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

Rebecca Diamond, *American Economic Review*, 2016

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Introduction

Paper looks at two stylized facts:

- Dramatic increase in the wage gap between high school and college graduates in the U.S. between 1980-2000.

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- Dramatic increase in the wage gap between high school and college graduates in the U.S. between 1980-2000.
- Some metropolitan areas receiving an increasing share of college graduates during 1980-2000.
- Creates phenomenon of the "Great Divergence".

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- Changes in relative demand for high and low skill workers were a big driver of migration patterns.
- However, once cities attracted more college graduates, they became more desirable and expensive places to live.
- High-wage workers were willing to pay for amenities of large cities, low-wage workers were not.

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- As an example, Diamond looks at differing fates of Detroit and Boston.
  - Detroit loses auto manufacturing jobs, but also suffers from declining educational attainment.
  - Boston has attracted high-skill workers and has increasing educational attainment.

Methodology

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- Workers with different characteristics make different trade-offs. The most important worker characteristic is skill level – operationalized by graduation from a four-year college.
- A city's skill-mix will influence local amenity levels – paper looks at 15 amenities, which is combined into a single index using Principal Component Analysis (PCA).

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  2. Second step is to use a simultaneous-equation, non-linear GMM estimator to estimate local labor demand, housing supply, labor supply, and amenity supply to cities.
- Model is identified using local labor demand shocks from the local industry mix and their interactions with local housing supply elasticities.

Punchline

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- While both college and noncollege 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.
- Welfare impacts from wage, rent, and endogenous amenity changes led to an increase in well-being equivalent to at least a 25% increase in the college wage gap – which is larger than the actual increase in the college wage gap.

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- However, results are important for the way that we think about the welfare effects of trade.
- Papers we have looked at thus far assume that trade shocks cause a reallocation of labor to more "efficient" uses. But what if the adjustment costs are non-trivial?
- Diamond establishes facts that Autor, Dorn, and Hanson will elaborate on next week – jobs created by trade are not always in the same places as jobs lost by trade. Adjustment costs may be substantial.

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- Paper uses the 5 percent samples of the US census from the 1980, 1990, and 2000 Integrated Public Use Microdata Series (IPUMS) dataset.
- All analysis is restricted to 25-55 year-olds working at least 35 hours per week and 48 weeks per year.
- The geographical unit of analysis is the metropolitan statistical area (MSA) of residence. Census includes 218 MSAs across all three decades of data. Rural areas are not in an MSA, but rural areas within each state are grouped together as a single MSA.

Education and Amenities

- Workers divided into college degree or higher and no four-year college degree, as this seems to be the biggest dividing line between skilled and nonskilled workers according to Katz and Murphy (1992) and Goldin and Katz (2008).

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- MSA amenities classified into six categories – retail, transportation, crime, environmental, schooling, and job quality.
- MSA data supplemented with measures of geographic constraints and land use regulations to measure differences in housing supply elasticities.

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Summary Statistics

TABLE 1—SUMMARY STATISTICS

	Observations	Mean	Standard deviation	Min.	Max.
Panel A. Prices					
ln Noncollege wage	804	6.362	0.125	5.919	6.703
ln College wage	804	6.765	0.143	6.433	7.585
ln Rent	804	6.563	0.240	6.033	7.721
Panel 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 1,000 residents	651	0.136	1.132	−4.899	6.175
ln Eating and drinking places per 1,000 residents	651	0.090	1.273	−3.804	9.463
ln Movie theaters per 1,000 residents	650	−0.058	1.159	−2.960	4.977
ln Property crimes per 1,000 residents	643	−0.086	1.215	−4.287	4.827
ln Violent crimes per 1,000 residents	643	0.156	1.408	−3.147	5.910
ln Average daily traffic—interstates	651	0.152	1.352	−3.348	5.610
ln Average 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 Government 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
Panel 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 to 1990 and from 1990 to 2000. The Bartik shocks are also measured across decades. The sample reported for MSAs' wages, rents, and population includes 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 and 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 city's workforce employed in that industry. College Bartik uses only wages and employment shares from college workers. Noncollege Bartik uses noncollege workers. Aggregate Bartik combines these. Land unavailability measures the share of land within a 50 km 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 four-year college degree to the number of full-time employed lower skill workers living in the city. See online Appendix for further details.

Correlations

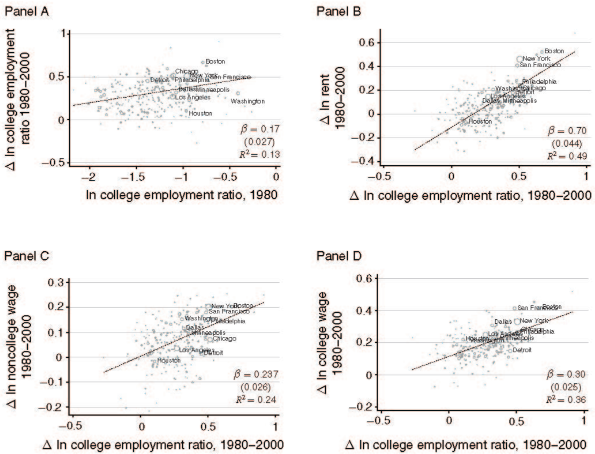

FIGURE 1. CHANGES IN WAGES, RENTS, AND COLLEGE EMPLOYMENT RATIOS, 1980–2000

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

Correlations

- Panel A of Figure 1 shows that college employment ratio in 1980 is positively associated with growth in the college employment ratio from 1980-2000. A 1% increase in 1980 is associated with a 0.17% larger increase from 1980-2000.

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- Panel B of Figure 1 shows that an increase in the college employment ratio between 1980-2000 is positively associated with an increase in rents between 1980-2000. A one percentage increase in college employment is associated with a 0.70% increase in rents.
- Panel C of Figure 1 shows that an increase in the college employment ratio between 1980-2000 is positively associated with an increase in noncollege wages between 1980-2000. A one percentage increase in college employment is associated with a 0.24% increase in noncollege wages.

