

## Real Wage Inequality<sup>†</sup>

By ENRICO MORETTI\*

*While nominal wage differences between skilled and unskilled workers have increased since 1980, college graduates have experienced larger increases in cost of living because they have increasingly concentrated in cities with high cost of housing. Using a city-specific CPI, I find that real wage differences between college and high school graduates have grown significantly less than nominal differences. Changes in the geographical location of different skill groups are to a significant degree driven by city-specific shifts in relative demand. I conclude that the increase in utility differences between skilled and unskilled workers since 1980 is smaller than previously thought based on nominal wage differences. (JEL J22, J23, J24, J31, R23, R31)*

One of the most important developments in the US labor market over the past 30 years has been a significant increase in wage inequality. For example, the difference between the wage of skilled and unskilled workers has increased significantly since 1980. The existing literature has focused on three classes of explanations: an increase in the relative demand for skills caused, for example, by skill-biased technical change; a slowdown in the growth of the relative supply of skilled workers; and the erosion of labor market institutions that protect low-wage workers.<sup>1</sup>

In this paper, I reexamine how inequality is measured and how it is interpreted. I begin by noting that skilled and unskilled workers are not distributed uniformly across cities within the United States, and I assess how existing estimates of inequality change when differences in the cost of living across locations are taken into account. I then use a simple general equilibrium model of the housing and labor markets to understand how changes in these measures of real wage inequality relate to changes in utility inequality.

\*Department of Economics, University of California at Berkeley, Evans Hall, 94720, Berkeley, CA (e-mail: [moretti@econ.berkeley.edu](mailto:moretti@econ.berkeley.edu)). I thank David Autor, Dan Black, David Card, Tom Davidoff, Ed Glaeser, Chang-Tai Hsieh, Matt Kahn, Pat Kline, Douglas Krupka, David Levine, Adam Looney, and Krishna Pendakur for insightful conversations. I am grateful to the referees and seminar participants at Banco de Portugal, University of California (UC) Berkeley Department of Economics, UC Berkeley Haas School of Business, Bocconi University, University of Bologna, University of British Columbia, University of Chicago Harris School of Public Policy Studies, Collegio Carlo Alberto, the University of Edinburgh, Federal Reserve Board of Governors, IZA, Milano, Missouri, National Bureau of Economic Research (NBER) Summer Institute, Northwestern University, Oxford University, San Francisco Federal Reserve, Simon Fraser, Stanford University, Stanford University Graduate School of Business, University of California at Los Angeles, UC Santa Cruz, University of Toronto, Tulane University, UC Merced, University of Verona, and Victoria University for many useful comments. I thank Emek Basker for generously providing the Accra data on consumption prices. Issi Romen, Mariana Carrera, Justin Gallagher, Jonas Hjort, Max Kasy, and Zach Liscow provided excellent research assistance.

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<sup>1</sup>Comprehensive discussions of this literature are found in Katz and Autor (1999); Lemieux (2008); and Autor, Katz, and Kearney (2008).

I focus on changes between 1980 and 2000 in the difference in the average hourly wage for workers with a high school degree and workers with college or more. Using census data, I show that from 1980 to 2000, college graduates have increasingly concentrated in metropolitan areas with a high cost of housing. This is due both to the fact that college graduates in 1980 are overrepresented in cities that experience large increases in housing costs and that much of the growth in the number of college graduates has occurred in cities with initial high housing costs. College graduates are therefore increasingly exposed to a high cost of living and the relative increase in their real wage may be smaller than the relative increase in their nominal wage.

To measure the wage difference between college graduates and high school graduates in *real* terms, I deflate nominal wages using a cost-of-living index that allows for price differences across metropolitan areas. I closely follow the methodology that the Bureau of Labor Statistics uses to build the official consumer price index (CPI), while allowing for changes in the cost of housing to vary across metropolitan areas. Since housing is by far the largest item in the CPI—accounting for more than a third of the index—geographical differences in housing costs have the potential to significantly affect the local CPI. In some specifications, I also allow for local variation in nonhousing prices.

I find that between 1980 and 2000, the cost of housing for college graduates grows much faster than the cost of housing for high school graduates. Specifically, in 1980, the difference in the average cost of housing between college and high school graduates is only 4 percent. This difference grows to 14 percent in 2000, or more than three times the 1980 difference. Consistent with what is documented by the previous literature, I find that the difference between the *nominal* wage of high school and college graduates has increased 20 percentage points between 1980 and 2000. However, the difference between the *real* wage of high school and college graduates has increased significantly less. Changes in the cost of living experienced by high school and college graduates account for about a quarter of the increase in the nominal college premium over the 1980–2000 period. For older workers, this figure is 45 percent. This finding does not appear to be driven by different trends in relative worker ability or housing quality and is robust to a number of alternative specifications. Moreover, the difference between the wage of college graduates and high school graduates is smaller in real terms than in nominal terms for each year. For example, in 2000 the difference is 60 percent in nominal terms and 51 percent in real terms.

Overall, the difference in the real wage between skilled and unskilled workers is smaller than the nominal difference and has grown less.<sup>2</sup> Does this finding mean that the significant increases in wage disparities that have been documented by the previous literature over the last 30 years have failed to translate into significant increases in disparities in well-being? Not necessarily. Since local amenities differ significantly across cities, changes in real wages do not necessarily equal changes in well-being.

To understand the implications of my empirical findings for well-being inequality, I use a simple framework with two skill groups, where productivity and amenity shocks

<sup>2</sup> It is worth stressing that changes in cost of living, while clearly important, account only for a fraction of the overall increase in wage inequality in this period.

to a local labor market are reflected in local wages and local housing costs. The model indicates that the implications of my empirical findings for well-being inequality crucially depend on why college graduates tend to sort into expensive metropolitan areas. I consider two possible explanations. First, it is possible that college graduates move to expensive cities because firms in those cities experience an increase in the *relative demand* for skilled workers. This increase can be due to localized skill-biased technical change or positive shocks to the product demand for skill-intensive industries that are predominantly located in expensive cities (for example, high tech and finance are mostly located in expensive coastal cities). If college graduates increasingly concentrate in expensive cities, such as San Francisco and New York, because the jobs for college graduates are increasingly concentrated in those cities, and not because they particularly like living in San Francisco and New York, then the increase in their utility level is smaller than the increase in their nominal wage. In this scenario, the increase in well-being inequality is smaller than the increase in nominal wage inequality because of the higher costs of living faced by college graduates.

Alternatively, it is possible that college graduates move to expensive cities because the *relative supply* of skilled workers increases in those cities. This may be due, for example, to an increase in the local amenities that attract college graduates. In this scenario, increases in the cost of living in these cities reflect the increased attractiveness of the cities and represent the price to pay for the consumption of desirable amenities. This consumption arguably generates utility. If college graduates move to expensive cities like San Francisco and New York because they want to enjoy the local amenities, and not primarily because of labor demand, then there may still be a significant increase in utility inequality even if the increase in real wage inequality is limited. Of course, the two scenarios are not mutually exclusive, since, in practice, it is possible that both relative demand and supply shift at the same time.

To determine whether relative demand or relative supply shocks are more important in practice, I analyze the empirical relationship between changes in the college premium and changes in the share of college graduates across metropolitan areas. My model indicates that under the relative demand hypothesis, one should see a *positive* equilibrium relationship between changes in the college premium and changes in the college share. Intuitively, increases in the relative demand of college graduates in a city should result in increases in their relative wage there. Under the relative supply hypothesis, one should not see such a positive relationship.<sup>3</sup>

Consistent with relative demand shocks playing an important role, I find a strong *positive* association between changes in the college premium and changes in the college share. As a second piece of evidence, I present instrumental variable estimates of the relationship between changes in the college premium and changes in the college share based on a shift-share instrument. The IV estimate establishes what happens to the college premium in a city when the city experiences an increase in the number of college graduates that is driven purely by an increase in the relative demand for college graduates. By contrast, the OLS estimate establishes what happens to the college premium in a city when the city experiences an increase in

<sup>3</sup> This test is related to the test proposed by Katz and Murphy (1992) to understand nationwide changes in inequality.

the number of college graduates that may be driven by either demand or supply shocks. The comparison of the two estimates is therefore informative about the relative importance of demand and supply shocks.

