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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ECON 860 – International Trade Theory
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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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- Workers' preferences for cities are estimated using a two-step estimator.
  1. First step, MLE is used to identify how desirable a city is to each type of worker.
  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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- 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

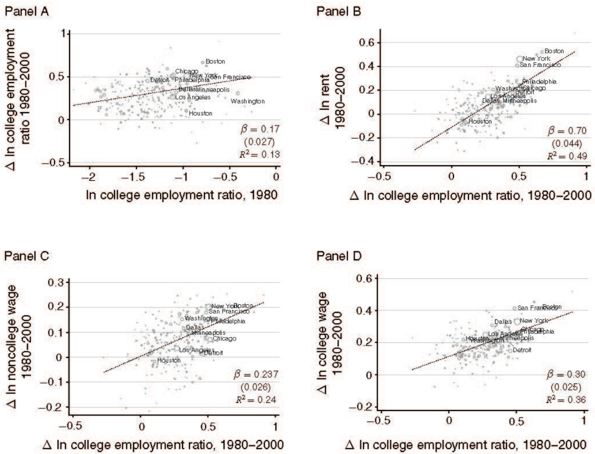

FIGURE 1. CHANGES IN WAGES, RENTS, AND COLLEGE EMPLOYMENT RATIOS, 1980–2000

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

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

and

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

Labor Productivity and Wages

- Equations (1) and (2) show that labor productivity is determined by exogenous and endogenous factors. Exogenous productivity shocks are given by the terms $e^L_{j,t}$ and $e^H_{j,t}$.

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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:

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

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

$$\kappa_t = N^{\alpha}_{d,j,t} K^{-\alpha}_{d,j,t}\left(1-\alpha\right)$$

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:

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

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

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

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:

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

Amenities and Labor Supply

- 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.

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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.

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

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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 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

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- 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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- 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:

$$H^{*}_{j,t} = \sum_{i \in H_t} \frac{\exp\left(\delta^{z}_{j,t} + x^{st}_{j}\beta^{st}_{i} z_i + x^{div}_{j}\beta^{div}_{i} z_i\right)}{\sum_{k}^{J} \exp\left(\delta^{z}_{j,t} + x^{st}_{j}\beta^{st}_{i} z_i + x^{div}_{j}\beta^{div}_{i} z_i\right)} \tag{5}$$

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$$w_{j,t}^{H^*} = \gamma_{HH} \log\left(H_{j,t}^{*}\right) + \gamma_{HL} \log\left(L_{j,t}^{*}\right) + \varepsilon_{j,t}^{H}$$

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

$$L_{j,t}^{*} = \sum_{i \in L_t} \frac{\exp\left(\delta_{j,t}^{z} + x_j^{st}\beta_i^{st} z_i + x_j^{div}\beta_i^{div} z_i\right)}{\sum_k^J \exp\left(\delta_{j,t}^{z} + x_j^{st}\beta_i^{st} z_i + x_j^{div}\beta_i^{div} z_i\right)} \tag{6}$$

$$w_{j,t}^{L^*} = \gamma_{LH} \log\left(H_{j,t}^{*}\right) + \gamma_{LL} \log\left(L_{j,t}^{*}\right) + \varepsilon_{j,t}^{L}$$

Equilibrium #2

- Housing demand equals housing supply:

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

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

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- Endogenous amenities demand equals endogenous amenities supply:

$$a^*_{j,t} = \gamma^a \log\left(\frac{H^*_{j,t}}{L^*_{j,t}}\right) + \varepsilon^a_{j,t}$$

$$\delta^z_{j,t} = \left(w^{edu^*}_{j,t} - \xi r^*_{j,t}\right)\beta^w z + a^*_{j,t}\beta^a_i z + x^a_{j,t}\beta^x_i z, \forall z$$

Table of Contents

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

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- 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

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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:

$$\Delta w^{H}_{j,t} = \gamma_{HH}\Delta H_{j,t} + \gamma_{HL}\Delta L_{j,t} + \Delta\varepsilon^{H}_{j,t} \tag{9}$$

$$\Delta w^{L}_{j,t} = \gamma_{LH}\Delta H_{j,t} + \gamma_{LL}\Delta L_{j,t} + \Delta\varepsilon^{L}_{j,t} \tag{10}$$

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

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

- 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:

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

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

- 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:

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

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

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

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.
$$\zeta^{z}_{j,t} = \beta^{A} z \Delta x^{A}_{j,t}$$
- Plugging this expression back into equation (11) gives us:

$$\delta^{z}_{j,t} = \left(\Delta w^{edu}_{j,t} - \xi \Delta r_{j,t}\right) \beta^{w} z + \Delta a_{j,t} \beta^{a}_{i} z + \Delta\zeta^{z}_{j,t} \tag{12}$$

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:

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