Urban Growth and Housing Supply

Edward L. Glaeser, Joseph Gyourko and Raven Saks

July 29, 2004, Preliminary Draft

Abstract

Cities are physical structures, but the modern literature on urban economic development rarely acknowledges that fact. The elasticity of housing supply helps determine the extent to which increases in productivity will create bigger cities or just higher paid workers and more expensive homes. In this paper, we present a series of facts documenting the important role that the housing supply plays in mediating urban growth. We also show that differences in the regulatory environment across space are not only responsible for higher housing prices, but also affect how cities respond to increases in productivity.

We are grateful toe the Taubman Center for State and Local Government at Harvard University and the Research Sponsors Program of the Zell/Lurie Real Estate Center at The Wharton School of the University of Pennsylvania for financial support. Jesse Shapiro provided helpful comments and data.

I. Introduction

The modern literature on urban growth and economic geography generally ignores housing supply. In the index of the recent *Oxford Handbook of Economic Geography*, the subject of housing only appears in John Kain's essay on racial and economic segregation (Kain (2000)). The subject "real estate" does not appear at all. Virtually none of the papers on urban growth that have appeared in general interest economics journals over the past 20 years ever mention the supply of housing. At the same time, the real estate literature has focused on variety of other issues such as the determinants of housing prices and housing as a financial asset that tend to ignore housing's larger role in economic geography.

In this paper, we argue that it is impossible to understand many aspects of urban dynamics without understanding housing supply, and that it is difficult to think sensibly about real estate in many contexts without understanding the urban equilibrium which determines the price and quantity of housing. This observation is not new. Many of the great early urban economists including William Alonso (1964), Richard Muth (1969), Edward Mills (1967) and John Kain (1962, 1968) were keenly focused on the interplay between housing markets and the urban economy. But in the years since their seminal work, real estate and urban economics increasingly have become separate subject areas. In this paper, we update their early observations and explore empirically the role that housing supply plays in mediating urban dynamics in recent decades.

Different types of evidence are presented supporting our contention that research on urban growth and decline requires that attention be paid to the housing market. We begin in Section II by reviewing the extraordinarily tight link between the stock of housing and population in an area. The number of people and the number of workers in an area can be thought of as a multiple of the number of housing units. This relationship is true both in levels and in growth rates.

We also examine changes in vacancy rates and household size. To break the tight link between the number of homes and the number of people, it would have to be true that there is significant variation in vacancy rates or household size over space and time. While there certainly is variation in these variables, our investigation of the data shows that generally it is not enough to create meaningful variation in population across cities absent a change in the size of the housing stock.

The correlation between housing supply and population change provides a necessary, but not sufficient, element of the case that the nature of the supply of housing is important for understanding urban growth and decline. In principle, city growth could be completely determined by other variables, with the housing supply simply responding to those factors. In order to make the case that housing actually influences the course of city dynamics, we discuss particular features of its supply. First, we turn to recent research by Glaeser and Gyourko (2004) which focuses on the fact that housing is durable. This implies that supply is inelastic with respect to downward shocks, which means that cities will lose housing units and people only very gradually after they receive negative shocks. That work examines declining cities in recent decades and reports much evidence that urban decline is mediated by durable housing. We then provide additional evidence here on the durability of housing, documenting that net losses from a city's housing stock almost never exceed 1% per annum over decade-length periods. This is confirmed with data from the *American Housing Survey* showing that permanent losses from the housing stock of America's cities average no more than 0.5% per year.

Next, we examine whether the nature of housing supply affects the form that urban success takes. A simple model suggests that it could lead to more people and houses, higher house prices, higher wages, or some combination of these outcomes depending upon the elasticity of supply. Initially, we turn to the role of density and inelastic supply. Building up is known to make construction more expensive, suggesting that housing supply should be more inelastic in denser places. This implies that when dense places become more productive, there will be larger increases in prices and wages and smaller increases in population than when less dense places become more productive. Following

Glaeser and Saiz (2004), we use the initial skill level in the city as the source of variation in productivity shocks. We find that skills have a stronger impact on population growth in less dense areas, while they have a stronger impact on wage growth in more dense areas. In the housing price regressions, coefficients are estimated much less precisely and we do not find a significant interaction between density and skills.

After reviewing this preliminary evidence, Section III presents a simple growth model to provide a more formal structure for thinking about changes in population, housing prices and wages across cities with different elasticities of housing supply. This model formalizes the observation that shocks to places with more inelastic housing supply will have bigger impacts on wage and house price growth and smaller impacts on population growth. Its primary contribution is to provide a framework for empirical work that integrates housing supply heterogeneity into urban growth studies.

In Section IV, we estimate the parameters of the model using data on metropolitan areas in the 1990s. Following Saks (2003) and Glaeser, Gyourko and Saks (2004), we argue that housing supply has become very inelastic in many areas of this country because of restrictive land use regulations. Using proxies for the severity of restrictions on new construction, we show that in places where land use regulation is less severe, the population (and new housing supply) response to positive shocks is much stronger than in places where land use regulation is more severe. Finally, we show that high levels of land use regulation restrict population growth, but keep housing prices and ultimately wages high. As such, housing supply is important not only for understanding changes in population levels within metropolitan areas, but also changes in wages within those areas as well. A brief conclusion summarizes our results and discusses potential avenues for future research.

II. Housing and Urban Dynamics

This section documents the stylized facts that help make the case housing supply is an important factor influencing the nature of urban growth and decline. We start with what must be the most obvious aspect of the relationship between the housing stock and urban population—the extraordinarily high correlations between these two variables. We then turn to somewhat more subtle aspects of the relationship.

Correlations between the Housing Stock and Urban Growth

The deep connection between urban change and the housing stock is clearly evident in the strong correlation between population levels and housing units. We begin with a sample of 314 American cities with at least 30,000 residents in 1970 for which we have complete data on housing units and population for 1970, 1980, 1990 and 2000. The top panel of Table 1 reports the correlation between the logarithm of the number of housing units and the logarithm of the population in every decade between 1970 and 2000. Unsurprisingly, the correlations are quite tight, with the R^2 in each regression being at least 0.98. Not only is the fit of the relationship almost perfect, but the estimated coefficients are remarkably close to one, ranging from 0.97 to 1.02 across the census years. Figure 1 plots the relationship between the logarithm of population and the logarithm of housing units in 2000, along with the fitted regression line. Across cities, there is little doubt that the number of people is a simple multiple of the number of housing units.

Of course, the tight correlation between population and housing units at a point in time does not necessarily imply that changes in population and changes in the housing stock also line up perfectly. To examine this issue, the bottom panel of Table 1 reports the correlations between the change in the logarithm of population and the change in the logarithm of the number of housing units. The R^2 for the 1970s is 94 percent and the R^2s for the 1980s and 1990s are both around 80 percent. For the 30 years spanning the 1970-2000 period, the R^2 from the analogous regression is 91 percent. While these numbers are below than those seen in the cross-section relationships, they still reflect quite strong relationships.

The point estimates of the housing unit—population elasticity also differ slightly from one, at least after the 1970s. In the 1970s, the estimated coefficient is 1.01. In the 1980s and 1990s, the estimated coefficients decline to 0.86 and 0.77 respectively. Over the entire 30-year period, the estimated coefficient is 0.92. This relationship is graphed in Figure 2. Even though the relationship between changes in population and housing supply is not perfect, the raw correlations suggest that the overwhelming variation in population is accomplished through changing the number of units, not in changing the number of people per unit. Nevertheless, for completeness we next discuss the reasons why population might differ from the housing stock—namely, vacancy rates and household size.

Vacancy Rates and Changing Household Size

The number of people in a city equals the number of housing units times the number of people per housing unit. There are two ways in which the number of people per housing unit can change. First, the number of people in an occupied unit can grow or contract. Second, the vacancy rate—that is, the share of housing units that are unoccupied--can change. In principle, if either the vacancy rate or household size is sufficiently flexible, then the actual stock of housing might not be so tightly linked with the size of the population.

Looking at one year of our data—1990—for illustrative purposes finds that the mean residential vacancy rate across our sample of 314 American cities was 8.3%. The standard deviation of this variable was 3.4%, with the vacancy rate of the city in the 10^{th} percentile of the distribution being 4.5% and the vacancy rate of the city in the 90^{th} percentile of the distribution being 12.3%. Thus, if a city dropped from being one of the one-tenth least vacant cities in the nation to one of the one-tenth most vacant cities in the U.S., the total decline in population (holding people per occupied unit constant) would be 7.8%. As most declining cities already have significant vacancy rates, further increases in vacancy rates seem unlikely to produce substantial additional decreases in population (given the range we see in the data, at least). In growing cities, vacancy rates are already fairly low, so there is little chance that decreases in vacancy rates can account for population growth in those places.

Another way to think about this relationship is to consider the correlation between increases in population and changes in vacancy rates. Figure 3 shows the relationship between the growth rate of population in the 1990s and the change in the vacancy rate over the same time period. There is indeed a negative relationship (and it is statistically significant), but it is relatively small. A 0.1 log point increase in population is associated with just over a .8 percentage point decrease in vacancy rate. This coefficient means that as a city grows by 10 percent, that city's vacancy rate declines by eight-tenths of one percent.[1]

In some traditional analyses of urban systems (e.g., Roback, 1982), housing is a flexible variable and changes in demand will readily lead to changes in housing consumed per capita. Even if the amount of occupied housing remains the same, changes in a city's population could occur if the number of people per household changed.[2] For example, declining house prices could lead smaller households to occupy more space. Or, rising housing prices might cause larger households to crowd into smaller homes. In either case, the overall population level would not be tied as strongly to the size of the housing supply.

