The Determinants and Welfare Implications of US Workers' Diverging Location Choices by Skill: 1980-2000

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Abstract

From 1980 to 2000, the rise in the U.S. college-high school graduate wage gap coincided with increased geographic sorting as college graduates concentrated in high wage, high rent cities. This paper estimates a structural spatial equilibrium model to determine causes and welfare consequences of this increased skill sorting. While local labor demand changes fundamentally caused the increased skill sorting, it was further fueled by endogenous increases in amenities within higher skill cities. Changes in cities' wages, rents, and endogenous amenities increased inequality between high-school and college graduates by more than suggested by the increase in the college wage gap alone.

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1 Introduction

The dramatic increase in the wage gap between high school and college graduates over the past three decades has been accompanied by a substantial increase in geographic sorting of workers by skill.[1] Metropolitan areas which had a disproportionately high share of college graduates in 1980 further increased their share of college graduates from 1980 to 2000. Increasingly high skill cities also experienced higher wage and housing price growth than less skilled cities (Moretti (2004*a*), Shapiro (2006)). Moretti (2012) coins this phenomenon "The Great Divergence."

These facts call into question whether the increase in the college wage gap reflects a similar increase in the college economic well-being gap. Since college graduates increasingly live in areas with high housing costs, local price levels might offset some of the consumption benefits of their high wages. The increase in wage inequality might overstate the increase in economic well-being inequality (Moretti (2013)). Alternatively, high housing cost cities may offer workers desirable amenities, compensating them for high house prices, and possibly increasing the well-being of workers in these cities. The welfare implications of the increased geographic skill sorting depend on why high and low skill workers increasingly chose to live in different cities.

This paper examines the determinants of high and low skill workers' choices to increasingly segregate themselves into different cities and the welfare implications of these choices. By estimating a structural spatial equilibrium model of local labor demand, housing supply, labor supply, and amenity supply in cities, I show that changes in firms' relative demands for high and low skill labor across cities, due to local productivity changes, were the underlying drivers of the differential migration patterns of high and low skill workers.[2] Despite local wage changes being the initial cause of workers' migration, I find that cities which attracted a higher share of college graduates endogenously became more desirable places to live and more productive for both high and low skill labor. The combination of desirable wages and amenities made college workers willing to pay high housing costs to live in these cities. While lower skill workers also found these areas' wages and amenities desirable, they were less willing to pay high housing costs, leading them to choose more affordable cities. Overall, I find that the welfare effects of changes in local wages, rents, and endogenous amenities led to an increase in well-being inequality between college and high school graduates which was *significantly larger* than would be suggested by the increase in the college wage gap alone.

To build intuition for this effect, consider the metropolitan areas of Detroit and Boston. The economic downturn in Detroit has been largely attributed to decline of auto manufacturing (Martelle (2012)), but the decline goes beyond the loss of high paying jobs. In 2009, Detroit public schools had the lowest scores ever recorded in the 21-year history of the national math proficiency test (Winerip (2011)). In contrast, Detroit's public school system was lauded as a model for the nation in urban education (Mirel (1999)) in the early 20th century when manufacturing was booming.

By comparison, Boston has increasingly attracted high skill workers with its cluster of biotech,

[1] This large increase in wage inequality has led to an active area of research into the drivers of changes in the wage distribution nationwide. See Goldin and Katz (2007) for a recent survey.

[2] Work by Berry and Glaeser (2005) and Moretti (2013) come to similar conclusions. Berry and Glaeser (2005) consider the role of entrepreneurship in cities. Moretti (2013) analyzes the differential labor demands for high and low skill workers across industries.

medical device, and technology firms. In the mid 1970s, Boston public schools were declining in quality, driven by racial tensions from integrating the schools (Cronin (2011)). In 2006, however, the Boston public school district won the Broad Prize, which honors the urban school district that demonstrates the greatest performance and improvement in student achievement. The prosperity of Boston and decline of Detroit go beyond jobs and wages, directly impacting the amenities and quality-of-life in these areas.

I illustrate these mechanisms more generally using U.S. Census data by estimating a structural spatial equilibrium model of cities. The setup shares features of the Rosen (1979) and Roback (1982) frameworks, but I extend the model to allow workers to have heterogenous preferences for cities. In addition to treating prices (both wages and housing costs) as endogenous, I allow the supply of amenities to respond to the skill-mix of the city. The fully estimated model allows me to assess the importance of changes in cities' wages, rents, and amenities in differentially driving high and low skill workers to different cities.

I use a static discrete choice setup to model workers' city choices. The model allows workers with different demographics to differentially trade off the relative values of cities' characteristics, leading them to make different location decisions.[3] Firms in each city use capital, high skill labor, and low skill labor as inputs into production. Housing markets differ across cities due to heterogeneity in their elasticity of housing supply.

The key distinguishing worker characteristic is skill, as measured by graduation from a 4-year college. Cities' local productivity levels differ across high and low skill workers, and the productivity levels of both high and low skill workers within a city can be impacted by the skill-mix in the city. Thus, changes in the skill-mix of a city will impact local wages both by moving along firms' labor demand curves and by directly impacting worker productivity.

A city's skill-mix is also allowed to influence local amenity levels. I create an index of observable amenities which endogenously respond to the skill-mix of the city. To capture as broad and inclusive measures of city amenities as possible, I collect data on fifteen different amenities which can be broadly bucketed into six different categories: the retail environment, transportation infrastructure, crime, environmental quality, school quality, and job quality. To combine these fifteen data sources into a single index of amenities, I use principal component analysis (PCA). The amenity index in each city should capture the bundle of amenities that endogenously respond to the demographics of cities' residents.

Workers' preferences for cities are estimated using a two-step estimator, similar to the methods used by Berry, Levinsohn and Pakes (2004) and the setup proposed by McFadden (1973). In the first step, a maximum likelihood estimator is used to identify how desirable each city is to each type of worker, on average, in each decade, controlling for workers' preferences to live close to their state of birth. The utility levels for each city estimated in the first step are used in the second step to estimate how workers trade off wages, rents, and amenities when selecting a location to live. The second step of estimation uses a simultaneous equation non-linear GMM estimator. Moment restrictions on

[3] Estimation of spatial equilibrium models when households have heterogeneous preferences using hedonics have been analyzed by Epple and Sieg (1999).

workers' preferences are combined with moments identifying cities' labor demand, housing supply, and amenity supply curves. These moments are used to simultaneously estimate local labor demand, housing supply, labor supply, and amenity supply to cities.

The model is identified using local labor demand shocks driven by the industry mix in each city and their interactions with local housing supply elasticities. Variation in productivity changes across industries differentially impact cities' local labor demand for high and low skill workers based on the industrial composition of the city's workforce (Bartik (1991)). I measure exogenous local productivity changes by interacting cross-sectional differences in industrial employment composition with national changes in industry wage levels separately for high and low skill workers.

I allow cities' housing supply elasticities to vary based on geographic constraints on developable land around a city's center and land-use regulations (Saiz (2010), Gyourko, Saiz and Summers (2008)). A city's housing supply elasticity will influence the equilibrium wage, rent, and population response to the labor demand shocks driven by industrial labor demand changes.

Workers' migration responses to changes in cities' wages, rents, and endogenous amenities driven by the Bartik labor demand shocks and the interactions of these labor demand shocks with housing supply elasticities identify workers' preferences for cities' characteristics.[4] Housing supply elasticities are identified by the response of housing rents to the Bartik shocks across cities. The interactions of the Bartik productivity shocks with cities' housing markets identify the labor demand elasticities.

The parameter estimates of workers' preferences show that while both college and non-college workers find higher wages, lower rents, and higher amenity levels desirable, high skill workers' demand is relatively more sensitive to amenity levels and low skill workers' demand is more sensitive to wages and rents.[5] Turning to labor demand, the combined estimates of firms' elasticity of labor substitution with the productivity spillovers show an increase in a city's college worker population raises *both* local college and non-college wages. An increase in a city's non-college worker population increases college wages, but decreases and non-college wages.

Using the estimated model, I decompose the changes in cities' college employment ratios into the underlying changes in labor demand, housing supply, and labor supply to cities. I show that changes in high and low skill labor demand across cities strongly predicts the differential migration patterns of high and low skill workers.

The model estimates can then quantify the change in well-being inequality. I find the welfare impacts due to wage, rent, and endogenous amenity changes from 1980 to 2000 led to an increase in well-being inequality equivalent to *at least* a 25 percentage point increase in the college wage gap, which is 30% *more* than the actual increase in the college wage gap. In other words, the additional utility college workers gained from of being able to consume more desirable amenities made them better off relative to high school graduates, *despite* the high local housing prices.

This paper is related to several literatures. Most closely related is work studying how local wages,

[4] Data from the Consumer Expenditure Survey is also used to help pin down households' expenditure shares on locally priced goods.

[5] These results are consistent with a large body of work in empirical industrial organization which finds substantial heterogeneity in consumers' price sensitivites. A consumer's price sensitivity is also found to be closely linked to his income. See Nevo (2011) for a review of this literature.

rents, and employment respond to local labor demand shocks (Topel (1986), Bartik (1991), Blanchard and Katz (1992), Saks (2008), Notowidigdo (2011). See Moretti (2011) for a review.) Traditionally, this literature has only allowed local labor demand shocks to influence worker migration through wage and rents changes.[6] My results suggest that endogenous local amenity changes are an important mechanism driving workers' migration responses to local labor demand shocks.

A growing literature has considered how amenities change in response the composition of an area's local residents (Chapter 5 in Becker and Murphy (2000), Bayer, McMillan and Rueben (2004), Bayer, Ferreira and McMillan (2007), Card, Mas and Rothstein (2008), Guerrieri, Hartley and Hurst (2013), Handbury (2012)). Work by Bayer, McMillan and Rueben (2004) and Bayer, Ferreira and McMillan (2007) study residential sorting patterns at the neighborhood level using a similar discrete choice setup and estimate households' preferences for neighbors' socio-demographics.

My findings also relate to the literature studying changes in the wage structure and inequality within and between local labor markets (Berry and Glaeser (2005), Beaudry, Doms and Lewis (2010), Black, Kolesnikova and Taylor (2009), Moretti (2013), Autor and Dorn (2013), Autor, Dorn and Hanson (2013)). Most related to this paper is Moretti (2013), who is the first to show the importance of accounting for the diverging location choices of high and low skill workers when measuring both real wage and well-being inequality changes.

Another strand of this literature, most specifically related to my labor demand estimates, studies the impact of the relative supplies of high and low skill labor on high and low skill wages (Katz and Murphy (1992), Card and Lemieux (2001), Card (2009)). Card (2009) estimates the impact of local labor supply on local wages in cities. My paper presents a new identification strategy to estimate city-level labor demand and allows for endogenous productivity changes. Further, my findings show that an increase in a city's education level also spills over onto all workers' well-being through endogenous amenity changes.

The labor supply model and estimation draws on the discrete choice methods developed in empirical industrial organization (McFadden (1973), Berry, Levinsohn and Pakes (1995), Berry, Levinsohn and Pakes (2004)). These methods have been applied to estimate households' preferences for neighborhoods by Bayer, Ferreira and McMillan (2007). My paper adapts these methods to estimate the determinants of workers' labor supply to cities.[7] Heterogenous preferences for amenities has been discussed in the context of spatial equilibrium previously by Roback (1988) and Beeson (1991), however these papers did not focus on estimation of these preferences.

The rest of the paper proceeds as follows. Section 2 discusses the data. Section 3 presents reduced form facts. Section 4 lays out the model. Section 5 discusses the estimation techniques. Section 6 presents parameter estimates. Section 7 discusses the estimates. Section 8 analyzes the determinants of cities' college employment ratio changes. Section 9 presents welfare implications. Section 10 concludes.

[6] Notowidigdo (2011) allows government social insurance programs in a city to endogenously respond to local wages, which is one of many endogenous amenity changes.

[7] Similar methods have been used by Bayer, Keohane and Timmins (2009), Bishop (2010), and Kennan and Walker (2011) to estimate workers' preferences for cities. However, these papers do not allow local wages and rents to be freely correlated with local amenities. Bayer, Keohane and Timmins (2009) focuses on the demand for air quality, while Bishop (2010) and Kennan and Walker (2011) study the dynamics of migration over the life-cycle exclusively for high school graduates.

2 Data

The paper uses the 5 percent samples of the U.S. Censuses from the 1980, 1990, and 2000 Integrated Public Use Microdata Series (IPUMS) (Ruggles et al. (2010)). These data provide individual level observations on a wide range of economic and demographic information, including wages, housing costs, and geographic location of residence. All analysis is restricted to 25-55 year-olds working at least 35 hours per week and 48 weeks per year.[8] The geographical unit of analysis is the metropolitan statistical area (MSA) of residence, however I interchangeably refer to MSAs as cities. The Census includes 218 MSAs consistently across all three decades of data. Rural households are not assigned to an MSA in the Census. To incorporate the choice to live in rural areas, all areas outside of MSAs within each state are grouped together and treated as additional geographical units.[9]

The IPUMS data are also used to construct estimates of local area wages, population, and housing rents in each metropolitan and rural area. A key city characteristic I focus on is the local skill mix of workers. I define high skill or college workers as full-time workers who have completed at least 4 years of college, while all other full-time workers are classified as low skill or non-college. Throughout the paper, the local college employment ratio is measured by the ratio of college employees to non-college employees working within a given MSA. I use a two skill group model since the college/non-college division is where the largest divide in wages across education is seen, as found by Katz and Murphy (1992) and Goldin and Katz (2008).

To capture how amenities have changed across cities over time, I have collected a diverse set of data on cities' local amenities. I categorized the amenities into six broad categories: retail amenities, transportation amenities, crime amenities, environmental amenities, schooling amenities, and job quality amenities. Retail amenities capture the breadth and diversity of the retail and entertainment environment within cities and are measured by apparel stores per capita, eating and drinking places per capita and movie theaters per capita. Transportation amenities capture the quality of public transit and road infrastructure. These data include busses per capita, an overall public transit index, and average daily traffic on interstates and major urban roads.[10] Crime amenity measures report both violent and property crimes per capita. Environmental amenities include per capita government spending on parks and recreation and the EPA's air quality index. School quality measures include government spending on K-12 education per pupil and average student teacher ratios within public K-12 schools. The quality of the local job market is measured by the employment to population ratio of 25-55 year-olds and the number of patents issued per capita from the NBER patent database(Jaffe, Trajtenberg and Henderson (1993)). Higher patenting per capita likely indicates more interesting jobs for workers, as well as possibly expected future wage growth as these patents might bring future profits to these firms. A higher employment to population ratio suggests that finding a job is easier.

For additional city characteristics, I supplement these data with Saiz (2010)'s measures of geographic constraints and land use regulations to measure differences in housing supply elasticities.

[8] Workers with positive business or farm income are also dropped from the analysis. Results are unchanged when including these workers.

[9] Households living in MSAs which the census does not identify in all 3 decades are included as residents of states' rural areas.

[10] These data come from (Duranton and Turner (2011)).

Table 1 reports summary statistics for these variables. Appendix A contains remaining data and measurement details.

3 Descriptive Facts

From 1980 to 2000, the distribution of college and non-college workers across metropolitan areas was diverging. Specifically, a MSA's share of college graduates in 1980 is positively associated with larger growth in its share of college workers from 1980 to 2000. Figure 1.A shows a 1% increase in a city's college employment ratio in 1980 is associated with a .17% larger increase in the city's college employment ratio from 1980 to 2000. This fact has also been documented by Moretti (2004*a*), Berry and Glaeser (2005), and Moretti (2013).

The distribution and divergence of worker skill across cities are strongly linked to cities' wages and rents. Figure 1.B shows a 1% increase in the local college employment ratio is associated with a .70% increase in local rents. Further, the relationship between rent and college employment ratio is quite tight. Variation in cities' college employment ratio changes can explain 49% of the variation of rent changes across cities.

Cities' local wages have a similar, but less strong relationship with the local college employment ratio. Figure 1.C plots changes in local college employment ratios against changes in local non-college wages from 1980 to 2000. A 1% increase in college employment ratio is associated with a 0.24% increase in non-college wages. Low skill workers were both initially and increasingly concentrating in low wage cities.

Figure 1.D shows that a 1% increase in a city's college employment ration is associated with a 0.30% increase in college wages. Additionally, college employment ratio changes can explain 36% of the variation in local college wage changes. College workers are increasingly concentrating in high wage cities and high skill wages are closely linked to a city's skill-mix. Moretti (2013) has also documented this set of facts and refers to them as "The Great Divergence" in Moretti (2012).

The polarization of skill across cities coincided with a large, nationwide increase in wage inequality. Table 8, along with a large body of literature, documents that the nationwide average college-high school graduate wage gap has increased from 38% in 1980 to 57% in 2000.[11]

Moretti (2013) points out that the increase in geographic skill sorting calls into question whether the rise in wage inequality represents a similar increase in well-being or "utility" inequality between college and high school graduates. Looking only at changes in workers' wages and rents, it appears the differential increases in housing costs across cities disproportionately benefited low skill workers. However, high skill workers were free to live in more affordable cities, but they chose not too. As Moretti (2013) notes, the welfare impacts of the changes in rents across cities depends crucially on why high and low skill workers elected to live in high and low housing price cities.

While wage differences across cities are a possible candidate for driving high and low skill workers to different cities, it is possible that the desirability of cities' local amenities differentially influenced

[11] This is estimated by a standard Mincer regression using individual 25-55 year old full time full year workers' hourly wages and controls for sex, race dummies, and a quartic in potential experience.

high and low skill workers' city choices. If college workers elected to live in high wage, high housing cost cities because they found the local amenities desirable, then the negative welfare impact of high housing costs would be offset by the positive welfare impact of being able to consume amenities.

Table 2 presents the relationships between changes in cities' college employment ratios from 1980 to 2000 and changes in a large set of local amenities. Increases in cities' college employment ratios are associated with larger increases in apparel stores per capita, eating and drinking places per capita, per pupil government spending on K-12 education, as well as larger decreases in pollution levels, traffic, busses per capita, and property crime rates. There are similar point estimates for movie theaters per capita, an index of public transit access, per capita government spending on parks and recreation, patents per capita, and the employment-to population ratio, but the estimates are not statistically significant.[12] It appears that the cities which increased their share of college graduates not only experienced larger increases in wages and rents, but also had larger increases in amenities.

To understand why college workers elected to live in high wage, high rent, high amenity cities, one needs causal estimates of workers' migration elasticities with respect to each one of these city characteristics. Further, the impact of changes in high and low skill worker populations on wages, rents, and amenities depends on the elasticities of local housing supply, local labor demand, and amenity supply. To gauge how this set of supply and demand elasticities interact and lead to equilibrium outcomes, it useful to view these elasticities through the lens of a structural model. Further, using a utility microfoundation of workers' city choices allows migration elasticities to be mapped to utility functions. The estimated parameters can then be used to quantify the welfare impacts of changes in wage, rents, and amenities.

4 An Empirical Spatial Equilibrium Model of Cities

This section presents a spatial equilibrium model of local labor markets that captures how wages, housing rents, amenities, and population are determined in equilibrium. The setup shares many features of the Rosen (1979) and Roback (1982) frameworks, but I enrich the model to more flexibly allow for heterogeneity in workers' preferences, cities' productivity levels, and cities' housing supplies. Further, I allow local productivity and amenities levels to endogenously respond to the skill-mix of the city. The sections below describe the setup for labor demand, housing supply, worker labor supply, and amenity supply, and how they jointly determine the spatial equilibrium across cities.

[12] Changes in violent crime rates and student-teacher ratios are positively associated with local college employment ratios, however the estimates are not statistically significant.

4.1 Labor Demand

Each city, indexed j, has many homogeneous firms, indexed by d, in year t.[13] [14] They produce a homogenous tradeable good using high skill labor (H_{djt}), low skill labor (L_{djt}), and capital (K_{djt}) according to the production function:

$$Y_{djt} = N_{djt}^{\alpha} K_{djt}^{1-\alpha}, \tag{1}$$

$$N_{djt} = \left(\theta_{jt}^{L} L_{djt}^{\rho} + \theta_{jt}^{H} H_{djt}^{\rho}\right)^{\frac{1}{\rho}}$$

$$\theta_{jt}^{L} = f_L\left(H_{jt}, L_{jt}\right) \exp\left(\varepsilon_{jt}^{L}\right) \tag{2}$$

$$\theta_{jt}^{H} = f_H\left(H_{jt}, L_{jt}\right) \exp\left(\varepsilon_{jt}^{H}\right) \tag{3}$$

The production function is Cobb-Douglas in the labor aggregate N_{djt} and capital, K_{djt}.[15][16] The labor aggregate hired by each firm, N_{djt}, combines high skill labor, H_{djt}, and low skill labor, L_{djt}, as imperfect substitutes into production with a constant elasticity of substitution, where the elasticity of labor substitution is $\frac{1}{1-\rho}$. The large literature on understanding changes in wage inequality due to the relative supply of high and low skill labor uses this functional form for labor demand, as exemplified by Katz and Murphy (1992).