While I cannot rule out supply factors completely, the empirical evidence suggests that relative demand shocks played an important role in driving changes in the number of skilled workers across metropolitan areas. If this is true, the increase in well-being disparities between 1980 and 2000 is significantly smaller than we previously thought based on the existing literature.<sup>4</sup>

This paper illustrates the importance of accounting for general equilibrium effects when thinking about the effects of group specific labor market shocks. Labor economists often approach the analysis of labor market shocks using a partial equilibrium analysis. However, this study shows that a partial equilibrium analysis can miss important parts of the picture, since the endogenous reaction of factor prices and quantities can significantly alter the ultimate effects of a shock. Because aggregate shocks to the labor market are rarely geographically uniform, the geographic reallocation of factors and local price adjustments are empirically important. It is difficult to fully understand *aggregate* labor market changes, such as changes in relative wages, if ignoring the spatial dimension of labor markets. This paper shows that labor flows across localities and changes in local prices have the potential to undo some of the direct effects of labor market shocks, and this may alter the implications for policy.

My empirical findings are consistent with previous studies that identify shifts in labor demand, whether due to skill-biased technical change or product demand shifts across industries with different skill intensities, as an important determinant of the increase in wage inequality (for example, Katz and Murphy 1992). But unlike the previous literature, my evidence points to an important role for the *local* component of these demand shifts. Relative labor demand shifts have not occurred to the same extent in all locations, but instead have occurred more in some cities than in others. This highlights the critical role played by geography in determining aggregate changes in the American labor market. While in this paper I take these local demand shifts as exogenous, a crucial question for future research centers on the economic forces that make skilled workers more productive in some parts of the country.<sup>5</sup>

My findings complement the literature on consumption inequality, which has documented that income inequality is higher and has grown faster than consumption inequality in many countries, including the United States. See Krueger et al. (2010)

<sup>4</sup> I note that the exact magnitude of the increase in well-being disparities remains unknown. While my estimates indicate that the increase in well-being disparities is smaller than suggested by existing estimates, a full account of changes in well-being disparities would require several additional pieces of information. For example, it would require estimates of relative changes in features of jobs other than wages (job amenities, other forms of compensation, etc.) and estimates of the relative changes in housing wealth induced by changes in housing prices. A full empirical treatment of these issues is complicated and is beyond the scope of this paper.

<sup>5</sup> See, for example, Moretti (2004a, b) and Greenstone, Hornbeck, and Moretti (2010). The notion that demand shocks are important determinants of population shifts is consistent with the evidence in Blanchard and Katz (1992) and Bound and Holzer (2000). Chen and Rosenthal (2008) document that jobs are the key determinant of mobility of young individuals. Mobility of older individuals seems more likely to be driven by amenities. The specific finding that variation in the college share is mostly driven by demand factors is consistent with the argument made by Berry and Glaeser (2005) and Beaudry, Doms, and Lewis (2008).

for a recent review of the evidence. In principle, my estimates have the potential to provide an explanation for the slower increase in consumption inequality in this period.<sup>6</sup> My approach is also related to a paper by Black, Kolesnikova, and Taylor (2009) which, along with earlier work by Dahl (2002), criticizes the standard practice of treating the returns to education as uniform across locations.<sup>7</sup>

The rest of the paper is organized as follows. In Section I, I describe how the official CPI is calculated by the BLS, and I propose two alternative CPI's that allow for geographical differences across skill groups. In Section II, I present estimates of nominal and real college premia. In Section III, I present a simple model that can help interpret the empirical evidence. In Section IV, I discuss the different implications of the demand pull and supply push hypotheses and present empirical evidence to distinguish the two. Section V concludes.

## I. Cost of Living and the Location of Skilled and Unskilled Workers

In this section, I begin with some descriptive evidence on recent changes in the geographical location of skilled and unskilled workers and housing costs (Section IA). I then describe how the Bureau of Labor Statistics computes the official CPI, and I propose two alternative measures of cost of living that account for geographical differences (Section IB). Finally, I use my measures of cost of living to document the differential change in the cost of living experienced by high school and college graduates between 1980 and 2000 (Section IC).

### A. Changes in the Location of Skilled and Unskilled Workers

Throughout the paper, I use data from the 1980, 1990, and 2000 Censuses of Population.<sup>8</sup> The geographical unit of analysis is the metropolitan statistical area (MSA) of residence. Rural households in the census are not assigned to an MSA. In order to keep my wage regressions as representative and as consistent with the previous literature as possible, I group workers who live outside an MSA by state, and treat these groups as additional geographical units.

Table 1 documents differences in the fraction of college graduates across some US metropolitan areas. Specifically, the top (bottom) panel reports the 10 cities with the highest (lowest) fraction of workers with a college degree or more in 2000. Throughout the paper, college graduates also include individuals with a post-graduate education. The metropolitan area with the largest share of workers with a college degree among its residents is Stamford, CT, where 58 percent of workers have a college degree or more. The fraction of college graduates in Stamford, CT

<sup>6</sup> See also Duranton (2008) on spatial wage disparities, and Aguiar and Hurst (2007), who focus on the role of differential changes in labor supply and leisure, by skill group. My results are also related to a series of papers by Pendakur (2002) and Crossley and Pendakur (forthcoming) on the correct use of price indexes on the measurement of inequality.

<sup>7</sup> Black, Kolesnikova, and Taylor (2009) show that, in theory, the return to schooling is constant across locations only in the special case of homothetic preferences, and argue that the returns to education are empirically lower in high-amenity locations.

<sup>8</sup> Because my data end in 2000, my empirical analysis is not affected by the run-up in home prices during the housing bubble years and the subsequent decline in home prices.

TABLE 1—METROPOLITAN AREAS WITH THE LARGEST AND SMALLEST SHARE OF COLLEGE GRADUATES IN THE WORKFORCE

	College share in 2000	Change in college share 1980–2000	Monthly rent in 2000	Change in monthly rent 1980–2000
<i>Metropolitan areas with the largest college share in 2000</i>				
Stamford, CT	0.58	0.26	1,109	759
San Jose, CA	0.48	0.15	1,231	892
Washington, DC/MD/VA	0.48	0.08	834	532
Boston, MA-NH	0.45	0.17	854	556
San Francisco-Oakland-Vallejo, CA	0.44	0.12	1,045	724
Ann Arbor, MI	0.43	0.02	724	417
Columbia, MO	0.43	0.06	485	239
Raleigh-Durham, NC	0.42	0.12	669	427
Fort Collins-Loveland, CO	0.42	0.10	693	419
Trenton, NJ	0.41	0.14	776	494
<i>Metropolitan areas with the smallest college share in 2000</i>				
Ocala, FL	0.15	0.02	514	285
Williamsport, PA	0.15	0.04	434	229
Lima, OH	0.15	0.05	444	226
Hickory-Morgantown, NC	0.15	0.02	486	286
Johnstown, PA	0.14	0.01	370	165
Flint, MI	0.14	0.01	481	217
Vineland-Milville-Bridgetown, NJ	0.13	0.01	617	368
Mansfield, OH	0.13	0.01	460	242
Visalia-Tulare-Porterville, CA	0.13	0.00	495	270
Danville, VA	0.12	0.02	401	231

Notes: Share of college graduates is the share of full-time workers between 25 and 60 years old with a college degree or more who live in the relevant city. Monthly rent refers to the average rent paid for a two or three bedroom apartment.

is almost five times the fraction of college graduates in the city at the bottom of the distribution (Danville, VA), where only 12 percent of workers have a college degree. Other metropolitan areas in the top group include MSAs with an industrial mix that is heavy in high tech and R&D; such as San Jose, CA, San Francisco, CA, Boston, MA and Raleigh-Durham, NC; and MSAs with large universities, such as Ann Arbor, MI and Fort Collins, CO. Metropolitan areas in the top panel have a higher cost of housing, as measured by the average monthly rent for a two or three bedroom apartment, than metropolitan areas in the bottom panel. College share and the cost of housing vary substantially not only in their levels across locations, but also in their changes over time. While cities like Stamford, Boston, San Jose, and San Francisco experienced large increases in both the share of workers with a college degree and the monthly rent between 1980 and 2000, cities in the bottom panel experienced more limited increases. The relationship in the table is not limited to the top and bottom ten cities. Table 2 breaks out all MSAs by quintile of college share in 2000, and shows that the relationship between changes in college share, wages, and rental costs extends throughout the distribution.