It is indeed true that changes in the size of households can have a significant impact on urban population levels. In Table 2, we show the number of people in households per occupied unit across different decades. As households have become smaller and families with children have left cities, the overall number of people in each housing unit has fallen. In 1970, there were 3.03 people per occupied housing unit on average in our sample of cities; by 2000, there were only 2.51. Note that the bulk of this decline took

[1] Further evidence suggesting that vacancy rates do not play a large role in urban dynamics can be found in Hwang and Quigley (2004), who find that local macroeconomic conditions (like income and unemployment) do not have a significant impact on vacancy rates.
[2] The so-called 'crowding' literature has a long and distinguished history. The issue was central to some of the early work in modern urban economics. In addition to the works cited above, also see Kain and Quigley (1975) for an examination in the context of race and discrimination.

place over the 1970s. Changes in household size help to explain why population levels declined much more quickly than the housing stock in some places like Detroit in the 1970s. Smaller family size meant that population could fall even with little change in the vacancy rate and only modest shrinkage of the housing stock. If the typical household size in a city shrank by the national average and if no new homes were built, city population could have fallen by as much as 15% in the 1970s. In contrast, the average household size shrank by only 3% in the 1980s, and did not change much at all in the 1990s. Thus, in the past two decades, falling household size cannot account for much of the declines in population we observe in some of our cities.

While it is true that declining household sizes in the 1970s made it possible for some cities to shrink significantly despite the durability of housing, only a small amount of the variation in the city population levels occurs through changes in household size. This is true for both cities with population declines and cities with growing populations. In the cross section of cities, there is a statistically significant elasticity between the logarithm of city population and the logarithm of average household size. However, it is small and not economically important. Figure 4 plots the relationship with data from the 2000 census. The R^2 from the underlying regression is only 0.01, and the dispersion in the graph shows clearly that there is much more driving population differences across cities than differences in household sizes. Essentially, these results support our contention that relatively little growth or decline has occurred recently through changes in household size. Instead, growth occurs by changing the number of households, which requires changes in the number of housing units.

Urban Decline and Durable Housing

Previous research by Glaeser and Gyourko (2004) contends that many features of declining cities can be understood only as the result of the durable nature of housing—which makes the elasticity of housing supply very inelastic for such cities. The key predictions of the model in their paper are that (1) cities grow more quickly than they decline; thus, the distribution of population growth rates is skewed to the left; (2) urban decline is more persistent than urban growth; (3) there is a concave relationship between changes in prices and changes in population across cities; (4) there is a convex relationship between changes in population and exogenous shocks to urban growth; (5) there is a concave relationship between changes in prices and exogenous shocks to urban growth; and (6) the less skilled will congregate in cities. The authors report much data that is strongly consistent with each of these implications, supporting the claim that the supply side of the housing market has important effects on the nature of decline in cities suffering negative shocks.

Next, we provide evidence pertaining to two additional aspects of durable housing and urban decline. By durable housing, we mean that housing units very rarely disappear from the stock of housing. To support that claim, we turn to the *American Housing Survey* (*AHS*). The *AHS* is a panel of housing units, so we can track the extent to which housing units cease to exist. Table 3 shows the permanent loss rates of central city housing units between 1985 and 1993. Every two years, between 1.3 and 1.8 percent of housing units either permanently exit the housing stock or suffer such severe damage as to render the units uninhabitable. These rates of permanent loss suggest that the housing stock of a city is unlikely to decline by more than 1 percent per year or 10 percent per decade. Data from the decennial censuses on the aggregate change in housing units over decadal periods is quite consistent with these figures (see Table 4 below for more detail).

To investigate this implication more closely—which is at the heart of the implication that growth rates will be skewed—Table 4 reports data on the fastest and slowest growing cities in terms of housing stock during the 1970s, 1980s, and 1990s. In order to observe a larger amount of variation, in this table we allow the sample of cities to grow over time by including all cities with more than 100,000 residents at the beginning of each decade.

The table shows that cities can expand their housing stocks extremely rapidly—if they so desire. For example, housing units in Las Vegas grew by approximately 50% in both the 1980s and the 1990s. The stock of units in Colorado Springs grew by more than 60% during the 1970s. While there seems almost no upper bound on growth even for these cities which already are fairly large in the sense they begin each decade with at least 100,000 residents, declines rarely exceed -10%. Over the entire 30 year period, in only five cases did a city lose 11% or more of its housing stock in a single decade: Newark in the 1980s (-16.9%), St. Louis in the 1970s (-16.5%), Gary in the 1980s (-14.5%), Detroit in the 1980s (-14%) and Detroit in the 1970s (-11.5%).

In the absence of significant increases in the vacancy rate or a major decline in the number of people per housing unit, declines in a city's population will also be limited to about 10% per decade. Due to the declines in household size documented above, population declines were larger in the 1970s than changes in the housing stock. Nonetheless, the maximum positive population growth rate in the 1970s still is double highest rate of population decline. In later decades, population growth declines match housing unit declines very closely. For example, in the 1980s, Newark lost 17.9% of its population or barely more than the decline in its housing stock. In the 1990s, the most severe population loss among cities with at least 100,000 residents was a 13.9% decline in Hartford. These figures demonstrate that the biggest population declines have only been modestly more severe than the corresponding changes in the housing stock.

In sum, many of America's declining cities have housing prices that are too low to justify new construction. In a sense, houses in these places continue to exist because of the durable nature of the housing stock. To understand the population and employment dynamics of this group, it is particularly important to recognize the role played by housing supply. In particular, these cities are not on the verge of a population turnaround. To gain net new population, there must be new construction. And, for there to be new construction, prices must rise far above their current levels to make bringing new units to market financially attractive to developers.

Density and the Growth of Population, Housing Prices and Income

This subsection reports preliminary evidence that differences in housing supply impact the form that urban success will take. When a city experiences an outward shift in demand, we should expect an increase in population if the housing supply is relatively elastic (see point A in Figure 5). The corresponding increase in housing prices should be relatively modest. The positive shock will generate a large enough increase in the number of new homes to prevent the price of housing from rising above construction costs. If homes can always be supplied at a price equal to $80 per square foot (the norm in much of America--see Glaeser and Gyourko (2003)), then this will be the price of housing. Moreover, new construction will also help ensure that wages do not rise dramatically because an elastic supply of homes helps create an elastic supply of labor.

However, if housing supply is inelastic, then positive shocks to urban productivity will have little impact on new construction or urban population. Because the number of homes does not increase significantly, housing prices must rise (see point B in Figure 5). Wages must rise as well, both because firms have become more productive and because workers must be compensated for rising housing prices. In contrast, if an amenity level rises in a city with an inelastic housing supply, then nominal wages (which are determined by labor demand) will be unchanged and housing prices will rise, implying a decline in real wages.

Empirically, there are several ways to identify which locations may have a more inelastic housing supply than others. We will work with differences in land use regulation later in the paper. Here we focus on a simpler determinant of housing supply elasticity: urban density. Density is likely to reflect attributes of an area related to housing demand, so these findings should be viewed as illustrative and as setting the stage for the more formal model that is estimated below in Section IV. Still, we find evidence consistent with the hypotheses that the elasticity of housing supply is an important determinant of housing prices and population in a city, as illustrated in Figure 5.

There is little argument that less land makes it more difficult to build. At Manhattan-like extremes, this is obvious. The price per square foot in multi-floor apartments is considerably higher than the price per square foot in single-family detached homes.[3] However, with the single-family house category, there are only modest differences in cost per square foot between a 1- and 3-story home.

Certainly, as Figure 6 shows, there is a robust empirical connection across cities between housing prices and density. This figure plots the relationship between the logarithm of median self-reported housing value and the logarithm of density in 1990 for our sample of 314 cities. The estimated elasticity is 0.34, so that as density doubles, housing prices rise by 34%. These results are consistent with it being more difficult and more expensive to build at higher densities.

If housing supply is more inelastic at high densities, then it follows that positive shocks to the demand for housing will have a greater impact on population in less dense places. Correspondingly, there will be a greater impact on housing prices in more dense places. Because urban productivity creates an increase in the demand for housing, shocks to urban productivity also will have a larger impact on income in more dense places. To examine these contentions empirically, we use the share of highly educated adults (e.g., those over 25 years of age with at least a bachelor's degree) as an indicator of changing housing demand for a particular locale in the 1990s. A host of research documents the strong positive correlation between the skill level of a city's population and city growth in recent decades. We take this relationship as evidence that a larger amount of human capital in a city increases productivity (Glaeser and Saiz (2003), Moretti (2004a,b)). Because it is more difficult to build in denser areas, we should expect to see the effect of the share of college graduates on population growth to be smaller in denser cities. Similarly, the relationship between the share of college graduates and housing price appreciation should be larger in denser areas.

Table 5 reports the impact of the skill level and its interaction with density on population growth, house price appreciation, and household income growth during the 1990s. For

---

[3] A primary reason is that elevators are not required and interior and exterior stairwells are not required for exit routes in single family homes. Data reported by the R.S. Means Company (2000a,b) provides the details.

these estimates, we use a bigger sample of cities that includes all large cities in 1990.[4] All estimations are OLS. Each specification includes the share of college graduates in 1990, population density in 1990 (in log form), and an interaction between the two. Each regression also includes initial period city population, median house price, and median household income (all in log form) as control variables.