Cities' production functions differ based on productivity. Each city's productivity of high skill workers is measured by θ_{jt}^{H} and low skill productivity is measured by θ_{jt}^{L}. Equations (2) and (3) show that local productivity is determined by exogenous and endogenous factors. Exogenous productivity differences across cities and worker skill are measured by $\exp\left(\varepsilon_{jt}^{L}\right)$ and $\exp\left(\varepsilon_{jt}^{H}\right)$.

Additionally, productivity is endogenously determined by the skill mix in the city. The literature on the social returns to education has shown that areas with a higher concentration of college workers could increase all workers' productivity through knowledge spillovers. For example, increased physical proximity with educated workers may lead to better sharing of ideas, faster innovation, or faster technology adoption.[17] Productivity may also be influenced by endogenous technological changes or technology adoption, where the development or adoption of new technologies is targeted at new technologies which offer the most profit (Acemoglu (2002), Beaudry, Doms and Lewis (2010)). Previous

[13] Autor and Dorn (2013) model local labor demand using a two sector model, where one sector produces nationally traded goods, and the other produces local goods. My use of a single tradable sector allows me to derive simple expressions for city-wide labor demand. I do not mean to rule out the importance of local goods production, which is surely an significant driver of low skill worker labor demand.

[14] I model firms as homogenous to derive a simple expression for the city-wide aggregate labor demand curves. Alternatively, one could explicitly model firms' productivities differences across industries to derive an aggregate labor demand curve.

[15] The model could be extended to allow local housing (office space) to be an additional input into firm production. I leave this to future work, as it would require a more sophisticated model of how workers and firms compete in the housing market. Under the current setup, if office space is additively separable in the firm production function, then the labor demand curves are unchanged.

[16] Ottaviano and Peri (2012) explicitly consider whether Cobb-Douglas is a good approximation to use when estimating labor demand curves. They show that the relative cost-share of labor to income is constant over the long run in the US. This functional form is also often used by the macro growth literature since the labor income share is found to be constant across many countries and time. See Ottaviano and Peri (2012) for further analysis.

[17] See Moretti (2011) for a literature review of these ideas.

research has little to say about the exact functional forms of these spillovers. To remain agnostic to the shape of these spillovers, I allow high and low skill employment to impact high skill productivity by $f_H(H_{jt}, L_{jt})$ and low skill productivity by $f_L(H_{jt}, L_{jt})$.

Since there are a large number of firms and no barriers to entry, the labor market is perfectly competitive and firms hire such that wages equal the marginal product of labor. A frictionless capital market supplies capital perfectly elastically at price κ_t, which is constant across all cities.[18] Each firm's demand for labor and capital is:[19]

$$\begin{aligned} W_{jt}^H &= \alpha N_{djt}^{\alpha-\rho} K_{djt}^{1-\alpha} H_{djt}^{\rho-1} f_H(H_{jt}, L_{jt}) \exp\left(\varepsilon_{jt}^H\right), \\ W_{jt}^L &= \alpha N_{djt}^{\alpha-\rho} K_{djt}^{1-\alpha} L_{djt}^{\rho-1} f_L(H_{jt}, L_{jt}) \exp\left(\varepsilon_{jt}^L\right), \\ \kappa_t &= N_{djt}^{\alpha} K_{djt}^{-\alpha}(1-\alpha). \end{aligned}$$

Firm-level labor demand translates directly to city-level aggregate labor demand since firms face constant returns to scale production functions and share identical production technology. Substituting for equilibrium levels of capital, the city-level log labor demand curves are:

$$w_{jt}^H = \ln W_{jt}^H = c_t + (1-\rho)\ln N_{jt} + (\rho-1)\ln H_{jt} + \ln\left(f_H(H_{jt}, L_{jt})\right) + \varepsilon_{jt}^H \tag{4}$$

$$\begin{aligned} w_{jt}^L &= \ln W_{jt}^L = c_t + (1-\rho)\ln N_{jt} + (\rho-1)\ln L_{jt} + \ln\left(f_L(H_{jt}, L_{jt})\right) + \varepsilon_{jt}^L & (5) \\ N_{jt} &= \left(\exp\left(\varepsilon_{jt}^L\right) f_L(H_{jt}, L_{jt}) L_{jt}^{\rho} + \exp\left(\varepsilon_{jt}^H\right) f_H(H_{jt}, L_{jt}) H_{jt}^{\rho}\right)^{\frac{1}{\rho}} & (6) \\ c_t &= \ln\left(\alpha\left(\frac{(1-\alpha)}{\kappa_t}\right)^{\frac{1-\alpha}{\alpha}}\right). \end{aligned}$$

The equations above show how labor supply impacts wages through two channels: imperfect labor substitution of high and low skill workers within firms (governed by ρ) and city-wide productivity changes (governed by $f_L(H_{jt}, L_{jt})$ and $f_H(H_{jt}, L_{jt})$). When estimating the equations above, the only way to separate the wage impacts of endogenous productivity from imperfect labor substitution would be through strong parametric assumptions (parameterizing $f_L(H_{jt}, L_{jt})$ and $f_H(H_{jt}, L_{jt})$). Instead of imposing parametric restrictions, the labor demand equations can be rewritten as unknown functions of employment levels (H_{jt}, L_{jt}) and exogenous productivity $(\varepsilon_{jt}^H, \varepsilon_{jt}^L)$:

$$\begin{aligned} w_{jt}^H &= g_H(H_{jt}, L_{jt}) + \varepsilon_{jt}^H & (7) \\ w_{jt}^L &= g_L(H_{jt}, L_{jt}) + \varepsilon_{jt}^L, & (8) \end{aligned}$$

[18] An alternative assumption would be to assume that capital is fixed across areas, leading to downward slopping aggregate labor demand within each city. Ottaviano and Peri (2012) explicitly consider the speed of capital adjustment to in response to labor stock adjustment across space. They find the annual rate of capital adjustment to be 10%. Since my analysis of local labor markets is across decades, I assume capital is in equilibrium.

[19] Note that the productivity spillovers are governed by the city-level college employment ratio, so the hiring decision of each individual firm takes the city-level college ratio as given when making their hiring decisions.

where $g_H(H_{jt}, L_{jt})$ and $g_L(H_{jt}, L_{jt})$ capture the combined effects of imperfect labor substitution and endogenous productivity. I will approximate these functions using log-linear aggregate labor demand:

$$w_{jt}^H = \gamma_{HH} \ln H_{jt} + \gamma_{HL} \ln L_{jt} + \varepsilon_{jt}^H \quad (9)$$
$$w_{jt}^L = \gamma_{LH} \ln H_{jt} + \gamma_{L:L} \ln L_{jt} + \varepsilon_{jt}^L. \quad (10)$$

I, the econometrician, observe wages $\left(w_{jt}^H, w_{jt}^L\right)$ and employment (H_{jt}, L_{jt}), but exogenous productivity $\left(\varepsilon_{jt}^H, \varepsilon_{jt}^L\right)$ is unobserved. Parameters to be estimated are the reduced-form aggregate labor demand elasticities $(\gamma_{HH}, \gamma_{HL}, \gamma_{LH}, \gamma_{LL})$.

4.2 Labor Supply to Cities

Each head-of-household worker, indexed by i, chooses to live in the city which offers him the most desirable bundle of wages, local good prices, and amenities. Wages in each city differ between college graduates and lower educated workers. A worker of skill level edu living in city j in year t inelastically supplies one unit of labor and earns a wage of W_{jt}^{edu}.

The worker consumes a local good M, which has a local price of R_{jt} and a national good O, which has a national price of P_t, and gains utility from the vector of amenities A_{jt} in the city. The worker has Cobb-Douglas preferences for the local and national good, which he maximizes subject to his budget constraint:

$$\max_{M,O} \ln\left(M^{\zeta}\right) + \ln\left(O^{1-\zeta}\right) + s_i(A_{jt}) \quad (11)$$
$$s.t.\ P_t O + R_{jt} M \leq W_{jt}^{edu}.$$

Workers' relative taste for national versus local goods is governed by ζ, where $0 \leq \zeta_i \leq 1$. I assume ζ is constant across households, an assumption I will test in the data. The worker's optimized utility function can be expressed as an indirect utility function for living in city j. If the worker were to live in city j in year t, his utility V_{ijt} would be:

$$V_{ijt} = \ln\left(\frac{W_{jt}^{edu}}{P_t}\right) - \zeta \ln\left(\frac{R_{jt}}{P_t}\right) + s_i(A_{jt}), \quad (12)$$
$$= w_{jt}^{edu} - \zeta r_{jt} + s_i(A_{jt}),$$

where $w_{jt}^{edu} = \ln\left(\frac{W_{jt}^{edu}}{P_t}\right)$ and $r_{jt} = \ln\left(\frac{R_{jt}}{P_t}\right)$.[20] The price of the national good is measured by the CPI-U index for all goods excluding shelter and measured in real 2000 dollars. The worker's optimized utility function also leads to his local good demand (HD_{ijt}):

$$HD_{ijt} = \frac{\zeta W_{jt}^{edu}}{R_{jt}}. \quad (13)$$

[20] Since the worker's preferences are Cobb-Douglas, he spends ζ share of his income on the local good, and $(1-\zeta)$ share of his income on the national good.

Workers are heterogenous in how much they desire the local non-market amenities. I define amenities broadly as all characteristics of a city which could influence the desirability of a city beyond local wages and prices. This includes the generosity of the local social insurance programs as well as more traditional amenities like annual rainfall. All residents within the city have access to these amenities simply by choosing to live there. Some amenity differences are due to exogenous factors such as climate or proximity to the coast. These amenities could include both fixed factors and time varying amenities. I refer to exogenous amenities in city j in year t by the vector x_{jt}^{A}.I also consider the utility value one gets from living in a city in or near one's state of birth to be an amenity of the city.

Finally, households also value a single-index bundle of amenities, a_{jt}. The key distinguishing characteristic of a_{jt} is that it will be allowed to endogenously respond to the skill mix of the city, while amenities within x_{jt}^{A} do not respond to endogenous forces within the model. Specifically, a_{jt} is measured as the first principal component of a bundle of amenities related to school quality, the retail environment, crime, the environment, transportation infrastructure, and the quality of the job market. Section 4.4 will discuss the details of the endogenous amenity supply of a_{jt} and Section 5.1 will give more details on exact measurement of a_{jt}.

The function $s_i(A_{jt})$ maps the vector of city amenities, A_{jt}, to the worker's utility value for them. Worker i's value of amenities A_{jt} is:

$$
\begin{aligned}
s_i(A_{jt}) &= a_{jt}\beta_i^a + x_{jt}^A\beta_i^x + x_j^{st}\beta_i^{st} + x_j^{\text{div}}\beta_i^{\text{div}} + \sigma_i\varepsilon_{ijt} && (14)\\
\beta_i^x &= \beta^x z_i \\
\beta_i^a &= \beta^a z_i && (15)\\
\beta_i^{st} &= st_i\beta^{st} z_i \\
\beta_i^{\text{div}} &= \text{div}_i\,\beta^{\text{div}} z_i && (16)\\
\sigma_i &= \beta^\sigma z_i && (17)\\
\varepsilon_{ijt} &\sim \text{Type I Extreme Value.}
\end{aligned}
$$

β_i^{st} and β_i^{div} measure worker i's value of living in his state of birth and census division of birth, respectively. Worker i's marginal utility of the exogenous amenities β_i^x, endogenous amenities β_i^a, and birthplace amenities $\left(\beta_i^{st}, \beta_i^{\text{div}}\right)$, are each a function of his demographics $z_i.z_i$ is a 3x1 vector of dummy variable with each entry equal to 1 if the work is white, black, or an immigrant, respectively. The coefficients $\left(\beta^x, \beta^a, \beta^{st}, \beta^{\text{div}}, \beta^\sigma\right)$ are each 1x3 vectors measuring the utility value of the city characteristic to the given demographic group. x_j^{st} is a 1x50 binary vector where each element k is equal to 1 if part of city j is contained in state k. Similarly, I define x_j^{div} as a 1x9 binary vector where each element k is equal to 1 if part of city j is contained within Census division k. st_i is a 50x1 binary vector where each element is equal to 1 if worker i was born in that state. div_i is defined similarly for census divisions.

Each worker also has an individual, idiosyncratic taste for cities' amenities, which is measured by ε_{ijt}. ε_{ijt} is drawn from a Type I Extreme Value distribution. The variance of workers' idiosyncratic tastes for each city differs across demographic groups, as shown in equation (16).

To simplify future notation and discussion of estimation, I re-normalize the utility function by dividing each workers' utility by $\beta^{\sigma} z_i$. Using these units, the standard deviation of worker idiosyncratic preferences for cities is normalized to one. The magnitudes of the coefficient on wages, rents, and amenities now represent the elasticity of workers' demand for a small city with respect to its local wages, rents, or amenities, respectively.[21] With a slight abuse of notation, I redefine the parameters of the re-normalized utility function using the same notation of the utility function measured in wage units. The indirect utility for worker i of city j is now represented as:

$$V_{ijt} = \left(w_{jt}^{edu} - \zeta r_{jt}\right) \beta^w z_i + a_{jt}\beta_i^a + x_{jt}^A \beta_i^x + x_j^{st}\beta_i^{st} + x_j^{\text{div}}\beta_i^{\text{div}} + \varepsilon_{ijt}$$

To simplify exposition, I introduce some additional notation. The preferences of different workers with identical demographics z for a given city differ only due to workers' birth states and divisions (st_i, div_i) and their idiosyncratic taste for the city, ε_{ijt}. I define δ_{jt}^z as utility value of the components of city j which all workers' of type z value identically:

$$\delta_{jt}^z = \left(w_{jt}^{edu} - \zeta r_{jt}\right) \beta^w z + a_{jt}\beta^a z + x_{jt}^A \beta^x z.$$

Rewriting the utility function in terms of δ_{jt}^z gives:

$$V_{ijt} = \delta_{jt}^z + x_j^{st} st_i \beta^{st} z_i + x_j^{\text{div}} \,\text{div}_i\, \beta^{\text{div}} z_i + \varepsilon_{ijt}.$$

This setup is the conditional logit model, first formulated in this utility maximization context by McFadden (1973). Aggregate population differences of workers of a given type z across cities represent differences in these workers' mean utility values for these cities. The total expected population of city j is simply the probability each worker lives in the city, summed over all workers.[22] Thus, the total high and low skill populations of city j are:

$$\begin{aligned} H_{jt} &= \sum_{i \in \mathcal{H}_t} \frac{\exp(\delta_{jt}^{z_i} + x_j^{st} st_i \beta^{st} z_i + x_j^{\text{div}} \,\text{div}_i\, \beta^{\text{div}} z_i)}{\sum_k^J \exp(\delta_{kt}^{z_i} + x_k^{st} st_i \beta^{st} z_i + x_k^{\text{div}} \,\text{div}_i\, \beta^{\text{div}} z_i)} \\ L_{jt} &= \sum_{i \in \mathcal{L}_t} \frac{\exp(\delta_{jt}^{z_i} + x_j^{st} st_i \beta^{st} z_i + x_j^{\text{div}} \,\text{div}_i\, \beta^{\text{div}} z_i)}{\sum_k^J \exp(\delta_{kt}^{z_i} + x_k^{st} st_i \beta^{st} z_i + x_k^{\text{div}} \,\text{div}_i\, \beta^{\text{div}} z_i)}. \end{aligned}$$

$\mathcal{H}_t$ and $\mathcal{L}_t$ are the set of high and low skill workers in the nation, respectively.

While population reflects a city's desirability, this relationship can be attenuated in the presence of moving costs, since households will be less willing to move to nicer cities and away from worse cities

[21] Due to the functional form assumption for the distribution of workers' idiosyncratic tastes for cities, the elasticity of demand of workers with demographics z for a city j with respect to local rents, for example, is:$(1 - s_{jz})\beta^r z$. s_{jz} is the share of all workers of type z in the nation, living in city j. For a small city, where the share of all type z workers living in city j is close to zero, the demand elasticity for rent is simply $\beta^r z$.

[22] The probability worker i chooses to live in city j is:

$$\Pr(V_{ijt} > V_{i-jt}) = \frac{\exp(\delta_{jt}^{z_i} + \beta^{st} z_i st_i x_j^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_j^{\text{div}})}{\sum_k^J \exp(\delta_{kt}^{z_i} + \beta^{st} z_i st_i x_k^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_k^{\text{div}})}.$$

in the presence of moving costs. I capture moving costs by allowing workers to prefer to live in or near their state of birth.[23] The utility value of living in or near one's birth state represents both the value of being near one's family and friends, as well as the psychic and financial costs of moving away.[24]

In the equations above, I observe high and low skill population $(H_{jt}$ and $L_{jt})$, wages $\left(w_{jt}^{edu}\right)$, rent (r_{jt}), the endogenous amenity index a_{jt}, workers' demographics z, and workers' state and census division of birth $(st_i$ and $\text{div}_i)$. Exogenous amenities $\left(x_{jt}^{A}\right)$ and workers' idiosyncratic taste for each city (ε_{ijt}) are unobserved. Parameters to be estimated are workers' preferences for wages, rent, and amenities $\left(\beta^{w}, \zeta, \beta^{a}, \beta^{x}, \beta^{st}, \beta^{\text{div}}\right)$.

4.3 Housing Supply

Local prices, R_{jt}, are set through equilibrium in the housing market. The local price level represents both local housing costs and the price of a composite local good, which includes goods such as groceries and local services which have their prices influenced by local housing prices. Inputs into the production of housing include construction materials and land. Developers are price-takers and sell homogenous houses at the marginal cost of production.

$$P_{jt}^{\text{house}} = MC\left(CC_{jt}, LC_{jt}\right).$$

The function $MC\left(CC_{jt}, LC_{jt}\right)$ maps local construction costs, CC_{jt}, and local land costs, LC_{jt}, to the marginal cost of constructing a home. In the asset market steady state equilibrium, there is no uncertainty and prices equal the discounted value of rents. Local rents are:

$$R_{jt} = \iota_t * MC\left(CC_{jt}, LC_{jt}\right),$$

where ι_t is the interest rate. Housing is owned by absentee landlords who rent the housing to local residents.

The cost of land LC_{jt} is a function of the aggregate demand for local goods. Equation (13) shows that households increase their local good demand when wages rise or local good prices fall. The extensive margin of in-migration also increases housing demand.

[23] This setup can be thought of as there being a childhood period of life before one's career. During childhood, workers are born into their birth locations, and as adults, they are allowed to move to a new city for their career.

[24] In a fully dynamic model, workers can elect to move every period, and they are no longer always moving away from their birth state. Panel data is needed to estimate a model of this nature, such as the NLSY used by Kennan and Walker (2011) and Bishop (2010). However, this dataset is significantly smaller and is not large enough to consistently estimate my model.

I parameterize the log housing supply equation as:[25]

$$r_{jt} = \ln(R_{jt}) = \ln(\iota_t) + \ln(CC_{jt}) + \gamma_j \ln(HD_{jt}), \tag{18}$$

$$\gamma_j = \gamma + \gamma^{geo} \exp\left(x_j^{geo}\right) + \gamma^{reg} \exp\left(x_j^{reg}\right), \tag{19}$$

$$HD_{jt} = L_{jt} \frac{\zeta W_{jt}^L}{R_{jt}} + H_{jt} \frac{\zeta W_{jt}^H}{R_{jt}}, \tag{20}$$

where HD_{jt} is the aggregate local good demand in city j in year t. The elasticity of rent with respect to local good demand, varies across cities, as measured by γ_j. House price elasticities are influenced by characteristics of the city which impact the availability of land suitable for development. Geographic characteristics, which make land in the city undevelopable, lead to a less elastic housing supply. With less available land around to build on, the city must expand farther away from the central business area to accommodate a given amount of population. x_j^{geo} measures the share of land within 50 km of each city's center which is unavailable for development due to the presence of wetlands, lakes, rivers, oceans, and other internal water bodies as well as share of the area corresponding to land with slopes above 15 percent grade. This measure was developed by Saiz (2010). In equation $(19), \gamma^{geo}$ measures how variation in $\exp\left(x_j^{geo}\right)$ influences the inverse elasticity of housing supply, γ_j.

