (Hartford, CT, had the largest population loss of −13.9 percent

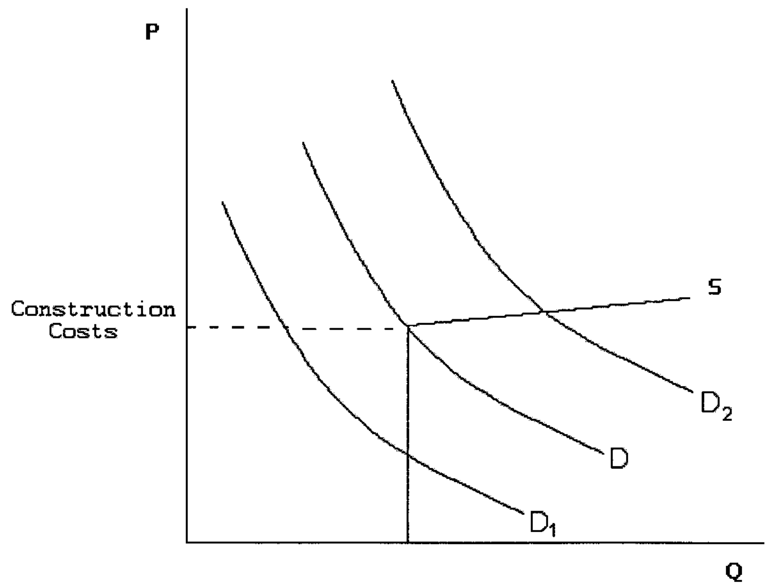

FIG. 1.—The nature of housing supply and construction costs

among cities with at least 100,000 people at the beginning of the 1990s). Durable housing largely explains why decline typically is such a lengthy process. The eight consistently declining cities referenced above remain large places even after five consecutive decades of population loss.

As figure 1 suggests, a durable housing model predicts that increases in population will be associated with small increases in prices, but decreases in population will be associated with large decreases in prices. The data support this prediction. Durable housing also suggests that exogenous forces predicting urban growth will have large effects on population and small effects on prices. Conversely, exogenous forces that predict urban decline will have small effects on population and big effects on prices. Using the weather as a source of exogenous changes in the attractiveness of cities, we find support for these predictions.

Durability also implies that a negative shock to a city's productivity will continue to cause population declines over many subsequent decades. This is consistent with our results, which show that the degree of persistence in population change among declining cities is double that for growing cities. Durability of housing also implies that the distribution of house prices should predict future growth, and not merely because high house prices reflect future price appreciation. Population growth is indeed much lower in cities with larger fractions of their housing stocks valued below the cost of new construction. This is not a causal connection, but it does suggest the role that the housing market plays in mediating urban growth.

In addition, durable housing helps account for the connection between urban decline and poverty. The simple correlation between the family poverty rate in 1999 and population growth in the 1990s for places with at least 100,000 residents is −0.48. When urban productivity falls, the most active members of the labor force will naturally flee; but durable housing ensures that their homes will then be occupied by those that are less connected to the labor market. As our model suggests, the correlation between poverty and a decline in population disappears after one controls for the presence of abundant, cheap housing. This finding may help us understand why declining cities so often are centers of social distress.

Section II provides a simple model of urban growth with durable housing that derives the asymmetry illustrated in figure 1. Section III takes the various implications of that model to the data, providing the empirical detail behind the key features of urban decline. Section IV shows that our "bricks and mortar" perspective on decline is robust to other possible explanations, including those associated with the presence of other durable and fixed factors, as well as filtering in the housing market. A brief summary in Section V concludes the paper.

II. Spatial Equilibrium and a Framework

Rosen (1979) and Roback (1980, 1982) provide the foundation for our understanding of intercity differences in wages and rents. In their long-run, equilibrium framework, some individuals are mobile enough to eliminate utility differences across space. For similar people, this implies that

$$\text{wages} + \text{amenities} - \text{housing costs} = \text{reservation utility}. \tag{1}$$

This "no-arbitrage" relationship defines a spatial equilibrium in which differences in housing costs across cities must reflect differences in earnings or differences in amenities for a given individual. Using 1980 census data for illustrative purposes, we estimate a simplified version of the Rosen-Roback specification in which city-level median house values are regressed on median family income and the barest of amenity measures—mean January temperature—for 102 cities with 1980 populations of at least 150,000:

$$\begin{aligned}&\text{median house price} =\\ &\quad -155{,}954\ (21{,}623) + 4.56\ (0.46) \times \text{median family income}\\ &\quad + 1{,}441\ (219) \times \text{January temperature},\end{aligned} \tag{2}$$

where all monetary variables are in 2000 dollars, standard errors are in parentheses, and the $R^2 = 0.60$. Figure 2 graphs median house prices against the fitted values from this regression. There are many valid criticisms of this type of regression, and a more thorough analysis would use exogenous sources of labor demand and allow for individual heterogeneity as in Blomquist, Berger, and Hoehn (1988) and Gyourko and Tracy (1991), but the results highlight the empirical power of the Rosen-Roback equilibrium concept. High housing prices generally are associated with either high incomes or a more attractive (i.e., warmer) climate.

But just as figure 2 is consistent with the Rosen-Roback framework, it also contains the puzzle that motivates our analysis. The dashed horizontal line at \$97,794 represents the estimated cost of a modest-quality, 1,200–square foot home in 2000 dollars. (The measurement of construction costs is discussed below in detail.) In at least one-quarter of the sample, median housing prices are well below this level. For housing prices to be low enough for people to live in low-wage, low-amenity places such as Buffalo, Detroit, Philadelphia, and St. Louis, houses in those cities must sell for much less than they cost to build. Thus the spatial equilibrium for people cannot be a static equilibrium for the housing market.

The solution to the puzzle is that places can have housing values below construction costs because once homes are built, there is no lower bound on their prices until they fall to zero. The cities of the Rust Belt once had amenities and wages that justified new construction. They no longer do, but the cities remain because their homes have lasted. To understand America's spatial equilibrium, we must embed the Rosen-Roback framework in a dynamic setting with durable housing. In doing so, we draw on a rich literature on durability and urban development; but we focus on urban decline, whereas previous research overwhelmingly has dealt with urban growth.[1]

Starting from equation (1) above, we assume that every person who chooses to live in a given house receives each period a city-specific wage level W, a city-specific amenity level A, and a location-specific amenity level a and pays rent r. We assume that everyone is a renter, but equivalently, each resident can be thought of as an owner-occupier if r represents the user cost of housing. We normalize the reservation utility to zero and denote $\theta \equiv W + A$, so that free mobility implies $\theta + a = r$. On

[1] The literature is voluminous. Important primary contributions include Arnott (1980), Brueckner (1980, 1981), Hochman and Pines (1982), Wheaton (1982), and Braid (1988). See Brueckner (2000) for a recent review. The closest research to ours is that on filtering, where houses cheapen as they age. We compare our results to that implied by a filtering story later in the paper.