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- Panel C of Figure 1 shows that an increase in the college employment ratio between 1980-2000 is positively associated with an increase in noncollege wages between 1980-2000. A one percentage increase in college employment is associated with a 0.24% increase in noncollege wages.
- Panel D of Figure 1 shows that an increase in the college employment ratio between 1980-2000 is positively associated with an increase in college wages between 1980-2000. A one percentage in college employment is associated with a 0.30% increase in college wages.

Wage Polarization

The polarization of skill across cities coincided with a large nationwide increase in wage inequality. Table 2 shows that the nationwide college/high school wage gap increased from 38% in 1980 to 57% in 2000.

TABLE 2—OBSERVED CHANGES IN WAGES AND LOCAL REAL WAGES, 1980–2000

Year	College/high school grad wage gap (1)	College/high school grad rent gap (2)	Local real wage gap (3)
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, 1980–2000	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 differences in housing size choices. Local real wage gap measures the wages net of local rents gap.

Amenities Polarization

Table 3 shows the relationships between changes in cities' college employment ratios and their changes in a large set of local amenities.

TABLE 3—MSA COLLEGE RATIO CHANGES ON AMENITY CHANGES, 1980–2000

Panel A. Retail amenities

	Apparel stores per 1,000 residents	Eating and drinking places per 1,000 residents	Movie theaters per 1,000 residents
Δ College emp. ratio	0.477***	0.182***	0.230
	[0.0928]	[0.0539]	[0.166]

Panel B. Transportation amenities

	Bus routes per capita	Public transit index	Avg. daily traffic: interstates	Avg. daily traffic: major roads
Δ College emp. ratio	1.045***	0.0161	−0.169*	−0.0513
	[0.376]	[0.338]	[0.0979]	[0.0704]

	Property crimes per 1,000 residents	Violent crimes per 1,000 residents	Gov. spending on parks per capita	EPA air quality index
	Panel C. Crime amenities		*Panel D. Environment amenities*	
Δ College emp. ratio	−0.231*	0.115	0.263	−0.539***
	[0.122]	[0.155]	[0.172]	[0.171]

	Gov. K–12 spending per student	Student–teacher ratio	Patents per capita	Employment rate
	Panel E. School amenities		*Panel F. Job amenities*	
Δ College emp. ratio	0.129**	0.00423	0.104	0.0105
	[0.0639]	[0.0631]	[0.234]	[0.00787]

Notes: Standard errors in brackets. Changes measured between 1980 and 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 is from the EPA. Higher values of the air quality index indicate more pollution.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

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- Structural model is similar to Rosen (1979) and Roback (1982), but allows more flexibility for heterogeneity in worker preferences and city housing supplies.
- Local worker productivity and amenities respond endogenously to the skill-mix of the city.

Labor Demand

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- Each city j has many homogeneous firms d in year t.
- These firms produce a homogeneous tradeable good using high skill labor $H_{d,j,t}$, low skill labor $L_{d,j,t}$, and capital $K_{d,j,t}$ according to a Cobb-Douglas production function where high skill and low skill labor are substitutable:

$$Y_{d,j,t} = N_{d,j,t}^{\alpha} K_{d,j,t}^{1-\alpha}$$

where

$$N_{d,j,t} = \left[\theta_{j,t}^{L} L_{d,j,t}^{\rho} + \theta_{j,t}^{H} H_{d,j,t}^{\rho}\right]^{\frac{1}{\rho}}$$

and

$$\theta_{j,t}^{L} = f_L\left(H_{j,t}, L_{j,t}\right) \exp\left(\epsilon_{j,t}^{L}\right) \tag{1}$$

and

$$\theta_{j,t}^{H} = f_H\left(H_{j,t}, L_{j,t}\right) \exp\left(\epsilon_{j,t}^{H}\right) \tag{2}$$

Labor Productivity and Wages

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- While there is some evidence to indicate that the presence of more high skill workers leads to productivity spillovers for all workers, the functional form of the endogenous productivity functions f_L and f_H are agnostic for now.
- There are a large number of firms and no barriers to entry, so we can assume perfect competition and workers earn the value of their marginal product. Capital is supplied elastically across all cities at price κ_t. So:

$$
\begin{aligned}
W^H_{j,t} &= \alpha N^{\alpha-\rho}_{d,j,t} K^{1-\alpha}_{d,j,t} H^{\rho-1}_{d,j,t} f_H\left(H_{j,t}, L_{j,t}\right) \exp\left(\varepsilon^H_{j,t}\right) \\
W^L_{j,t} &= \alpha N^{\alpha-\rho}_{d,j,t} K^{1-\alpha}_{d,j,t} L^{\rho-1}_{d,j,t} f_L\left(H_{j,t}, L_{j,t}\right) \exp\left(\varepsilon^L_{j,t}\right) \\
\kappa_t &= N^{\alpha}_{d,j,t} K^{-\alpha}_{d,j,t} \left(1-\alpha\right)
\end{aligned}
$$

Aggregate Labor Demand

Firm level labor demand translates directly into city-level aggregate labor demand as firms within a city all have an identical constant-returns-to-scale production technology:

$$w_{j,t}^{H} = \log\left(W_{j,t}^{H}\right) = c_t + (1-\rho)\ \mathit{log}\left(N_{j,t}\right) + (\rho-1)\log\left(H_{j,t}\right) + \log\left(f_H\left(H_{j,t}, L_{j,t}\right)\right) + \varepsilon_{j,t}^{H}$$

$$w_{j,t}^{L} = \log\left(W_{j,t}^{L}\right) = c_t + (1-\rho)\ \mathit{log}\left(N_{j,t}\right) + (\rho-1)\log\left(L_{j,t}\right) + \log\left(f_L\left(H_{j,t}, L_{j,t}\right)\right) + \varepsilon_{j,t}^{L}$$

$$N_{j,t} = \left(\exp\left(\varepsilon_{j,t}^{L}\right) f_L\left(H_{j,t}, L_{j,t}\right) L_{j,t}^{\rho} + \exp\left(\varepsilon_{j,t}^{H}\right) f_H\left(H_{j,t}, L_{j,t}\right) H_{j,t}^{\rho}\right)^{\frac{1}{\rho}}$$

where:

$$c_t = \log\left(\alpha\left(\frac{1-\alpha}{\kappa_t}\right)^{\frac{1-\alpha}{\alpha}}\right)$$