The relation between changes in the number of college graduates and changes in housing costs is shown more systematically in Figure 1. The top panel shows how the 1980–2000 change in the share of college graduates relates to the 1980 share of college graduates. The size of the bubbles reflects population in 1980. The

TABLE 2—SHARE OF COLLEGE GRADUATES IN THE WORKFORCE, WAGES, AND MONTHLY RENT, BY QUINTILE

2000 college share quintile	College share in 2000	Change in college share 1980–2000	Monthly rent in 2000	Change in monthly rent 1980–2000
1	0.16	0.029	464	252
2	0.21	0.039	503	271
3	0.25	0.051	544	297
4	0.29	0.074	590	337
5	0.37	0.101	685	418

*Notes:* Share of college graduates is the share of full-time workers between 25 and 60 years old with a college degree or more who live in the relevant city. Monthly rent refers to the average rent paid for a two or three bedroom apartment.

positive relationship indicates that college graduates are increasingly concentrated in metropolitan areas that have a large share of college graduates in 1980. This relationship has been documented by Berry and Glaeser (2005) and Moretti (2004), among others.<sup>9</sup>

The middle panel of Figure 1 shows how the 1980–2000 change in the share of college graduates relates to the average cost of housing in 1980. The positive relationship indicates that college graduates are increasingly concentrated in MSAs where housing is initially expensive.<sup>10</sup> The bottom panel plots the 1980–2000 change in college share as a function of the 1980–2000 change in the average monthly rental price. The positive relationship suggests that the share of college graduates has increased in MSAs where housing has become more expensive.<sup>11</sup>

These relationships do not have a causal interpretation, but instead need to be interpreted as equilibrium relationships. Taken together, the panels in Figure 1 show that the metropolitan areas that have experienced the largest increases in the share of college graduates are the metropolitan areas where the average cost of housing in 1980 is highest and also the areas where the average cost of housing has increased the most.

### B. Local Consumer Price Indexes

A cost-of-living index seeks to measure changes over time in the amount that consumers need to spend to reach a certain utility level or “standard of living.” Changes in the official CPI between period  $t$  and  $t + 1$  as measured by the Bureau of Labor Statistics are a weighted average of changes in the price of the goods in a representative consumption basket. The basket is the original consumption basket at

<sup>9</sup> The regression of the 1980–2000 change in college share on the 1980 level in college share weighted by the 1980 MSA size yields a coefficient equal to 0.460 (0.032), indicating that a 10 percentage point difference in the baseline college share in 1980 is associated with a 4.6 percentage point increase in college share between 1980 and 2000.

<sup>10</sup> The regression of the 1980–2000 change in college share on the 1980 cost of housing weighted by the 1980 MSA size yields a coefficient equal to 0.0011 (0.00006), indicating that a \$100 difference in the baseline monthly rent in 1980 is associated with a 4.7 percentage point increase in college share between 1980 and 2000.

<sup>11</sup> The regression yields a coefficient equal to 0.0003 (0.00001).

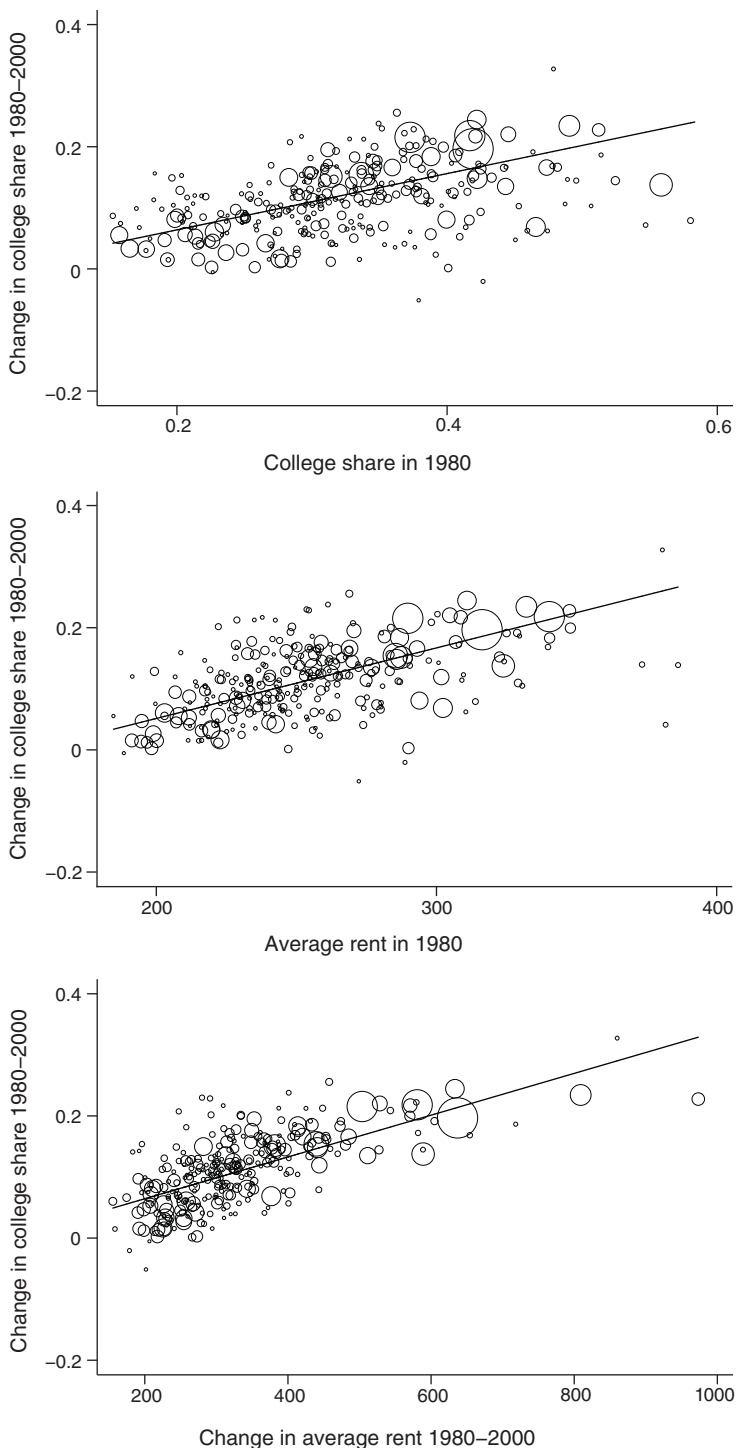


FIGURE 1. HOW CHANGES IN THE SHARE OF COLLEGE GRADUATES RELATE TO THE INITIAL SHARE OF COLLEGE GRADUATES, THE INITIAL COST OF HOUSING, AND CHANGES IN COST OF HOUSING

Notes: Each bubble is a metropolitan area. The size of the bubbles reflect population in 1980. Average rent is the average monthly rental price of a two or three bedroom apartment.



TABLE 3—RELATIVE IMPORTANCE OF THE MAIN AGGREGATE COMPONENTS  
IN THE BLS CONSUMER PRICE INDEX (CPI-U)

Housing	42.7%	
Shelter		32.8%
Fuel and utilities		5.3%
Other housing		4.6%
Transportation	17.2%	
Food and beverages	14.9%	
Medical care	6.2%	
Education and communication	6.0%	
Recreation	5.5%	
Apparel	3.7%	
Other goods and services	3.5%	

time  $t$ , and the weights reflect the share of income that the average consumer spends on each good at time  $t$ .<sup>12</sup>

Table 3 shows the relative importance of the main aggregate components of the CPI for all urban consumers, CPI-U, in 2000. The largest component by far is housing. In 2000, housing accounts for more than 42 percent of the CPI-U. The largest subcomponents of housing costs are shelter and fuel and utilities. The second and third main components of the CPI-U are transportation and food. They only account for 17.2 percent and 14.9 percent of the CPI-U, respectively. The weights of all the other categories are 6 percent or smaller.