The interaction between the college graduate share and the log of city density is of particular interest (see row 3). This interaction term is strongly negatively related to population growth, indicating that in denser cities, our proxy for higher productivity does not lead to as much growth as in less dense places. However, column (2) of Table 5 shows that this interaction term is not significantly associated with higher house price appreciation. Although the point estimate is negative as expected, it is not close to being statistically significant.

Since college graduation rates appear to work through productivity increases, our model also predicts that income increases will be steeper in those cities with higher density levels. Columm 3 of Table 5 reports results using the log change in median household income as the dependent variable. The coefficient on the interaction term is strongly positive, indicating that the impact of initial skills on income growth is greater in denser areas that presumably have constricted housing supplies.

While these regressions provide suggestive evidence that the nature of housing supply can affect the form that urban success takes, a more formal model is needed to interpret the coefficients properly. We now turn to that framework.

III. Housing Supply and Urban Dynamics: An Empirical Framework

[4] There is potentially severe selection bias associated with using the smaller city sample used above that only included cities with at least 30,000 people in 1970. It is unlikely they will be representative of density across places in the 1990s. Hence, Table 5 uses a 976-city sample of places with at least 30,000 residents as of 1990. In addition, we required that the city's boundaries not change materially between 1990-2000.

In this section, we present a simple model of regional growth that incorporates housing supply. Because we have dealt elsewhere with issues surrounding urban decline (Glaeser and Gyourko (2004)), here we focus on urban growth and the impact that differences in housing supply will have on the form that growth takes.

We assume the economy is composed of many metropolitan areas, each denoted "j". Following much of the urban growth literature, we start with the simplifying assumption of homogenous workers, who are indifferent across metropolitan areas and everywhere receive a real reservation utility equal to $\underline{U}$. Utility in each location equals $C_j + W_j - R_j$, where C_j is a city-specific amenity flow consumed by residents, W_j is the city-specific wage paid to workers, and R_j is the cost of housing and transportation in city j. Together these assumptions imply that $\underline{U} + R_j = W_j + C_j$.

To capture labor demand, we assume there exists a distribution of tasks within the city that is indexed by productivity. The distribution of these tasks is characterized by an exponential distribution, so that the number of tasks with productivity greater than W_j is $e^{\alpha(A_j - W_j)}$. At a given wage, these opportunities will be exploited to the point where the output of the marginal activity equals the wage. This means that that the total labor demand is determined by $Log(N_j) = \alpha A_j - \alpha W_j$, where N_j denotes city employment.

To close the system, we also must describe the housing market. There are several issues that make housing complex. As already discussed above, housing is durable. Thus, if rents are not high enough to justify new construction, the supply of housing essentially is perfectly inelastic. If rents do justify new construction, then the price of housing will be determined by the cost of new construction. This cost is composed of the physical cost of new construction plus any costs related to regulatory barriers or other limits on housing supply. We make the simplifying assumption that the cost of new construction equals $K_j + \delta Log(N_j / L_j)$, where L_j reflects the land area in the city. Thus, the cost of new construction is based on a fixed city-specific factor (K) and is an increasing function of land density, where a low value for δ indicates a relatively elastic supply of housing. This dependence on density is meant to capture the myriad of ways that housing supply regulations can increase the cost of construction. To convert housing prices into rent, we assume that rents equal a fixed capitalization rate (denoted ρ) times construction costs. We let H_j denote housing prices in the city.

Combing the three separate markets, we can determine wages, rents and population in a non-declining city. This produces the following equations:

(1) $Log(N_j) = \dfrac{\alpha A_j + \alpha C_j + \alpha\rho\delta Log(L_j) - \alpha \underline{U} - \alpha\rho K_j}{1+\alpha\rho\delta}$,

(2) $W_j = \dfrac{\alpha\rho\delta A_j + \underline{U} + \rho K_j - C_j - \rho\delta Log(L_j)}{1+\alpha\rho\delta}$, and

(3) $H_j = \dfrac{\alpha\delta A_j + \alpha\delta C_j + K_j - \delta Log(L_j) - \alpha\delta \underline{U}}{1+\alpha\rho\delta}$

These three equations yield comparative statics that are reassuring, if unsurprising. The effects of changes in productivity (A_j) or changes in the attractiveness of an area (C_j) are summarized in Table 6. If an area becomes more productive then population, wages and housing prices each increase. If an area becomes more attractive, then housing prices and population will rise, but wages will fall.

Given exogenous variation in the level of amenities or productivity, the parameters of the model can be estimated from the equations above. Our primary focus will be on the effects of changes in the productivity level, A_j , and the consumer amenity level, C_j . We presume that these are the only city-specific attributes that change over time. More specifically, we assume that $A_{j,t+1} - A_{j,t} = \sum_k \beta_A^k X_{j,t}^k + \varepsilon_{j,t}^A$ and

$C_{j,t+1} - C_{j,t} = \sum_k \beta_C^k X_{j,t}^k + \varepsilon_{j,t}^C$, where $X_{j,t}^k$ are city-specific characteristics at time t.

One example of a component of $X^k_{j,t}$ is the skill composition of the city, which should increase productivity as discussed above. Thus,

$$(1') \; Log\left(\frac{N_{j,t+1}}{N_{j,t}}\right) = I^N + \frac{\alpha}{1+\alpha\rho\delta}\sum_k\left(\beta^k_A + \beta^k_C\right)X^k_{j,t} + \mu^N_{j,t}$$

$$(2') \; W_{j,t+1} - W_{j,t+1} = I^W + \frac{\alpha\rho\delta}{1+\alpha\rho\delta}\sum_k\left(\beta^k_A - \frac{\beta^k_C}{\alpha\rho\delta}\right)X^k_{j,t} + \mu^W_{j,t}$$

$$(3') \; H_{j,t+1} - H_{j,t} = I^H + \frac{\alpha\delta}{1+\alpha\rho\delta}\sum_k\left(\beta^k_A + \beta^k_C\right)X^k_{j,t} + \mu^W_{j,t}$$

where I^i for i=N, W, Q is an intercept term that is constant across cities, and $\mu^i_{j,t}$ is an error term, which has a zero mean and is orthogonal to the $X^k_{j,t}$ terms as long as the underlying error terms, $\varepsilon^i_{j,t}$, also are mean zero and orthogonal to the $X^k_{j,t}$ terms.

Equation (1'), (2') and (3') allow us to use the differences in the coefficients from population, wage and price growth regressions to determine the values of δ and ρ for any $X^k_{j,t}$ variable. The intuition behind this claim is that if a variable increases population and prices, but not wages, then the variable itself reflects increasing consumption amenities. However, if the variable is correlated with increasing population and housing prices, more so than with wages, the implication is that the variable reflects increasing productivity.[5]

[5] More specifically, any $X^k_{j,t}$ that leads to an increase in consumption amenities will have effects equal to those shown in the second column of Table 6 multiplied by a factor of β^k_C. Similarly, an $X^k_{j,t}$ that leads to productivity increases will have an effect equal to that reported in the first column of Table 6 multiplied by β^k_A. Note also that the impact of productivity on housing prices is larger than the effect on wages because the ratio of the two effects is ρ, which should be less than 1. The intuition for this result is that, because land is not used in the production of goods, an increase in productivity will have the same impact on wages and rents. Since housing prices reflect the capitalization of all future rents, the net impact on housing prices will be larger.

Our primary interest is in the differences in housing supply across areas, which we model as differences in δ. Because the impact of productivity on population is decreasing in δ, we expect to see variables that raise productivity be associated with larger increases in population in places where housing supply is elastic (i.e., where δ is low). Conversely, the effect of a productivity shock on wages and housing prices will be smaller in these areas. In places where housing supply is inelastic, we expect to see variables that raise productivity be associated with relatively small increases in population, while the effects on wages and housing prices will be larger.[6]

IV. Estimation

In this section, we measure the elasticity of housing supply in different metropolitan areas and examine how it impacts urban growth outcomes. Our basic strategy is to estimate growth equations where changes in population, income and housing prices are regressed on variables reflecting productivity and amenity differences across areas. By allowing the relevant coefficients to differ across more and less regulated areas, we obtain estimates of the parameters to the underlying model and examine whether they can help explain key differences across locations as discussed above.

The regressions below use more direct measures of housing market regulation than the density measure employed above. New construction should respond readily to increases in demand in areas where housing markets are essentially unfettered. In housing markets

---

[6] Another useful set of predictions from this structure is that comparing the effects of productivity or amenity shocks on each of the outcome variables can provide estimates of δ and ρ. For example, the effect of an increase in productivity on changes in housing prices is $\frac{\alpha\delta}{1+\alpha\rho\delta}$, while the effect on changes in employment is $\frac{\alpha}{1+\alpha\rho\delta}$. Thus, the ratio of these two coefficients is δ. In the regressions below, we will take advantage of this relationship to estimate values of δ in low and high regulation metropolitan areas. An important advantage of using this method to estimate the elasticity of housing supply is that the parameter α cancels out of the ratio. Therefore, we can obtain estimates of δ even if there are differences in productivity (or α) across areas.

with binding development restrictions, new supply should be far more inelastic.[7] While there is no obvious proxy that is completely purged of demand side effects, housing market regulations seem to be a closer reflection of exogenous differences in the elasticity of housing supply. The drawback of using them is that they are difficult to measure because land use regulation itself has become so complex. There are many possible avenues or vehicles by which a project can be delayed or stopped: zoning boards, city councils, the court system, public health officials, wetlands conservation reviews, etc. The very richness of the regulatory environment means that there are no obvious laws that would allow us to pinpoint some metropolitan areas as being more onerously regulated compared with others. Moreover, it is not obvious that the rules on the books necessarily reflect the full extent of the zoning environment. While it is possible to use comparisons within a narrow geographic area to assess the impact of particular types of regulations (e.g., as in Katz and Rosen (1987)), comparisons across metropolitan areas are much more difficult.