Local land use regulation has a similar effect by further restricting housing development. Data on municipalities' local land use regulation was collected in the 2005 Wharton Regulation Survey. Gyourko, Saiz and Summers (2008) use the survey to produce a number of indices that capture the intensity of local growth control policies in a number of dimensions. Lower values in the Wharton Regulation Index, can be thought of as signifying the adoption of more laissez-faire policies toward real estate development. I use Saiz (2010)'s metropolitan area level aggregates these data as my measure of land use regulation x_j^{reg}. See Table 1 for summary statistics of these measures. In equation $(19), \gamma^{reg}$ measures how variation in $\exp\left(x_j^{reg}\right)$ influences the inverse elasticity of housing supply γ_j. γ measures the "base" housing supply elasticity for a city which has no land use regulations and no geographic constraints limiting housing development.

In the housing supply equation (18), housing rent (r_{jt}), land unavailability $\left(x_j^{geo}\right)$, land-use regulation $\left(x_j^{reg}\right)$, and local good demand (HD_{jt}) are observed by the econometrician. Construction costs (CC_{jt}) and the interest rate ι_t are unobserved. Parameters to be estimated are house supply elasticities $(\gamma, \gamma^{geo}, \gamma^{reg})$ and the local good expenditure share (ζ).

4.4 Amenity Supply

Cities differ in the amenities they offer to their residents. Many amenities supplied in a city are due to exogenous factors outside of this model (e.g unrelated to supply and demand of labor and housing.) I represent this vector of amenities as x_{jt}^A.

Some city amenities endogenously respond to the types of residents who choose to live in the city.

[25] I exponentiate the housing supply elasticity measures to ensure all housing supply elasticities are always positive. Using a linear measure leads to a couple cities to have a negative point estimate for their housing supply elasticity. However, results are robust to using a linear specification.

In general, there are likely many different types of amenities, each which differently respond to the types of households living within a city. To keep the model parsimonious, I allow a single index a_{jt}, measured by a bundle of observed amenities, to endogenously respond to the types of workers living in the city. Specifically, a_{jt} is measured as the first principal component of a bundle of amenities related to school quality, the retail environment, crime, the environment, transportation infrastructure, and the quality of the job market (beyond wages). Section 5.1 will give more details on exact measurement of a_{jt}.

I model the level of the endogenous amenity index to be determined by cities' college employment ratios, $\frac{H_{jt}}{L_{jt}}$:

$$a_{jt} = \gamma^a \ln\left(\frac{H_{jt}}{L_{jt}}\right) + \varepsilon^a_{jt}.$$

γ^a is the elasticity of amenity supply, and ε^a_{jt} is the exogenous component of the amenity index a_{jt}. This setup is motivated by work by Guerrieri, Hartley and Hurst (2013), Handbury (2012), and Bayer, Ferreira and McMillan (2007). Guerrieri, Hartley and Hurst (2013) shows that local housing price dynamics suggest local amenities respond to the income levels of residents. Bayer, Ferreira and McMillan (2007) show that at the very local neighborhood level, households have preferences for the race and education of neighboring households. Handbury (2012) shows that cities with higher income per capita offer wider varieties of high quality groceries. The quality of the products available within a city are an amenity. I approximate these forces by cities' college employment ratios as an index for local endogenous amenity levels. Regressions of changes in observable amenities over time discussed earlier in Section 3 suggest that amenities are positively associated with a city's college employment, which further motivates this setup.

The vector of all amenities in the city, A_{jt}, is:

$$A_{jt} = \left(x^A_{jt}, x^{st}_j, x^{\text{div}}_j, a_{jt}\right).$$

I observe MSAs' states $\left(x^{st}_j\right)$, census divisions $\left(x^{\text{div}}_j\right)$, endogenous amenity indices a_{jt}, and the college employment ratio $\left(\frac{H_{jt}}{L_{jt}}\right)$. Exogenous amenities $\left(x^A_{jt}\right)$and the exogenous component of the amenity index $\left(\varepsilon^a_{jt}\right)$ are unobserved. The elasticity of amenity supply (γ^a) is the parameter to be estimated.

4.5 Equilibrium

Equilibrium in this model is defined by a menu of wages, rents and amenity levels, $\left(w^{L*}_t, w^{H*}_t, r^*_t, \frac{H^*_{jt}}{L^*_{jt}}\right)$ with populations $\left(H^*_{jt}, L^*_{jt}\right)$ such that:

- The high skill labor demand equals high skill labor supply:

$$\begin{aligned} H^*_{jt} &= \sum_{i\in\mathcal{H}_t} \frac{\exp(\delta^{z_i}_{jt} + \beta^{st} z_i st_i x^{st}_j + \beta^{\text{div}} z_i \,\text{div}_i\, x^{\text{div}}_j)}{\sum_k^J \exp(\delta^{z_i}_{kt} + \beta^{st} z_i st_i x^{st}_k + \beta^{\text{div}} z_i \,\text{div}_i\, x^{\text{div}}_k)} \qquad (21) \\ w^{H*}_{jt} &= \gamma_{HH} \ln H^*_{jt} + \gamma_{HL} \ln L^*_{jt} + \varepsilon^H_{jt} \end{aligned}$$

- The low skill labor demand equals low skill labor supply:

$$\begin{aligned} L_{jt}^{*} &= \sum_{i\in\mathcal{L}_t} \frac{\exp(\delta_{jt}^{z_i} + \beta^{st} z_i st_i x_j^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_j^{\text{div}})}{\sum_k^J \exp(\delta_{kt}^{z_i} + \beta^{st} z_i st_i x_k^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_k^{\text{div}})} \\ w_{jt}^{L*} &= \gamma_{LH} \ln H_{jt}^{*} + \gamma_{L:L} \ln L_{jt}^{*} + \varepsilon_{jt}^{L} \end{aligned} \tag{22}$$

- Housing demand equals housing supply:

$$\begin{aligned} r_{jt}^{*} &= \ln(\iota_t) + \ln(CC_{jt}) + \gamma_j \ln\left(HD_{jt}^{*}\right), \\ HD_{jt}^{*} &= L_{jt}^{*} \frac{\zeta \exp\left(w_{jt}^{L*}\right)}{\exp\left(r_{jt}^{*}\right)} + H_{jt}^{*} \frac{\zeta \exp\left(w_{jt}^{H*}\right)}{\exp\left(r_{jt}^{*}\right)} \end{aligned}$$

- Endogenous amenities demand equals endogenous amenity supply:

$$a_{jt}^{*} = \gamma^{a} \ln\left(\frac{H_{jt}^{*}}{L_{jt}^{*}}\right) + \varepsilon_{jt}^{a}$$

$$\delta_{jt}^{z} = \beta^{w} z \left(w_{jt}^{edu*} - \zeta r_{jt}^{*}\right) + \beta^{x} z x_{jt}^{A} + \beta^{a} z a_{jt}^{*}, \forall z.$$

The model does not allow me to solve for equilibrium wages and local prices analytically, but this setup is useful in estimation.

5 Estimation

Before discussing identification of the model parameters, I construct the endogenous amenity index a_{jt} and present an instrumental variable which will be used in model estimation.

5.1 The Endogenous Amenity Index

The amenity index of a city should ideally capture the whole bundle of amenities which endogenously responds to the skill mix of the city. To capture as broad and inclusive measures of city amenities as possible, I collect data on fifteen different amenities which can be broadly bucketed into six different categories: the retail environment, transportation infrastructure, crime, environmental quality, school quality, and job quality (beyond wages). To combine these fifteen data sources into a single index of amenities, I use principal component analysis (PCA). This method will extract a single measure for each city which can best predict the many amenities in each city. The first principle component of these amenities will be used as the amenity index a_{jt}.

Some categories of amenities have more data sources than others due to availability of consistent historical data from 1980 to 2000. Since PCA will put more weight on amenity categories with more data sources, I first create an amenity index using the first principal component within each amenity category and then create and overall amenity index using the first principal component of all the amenity category indices. Table 3 reports the loadings on each amenity. Table 3.A shows all retail amenities receive positive loadings for the retail amenity index, suggesting a single measure of the retail environment can capture these different types of retails establishments reasonably well. Similarly, the transportation amenity index places positive loadings on all road and transport amenities. The crime amenity index places positive loadings on both violent and property crime. The environment index places a positive loading on government park and recreation spending, but a negative weight on air pollution levels, accurately picking up that pollution is a measure of poor environmental quality, while parks are a positive measure. Similarly, the school quality index positively weights government spending per student, but negatively weights student teacher ratios, accurately reflecting that large classes are likely a signal of worse school quality. The job amenity index positively weights both patenting per capita and the employment rate. Higher patenting per capita likely indicates more interesting jobs for workers as well as possibly expected future wage growth as these patents might bring future profits to these firms. A higher employment to population ratio suggests that finding a job should be easier.

Combining these individual amenity category indices into an overall amenity index leads to positive loadings on job quality, school quality, environmental quality, and transportation quality. The index accurately places a negative loading on crime levels, but it also places a negative weight on the retail quality index. While retail quality may be a positive amenity, it does not seem to co-move with these other types of amenities, making it receive a negative loading. Despite this slight short coming, a single amenity index which best explains the variation in a large number of different amenities appears to reflect a significant common component across many amenity types. The loadings chosen by the PCA analysis were not influenced by any prior information about which amenities are thought to be desirable versus undesirable, yet nonetheless the loadings appear to accurately reflect a common component of amenity quality across many different amenities. These results help substantiate the assumption that a single dimensional amenity index can reasonably approximate the full bundle of amenities which endogenously respond to the skill-mix of a city.

5.2 Bartik Labor Demand Shocks

A key component in identifying the model parameters will be to use how many of the cities' economic outcomes respond to plausibly exogenous shocks to local firms' productivities. I harness the fact that changes in the productivity levels of the industries located within each city contribute to the city's productivity change. Variation in productivity changes across industries will differentially impact cities' local high and low skill productivity levels based on the industrial composition of the city's workforce (Bartik (1991)). I measure exogenous local productivity changes by interacting cross-sectional differences in industrial employment composition with national changes in industry wage levels, separately for high and low skill workers.[26] I refer to these as Bartik labor demand shocks.

[26] Other work has measured industry productivity changes by using national changes in employment shares of workers across industries, instead of changes in industry wages. (See Notowidigdo (2011), and Blanchard and Katz (1992).) They use the productivity shocks as an instrument for worker migration to cities. Thus, it makes sense to measure the shock in units of workers, instead of wages units. I focus on how these industry productivity shocks impact wages, which is why I measure the shock in wages units. Guerrieri, Hartley and Hurst (2013) also constructs the instrument using industry

Formally, I define the Bartik shock for high and low skill workers, as:

$$\Delta B_{jt}^{H} = \sum_{ind} \left(w_{ind,-j,t}^{H} - w_{ind,-j,1980}^{H}\right) \frac{H_{ind,j1980}}{H_{j1980}} \quad (23)$$

$$\Delta B_{jt}^{L} = \sum_{ind} \left(w_{ind,-j,t}^{L} - w_{ind,-j,1980}^{L}\right) \frac{L_{ind,j1980}}{L_{j1980}},$$

where $w_{ind,-j,t}^{H}$ and $w_{ind,-j,t}^{L}$ represent the average log wage of high and low skill workers, respectively, in industry *ind* in year t, excluding workers in city j and workers within a city that has a border within 25 miles of city j's border.[27] $H_{ind,j1980}$ and $L_{ind,j1980}$ measure the number of high and low skill workers, respectively, employed in industry *ind* in city j, in year 1980.

These Bartik labor demand shocks are a component of a city's exogenous productivity changes over time. Specifically, the exogenous high and low skill productivity changes from equations (9) and (10) can be written:

$$\Delta \varepsilon_{jt}^{H} = \gamma_{BHH} \Delta B_{jt}^{H} + \gamma_{BHL} \Delta B_{jt}^{L} + \Delta \tilde{\varepsilon}_{jt}^{H}, \quad (24)$$

$$\Delta \varepsilon_{jt}^{L} = \gamma_{BLH} \Delta B_{jt}^{H} + \gamma_{BLL} \Delta B_{jt}^{L} + \Delta \tilde{\varepsilon}_{jt}^{H}, \quad (25)$$

where $\left(\Delta \varepsilon_{jt}^{H}, \Delta \varepsilon_{jt}^{L}\right)$ are the high and low skill exogenous productivity changes in city j in year t, relative to 1980. $(\gamma_{BHH}, \gamma_{BHL}, \gamma_{BLH}, \gamma_{BLL})$ are parameters from the projection of $\Delta \varepsilon_{jt}^{H}$ and $\Delta \varepsilon_{jt}^{L}$ onto ΔB_{jt}^{L} and ΔB_{jt}^{H}. This defines $\Delta \tilde{\varepsilon}_{jt}^{H}$ and $\Delta \tilde{\varepsilon}_{jt}^{L}$ to be the components of exogenous local productivity changes which is uncorrelated with the Bartik local labor demand shocks. The sections below will discuss how these Bartik labor demand shocks are used in identifying the model parameters. All of the estimation will use changes in cities' economic outcomes since 1980, since the Bartik local labor demand shocks lead to variation in changes over time.

5.3 Labor Demand

As discussed in the Section 4.1, a city's high and low skill labor demand curves determine the quantity of labor demanded by local firms as a function of local productivity and wages. Differencing cities' wages relative to their 1980 level gives:

$$\Delta w_{jt}^{H} = \gamma_{HH} \Delta \ln H_{jt} + \gamma_{HL} \Delta \ln L_{jt} + \Delta \varepsilon_{jt}^{H} \quad (26)$$

$$\Delta w_{jt}^{L} = \gamma_{LH} \Delta \ln H_{jt} + \gamma_{L:L} \Delta \ln L_{jt} + \Delta \varepsilon_{jt}^{L} \quad (27)$$

Changes over time in cities' high and low skill exogenous productivity levels, $\Delta \varepsilon_{jt}^{L}$ and $\Delta \varepsilon_{jt}^{H}$, shift the local labor demand curves, directly impacting wages.

wage changes.

[27] I not only exclude the own city's contribution to the nationwide wage changes, but also the contribution of all cities which have borders within 25 miles of the border of a given city. This is to ensure that unobserved city characteristics which might be shared between neighboring cities do not drive the measured local labor demand shocks.

Plugging the Bartik labor demand shocks (equations 24 and 25) into the labor demand equations (26) and (27):

$$\Delta w_{jt}^{H} = \gamma_{HH}\Delta \ln H_{jt} + \gamma_{HL}\Delta \ln L_{jt} + \gamma_{BHH}\Delta B_{jt}^{H} + \gamma_{BHL}\Delta B_{jt}^{L} + \Delta\tilde{\varepsilon}_{jt}^{H} \tag{28}$$

$$\Delta w_{jt}^{L} = \gamma_{LH}\Delta \ln H_{jt} + \gamma_{L:L}\Delta \ln L_{jt} + \gamma_{BLH}\Delta B_{jt}^{H} + \gamma_{BLL}\Delta B_{jt}^{L} + \Delta\tilde{\varepsilon}_{jt}^{L}. \tag{29}$$

The direct effect of the Bartik shocks shift the local labor demand curves, directly influencing local wages.

The aggregate labor demand elasticities $(\gamma_{HH}, \gamma_{HL}, \gamma_{LH}, \gamma_{LL})$ are identified by variation in labor supply which is uncorrelated with unobserved changes in local productivity $\left(\Delta\tilde{\varepsilon}_{jt}^{H}, \Delta\tilde{\varepsilon}_{jt}^{L}\right)$. The interaction of Bartik local labor demand shocks with cities' housing supply elasticities lead to variation in labor supply uncorrelated with unobserved changes in local productivity $\left(\Delta\tilde{\varepsilon}_{jt}^{H}, \Delta\tilde{\varepsilon}_{jt}^{L}\right)$. As discussed in Section 4.3, land unavailable for housing development due to geographic features x_j^{geo} and land-use regulation x_j^{reg} impact local housing supply elasticity.

Conceptually, variation in housing supply elasticity can identity the slope of the labor demand curves because the elasticity of housing supply influences the amount of migration in response to a local labor demand shock. Consider two cities which receive the same increase in local labor demand. One city has a very elastic housing supply, while the housing supply of the other is very inelastic. As workers migrate into these cities to take advantage of the increased wages, they drive up the housing prices by increasing the local demand for housing. The housing inelastic city exhibits much larger rent increases in response to a given amount of migration than the elastic city. These rent increases lead to relatively less in-migration to the housing inelastic city because the sharp rent increase driven by a relatively small amount of in-migration offsets the desirability of high local wages.[28]

The exclusion restriction assumes that the level of land-unavailability and land-use regulation are uncorrelated with unobserved local productivity changes.[29] Specifically the moment restrictions are:

$$E\left(\Delta\tilde{\varepsilon}_{jt}^{H}\Delta Z_{jt}\right) = 0$$

$$E\left(\Delta\tilde{\varepsilon}_{jt}^{L}\Delta Z_{jt}\right) = 0$$

$$\text{Instruments:}\Delta Z_{jt} \in \left\{ \begin{array}{c} \Delta B_{jt}^{H} x_j^{reg}, \Delta B_{jt}^{L} x_j^{reg} \\ \Delta B_{jt}^{H} x_j^{geo}, \Delta B_{jt}^{L} x_j^{geo} \end{array} \right\}$$

These moment restrictions will be combined with the moments identifying other model parameters. All parts of the model will be estimated jointly using two-step GMM estimation.

[28] Saks (2008) has also analyzed how labor demand shocks interact is local housing supply elasticities to influence equilbrium local wages, rents, and populations.

[29] Since $\Delta\tilde{\varepsilon}_{jt}^{L}$ and $\Delta\tilde{\varepsilon}_{jt}^{H}$ are defined as the residuals of a projection of total exogenous productivity changes on Bartik labor demand shocks, as in equations (24) and (25), these error terms are uncorrelated with the Bartik labor demand shocks by construction.

5.4 Housing Supply

I rewrite the housing supply curve in changes since 1980:

$$\begin{aligned}
\Delta r_{jt} &= \Delta \ln(i_t) + \left(\gamma + \gamma^{geo}\exp\left(x_j^{geo}\right) + \gamma^{reg}\exp\left(x_j^{reg}\right)\right)\Delta\ln(HD_{jt}) + \Delta\ln(CC_{jt}),\\
HD_{jt} &= L_{jt}\frac{\zeta W_{jt}^{L}}{R_{jt}} + H_{jt}\frac{\zeta W_{jt}^{H}}{R_{jt}}.
\end{aligned}$$

$\ln(CC_{jt})$ measures local changes in construction costs and other factors impacting housing prices not driven by population change, and is unobserved in the data. To identify the elasticities of housing supply($\gamma, \gamma^{geo}, \gamma^{reg}$), one needs variation in a city's housing demand ($\Delta\ln(HD_{jt})$) which is unrelated to changes in unobserved factors driving housing prices ($\Delta\ln(CC_{jt})$). I use the Bartik shocks discussed above, which shift local wages leading to a migration response of workers, as instruments for housing demand. The key identifying assumption is that Bartik labor demand shocks are uncorrelated with changes in local construction costs. Specifically, the moment restrictions are:

$$E\left(\Delta\ln(CC_{jt})\,\Delta Z_{jt}\right) = 0$$

$$\text{Instruments:}\Delta Z_{jt} \in \left\{\begin{array}{c} \Delta B_{jt}^{H}, \Delta B_{jt}^{L} \\ \Delta B_{jt}^{H} x_j^{reg}, \Delta B_{jt}^{L} x_j^{reg} \\ \Delta B_{jt}^{H} x_j^{geo}, \Delta B_{jt}^{L} x_j^{geo} \end{array}\right\}$$

5.5 Labor Supply

Recall that the indirect utility of city j for worker i with demographics z_i is:

$$\begin{aligned}
V_{ijt} &= \delta_{jt}^{z} + \beta^{st} z_i st_i x_j^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_j^{\text{div}} + \varepsilon_{ijt}\\
\delta_{jt}^{z_i} &= \beta^{w} z_i \left(w_{jt}^{edu} - \zeta r_{jt}\right) + \beta^{x} z_i x_{jt}^{A} + \beta^{a} z_i a_{jt}.
\end{aligned}$$

To estimate workers' preferences for cities, I use a two-step estimator similar to Berry, Levinsohn and Pakes (2004).

In the first step, I use a maximum likelihood estimator, in which I treat the mean utility value of each city for each demographic group in each decade δ_{jt}^{z} as a parameter to be estimated.[30] Observed population differences in the data for a given type of worker identify the mean utility estimates for each city.[31] The maximum likelihood estimation measures the mean utility level for each city, for each demographic group, for each decade of data.

The second step of estimation decomposes the mean utility estimates into how workers value wages, rents, and amenities. Differencing cities' mean utility estimates for workers with demographics

[30] Recall the discussion from Section (4.2) that shows how differences in the mean utility value of cities leads to population differences across cities for a given type of worker.