Although most households in the United States are homeowners, changes in the price of housing are measured by the BLS, using changes in the cost of renting an apartment (Poole, Ptacek, and Verbrugge 2006; Bureau of Labor Statistics (BLS) 2007). The rationale for using rental costs instead of home prices is that rental costs are a better approximation of the user cost of housing. Since houses are an asset, their price reflects both the user cost as well as expectations of future appreciation.

Rental costs vary significantly across metropolitan areas. For example, in 2000, the average rental cost for a 2 or 3 bedroom apartment in San Diego, CA—the city at the ninetieth percentile of the distribution—was \$894. This rental cost is almost three times higher than the rental cost for an equally sized apartment in Decatur, AL, the city at the tenth percentile. Changes over time in rental costs also vary significantly across metropolitan areas. For example, between 1980 and 2000, the rental cost increased by \$165 in Johnstown, PA—one of the cities at the bottom of the distribution—and by \$892 in San Jose, CA—one of the cities at the top of the distribution.

Although the cost of living varies substantially across metropolitan areas, wage and income are typically deflated using a single, nationwide deflator, such as the CPI-U calculated by the BLS. The use of a nationwide deflator is particularly striking in light of the fact that more than 40 percent of the CPI-U is driven by housing costs (Table 3), and that housing costs vary so much across locations. To investigate

<sup>12</sup> One well-known problem with the CPI is the potential for substitution bias, which is the possibility that consumers respond to price changes by substituting relatively cheaper goods for goods that have become more expensive. While the actual consumption baskets may change, the CPI reports inflation for the original basket. Details of the BLS methodology are described in Chapter 17 of the *Handbook of Methods* (BLS 2007), titled “The Consumer Price Index.”

the role of cost-of-living differences on wage differences between skill groups, I propose two alternative CPI indexes that vary across metropolitan areas. I closely follow the methodology that the BLS uses to build the official CPI, but I generalize two of its assumptions.<sup>13</sup>

*Local CPI 1.*—First, I compute a CPI that allows for the fact that the cost of housing varies across metropolitan areas. I call the resulting local price index “Local CPI 1.” Following the BLS methodology, I define Local CPI 1 as the properly weighted sum of local cost of housing, with the average across cities normalized to 1 in 1980; and nonhousing consumption, normalized to 1 in 1980. I measure the cost of housing faced by an individual in metropolitan area  $c$  in two ways. In my preferred specification, I follow the BLS methodology, and I use rental costs. I assign the cost of housing to residents in a metropolitan area based on the relevant average monthly rent. Specifically, I take the average of the monthly cost of renting a two or three bedroom apartment among all renters in area  $c$ . As an alternative way to measure cost of housing, in some models, I use the price of owner-occupied houses instead of rental costs. Specifically, I take the average reported value of all two or three bedroom owner-occupied single family houses in area  $c$ . Both rental costs and housing prices are from the Census of Population. As I discuss later, empirical results are not sensitive to measuring housing costs using rental costs or housing prices. The price of nonhousing goods and services is assumed to be the same in a given year, irrespective of location. This assumption is relaxed in Local CPI 2.

I describe the details of this approach in the Appendix. It is important to note that this methodology ensures that the deflator that I use for a given worker does not reflect the increase in the cost of the apartment rented or the cost of the house owned by that specific worker. Instead, it reflects the increase in the cost of housing experienced by residents in the same city, irrespective of their own individual housing cost and irrespective of whether they rent or own.

*Local CPI 2.*—In local CPI 1, changes in the cost of housing can vary across localities, but changes in the cost of nonhousing goods and services are assumed to be the same everywhere. While the cost of housing is the most important component of the CPI, the price of other goods and services is likely to vary systematically with the cost of housing. In cities where land is more expensive, production and retail costs are higher, and, therefore, the cost of many goods and services is higher. For example, a slice of pizza or a haircut are likely to be more expensive in New York City than in Indianapolis, IN, since it is more expensive to operate a pizza restaurant or a barber shop in New York City than Indianapolis.

Local CPI 2 allows for both the cost of housing and the cost of nonhousing consumption to vary across metropolitan areas. Systematic, high quality, city-level data on the price of nonhousing good and services are not available for most cities over a long time period. To overcome this limitation, I use two alternative approaches. First, in my preferred specification, I use the fact that the BLS releases a local CPI

<sup>13</sup> Recently, there has been a considerable amount of work building regional price indexes. See for example Albouy (2011). Carrillo, Early, and Olsen (2010) have a recent review of different price indexes.

for a limited number of metropolitan areas. This local CPI is not ideal because it is made available by the BLS only for 23 MSAs in the period under consideration, and there are 315 MSAs in the 2000 census. Additionally, it is normalized to 1 in a given year, thus precluding cross-sectional comparisons. However, it can still be used to impute the part of local nonhousing prices that varies systematically with housing costs. The local CPI computed by the BLS for city  $c$  in year  $t$  is a weighted average of housing cost ( $HP_{ct}$ ) and nonhousing costs ( $NHP_{ct}$ ):  $BLS_{ct} = wHP_{ct} + (1 - w)NHP_{ct}$ , where  $w$  is the CPI weight used by BLS for housing. Nonhousing costs can be divided in two components:

$$(1) \quad NHP_{ct} = \pi HP_{ct} + v_{ct},$$

where  $\pi HP_{ct}$  is the component of nonhousing costs that varies systematically with housing costs; and  $v_{ct}$  is the component that is orthogonal to housing costs. If  $\pi > 0$ , it means that cities with higher cost of housing also have higher costs of nonhousing goods and services. I use the small sample of MSAs for which a local BLS CPI is available to estimate  $\pi$ .<sup>14</sup> I then impute the systematic component of nonhousing costs to all MSAs, based on their housing cost:  $E(NHP_{ct}|HP_{ct}) = \hat{\pi}HP_{ct}$ . Finally, I compute Local CPI 2 as a properly weighted sum of the cost of housing, the component of nonhousing costs that varies with housing ( $\hat{\pi}HP_{ct}$ ), and the component of nonhousing costs that does not vary with housing. See the Appendix for more details.

As an alternative strategy to measure local variation in nonhousing prices, I use data on nonhousing prices taken from the Accra dataset, which is collected by the Council for Community and Economic Research.<sup>15</sup> The Accra data have both advantages and disadvantages. On one hand, the Accra data are available for most cities, and therefore do not require any imputation. Furthermore, the detail is such that price information is available at the level of specific consumption goods and the price is not normalized to a base year. On the other hand, the Accra data are available only for a very limited number of goods.<sup>16</sup> Importantly, the sample size for each good and city is quite small, so that local price averages are noisy. Additionally, the set of cities covered changes over time. In practice, the empirical findings based on the version of local CPI 2 that uses the imputation and those based on the version of local CPI 2 that uses Accra data are similar.

In sum, local CPI 2 is more comprehensive than Local CPI 1 because it includes local variation in both housing and nonhousing costs, but it has the limitation that nonhousing costs are imputed or come from Accra data. For this reason, in the next section, I present separate estimates for Local CPI 1 and Local CPI 2.

<sup>14</sup> To do so, I first regress changes in the BLS local index on changes in housing costs:  $\Delta BLS_{ct} = \beta \Delta HP_{ct} + e_{ct}$ . Estimating this regression in differences is necessary because  $BLS_{ct}$  is normalized to 1 in a given year. While cross-sectional comparisons based on  $BLS_{ct}$  are meaningless,  $BLS_{ct}$  does measure changes in prices within a city. Once I have an estimate of  $\beta$ , I can calculate  $\hat{\pi} = \frac{\hat{\beta} - w}{1 - w}$ . Empirically,  $\hat{\beta}$  is equal to 0.588 (0.001), and  $\hat{\pi}$  is equal to 0.35 in 2000.