Because measurement of the laws themselves is so difficult, past studies of zoning have focused on measuring the speed and ease of getting building approvals. For example, the Wharton land use control survey conducted by Linneman, et. al. (1990) describes the severity of the regulatory environment for 60 metropolitan areas. Indications of housing supply regulation include the length of time it takes to go through the zoning process and the probability of success of obtaining a permit. Although these variables still may reflect demand-related factors such as the number and quality of projects trying to get permitted, we believe that these concerns are far less severe than with less direct measures such as urban density.

Given our concerns about the survey evidence, we avoid using these measures as continuous variables. Instead, we group metropolitan areas into heavily and lightly zoned areas. To do this, we combine evidence from two separate surveys. The first is the Wharton survey, from which we use the answers to six questions about the regulatory

[7] A growing literature has documented a significant impact of these types of regulations on new construction and housing prices. For example, see Glaeser and Gyourko (2003), Glaeser, Gyourko, and Saks (2004), Malpezzi (1996), and Mayer and Somerville (2000).

environment.[8] The second is a survey of statewide regulations carried out by the American Institute of Planners (see Malpezzi (1996)).[9] These two surveys have a total of 54 metropolitan areas in common.

We create our regulatory index by adding up the survey responses after normalizing each to have a mean of zero and a variance of one. Our final measure is increasing in the amount of regulation, with a mean of -.02 and a variance of 2.1. However, the distribution is fairly discontinuous, with 24% of the metropolitan areas clustered within one third of a standard deviation of the median and a number of highly-regulated areas in a fairly large right tail. To reflect this discontinuity, we define highly-regulated areas as those with an index value greater than 0.5, which includes 38% of the sample. Because there is so much clustering around the median, we believe this break point creates a more reasonable distinction between the more and less regulated areas. Dividing the areas around the median would arbitrarily categorize many similar communities into different groups.

As an alternative method of classifying metropolitan areas by the degree of land use regulation, we also create a state-level index by taking the average of our metropolitan index for each state. We then classify all of the metropolitan areas in the state based on the state-wide average. Thus, metropolitan areas are considered highly regulated if they are in a state where other metropolitan areas are highly regulated. The disadvantages of this approach are obvious: there is heterogeneity within states that is deliberately obscured by this classification. This problem will be particularly extreme in large states like New York or California that combine both restrictive and non-restrictive areas.

---

[8] These questions are: the average length of time for re-zoning permits to be approved, the average length of time for subdivision permits to be approved, the fraction of zoning applications approved, a rating of the adequacy of the provision of infrastructure for growth needs, a rating of the importance of regulation in the development process, and the amount of impact fees per housing unit.

[9] The regulations that make up this index are: comprehensive land use planning, coastal zone management plans, wetlands management regulations, floodplain management, designation of some locations as "critical" for land use regulation, enabling legislation for "new towns," requirement for environmental impact statements, and regulations preempting local regulations for "developments of greater than local impact."

There are, however, two advantages to this approach that, in our opinion, outweigh this cost. First, by using the state average, the sample size increases by a factor of four, from 54 to 251 metropolitan areas.[10] Furthermore, the state average will capture general legal or political aspects that pertain to the whole state. For those cities that are not specifically covered by either of the two surveys, this measure will be free from some of the endogeneity problems created by using time-to-permit and other potentially demand-influenced measures. Indeed, within-state heterogeneity and mismeasurement of the regulatory environment in a particular metropolitan area should bias us against finding any impact of this regulation variable.

We begin by estimating models suggested by equations (1'), (2') and (3'), where changes in the logarithm of population, per capita income and housing prices are regressed on metropolitan-level characteristics that predict economic growth. Initially, separate equations are estimated for high regulation and low regulation areas using the larger sample of 251 MSAs. Then, we limit the sample to MSAs where we actually actual survey-based measures of the regulatory environment.

Two different city-level characteristics that predict economic growth are employed. First, we follow Bartik (1991) and use the industrial composition in the area multiplied by the growth in the industry over the subsequent decade. This measure predicts the extent that employment in the area would have grown if its composition had stayed at its 1990 levels and if the area's industries had grown at exactly the same rate as those industries had nationally. Industries are defined at the level of 2-digit SIC codes from county-level data and aggregated to the metropolitan level using 1990 MSA definitions. Second, we follow Glaeser and Saiz (2003) and use the initial share of adults with at least a bachelor's degree as a predictor of local economic growth. Housing prices are measured using the median housing price from the 1990 Census as a base and

[10] The reason why there are only 251 metropolitan areas instead of the full 318 in the United States is that we do not have estimates of the regulatory index for every state.

extrapolating this level to the year 2000 with the MSA-specific constant-quality price indexes published by the Office of Federal Housing Enterprise Oversight.[11]

The top panel of Table 7 reports estimates from specifications in which regulation is defined by state averages. The entry in the first row and first column shows that the Bartik-type labor demand variable strongly predicts population growth among low regulation metropolitan areas. In fact, the coefficient is quite close to one, suggesting that for these areas, population rises proportionately with predicted labor demand. The results for metropolitan areas in high regulation states are quite different (see row 2 of column 1). The coefficient on the labor demand variable is one-fifth of the size of the coefficient in the low regulation states and is statistically indistinguishable from zero. As shown in the third row of the first column, these two coefficients are statistically different from one another

.

Column 2 of this panel reports results for the impact of the labor demand variable on income per capita in high versus low regulation areas. The impact of the labor demand variable is three times larger in high regulation areas, but the coefficients are statistically different only at the 10 percent level. Still, these results match the predictions of the model. In places where housing supply is elastic, increases in labor demand are associated with relatively small increases in wages and relatively large increases in population. In contrast, increases in labor demand are associated with large increases in wages and small increases in population in places where housing is in inelastic supply.

[11] There are two advantages to using the OFHEO price indexes instead of Census data on median housing values or rents. Because the definition of metropolitan areas changed between 1990 and 2000, median housing values in some expanding places in 2000 will reflect a larger geographic area than in 1990. If the average housing price is lower in the outlying regions of a metropolitan area, the overall change in the median housing value will be biased downward. Another problem with using the Census data is that a portion of the change in housing values will reflect changes in the quality of housing, which could differ systematically across metropolitan areas. Neither of these problems are present in the OFHEO price indexes because the definitions of metropolitan areas remain constant over time. Also, housing price changes are calculated from repeated sales of the same house, which avoids the bulk of the concerns about changes in quality. Nevertheless, the results we present below are not materially different from those obtained when using median housing values instead of the OFHEO price indexes.

The impact of the labor demand variable on changes in housing prices is documented in the final column of Table 7. The pattern of coefficients is again exactly that predicted by the model. Labor demand strongly increases housing prices in highly regulated states and has a much weaker impact in less regulated areas. The coefficient is almost four times higher in the more regulated places. However, these coefficients are very imprecisely estimated so that we cannot conclude they are statistically different from one another at anything approaching standard confidence levels.

The bottom panel of Table 7 reports results using the initial share of the adult population with college degrees to reflect productivity differences. Column one shows that this variable statistically significantly predicts population growth in the relatively unregulated areas. While this coefficient is nearly 50% larger than in highly regulated areas, the difference between the coefficients is not statistically significant (see the bottom row of the table). Looking at the impact of human capital on the growth in wages and housing prices in the second and third columns finds all four coefficients statistically significant and positive. Furthermore, the coefficients in the highly regulated areas are much larger than in the less regulated areas and, in both cases, the difference between the coefficients is statistically significant. Thus, in more regulated areas, high human capital has a stronger impact on income and housing price growth and a weaker impact on population growth. Overall, the pattern of coefficients is supportive of the model, suggesting the significant role that housing supply plays in mediating local economic growth.[12]

Next, we examine the implications of our estimates for the parameters of the model. If we assume that our labor demand and human capital variables operate solely by increasing productivity and not by increasing amenities, then comparing the coefficients across equations provides back-of-the-envelope estimates of δ and ρ. As can readily be determined by forming the ratio of the formulae in the 2nd and 3rd rows of column one in

[12] In Appendix Table A.1, we report analogous results using only those metropolitan areas where we have direct measures of housing market regulation. The pattern of coefficients is completely consistent with the pattern shown in Table 7. However, due to the smaller sample sizes, the differences between coefficients are almost never statistically significant. Only in the case of the population growth regressions using the human capital measure can we reject the null hypothesis that the two coefficients are equal and then only at the ten percent level.