[31] In the simple case where workers do not gain utility from living close to their birth state, the estimated mean utility levels for each city would exactly equal the log population of each demographic group observed living in that city.

z relative to their 1980 levels gives:

$$\Delta\delta^z_{jt} = \beta^w z\left(\Delta w^{edu}_{jt} - \zeta\Delta r_{jt}\right) + \beta^x z\Delta x^A_{jt} + \beta^a z\Delta a_{jt}. \quad (30)$$

I observe changes in cities' wages, rents, and the amenity index in the data. However, I do not observe the exogenous amenity changes. Define $\Delta\xi^z_{jt}$ as the change in utility value of city $j's$ amenities unobserved to the econometrician across decades for workers with demographics z:

$$\Delta\xi^z_{jt} = \beta^A z\Delta x^A_{jt}.$$

Plugging this into equation (30) gives:

$$\Delta\delta^z_{jt} = \beta^w z\left(\Delta w^{edu}_{jt} - \zeta\Delta r_{jt}\right) + \beta^a z\Delta a_{jt} + \Delta\xi^z_{jt}. \quad (31)$$

To identify workers' preferences for cities' wages, rents, and the amenity index, I need variation in these city characteristics which is uncorrelated with unobserved local amenity changes, $\Delta\xi^z_{jt}$. I instrument for these outcomes using the Bartik labor demand shocks and their interaction with housing supply elasticity characteristics (land-use regulation and land availability). The Bartik shocks provide variation in local labor demand unrelated to changes in unobserved local amenities $\left(\Delta\xi^z_{jt}\right)$. Since workers will migrate to take advantage of desirable wages driven by the labor demand shocks, they will bid up rents in the housing market. Heterogeneity in cities' housing supply elasticities provides variation in the rental rate response to the induced migration. Thus, the interactions of housing supply elasticity characteristics with the Bartik shocks impact changes in rents (and wages) unrelated to unobserved changes in local amenities.

Theoretically, the Bartik shocks and housing supply elasticity characteristics should provide enough variation to separately identify workers' preferences for wages and local prices. However, I supplement these instruments with additional data which provide extra power in identifying workers' preferences for rents, relative to wages (ζ). As shown in equation (12), ζ represents households' expenditure share on housing and local goods. Thus, this parameter can directly measured in external data on households' expenditures. Using the micro data from the 2000 Consumer expenditure survey, I find housing expenditure shares to be 39% for non-college households and 43% for college households. See Appendix B.1 for further discussion of measuring housing expenditure shares. It appears college graduates spend a bit more on housing than the less skilled. These expenditure levels are lower bounds on total local goods expenditures, since many products prices will be influenced by local housing prices. To account for the additional effects of housing prices on non-housing goods, I follow Moretti (2013) and use a local good expenditure share of 0.62.[32] I will also estimate the model without using the CEX data, relying on the Bartik shocks and housing supply elasticities for identification.

To identify the migration elasticity of workers within a given skill group with respect to amenity

[32] Moretti (2013) estimates this additional local goods expenditure by regressing changes in consumer price indices for individual cities (reported by the BLS) on local housing price changes within those cities. Albouy (2008) calibrates this parameter to be 0.67 accounting for additional forces that influence the wage-rent trade off such as taxes and non-labor income. My estimates are robust to using 0.67.

index, the Bartik shock to the *other* skill group is useful. For example, the low skill Bartik shock impacts the quantity of low skill workers living in a city, which leads to endogenous amenity changes by shifting the local college employment ratio. This shift in endogenous amenities will impact high skill workers' migration, identifying high skill workers' preference for the amenity index. While the low skill Bartik shocks also influence local prices and high skill workers' wages, jointly instrumenting for all three endogenous parameters simultaneously (wages, local prices, amenity index) allows all instruments to impact all endogenous outcomes and simultaneously identifies all three parameters.

The exclusion restrictions assume that these instruments are uncorrelated with unobserved exogenous changes in the city's local amenities. Since Bartik productivity shocks are driven by national changes in industrial productivity, they should be unrelated to local exogenous amenity changes. While local housing supply elasticity characteristics, such as coastal proximity and mountains, likely are amenities of a city, they do not change over time. The identifying assumption is that housing supply elasticity characteristics are independent of changes in local exogenous amenities. Specifically, the moment restrictions are:

$$E\left(\Delta\xi^{z}_{jt}\Delta Z_{jt}\right) = 0$$

$$\text{Instruments:}\Delta Z_{jt} \in \left\{ \begin{array}{c} \Delta B^{H}_{jt}, \Delta B^{L}_{jt} \\ \Delta B^{H}_{jt}x^{reg}_{j}, \Delta B^{L}_{jt}x^{reg}_{j} \\ \Delta B^{H}_{jt}x^{geo}_{j}, \Delta B^{L}_{jt}x^{geo}_{j} \end{array} \right\}.$$

5.6 Amenity Supply

Differencing the amenity supply equation relative to its 1980 level gives:

$$\Delta a_{jt} = \gamma^{a}\Delta \ln\left(\frac{H_{jt}}{L_{jt}}\right) + \Delta\varepsilon^{a}_{jt}.$$

The elasticity of amenity supply γ^{a} is identified by instrument for changes in the college employment ration with the Bartik labor demand shocks and their interactions with the housing supply elasticity characteristics. The exclusion restrictions assume that these instruments are uncorrelated with unobserved exogenous changes in the city's local amenities which make up the amenity index $\left(\Delta\varepsilon^{a}_{jt}\right)$. The moment restrictions are:

$$E\left(\Delta\varepsilon^{a}_{jt}\Delta Z_{jt}\right) = 0$$

$$\text{Instruments:}\Delta Z_{jt} \in \left\{ \begin{array}{c} \Delta B^{H}_{jt}, \Delta B^{L}_{jt} \\ \Delta B^{H}_{jt}x^{reg}_{j}, \Delta B^{L}_{jt}x^{reg}_{j} \\ \Delta B^{H}_{jt}x^{geo}_{j}, \Delta B^{L}_{jt}x^{geo}_{j} \end{array} \right\}.$$

All parameters are jointly estimated using 2-step GMM.[33] Standard errors are clustered by MSA in all estimating equations.

[33] All equations contain decade fixed effects to absorb nationwide changes over time.

6 Parameter Estimates

6.1 Worker Labor Supply

I estimate four specifications of the model to highlight the importance of endogenous amenities and productivity in influencing migration, wages and housing prices from 1980 to 2000. First, I estimate the "standard" model, which assumes local amenities and firms' local productivity levels are exogenous and thus do not depend on the college employment ratio. I assume local demand elasticities are solely determined by the elasticity of labor substitution between college and non-college workers, as determined by parameter ρ.[34] Further, this model does not calibrate households' expenditure shares on local goods, in order to highlight how workers appear to trade off wages and local prices when amenities are assumed exogenous. These estimates are in Column 1 of Table 4.

Panel A of Table 4 reports the estimates of workers' demand elasticities for cities with respect to wages and rents. In this "standard" model, both college and non-college workers prefer higher wages and lower rents. However, their willingness to trade off wages and rents are extremely different, indicating they appear to have very different expenditure shares on local goods.[35] College workers appear to spend 25% of these expenditure on housing and local goods, while non-college workers spend 58%. Under the imposed assumption that amenities are exogenous, these estimates suggest the divergence in skill sorting across cities was due to non-college workers' local expenditure share being more than twice that of college workers. As previously shown from the CEX data, college workers spend 44% of their expenditure on housing alone, which is a lower bound for total local goods consumption. This rejects the model's parameter estimate of a 25% expenditure share. The giant gap in local good expenditure shares estimated by the model between the college and non-college is also rejected by the CEX. If anything, the CEX data suggest college workers spend slightly more on housing than the non-college.

Since the CEX data allow us to directly observed local expenditure shares, I re-estimate the "standard" model where I calibrate local expenditure shares to 62% and estimate workers migration elasticities with respect to wages, net of local good prices. I refer to this model as the "restricted standard" model. These estimates are in Column 2 of Table 4. These estimates show that college workers' appear to prefer *lower* real wages. In other words, if college workers spend 62% of their expenditure on local goods, they must *enjoy have lower real wages* in order to rationalize why they would move to such high price cities. The estimates for non-college workers when calibrating their local expenditure share to 62% are very similar to the unrestricted standard model.

To directly assess whether calibrating the local good expenditure share is consistent with the data, I test whether the parameter values from the restricted standard model are statistically significantly different from the parameter estimates from the unrestricted standard model. The test strongly rejects that the parameters are same with a p-value of less than 0.01%. A local expenditure share of 0.62 is

[34] Spefically, this "standard model" estimates labor demand equations (4) and (5), where I assume $f_H(H_{jt}, L_{jt}) = 0$, $f_L(H_{jt}, L_{jt}) = 0$.

[35] The ratio of workers' demand elasticities for rents to wages measures their expenditure share on local goods. As derived in Section 4, since workers' preferences are Cobb-Douglas in the national and local good, the indirect utility value of rent measured in wage units represents the share of expenditure spent on locally priced goods.

rejected by the migration data when amenities are assumed exogenous.

College workers' apparent indifference towards high local prices suggests that there is an omitted variable which is positively correlated with local prices that is influenced by Bartik shocks and housing supply. Changes in cities' amenities could explain this puzzle. I run a test of the over-identifying restrictions to assess whether my instruments are jointly uncorrelated with unobserved local amenity changes. In both the restricted and unrestricted standard modes, I reject the hypothesis that my instruments are jointly uncorrelated with unobserved local amenity changes with p-values less then 0.05. This further motivates the inclusion of endogenous amenities to the model.

Column 3 of Table 4 adds the amenity index, constructed in Section 5.1, as an endogenous city characteristic. These estimates also relax the CES functional form for land demand, allowing a more flexible labor demand model. I also assume a local expenditure share of 0.62. I refer to this as the "full" model. Under these estimates, college and non-college workers prefer higher wages, lower rents, and a higher amenity index level. Unlike the standard restricted model, a local good expenditure share of 0.62 no longer implies that college workers prefer lower real wages. Instead, they prefer higher real wages, but they also desire high quality amenities. The key point of preference heterogeneity between the college and non-college is due to the relative value of high real wages versus high amenity levels. Non-college workers have a migration elasticity with respect to real wages of 4.03, while college workers are less responsive, with an elasticity of 2.12. College workers, however, are much more sensitive to the amenity index level, with a migration elasticity of 1.01, compared to non-college workers elasticity of 0.27.[36]

In the full model, I test whether the over identifying restrictions can be jointly satisfied. I am now unable to reject the null that all moment restrictions are true, with a p-value of 13.5%. The endogenous amenity index appears to capture the omitted variable that previously led to violations of the over identifying restrictions.

Column 4 of Table 4 drops the assumption that local expenditure shares are 0.62 and tries identify this parameter from the migration data. The estimates under this model are noisier, likely due to the fact that housing rent are quite correlated with amenities. Under this fully flexible model, I test whether the parameter values estimated from the full model (with calibrated expenditure shares) could be rejected under this fully flexible model. I am unable to reject that the parameter values estimated when calibrating local expenditure shares are significantly different from the parameters estimated under the fully flexible model, with a p-value of 48.9%. Calibrating the local expenditure share from the CEX appears to be a good assumption.

The bottom half of Panel A of Table 4 reports additional preference heterogeneity for Blacks and

[36] These results are consistent with previous work by Bound and Holzer (2000). They do not directly incorporate cost of living changes or endogenous amenity effects when studying the migration response of college and non-college workesr to Bartik labor demand shocks. They find college workers's migration is elastic to local labor demand changes, but low-skill workers are essentially inelastic. Looking at Column 1 of Table 4, which do not include endogenous amenities in the model, I find a higher migration elasticity with respect to wages for college workers than non-college. This because in-migration of college workers improves amenities, further fueling in-migration on the margin, as compared to in-migration of non-college workers. I have run the model where I completely drop housing prices from the model and estimate migration elasticities with respect to wages only. In these estimates (available upon request), college workers have an estimated migration elasticity of 2.7, while the point estimate for non college is negative at -0.50 (and indistinguishable from zero). These numbers are quite close to Bound and Holzer (2000).

immigrants. Overall, both Black and immigrants appears to be more elastic, in general, with respect to wages, rent, and the amenity index. However, these estimates are somewhat noisy.

Table 5 reports estimates for workers' preferences to live in their own state of birth or Census Division of birth.[37] Non-college workers are 4.4 times more likely to live in a given MSA if it is located is his state of birth than if it is not, while college workers are only 3.5 times more likely. Both college and non-college workers are 2.2 times more likely to live in an MSA located in his Census Division of birth than an MSA farther away. These estimates are similar for Blacks. Unlike the endogenous amenity index, the amenity of living near one's place of birth influences the city choices of low skill workers more than high skill. [38]

6.2 Housing Supply

Panel B of Table 4 presents the inverse housing supply elasticity estimates. Consistent with the work of Saiz (2010) and Saks (2008), I find housing supply is less elastic in areas with higher levels of land-use regulation and less land near a city's center available for real estate development. The inverse housing supply elasticity estimates do not differ much between the four model specifications, which is not surprising since the all have identical housing supply models. I use the parameter estimates to predict the inverse elasticity of housing supply in each city. The average inverse housing supply elasticity is 0.21, with a standard deviation of 0.22. A regression of my inverse housing supply elasticity estimates on Saiz (2010)'s estimates yields a coefficient of 0.86 (0.14), suggesting we find similar amounts of variation in housing supply elasticities across cities. However, Saiz (2010)'s inverse housing supply estimates are higher than mine by 0.26, on average. The overall level of my estimates is governed by the "base" inverse housing supply term, γ. This parameter is the least precisely estimated of the housing supply elasticity parameters, with a point estimate of 0.01 (0.089), which could explain why I find lower inverse housing supply estimates overall. Further, Saiz's estimates are identified using a single, long run change in housing prices from 1970-2000, while I am looking at changes relative to 1980. Differences in time frame could impact these parameter estimates as well.

6.3 Labor Demand

Panel C of Table 4 presents parameter estimates for the local labor demand curves. In the standard model with un-calibrated local expenditure shares and exogenous amenities and productivity, I estimate ρ to be 0.392, which implies a elasticity of labor substitution of 1.6. The standard model with calibrated local expenditure shares has an almost identical estimate of ρ of 0.393. These estimates are very close to others in the literature, which tend to be between 1 and 3.[39] Work by Card (2009) estimates the elasticity of labor substitution at the MSA level and finds an elasticity of 2.5, which is

[37] I estimate decade-specific parameters for workers' preferences to live close to their state of birth. This is purely for computational convenience. Since these parameters are jointly estimated along with the mean utility levels for each city for each demographic group for each decade, estimating each decade's parameters in a separate optimization allowed for a signficant decrease in the computational memory requirements needed for estimation.

[38] This is consistent with the migration literature that finds high skilled workers are more likely to move away from their place of birth. See Greenwood (1997) for a review of this literature.

[39] See Katz and Autor (1999) for a literature review of this work.

close to my results.

In the full model specifications, I allow for a more flexible labor demand curve. This reduced form labor demand curve bundles the impacts of imperfect labor substitution between college and non-college workers within firms with the city-wide endogenous productivity effects of changes in a city's skill-mix. For non-college labor demand I find downward sloping labor demand, with an inverse labor demand elasticity for non-college workers of -0.552. The elasticity of non-college wages with respect to college employment is positive at 0.697. These inverse labor demand estimates on non-college wages are consistent with the standard model where there are no endogenous productivity effects impacting non-college wages.[40] The estimates in Column 4 of Table 4, which do not calibrated local expenditure shares, are very similar.

The impacts of labor supply on college wages, however, is quite different. I find *upward sloping* aggregate inverse labor demand with respect to college wages, with a point estimate of 0.229. The standard errors are large, making me unable to rule out a zero effect. However, I am able to reject that the elasticity of college labor demand with respect college wages is equal to the elasticity of non-college labor demand with respect to non-college wages. These elasticities are assumed to be the same under the standard CES production function commonly used in the literature. Overall, the positive aggregate labor demand elasticities for college workers suggests that the endogenous productivity effects of college workers on college workers' productivity may be large and could overwhelm the standard forces leading to downward sloping labor demand.

Moretti (2004*b*) also analyzes the impact of high and low skill worker labor supply on workers' wages within a city. He estimates a 1% increase in a city's college employment ratio leads to a .16% increase in the wages of high school graduates and a .10% increase in the wages of college graduates, both of which are smaller than my findings.[41] His estimates are identified off of cross-sectional variation in city's college shares, driven by the presence of a land grant college, while my estimates are estimated off of changes in skill-mix driven by housing supply elasticity heterogeneity. Additionally, my estimates explicitly combine the impact of movement along firm's labor demand curves with endogenous productivity spillovers, while Moretti controls for labor demand variation. He also uses the lagged age structure of the city as a instrument for changes in cities' skill mix. Using this identification strategy, he finds slightly larger effects (point estimates become 0.39 for high school graduate wages and 0.16 for college wages,) which are quite close to my findings.[42]

[40] Even though the non-college inverse labor demand elasticities are consistent with no productivity spillovers impacting their wages, one cannot rule out their influence on aggregate labor demand elasticities for the non-college. Identifying the direct effects of endogenous productivity on wages is not identified with my data.

[41] Moretti (2004*b*)'s setup looks at the impact of a city's share of college graduates $\left(\frac{H_{jt}}{H_{jt}+L_{jt}}\right)$ on workers' wages by education level, while my setup measures the local education mix using the log ratio of college to non-college workers $\left(\ln\frac{H_{jt}}{L_{jt}}\right)$. To transform Moretti's estimates into the same units of my own, note that $\frac{H_{jt}}{H_{jt}+L_{jt}} = \frac{\frac{H_{jt}}{L_{jt}}}{1+\frac{H_{jt}}{L_{jt}}}$. Moretti estimates: $w_{jt} = \beta\frac{H_{jt}}{H_{jt}+L_{jt}}$. Thus, $\frac{\partial w_{jt}}{\partial \ln\left(\frac{H_{jt}}{L_{jt}}\right)} = \frac{\partial w_{jt}}{\partial\frac{H_{jt}}{H_{jt}+L_{jt}}}\frac{\partial\frac{H_{jt}}{H_{jt}+L_{jt}}}{\partial\ln\left(\frac{H_{jt}}{L_{jt}}\right)} = \beta * \left(\left(\frac{H_{jt}}{H_{jt}+L_{jt}}\right)\left(1-\frac{H_{jt}}{H_{jt}+L_{jt}}\right)\right)$. Plugging in the average college share in 1990, 0.25 gives: $\frac{\partial w_{jt}}{\ln\left(\frac{H_{jt}}{L_{jt}}\right)} = \beta * (0.1875)$. Thus, I scale Moretti's estimates by 0.1875 to make them in the same units as my own.

[42] Ciccone and Peri (2006) also estimate the productivity spillovers of education. However, they focus on the social

The elasticity of college wages with respect to non-college labor is positive at 0.312, however the estimates are noisy and I cannot rule out zero effect. While effects of college wages on labor demand is not very precisely estimated, these estimates viewed together shows that the commonly used CES labor demand assumptions may impose very restrictive structure the shapes of MSA-level labor demand, which may be due to endogenous productivity effects.

6.4 Amenity Supply

Panel D of Table 4 estimates the elasticity of supply of the amenity index with respect the college employment ratio. Columns 3 and 4 report the estimates under the full model with and without calibrated local expenditure shares. Both models report very similar elasticities of amenity supply between 2.60 and 2.65. An increase in a city's college employment ratio endogenously improves local amenities in the area. This mechanism is exactly why the Bartik shocks and housing supply elasticities instruments cause change in local amenities: they influence cities' shares of college graduates.

6.5 Estimation Robustness

To assess whether the parameter estimates of the model are sensitive to ways that I have measured wages, rents, and Bartik shocks, I re-estimate the model using a variety of different variable definitions. These results are in Appendix Table A.3. To summarize, the estimates are similar when wages and rent are hedonically adjusted for detailed housing and worker characteristics, whether housing costs are used only from the college or non-college population within cities, different values of the calibrated local expenditure share parameter, and using the college employment ration directly as the index of endogenous amenities. I also estimate models "in between" the standard model and the full model, where I incorporate the endogenous amenity model separately from incorporating the endogenous productivity model. Appendix B.3 discusses these robustness checks in more details.[43] Throughout the rest of the paper, I will use the estimates from Column 3 of Table 4, which calibrate the local goods expenditure share to 0.62.