<sup>15</sup> The data were generously provided by Emek Basker. Basker (2005) and Basker and Noel (2007) describe the Accra dataset in detail.

<sup>16</sup> Only 48 goods have prices that are consistently defined for the entire period under consideration. The BLS basket includes more than 1,000 goods.

TABLE 4—CHANGES IN THE COST OF LIVING, BY EDUCATION GROUP

	1980 (1)	1990 (2)	2000 (3)	Percent increase 1980–2000 (4)
<i>Official CPI</i>				
High school	1	1.53	2.02	102
College	1	1.53	2.02	102
Percent difference	0	0	0	
<i>Monthly rent</i>				
High school	247	432	563	127
College	259	491	642	147
Percent difference	4	11	14	
<i>Local CPI 1</i>				
High school	0.99	1.49	1.95	96
College	1.01	1.58	2.07	105
Percent difference	2	4	6	
<i>Local CPI 2</i>				
High school	0.98	1.57	2.04	108
College	1.01	1.71	2.22	119
Percent difference	3	7	9	

Notes: Local CPI 1 allows for local variation only in the cost of housing. Local CPI 2 allows for local variation both in the cost of housing and the cost of nonhousing goods and services.

### *C. Changes in the Cost of Living Experienced by Skilled and Unskilled Workers between 1980 and 2000*

I now quantify the changes in the cost of living experienced by high school and college graduates between 1980 and 2000. The top panel of Table 4 shows changes in the official CPI-U, as reported by the BLS, and normalized to 1 in 1980. This is the most widely used measure of inflation, and it is the measure that is almost universally used to deflate wages and incomes. According to this index, the price level doubled between 1980 and 2000. This increase is, by construction, the same for college graduates and high school graduates.

The next panel shows the increase in the cost of housing faced by college graduates and high school graduates. College graduates and high school graduates are exposed to very different increases in the cost of housing. In 1980 the cost of housing for the average college graduate is only 4 percent more than the cost of housing for the average high school graduate. This gap grows to 11 percent in 1990 and reaches 14 percent by 2000. Column 4 indicates that housing costs for high school and college graduates increased between 1980 and 2000 by 127 percent and 147 percent, respectively.

The third panel shows Local CPI 1 normalized to 1 in 1980 for the average household.<sup>17</sup> The panel shows that in 1980 the overall cost of living experienced by college graduates is only 2 percent higher than the cost of living experienced by high school

<sup>17</sup> Here I use rental costs to measure housing costs. Using property values for owner-occupied houses yields similar results.

graduates. This difference increases to 6 percent by the year 2000. The difference in Local CPI 1 between high school and college graduates is less pronounced than the difference in monthly rent because Local CPI 1 includes nonhousing costs as well as housing costs.

The differential increase in cost of living faced by college graduates relative to high school graduates is more pronounced when the price of nonhousing goods and services is allowed to vary across locations, as in the bottom panel. In the case of Local CPI 2, the cost of living is 3 percent higher for college graduates relative to high school graduates in 1980 and 9 percent in 2000. Column 4 indicates that the increase in the overall price level experienced by high school graduates between 1980 and 2000 is 108 percent. The increase in the overall price level experienced by college graduates between 1980 and 2000 is 119 percent.

The relative increase in the cost of housing experienced by college graduates between 1980 and 2000 can be decomposed into two parts: the first part is due to geographical mobility; the second part is due to the fact that already in 1980 college graduates are overrepresented in cities that experience large increases in costs. Specifically, the 1980–2000 nationwide change in the cost of housing experienced by skill group  $j$  ( $j = \text{high school or college}$ ), can be written as

$$(2) \quad P_{j2000} - P_{j1980} = \sum_c \omega_{jc2000} P_{c2000} - \sum_c \omega_{jc1980} P_{c1980} \\ \sum_c (\omega_{jc2000} - \omega_{jc1980}) P_{c2000} + \sum_c \omega_{jc1980} (P_{c2000} - P_{c1980}),$$

where  $\omega_{jct}$  is the share of workers in skill group  $j$  who live in city  $c$  in year  $t$ , and  $P_{ct}$  is the cost of housing in city  $c$  in year  $t$ . The equation illustrates that the total change in cost of housing is the sum of two components: partly due to the change in the share of workers in each city, given 2000 prices ( $\sum_c (\omega_{jc2000} - \omega_{jc1980}) P_{c2000}$ ); and partly due to the differential change in the cost of housing across cities, given the 1980 geographical distribution ( $\sum_c \omega_{jc1980} (P_{c2000} - P_{c1980})$ ). The change in the cost of housing of college graduates *relative* to high school graduates is therefore the difference of these two components for college graduates and high school graduates.

Empirically, I find that both factors are important. About 43 percent of the total increase in cost of housing of college graduates relative to high school graduates is due to the first component (geographical mobility of college graduates toward expensive cities), and 57 percent is due to the second component (larger cost increase in cities that have many college graduates in 1980).

## II. Nominal and Real Wage Differences

In this section, I estimate how much of the increase in nominal wage differences between college graduates and high school graduates is accounted for by differences in the cost of living. In particular, in Section IA, I show estimates of the college premium in nominal and real terms. In Section IB, I discuss whether my estimates are biased by the presence of unobserved worker characteristics or unobserved housing characteristics. In Section IC, I show estimates of the college premium in real terms

TABLE 5—NOMINAL AND REAL CONDITIONAL WAGE DIFFERENCE BETWEEN WORKERS WITH A HIGH SCHOOL DEGREE AND WORKERS WITH COLLEGE OR MORE, BY YEAR—BASELINE ESTIMATES

	1980	1990	2000	1980–2000 increase	1980	1990	2000	1980–2000 increase
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
<i>Model 1</i>								
Nominal wage difference	0.40 (0.011)	0.53 (0.012)	0.60 (0.013)	0.20	0.35 (0.007)	0.47 (0.006)	0.53 (0.007)	0.18
<i>Model 2</i>								
Real Wage Difference — Local CPI 1	0.38 (0.010)	0.48 (0.008)	0.53 (0.008)	0.15	0.37 (0.008)	0.46 (0.006)	0.52 (0.007)	0.15
Percent of nominal increase accounted for by cost of living				25%				17%
<i>Model 3</i>								
Real Wage Difference — Local CPI 2	0.37 (0.009)	0.45 (0.008)	0.51 (0.008)	0.14	0.37 (0.008)	0.46 (0.006)	0.51 (0.007)	0.14
Percent of nominal increase accounted for by cost of living				30%				22%
MSA Fixed Effects	No	No	No		Yes	Yes	Yes	

*Notes:* Standard errors clustered by metropolitan area in parentheses. The dependent variable in Model 1 is the log of nominal hourly wage. The dependent variable in Model 2 is the log of real hourly wage, where real hourly wage is the ratio of nominal wage and Local CPI 1. The dependent variable in Model 3 is the log of real hourly wage, where real hourly wage is the ratio of nominal wage and Local CPI 2. All models include dummies for gender and race, a cubic in potential experience, and year effects. Models in columns 5–8 also include MSA fixed effects. Sample size is 5,024,221.

based on an alternative local CPI that varies not just by metropolitan area, but also by skill level within a metropolitan area.

### A. Main Estimates

Model 1 in the top panel of Table 5 estimates the conditional *nominal* wage difference between workers with a high school degree and workers with a college education or more, by year. Estimates in columns 1–4 are from a regression of the log nominal hourly wage on an indicator for college interacted with an indicator for year 1980, an indicator for college interacted with an indicator for year 1990, an indicator for college interacted with an indicator for year 2000, year dummies, a cubic in potential experience, and dummies for gender and race. Estimates in columns 5–8 are from models that also include MSA fixed effects. Entries are the coefficients on the interactions of college and year, and represent the conditional wage difference for the relevant year. The sample includes all US born wage and salary workers aged 25–60 who have worked at least 48 weeks in the previous year.<sup>18</sup>

<sup>18</sup> The sample includes both men and women. This may be a concern, since in a recent paper by Black et al. (2010) shows that female labor force participation is different in different cities. At the end of this section, I discuss a number of alternative specifications, including one when I estimate the college premium for men and women separately. Estimates by gender are similar to those obtained from the pooled sample.