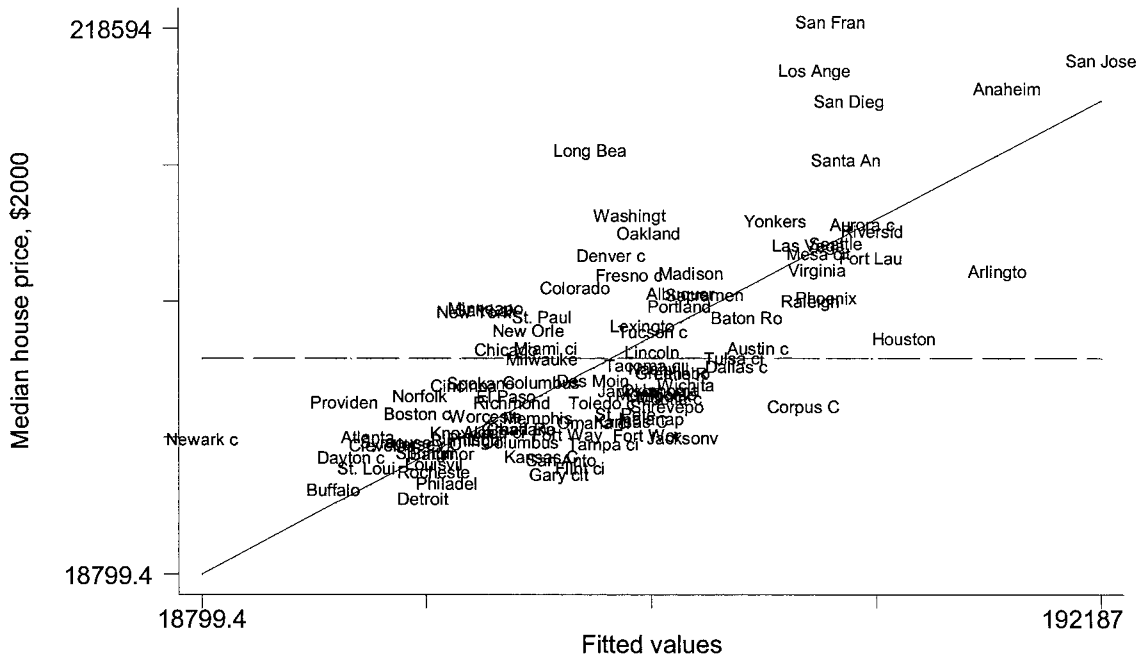

FIG. 2.—Median price regression and construction costs. The dashed horizontal line represents the $97,974 construction costs (in 2000 dollars) for a modest-quality, 1,200–square foot single-family home estimated by R. S. Means (2000*a*). The observation for Honolulu is not plotted for ease of presentation.

the margin, the rent paid equals the sum of the benefits associated with city-specific and location-specific traits.

There is a supply of N lots for each value of $a < \bar{a}$. These location-specific amenities could capture distance to the city center in a conventional monocentric city model or other positive amenities in a richer urban model such as that of Lucas and Rossi-Hansberg (2002). Each lot can contain only one house, and each house is identical and can contain one person.

To capture depreciation, we assume that houses occasionally need to be rebuilt and that the cost of rebuilding is the same as the cost of new construction. At the level of the city, this assumption approximates a more continuous decay process, with lower algebraic costs. If current rent is a sufficient statistic for predicting future rents (which we assume), then a lot will be developed or rebuilt when its rent rises above a cutoff rent $\underline{r}$. If a lot's rent falls below $\underline{r}$, then a home that had been developed will not be rebuilt if it collapses. Declines in population occur when homes on developed lots whose rents have fallen below $\underline{r}$ collapse.

For simplicity of exposition, we do not assume a specific stochastic process for θ. Rather, we take the existence of a minimum rent level as given and initially consider the time path of the city between two periods, where $\theta = \theta_0$ in the first period and $\theta = \theta_0 + \Delta$ in the second period. To avoid unnecessary complications, we further assume that θ has not risen above the maximum of θ_0 and $\theta_0 + \Delta$ at any point and that Δ is small enough in absolute value so that $\bar{a} + \theta_0 + \Delta > \underline{r}$, which ensures that some houses will be rebuilt if they collapse. We further assume that all construction and reconstruction decisions are made at the end of the period after observing $\theta_0 + \Delta$.[2]

If $\Delta > 0$, then new construction will occur on all lots with amenity levels greater than $\underline{r} - \theta_0 - \Delta$. Population will rise by ΔN in this case. If $\Delta < 0$, then no new construction will occur, and homes with amenity levels less than $\underline{r} - \theta_0 - \Delta$ that collapse will not be rebuilt. Under the assumption that a proportion δ of all homes collapse, the total population loss is $\delta \Delta N$. While the rent for any given lot will increase or decrease by Δ, changes in supply will affect changes in the average rent in the city. When $\Delta > 0$, ΔN new homes will be built. These marginal homes have relatively low amenity levels, and new construction of these homes will cause average rent in this city to rise by only 0.5Δ. When $\Delta < 0$, the city sheds low-amenity units; but since housing supply falls

[2] A more complex model that specifies a stochastic process for θ as in Dixit and Pindyck's (1994) real options framework is available at http://post.economics.harvard.edu/faculty/glaeser/papers.html. While many of those model details differ, no key results are affected. In particular, a calibration exercise also available on the Web page shows that option value is not a key driver of development.

by only $\delta\Delta N$, average rent declines by more than 0.5Δ. In the extreme case in which no homes collapse, the average rent declines by Δ.

This framework captures the asymmetry that gives us the supply curve shown in figure 1 and leads to the first proposition (all proofs are in App. B).

Proposition 1. If Δ is a random variable that is symmetrically distributed across cities around a nonnegative number and no other parameters differ across cities, then the following statements are true:

a. The distribution of city population growth will be skewed in the sense that the mean is greater than the median.
b. The coefficient estimated when the change in housing price is regressed on the change in population is greater when population is declining than when population is growing.
c. If $\Delta = \beta z$, then the derivative of population growth with respect to z will be greater when $z > 0$ than when $z < 0$. The derivative of price growth with respect to z will be greater when $z < 0$ than when $z > 0$.

The proposition emphasizes that durable housing predicts a skewed distribution of city growth rates because durability means that cities decline slowly. Negative shocks will tend to affect prices more than population, and positive shocks will affect population more than prices. As a result, the relationship between price growth and population growth will be concave.

We now include two growth periods to make predictions about persistence and the correlation between housing prices and future urban dynamics. In this case, we assume that the value of θ changes from $\theta_0 + \Delta$ to $\theta_0 + \Delta + \Delta_2$ between the second and third periods (with $\mathrm{Cov}(\Delta, \Delta_2) = 0$). Proposition 2 holds if we further assume that θ has not risen above the maximum of θ_0, $\theta_0 + \Delta$, and $\theta_0 + \Delta + \Delta_2$ between the second and third periods and that some houses will be rebuilt even if they collapse at the end of the third period.

Proposition 2. (*a*) The derivative of current population growth with respect to lagged population growth will be greater when lagged growth is negative than when it is positive. (*b*) The growth rate of the city between the second and third periods declines with the share of its housing stock with rents below $\underline{r}$.

Decline is more persistent than growth because durability means that it can take decades for negative urban shocks to be fully reflected in urban population levels. While cities are experiencing long, slow declines, they will have an abundance of very cheap housing, the existence of which will statistically predict future decline.

To examine the interaction between urban decline and the human capital composition of the city, we now allow for high– and low–human capital workers. Low–human capital workers receive wages of W, have a reservation utility outside of the city of zero, and receive amenity flows of $A + a$ from living at a particular site in the city. High–human capital types have wages equal to $(\phi + 1)W$, have a reservation utility equal to $\overline{U}$, and receive utility from amenities equal to $(\phi + 1)(a + A)$. The taste for amenities increases with wages to allow for the possibility that high-wage people are willing to spend more to obtain things such as better schools or proximity to work. Everyone still consumes one unit of housing.

Given these assumptions, low–human capital workers are willing to pay rent of $W + A + a$ and high–human capital workers are willing to pay rent of $(1 + \phi)(W + A + a) - \overline{U}$. High–human capital workers are willing to pay more for homes where $a > (\overline{U}/\phi) - \theta$. As long as $\bar{a} > (\overline{U}/\phi) - \theta > \underline{r} - \theta$, there will be individuals of both types in the city, and we assume that is the case. The share of high-skill workers in the city will equal $[\bar{a} + \theta - (\overline{U}/\phi)]/(\bar{a} + \theta - \underline{r})$. If we then make the same assumptions about changes in θ as in the initial proposition, proposition 3 follows.

PROPOSITION 3. The proportion of city workers who are high-skilled rises less with an increase in city population growth than it declines with a decrease in city population of equal magnitude.

This proposition suggests that we should expect to see declining skill levels in shrinking cities. The intuition of this proposition is that when W or A declines, this loss is offset by a decrease in housing prices. But skilled people particularly value a robust labor market and high amenities, so they leave even though durable housing keeps the overall size of the population roughly constant.