7 Amenities & Productivity Across Cities

Using the estimated parameters, one can infer the exogenous productivity of local firms and the desirability local amenities in each city. There is a large literature which attempts to estimate which

return to an additional year of average education, without diffentiating between college and non-college years of education. They also use lagged age structure of a city as an instrument for the local skill mix, but do not find any evidence of spillovers. Since they do not explicitly analyze spillovers due to college versus. non-college skill mix, it is hard to compare exactly why these estimates differ. Their analysis also does not include the 2000 census.

[43] I have also explored whether weak instruments are a problem for the model estimation. I have re-estimated the model using two-stage least squares seperately for each equation. These estimates in Table A.4, along with the partial-F test for each endogenous variable. The point estimates using two-stage least squares are similar to the GMM tests, but the F-stats are a bit low. To further assess the extent of the weak instrument issue, Table A.4 also reports LIML estimates, estimated seperately for each equation for the model. The point estimates are similar to the main estimates, however the labor demand estimate have larger standard errors. While I cannot rule out whether parts of the model are weakly identified, the LIML estiamtes suggest this is not a large issue for the preference estimates or the endogenous amenity supply estimates.

cities offer the most desirable amenities using hedonic techniques.[44] This paper infers cities' amenity levels using a different approach. Recalling equation (31) , the utility value of the amenities in a city to workers of a given demographic group is measured by the component of the workers' common utility level for each city which is not driven by the local wage and rent level. The utility workers of type z receive from the amenities in city j in year t, $Amen^z_{jt}$, is thus:

$$Amen^z_{jt} = \beta^a_i a_{jt} + \xi^z_{jt} = \delta^z_{jt} - \beta^w z \left(w^{edu}_{jt} - \zeta r_{jt} \right).$$

Intuitively, amenities are inferred to be highest in cities which have higher population levels of a given demographic group than would be expected, given the city's wage and rent levels and workers' preferences for wages and rent.

A test of whether the model fits the data well is to asses whether the amenity rankings appear "intuitive." Of the largest 75 cities, as measured by their population in 1980, Appendix Table A.5 reports the top 10 cities with the most desirable and undesirable amenities for college and non-college workers in 1980 and 2000, as well as the cities with the largest improvements and declines in amenities during this time period. In 2000, Los Angeles-Long Beach, CA had the most desirable amenities for non-college workers, followed by Phoenix, AZ, Denver-Boulder, CO, Tampa-St. Petersburg-Clearwater, FL, and Seattle-Everett, WA. The cities with the most desirable amenities for college workers in 2000 were: Los Angeles-Long Beach CA, Washington, DC/MD/VA, San Francisco-Oakland-Vallejo, CA, Seattle-Everett, WA, and Denver-Boulder, CO. These cities are known to have vibrant cultural scenes, desirable weather, and often considered to have high quality-of-life.

The least desirable city amenities for college workers in 2000 are located in Youngstown-Warren, OH-PA, which is followed by Allentown-Bethlehem-Easton, PA/NJ, Syracuse, NY, Harrisburg-Lebanon–Carlisle, PA, and Scranton-Wilkes-Barre, PA. Similarly, non-college workers find the least desirable amenities in Youngstown-Warren, OH-PA, followed by Toledo, OH/MI, Syracuse, NY, Buffalo-Niagara Falls, NY, and Allentown-Bethlehem-Easton, PA/NJ. All of these cities are located in America's Rust Belt, where the cities have historically had high levels of pollution due the concentration of manufacturing jobs. They have recently faced large declines in manufacturing jobs, population declines, and growing crime rates since the 1980s.

A similar validation test can be done by analyzing which cities have the highest and lowest productivity levels. Since the estimated labor demand equations are reduced forms, their residuals have a less clear theoretical relationship with cities' productivity levels. I focus on looking at changes in these measures of productivity, since these reduced form labor demand equations were estimated using changes. Appendix Table A.6 reports the largest and smallest productive changes between 1980 and 2000 for college and non-college workers. The city with large increase in college productivity was San Jose, CA. Other cities in the top ten include Milwaukee, WI, San Francisco-Oakland-Vallejo, CA, New York-Northeastern NJ, and Philadelphia, PA/NJ. These cities are the hubs of many of the most

[44] The hedonic methods infer a city's amenities by directly comparing local real wages across cities. In a model where workers have homogeneous preferences for cities, the equilibrium local real wages across cities must be set to equate all workers utility values in all cities. In equilibrium, the difference in real wages across cities is a direct measure of the amenity value of the city. A low amenity city must offer a high real wage in order to offer the same utility as a high amenity city. See Albouy (2008) for recent amenity estimates using these techniques.

productive industries such as high tech in Silicon Valley and San Francisco and finance in New York.

The largest increases in productivity for low skill workers was Fresno, CA, with other top ten cities including Baton Rouge, LA, Greensboro-Winston Salem-High Point, NC, and Riverside-San Bernardino,CA. Fresno has become an increasingly productive agricultural hub, with many large-scale agricultural firms providing farm jobs, as well as food canning and packaging jobs. Similarly, Riverside-San Bernardino, CA is where many of the largest manufacturing companies have chosen to place their distribution centers. These centers transport finished goods and materials from the ports surrounding Los Angeles to destinations around the US. Shipping, distribution, and food production provide many relatively high paying jobs for low skill workers here, which are very difficult to outsource to countries with lower labor costs (Autor, Dorn and Hanson (2013)).

These lists of cities above show that there are striking differences in which cities have had the largest changes in productivity for high skill labor vs low skill from 1980 to 2000. Table 6 presents this finding as a regression of the model's predicted change in cities' high skill productivities on their predicted changes in low skill productivities. I find a weakly positive relationship between local high skill productivity change, and local low skill productivity change, with an R squared of 0.019. Note that this weak relationship between changes in local high skill productivity and low skill productivity cannot be seen by simply comparing changes in local high skill wages with changes in local low skill wages. Table 6 shows that changes in high and low skill wages are strongly positively correlated, with an R squared of 0.49. Movement along local labor demand curves driven by migration masks the large differences local productivity changes by skill.

The differences in high and low skill workers' preferences for a city's amenities is unlikely to differ by the same magnitude. One would expect that college workers' overall utility value for a city's amenities to be positively associated with non-college workers' utility value for the same city's amenities. Table 6 shows that the utility value of college and non-college amenity changes across cities are strongly positively correlated. Changes in non-college workers' utility due to changes in cities' amenities explains 43% of the variation in changes in college workers' utility for the same cities' amenities.

The inferred local productivity and amenity changes across cities appear consistent with outside knowledge on these measures, and the relationships between productivity and amenities changes also appear intuitive.

8 The Determinants of Cities' College Employment Ratio Changes

I use the estimated model to assess the contributions of productivity, amenities, and housing supply elasticities to the changes in cities' college employment ratios.

8.1 College Employment Ratio Changes and Productivity

I first consider how much of the observed changes in cities' college employment ratios can be explained by changes in cities' exogenous productivity levels. Changes in local productivity directly impact wages, but also influence local prices and endogenous amenities through migration. First, I focus on the direct effect of productivity changes on local wages. I compute the direct effect of the exogenous productivity changes from 1980 to 2000 inferred from the model on local high and low skill wages. These counterfactual college and non-college wages in 2000, $\hat{w}^H_{j2000}$ $\hat{w}^L_{j2000}$ are:

$$\hat{w}^H_{j2000} = \underbrace{\gamma_{HH} \ln H_{j1980} + \gamma_{HL} \ln L_{j1980}}_{\text{Labor Supply in 1980}} + \underbrace{\varepsilon^H_{j2000}}_{\text{Exog. Productivity in 2000}}$$
$$\hat{w}^L_{j2000} = \underbrace{\gamma_{LH} \ln H_{j1980} + \gamma_{LL} \ln L_{j1980}}_{\text{Labor Supply in 1980}} + \underbrace{\varepsilon^L_{j2000}}_{\text{Exog. Productivity in 2000}}$$

The counterfactual wages only reflect the shifts in local labor demand curves driven by the exogenous changes in local productivity from 1980 to 2000, but not the movement along cities' labor demand curves or endogenous productivity changes due to migration.

Using these counterfactual year 2000 wages, while holding rents and amenity levels fixed at their 1980 levels, I use the model to predict where workers would have chosen to live if they had to choose among this set of hypothetical cities. Specifically, worker i's utility for hypothetical city j is:

$$V_{ijt} = \beta^w z_i \left(\hat{w}^{edu}_{j2000} - \zeta r_{j1980} \right) + \beta^a z_i a_{j1980} + \xi^z_{j1980} + \beta^{st} z_i st_i x^{st}_j + \beta^{\text{div}} z_i \,\text{div}_i \, x^{\text{div}}_j + \varepsilon_{ij80}.$$

The predicted cities' college employment ratios from this hypothetical world are then compared to those observed in the data. This counterfactual scenario assesses whether the cities which became disproportionately productive for college, relative to non-college workers, were also the cities which experienced disproportionate growth in their college versus non-college populations. Figure 2.A plots the observed college employment ratio changes against these predicted counterfactual changes. The predicted and actual changes are strongly correlated with a correlation coefficient of 0.80. Local productivity changes explain a large share of the changes in cities' local college employment ratios from 1980 to 2000. However, workers' actual migration decisions depended on how local productivity changes influenced the overall desirability of cities's wages, rents, and amenities.

In a model where amenities are assumed to be exogenous, the only ways which productivity changes can influence workers' location decisions is by influencing local wages and rents. To test whether the wages and rent alone capture the observed migration patterns well, I use the model to predict workers' city choices in 2000, using only the observed changes in wages and rent. Holding amenities fixed at the 1980 levels, I set local wages and rents to the levels observed in 2000. Specifically, worker i's utility for hypothetical city j is:

$$V_{ijt} = \beta^w z_i \left(w^{edu}_{j2000} - \zeta r_{j2000} \right) + \xi^z_{j1980} + \beta^a z_i a_{j1980} + \beta^{st} z_i st_i x^{st}_j + \beta^{\text{div}} z_i \,\text{div}_i \, x^{\text{div}}_j + \varepsilon_{ij80}.$$

I predict where workers would have chosen to live if they had to choose from this set of counterfactual cities. If endogenous amenity changes were not an important factor in how productivity changes influenced cities' college employment ratio changes, then local wage and rent changes should be at least as strong of a predictor of college employment ratio changes. Figure 2.B plots the observed college employment ratio changes against these counterfactual predicted college employment ratio changes.

The correlation of the predicted versus actual college employment ratio changes falls significantly to 0.32. This suggests endogenous amenity changes are an important component through which exogenous productivity changes led to changes in cities' college employment ratios.

To test this, I create a third set of counterfactual cities. These cities hold the exogenous amenities fixed at their 1980 levels, but allow wages, rents, and endogenous amenities driven by the college employment ration to shift to the levels observed in 2000. Specifically, worker i's utility for hypothetical city j is:

$$\begin{aligned} V_{ijt} &= \beta^{w} z_i \left(w^{edu}_{j2000} - \zeta r_{j2000} \right) + \xi^{z}_{j1980} + \beta^{a} z_i \hat{a}_{j2000} + \beta^{st} z_i st_i x^{st}_{j} + \beta^{\text{div}} z_i \,\text{div}_i \, x^{\text{div}}_{j} + \varepsilon_{ij80}, \\ \hat{a}_{j2000} &= \gamma^{a} \ln \left(\frac{H_{j2000}}{L_{j2000}} \right) + \varepsilon^{a}_{j1980.} \end{aligned}$$

Note that I am only allowing for the effect of amenities due the changes in the college employment ratio (the endogenous part of amenities). This highlights the piece of amenities influenced by local productivity changes.

I use the model to predict where workers would have chosen to live within this set of counterfactual cities. Figure 2.C plots actual college employment ratio changes against these predicted changes due to wages, rents, and endogenous amenities. The correlation coefficient is now 0.86, a 250% increase relative to the predictive power of wage and rent changes alone. The combination of wage, rent, and endogenous amenity changes have more predictive power than the productivity shifts alone, showing that the endogenous amenity response was a key mechanism through which local productivity changes led to migration changes.

8.2 Corroborating Reduced Form Evidence

As an alternative method to assess the role of local productivity changes in driving local migration patterns, I analyze the reduced form relationship between the exogenous productivity changes estimated from the model and cities' college employment ratios. This simply measures whether the estimated exogenous productivity changes are predictive of college employment share changes, without imposing the structural parameters of how workers' migrate. The regression is:

$$\ln \left(\frac{H_{j2000}}{L_{j2000}} \right) - \ln \left(\frac{H_{j1980}}{L_{j1980}} \right) = \beta_1 \left(\varepsilon^{H}_{j2000} - \varepsilon^{H}_{j1980} \right) + \beta_2 \left(\varepsilon^{L}_{j2000} - \varepsilon^{L}_{j1980} \right) + \epsilon_j .$$

Consistent with the findings of Moretti (2013), Column 1 of Table 7 shows that high skill exogenous productivity changes strongly predict increases in cities' college employment ratios, while low skill exogenous productivity changes are negatively predictive. Further, the R-squared of this regression shows that 62% of the variation in changes in cities' college employment ratios can be explained by changes in local productivity.

As a point of comparison, I now asses how well the model inferred *exogenous* amenity changes $\left(\Delta \xi^{z}_{jt}\right)$ predict changes in the college employment ratio.[45] Column 2 of Table 7 shows that the

[45] I use the model-inferred exogenous amenities changes for non-black, non-immigrant households, since this represents

exogenous amenity changes negatively predict changes in the college employment ratio. However, their explanatory power is low, with an R-squared of 0.048.

Column 3 of Table 7 combines the exogenous amenity changes and exogenous productivity changes into the same regression. Again, the exogenous productivity changes strongly predict the college employment ratio changes. The R-squared increased by only 0.014 from including the exogenous amenity changes, relative to only using the productivity changes. Local productivity changes were the key driver of changes in cities' college employment ratios.

I now turn to whether *endogenous* amenity changes were a key channel through which local productivity changes led to college employment ratio changes. I analyze the relationship between local real wage changes and the college employment ratio. Since local productivity changes appear to be a key driver in college employment ratio changes, local real wage changes should also explain the college employment ratio changes well. Local real wages are defined as wages, net of local good prices:

$$\text{local real wage}_{jt}^{edu} = w_{jt}^{edu} - (.62) * r_{jt}.$$

Column 4 of Table 7 shows that an increase in the college real wage is associated with *decreases* in the college employment ratio. For college graduates to increasingly choose to live in lower real wage cities, they either must prefer low real wages or they must be compensated for lower real wages with amenities. Thus, this reduced form regression strongly supports the structural model estimates previously discussed. Without amenity changes, college graduates's revealed preferences appear to prefer lower real incomes.

Looking directly at the impact of local productivity changes on real wages, Column 5 of Table 7 shows that a increase in college productivity led to *lower* real wages for college graduates. When college graduates migrated to these cities with increased wages due to high productivity, they bid up housing prices. If the amenities did not also increase from this in-migration, the in-migration would cease once the increase in housing prices offset the benefit of the higher wages. However, this is not what we see in the data. College workers continued to migrate in and bid up housing prices so high that they received lower real wages. It is hard to rationalize why college workers would disproportionately migrate to areas with decreases in local real wages, unless the local productivity changes caused those areas to also simultaneously increase their local amenities.

Column 6 of Table 7 performs a similar regression on non-college real wages. Increases in non-college productivity lead to *increases* in non-college real wages. Consistent with the structural model estimated, the effects of endogenous amenities appear to be much more important for understanding college workers' migration than that of non-college workers'.

9 Welfare Implications & Well-Being Inequality

It is well documented that the nationwide wage gap between college workers and high school graduates has increased significantly from 1980 to 2000. Table 8 shows that the nationwide college wage gap has

the vast majority of the population.

increased by 0.19 log points.[46] However, increases in wage inequality do not necessarily reflect increases in well-being inequality. College workers increasingly chose to live in cities with higher wages, high rents, and more desirable amenities than non-college workers. The additional welfare effects of local rents and amenities could either add to or offset the welfare effects of wage changes.

Looking only at wage and rent changes, I measure changes in the college "local real wage gap." A worker's local real wage is defined as his utility from wages and rent, measured in log wage units. Similar to the findings of Moretti (2013), Table 8 shows the local real wage gap has increased 0.15 log points, 25% less than the increase in the college wage gap. However, this is not a full welfare metric.

Part of the reason college workers chose to pay such high housing rents was because they gained utility from areas' amenities. To measure how changes in cities' wages, rents, and amenities each contributed to well-being inequality, I conduct a welfare decomposition. First, I measure each worker's expected utility change from 1980 to 2000 if only cities' wages had changed, but local rents and amenities had stayed fixed. See Appendix B.2 for exact details of this calculation.[47] The expected utility change measures each workers willingness to pay (in log wages) to live in his first choice counterfactual city instead of his first choice city from the set available in 1980. I compute the expected utility change driven only by cities' wage changes from 1980 to 2000 for each worker and compare the average utility impact for college workers to the that of non-college workers.

Table 9 reports that from 1980-2000, changes in cities' wages led to an increase in the college well-being gap equivalent to a nationwide increase of 0.218 log points in the college wage gap, which is quite close to observed increase of 0.19 in the college wage gap. Even if local amenities and rents had not changed, there still would have been a substantial increase in well-being inequality between college and non-college workers due to local wage changes.

To account for the additional effect of local rent changes, I perform a similar calculation that allows local wages and rents to adjust to the level observed in 2000. Table 9 shows the change in well-being inequality between college and high school graduates due to wage and rent changes from 1980 to 2000 is equivalent to a nationwide increase of 0.194 log points in the college wage gap. The welfare impacts of wages and rents lead to a smaller increase in well-being inequality because the cities which offered the most desirable wages for college workers also had the highest rents, offsetting some of the wage benefits.

To measure the additional contribution of amenity changes to well-being inequality, I can only quantify the welfare impacts of endogenous amenity changes due to changes in cities' college employment ratios.[48] Since the model infers unobserved exogenous amenity changes by measuring which

[46] I focus on the college graduate-high school graduate wage gap because most of the literature has used this as a key wage inequality statistic. My model assumes all non-college workers face the same wage diffentials across cities. To make the welfare analysis comparable to the college-high school wage gap, I adjust the non-college workers' wages nationwide to represent the wages of a high school graduate, instead of the typical non-college worker. This does not impact the relative wages across cities.

[47] I measure each workers' expected utility from his top-choice city after integrating out over the distribution of extreme value errors. A given worker's true utility value would also depend on his idiosyncratic tastes for each city, as modeled by the random draws from the extreme value distribution. Since I do not observed these for each worker, I integrate them out.

[48] I only account for the effects of endogenous amenities due to the college employment ratio, instead of the effect of the overall amenity index, because I do not observe the amenity index in all MSAs in the data. This is especially true for the synthetic MSAs making up the rural parts of each state. The college employment ratio, however, is observed in

cities have larger population growth than would be expected from the local wage and rent changes, the model only identifies *relative* amenity changes between cities across years. The model cannot identify the overall magnitude of unobserved amenity changes across decades.[49]

The welfare effects of endogenous amenity changes over time, however, can be measured. Since a city's college employment ratio represents a component of the city's endogenous amenity level, an increase in a city's college employment ratio over time means that the endogenous amenities must have improved from one year to the next. This welfare effect can be measured directly.

There are two main reasons the endogenous amenities of cities have changed over time. First, there has been a nationwide increase in the share of the population with a college degree. This led to increases in the college shares of almost all cities from 1980 to 2000. Second, there has been a re-sorting of college and non-college workers across cities, which, coupled with the nationwide college share increase, led to increases in some cities' college shares more than others.

First, I measure the impact of amenity changes on well-being inequality driven only by the re-sorting of workers, holding the nationwide college share fixed at the 1980 level. The change in well-being inequality between college and high school graduates due to wage, rent, and endogenous amenities driven by workers re-sorting from 1980 to 2000 is equivalent to a nationwide increase of 0.256 log points in the college wage gap. This change in well-being inequality is 30% *larger* than the observed increase in the actual college wage gap from 1980 to 2000.

The additional nationwide growth in the country's share of college graduates led to large amenity changes across almost all US cities. Adding on the additional effect of the change in endogenous amenities due to the nationwide increase in all cities' college shares leads to an overall increase in well-being inequality equivalent to 0.573 log point increase in the college wage gap. This figure, however, should be interpreted with caution. There are surely many other nationwide changes in the US which differentially effected the well-being of college and non-college workers. For example, nationwide improvements in health care, life expectancy, air-conditioning, television, and the internet likely influenced the well-being of all workers nationwide. Since the model can only capture the welfare effects of college share changes and not the many other nationwide change, one should not interpret the welfare effects of the nationwide increase in college graduates as an accurate measure of changes in overall well-being inequality. It is difficult to gauge what aspects of well-being inequality changes are measured in the nationwide increase in cities' endogenous amenities.