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- 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_H and f_L).
- Instead of imposing parametric restrictions, the labor demand functions can be rewritten as:

$$w_{j,t}^H = g_H \left(H_{j,t}, L_{j,t}\right) + \varepsilon_{j,t}^H$$
$$w_{j,t}^L = g_L \left(H_{j,t}, L_{j,t}\right) + \varepsilon_{j,t}^L$$

- We can approximate these functions using a log-linear specification:

$$w_{j,t}^H = \gamma_{HH} \log H_{j,t} + \gamma_{HL} \log L_{j,t} + \varepsilon_{j,t}^H$$

and

$$w_{j,t}^L = \gamma_{LH} \log H_{j,t} + \gamma_{LL} \log L_{j,t} + \varepsilon_{j,t}^L$$

Labor Supply

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- The worker consumes a local good M, which has a local price $R_{j,t}$, and a national good O, which has a national price p_t, and gains utility from the vector of amenities $A_{j,t}$ in the city.

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- The worker consumes a local good M, which has a local price $R_{j,t}$, and a national good O, which has a national price p_t, and gains utility from the vector of amenities $A_{j,t}$ in the city.
- The worker has Cobb-Douglas preferences for the local and national good, and the utility function looks like:

$$\max_{M,O} \log\left(M^{\xi}\right) + \log\left(O^{1-\xi}\right) + s_i\left(A_{j,t}\right)$$

subject to:

$$P_t O + R_{j,t} M \leq W_{j,t}^{edu}$$

Worker's Utility

- The worker's optimized utility function can be expressed as an indirect utility function

$$V_{i,j,t} = \log\left(\frac{w_{j,t}^{edu}}{P_t}\right) - \xi \log\left(\frac{R_{j,t}}{P_t}\right) + s_i\left(A_{j,t}\right)$$

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- The price index used in the denominator above, is the CPI-U index for all goods excluding shelter measured in year 2000 U.S. dollars.
- The workers' optimized utility function also leads to his local good demand

$$HD_{i,j,t} = \frac{\xi w_{j,t}^{edu}}{R_{j,t}} \tag{4}$$

Amenities and Labor Supply

- Some amenities are exogenous to the labor market mix of the city – define this as vector $x^A_{j,t}$. Other amenities respond endogenously to the labor mix. Specifically, define $a_{j,t}$ as the first principal comoponent of a bundle of amenities related to school quality, retail, crime, the environment, transportation, and the quality of the job market.

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- The function $s\left(A_{j,t}\right)$ maps the vector of city amenities to the worker's utility value for them:

$$
\begin{aligned}
s\left(A_{j,t}\right) &= a_{j,t}\beta^a_i + x^A_{j,t}\beta^x_i + \beta^{st}_i x^{st}_j + \beta^{div}_i x^{div}_j + \sigma_i \varepsilon_{i,j,t} \\
\beta^x_i &= \beta^x z_i \\
\beta^a_i &= \beta^a z_i \\
\beta^{st}_i &= st_i \beta^{st} z_i \\
\beta^{div}_i &= div_i \beta^{div} z_i \\
\sigma_i &= \beta^\sigma z_i \\
\varepsilon_{i,j,t} &\sim \text{Type I Extreme Value}
\end{aligned}
$$

- β_i^{st} and β_i^{div} measure a worker's value of living in his or her state of birth and census division of birth.

Amenities and Labor Supply

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Amenities and Labor Supply

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- Worker i's marginal utility of the different types of amenities are a function of a 3 vector of demographic variables z_i, which include dummy variables indicating if a worker is white, black, or an immigrant.
- x_j^{st} is a 50×1 vector where each element k takes on a value of 1 if MSA j is partly located in state k. Similarly, x_j^{div} is a 9×1 vector where element k takes on a value of 1 if MSA j is located in census division k.

Utility Function Revisited

- $\varepsilon_{i,j,t}$ is an idiosyncratic preference term for worker i. The indirect utility function (3) is renormalized by dividing each worker's utility by $\beta^{\sigma} z_i$ so that the standard deviation of worker idiosyncratic preferences is normalized to 1.

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- The indirect utility function for worker i in city j can now be written as:

$$V_{i,j,t} = \left(w_{j,t}^{edu} - \xi r_{j,t}\right) \beta^{w} z_i + a_{j,t}\beta_i^{a} + x_{j,t}\beta_i^{x} + x_j^{st}\beta_i^{st} + x_j^{div}\beta_i^{div} + \varepsilon_{i,j,t}$$

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- Define $\delta_{j,t}^{z}$ as the utility value of the components of city j that all workers of type z value identically:

$$\delta_{j,t}^{z} = \left(w_{j,t}^{edu} - \xi r_{j,t}\right)\beta^{w} z_i + a_{j,t}\beta_i^{a} z_i + x_{j,t}\beta_i^{x} z_i$$

and rewriting the utility function in terms of $\delta_{j,t}^{z}$, we have:

$$V_{i,j,t} = \delta_{j,t}^{z} + x_j^{st}\beta_i^{st} z_i + x_j^{div}\beta_i^{div} z_i + \varepsilon_{i,j,t}$$

Conditional Logit Model

- The total expected population of city j is simply the probability that each worker lives in the city, summed over all workers. This can be rewritten as a conditional logit model for high skill workers:

$$H_{j,t} = \sum_{i \in H_t} \frac{\exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)}{\sum_k^J \exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)}$$

and for low skill workers:

$$L_{j,t} = \sum_{i \in L_t} \frac{\exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)}{\sum_k^J \exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)}$$

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- Observed variables are the high and low skilled population, wages, rent, the amenity index, worker demographics, and workers' states and census divisions of birth. Exogenous amenities and idiosyncratic taste preferences are unobserved. Estimated parameters are the workers' preferences for wages, rent, and amenities (β, ξ).