III. Testing the Implications of the Model

In order to take the implications of the model to the data, we use a sample of municipal jurisdictions with at least 30,000 residents in 1970. There are 321 cities with consistent data over the three decades of the 1970s, 1980s, and 1990s in our sample. The core house price and population data are taken from the decennial censuses. All other variables are described more fully below or in Appendix A.

The first implication of proposition 1 is that population growth should be skewed, with the mean exceeding the median. Summary statistics for the 963 decadal population growth rates available between 1970 and 2000 for our 321 cities show a mean growth rate that is 86 percent greater than the median: 9.1 percent versus 4.9 percent, respectively. Cities expand much more rapidly than they contract. A similar pattern holds, with the mean being about twice as large as the median, if we examine the 642 20-year or the 321 30-year population growth rates of

TABLE 1
Relationship between Price Changes and Population Changes from Equation (3) (Part *b* of Proposition 1)

	α_1 (1)	α_2 (2)	Test for $\alpha_1 = \alpha_2$ (3)	R^2 (4)
Results from pooled decadal observations ($N = 963$)*	1.80 (.20)	.23 (.05)	$F(1, 320) = 45.20$ Prob > F = .00	.19
Results from three-decade change ($N = 321$)†	1.64 (.19)	.09 (.04)	$F(1, 320) = 55.16$ Prob > F = .00	.15

Note.—Standard errors (in parentheses) are based on clustering at the city level. There are 321 city clusters in each regression. Specifications are estimated using data on cities with at least 30,000 residents in 1970. There are 963 observations on the pooled decadal changes and 321 observations on the 30-year changes. Population and house prices are obtained from the decennial censuses. Decadal dummy coefficients and intercepts are suppressed throughout. Full results are available on request. See the text for added detail on the specification.
* Observations pertain to the 1970s, 1980s, and 1990s.
† Observations pertain to 1970–2000.

our cities. If housing was not durable, we would expect to see much more of a quantity response in declining cities over longer time spans, reducing the asymmetry predicted by our model.

The second implication of proposition 1 is that price changes are more sensitive to population changes when the changes are negative. While there obviously is no causal linkage implied here, a concave relationship between price appreciation and population growth is an important testable hypothesis implied by our framework. To investigate this issue, we regress the percentage growth in housing prices (all prices are in 2000 dollars) on a transformation of its population growth as shown in equation (3) below. Population growth is entered in piecewise linear form to allow for differential effects in expanding versus declining cities. Thus the $\text{POPLOSS}_{i,t}$ variable takes on a value of zero if city i's population grew during decade t and equals city i's actual percentage decline in population if the city lost population during the relevant decade. Analogously, the $\text{POPGAIN}_{i,t}$ variable equals zero if the city lost population during time period t and equals the actual population growth rate if the city gained population. Whenever observations are pooled across decades, we include time dummies (δ_t) to allow for different intercepts across decades and correct for intertemporal correlation in the error terms associated with multiple observations on the same city over time. The actual specification estimated is

$$\text{house price appreciation rate } (\%)_{i,t} =$$

$$\alpha_0 + \alpha_1 \times \text{POPLOSS}_{i,t} + \alpha_2 \times \text{POPGAIN}_{i,t} + \alpha_3 \times \delta_t + \epsilon_{i,t}, \qquad (3)$$

where $\epsilon_{i,t}$ is the standard error term.

The first row of table 1 reports results from a specification that pools the 963 observations on decadal price and population growth that we have for our 321-city sample. Among cities that lost population, the estimate of α_1 indicates an elasticity of price change with respect to population of 1.8. Thus a one-percentage-point greater rate of population decline is associated with nearly a two-percentage-point greater decline in real house prices over the decade. Among cities that are gaining population, the elasticity of real house price change with respect to population change is only 0.23. As the F-test statistic reported in column 3 shows, these effects are statistically different from one another.

The second row of table 1 indicates that there is no economically meaningful change in this pattern if the specification is estimated using longer-run price and population changes between 1970 and 2000. Figure 3 then plots the fitted versus actual price appreciation rates from this specification, with the observations sorted by population growth.[3] While the prediction of our model is statistically validated, figure 3 illustrates that there is a small set of cities, primarily along the coast of California, but also including Seattle and Boulder, with extremely high rates of growth in real house prices. These places experience positive demand shocks that drive up prices more than population. In Glaeser, Gyourko, and Saks (2005), we argue that these places face binding regulatory constraints on new construction.[4]

We now examine the final implication of proposition 1: that a specific positive exogenous shock will have a greater impact on population growth than a specific negative exogenous shock, and that the negative exogenous shock will have a greater impact on price appreciation than a positive exogenous shock. While most shocks to the attractiveness of urban areas are difficult to measure and are unobservable to us as econometricians, Glaeser and Shapiro (2003) suggest that the weather

[3] The plot of the results from the first specification in table 1 using decadal changes exhibits much the same pattern, but it is more difficult to read because of the multiple observations on cities across decades. It should also be noted that the strongly concave relationship between price changes and population changes in fig. 3 is not dependent on a few outliers. For example, dropping the initially relatively small cities of Glendale, AZ, and Mesa, AZ (populations 36,305 and 62,929, respectively), which grew by about 500 percent between 1970 and 2000, does not materially change the results.

[4] As this relationship involves two endogenous variables, we also estimated the reverse regression of population changes on price changes (entered in piecewise linear form so that separate effects can be estimated for cities experiencing declining vs. rising real house values). The pooled regression of decadal population growth on decadal real price growth does yield a larger coefficient when house price appreciation is positive, as our model predicts, but it is not statistically significantly different from that found when real prices decline. This specification suffers from three problems. First, there is greater measurement error of house prices than of population, and that error is in the explanatory variable in this case. Second, there is no natural break point for price changes at zero, especially since construction costs are declining in real terms in many markets, including some with expanding populations (see Gyourko and Saiz 2004). Third, differences in supply elasticities among attractive cities further compromise the reverse regression, as suggested by the small number of primarily California cities noted above that have extremely high appreciation of house prices without commensurate population growth.

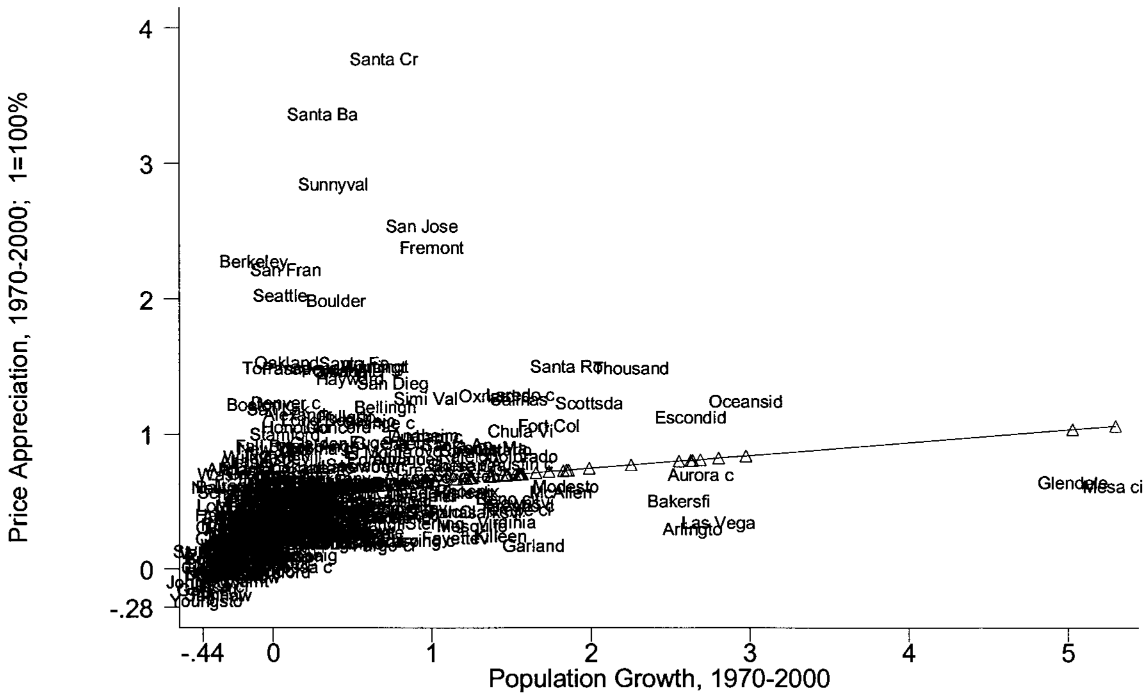

FIG. 3.—Price appreciation and urban growth

is one likely observable source of exogenous variation in the demand for particular locales. The weather is powerfully associated with city population growth, and the simple correlation between mean January temperature and growth in our cities has ranged from 0.47 to 0.73 in the three decades since 1970. Obviously, the weather of cities is not changing. Rather, rising incomes or factors such as 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 $A = v \times X$, where v is the taste for the weather and X is the weather. The shock comes through a change in v, not a change in X.