For these reasons, I place more confidence in the estimated changes in well-being inequality due to wage, rent, and endogenous amenity changes driven by workers re-sorting across cities. The combined welfare effects of changes in wages, rents, and endogenous amenities driven only by the re-sorting of workers across locations have led to at least a 30% larger increase in well-being inequality than is

every MSA in every year of the data.

[49] To see this consider a simple example of 2 cities: New York and Chicago. New York and Chicago are equally appealing in year 1, and have equal populations. In year 2, there is large migration from New York to Chicago, which cannot be explained by wage and rent changes. One can conclude that the amenities of Chicago must have improved, *relative* to the amenities of New York. If the amenities of New York stayed fixed, while the amenities of Chicago improved, workers were able increase their utility, since New York is equally desirable in years 1 and 2, but Chicago improved. In contrast, if the amenities of New York declined, but Chicago's amenities stayed fixed, workers would be worse off in year 2 than year 1. Yet these two scenarios produced *identical* migration patterns, which makes inferring the welfare effects of unobserved amenity changes over time impossible.

apparent in the changes in the college wage gap alone.

10 Conclusion

The divergence in the location choices of high and low skill workers from 1980 to 2000 was fundamentally caused by a divergence in high and low skill productivity across space. By estimating a structural spatial equilibrium model of local labor demand, housing supply, labor supply to cities, and amenity supply I quantify the ways through which local productivity changes led to a re-sorting of workers across cities. The estimates show that cities which became disproportionately productive for high skill workers attracted a larger share of skilled workers. The rise in these cities' college shares caused increases in local productivity, boosting all workers' wages, and improved the local amenities. The combination of desirable wage and amenity growth caused large amounts of in-migration, driving up local rents. However, low skill workers were less willing to pay the "price" of a lower real wage to live in high amenity cities, leading them to prefer more affordable, low amenity locations.

The net welfare impacts of the changes in cities' wages, rents, and endogenous amenities led to an increase in well-being inequality between college and high school graduates of at least 30% more than the increase in the college wage gap alone. The additional utility college workers gained from of being able to enjoy more desirable amenities, despite the high housing local prices, increased college workers' well-being, relative to high school graduates.

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Table 1: Summary Statistics

	Obs	Mean	Std. Dev.	Min	Max
A. Prices					
Ln College Wage	804	6.362	0.125	5.919	6.703
Ln Non-College Wage	804	6.765	0.143	6.433	7.585
Ln Rent	804	6.563	0.240	6.033	7.721
B.Amenities					
Ln College Employment Ratio	804	-1.186	0.383	-2.177	0.301
Ln Student Teacher Ratio	651	0.054	1.262	-8.156	4.062
Ln K-12 Spending per Student	651	-0.032	1.251	-1.212	21.623
Ln Apparel Stores per 1000 Residents	651	0.136	1.132	-4.899	6.175
Ln Eating and Drinking Places per 1000 Residents	651	0.090	1.273	-3.804	9.463
Ln Movie Thearters per 1000 Residents	650	-0.058	1.159	-2.960	4.977
Ln Propery Crimes per 1000 Residents	643	-0.086	1.215	-4.287	4.827
Ln Violent Crimes Per 1000 Residents	643	0.156	1.408	-3.147	5.910
Ln Avg Daily Traffic- Interstates	651	0.152	1.352	-3.348	5.610
Ln Avg Daily Traffic- Major Roads	651	0.099	1.359	-3.494	5.134
Ln Bus Routes Per Capita	651	0.044	1.284	-2.413	5.814
Ln Public Transit Index	651	-8.913	1.273	-13.309	-6.738
Ln EPA Air Quality Index	632	-0.016	1.218	-3.610	4.770
Ln Gov Spending on Parks per capita	651	-0.055	1.230	-2.029	11.664
Ln Employment Rate	651	-0.054	1.287	-7.384	3.043
Ln Patents Per Capita	651	-0.059	1.148	-1.418	12.359
C. Housing Supply Elasticity Measures					
Land Unavailability	194	0.256	0.215	0.005	0.860
Land Use Regulation	194	-0.038	0.736	-1.677	2.229

Notes: Summary statistics for changes pool decadal changes in wages, rents, population from 1980-1990 and 1990-2000. The Bartik shocks are also measured across decades. The sample reported for MSAs' wages, rents, and population include a balanced panel of MSAs and rural areas which the 1980, 1990, and 2000 Censuses cover. The sample used for statistics on the Bartik shocks and housing supply elasticity characteristics are MSAs which also contain data on housing supply elasticity characteristics & always have positive population reported for the head of household sample within each demographic group of worker. Wages, rents, and population are measured in logs. Bartik shocks use national changes in industry wages weighted by the share of a cities work force employed in that industry. College Bartik uses only wages and employment shares from college workers. Non-College Bartik uses non-college workers. Aggregate Bartik combines these. Land Unavailability measures the share of land within a 50Km radius of a city's center which cannot be developed due to geographical land constraints. Land use regulation is an index of Land-Use regulation policies within an MSA. College employment ratio is defined as the ratio of number of full-time employed workers in the city with a 4 year college degree to the number of full-time employed lower skill workers living in the city. See data appendix for further details.

Table 2: MSA College Ratio Changes on Amenity Changes: 1980-2000

	A. Retail Amenities			
	Apparel Stores per 1000 Residents	Eating and Drinking Places per 1000 Residents	Movie Thearters per 1000 Residents	
Δ College Emp Ratio	0.477***	0.182***	0.230	
	[0.0928]	[0.0539]	[0.166]	
	B. Transportation Amenities			
	Bus Routes Per Capita	Public Transit Index	Avg Daily Traffic- Interstates	Avg Daily Traffic- Major Roads
Δ College Emp Ratio	-0.316**	0.0161	-0.169*	-0.0513
	[0.159]	[0.338]	[0.0979]	[0.0704]
	C. Crime Amenities		D. Environment Amenities	
	Propery Crimes per 1000 Residents	Violent Crimes Per 1000 Residents	Gov Spending on Parks per capita	EPA Air Quality Index
Δ College Emp Ratio	-0.231*	0.115	0.263	-0.539***
	[0.122]	[0.155]	[0.172]	[0.171]
	E. School Amenities		F. Job Amenities	
	Gov K-12 Spending per Student	Student-Teacher Ratio	Patents Per Capita	Employment Rate
Δ College Emp Ratio	0.129**	0.00423	0.104	0.0105
	[0.0639]	[0.0631]	[0.234]	[0.00787]

Notes: Standard erorrs in brackets. Changes measured between 1980-2000. All variables are measured in logs. College employment ratio is defined as the ratio of number of full-time employed college workers to the number of full-time employed lower skill workers living in the city. Retail and local service establishments per capita data come from County Business Patters 1980, 2000. Crime data is from the FBI. Air Quality Index in from the EPA. Higher values of of the air quality index indicate more pollution. *** p<0.01, ** p<0.05, * p<0.1

Table 3: Principle Compenent Analysis for Amenity Indices

A. Retail Index			B. Transportation Index		
	Loading	Unexplained Variance		Loading	Unexplained Variance
Apparel Stores per 1000 Residents	0.653	0.411	Public Busses Per Capita	0.566	0.8315
Eating and Drinking Places per 1000 Residents	0.525	0.619	Public Transit Index	0.7015	0.8823
Movie Thearters per 1000 Residents	0.545	0.591	Avg Daily Traffic- Interstates	0.332	0.5099
			Avg Daily Traffic- Major Roads	0.277	0.2476
C. Crime Index			**D. Environment Index**		
	Loading	Unexplained Variance		Loading	Unexplained Variance
Propery Crimes per 1000 Residents	0.707	0.395	Gov Spending on Parks per capita	0.707	0.4541
Violent Crimes Per 1000 Residents	0.707	0.395	EPA Air Quality Index	-0.707	0.4541
E. School Index			**F. Job Index**		
	Loading	Unexplained Variance		Loading	Unexplained Variance
Gov K-12 Spending per Student	0.707	0.3425	Patents Per Capita	.707	0.4417
Student-Teacher Ratio	-0.707	0.3425	Employment Rate	.707	0.4417

G. Overall Amenity Index

	Loading	Unexplained Variance
Retail Index	-0.2367	0.9039
Transportation Index	0.4861	0.5948
Crime Index	-0.1518	0.9605
Environment Index	0.3973	0.7293
School Index	0.5222	0.5323
Job Index	0.5041	0.5643

Notes: All amenity data measured in logs. See data appendix for detailed description of ammenity data and their data sources. Panels A through F report weights used in each sub-index construction. Panel G reports loadings on each sub index to create overall amenity index. See text for further details.

Table 4: GMM Estimates of Model Parameters

	[1]		[2]		[3]		[4]	
A. Worker Preferences for Cities								
	Non-College	College	Non-College	College	Non-College	College	Non-College	College
Wage	4.155***	5.523***	3.757***	-1.783***	4.026***	2.116***	3.261***	4.976***
	[0.603]	[1.797]	[0.561]	[0.682]	[0.727]	[1.146]	[1.064]	[1.671]
Rent	-2.418***	-1.404	-2.329***	1.105***	-2.496***	-1.312***	-2.944***	-2.159***
	[0.349]	[0.833]	[0.348]	[0.423]	[0.451]	[0.711]	[0.551]	[0.821]
Expenditure Share	0.582***	0.254**	0.62	0.62	0.62	0.62	0.903***	0.434***
	[0.0678]	[0.078]	-	-	-	-	[0.261]	[0.0810]
Amenity Index	-	-	-	-	0.274*	1.012***	0.771***	0.638***
					[0.147]	[0.115]	[0.307]	[0.185]
Differential Effects: Blacks								
Wage	3.146***	7.852*	0.299	2.549*	1.681	5.423***	4.604***	8.882***
	[0.971]	[3.701]	[0.872]	[1.390]	[2.122]	[2.019]	[1.629]	[4.059]
Rent	-0.620	-3.443*	-0.173	-1.478*	-0.975	-3.362***	0.181	-4.565***
	[0.555]	[1.637]	[0.506]	[0.806]	[1.231]	[1.252]	[0.679]	[1.795]
Amenity Index	-	-	-	-	0.741***	1.077***	-1.103***	0.551
					[0.221]	[0.271]	[0.406]	[0.387]
Differential Effects: Immigrants								
Wage	1.786	7.780**	-3.872***	-4.022**	0.307	0.942	1.682	7.054*
	[1.157]	[3.259]	[1.066]	[1.402]	[3.052]	[2.138]	[2.288]	[3.785]
Rent	1.324**	-1.501	2.246**	2.333	-0.190	-0.594	1.490*	-1.177
	[0.635]	[1.361]	[0.618]	[0.813]	[-1.893]	[1.325]	[0.807]	[1.510]
Amenity Index	-	-	-	-	1.075***	0.982***	-0.544	-0.348
					[0.300]	[0.238]	[0.444]	[0.358]

Notes: Table 4 continues on following page. See bottom of table on following page for differences in model specifications in columns 1 through 4 above.

Table 4 Continued

	[1]	[2]	[3]	[4]
B. Housing Supply				
Exp(Land Use Regulation)	0.084***	0.064***	0.091***	0.101***
	[0.020]	[0.013]	[0.019]	[0.027]
Exp(Land Unavailability)	0.019*	0.014*	0.021**	0.025**
	[0.011]	[0.007]	[0.010]	[0.012]
Base House Supply Elasticity	0.002	0.063	0.014	-0.021
	[0.084]	[0.072]	[0.089]	[0.102]
C. Labor Demand				
Rho	0.392***	.393***		
	[0.119]	[0.1371]		
Elasticity of College Wage wrt College Emp			0.229	0.205
			[0.307]	[0.320]
College Wage wrt Non-College Emp			0.312	0.376
			[0.367]	[0.388]
Non-College Wage wrt Non-College Emp			-0.552***	-0.448***
			[0.202]	[0.196]
Non-College Wage wrt College Emp			0.697***	0.642***
			[0.163]	[0.172]
D. Amenity Supply				
College Emp Ratio			2.60**	2.65***
			[1.13]	[1.107]
Hansen's J (p-value):	0.0185	0.0095	0.135	0.213
$\chi 2$ test: estimates = calibrated local expenditure model estimates (p-value):	0.0000			0.489
Endogenous Amenity Index			X	X
Calibrated local good expenditure share		X	X	
CES Labor Demand:	X	X		
Reduced Form Labor Demand			X	X

Notes: Standard errors in brackets. Data includes 334 observations from 167 cities. Changes measured relative to 1980. For workers' preferences, Black and immigrant estimates measure the differential preferences of these groups for each city characteristic, relative to base estimates for college and non-college workers. Magnitude of workers' preference estimates represent worker's demand elasticity with respect to the given city characteristic, in a small city. Sample is all heads of household with positive labor income working at least 35 hours per week and 48 weeks per year. See text for model details. Housing supply estimates measure parameters in the inverse housing supply equation. Rho in the labor demand equations comes from the CES functional form. Reduced form labor demand estimates meaure own and cross-price inverse labor demand elasticities with respect to college and non-college wages. Amenity supply measures the elasticity of amenity supply with respect to the college employment ratio. Standard errors clustered by MSA. *** p<0.01, ** p<0.05, * p<0.1

Table 5: Value of Living in Own Birth State & Division

	1980		1990		2000	
A. Birth State						
	Base	Black	Base	Black	Base	Black
Non-College	3.430	-0.125	3.422	0.053	3.433	0.159
	[0.004]	[0.013]	[0.004]	[0.012]	[0.004]	[0.011]
College	2.546	0.215	2.535	0.250	2.637	0.212
	[0.006]	[0.031]	[0.006]	[0.025]	[0.005]	[0.020]
B. Birth Division						
	1980		1990		2000	
	Base	Black	Base	Black	Base	Black
Non-College	1.292	-0.324	1.271	-0.537	1.219	-0.537
	[0.005]	[0.014]	[0.004]	[0.013]	[0.004]	[0.012]
College	1.200	-0.482	1.194	-0.511	1.142	-0.387
	[0.007]	[0.032]	[0.006]	[0.026]	[0.005]	[0.021]

Notes: Standard erorrs in brackets. Estimates from maximum likelihood of conditional logit model of city choice. Magnitudes represent the semi-elasticity of demand for a small city with respect to whether the city is located within one's birth state or division. Black estimates are relative to base estimates. Sample is all full-time employed heads of household.

Table 6: Relations between Amenity and Productivity Changes

	[1] Δ College Amentity	[2] Δ College Productivity	[3] Δ College Wage
Δ Non-College Amenity	2.497***		
	[0.198]		
Δ College Productivity		0.212**	
		[0.103]	
Δ Non-College Wage			0.672***
			[0.0471]
Constant	-0.103**	-0.0105	0.155***
	[0.0421]	[0.0220]	[0.00520]
Observations	217	217	217
R-squared	0.426	0.019	0.487

Standard errors in brackets. Changes in amenities and productivities are measured between 1980 and 2000. Cities' amenities and productivity levels are inferred from model estimates. See text for further details. *** p<0.01, ** p<0.05, * p<0.1

Table 7: Reduced Form Relationships between College Employment Ratios, Local Real Wages & Local Employment Shocks

	[1]	[2]	[3]	[4]	[5]	[6]
	Δ College Employment Ratio	Δ College Employment Ratio	Δ College Employment Ratio	Δ College Employment Ratio	Δ College Local Real Wage	Δ Non-College Local Real Wage
Δ College Local Real Wage				-0.845***		
				[0.199]		
Δ Non-College Local Real Wage				-0.488***		
				[0.187]		
Δ College Productivity	0.480***		0.473***		-0.109***	-0.220***
	[0.0444]		[0.0516]		[0.0257]	[0.0225]
Δ Non-College Productivity	-1.261***		-1.237***		0.130***	0.288***
	[0.0806]		[0.0836]		[0.0467]	[0.0408]
Δ College Amentity		-0.0825***	-0.0450***			
		[0.0255]	[0.0160]			
Δ Non-College Amenity		0.231**	0.161**			
		[0.110]	[0.0745]			
Constant	0.110***	0.360***	0.118***	0.481***	0.163***	0.0480***
	[0.0179]	[0.0207]	[0.0258]	[0.0300]	[0.0104]	[0.00905]
Observations	217	217	217	217	217	217
R-squared	0.621	0.048	0.635	0.214	0.105	0.398

Notes: Standard errors in brackets. Changes measured between 1980-2000. Weighted by MSA population in 1980. College employment ratio is defined as the ratio of number of full-time employed college workers to the number of full-time employed lower skill workers living in the city. Δ Real Wage = Δ ln(Wage)-.62*ΔLn(Rent). *** p<0.01, ** p<0.05, * p<0.1

Table 8: Observed Changes in Wages & Local Real Wages: 1980-2000

Year	[1] College-High School Grad Wage Gap	[2] College-High School Grad Rent Gap	[3] Local Real Wage Gap
1980	0.383	0.048	0.353
	[0.0014]	[0.0004]	[0.0014]
1990	0.544	0.145	0.454
	[0.0010]	[0.0007]	[0.0009]
2000	0.573	0.119	0.499
	[0.0009]	[0.0004]	[0.0009]
Change: '80-'00	0.190	0.072	0.146

Notes: Wage gap measures the log wage difference between college and high school graduates. Rent gap measures the log rent difference between college and high school graduates. Note that rent is measured as the city-level rent index and does not reflect diffrences in housing size choices. Local real wage gap measures the wages net of local rents gap.

Table 9: Decomposition of Well-Being Inequality:Wages, Rents, & Endogenous Amenities: 1980-2000

Year	[1]	[2]	[3]	[4]
1980	0.383	0.383	0.383	0.383
	-	-	-	-
1990	0.540	0.519	0.570	0.730
	[0.0021]	[0.0027]	[0.0335]	[0.1350]
2000	0.601	0.577	0.639	0.956
	[0.0031]	[0.0011]	[0.0387]	[0.2398]
Change: '80-'00	0.218	0.194	0.256	0.573
	[0.0031]	[0.0011]	[0.0387]	[0.2398]
Wages:	X	X	X	X
Rents:		X	X	X
Endog. amenities from re-sorting of workers:			X	X
Endog. amenities from national supply of college graduates:				X

Notes: Well-being gap is measured by the difference in a college and high school graduate's willingness to pay to live in his first choice city from the choices availble in 2000 versus his first choice in 1980. For example, the well-being gap due to wage changes only accounts for the welfare impact of wage changes from 1980 to 2000, while the well-being due to wages and rents accounts for both the impacts of wages and rents. The well-being gap is normalized to the college wage gap in 1980. Standard errors for welfare estimates use the delta method.