Housing Supply

- Local prices $R_{j,t}$, are set through equilibrium in the housing market.

Housing Supply

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- Developers are price takers and sell homogeneous houses at the marginal cost of production:

$$P_{j,t}^{home} = MC\left(CC_{j,t}, LT_{j,t}\right)$$

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  where $CC_{j,t}$ are local construction costs and $LC_{j,t}$ are local land costs.
- In a steady-state real estate market equilibrium, there is no uncertainty and prices are equal to the discounted value of rents:

$$R_{j,t} = \iota_t \times MC\left(CC_{j,t}, LT_{j,t}\right)$$

  where ι_t is the interest rate.

Housing Supply Equation

- The cost of land is a function of the aggregate demand for local goods given by equation (4), which shows that local goods demand increases when wages rise or the price of local goods falls. In-migration also affects housing demand.

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- The cost of land is a function of the aggregate demand for local goods given by equation (4), which shows that local goods demand increases when wages rise or the price of local goods falls. In-migration also affects housing demand.
- The log housing supply equation is parameterized as:

$$r_{j,t} = \log\left(R_{j,t}\right) = \log\left(\iota_t\right) + \log\left(CC_{j,t}\right) + \gamma_j \log\left(HD_{j,t}\right)$$

$$\gamma_j = \gamma + \gamma^{geo} \log\left(x_j^{geo}\right) + \gamma^{reg} \log\left(x_j^{reg}\right)$$

$$HD_{j,t} = L_{j,t} \frac{\xi w_{j,t}^L}{R_{j,t}} + H_{j,t} \frac{\xi w_{j,t}^H}{R_{j,t}}$$

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- We can observe housing rent, land availability, land-use regulation, and local good demand. Construction costs and the interest rate are unobserved. Parameters to be estimated are housing supply elasticities (γ) and the local good expenditure share (ξ).

Amenity Supply

- Some amenities supplied in a city are due to exogenous factors outside the model, these amenities are represented by the vector $x_{j,t}^A$.

Amenity Supply

- Some amenities supplied in a city are due to exogenous factors outside the model, these amenities are represented by the vector $x^A_{j,t}$.
- Some amenities respond endogenously to the types of residents who live in the city. The bundle of observable amenities will be represented by $a_{j,t}$ (which is the first principal component of a large vector of amenities).

Amenity Supply Equation

- The level of the endogenous amenity index is determined by the high skill employment ratio $\frac{H_{j,t}}{L_{j,t}}$.

$$a_{j,t} = \gamma^a \log\left(\frac{H_{j,t}}{L_{j,t}}\right) + \varepsilon^a_{j,t}$$

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$$a_{j,t} = \gamma^a \log\left(\frac{H_{j,t}}{L_{j,t}}\right) + \varepsilon^a_{j,t}$$

- We can observe the MSAs' state, census division, and endogenous amenities, and the college employment ratio. Exogenous amenities and the exogenous component of the amenity index are unobserved. The elasticity of amenity supply (γ^a) is estimated.

Equilibrium #1

Equilibrium in the model is defined by a menu of wages, rents, and amenity levels with populations such that:

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

$$
\begin{aligned}
H^*_{j,t} &= \sum_{i \in H_t} \frac{\exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)}{\sum_k^J \exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)} \\
w^{H^*}_{j,t} &= \gamma_{HH} \log\left(H^*_{j,t}\right) + \gamma_{HL} \log\left(L^*_{j,t}\right) + \varepsilon^H_{j,t}
\end{aligned} \tag{5}
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$$w^{H^*}_{j,t} = \gamma_{HH} \log\left(H^*_{j,t}\right) + \gamma_{HL} \log\left(L^*_{j,t}\right) + \varepsilon^H_{j,t}$$

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

$$L^*_{j,t} = \sum_{i \in L_t} \frac{\exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)}{\sum_k^J \exp\left(\delta^z_{j,t} + x^{st}_j \beta^{st}_i z_i + x^{div}_j \beta^{div}_i z_i\right)} \tag{6}$$

$$w^{L^*}_{j,t} = \gamma_{LH} \log\left(H^*_{j,t}\right) + \gamma_{LL} \log\left(L^*_{j,t}\right) + \varepsilon^L_{j,t}$$

Equilibrium #2

- Housing demand equals housing supply:

$$r^*_{j,t} = \log\left(\iota_t\right) + \log\left(CC_{j,t}\right) + \gamma_j \log\left(HD^*_{j,t}\right)$$

$$HD^*_{j,t} = L^*_{j,t}\frac{\xi \exp\left(w^{L^*}_{j,t}\right)}{\exp\left(r^*_{j,t}\right)} + H^*_{j,t}\frac{\xi \exp\left(w^{H^*}_{j,t}\right)}{\exp\left(r^*_{j,t}\right)}$$

Equilibrium #2

- Housing demand equals housing supply:

$$r_{j,t}^{*} = \log\left(\iota_t\right) + \log\left(CC_{j,t}\right) + \gamma_j \log\left(HD_{j,t}^{*}\right)$$

$$HD_{j,t}^{*} = L_{j,t}^{*} \frac{\xi \exp\left(w_{j,t}^{L^*}\right)}{\exp\left(r_{j,t}^{*}\right)} + H_{j,t}^{*} \frac{\xi \exp\left(w_{j,t}^{H^*}\right)}{\exp\left(r_{j,t}^{*}\right)}$$