Part *c* of proposition 1 suggests a specification that permits estimation of separate slopes for negative shocks and positive shocks. As 35.5 percent of our sample of decadal observations on population growth were negative over the 1970s, 1980s, and 1990s, we assume that the lowest 35.5 percent of mean January temperatures can be thought of as reflecting a negative population shock from the weather. This cutoff implies that all cities with mean January temperatures above 29.1 degrees Fahrenheit received a positive shock from the weather, and cities with temperature levels colder than that experienced a negative shock. Our model does not require this particular choice, but the results are robust to reasonable alternative cutoff points.

With this transformation, the weather "shock" is entered in piecewise linear fashion as the COLD and WARM variables in the regressions for population growth rate and house price appreciation rate described in equations (4) and (5). Specifically, the variable COLD_i takes on a value of zero if city i's mean January temperature is greater than 29.1 degrees and equals the city's actual mean January temperature otherwise. The variable WARM_i equals zero if city i is colder than 29.1 degrees, on average, in January and equals the city's actual mean January temperature otherwise:

$$\text{population growth rate } (\%)_{i,t} = \alpha_0 + \alpha_1 \times \text{COLD}_i + \alpha_2 \times \text{WARM}_i + \alpha_3 \times \delta_t + \epsilon_{i,t} \quad (4)$$

and

$$\text{house price appreciation rate } (\%)_{i,t} = \beta_0 + \beta_1 \times \text{COLD}_i + \beta_2 \times \text{WARM}_i + \beta_3 \times \delta_t + \gamma_{i,t}. \quad (5)$$

As before, we allow for different decadal intercepts when pooling observations across decades. However, robust standard errors based on clustering at the metropolitan area level, not the city level, are reported

TABLE 2
Population and Price Growth and the Weather (Part *c* of Proposition 1)

A. Based on Equation (4)

	α_1 (1)	α_2 (2)	Test for $\alpha_1 = \alpha_2$ (3)	R^2 (4)
Population growth results	.0008 (.0020)	.0069 (.0012)	$F(1, 261) = 4.79$ Prob > F = .03	.15

B. Based on Equation (5)

	β_1 (1)	β_2 (2)	Test for $\beta_1 = \beta_2$ (3)	R^2 (4)
House price apprecia-tion results	.0060 (.0016)	.0023 (.0011)	$F(1, 261) = 2.39$ Prob > F = .12	.11

Note.—Standard errors (in parentheses) are based on clustering at the metropolitan area level. There are 262 metropolitan area clusters in each regression. Specifications are estimated using data on 321 cities with at least 30,000 residents in 1970. There are 963 observations across the three decades of the 1970s, 1980s, and 1990s. Population and house prices are obtained from the decennial censuses. Mean January temperature is a 30-year average that was collected from the 1992 County and City Data Book. This variable does not vary over time. Decadal dummy coefficients and intercepts are suppressed throughout. Full results are available on request. See the text for added detail on the specifications.

here because there is no variation in reported temperature within a metropolitan area.

The first row of table 2 finds the strong convexity of population change with respect to weather shocks predicted by part *c* of proposition 1. Among colder cities, there is no statistically or economically meaningful relationship between being more (or less) cold and population growth. The result is quite different for warmer places. Among these cities, being warmer is strongly associated with greater population growth. The coefficient of 0.0069 implies that an increase of 16 degrees, which is the interquartile range of mean January temperatures for warmer cities (from 36 to 52 degrees), is associated with a 10.8 percent higher decade population growth rate. That is an economically meaningful effect, since the mean decadal increase in population for the warm cities is 13.5 percent. The *F*-test results reported in column 3 show that we can conclude with high confidence that the impacts of these negative and positive "weather shocks" on population growth are different.

The next row of table 2 reports results for house price appreciation. As predicted by part *c* of proposition 1, there is a concave relationship between price changes and weather shocks. A negative shock has a greater impact on price than a positive shock of equal magnitude. Among colder places, a 10-degree higher temperature is associated with a 6 percent greater rate of house price growth ($0.0060 \times 10 = 0.06$), with the same increase among warmer cities being associated with only a 2.3 percent higher rate of price appreciation ($0.0023 \times 10 = 0.023$).

TABLE 3
Persistence of Population Decline Based on Equation (6)
(Part *a* of Proposition 2)

	α_1 (1)	α_2 (2)	$\alpha_1 = \alpha_2$ (3)	R^2 (4)
Results from pooled decadal observations	1.001 (.076)	.455 (.039)	$F(1, 320) = 29.0$ Prob > $F = .00$	.51

Note.—Standard errors (in parentheses) are based on clustering at the city level. There are 321 city clusters. Specifications are estimated using data on 321 cities with at least 30,000 residents in 1970. In this table, population growth rates from the 1980s and 1990s are regressed on transformed lags of their respective growth rates and a single decadal dummy as described in the text. There are 642 decadal observations. All population data were obtained from decennial censuses. The time dummy coefficient and the intercept are suppressed throughout. All results are available on request.

While this is consistent with our model, the *F*-test results reported in column 3 show that the effects are different at only the 88 percent level.

Table 3 addresses part *a* of proposition 2 that housing durability should make population decline especially persistent because it can take many decades for negative shocks to be fully reflected in the size of the housing stock and population. As in table 1, we allow the estimation of differential effects of growth versus decline so that the POPLOSS and POPGAIN variables are as defined as above. Because we are interested in persistence, current-period population growth is regressed on lagged growth (where the $t-1$ subscript signifies the decade prior to t), and we estimate the following specification:

$$\text{population growth rate } (\%)_{i,t} =$$
$$\alpha_0 + \alpha_1 \times \text{POPLOSS}_{i,t-1} + \alpha_2 \times \text{POPGAIN}_{i,t-1} + \alpha_3 \times \delta_t + \epsilon_{i,t}. \quad (6)$$

The use of lags results in the loss of one decade of data (the 1970s) and reduces the number of observations to 642 as described in table 3.

The coefficient on past growth when growth was negative is twice that when past growth was positive. Among cities that declined in the previous decade, a 1 percent greater population loss is associated with a 1 percent larger population decline this decade. The positive coefficient of about 0.46 on the lagged value of POPGAIN indicates that there is some persistence for cities that were growing, too. However, we can comfortably reject the null hypothesis that these are the same effects (see col. 3 of table 3). These findings reflect the permanence of decline among American Rust Belt cities especially. There were 39 U.S. cities with at least 100,000 people in 1950 that lost population during the 1950s. Of these, 33 declined in the 1960s, 37 declined in the 1970s, 22 declined in the 1980s, and 23 declined in the 1990s.

The final implication of proposition 2 implies that cities with an abundance of cheap housing that is priced below current replacement cost will not tend to grow as much in the future. This connection is not causal. Cities with relatively large fractions of housing priced below construction cost have suffered significant economic shocks that are the true drivers of decline.