Figure 1: Changes in Wages, Rents, and College Employment Ratios: 1980-2000

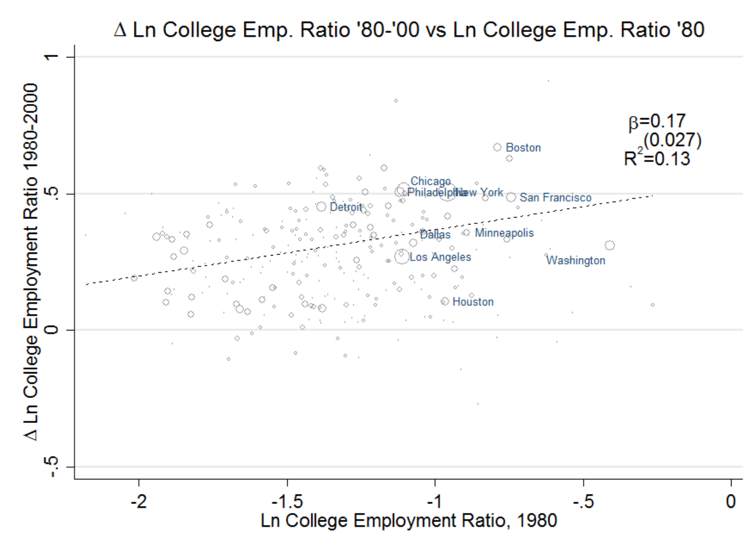

Figure 1.A

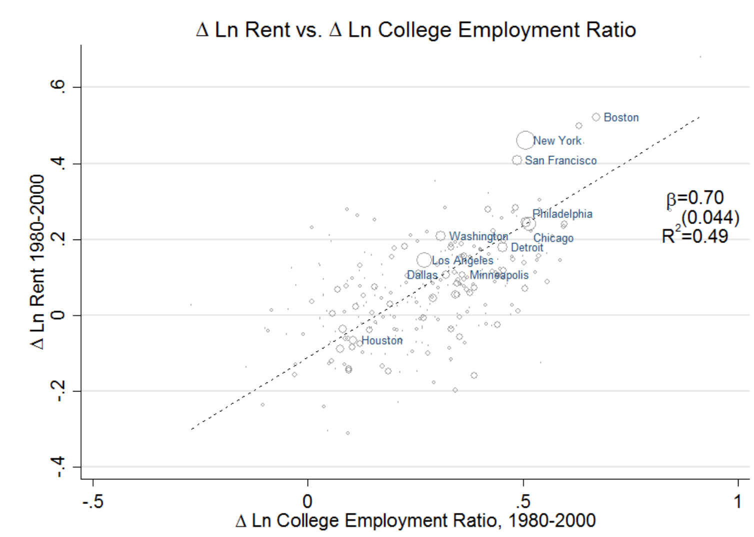

Figure 1.B

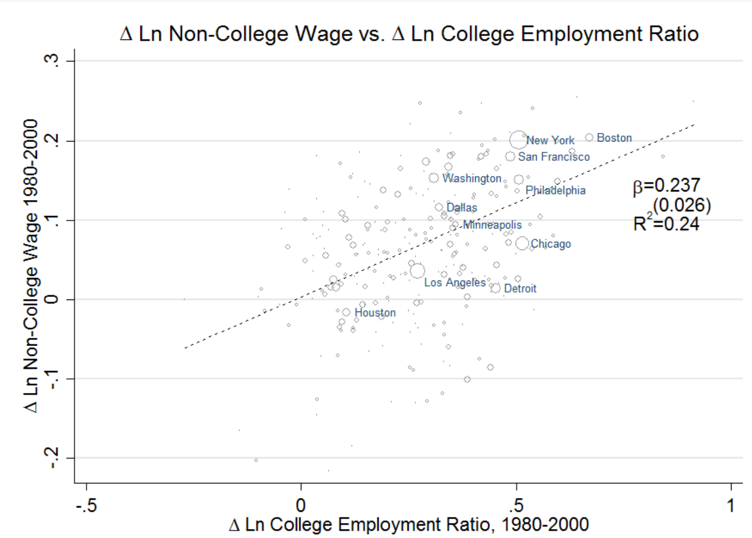

Figure 1.C

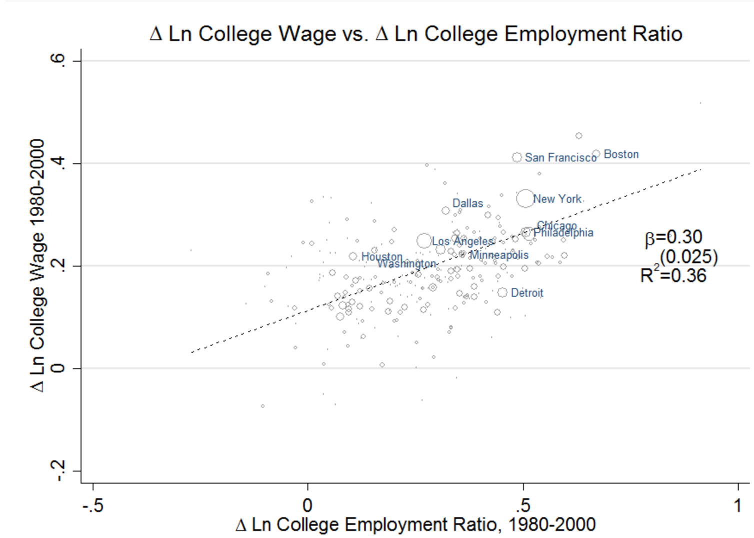

Figure 1.D

Weighted by 1980 population. Largest 15 MSAs in 1980 labeled.

Figure 2: Predicted Changes in Ln College Employment Ratio: 1980-2000

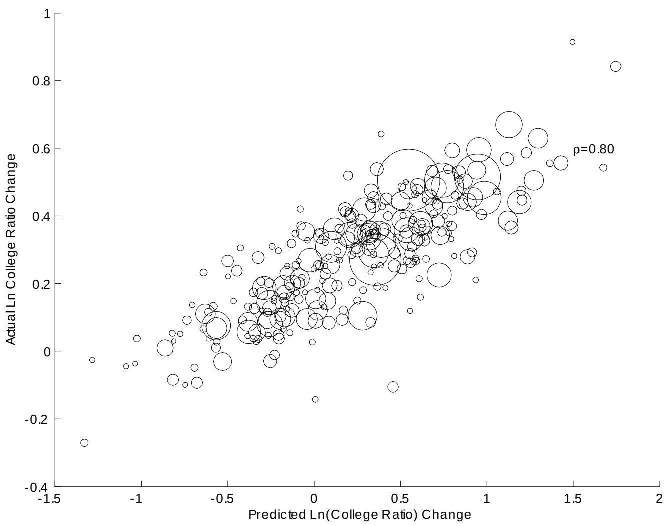

Figure 2.A: Predicted change in ln college ratio due only to productivity changes

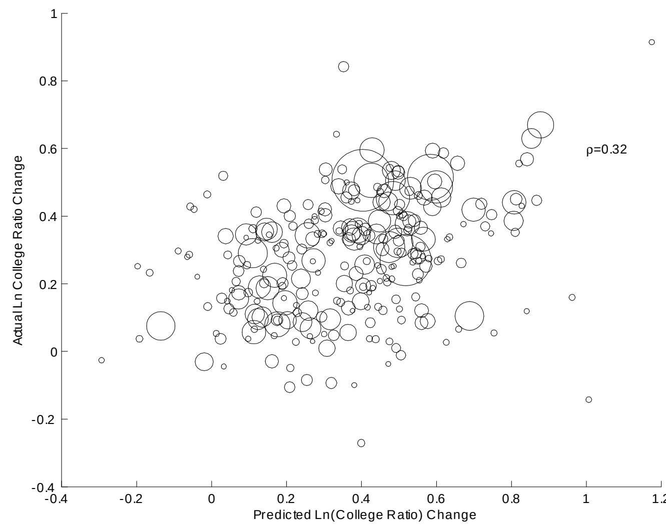

Figure 2.B: Predicted change in ln college ratio due to observed wage & rent changes

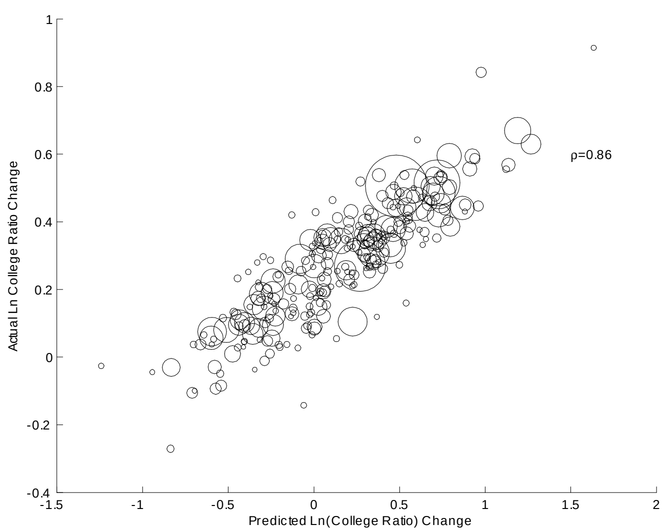

Figure 2.C: Predicted change in ln college ratio due to observed changes in wage, rent, and endogenous amenities

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A Data Appendix

Variable	Source	Sample	Notes
Metropolitan Statistical Area	US Census 1980, 1990, 2000	All MSAs identified across all 3 censuses. Rural areas of each state are included as additional geographic units.	MSAs identified in some, but not all of the censuses are included in rural areas of each state.
Local High Skill and Low Skill Wages	US Census 1980, 1990, 2000	All individuals with no business or farm income ages 25-55 working at least 35 hours per week and 48 weeks per year and earn no business or farm income.	Local wages in each MSA are averages of workers for each skill level living in each city. High skill worker is defined as a worker with at least a 4 year college degree. All other workers are considered low skill.
Local Housing Rent	US Census 1980, 1990, 2000	All households where the head-of-household is between the ages of 25 and 55 and works at least 35 hours per week and 48 weeks per year and earn no business or farm income.	Rental rates are measured as the gross rent, which includes both the housing rent and the cost of utilities. Rents are imputed for households which own their home. Imputed rents are converted from housing values using a discount rate of 7.85 percent (Peiser and Smith 1985), to which electricity and gas utility costs are added.
Local College Employment Ratio	US Census 1980, 1990, 2000	All full-time employed workers between the ages of 25 and 55 without business or farm income.	College employment ratio is defined as the ratio of number of full-time employed workers in the city with a 4 year college degree to the number of full-time employed lower skill workers living in the city.
Worker's Race	US Census 1980, 1990, 2000	All households where the head-of-household is between the ages of 25 and 55 and works at least 35 hours per week and 48 weeks per year and earn no business or farm income.	A household is classified as black if the head of household reports his race as black.
Worker's Immigrant Status	US Census 1980, 1990, 2000	All households where the head-of-household is between the ages of 25 and 55 and works at least 35 hours per week and 48 weeks per year and earn no business or farm income.	A household is classified as an immigrant if the head-of-household was born outside of the United States.
Local Bartik Shocks	US Census 1980, 1990, 2000	To measure local share weights: All employed workers between the ages of 25 and 55. To measure national industry wages: All individuals ages 25-55 working at least 35 hours per week and 48 weeks per year with no business or farm income.	Industries are defined by the Census, which is very close to 3 digit SIC codes. When measuring the Bartik shock for a given city, the wages of that city's workers are dropped when calculating the nationwide shock.

Variable	Source	Sample	Notes
Workers' Mean Utility Level for Each City	US Census 1980, 1990, 2000	All households where the head-of-household is between the ages of 25 and 55 and works at least 35 hours per week and 48 weeks per year and earn no business or farm income.	Workers' preference estimates are estimated off a sample which only included head of households. Household members are assumed to move with the head-of-household.
Land Unavailability	Saiz (2010)	All MSAs covered in Saiz's sample	Measure the share of land within 50km of a city's center which cannot be developed due to geographic constraints.
Wharton Regulation Index	Gyourko, Saiz, Summers (2007)	All MSAs covered in Saiz's sample	Land use regulation index of municipalities based on the 2005 Wharton Land Use Regulation Survey. Saiz (2010) aggregates the municipal indices to an MSA level index.
Apparel Stores, Eating and Drinking Places, and Movie Theaters per 1000 Residents	County Business Patterns 1980, 1990 2000	All non-rural MSAs.	Counties aggregated to MSAs based on 1999 MSA definitions.
Property Crimes and Violent Crimes per 1000 Residents	FBI Uniform Crime Reports 1980, 1990, 2000	All non-rural MSAs which the FBI data covers.	
EPA Air Quality Index	Environmental Protection Agency	All non-rural MSAs which the EPA reports data on.	
Busses per capita	Duranton & Turner (2011)	All MSAs covered in Duranton & Turner's sample.	Data measures number of large busses in each MSA at peak service per capita. Data are from 1984, 1994, and 2004.
Public Transit Index	Duranton & Turner (2011)	All MSAs covered in Duranton & Turner's sample.	Count of number of large busses and rail cars in each MSA at peak service per capita divided by population. Data are from 1984, 1994, and 2004.
Average Annual Daily Traffic-Interstates	Duranton & Turner (2011)	All MSAs covered in Duranton & Turner's sample.	Average number of vehicles on interstate roads per lane per day. Data are from 1983, 1993, and 2003.

Variable	Source	Sample	Notes
Average Annual Daily Traffic-Major Urban Roads	Duranton & Turner (2011)	All MSAs covered in Duranton & Turner's sample.	Average number of vehicles on major urban roads per lane per day. Major urban road is defined as roads which are "collectors", "minor arterial", "principal arterial", or "other highways" by the Department of Transportation. Data are from 1983, 1993, and 2003.
Government Spending on Parks and Recreation per capita.	Census of Governments County-area file.	All non-rural MSAs.	Per capita government spending by all branches of local government within the MSA on parks and recreation. Data are from 1982, 1992, and 2002.
Government Spending on K-12 Education	Census of Governments County-area file.	All non-rural MSAs.	Total government spending on K-12 education by all branches of local government with the MSA. Data are from 1982, 1992, and 2002.
Pupils Enrolled in Public K-12 Education	National Center of Education Statistics Common Core of Data	All non-rural MSAs.	Total pupils enrolled in K-12 public schools. Data are from 1982, 1992, and 2002.
Number of employed Teachers in Public K-12 Education	Census of Governments County-area file.	All non-rural MSAs.	Total Full-time Equivalents of Teachers Employed in K-12 education within all branches of local government within the MSA. Data are from 1982, 1992, and 2002.
Patents Per Capita	NBER Patent Database	All non-rural MSAs.	The addresses from the inventor file were geocoded to MSAs based on their reported city, state, and zip code. The data are from year 1980, 1990, and 1999.
Employment Rate	US Census 1980, 1990, 2000	All individuals between ages 25 and 55.	Defined as the share of the 25-55 population employed. Includes those out of the labor force.

B Estimation Appendix

B.1 Local Expenditure Share Analysis

Microdata from the 2000 Consumer Expenditure Survey report households' annual expenditures. These are broken down into a number of categories including housing. I remove expenditures on savings and contributions to retirement plans, since these are measuring future consumption on both housing and non-housing goods. I include 25 to 55 year old household heads with positive labor income, to match the sample analyzed within my model. Table A.2 reports summary statistics of households' expenditure shares on housing. Non-college households spend an average of 39% of expenditure on housing, with a standard deviation of 16%. College workers spend an average of 44% on housing, with a standard deviation of 16%. To assess whether these housing expenditure shares are due to college and non-college workers facing difference average housing prices, I regress these housing expenditure shares on a dummy for college graduate, and control population size of the cities these households live in.[50] Panel B of Table A.2 shows that with these controls college graduates spend an average of 46% on housing and non college spend 43%.

While a number of older studies have found that housing is a normal good with an income elasticity of less than one (Polinsky and Ellwood (1979)), recent work has found that not to be the case across most parts of the income distribution (Lewbel and Pendakur (2009)). Lewbel and Pendakur (2009) finds expenditure shares on housing have a non-monotonic relationship with income, where expenditures shares are increasing at the very low end of the income distribution, and then decreasing at higher levels of income. Averaging these expenditure shares within college and non-college workers would lead to very similar levels of housing expenditure shares across the two groups.

B.2 Welfare Calculation

A worker $i's$ expected utility in 1980 is measured by the expected utility he would receive from living in his first choice city:

$$
\begin{aligned}
E\left(U_{i1980}\right) &= E\left(\max_j V_{ij1980}\right) \\
V_{ij1980} &= \beta^w z_i w_{j1980}^{edu} - \beta^r z_i r_{j1980} + \xi_{j1980}^z + \beta^a z_i \left(\gamma^a \ln\left(\frac{H_{j1980}}{L_{j1980}}\right) + \varepsilon_{j1980}^a\right) + \beta^{st} z_i st_i x_j^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_j^{\text{div}} + \varepsilon_{ij1980}.
\end{aligned}
$$

Since I do not observe each worker's idiosyncratic taste for each city, I must integrate out over the error distribution to calculate his expected utility from the city he chooses to live in. Since the error terms are distributed Type I extreme value, a worker's expected utility from his top choice city is:

$$
E\left(U_{i1980}\right) = \ln\left(\sum_j \exp\left(\beta^w z_i w_{j1980}^{edu} - \beta^r z_i r_{j1980} + \xi_{j1980}^z + \beta^a z_i \left(\gamma^a \ln\left(\frac{H_{j1980}}{L_{j1980}}\right) + \varepsilon_{j1980}^a\right) + \beta^{st} z_i st_i x_j^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_j^{\text{div}}\right)\right.
$$

Similarly, worker i's expected utility if wages adjust to the levels observed in 2000, $E\left(\hat{U}_{i2000}^w\right)$, is measured by:

$$
E\left(\hat{U}_{i2000}^w\right) = \ln\left(\sum_j \exp\left(\beta^w z_i w_{j2000}^{edu} - \beta^r z_i r_{j1980} + \xi_{j1980}^z + \beta^a z_i \left(\gamma^a \ln\left(\frac{H_{j1980}}{L_{j1980}}\right) + \varepsilon_{j1980}^a\right) + \beta^{st} z_i st_i x_j^{st} + \beta^{\text{div}} z_i \,\text{div}_i\, x_j^{\text{div}}\right)\right.
$$

[50] Due to confidentiality reasons, the CEX does not report households' MSA of residence. Instead they report whether the household lives in a city with more than 4 million people, 1.2-4 million, .33-1.2 million, 125-329 thousand, or less than 125 thousand. I include these dummy variables as controls in the regrssion.

$E\left(\hat{U}^{w}_{i2000}\right)$ measures the utility worker i receives from living in the city he finds most desirable. Combining these, the expected utility impact due to cities' wage changes from 1980 to 2000 is:

$$\frac{E\left(\hat{U}^{w}_{i2000}\right) - E\left(\hat{U}^{w}_{i1980}\right)}{\beta^{w} z_i}.$$

The change in utility is divided by worker i's marginal utility of wages, so that utility is measured in log wage units.

The expected utility of worker i if wages and rent adjust to the level observed in 2000 $E\left(\hat{U}^{wr}_{i2000}\right)$ is:

$$E\left(\hat{U}^{wr}_{i2000}\right) = \ln\left(\sum_j \exp\left(\beta^{w} z_i w^{edu}_{j2000} - \beta^{r} z_i r_{j2000} + \xi^{z}_{j1980} + \beta^{a} z_i \left(\gamma^{a} \ln\left(\frac{H_{j1980}}{L_{j1980}}\right) + \varepsilon^{a}_{j1980}\right) + \beta^{st} z_i st_i x^{st}_j + \beta^{\text{div}} z_i \,\text{div}_i\, x^{\text{div}}_j\right.\right.$$

The expected utility of worker i if wages, rents, and endogenous amenities due to resorting adjust to the level observed in 2000 $E\left(\hat{U}^{wr}_{i2000}\right)$, is measured by:

$$\begin{aligned} E\left(\hat{U}^{wr}_{i2000}\right) &= \ln\left(\sum_j \exp\left(\begin{array}{c} \beta^{w} z_i w^{edu}_{j2000} - \beta^{r} z_i r_{j2000} + \xi^{z}_{j1980} + \beta^{a} z_i \left(\gamma^{a} \ln\left(\frac{\hat{H}_{j2000}}{\hat{L}_{j2000}}\right) + \varepsilon^{a}_{j1980}\right) \\ + \beta^{st} z_i st_i x^{st}_j + \beta^{\text{div}} z_i \,\text{div}_i\, x^{\text{div}}_j \end{array}\right)\right) \\ \hat{H}_{j2000} &= \frac{H_{j2000}}{H_{2000}} H_{1980}, \hat{L}_{j2000} = \frac{L_{j2000}}{L_{2000}} L_{1980}. \end{aligned}$$

$\hat{H}_{j2000}$ measures the share of all high skill workers living in city j in year 2000, scaled by the national population size of high skill workers in 1980:H_{1980}. $\hat{L}_{j2000}$ is similarly defined, for low skill workers.

B.3 Robustness Checks

I first assess the sensitivity to whether I hedonically adjust local wage and rent changes. Wages are adjusted for a more fine measure of education, a quadratic in experience, gender, and race. I adjust rents by number of rooms, number of bedrooms, and age of structure. Column 1 of Table A.3 reports these parameter estimates. The model estimates using these wage and rent measures are qualitatively the same. The magnitude of elasticity of labor demand for non-college workers with respect to non-college wages falls somewhat, but the sign does not change.

As additional robustness tests, I assess whether the local housing prices face by college workers appear to respond differently than the local housing prices faced by non-college workers living within the same city. Columns 2 and 3 of Table A.3 show that parameter estimates are quite similar regardless of whether local housing prices are measured only using housing prices from the non-college population or the college population.

I test whether the estimates are robust to changes in the calibrated local expenditure parameters. Columns 4 and 6 of Table A.3 show that the parameter estimates are quite similar when using a local expenditure share of 0.58 or 0.67.

Next, I consider whether the college employment ratio itself could be used as the index for endogenous amenities. The model in the main text assumes that workers enjoys better amenities in high college share cities through the indirect effects of the college share on the bundle of observed amenities. Using the college share itself as the endogenous amenity index combines the value of these observable amenities with the possibility that workers by get direct utility for more educated neighbors, not just indirectly through betters schools and lower crime. The estimates of this model are in Column 6 of Table A.3. The estimates are similar, however the elasticity of demand for the endogenous amenity has increased somewhat. These estimates suggest that the amenity value of highly educated neighbors may include a direct preference for neighbors' education, not just an indirect preference through other amenities.