- Endogenous amenities demand equals endogenous amenities supply:

$$a_{j,t}^{*} = \gamma^{a} \log\left(\frac{H_{j,t}^{*}}{L_{j,t}^{*}}\right) + \varepsilon_{j,t}^{a}$$

$$\delta_{j,t}^{z} = \left(w_{j,t}^{edu^*} - \xi r_{j,t}^{*}\right) \beta^{w} z + a_{j,t}^{*} \beta_{i}^{a} z + x_{j,t}^{a} \beta_{i}^{x} z, \forall z$$

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Estimating the Endogenous Amenity Index

- Data is collected on 15 different amenities, which are grouped into 6 categories: retail, transportation, crime, environment, school quality, and job quality (beyond wages). Amenities are combined into a single index $a_{j,t}$ using a principal components analysis.

Estimating the Endogenous Amenity Index

- Data is collected on 15 different amenities, which are grouped into 6 categories: retail, transportation, crime, environment, school quality, and job quality (beyond wages). Amenities are combined into a single index $a_{j,t}$ using a principal components analysis.
- In order to avoid overweighting one category, analysis first creates a PCA index within each category, and then creates a PCA with each category's index. Table 4 shows the various weightings.

Table 4

TABLE 4—PRINCIPLE COMPONENT ANALYSIS FOR AMENITY INDICES

	Loading	Unexplained variance
Panel A. Retail index		
Apparel stores per 1,000 residents	0.653	0.411
Eating and drinking places per 1,000 residents	0.525	0.619
Movie theaters per 1,000 residents	0.545	0.591
Panel B. Transportation index		
Public buses per capita	0.566	0.5099
Public transit index	0.7015	0.2476
Average daily traffic—interstates	0.332	0.8315
Average daily traffic—major roads	0.277	0.8823
Panel C. Crime index		
Property crimes per 1,000 residents	0.707	0.395
Violent crimes per 1,000 residents	0.707	0.395
Panel D. Environment index		
Government spending on parks per capita	0.707	0.4541
EPA air quality index	−0.707	0.4541
Panel E. School index		
Government K–12 spending per student	0.707	0.3425
Student–teacher ratio	−0.707	0.3425
Panel F. Job index		
Patents per capita	0.707	0.4417
Employment rate	0.707	0.4417
Panel G. Overall amenity index		
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 online Appendix for detailed description of amenity data and their data sources. Panels A–F report weights used in each subindex construction. Panel G reports loadings on each subindex to create overall amenity index. See text for further details.

Bartik Labor Demand Shocks

- Key to identifying model parameters is estimating how cities' economic outcomes respond to exogenous shocks in local firm productivities based on Bartik (1991).

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- The Bartik shocks for high and low skill workers are:

$$\Delta B^H_{j,t} = \sum_{ind} \left(w^H_{ind,-j,t} - w^H_{ind,-j,1980} \right) \frac{H_{ind,j,1980}}{H_{j,1980}}$$
$$\Delta B^L_{j,t} = \sum_{ind} \left(w^L_{ind,-j,t} - w^L_{ind,-j,1980} \right) \frac{L_{ind,j,1980}}{L_{j,1980}}$$

where $w^H_{ind,-j,t}$ and $w^L_{ind,-j,t}$ are the average log wages of high and low skill workers in industry *ind* in cities other than j in year t.

Bartik Shocks and Labor Demand

Bartik labor demand shocks are a component of a city's exogenous productivity changes over time. The productivity changes from equations (5) and (6) can be written as:

$$\Delta \varepsilon^{H}_{j,t} = \gamma_{BHH} \Delta B^{H}_{j,t} + \gamma_{BHL} \Delta B^{L}_{j,t} + \Delta \tilde{\varepsilon}^{H}_{j,t} \tag{7}$$

$$\Delta \varepsilon^{L}_{j,t} = \gamma_{BLH} \Delta B^{H}_{j,t} + \gamma_{BLL} \Delta B^{L}_{j,t} + \Delta \tilde{\varepsilon}^{L}_{j,t} \tag{8}$$

Labor Demand

- Using equations (5) and (6) and differencing cities' wages relative to their 1980 levels gives us:

$$\Delta w_{j,t}^{H} = \gamma_{HH}\Delta H_{j,t} + \gamma_{HL}\Delta L_{j,t} + \Delta\varepsilon_{j,t}^{H} \tag{9}$$

$$\Delta w_{j,t}^{L} = \gamma_{LH}\Delta H_{j,t} + \gamma_{LL}\Delta L_{j,t} + \Delta\varepsilon_{j,t}^{L} \tag{10}$$

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$$\Delta w_{j,t}^{L} = \gamma_{LH} \Delta H_{j,t} + \gamma_{LL} \Delta L_{j,t} + \Delta \varepsilon_{j,t}^{L} \tag{10}$$

- Plugging the Bartik shock equations (7) and (8) into the wage change equations (9) and (10) gives us:

$$\Delta w_{j,t}^{H} = \gamma_{HH} \Delta H_{j,t} + \gamma_{HL} \Delta L_{j,t} + \gamma_{BHH} \Delta B_{j,t}^{H} + \gamma_{BHL} \Delta B_{j,t}^{L} + \Delta \tilde{\varepsilon}_{j,t}^{H}$$

$$\Delta w_{j,t}^{L} = \gamma_{LH} \Delta H_{j,t} + \gamma_{LL} \Delta L_{j,t} + \gamma_{BLH} \Delta B_{j,t}^{H} + \gamma_{BLL} \Delta B_{j,t}^{L} + \Delta \tilde{\varepsilon}_{j,t}^{L}$$

Bartik Shocks and Exclusion Restrictions

- The Bartik shocks provide plausibly exogenous labor demand shifters. The labor demand elasticities will be identified through variations in the labor supply that come through housing supply.