To measure the fraction of a city's housing stock that is priced below the cost of new construction, we use data on self-reported housing values from the Integrated Public-Use Microdata Series (IPUMS) maintained by the Minnesota Population Center at the University of Minnesota and compare those prices to the costs of building the physical unit in 1980 and 1990 using information provided by the R. S. Means Company, a consultant to the home-building industry.[5] We focus on single-unit residences that are owner-occupied. The construction cost data are available per square foot of living area for single-family homes in a wide variety of cities.[6] These data include material costs, labor costs, and equipment costs for four different qualities of single-unit residences. No land costs are included. We developed cost series for a one-story, modest-quality house, with an unfinished basement; the average cost associated with four possible types of siding and building frame; and the cost of different sizes in terms of living area (i.e., small or less than 1,550 square feet, medium or between 1,550 and 1,850 square feet, and large or between 1,850 and 2,500 square feet).

House price and construction cost data were successfully matched for 123 cities in 1980 and 92 cities in 1990. Nationally, 42 percent of single-unit housing in our cities was valued below the cost of new construction in 1980. In 1990, the fraction was 31 percent. There is substantial variation across regions. The fraction is very low for homes in western region cities, but nearly 60 percent of northeastern and midwestern homes in our sample were valued below replacement cost in 1980. At the city level, Los Angeles, San Diego, and Honolulu have well under 10 percent of their single-family housing stock priced below construction cost in 1980 or 1990. In contrast, some of the older, manufacturing cities such as Flint, Michigan, and Gary, Indiana, have two-thirds or more of their single-family stocks valued below replacement cost in both decades.[7]

[5] Two publications (R. S. Means 2000*a*, 2000*b*) are particularly relevant for greater detail on the underlying cost data.

[6] Given that construction costs are reported on a per square foot basis, we need to convert housing values into the same metric. Unfortunately, the census does not report unit size. Hence, we turn to the American Housing Survey (AHS), which does report the square footage of living area. We impute unit size in the IPUMS data via the results of a regression analysis of square footage on a vector of physical traits common to the AHS and census data sets. See App. A for those details.

[7] The data are adjusted 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 that 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. Appendix A discusses these and other data construction issues in detail. See our working paper (Glaeser and Gyourko 2001) for the complete listing of each city's distribution of house price relative to construction costs.

TABLE 4
Distribution of House Prices and Population Growth (Part *c* of Proposition 2)

	Specification	
	(1)	(2)
α_1	−.270	−.267
	(.042)	(.084)
R^2	.20	.55

Note.—Standard errors (in parentheses) are based on clustering at the city level. There are 127 city clusters. Specifications are estimated using data on 215 cities—123 with 1980s data and 92 with 1990s data. Population data are taken from the decennial censuses. House price data are taken from the IPUMS maintained by the University of Minnesota. Construction cost data on single-family homes are taken from R. S. Means (2000*a*, 2000*b*). Various adjustments to both the numerator and denominator are made in creating the ratio of price to construction cost in the −house *q* variable. See the text and App. A for the details. Specification 1 is taken from eq. (7). The local controls included in specification 2 include the log of median house price at the beginning of the decade, the percentage of the city housing stock at the beginning of the decade composed of single-unit dwellings, census region dummies, the log of city population at the beginning of the decade, the city's family poverty rate at the beginning of the decade, and 30-year averages for January temperature, July temperature, and annual rainfall. The time dummy coefficient and the intercept are suppressed throughout. All results are available on request.

This ratio of market value to replacement cost is akin to a Tobin's q-value for a city's housing stock. However, Tobin's q increases with the premium over replacement cost, whereas our variable rises in value the greater the fraction of the housing stock priced below cost. In equation (7), which describes a regression of decadal city population growth on this measure of market value to replacement cost at the beginning of the decade, this variable is labeled −house $q_{i,t\_}$, where the minus sign in front indicates that a higher value is associated with more, not fewer, units being valued below physical construction costs. The $t\_$ subscript indicates that the value is taken from the beginning of the relevant decade:

$$\text{population growth rate }(\%)_{i,t} = \alpha_0 + \alpha_1 \times -\text{house } q_{i,t\_} + \alpha_2 \times \delta_t + \epsilon_{i,t}. \qquad (7)$$

After we pool observations across the two available decades of construction cost data, column 1 of table 4 reports that our estimate of α_1 is −0.27. This highly statistically significant result (standard error of 0.042) 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 2.7 percent. This is over half the median decadal growth rate of 4.9 percent and almost one-third of the 9.1 percent mean decadal rate of population growth among our 321 cities. Moreover, the mean value of −house q is 37.3 percent, with a standard deviation of 25.3 percent, so that a one-standard-deviation increase in the fraction of the city housing stock that is priced below physical construction costs is associated with almost a 7 percent lower population growth rate. The distribution of house prices strongly predicts future population growth.

A reasonable criticism of any regression involving housing prices and urban dynamics is that these correlations exist only because housing prices reflect expectations about future housing price growth, which is itself a function of future urban growth. We address this concern in two ways. First, we have examined the correlation between the share of the city's housing stock that is priced below the cost of new construction at the beginning of a decade and the growth of real house prices over the ensuing 10 years. If the expectations hypothesis is relevant here, we would expect this relationship to be negative, but it is in fact slightly positive. Second, as the current median housing price should reflect at least some of the expectations about future changes in housing prices, controlling for house price should help mitigate the problem. When house price at the beginning of the decade is included with a host of other controls, the coefficient on the fraction of the stock priced below construction costs is essentially unchanged at −0.267, as reported in column 2 of table 4.

We close this section by addressing the connection between human capital and urban decline described in proposition 3. Declining cities both are poor and have high levels of less well-educated workers. Glaeser, Kahn, and Rappaport (2000) argue that the tendency of the poor to live close to city centers is driven by a desire to economize on transport costs, especially car ownership. Their work helps explain patterns of wealth and poverty across jurisdictions within a metropolitan area, but it cannot account for the variation across metropolitan areas because the costs of car ownership, especially for poorer or low-skill households, probably do not differ all that much across growing versus declining cities.

In our empirical analysis of whether cheap, durable housing can account for the relationship between urban decline and falling human capital levels, we use a conventional measure of education, the share of college graduates in the city's adult population (defined as those at least 25 years of age), to reflect the skill level of the area. In the regression specifications below, the variable $\Delta\mathrm{COL}_{i,t}$ represents the change in city i's share of college graduates over decade t. We begin by documenting that there is, in fact, a significantly higher rate of loss of college

TABLE 5
HUMAN CAPITAL, CHEAP HOUSING, AND URBAN DECLINE (Proposition 3)

	Specification		
	(1)	(2)	(3)
α_1	8.28	.30	8.35
	(1.86)	(1.80)	(2.03)
α_2	.83	−.25	1.99
	(.58)	(.56)	(.61)
F-tests	$F(1, 320) = 12.75$	$F(1, 320) = .08$	$F(1, 261) = 9.33$
	Prob > F = .00	Prob > F = .78	Prob > F = .00
R^2	.15	.26	.25

NOTE.—Standard errors (in parentheses) are based on clustering at the city level in the first two specifications and at the metropolitan area level in the third specification. There are 321 city clusters and 262 metropolitan area clusters. Clustering by metropolitan area occurs when weather-related variables are included in the specification. Specifications are estimated using data on 321 cities with at least 30,000 residents in 1970. Specification 1 is based on eq. (8). Specification 2 adds median house price (at the end of each decade) to the basic model in eq. (8). Specification 3 includes city population; the family poverty rate; the change in Hispanic population share; weather conditions as reflected in mean January temperature, mean July temperature, and average annual rainfall; and region dummies. College graduate shares and the family poverty rate were obtained from various issues of the County and City Data Book and Housing and Urban Development's State of the Cities data system. Population, house prices, and Hispanic share were obtained from the decennial censuses. All weather variables represent 30-year averages that were collected from the County and City Data Book. Time dummy coefficients and the intercept are suppressed throughout. All results are available on request.