Table 6, the ratio of the coefficients in the income and housing regressions gives us an estimate of ρ, the extent to which higher housing prices translate into higher user costs of housing. When using predicted changes in labor demand, ρ=0.21 in low regulation areas and ρ=0.17 in high regulation areas. When measuring productivity with the share of the adult population with a bachelor's degree, the analogous computation yields a ρ=0.11 for low regulation areas and ρ=0.06 for high regulation areas.[13]

The value of δ can be inferred by the ratio of the coefficient on the productivity control in the house price growth regression to that in the population growth regression (i.e., compute the ratio of the term in the third row of column one of Table 6 to that in the first row of the first column). The implied values of δ are 52,788 (~54,899/1.04)and 1,023,560 (~204,730/0.20) in the two labor demand regressions, and 133,783 (~8,027/.06) and 923,200 (~36,928/.04) in the two human capital regressions. The economic interpretation of these numbers is that they reflect the amount that housing prices rise with a 1 log point (approximately 100 percent) increase in the population density of the metropolitan area. Thus, an estimated value of δ equal to 1 million means that if the density of the city rises by 10 percent, housing prices will rise by about $100,000. From our perspective, the important point is the vast difference between the high and low regulation areas. In the low regulation areas, a ten percent increase in city population appears to raise housing costs by between $5,000 and $13,000. In high regulation areas, a ten percent increase in city population raises housing costs by about $100,000. Thus, the impact in highly-regulated metropolitan areas is about ten times higher.

A more statistically precise way to estimate δ is to combine the equations in a joint system and restricting ρ to some reasonable value. Table 8 reports estimated values of δ using this procedure when ρ=0.15 (the midpoint of the range of estimates from

[13] In terms of gauging the sensibility of these results, the estimates using the college graduate share of the population to measure productivity are close in sizes to published estimates of the user cost of housing (e.g., see Peiser and Smith (1985) who report an estimate of about 8% or 0.08). User costs do change over time for a variety of reasons, and Poterba (1992) reports higher numbers, so that even the estimates based on predicted changes in labor demand are not completely out of reasonable range.

above).[14] In low regulation areas, δ equals about 75,000 and 137,000, respectively. Our estimates of δ in high regulation areas equal 499,000 and 1.4 million. While we again find large differences between low and high-regulation areas, the estimates are imprecise enough that we cannot reject the hypothesis that the housing supply elasticities are equal in the two areas. In future work, we hope to explore other methods that will allow us to estimate these coefficients more precisely.

Finally, amenity shocks, rather than productivity differences, are used to identify the parameters of the model. One measure of the value of living in different geographic locations is the climate, and we use mean January temperature to reflect amenity differences across locations. Because the climate has not changed significantly over the past decade, this variable is perhaps more naturally a determinant of the level of an amenity rather than a change in an amenity. Therefore, we begin by estimating the model from the levels of log(population), housing prices and income. As long as mean January temperature is exogenous (i.e., not correlated with omitted variables), the coefficients based on estimating equations (1) –(3) should yield the same estimates as (1')-(3'). For comparison we also estimate the equations in changes, which does require the assumption that the value of warmer January temperatures increased during the past decade. Whether in levels or changes, the predictions of the model are that amenities will have a positive impact on population and housing prices and a negative impact on income. The model also predicts that the magnitudes of the effects on population and income will be smaller in more regulated areas, and that the effects on housing prices will be larger.

Table 9 reports the impact of mean January temperature using our full set of 251 metropolitan areas. The top panel shows the results in levels; the bottom panel shows the results in changes. As before, we begin by estimating separate equations for each dependent variable and each type of metropolitan area. The first column shows the

[14] To be specific, a joint system of three equations with changes in population, real income per capita, and real housing prices as the dependent variables is estimated. The independent variables in each equation are the productivity shock (either predicted changes in labor demand or the share of college educated), an indicator for highly regulated areas, and the interaction between the two. Then, δ is calculated after imposing the nonlinear restriction that the ratio of the coefficient on the productivity shock in the housing price equation to the same coefficient in the wage equation must equal 0.15.

impact of the logarithm of January temperature on the logarithm of the population. In the levels regressions, higher temperatures are associated with relatively greater population in high regulation areas. This result is contrary to the basic theory, but the difference between the coefficients is small and statistically insignificant. Using population growth (column one of the bottom panel), the difference between the two areas goes in the expected direction, although it, too, is not statistically meaningful. In the regression using income per capita as the dependent variable, we find that higher temperatures are associated with lower levels of income in low regulation areas, as expected. Although the effect is less negative in high-regulation areas, it is so much larger that the point estimate is positive. However, the standard errors are large enough that neither of these estimates is significantly different from zero, so all we can say here is that the results are not inconsistent with the model.

Turning to the effects on housing prices in column three, we find that temperature raises housing prices in high regulation areas, but reduces housing prices in low regulation areas. In the case of the level regressions, the differences are statistically significant (top panel). Although the signs of these differences go in the expected direction (housing prices react more to positive amenities in highly-regulated areas), the negative impact in low-regulation areas is a bit disturbing. One possible explanation is that higher January temperatures actually make construction easier, which would imply that this amenity shock is correlated with the housing supply. Another possibility is that this variable could be correlated with omitted productivity variables.[15] Further investigation of this issue is an important topic for future research.

Generally, the results reported in this section show that population, income, and housing prices behave differently in low regulation and high regulation metropolitan areas. Although we do not yet fully understand the channels through which the amenity variable is impacting urban development, it seems clear that the housing supply matters.

[15] Table A2 in the Appendix shows the results for the smaller set of metropolitan areas for which we observe direct measures of housing supply regulation. As before, the pattern of results is similar to that in the broader sample, with the coefficients being less precisely estimated.

V. Conclusion

Cities and regions are not just made up of people and firms, but of bricks and mortar as well. The growth and decline of a region's economy is mediated by the physical structure of the city. In declining cities, housing prices and incomes fall long before houses collapse. Until those houses collapse, population levels in cities remain high. Thus, cities decline slowly because housing and other infrastructure is durable.

Not only is the pace of urban decline determined by the durability of residential structures, but the growth of cities is determined by the elasticity of the supply of housing. In places where limited regulation and low density facilitate the construction of new homes, urban success is more likely to take the form of higher population levels. In contrast, in places with high density and high levels of regulation, urban success is more likely to leave population levels relatively unchanged. It is housing prices and income levels that rise in these places. Thus, it is impossible to understand that both Cambridge, MA, and Las Vegas, NV, were successful cities in the 1990s without recognizing that Cambridge faces an enormously restrictive building environment and Las Vegas does not.

The primary message of this paper is that housing and real estate cannot be seen as research areas apart from the mainstream of urban economics. Researchers who care about urban and regional growth must think about housing markets as well—and the nature of housing supply in particular. After all, firms in a region cannot expand employment without new homes to house new workers. Researchers who care about real estate and housing markets are likewise dependent on understanding the urban markets that determine prices. Moreover, it is important for researchers from both disciplines to recognize the crucial role that the housing supply plays in creating the differences that exist across urban America.

Selected References

Alonso, William (1964). *Location and Land Use.* Cambridge, MA: Harvard University Press.

Bartik, Timothy (1991). Who Benefits from State and Local Economic Development Policies?, Kalamazoo: W.E. Upjohn Institute for Employment Research.

Case, Karl and Christopher Mayer, "Housing Price Dynamics Within a Metropolitan Area," *Regional Science and Urban Economics*, Vol. 26.

Glaeser, Edward and Joseph Gyourko (2001). "Urban Decline and Durable Housing", NBER Working Paper #8598, November 2001-revised July 2004.

______________________________ (2003). "The Impact of Zoning on Housing Affordability", *Economic Policy Review,* Vol. 9, no 2 (June 2003): 21-39, Federal Reserve Bank of New York.

Glaeser, Edward, Joseph Gyourko and Raven Saks (2003). "Why Is Manhattan So Expensive? Regulation and the Rise in House Prices", NBER Working Paper 10134, November 2003—revised May 2004.

Glaeser, Edward and Albert Saiz (2003). "The Rise of the Skilled City", NBER Working Paper 10191.

Hwang, Min and John Quigley (2004). "Economic Fundamentals in Local Housing Markets: Evidence from U.S. Metropolitan Regions," Unpublished Working Paper, February 2004.

Kain, John (1962). "The Journey to Work as a Determinant of Residential Location", *Papers of the Regional Science Association*, IX: 137-160.

_________ (1968a). "Housing Segregation, Negro Employment, and Metropolitan Decentralization", *Quarterly Journal of Economics*, Vol. 82, no. 2: 175-197.

_________ (1968b). "The Distribution and Movement of Jobs and Industry" in James Q. Wilson (ed) *The Metropolitan Enigma*. Cambridge, MA: Harvard University Press.

__________(2000). "Racial and economic segregation in US metropolitan areas," in Oxford Handbook of Economic Geography, Gordon L. Clark, Maryann P. Feldman, and Meric S. Gertler eds. New York : Oxford University Press, 2000.

Kain, John and John Quigley. *Housing Markets and Racial Discrimination: A Micro Economic Analysis.* New York, NY: Columbia University Press.

Katz, Lawrence and Kenneth Rosen. "The Interjurisdictional Effects of Growth Controls on Housing Prices", *Journal of Law & Economics*, Vol. 30, no. 1 (1987): 149-160.

Linneman, Peter, Anita Summers, Nancy Brooks, and Henry Buist (1990). "The State of Local Growth Management", Wharton Real Estate Center Working Paper No. 81, The Wharton School, University of Pennsylvania.

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

Mayer, Christopher J. and C. Tsuriel Somerville (2000). "Land Use Regulation and New Construction," *Regional Science and Urban Economics*, Vol. 30, .