Bartik Shocks and Exclusion Restrictions

- The Bartik shocks provide plausibly exogenous labor demand shifters. The labor demand elasticities will be identified through variations in the labor supply that come through housing supply.
- In order for housing supply to help to identify labor market equilibrium, we need to make the following exclusion restrictions:

$$E\left[\Delta\tilde{\varepsilon}^{H}_{j,t}, \Delta Z_{j,t}\right] = 0$$
$$E\left[\Delta\tilde{\varepsilon}^{L}_{j,t}, \Delta Z_{j,t}\right] = 0$$

where instruments:

$$\Delta Z_{j,t} \in \left\{ \begin{matrix} \Delta B^{H}_{j,t} x^{reg}_{j}, \Delta B^{L}_{j,t} x^{reg}_{j} \\ \Delta B^{H}_{j,t} x^{geo}_{j}, \Delta B^{L}_{j,t} x^{geo}_{j} \end{matrix} \right\}$$

In words, the Bartik labor shocks have to be uncorrelated with the level of land use regulations and land availability measures by MSA.

Housing Supply

- Rewrite the housing supply curve in changes since 1980:

$$\Delta r_{j,t} = \Delta \log\left(\iota_t\right) + \Delta \log\left(CC_{j,t}\right) + \left(\gamma + \gamma^{geo} \exp\left(x_j^{geo}\right) + \gamma^{reg} \exp\left(x_j^{reg}\right)\right) \Delta \log\left(HD_{j,t}\right)$$

$$HD_{j,t} = L_{j,t} \frac{\xi w_{j,t}^{L}}{R_{j,t}} + H_{j,t} \frac{\xi w_{j,t}^{H}}{R_{j,t}}$$

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$$HD_{j,t} = L_{j,t}\frac{\xi w^L_{j,t}}{R_{j,t}} + H_{j,t}\frac{\xi w^H_{j,t}}{R_{j,t}}$$

- However, we have a problem in that housing demand is a variable endogenous to the labor supply.

Housing Supply Identification

The key identifying assumption in the housing market is that Bartik labor demand shocks are uncorrelated with changes in local construction costs. Specifically:

$$E\left[\Delta \log\left(CC_{j,t}\right), \Delta Z_{j,t}\right] = 0$$

where:

$$\Delta Z_{j,t} \in \left\{ \begin{array}{c} \Delta B^{H}_{j,t}, \Delta B^{L}_{j,t} \\ \Delta B^{H}_{j,t} x^{reg}_{j}, \Delta B^{L}_{j,t} x^{reg}_{j} \\ \Delta B^{H}_{j,t} x^{geo}_{j}, \Delta B^{L}_{j,t} x^{geo}_{j} \end{array} \right\}$$

Labor Supply

- The indirect utility of city j for worker i with demographics z_i is:

$$V_{i,j,t} = \delta^{z}_{j,t} + x^{st}_{j}\beta^{st} z_i + x^{div}_{j}\beta^{div} z_i + \varepsilon_{i,j,t}$$

$$\delta^{z}_{j,t} = \left(w^{edu}_{j,t} - \xi r_{j,t}\right)\beta^{w} z + a_{j,t}\beta^{a}_{i} z + x^{A}_{j,t}\beta^{x}_{i} z$$

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

Labor Supply Estimates

- First step: MLE where mean utility value of each city j for each demographic group z is the parameter to be estimated. Observed population differences in the data for a given type of worker identify the mean utility estimates for each city.

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- Second step: decompose mean utility estimates into how workers value wages, rents, and amenities. Differencing cities' mean utility estimates for each demographic group relative to 1980 levels gives:

$$\delta_{j,t}^{z} = \left(\Delta w_{j,t}^{edu} - \xi \Delta r_{j,t}\right) \beta^{w} z + \Delta a_{j,t} \beta_i^{a} z + \Delta x_{j,t}^{A} \beta_i^{x} z \tag{11}$$

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- Observed values are changes in cities' wages, rents, and amenity index. Exogenous amenity changes are unobserved.

Labor Supply Estimates

- Define $\Delta\zeta^{z}_{j,t}$ as the change in the utility value of city j's amenities unobserved to us for workers with demographics z.

$$\zeta^{z}_{j,t} = \beta^{A} z \Delta x^{A}_{j,t}$$

Labor Supply Estimates

- Define $\Delta\zeta_{j,t}^{z}$ as the change in the utility value of city j's amenities unobserved to us for workers with demographics z.

$$\zeta_{j,t}^{z} = \beta^{A} z \Delta x_{j,t}^{A}$$

- Plugging this expression back into equation (11) gives us:

$$\delta_{j,t}^{z} = \left(\Delta w_{j,t}^{edu} - \xi \Delta r_{j,t}\right) \beta^{w} z + \Delta a_{j,t} \beta_{i}^{a} z + \Delta\zeta_{j,t}^{z} \tag{12}$$

Estimator Moment Conditions

To identify workers' preferences for cities' wages, rents, and amenities, instrument for the endogenous variables with the Bartik labor demand shocks and their interactions with housing supply elasticity characteristics. This should be highly correlated with changes in the rental rate, but not the unobserved amenities. More formally, the estimator assumes:

$$E\left[\Delta\zeta^{z}_{j,t}, \Delta Z_{j,t}\right] = 0$$

where:

$$\Delta Z_{j,t} \in \left\{ \begin{array}{c} \Delta B^{H}_{j,t}, \Delta B^{L}_{j,t} \\ \Delta B^{H}_{j,t} x^{reg}_{j}, \Delta B^{L}_{j,t} x^{reg}_{j} \\ \Delta B^{H}_{j,t} x^{geo}_{j}, \Delta B^{L}_{j,t} x^{geo}_{j} \end{array} \right\}$$

Amenity Supply

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

$$\Delta a_{j,t} = \gamma^a \Delta \log \left(\frac{H_{j,t}}{L_{j,t}} \right) + \Delta \varepsilon^a_{j,t}$$