My estimates in columns 1–4 indicate that the conditional nominal wage difference between workers with a high school degree and workers with college or more has increased significantly. The difference is 40 percent in 1980 and rises to 60 percent by 2000. Column 4 indicates that this increase amounts to 20 percentage points. This estimate is generally consistent with the previous literature (see, for example, table 3 in Katz and Autor 1999).

Models 2 and 3 in Table 5 show the conditional *real* wage differences between workers with a high school degree and workers with college or more. To quantify this difference, I estimate models that are similar to Model 1, where the dependent variable is the nominal wage divided by Local CPI 1 (in Model 2) or by Local CPI 2 (in Model 3). Two features are noteworthy. First, the level of the conditional college premium is lower in real terms than in nominal terms in each year. For example, in 2000, the conditional difference between the wage for college graduates and high school graduates is 0.60 in nominal terms and only 0.53 in real terms when Local CPI 1 is used as a deflator. The difference is smaller, 0.51 percentage points, when Local CPI 2 is used as a deflator. Second, the increase between 1980 and 2000 in college premium is significantly smaller in real terms than in nominal terms. For example, using Local CPI 1, the 1980–2000 increase in the conditional real wage difference between college graduates and high school graduates is 15 percentage points. In other words, cost-of-living differences as measured by Local CPI 1 account for 25 percent of the increase in conditional inequality between college and high school graduates between 1980 and 2000 (column 4).

The effect of cost-of-living differences is even more pronounced when the cost of living is measured by Local CPI 2. In this case, the increase in the conditional real wage difference between college graduates and high school graduates is 14 percentage points. This implies that cost-of-living differences as measured by Local CPI 2 account for 30 percent of the increase in conditional wage inequality between college and high school graduates between 1980 and 2000 (column 4).

When I control for fixed effects for metropolitan areas in columns 5–8, the nominal college premium is slightly smaller, but the real college premium is generally similar. The increase in the college premium is 18 percentage points when measured in nominal terms, and 14–15 percentage points when measured in real terms, depending on whether CPI 1 or CPI 2 is used as a deflator. After conditioning on MSA fixed effects, cost-of-living differences account for 22 percent of the increase in conditional inequality between college and high school graduates between 1980 and 2000 when CPI 2 is used as a deflator (column 8).

### B. Alternative Models

In Table 6, I show estimates by age group. In particular, I split the sample in three groups: young (25–35), middle age (36–50), and old (51–65). Estimates indicate that nominal wage inequality has increased more for younger workers. But the share accounted for by local cost of living grows with the age of the workers. Specifically, it is 24 percent for the young group, 31 percent for the middle age group, and 45 percent for the old group.

TABLE 6—MODELS BY AGE

	1980	1990	2000	1980–2000 increase	Percent of nominal increase accounted for by cost of living
<i>Age 25–35</i>					
Nominal wage difference	0.36 (0.010)	0.56 (0.012)	0.60 (0.012)	0.24	
Real Wage — Local CPI 2	0.33 (0.010)	0.47 (0.009)	0.51 (0.008)	0.18	24
<i>Age 36–50</i>					
Nominal wage difference	0.43 (0.011)	0.52 (0.011)	0.60 (0.013)	0.17	
Real Wage — Local CPI 2	0.40 (0.009)	0.44 (0.0108)	0.52 (0.008)	0.12	31
<i>Age 51–65</i>					
Nominal wage difference	0.39 (0.011)	0.50 (0.011)	0.53 (0.013)	0.14	
Real Wage — Local CPI 2	0.37 (0.010)	0.42 (0.009)	0.44 (0.009)	0.07	45

*Notes:* Standard errors clustered by metropolitan area in parentheses. Models estimated correspond to the specifications in columns 1–4 of Table 5. See text for details.

In Table 7, I investigate how sensitive my estimates are to alternative measures of housing costs. In model 1, I show estimates where I deflate nominal wages based on local CPIs that measure housing costs using the average price of owner-occupied houses instead of average rental costs. In particular, as discussed above, I measure local housing prices by taking the average reported property value of all two or three bedroom single family owner-occupied houses in the relevant MSA. In the next panel, I show what happens when I deflate nominal wages based on local CPIs that measure housing costs using average rental costs of all units, instead of including only two or three bedroom units. This is because it is possible that the type of people who live in a two or three bedroom apartment may not be representative.<sup>19</sup> In model 3, I compute Local CPI 2 using the Accra dataset previously described to measure local variation in nonhousing prices. In model 4, I compute the Local CPIs allowing for the expenditure share of housing and nonhousing goods to vary by metropolitan areas and skill level. (See the Appendix for more details). In model 5, I consider the possibility that commuting distance may vary differentially for high school and college graduates. For example, it is possible that increases in the number of college graduates in some cities lead high school graduates to live farther away from job locations. To account for possible differential changes in commuting times, I reestimate the baseline model where the dependent variable is wage per hour worked or spent commuting. In the baseline estimates, I calculate hourly wage by taking the ratio of weekly or monthly earnings over the sum of number of hours worked. By contrast, here I calculate hourly wage by taking the ratio of weekly or

<sup>19</sup> For example, one may be concerned that in cities with high college share my sample includes many college students, and that their housing is inherently different. However, in practice, it is unlikely that my sample includes many college students, since I only include individuals who are 25 and older and who work for most of the year.



TABLE 7—ADDITIONAL SPECIFICATIONS: PART I

	1980	1990	2000	1980–2000 increase	Percent of nominal increase accounted for by cost of living
<i>Model 1: CPI uses housing prices instead of rental costs</i>					
Nominal wage difference	0.40 (0.015)	0.53 (0.009)	0.60 (0.010)	0.20	
Real Wage — Local CPI 2	0.35 (0.010)	0.42 (0.011)	0.50 (0.009)	0.15	25
<i>Model 2: CPI uses all units, not only 2–3 bedrooms</i>					
Nominal wage difference	0.40 (0.015)	0.54 (0.009)	0.60 (0.010)	0.20	
Real Wage — Local CPI 2	0.37 (0.010)	0.45 (0.011)	0.51 (0.009)	0.14	29
<i>Model 3: ACCRA nonhousing prices</i>					
Nominal wage difference	0.40 (0.015)	0.53 (0.009)	0.60 (0.010)	0.20	
Real Wage — Local CPI 2 (ACCRA data)	0.39 (0.012)	0.48 (0.006)	0.54 (0.006)	0.15	25
<i>Model 4: Expenditure shares vary by MSA and skill group</i>					
Nominal wage difference	0.40 (0.015)	0.53 (0.009)	0.60 (0.010)	0.20	
Real Wage — Local CPI 2	0.37 (0.010)	0.46 (0.008)	0.51 (0.008)	0.14	29
<i>Model 5: Account for commuting time</i>					
Nominal wage difference	0.40 (0.010)	0.54 (0.009)	0.60 (0.011)	0.20	
Real Wage — Local CPI 2	0.37 (0.008)	0.45 (0.007)	0.51 (0.007)	0.14	30

*Notes:* Standard errors clustered by metropolitan area in parentheses. In Model 1, I report estimates where I deflate nominal wages based on local CPI's that measure housing costs using the average price of two or three bedroom owner-occupied houses instead of average rental costs. In Model 2, I report estimates where I deflate nominal wages based on local CPI's that measure housing costs using the rental costs of all units, not just those with two or three bedrooms. In Model 3, I compute Local CPI 2 using the ACCRA dataset to measure local variation in nonhousing prices. In Model 4, I compute the Local CPI's allowing for the expenditure share of housing and nonhousing goods to vary by metropolitan areas and skill level. In Model 5, the dependent variable is hourly wage defined as the ratio of weekly or monthly earnings over the sum of number of hours worked *plus time spent commuting*. Models estimated correspond to the specifications in columns 1–4 of Table 5. See text for details.

monthly earnings over the sum of number of hours worked *plus time spent commuting*. In general, estimates in Table 7 are consistent with the baseline estimates in Table 5.