Mills, Edwin (1967). "An Aggregative Model of Resource Allocation in a Metropolitan Area", *American Economic Review*, LVII(2): 197-210.

Moretti, Enrico (2004a). "Human Capital Externalities in Cities" in J.V. Henderson and J-F. Thisse (eds) *Handbook of Urban and Regional Economics*, Vol. 4. Amsterdam: North-Holland.

____________ (2004b). "Workers' Education, Spillovers, and Productivity: Evidence from Plant-Level Production Functions", *American Economic Review*, Vol. 94, no. 3: 656-690.

Muth, Richard (1969). *Cities and Housing*. Chicago: University of Chicago Press.

Peiser, Richard and Lawrence Smith (1985). "Homeownership Returns, Tenure Choice and Inflation", *American Real Estate and Urban Economics Association Journal*, Vol. 13 (Winter): 343-60.

Poterba, James (1992). "Taxation and Housing: Old Questions, New Answers," *American Economic Review*, Vol. 82, no. 2: 237-242.

R. S. Means. *Residential Cost Data, 19th Annual Edition*, R.S. Means Company, 2000.

_________. *Square Foot Costs, 21st Annual Edition*, R.S. Means Company, 2000.

Roback, Jennifer (1982). "Wages, Rents, and the Quality of Life", *Journal of Political Economy*, Vol. 90, no. 6: 1257-78.

Saks, Raven (2003). "From New York to Phoenix: Housing Supply Restrictions Across the United States". Harvard University Economics Department Working Paper, December 2003.

Table 1: City Housing and Population Since 1970—Levels and Changes		
Levels: Log Housing Units$_t$ = α_t + βLog Population$_t$ + ε_t		
Year (t)	β (standard error)	R^2
1970	1.016 (0.006)	0.99
1980	1.008 (0.006)	0.99
1990	0.995 (0.007)	0.98
2000	0.972 (0.008)	0.98
Changes: Log Change Housing Units$_t$ = α_t + βLog Change Population$_t$ + ε_t		
Decade (t)	β (standard error)	R^2
1970-1980	1.012 (0.014)	0.94
1980-1990	0.860 (0.024)	0.81
1990-2000	0.774 (0.022)	0.80

Note: Sample includes 314 cities with full data in each year.

Table 2: Persons in Households Per Occupied Housing Unit	
Year	*Persons Per Occupied Unit (standard deviation)*
1970	3.03 (0.28)
1980	2.61 (0.23)
1990	2.53 (0.28)
2000	2.51 (0.34)

Notes: Authors's calculations from the decennial censuses. The sample includes 314 cities with at least 30,000 residents in 1970.

Table 3: **Loss from the Permanent Housing Stock** ***American Housing Survey* National Core Files** **Central City Data, 1985-1993**				
	1985-1987	1987-1989	1989-1991	1991-1993
Probability of Severe Damage or Permanent Loss	1.3%	1.4%	1.5%	1.8%

Notes: Authors' calculations from the *American Housing Surveys*, 1985-1993. Observations are in identified central cities.

Table 4: Housing Unit Growth Cities With 100,000+ Residents			
1970-1980			
Bottom Five		Top Five	
St. Louis	-16.5%	Colorado Springs	64.1%
Detroit	-11.5%	Austin	53.7%
Cleveland	-9.8%	Albuquerque	52.2%
Buffalo	-6.0%	Stockton	48.4%
Pittsburgh	-5.8%	San Jose	46.4%
1980-1990			
Bottom Five		Top Five	
Newark	-16.9%	Las Vegas	49.1%
Gary	-14.5%	Raleigh	47.1%
Detroit	-14.0%	Virginia Beach	46.9%
Youngstown	-10.0%	Austin	39.3%
Dayton	-7.7%	Fresno	37.7%
1990-2000			
Bottom Five		Top Five	
Gary	-10.5%	Las Vegas	53.5%
Hartford	-10.3%	Charlotte	28.8%
St. Louis	-10.2%	Raleigh	25.0%
Youngstown	-9.6%	Austin	22.3%
Detroit	-9.3%	Winston-Salem	21.3%

Data source: Decennial censuses for 1970, 1980, 1990, 2000. Housing units defined to include owner-occupied and rental units.

Table 5: Density and Growth in Population, Incomes, and House Prices in the 1990s			
Independent Variables	*Dependent Variable*		
	Log Change City Population, 1990-2000	Log Change Median House Price, 1990-2000	Log Change Median Household Income, 1990-2000
College Grad Share, 1990	1.59** (0.41)	1.24** (0.55)	-0.75** (0.23)
Log Density, 1990 (log persons per square mile)	-0.03** (0.01)	0.03* (0.02)	-0.04** (0.01)
College Grad Share*Log Density, 1990	-0.20** (0.05)	-0.07 (0.07)	.11** (.03)
Log Median Household Income, 1990	0.06** (0.02)	0.20** (0.03)	-0.03** (0.01)
Log Population, 1990	0.013** (0.006)	0.004 (0.008)	0.006* (0.003)
Log Median House Price, 1990	0.05** (0.012)	-0.36** (0.02)	-0.03** (0.01)
Intercept	-1.02** (0.20)	1.93** (0.27)	1.20** (0.11)
# of Observations	976	976	976
R^2	0.13	0.46	0.17

Notes: Standard errors in parentheses. ** indicates significance at the 95% level or better; * indicates significance at the 90% level or better. Sample includes 976 cities with at least 30,000 residents in 1990 and no significant boundary changes between 1990 and 2000. Boundary changes are identified as places with changes in area less than –10% or greater than 50%.

Table 6: Predicted Effects of Productivity and Amenities on Urban Growth

	Productivity (A_j)	Amenities (C_j)
Ln(Population)	$\frac{\alpha}{1+\alpha\rho\delta}$	$\frac{\alpha}{1+\alpha\rho\delta}$
Wages	$\frac{1}{1+\frac{1}{\alpha\rho\delta}} = \frac{\alpha\rho\delta}{1+\alpha\rho\delta}$	$-\frac{1}{1+\alpha\rho\delta}$
Housing prices	$\frac{1}{\rho}\frac{1}{1+\frac{1}{\alpha\rho\delta}} = \frac{\alpha\delta}{1+\alpha\rho\delta}$	$\frac{1}{\rho}\frac{1}{1+\frac{1}{\alpha\rho\delta}} = \frac{\alpha\delta}{1+\alpha\rho\delta}$

Note. Each cell shows the effect of a 1-unit increase in either productivity or amenities on each of the variables in the left-hand column. See the text and equations (1)-(3) for details.

Table 7: Effects of Productivity Shocks on Changes in Income/Capita, Housing Prices and Population, 1990-2000

	ΔLn(Population)	Δ Income/capita	Δ Housing prices
Labor Demand			
Low Regulation	1.04	11,597	54,899
	(.28)	(3,917)	(37,478)
High Regulation	.20	34,651	204,730
	(.30)	(13,007)	(137,972)
Test low=high[1]	-2.03	1.71	1.06
	(.04)	(.09)	(.29)
Share of Population with Bachelors Degree[2]			
Low Regulation	.06	850	8,027
	(01)	(274)	(3,682)
High Regulation	.04	2,246	36,928
	(.03)	(552)	(7,761)
Test low=high[1]	-.57	2.28	3.40
	(.57)	(.02)	(.00)

Note. Each cell shows results from a separate regression. There are 179 low-regulation metropolitan areas and 72 high-regulation metropolitan areas. All regressions correct for heteroskedasticity using the White estimator.

1. T-test that the effect of a productivity shock is the same in high and low regulation metropolitan areas. P-values are shown in parentheses.
2. Share of population with a BA degree in 1990. All regressions control for the level of income per capita in 1990.

Table 8: Implied Estimates of δ

	Labor Demand	Share of Population with Bachelors Degree
Low Regulation	74,790 (59,231)	137,059 (46,531)
High Regulation	1,404,023 (3,592,845)	498,879 (251,279)
Test low=high	.14 (.71)	2.00 (.16)

Note. Coefficients are obtained by estimating all three equations simultaneously and imposing ρ=.15. The test that δ is the same across areas is a chi-squared test with 1 degree of freedom. P-values are shown in parentheses.

Table 9: Effects of Amenity Shocks on Income/Capita, Housing Prices and Population, 1990-2000.

	Ln(Population)	Income/capita	Housing prices
Levels			
Low Regulation	.36	-2,451	-9,742
	(.21)	(917)	(4,227)
High Regulation	.41	950	77,443
	(.33)	(1,827)	(23,365)
Test low=high[1]	.15	1.67	3.71
	(.89)	(.10)	(.00)
Changes			
Low Regulation	.011	-93	-899
	(.001)	(27)	(201)
High Regulation	.007	40	357
	(.003)	(92)	(865)
Test low=high[1]	-1.19	1.41	1.43
	(.24)	(.16)	(.16)

Note. Each cell shows results from a separate regression. The rows in the upper panel use the levels of ln(population), income per capita and housing prices as the dependent variable. The rows in the bottom panel use changes in each of these measures as the dependent variable. In each case, the amenity shock is the logarithm of mean January temperature. There are 179 low-regulation metropolitan areas and 72 high-regulation metropolitan areas. All regressions correct for heteroskedasticity using the White estimator.

1. T-test that the effect of the amenity shock is the same in high and low regulation metropolitan areas. P-values are shown in parentheses.