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$$\Delta a_{j,t} = \gamma^a \Delta \log \left(\frac{H_{j,t}}{L_{j,t}} \right) + \Delta \varepsilon^a_{j,t}$$

- The amenity supply elasticity is identified by instrumenting for changes in the college employment ratio with the Bartik labor demand shocks and their interactions with housing supply elasticity characteristics. Specifically, assume that:

$$E\left[\Delta \varepsilon^a_{j,t}, \Delta Z_{j,t}\right] = 0$$

where:

$$\Delta Z_{j,t} \in \left\{ \begin{matrix} \Delta B^H_{j,t}, \Delta B^L_{j,t} \\ \Delta B^H_{j,t} x^{reg}_j, \Delta B^L_{j,t} x^{reg}_j \\ \Delta B^H_{j,t} x^{geo}_j, \Delta B^L_{j,t} x^{geo}_j \end{matrix} \right\}$$

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Parameter Estimates

- All parameters are jointly estimated using two-step GMM. Standard errors are clustered by MSA.
- Four versions of the model are estimated. First estimate is the "standard" model, which assumes local amenities and firms' local productivity levels are exogenous and thus do not depend on the college employment ratio. Estimates are in column 1 of Table 5.

Table 5, Panel A

Table 5—GMM Estimates of Model Parameters

	Non-college (1)	College (1)	Non-college (2)	College (2)	Non-college (3)	College (3)	Non-college (4)	College (4)
Panel A. Worker preferences for cities								
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]
Implied local 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 5 continues on following page. See bottom of table on following page for differences in model specifications in columns 1 to 4 above.

(*Continued*)

Standard and Restricted Models

- Column 1 of Table 5 shows the "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.

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- Consumer Expenditure Survey (CEX) from 2000 census allows us to measure local expenditure share directly, which comes out to 62%. 2nd column of Table 5 re-runs standard model while restricting local expenditure share to 0.62.
- The restricted standard model seems to imply that college workers seem to *prefer* lower wages and higher rents.

Full Model

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- Column 3 of Table 5 adds the amenity index and keeps the 0.62 local expenditure restriction (she calls this the "full" model). This result shows that, other things equal, college workers do like higher wages and lower rents, but are somewhat less sensitive to it than non-college workers.

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- However, college workers do have a much stronger preference for local amenities.

Expenditure Parameters by Demographic Groups

- Column 4 of Table 5 allows the local expenditure parameter to be estimated by group and includes the amenity index. Expenditure shares are highly correlated with rents, so the estimate is noisier.

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- Bottom of Panel A of Table 5 looks at differences across demographic groups. Blacks and immigrants tend to be somewhat more sensitive to wages, rents, and amenities, but estimates are noisier.

Table 6

TABLE 6—VALUE OF LIVING IN OWN BIRTH STATE AND DIVISION

	1980		1990		2000	
	Base	Black	Base	Black	Base	Black
Panel A. Birth state						
Noncollege	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]
Panel B. Birth division						
Noncollege	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 errors 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.

Value of State and Census Division of Birth

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- Non-college workers are 4.4 times more likely to live in an MSA in their state of birth and college workers are only 3.5 times more likely.
- Same census division is 2.2 times more likely for both college and non-college workers.

Table 5, Panels B-D

Table 5—GMM Estimates of Model Parameters (*Continued*)

	1	2	3	4
Panel 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]
Panel C. Labor demand				
ρ	0.392***	0.393***		
	[0.119]	[0.1371]		
Elasticity of college wage w.r.t. college emp.			0.229	0.205
			[0.307]	[0.320]
College wage w.r.t. noncollege emp.			0.312	0.376
			[0.367]	[0.388]
Noncollege wage w.r.t. noncollege emp.			−0.552***	−0.448***
			[0.202]	[0.196]
Noncollege wage w.r.t. college emp.			0.697***	0.642***
			[0.163]	[0.172]
Panel 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
χ^2 test: estimates = calibrated local expenditure model estimates (p-value):	0.0000			0.489
Endogenous amenity index			—	—
Calibrated local good expenditure share		—	—	
CES labor demand	—	—		
Reduced-form labor demand			—	—

Notes: Standard errors in brackets. Data include 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 noncollege 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. ρ in the labor demand equations comes from the CES functional form. Reduced-form labor demand estimates measure own and cross-price inverse labor demand elasticities with respect to college and noncollege wages. Amenity supply measures the elasticity of amenity supply with respect to the college employment ratio. Standard errors clustered by MSA.

***Significant at the 1 percent level.
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Housing Supply

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- Housing supply is less elastic in MSAs with less land availability and more land use regulations. Estimates do not vary substantially across different models.

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- Full model allows for a more flexible labor demand curve. Downward sloping labor demand curve is found as expected for non-college workers, and they are substitutable for college workers.
- Demand for college workers is more interesting. The labor demand curve is *upwards* sloping, though not significantly different than zero, but significantly greater than for non-college labor. There may be an endogenous productivity effect from having college workers around.

Amenity Supply

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- Both models report similar elasticities of amenity supply between 2.60 and 2.65.
- An increase in the city's college employment ratio endogenously changes the supply of amenities in the area.

Estimation Robustness

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- Going by the indirect utility function (12), we can derive the utility that workers of type z receive from amenities in city j in year t as:

$$Amen^{z}_{j,t} = \beta^{a}_{i} a_{j,t} + \zeta^{z}_{j,t} = \beta^{w} z \left(w^{edu}_{j,t} - \xi r_{j,t} \right)$$

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- Basic idea is that amenities are inferred to be the highest in cities which have higher population levels of a given demographic group than expected given the city's wage and rent levels.

Amenities and Productitivity Across Cities

- Results seem to conform with intuition. Large coastal cities have the highest estimated amenity indexes, whereas the lowest estimated amenity indexes tend to be in rust-belt cities. Some differences exist between college and non-college workers, but they are not very different.