In Table 8, I present the results from several alternative specifications designed to assess how sensitive my estimates are to the choice of the estimation sample. In the top panel of Table 8, I show estimates that do not select based on the number of weeks worked in the previous year. In the next panel, I show what happens when workers with fewer than 25 hours a week are dropped (since hourly wages for part-time workers is known to have considerable measurement error in the 1980 census). In model 3, I include workers born outside the United States. In model 4, I drop rural workers (i.e., those who are not assigned an MSA). In model 5, I only

TABLE 8—ADDITIONAL SPECIFICATIONS: PART II

	1980	1990	2000	1980–2000	Percent accounted for by cost of living
<i>Model 1: Include workers with less than 48 weeks</i>					
Nominal wage difference	0.43 (0.009)	0.57 (0.010)	0.62 (0.012)	0.19	
Real Wage — Local CPI 1	0.42 (0.008)	0.52 (0.007)	0.56 (0.008)	0.14	26
Real Wage — Local CPI 2	0.41 (0.007)	0.49 (0.007)	0.53 (0.007)	0.12	37
<i>Model 2: Drop part-time workers</i>					
Nominal wage difference	0.40 (0.011)	0.53 (0.011)	0.60 (0.013)	0.20	
Real Wage — Local CPI 2	0.37 (0.010)	0.45 (0.008)	0.51 (0.008)	0.14	28
<i>Model 3: Include Immigrants</i>					
Nominal wage difference	0.40 (0.011)	0.54 (0.012)	0.61 (0.013)	0.21	
Real Wage — Local CPI 2	0.38 (0.010)	0.46 (0.010)	0.52 (0.010)	0.14	33
<i>Model 4: Only urban workers</i>					
Nominal wage difference	0.40 (0.011)	0.52 (0.008)	0.60 (0.010)	0.20	
Real Wage — Local CPI 2	0.38 (0.010)	0.47 (0.007)	0.53 (0.007)	0.15	25
<i>Model 5: Only men</i>					
Nominal wage difference	0.37 (0.010)	0.52 (0.011)	0.59 (0.013)	0.22	
Real Wage — Local CPI 2	0.34 (0.010)	0.43 (0.007)	0.50 (0.007)	0.16	28
<i>Model 6: Drop New York, Boston, San Francisco</i>					
Nominal wage difference	0.39 (0.009)	0.52 (0.010)	0.58 (0.011)	0.19	
Real Wage — Local CPI 2	0.36 (0.010)	0.45 (0.007)	0.50 (0.007)	0.14	27

*Notes:* Standard errors clustered by metropolitan area in parentheses. In Model 1, I include workers with fewer than 48 weeks. In Model 2, I drop workers who work less than 35 hours per week. In Model 3, I show estimates that include workers born outside the United States. In Model 4, I drop workers outside an MSA. In Model 5, I only include men. In Model 6, I drop New York, Boston, and San Francisco. Models estimated correspond to the specifications in columns 1–4 of Table 5.

include male workers. In model 6, I investigate what happens when I drop three large superstar cities (New York, San Francisco, and Boston) from the sample. In general, estimates in this table are not very different from the baseline estimates in Table 5. The inclusion of workers with less than 48 weeks of work results in a slightly larger percent of the nominal increase in inequality being accounted for by differences in cost of living.

I also have performed additional robustness checks that are not reported in the table due to space limitations and that are generally consistent with the estimates reported in the table. For example, when I allow for the effect of experience, race,

and gender to vary over time by controlling for the interaction of year with gender, race, and a cubic in experience, results are similar to Table 5. Estimates where the dependent variable is the log of weekly or yearly earnings are also generally consistent with Table 5. Finally, my estimates are not very sensitive to the exclusion of outliers (defined as the top 1 percent and the bottom 1 percent of each year's wage distribution).

The college premium is not the only measure of inequality. In Table A1 in the online Appendix, I examine what happens to alternative measures of inequality when I deflate wages using Local CPI 2. I follow Lemieux (2008), and present changes in the overall unconditional variance, the unconditional within component, the unconditional between component; overall conditional variance, the conditional within component, the conditional between component; and the changes in the conditional 90–50 and 50–10 gaps. The nominal estimates are not identical to the ones in Lemieux (2008), probably because he uses CPS data, but they are generally consistent. For example, total variance has increased, with the within component experiencing a larger increase than the between component. The 50–10 and 90–50 gaps have also increased. I find little evidence that deflating for cost of living reduces either cross-sectional inequality or changes in inequality. I conclude that the main effect of using a local deflator is on the college premium.

### *C. Heterogeneity in Worker Ability and Housing Quality*

One might be concerned about unobserved differences in worker ability. Ability of college graduates and high school graduates is likely to vary across metropolitan areas (Combes, Duranton, and Gobillon 2008). My estimates of the change in college premium in real terms are biased on if the change over time in the average ability of college graduates relative to high school graduates in a given city is systematically related to changes over time in cost of living in that city. The direction of the bias is a priori not obvious. If the average unobserved ability of college graduates relative to high school graduates grows more (less) in expensive cities compared to less expensive cities, then the estimates of the real college premia in Table 5 are biased downward (upward).

In Figure A1 in the online Appendix, I provide some evidence on the relationship between one measure of worker ability and housing costs. Specifically, I use NLSY data to relate the difference in average AFQT scores between college graduates and high school graduates across metropolitan areas to the cost of housing across metropolitan areas.<sup>20</sup> Not surprisingly, in most metropolitan areas college graduates have significantly higher average AFQT scores than high school graduates. However, the figure indicates that both in a cross section of cities, as well as in changes over time for the same city, differences in ability between skill groups are generally orthogonal to housing costs. This finding is consistent with the evidence in Glaeser and Mare (2001). Unfortunately, data limitation preclude definitive conclusions, because the

<sup>20</sup> My data contain AFQT score percentiles in 1980 and 1989. I merge these data with census data on housing costs for 1980 and 1990. Like in Section IIA, housing costs are measured using the average cost of renting a two or three bedroom apartment in the relevant MSA.

NLSY only focuses on a fairly narrow cohort. So, one would need a lot of movement across people to generate any substantial change in the AFQT gap between 1980 and 1990 at the city level. For this reason, this evidence should be interpreted as purely suggestive.

A second concern is the possibility that the changes in housing costs faced by skilled and unskilled workers reflect not just changes in cost of living, but also differential changes in the quality of housing. This could bias my estimates of the relative increase in the cost of living experienced by different skill groups, although the direction of the bias is not a priori obvious. On the one hand, the relative increase in the cost of housing experienced by college graduates may be overestimated if apartments in cities with many college graduates are subject to more quality improvements between 1980 and 2000 than apartments in cities with many high school graduates. In this case, part of the additional increase in the rental cost in cities with many college graduates relative to cities with many high school graduates reflects differential quality improvements. Take, for example, features like the presence of a fireplace, or quality of the kitchen and bathrooms. If these features have improved more in cities with many college graduates, I may be overestimating the relative increase in cost of living experienced by college graduates.

On the other hand, the relative increase in the cost of housing faced by college graduates may be underestimated if apartments in cities with many high school graduates experience more quality or size improvements. Take, for example, features like the size of an apartment,<sup>21</sup> or the availability of a garden, a garage, or a porch. The average apartment in New York or San Francisco is likely to be smaller than the average apartment in Houston or Indianapolis and it is also less likely to have a garden, a garage, or a porch. Moreover, these features are less likely to have increased between 1980 and 2000 in New York or San Francisco than in Houston or Indianapolis. Since the share of college graduates has increased more in denser and more expensive cities, the true change in quality-adjusted per-square-foot price faced by college graduates can, in principle, be larger than the one that I measure.