Appendix Tables: Effects of Productivity and Amenity Shocks for the Subset of MSAs with Observable Measures of Housing Supply Regulation

Table A1
Effects of Productivity Shocks on Changes in Income/Capita, Housing Prices and Population, 1990-2000.

	ΔLn(Population)	Δ Income/capita	Δ Housing prices
Labor Demand			
Low Regulation	1.92	28,529	135,846
	(1.15)	(14,000)	(218,547)
High Regulation	.75	45,035	263,510
	(.96)	(40,453)	(258,726)
Test low=high[1]	-.78	.39	.38
	(.44)	(.70)	(.71)
Share of Population with Bachelors Degree[2]			
Low Regulation	.25	3,158	12,294
	(.06)	(1,254)	(23,896)
High Regulation	.08	5,976	44,812
	(.07)	(2,188)	(21,529)
Test low=high[1]	-1.87	1.13	1.01
	(.07)	(.26)	(.32)

Note. Each cell shows results from a separate regression. There are 33 low-regulation metropolitan areas and 21 high-regulation metropolitan areas. All regressions correct for heteroskedasticity using the White estimator.
1. T-test that the effect of a productivity shock is the same in high and low regulation metropolitan areas. P-values are shown in parentheses.
2. Share of population with a BA degree in 1990. All regressions control for the level of income per capita in 1990.

Table A2
Implied Estimates of δ

	Labor Demand	Share of Population with Bachelors Degree
Low Regulation	83,830 (111,618)	65,187 (59,022)
High Regulation	377,193 (456,687)	551,555 (396,975)
Test low=high	.39 (.53)	1.47 (.23)

Note. Coefficients are obtained by estimating all three equations simultaneously and imposing that ρ=.15. The test that δ is the same across areas is a chi-squared test with 1 degree of freedom. P-values are shown in parentheses.

Table A3
Effects of Amenity Shocks on Income/Capita, Housing Prices
and Population, 1990-2000

	Ln(Population)	Income/capita	Housing prices
Levels			
Low Regulation	.29	-3,356	-8,164
	(.28)	(1,281)	(10,477)
High Regulation	.57	5,454	106,680
	(.48)	(4,777)	(61,316)
Test low=high	.51	1.81	1.87
	(.62)	(.08)	(.07)
Changes			
Low Regulation	.017	-67	393
	(.005)	(74)	(763)
High Regulation	.009	215	373
	(.005)	(286)	(2051)
Test low=high	-1.16	.97	-.01
	(.25)	(.34)	(.99)

Note. Each cell shows results from a separate regression. The rows in the upper panel use the levels of ln(population), income per capita and housing prices as the dependent variable. The rows in the bottom panel use changes in each of these measures as the dependent variable. In each case, the amenity shock is the logarithm of mean January temperature. There are 33 low-regulation metropolitan areas and 21 high-regulation metropolitan areas. All regressions correct for heteroskedasticity using the White estimator.

1. T-test that the effect of a productivity shock is the same in high and low regulation metropolitan areas. P-values are shown in parentheses.