Finally, Columns 7 of Table A.3 estimates the model where amenities are allowed to be endogenous, but the labor demand model imposes the CES structure, ruling out endogenous productivity effects. As suspected, the estimates for workers' preferences for cities look very similar to the full model estimates. The labor demand estimates look similar to the standard model's labor demand elasticity estimates. Column 8 of Table A.3 flips these around, allowing for endogenous productivity effects, but assuming amenities are exogenous. Consistent withe standard model estimates, these estimates suggest college workers desire lower real wages. The labor demand estimates are similar to the full model estimates, however the elasticity of college labor demand with respect to college labor is very close to zero now. Overall, the model estimates are robust to a number of different specifications.

Table A.1: Summary Statistics of Household Head City Choice Samples

	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
A. 1980										
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
	Non-College Sample					College Sample				
Black	1107042	0.113	0.317	0	1	352447	0.047	0.212	0	1
Immigrant	1107042	0.071	0.257	0	1	352447	0.079	0.269	0	1
Live in State of Birth	1028380	0.645	0.478	0	1	324709	0.480	0.500	0	1
B. 1990										
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
	Non-College Sample					College Sample				
Black	1264283	0.102	0.303	0	1	476737	0.053	0.224	0	1
Immigrant	1264283	0.086	0.280	0	1	476737	0.097	0.296	0	1
Live in State of Birth	1155798	0.660	0.474	0	1	430641	0.477	0.499	0	1
C.2000										
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
	Non-College Sample					College Sample				
Black	1457637	0.117	0.321	0	1	628372	0.066	0.248	0	1
Immigrant	1457637	0.123	0.328	0	1	628372	0.133	0.340	0	1
Live in State of Birth	1278937	0.670	0.470	0	1	544824	0.497	0.500	0	1

Notes: Sample is all heads of household between ages 25 and 55 working at least 35 hours per week and 48 weeks per year. This sample is used to estimate workers' preferences for cities. Summary statistics for whether a worker lives in his state of birth is restricted to non-immigrant workers. College is defined as having a 4 year college degree.

Table A.2: Housing Expenditure Shares: 2000 Consumer Expenditure Survey

A. Summary Statistics					
	Obs	Mean	Std. Dev.	Min	Max
Non-College Households	2904	0.3911	0.1596	0	1
College Households	1355	0.4347	0.1556	0	0.951

B. Housing Expenditure Shares, Controlling for City Population	
Non-College Households	0.4275***
	[0.005]
College Households	0.4615***
	[0.0055]

Notes: Data from 2000 Consumer Expenditure Survey mirco data. Housing expenditure share is measured by total spending on housing divided by total expenditure, net of savings and retirement contributions. Sample is 25-55 year old household heads with positive earnings.

Table A.3: Robustness Tests of Alternative Model Specifications

	Hedonic Adjusted Wage & Rent	Rents from College Workers	Rents from Non-College Workers	Local Expend. Share =.58	Local Expend. Share =.67	College Share Endog. Amenity	CES Labor Demand	Exog. Amenities
Household Preferences for Cities								
College Workers:								
Wage	1.029	1.907	4.058	2.592	1.666	3.358	1.326	-1.724
	[0.873]	[0.947]	[2.214]	[1.347]	[0.956]	[1.841]	[1.432]	[0.705]
Rent	-0.638	-1.183	-2.516	-1.607	-1.116	-2.082	-0.822	1.069
	[0.541]	[0.587]	[1.372]	[0.835]	[0.641]	[1.141]	[0.888]	[0.437]
Endogenous Amenity	0.915	0.880	1.108	1.002	1.016	4.209	0.974	-
	[0.162]	[0.12]	[0.186]	[0.116]	[0.117]	[1.768]	[0.18]	
Differential Effects: Blacks								
Wage	3.823	4.203	7.625	5.990	4.748	7.044	-0.128	1.863
	[1.375]	[1.771]	[3.875]	[2.335]	[1.722]	[2.564]	[0.37]	[1.359]
Rent	-2.371	-2.606	-4.727	-3.714	-3.181	-4.367	0.080	-1.155
	[0.852]	[1.098]	[2.402]	[1.448]	[1.153]	[1.59]	[0.229]	[0.842]
Endogenous Amenity	0.854	0.812	1.143	0.989	1.154	3.207	0.761	-
	[0.258]	[0.254]	[0.376]	[0.275]	[0.269]	[2.075]	[0.229]	
Differential Effects: Immigrants								
Wage	-1.636	1.383	3.577	2.170	-0.045	1.999	1.160	-3.162
	[1.329]	[2.045]	[3.562]	[2.419]	[1.847]	[3.66]	[0.329]	[1.446]
Rent	1.014	-0.857	-2.218	-1.346	0.030	-1.239	-0.719	1.960
	[0.824]	[1.268]	[2.209]	[1.5]	[1.145]	[2.269]	[0.204]	[0.896]
Endogenous Amenity	0.744	0.970	1.218	1.049	0.900	3.341	1.278	-
	[0.237]	[0.229]	[0.336]	[0.238]	[0.245]	[2.932]	[0.352]	
Non-College Workers:								
Wage	5.520	3.439	3.693	4.083	3.895	4.538	3.751	4.126
	[0.76]	[0.646]	[0.797]	[0.809]	[0.645]	[0.826]	[0.579]	[0.564]
Rent	-3.422	-2.132	-2.290	-2.532	-2.610	-2.813	-2.326	-2.558
	[0.471]	[0.4]	[0.494]	[0.502]	[0.432]	[0.512]	[0.359]	[0.35]
Endogenous Amenity	0.516	0.046	0.160	0.186	0.377	1.536	0.107	-
	[0.198]	[0.163]	[0.145]	[0.158]	[0.141]	[0.754]	[0.137]	
Differential Effects: Blacks								
Wage	-0.973	2.316	2.933	2.529	0.938	3.275	0.040	-0.117
	[1.167]	[1.981]	[3.174]	[2.482]	[1.779]	[2.486]	[0.247]	[0.932]
Rent	0.603	-1.436	-1.819	-1.568	-0.628	-2.031	-0.025	0.073
	[0.724]	[1.228]	[1.968]	[1.539]	[1.192]	[1.542]	[0.153]	[0.578]
Endogenous Amenity	0.383	0.728	0.820	0.757	0.711	3.013	0.172	-
	[0.205]	[0.215]	[0.276]	[0.22]	[0.225]	[1.639]	[2.266]	
Differential Effects: Immigrants								
Wage	-1.917	0.672	2.717	1.519	-0.638	2.713	-0.150	-4.570
	[1.861]	[2.752]	[4.871]	[3.532]	[2.55]	[4.199]	[3.107]	[1.168]
Rent	1.188	-0.417	-1.684	-0.942	0.428	-1.682	0.093	2.833
	[1.154]	[1.706]	[3.02]	[2.19]	[1.709]	[2.603]	[1.927]	[0.724]
Endogenous Amenity	0.865	1.155	1.355	1.154	0.978	5.441	1.278	-
	[0.303]	[0.282]	[0.372]	[0.298]	[0.306]	[3.372]	[0.352]	
Housing Supply								
Land Use Regulation	0.080	0.087	0.089	0.093	0.088	0.103	0.076	0.078
	[0.015]	[0.019]	[0.021]	[0.02]	[0.019]	[0.021]	[0.017]	[0.016]
Land Unavailability	0.051	0.022	0.018	0.020	0.023	0.016	0.014	0.024
	[0.012]	[0.011]	[0.01]	[0.01]	[0.01]	[0.012]	[0.01]	[0.008]
Base House Supply Elasticity	0.019	-0.086	-0.066	0.013	0.016	-0.020	0.031	-0.012
	[0.089]	[0.079]	[0.096]	[0.091]	[0.087]	[0.088]	[0.084]	[0.076]
Labor Demand								
Rho							0.367	
							[0.13]	
Elast. of Col Wage wrt Col Emp	0.112	0.233	0.370	0.245	0.211	0.143		-0.094
	[0.357]	[0.274]	[0.283]	[0.322]	[0.294]	[0.377]		[0.216]
Elast. of Col Wage wrt Non-Col Emp	0.418	0.296	-0.002	0.294	0.331	0.402		0.603
	[0.382]	[0.335]	[0.322]	[0.388]	[0.348]	[0.453]		[0.262]
Elast of Non-Col Wage wrt Col Emp	0.437	0.762	0.689	0.700	0.696	0.749		0.910
	[0.193]	[0.162]	[0.225]	[0.166]	[0.165]	[0.195]		[0.181]
Elast of Non-Col Wage wrt Non-Col Emp	-0.050	-0.650	-0.609	-0.569	-0.535	-0.618		-0.732
	[0.224]	[0.201]	[0.254]	[0.205]	[0.204]	[0.231]		[0.227]
Amenity Supply								
College Employment Ratio	2.496	2.807	2.412	2.610	2.601	-	3.017	-
	[0.902]	[1.183]	[2.483]	[1.124]	[1.121]		[1.116]	

Notes: Standard errors in brackets. Standard errors clustered by MSA. See text for details on all the alternative model specifications.

Table A.4 Additional Robustness Tests of Alternative Model Specifications

	2SLS	Partial F (from 2SLS)	LIML
Household Preferences for Cities			
College Workers:			
Wage	2.357**	5.620	6.347*
	[0.974]		[3.254]
Endogenous Amenity	0.197**	2.390	0.646*
	[0.0997]		[0.354]
Differential Effects: Blacks			
Wage	3.399***	5.620	6.272**
	[1.088]		[2.628]
Endogenous Amenity	0.0168	2.390	0.333
	[0.111]		[0.285]
Differential Effects: Immigrants			
Wage	0.553	5.620	5.175
	[1.269]		[4.084]
Endogenous Amenity	0.275**	2.390	0.827*
	[0.130]		[0.445]
Non-College Workers:			
Wage	5.664***	23.070	7.815***
	[0.686]		[1.375]
Endogenous Amenity	0.129*	5.760	0.451**
	[0.0751]		[0.196]
Differential Effects: Blacks			
Wage	0.756	23.070	1.105
	[0.646]		[0.862]
Endogenous Amenity	-0.102	5.760	0.00290
	[0.0707]		[0.115]
Differential Effects: Immigrants			
Wage	-2.063**	23.070	-0.608
	[0.922]		[1.668]
Endogenous Amenity	0.0681	5.760	0.428*
	[0.101]		[0.236]
Housing Supply			
Land Use Regulation	0.114***	78.300	0.150***
	[0.0177]		[0.0255]
Land Unavailability	0.0219*	15.020	0.0171
	[0.0131]		[0.0162]
Base House Supply Elasticity	-0.587***	35.870	-0.806***
	[0.101]		[0.297]
Labor Demand			
Elasticity of College Wage wrt College Labor	0.812***	3.660	0.753
	[0.239]		[0.658]
College Wage wrt Non-College Labor	-1.265*	0.310	-2.504
	[0.752]		[3.394]
Non-College Wages wrt College Labor	0.850***	3.660	0.838***
	[0.213]		[0.305]
Non-College Wage wrt Non-College Labor	-1.194*	0.310	-1.494
	[0.669]		[1.173]
Amenity Supply			
College Employment Ratio	4.730***	6.030	10.41***
	[1.416]		[3.444]

Notes: Standard errors in brackets. See text for details on all the alternative model specifications.

Table A.5: Largest and Smallest Amenity Changes across 75 Largest Cities

Largest Increases in College Amenities		Largest Increases in Non-College Amenities	
msa	Δ Amenity	msa	Δ Amenity
Raleigh-Durham, NC	0.318	Raleigh-Durham, NC	0.120
Las Vegas, NV	0.288	Scranton-Wilkes-Barre, PA	0.067
Charlotte-Gastonia-Rock Hill, NC-SC	0.283	Boston, MA-NH	0.063
Providence-Fall River-Pawtucket, MA/RI	0.232	Rochester, NY	0.058
Boston, MA-NH	0.214	Harrisburg-Lebanon--Carlisle, PA	0.034
Orlando, FL	0.205	Allentown-Bethlehem-Easton, PA/NJ	0.018
Tacoma, WA	0.187	Syracuse, NY	0.011
Scranton-Wilkes-Barre, PA	0.184	Atlanta, GA	0.010
Atlanta, GA	0.159	Pittsburgh, PA	0.009
West Palm Beach-Boca Raton-Delray Beach, FL	0.148	Charlotte-Gastonia-Rock Hill, NC-SC	0.007
Largest Decreases in College Amenities		**Largest Decreases in Non-College Amenities**	
msa	Δ Amenity	msa	Δ Amenity
Tulsa, OK	-0.347	Los Angeles-Long Beach, CA	-0.357
Baton Rouge, LA	-0.317	Ventura-Oxnard-Simi Valley, CA	-0.322
Fresno, CA	-0.307	San Jose, CA	-0.321
Los Angeles-Long Beach, CA	-0.305	San Diego, CA	-0.317
San Jose, CA	-0.279	San Francisco-Oakland-Vallejo, CA	-0.302
Oklahoma City, OK	-0.278	Fresno, CA	-0.299
Houston-Brazoria, TX	-0.274	Sacramento, CA	-0.253
Hartford-Bristol-Middleton- New Britain, CT	-0.226	Honolulu, HI	-0.225
New Orleans, LA	-0.208	Miami-Hialeah, FL	-0.209
Milwaukee, WI	-0.202	Fort Lauderdale-Hollywood-Pompano Beach, FL	-0.208
Best Amenities for College Workers, 1980		**Best Amenities for Non-College Workers, 1980**	
msa	Amenity	msa	Amenity
Los Angeles-Long Beach, CA	2.071	Los Angeles-Long Beach, CA	1.262
San Francisco-Oakland-Vallejo, CA	1.853	San Francisco-Oakland-Vallejo, CA	0.981
Washington, DC/MD/VA	1.761	San Diego, CA	0.932
Denver-Boulder, CO	1.666	Phoenix, AZ	0.883
Seattle-Everett, WA	1.569	Denver-Boulder, CO	0.843
New York-Northeastern NJ	1.529	Honolulu, HI	0.828
Chicago, IL	1.500	San Jose, CA	0.822
Dallas-Fort Worth, TX	1.500	Tampa-St. Petersburg-Clearwater, FL	0.814
Phoenix, AZ	1.465	New York-Northeastern NJ	0.762
Minneapolis-St. Paul, MN	1.456	Seattle-Everett, WA	0.749
Worst Amenities for College Workers, 1980		**Worst Amenities for Non-College Workers, 1980**	
msa	Amenity	msa	Amenity
Scranton-Wilkes-Barre, PA	0.000	Syracuse, NY	0.000
Youngstown-Warren, OH-PA	0.063	Rochester, NY	0.007
Syracuse, NY	0.076	Allentown-Bethlehem-Easton, PA/NJ	0.021
Allentown-Bethlehem-Easton, PA/NJ	0.086	Harrisburg-Lebanon--Carlisle, PA	0.031
Toledo, OH/MI	0.157	Toledo, OH/MI	0.039
Harrisburg-Lebanon--Carlisle, PA	0.170	Youngstown-Warren, OH-PA	0.045
Rochester, NY	0.292	Scranton-Wilkes-Barre, PA	0.049
Albany-Schenectady-Troy, NY	0.310	Albany-Schenectady-Troy, NY	0.126
Buffalo-Niagara Falls, NY	0.379	Buffalo-Niagara Falls, NY	0.140
Akron, OH	0.416	Grand Rapids, MI	0.154
Best Amenities for College Workers, 2000		**Best Amenities for Non-College Workers, 2000**	
msa	Amenity	msa	Amenity
Los Angeles-Long Beach, CA	1.767	Los Angeles-Long Beach, CA	0.905
Washington, DC/MD/VA	1.710	Phoenix, AZ	0.850
San Francisco-Oakland-Vallejo, CA	1.653	Denver-Boulder, CO	0.749
Seattle-Everett, WA	1.652	Tampa-St. Petersburg-Clearwater, FL	0.729
Denver-Boulder, CO	1.650	Seattle-Everett, WA	0.719
Boston, MA-NH	1.646	Las Vegas, NV	0.713
Atlanta, GA	1.609	Atlanta, GA	0.708
Phoenix, AZ	1.562	Boston, MA-NH	0.706
New York-Northeastern NJ	1.491	San Francisco-Oakland-Vallejo, CA	0.679
Chicago, IL	1.445	Orlando, FL	0.661
Worst Amenities for College Workers, 2000		**Worst Amenities for Non-College Workers, 2000**	
msa	Amenity	msa	Amenity
Youngstown-Warren, OH-PA	0.000	Youngstown-Warren, OH-PA	0.000
Allentown-Bethlehem-Easton, PA/NJ	0.076	Toledo, OH/MI	0.002
Syracuse, NY	0.134	Syracuse, NY	0.011
Harrisburg-Lebanon--Carlisle, PA	0.155	Buffalo-Niagara Falls, NY	0.037
Scranton-Wilkes-Barre, PA	0.184	Allentown-Bethlehem-Easton, PA/NJ	0.039
Toledo, OH/MI	0.207	Albany-Schenectady-Troy, NY	0.049
Akron, OH	0.308	Rochester, NY	0.065
Buffalo-Niagara Falls, NY	0.309	Harrisburg-Lebanon--Carlisle, PA	0.066
Albany-Schenectady-Troy, NY	0.323	Grand Rapids, MI	0.091
Fresno, CA	0.362	Akron, OH	0.103

Notes: Sample reports top and bottom 10 from the 75 biggest cities by 1980 population. Local amenities are inferred from model estimates. Local high and low skill amenities are normalized to 0 in city least with the least desirable amenities in 1980 and 2000. Units measure the log wage value equilvalent to the utility difference between the amenities in the given city and the city normalized to 0. See text for further details.

Table A.6: Largest and Smallest Productivity Changes across 75 Largest Cities

Largest Increases in College Productivity		Largest Increases in Non-College Productivity	
msa	Δ Productivity	msa	Δ Productivity
San Jose, CA	0.237	Fresno, CA	-0.014
Milwaukee, WI	0.236	Baton Rouge, LA	-0.058
Tulsa, OK	0.213	Austin, TX	-0.060
San Francisco-Oakland-Vallejo, CA	0.202	Greensboro-Winston Salem-High Point, NC	-0.090
New York-Northeastern NJ	0.170	Salt Lake City-Ogden, UT	-0.094
Hartford-Bristol-Middleton- New Britain, CT	0.168	New Orleans, LA	-0.103
Oklahoma City, OK	0.163	Honolulu, HI	-0.112
Philadelphia, PA/NJ	0.160	Hartford-Bristol-Middleton- New Britain, CT	-0.114
Chicago, IL	0.153	Sacramento, CA	-0.116
Birmingham, AL	0.131	Riverside-San Bernardino,CA	-0.117
Largest Decreases in College Productivity		**Largest Decreases in Non-College Productivity**	
msa	Δ Productivity	msa	Δ Productivity
Las Vegas, NV	-0.475	Pittsburgh, PA	-0.396
Riverside-San Bernardino,CA	-0.347	Louisville, KY/IN	-0.387
Orlando, FL	-0.345	Youngstown-Warren, OH-PA	-0.379
Raleigh-Durham, NC	-0.275	Fort Lauderdale-Hollywood-Pompano Beach, FL	-0.338
West Palm Beach-Boca Raton-Delray Beach, FL	-0.274	Indianapolis, IN	-0.335
Rochester, NY	-0.259	Scranton-Wilkes-Barre, PA	-0.333
Syracuse, NY	-0.222	Orlando, FL	-0.315
Phoenix, AZ	-0.214	Boston, MA-NH	-0.314
Tacoma, WA	-0.206	Allentown-Bethlehem-Easton, PA/NJ	-0.304
Jacksonville, FL	-0.205	Seattle-Everett, WA	-0.303
Largest Decrease in College-Non College Productivity Gap		**Largest Increase in College-Non College Productivity Gap**	
msa	Δ Productivity	msa	Δ Productivity
Riverside-San Bernardino,CA	-0.230	Milwaukee, WI	0.521
Las Vegas, NV	-0.216	San Jose, CA	0.509
Fresno, CA	-0.119	Chicago, IL	0.439
Greensboro-Winston Salem-High Point, NC	-0.105	Tulsa, OK	0.411
Rochester, NY	-0.065	Birmingham, AL	0.403
Tacoma, WA	-0.055	Pittsburgh, PA	0.394
Syracuse, NY	-0.050	Boston, MA-NH	0.389
Orlando, FL	-0.030	San Francisco-Oakland-Vallejo, CA	0.388
Austin, TX	-0.030	Buffalo-Niagara Falls, NY	0.384
Raleigh-Durham, NC	-0.026	Detroit, MI	0.380

Notes: Sample reports top and bottom 10 from the 75 biggest cities by 1980 population. Local productivity is inferred from model estimates. Local high and low skill productivities are normalized to 0 in city least productive in 1980. Unit measure difference in log wages between cities directly due to productivity differences. See text for further details.