graduates the greater the rate of population loss among declining cities. As before, we use a transformation of population growth to permit estimation of different effects for expanding versus shrinking cities so that the $\text{POPLOSS}_{i,t}$ and $\text{POPGAIN}_{i,t}$ variables are as defined above. Because data availability allows us to pool observations across all three decades in our sample, the usual time dummies are included, with robust standard errors estimated on the basis of clustering by city. Column 1 of table 5 reports the results of estimating equation (8):

$$\Delta\text{COL}_{i,t} = \alpha_0 + \alpha_1 \times \text{POPLOSS}_{i,t} + \alpha_2 \times \text{POPGAIN}_{i,t} + \alpha_3 \times \delta_t + \epsilon_{i,t}. \tag{8}$$

Among cities losing residents, a greater rate of loss is associated with a significant drop in population share of the highly educated; there is no significant correlation between the extent of population growth and the share of college-educated among growing cities. The F-test results also show that we can be sure that these effects are, in fact, different. Given the units of observation, the estimated α_1 coefficient of 8.28 from column 1 implies that a 10 percent greater rate of population decline over a decade is associated with a 0.83-percentage-point lower share of college graduates. There is just over a three-percentage-point gap between the average share of college graduates in expanding versus declining cities in our sample (16.9 percent among cities that were losing population in a given decade vs. 20.2 percent for those gaining residents), so this estimated impact can account for a significant fraction of the average difference we see in this local attribute.

If the model underlying proposition 3 is correct and cheap housing is relatively more attractive to those with lower wages (and, presumably, less skill), then controlling for the distribution of house prices at the end of the time period should weaken or eliminate the correlation pattern just identified. Column 2 of table 5 reports results in which the log of median house price at the end of each decade is added to the basic regression in equation (8). Simply controlling for one measure of central tendency of city house prices eliminates the relationship between the rate of population loss and the share of college graduates among declining cities. The relevant F-test statistics comparing the two effects show that we cannot reject the null that there is no difference in effects across growing versus declining cities once we control for end-of-period house prices.

If other local traits generated the same result, that would cast doubt on our contention that it is cheap housing that attracts or retains the poor in declining cities. We could not find any other variable that could do so. The findings in column 3 of table 5 report the results after including a host of other local controls (besides house prices), including the log of city population, the family poverty rate, weather conditions, region dummies, and changes in Hispanic population shares. These variables have very little impact on the relationship between decline and skill composition of the residents, and the specification still is estimated precisely enough that we can reject the null that there are no differences in impacts across the two types of cities. In sum, the housing price control, and no other local variable, has the effect of eliminating the connection between human capital and urban decline.[8]

IV. Alternative Explanations: Is the "Bricks and Mortar" Perspective on Urban Decline Robust?

In this section, we consider alternative explanations for our findings, including long-lived physical plant or infrastructure, immobile people, and filtering in the housing market. Some of these hypotheses are potentially complementary with our durable housing framework. In all

[8] We repeated the exercise using the change in the share of non–high school graduates and found that controlling for the distribution of house prices also can account for the correlation between this measure of human capital and city growth. In addition, we experimented with two income-based measures of human capital—median family income and the poverty rate—to similar effect. Admittedly, these two variables are problematic because if rising population levels are caused by rising labor demand, then we should expect to see a positive relationship even if the housing factors that drive our model are not important. Nonetheless, these variables may be better measures of human capital than educational degrees, so they were examined for robustness.

cases, we attempt to discern which is more consistent with the facts describing urban decline.

A. *Durable Plant and Infrastructure*

Declining cities might endure because they have a durable production infrastructure or long-lived agglomerations of firms (as in Krugman [1991*a*, 1991*b*]), not just durable homes. These explanations are not mutually exclusive, since both physical plant and housing could be empirically relevant. To investigate this possibility, we construct a measure of Tobin's q for firms headquartered in our sample of cities and use it to augment the specification estimated in equation (7), which showed that cities with a low housing q (i.e., those with a large fraction of their owner-occupied stocks valued below replacement cost) have much less future growth. By including a measure of corporate q for the city (described more fully below), we can see whether the data prefer it or house q as a predictor of future growth.[9]

If U.S. Steel's plants are the primary reason that many people still live in Gary, then irreversible industrial investment suggests that Tobin's q for such a firm located in the city should forecast future growth. Tobin's q was created for every publicly traded firm listed in the Compustat files in 1980 and 1990, with q calculated as the ratio of the market value of firm assets divided by the book value of assets as in Gompers, Ishii, and Metrick (2003). While this variable is widely used in financial economics research, it is not straightforward to match it to specific cities in our urban context. Tobin's q is a firm-level measure, and companies typically have assets in more than one jurisdiction. Compustat does identify the county (not the city) in which the company is headquartered, and we use that to match firms to cities. The corporate q for a city is the market value–weighted average of individual company q's located in the county in which the relevant central city is located. In the regression results reported below, we label this variable corporate q.

We are able to match a firm-based q to 206 of the 215 city-year pairs used in the house q regression reported in table 4.[10] The average number of firms making up a city's corporate q is 23, with a standard deviation of 39. The range of this number is wide, varying from one in a handful of places (e.g., Beaumont, TX; Corpus Christi, TX; Erie, PA; Lorain,

[9] We are grateful to the editor, John Cochrane, for suggesting this approach and to Andrew Metrick for helping with the Compustat data.

[10] The inability to match arises if Compustat does not report any firms headquartered in the home counties of one of our cities. They tend to be less populous locales and are spread across the country (e.g., they are in California, Louisiana, Michigan, Ohio, Pennsylvania, and Texas).

OH; Mobile, AL; South Bend, IN; Springfield, MA; and Topeka, KS) to well over 200 in the nation's major cities (e.g., Chicago, Los Angeles, and New York). We report results without correcting for the number of firms in the city's corporate *q*. There are many reasons why weighting by the number of firms is not necessarily better. Empirically, we find that weighting by firms or market capitalization does not increase the estimated importance of corporate *q* in our regressions (and weighting by the number of firms is always associated with a smaller impact).[11]

The average city-level corporate *q* is 1.51, with a standard deviation of 0.82. The median is 1.26. The lowest corporate *q* for any city is 0.63, with the maximum just below five. Cities with relatively large fractions of their owner-occupied housing stocks priced below construction cost tend to have a low value of corporate *q*. Because a high value for −house *q* reflects a larger share of housing valued below replacement cost, this means that the two variables are negatively correlated. The simple correlation between the share of a city's housing priced below physical replacement cost and the *q* of its local companies is −0.24. That correlation is statistically significant and does not vary much across the two decades for which we have data.

This raises the possibility that a city's corporate *q*, not its house *q*, really is behind the relationship identified above in table 4. To get at this issue, we begin by reestimating equation (7) on the slightly reduced number of observations for which we have both house *q* and corporate *q* measures. As column 1 of table 6 shows, the results are virtually unchanged, with a 10 percent higher share of the local housing stock that is priced below construction costs at the beginning of the decade still associated with about 2.7 percent lower population growth over the decade.

The second regression reported in table 6 estimates equation (9), which identifies the correlation between beginning-of-period corporate *q* and population growth:

$$\text{population growth rate } (\%)_{i,t} = \alpha_0 + \alpha_1 \times \text{corporate } q_{i,t\_} + \alpha_2 \times \delta_t + \epsilon_{i,t}. \tag{9}$$

Corporate *q* predicts population growth when we do not control for −house *q*.

The third regression reported in table 6 includes both −house *q* and

[11] Measurement error in the ratio of market to replacement value of a city's corporate assets need not decline with the number of firms located in a place. Corporate *q* based on the one company headquartered in Beaumont, TX, could more accurately describe the state of that city's fixed plant than the analogous value for Philadelphia, which is based on 32 companies. Not only is the local economy in Philadelphia more complex, but its firms in the Compustat files sometimes are global entities whose *q*-values are influenced by assets far from Philadelphia.