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- Biggest increases in productivity for high-skill workers were in major tech hubs.
- Biggest increases in productivity for low-skill workers were in metro areas that had lots of agricultural production and/or shipping centers with jobs that are difficult to offshore.

Table 7

TABLE 7—RELATIONS BETWEEN AMENITY AND PRODUCTIVITY CHANGES

	Δ College amenity (1)	Δ College productivity (2)	Δ College wage (3)
Δ Noncollege amenity	2.497***		
	[0.198]		
Δ College productivity		0.212**	
		[0.103]	
Δ Noncollege wage			0.672***
			[0.0471]
Constant	−0.103**	−0.0105	0.155***
	[0.0421]	[0.0220]	[0.00520]
Observations	217	217	217
R^2	0.426	0.019	0.487

Notes: 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.

*** Significant at the 1 percent level.
** Significant at the 5 percent level.
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- College and non-college wages are strongly correlated with each other.

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College Employment Ratio Changes and Productivity

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- Changes in local productivity directly impact wages, but also influence local prices and amenities through migration.
- The direct effect of exogenous productivity changes from 1980 to 2000 are inferred from the model and high and low skill wages:

$$\hat{w}^H_{j,2000} = \gamma_{HH} \log\left(H_{j,1980}\right) + \gamma_{HL} \log\left(L_{j,1980}\right) + \varepsilon^H_{j,2000}$$
$$\hat{w}^L_{j,2000} = \gamma_{LH} \log\left(H_{j,1980}\right) + \gamma_{LL} \log\left(L_{j,1980}\right) + \varepsilon^L_{j,2000}$$

where $\hat{w}^H_{j,2000}$ and $\hat{w}^L_{j,2000}$ are the counter factual high and low skill wages driven by exogenous productivity shocks and initial labor market composition.

College Employment Ratio Changes and Productivity

Using the counter factual wages and the amenity levels of 1980, we can use the model to predict where workers would live in a set of hypothetical cities with 2000 wages and 1980 amenities:

$$V_{i,j,t} = \left(\hat{w}^{edu}_{j,2000} - \xi r_{j,1980}\right) \beta^w z_i + a_{j,1980}\beta^a_i + x_{j,1980}\beta^x_i + x^{st}_j \beta^{st}_i + x^{div}_j \beta^{div}_i + \varepsilon_{i,j,1980}$$

Predicted cities' college employment ratios from this hypothetical world are compared to those observed in the data.

Figure 2

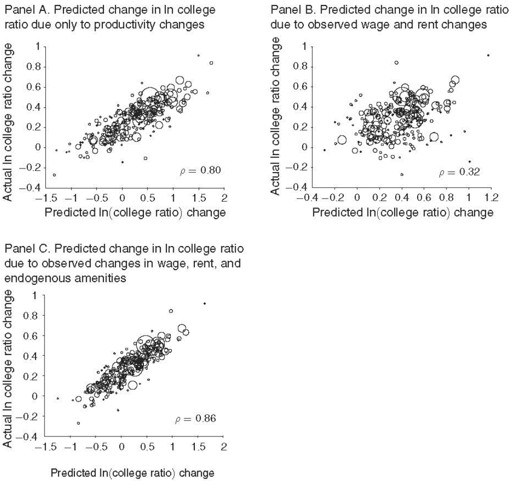

Figure 2. Predicted Changes in ln College Employment Ratio, 1980–2000

Counter Factuals vs. Observed Employment Ratios

- Panel A of Figure 2 shows the correlation of the observed college employment ratios against the counter factual ratios. The correlation between these is strongly positive with a coefficient of 0.80.

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- Panel B plots observed college employment ratio changes against predicted college employment ratio changes. The correlation is positive, but only 0.32, which suggests that amenity changes are important component through which cities' college employment ratios change.

Counter Factuals vs. Observed Employment Ratios

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- 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.
- Panel B plots observed college employment ratio changes against predicted college employment ratio changes. The correlation is positive, but only 0.32, which suggests that amenity changes are important component through which cities' college employment ratios change.
- Panel C repeats this analysis, but plots actual college employment ratio changes against changes predicted due to wages, rents, and endogenous amenities. The correlation coefficient is now 0.86, indicating that the combination of these three factors is important.

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Welfare Implications for Well-Being Inequality

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- Local real wage gap, which takes into account rents, has increased by 15%. But this doesn't capture why college graduates pay higher rents.
- To measure how changes in cities wages, rents, and amenities each contribute to well-being inequality, the paper conducts a welfare decomposition.

Table 9

Table 9—Decomposition of Well-Being Inequality: Wages, Rents, and 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
	[0.0022]	[0.0024]	[0.0316]	[0.1344]
2000	0.601	0.577	0.639	0.956
	[0.0033]	[0.0012]	[0.0364]	[0.2398]
Change: 1980–2000	0.218	0.194	0.256	0.573
	[0.0033]	[0.0012]	[0.0364]	[0.2398]
Wages	—	—	—	—
Rents		—	—	—
Endog. amenities from resorting of workers			—	—
Endog. amenities from national supply of college graduates				—

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 available 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.

Well-Being Inequality

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- Column 3 looks at impact of amenity changes holding the national share of college labor constant and only looking at re-sorting of workers across MSAs. Gap increases to 25.6%.
- Finally, Column 4 allows the national share of college labor to change and have average level of amenities adjust to increase in college labor. Gap widens significantly to 57.3%.

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- At the same time, college educated workers began to disproportionately concentrate in nicer but more expensive cities.
- Diamond shows that this labor sorting raised the welfare of college-educated workers over and above what is accounted for by looking at nominal wages.

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- Why do we care? International trade is blamed in part for the increase in wage dispersion.
- If new and better jobs are being created in some parts of the country, and not in others, it may be harder for people to adjust to the shocks from trade.