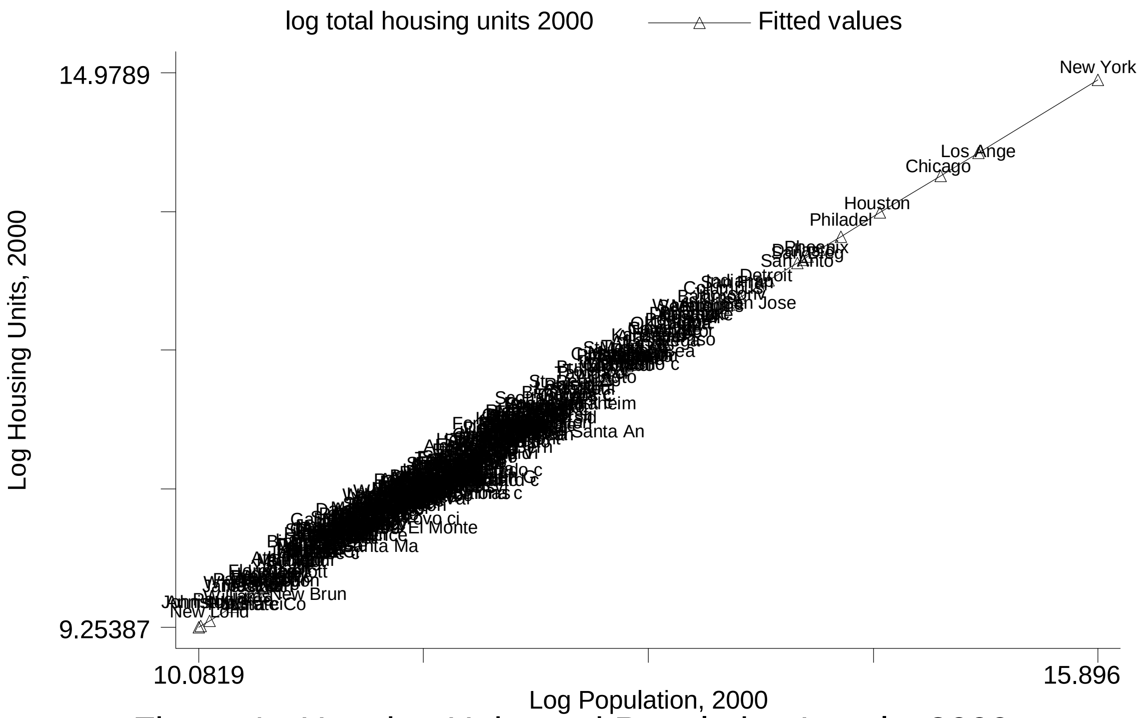


Figure 1: Housing Units and Population Levels, 2000

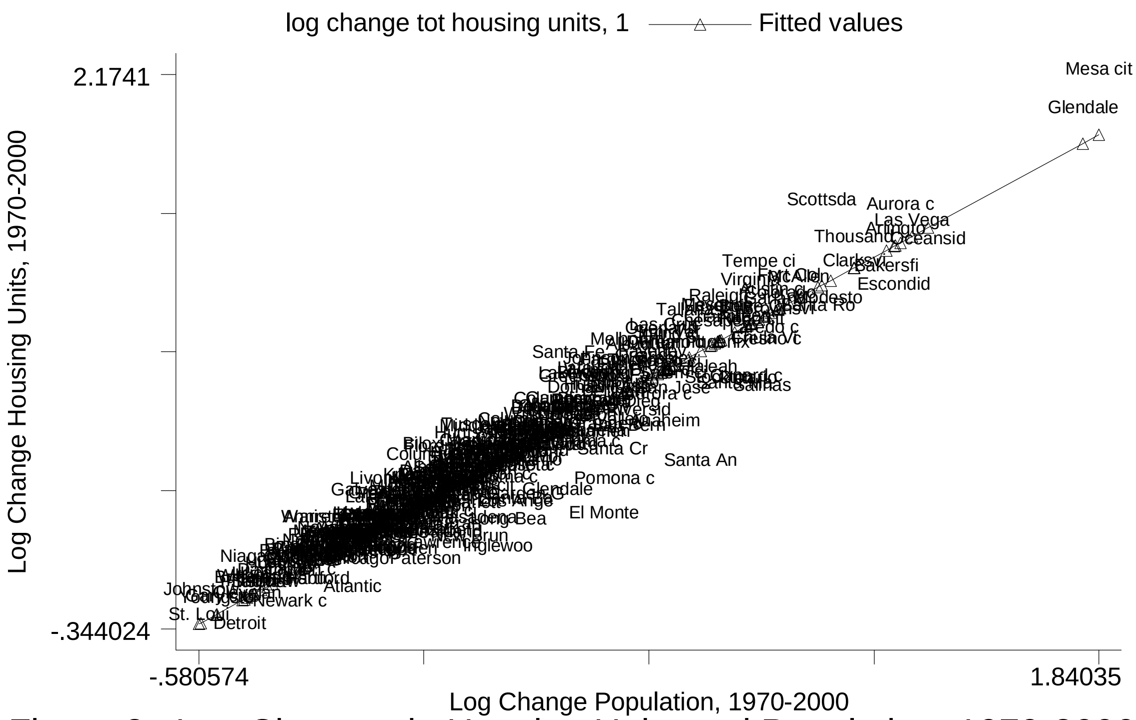


Figure 2: Log Changes in Housing Units and Population, 1970-2000

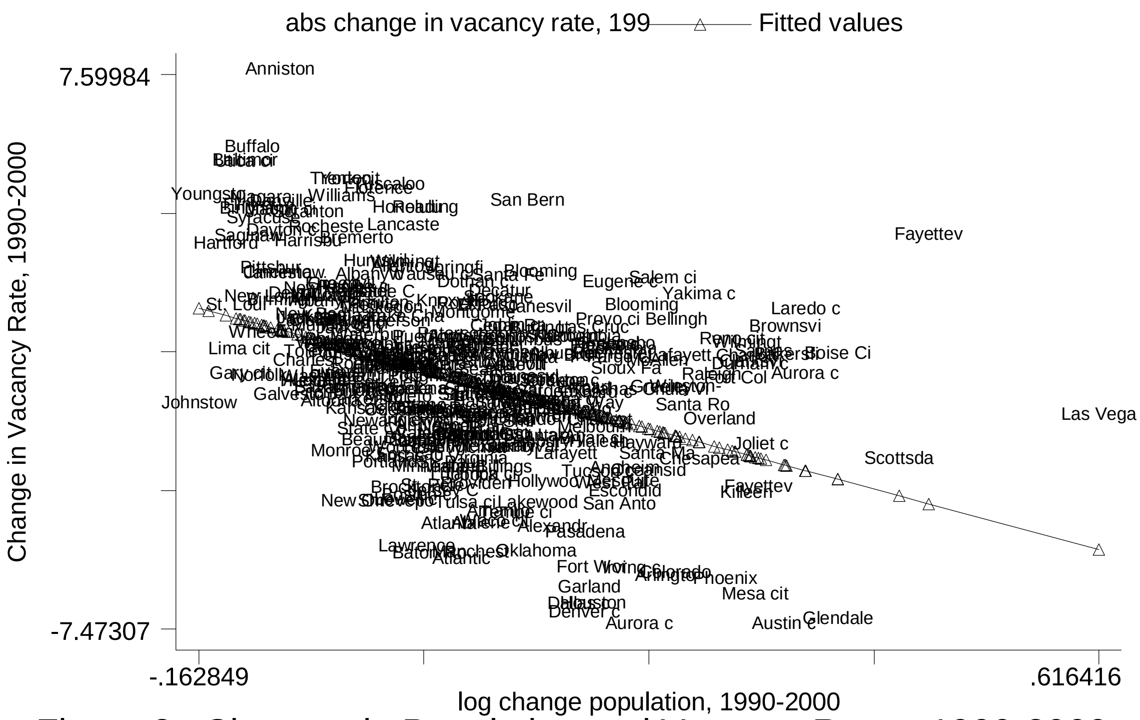


Figure 3: Changes in Population and Vacancy Rates, 1990-2000

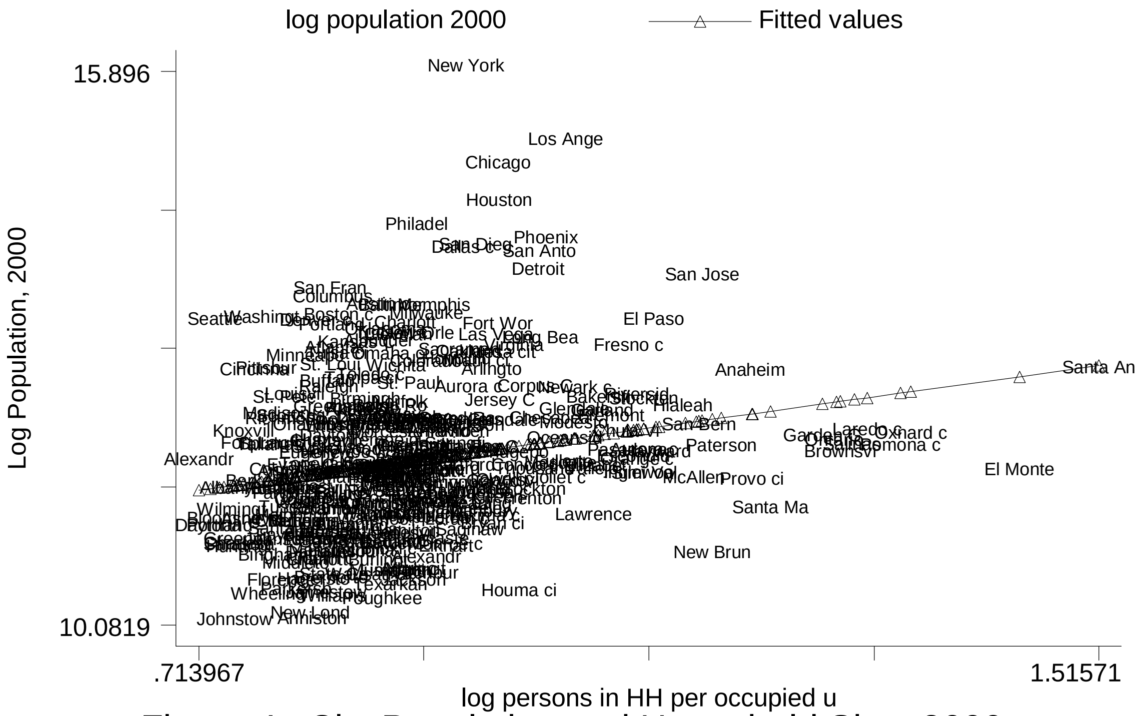
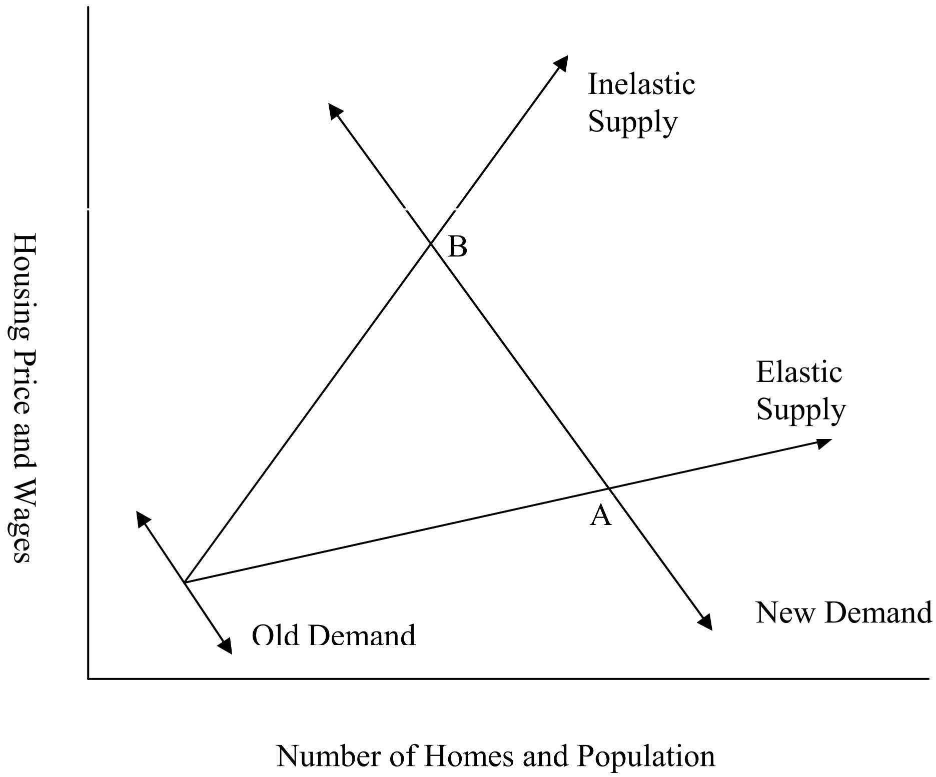


Figure 4: City Population and Household Size, 2000

Figure 5: The Nature of Housing Supply and the Impacts of Demand Shocks



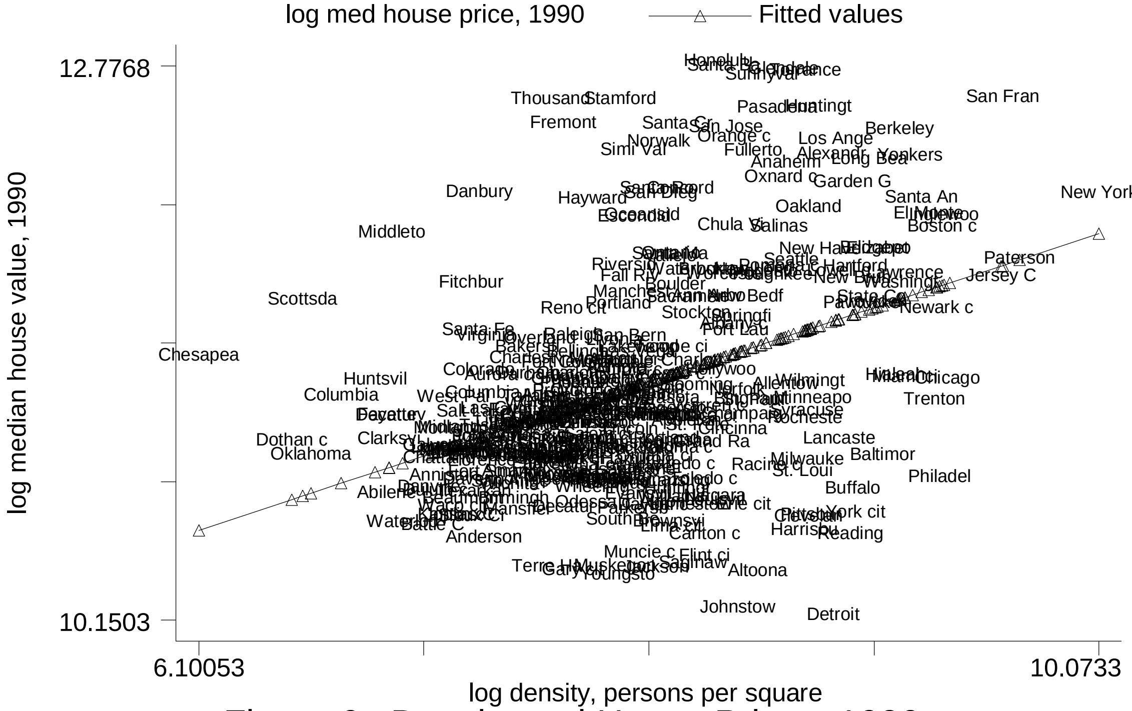


Figure 6: Density and House Prices, 1990