TABLE 6
HOUSE q, CORPORATE q, AND CITY POPULATION GROWTH FROM EQUATIONS (7) AND (9)

	Specification			
	(1)	(2)	(3)	(4)
−House q	−.266		−.238	−.242
	(.044)		(.043)	(.043)
Corporate q		.051	.033	
		(.019)	(.020)	
Corporate $q < 1$				−.104
				(.128)
Corporate $q > 1$				.037
				(.021)
Observations	206	206	206	206
R^2	.19	.08	.22	.23

NOTE.—Standard errors (in parentheses) are based on clustering at the city level. There are 124 city clusters. Specifications are estimated using data on 206 cities with nonmissing −house q and corporate q data in 1980 and 1990. Population data are taken from the decennial censuses. See the note to table 4 for data sources on the construction of the −house q variable. The corporate q variable is constructed as the market capitalization–weighted average of firm q's located in the home county of the relevant city. Firm q is constructed as in Gompers et al. (2003). See the text for more details. The time dummy coefficient and the intercept are suppressed throughout. All results are available on request.

corporate q. The coefficient on the ratio of corporate market to book value declines by over one-third and is no longer significant at standard confidence levels. The coefficient on the house q control remains statistically significant and declines only slightly in size. In economic terms, the coefficient on the city's corporate q implies a standardized marginal effect that is not even half as large as that for house q.[12] In column 4 of table 6, we report a specification in which corporate q is entered in piecewise linear form to allow estimation of separate effects depending on whether the city's corporate q is below or above one. Having a corporate q below one is associated with lower population growth, having a corporate q above one is associated with higher population growth, and the estimated effect of corporate $q > 1$ is significant at the 10 percent level.[13] The impact of house q is virtually unchanged.

While table 6 provides suggestive evidence that the durability of productive capital matters, there is no evidence that our house q variable was spuriously reflecting the impact of installed corporate capital. That said, this latter measure is noisy and always has the expected sign in

[12] The standard deviation of the fraction of city housing value below replacement cost is 0.25, and that for corporate q is 0.82. Given the two regression coefficients, the standardized marginal effect for house q is -0.06 ($\sim .25 \times -0.24$) and that for corporate q is 0.027 ($\sim 0.82 \times 0.033$).

[13] Changing the breakpoint to the median (1.26) or similar values does not affect the results in any material way. The coefficients always have the right sign, with a high corporate q predicting higher population growth at close to standard confidence levels, and the house q variable retaining its economic and statistical significance.

our regressions, so we do not interpret table 6 as concluding that there is nothing to the durable (nonhousing) infrastructure story.

Other data and implications of the Rosen-Roback model also support the primacy of durable housing in accounting for the nature of urban decline. If it were true that people remained in declining cities primarily because of a productive installed capital base or a valuable agglomeration of firms, then we should see signs of that in the labor market. For example, physical capital in the production sector should keep wages relatively high and unemployment relatively low. On the other hand, if declining cities endure primarily because of durable housing, then wages should be low and offset by low housing costs.

Recent census data show that wages are about 10 percent higher in the fastest-growing cities relative to the slowest-growing cities. The unemployment rate is about 40 percent higher in the slowest-growing cities, so layoff risk does not appear to be lower in declining cities, such as Gary, Detroit, and St. Louis, that have abundant installed manufacturing plant. Not only is there no evidence that remaining residents are compensated via the labor market, but the data are clear that housing is cheap in declining cities. Mean prices for a given size, owner-occupied home (i.e., those with three bedrooms) are about 50 percent lower in declining cities according to recent censuses. And, there is a similar gap in apartment rents. Thus the data are more consistent with cheap housing keeping people in declining areas, not the labor market benefits that would be associated with a productive fixed infrastructure or valuable agglomeration of firms.

B. *Immobile People*

A second alternative hypothesis is that declining cities endure because their residents just do not move (for whatever reason) after they arrived to take advantage of some initial agglomeration. In other words, it could be the people, not the homes, that create the "stickiness" generating the important asymmetries in our model. To investigate this possibility, we collected mobility data from the census. Specifically, we began by calculating in-migration rates for 111 cities using the 1980 census PUMS.[14] Declining cities have less in-migration than growing cities: the

[14] The 1980 data are especially well suited to our needs. No within-city moves are included in our in-migration figures using this sample. Moves within a county are included if the given county includes part of the suburbs of the city. Because the PUMS samples require the use of weights and some observations inevitably contain missing data, we checked the quality of our calculations by comparing the results for the few places in which the city and county are coterminus (e.g., Philadelphia, St. Louis, etc.) with the county-level in-migration rates reported at the county level by the Bureau of the Census in Study no. 8471 of the Inter-university Consortium for Political and Social Research. The findings were nearly identical in all cases.

correlation between the in-migration rate and log population change is 0.60. However, in-migration rates are still high even in declining cities. For example, 8.8 percent of Philadelphia's 1980 population, or almost 300,000 residents, had moved into the city over the previous five years. Every city in our sample had five-year in-migration rates that were at least 6 percent of total population, and all but three had in-migration rates in excess of 8 percent. Extrapolating these numbers over the decade implies that over 15 percent of the city's residents had moved in during the last 10 years—even in the places experiencing the greatest net decline in population. If these inflows had stopped, population decline would have more than doubled in most declining cities. Thus the data suggest that Americans are fairly mobile. It is the homes that are fixed.

C. *Filtering in the Housing Market*

A third alternative hypothesis for some of our findings is the filtering of housing. In filtering models, older houses are cheap because they are old, with Muth (1973) providing the classic statement on this framework. In our model, older houses are cheap primarily because demand for their location has collapsed. Using the 1999 national file of the AHS, we categorized homes of a given quality (defined by the characteristics of being single-family, owner-occupied, and with from two to four bedrooms) as new or old depending on whether they had been built within the last 10 years or at least 40 years ago. There is much truth to the filtering story since, in most places, old housing certainly is cheaper than new housing. However, a more detailed examination finds that the really important determinant of price is location, not age.

In declining cities such as Philadelphia and Detroit, old homes are indeed cheap, but the prices of new homes are also quite low. In Philadelphia's case, the median value of homes built within the past 10 years was $75,000 versus $60,000 for those at least four decades old. In Detroit, the median value of the newer homes is actually slightly below that of the older homes, at $62,500 versus $70,000. In contrast, in expensive places, the prices of old and new homes are all quite high, and there is little or no difference based on age in these places. In Los Angeles, the median new and old home was worth $200,000 according to the 1999 AHS. In San Francisco, the median older home was slightly more expensive than the median newer homes, at $350,000 versus $300,000. Filtering of housing down the quality spectrum occurs, but the data emphasize that in declining cities, housing is both cheap and old because demand has collapsed, not because old housing is cheap per se. Even new housing is relatively inexpensive in Philadelphia and Detroit, and even old housing in San Francisco is quite expensive.

V. Conclusion

Most of the urban growth literature ignores the physical nature of cities. While the durability of housing may not be a crucial element of urban dynamics for growing cities, it is essential for understanding the nature of urban decline, and many of our major cities are in decline. The supply side of the housing market helps explain why cities decline so slowly even though they can grow at very fast rates. Durable housing can also explain the striking persistence of urban decline.

Durable housing predicts that 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, since 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 a greater impact on growth because new supply dampens the effect on prices. Both asymmetries are borne out in the data. Another implication of durable housing is that the distribution of house prices is an excellent predictor of future population growth. The data show that growth is quite rare in cities with large fractions of their housing stock valued below the cost of new construction.

Finally, the model helps explain why cities in greater decline tend to have lower levels of human capital, since cheap housing is relatively more attractive to the poor. The tendency of declining cities to disproportionately attract the poor is particularly important if concentrations of poverty further deter growth. If low levels of human capital then create negative externalities or result in lower levels of innovation, this becomes particularly troubling because a self-reinforcing process can result in which an initial decline causes concentrated poverty, which then pushes the city further downward (e.g., Glaeser, Scheinkman, and Shleifer 1995; Cullen and Levitt 1999). However, that issue is for future research.

Appendix A

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. They 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 that 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, and 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).

Data frequently were 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.

Thus the linear specification estimated has the following form:

$$\begin{aligned}\text{SQUARE FOOTAGE}_i = f\{&\text{AGE}_i,\ \text{AGE}_i^2,\ \text{BEDROOMS}_i,\ \text{BATHROOMS}_i,\\ &\text{KITFULL}_i,\ \text{OTHROOMS}_i,\ \text{AIRCON}_i,\\ &\text{HEAT}_i,\ \text{DETACHED}_i,\ \text{MSA}_i,\ \text{REGION}_i\},\end{aligned}$$

where 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 and those without extreme square footage values (i.e., we deleted observations with less than 500 square feet and more than 5,000 square feet of living area [4,000 square feet was the top code in the 1989 survey]). The overall fits are reasonably good, with the adjusted R^2's being 0.391 in the 1985 data and 0.306 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 making that comparison. One adjustment takes into account the fact that research shows that owners tend to overestimate the value of their homes. Following the survey and recent estimation by Goodman and Ittner (1992), we presume that owners typically overvalue their homes by 6 percent.

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 and Ittner [1992] correction) in the relevant year (1985 or 1989) on a series of age controls and metropolitan area dummies. The age data are given in interval form so that we can tell whether a house is 0–5 years old, 6–10 years old, 11–25 years old, 25–36 years old, and more than 45 years old. Because slightly different intervals are reported in the AHS and IPUMS, we experimented with transformations based on each survey's intervals. The different matching produces very similar results. 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 1980–85 and 1989–90. In the case of 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.

The depreciation factors themselves are relatively large. After we make 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.

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 basement and that each unit in the Middle Atlantic division has 0.949 basement. Because of the very large gross differences in the propensity to have basements, this adjustment almost certainly reduces measurement error relative to assuming that all units have basements or that none have basements.

After these adjustments, house value "as if new" is then compared to construction costs to produce the distributions discussed in the text.

Appendix B

Proofs of Propositions

Proof of Proposition 1

Part *a*: If Δ is symmetrically distributed around $\hat{\Delta} \geq 0$ with cumulative distribution $F(\Delta)$, then the mean growth rate is $N\hat{\Delta} - \int_{\Delta=-\infty}^{0} (1-\delta)\Delta dF(\Delta)$, which is greater than the median growth rate, $N\hat{\Delta}$.

Part *b*: When Δ is positive, the change in price always equals $1/(2N)$ times the change in quantity, so the estimated regression coefficient will equal $1/(2N)$. When Δ is negative, the change in population is $\delta\Delta N$, and the change in rent is

$$\frac{\Delta}{2}\left[1 + \frac{(1-\delta)(\bar{a} - \underline{r} + \theta_0)}{\bar{a} - \underline{r} + \theta_0 + \delta\Delta}\right],$$

so the estimated regression coefficient equals

$$\left(\int_{\Delta<0} \Delta^2\left[1+\frac{(1-\delta)(\bar{a}-\underline{r}+\theta_0)}{\bar{a}-\underline{r}+\theta_0+\delta\Delta}\right]dF(\Delta)\right.$$

$$\left.-\left\{\int_{\Delta<0} \Delta\left[1+\frac{(1-\delta)(\bar{a}-\underline{r}+\theta_0)}{\bar{a}-\underline{r}+\theta_0+\delta\Delta}\right]dF(\Delta)\right\}\Delta_-\right)$$

$$\div\left\{2\delta N\left[\int_{\Delta<0} \Delta^2 dF(\Delta)-\Delta_-^2\right]\right\},$$

where $\Delta_- = \int_{\Delta<0}\Delta \cdot dF(\Delta)$. This is less than $1/(2N)$ as long as

$$\int_{\Delta<0}\frac{\Delta(\Delta-\Delta_-)}{\bar{a}-\underline{r}+\theta_0+\delta\Delta}dF(\Delta)>0,$$

which must be true because $\int_{\Delta<0}\Delta(\Delta-\Delta_-)dF(\Delta)>0$, and $\bar{a}-\underline{r}+\theta_0+\delta\Delta$ is decreasing in the absolute value of Δ.

Part *c*: When z is positive, the growth in population equals $N\beta z$, so the derivative of growth with respect to z equals $N\beta$. When z is negative, population change equals $\delta N\beta z$, so the derivative of growth with respect to z will equal $\delta N\beta$. When z is positive, the change in rents equals $0.5\beta z$, so the derivative of the change in rents with respect to z will equal 0.5β. When z is negative, the change in rents will equal

$$0.5\beta z\left[1+\frac{(1-\delta)(\bar{a}-\underline{r}+\theta_0)}{\bar{a}-\underline{r}+\theta_0+\delta\beta z}\right]$$

and the derivative with respect to z will equal

$$0.5\beta\left[1+\frac{(1-\delta)(\bar{a}-\underline{r}+\theta_0)}{\bar{a}-\underline{r}+\theta_0+\delta\beta z}-\frac{\delta\beta z(1-\delta)(\bar{a}-\underline{r}+\theta_0)}{(\bar{a}-\underline{r}+\theta_0+\delta\beta z)^2}\right]>0.5\beta.$$

Proof of Proposition 2

Part *a*: For cities that grew during the first time period, next-period growth is orthogonal to lagged growth, so the estimated coefficient will be zero. If lagged growth is negative, then growth in the next period equals $[\delta(1-\delta)\Delta+\delta\Delta_2]N$ if $\Delta_2<0$, $[\delta(1-\delta)(\Delta+\Delta_2)+\delta\Delta_2]N$ if $-\Delta>\Delta_2>0$, and $[(1-\delta)\Delta+\Delta_2]N$ if $\Delta_2>-\Delta$. Differentiation then tells us that expected growth is increasing in Δ or first-period growth.

Part *b*: The share of housing with rents below $\underline{r}$ in the second period equals $-\Delta(1-\delta)/(\bar{a}+\theta_0-\underline{r}+\delta\Delta)$, which is a monotonically negative function of Δ. If S is the share with rents below $\underline{r}$, then $\Delta=-S(\bar{a}+\theta_0-\underline{r})/[1-(1-S)\delta]$. And if expected growth is rising with Δ, then it is falling with S.

Proof of Proposition 3

If the city population grows an amount x because of an increase in either W or A, then the share of high-skilled workers in the city will increase from $[\bar{a} + \theta_0 - (\bar{U}/\phi)]/(\bar{a} + \theta_0 - r)$ to $[\bar{a} + \theta_0 + (x/N) - (\bar{U}/\phi)]/[\bar{a} + \theta_0 + (x/N) - \underline{r}]$. The change in the share of skilled workers in the city will equal

$$\frac{(x/N)[(\bar{U}/\phi) - \underline{r}]}{[\bar{a} + \theta_0 + (x/N) - \underline{r}](\bar{a} + \theta_0 - \underline{r})}.$$

If the city population declines by an amount x, then the share of high-skilled workers in the city will decline from $[\bar{a} + \theta_0 - (\bar{U}/\phi)]/(\bar{a} + \theta_0 - \underline{r})$ to $[\bar{a} + \theta_0 + (x/\delta N) - (\bar{U}/\phi)]/[\bar{a} + \theta_0 + (x/N) - \underline{r}]$, which implies a change in the number of skilled workers equal to

$$\frac{(x/N)[(\bar{U}/\phi) - \underline{r}]}{[\bar{a} + \theta_0 + (x/N) - \underline{r}](\bar{a} + \theta_0 - \underline{r})} + \frac{(1-\delta)x}{\delta N[\bar{a} + \theta_0 + (x/N) - \underline{r}]},$$

which is obviously larger in absolute value than

$$\frac{(x/N)[(\bar{U}/\phi) - \underline{r}]}{[\bar{a} + \theta_0 + (x/N) - \underline{r}](\bar{a} + \theta_0 - \underline{r})}.$$

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