While I cannot completely rule out the possibility of unmeasured quality differences, I present evidence based on a rich set of observable quality differences. I use data from the American Housing Survey, which includes richer information on housing quality than the Census of Population. Available quality variables include exact square footage, number of rooms, number of bathrooms, indicators for the presence of a garage, a usable fireplace, a porch, a washer, a dryer, a dishwasher, outside water leaks, inside water leaks, open cracks in walls, open cracks in ceilings, broken windows, presence of rodents, and a broken toilet in the last three months.<sup>22</sup>

I begin by reproducing the baseline estimates that do not control for quality. Nominal estimates based on the American Housing Survey in the top panel of Table 9 are generally similar to the corresponding baseline estimates based on the

<sup>21</sup> Although my measure of housing cost is the average rent for apartments with a fixed number of bedrooms, exact square footage may vary.

<sup>22</sup> Each year, the American Housing Survey has a sample size that is significantly smaller than the sample size in the census. To increase precision, instead of taking only 1980, 1990, and 2000, I group years 1978–1984, 1988–1992, and 1998–2002 together.

TABLE 9—NOMINAL AND REAL CONDITIONAL EARNINGS DIFFERENCE CONTROLLING FOR QUALITY OF HOUSING, BY YEAR: AMERICAN HOUSING SURVEY

	1980 (1)	1990 (2)	2000 (3)	1980–2000 increase (4)	Percent of nominal increase accounted for by cost of living (5)
<i>Nominal earnings difference</i>	0.37 (0.019)	0.47 (0.008)	0.56 (0.010)	0.19	
<i>Real earnings difference—not controlling for quality</i>					
Real Earnings—Local CPI 1	0.36 (0.010)	0.45 (0.006)	0.52 (0.010)	0.16	15
Real Earnings—Local CPI 2	0.35 (0.013)	0.44 (0.006)	0.51 (0.010)	0.16	15
<i>Real earnings difference—controlling for quality</i>					
Real Earnings—Local CPI 1	0.35 (0.012)	0.43 (0.007)	0.50 (0.012)	0.15	21
Real Earnings—Local CPI 2	0.34 (0.014)	0.42 (0.009)	0.49 (0.014)	0.15	21

*Notes:* Standard errors clustered by metropolitan area in parentheses. Data are from the American Housing Survey. Available housing quality variables include square footage, number of rooms, number of bathrooms, indicators for the presence of a garage, a usable fireplace, a porch, a washer, a dryer, a dishwasher, outside water leaks, inside water leaks, open cracks in walls, open cracks in ceilings, broken windows, rodents, and a broken toilet in the last three months. The dependent variable is log of yearly earnings (top row) or log of yearly earnings divided by the relevant CPI (middle and bottom panel).

census reported in Table 5.<sup>23</sup> These estimates indicate that the nominal college premium increases by 19 percentage points between 1980 and 2000. In the middle panel, I estimate the real college premium, without controlling for housing quality. Finally, in the bottom panel, I reestimate the same model holding constant all available measures of housing quality. As before, I measure housing cost using the rental price for renters. But, unlike before, I first regress housing costs on the vector of observable housing characteristics. The residual from this regression represents the component of the cost of housing that is orthogonal to my measures of dwelling quality. The bottom panel of Table 9 shows how the baseline estimates change when I use the properly renormalized residual as a measure of housing cost in my local CPI 1 and CPI 2. The comparison of the middle and the bottom panels suggests that the 1980–2000 increase in real college premium estimated controlling for quality is *smaller* than the corresponding increase in the real college premium estimated without controlling for quality. Specifically, column 4 indicates that the increase in real college premium estimated controlling for quality is 15 percentage points. The corresponding estimate that does not control for quality is 16 percentage points.

In sum, though I can not completely rule out the possibility of unmeasured quality differences, Table 9 indicates that controlling for a rich vector of observable

<sup>23</sup> Unlike Table 5, the dependent variable here is log of yearly earnings. In the American Housing Survey there is less information on number of hours worked than in the census. Since college graduates work longer hours, the estimated nominal college premium is slightly smaller than in Table 5.

quality differences results in differences between nominal and real college premium that are slightly larger than the baseline differences. This result is consistent with estimates in Malpezzi, Chun, and Green (1998).

#### D. *An Alternative Measure of Local Cost of Living*

My estimates in Section IIA are based on a definition of cost of living where the housing component of cost of living varies only by metropolitan area. In online Appendix Table A2, I show how my estimates change when an alternative definition of cost of living is adopted. In particular, I allow for the cost of housing experienced by different individuals to vary depending not just on their city of residence, but also on their education level, family structure, and race. The idea is that, within a city, not all households necessarily use the same type of housing. In New York, for example, the majority of residents in Manhattan have a college degree or more, while the majority of new residents in Staten Island or the Bronx have a high school degree or less.

Allowing for the cost of housing faced by different demographic groups in a given city to be different may matter if tastes and budget constraints differ across groups, so that the type of housing that is used by some demographic groups in a city is not identical to the one that is used by other groups. In this case, the group-specific rental cost is measured as the predicted value from a regression of rental cost on identifiers for metropolitan area, education group, number of children, race, and interactions, where the regression is estimated on the sample of renters of two or three bedroom apartments, and the predicted values are calculated for all households. Local CPI 3 only uses local variation in cost of living that arises from variation in predicted cost of housing. Local CPI 4 uses local variation both in predicted cost of housing and cost of nonhousing goods and services. Estimates in online Appendix Table A2 indicate that, relative to Table 5, a larger share of the increase in nominal wage differences appears to be accounted for by cost-of-living differences.<sup>24</sup>

### III. A Simple Framework

If the price of housing *fully* capitalizes all productivity and amenity shocks, and workers have no idiosyncratic preferences for location, then the utility of all workers is always the same irrespective of location. But this is not necessarily the case in the more realistic settings, where housing is elastically supplied and workers have idiosyncratic preferences for location, and therefore the utility of inframarginal workers can be significantly affected by productivity and amenity shocks. It is important to think under what conditions changes in real wages can be linked to changes in worker utility or well-being.

<sup>24</sup> An obvious concern is the possibility of differential changes in the unmeasured quality of housing for college graduates and high school graduates within a city. I have repeated the analysis of Table 9 and found results that are generally similar. Another concern is heterogeneity in neighborhood quality. If the unobservables are fixed over time, this is not an issue. If the unobservables change over time endogenously (for example because more skilled workers result in better amenities), then my estimates would be biased.

In the previous section, I have shown that over the 1980–2000 period, real wage inequality has grown less than nominal wage inequality. Does this mean that the large increases in nominal inequality have not translated into large increases in utility inequality? Not necessarily. In this section, I use the results of a simple general equilibrium model to investigate the implications of my empirical findings for changes in utility disparities. The implications are different depending on the reasons for the increase in the share of college graduates in expensive cities. I consider two alternative explanations for such an increase.

First, it is possible that skilled workers move to expensive cities because the *relative demand* of skilled labor increases in expensive cities, as firms located in these cities increasingly seek to hire skilled labor.

Different economic forces may be responsible for a localized increase in the relative demand of skilled workers. I model such an increase as a localized skill-biased technical change. This story is similar to the standard story proposed in the skill-biased technical change literature, but here the shock is localized, rather than nationwide, as relative productivity shocks occur in some cities but not in other cities. The dot-com boom experienced by the San Francisco Bay Area in the second half of the 1990s is arguably an example of a localized skill-biased shock. Driven by the advent of the Internet and the agglomeration of high-tech firms in the area, the demand for skilled workers increased significantly (relative to the demand for unskilled workers). More generally, Beaudry, Doms, and Lewis (2008) argue that over the past 30 years, technological change resulted in increases in the productivity of skilled workers in cities that already had many skilled workers. These cities also happen to be cities with a higher than average initial share of college graduates and cost of housing.<sup>25</sup>

Another possible explanation for the increase in the relative demand for skilled workers is a positive shock to the product demand faced by industries that employ relatively more skilled workers and are agglomerated in expensive cities. For example, the demand for financial services has increased significantly between 1980 and 2000. Since finance tends to employ skilled workers, this has caused an increase in the demand for skilled workers in cities like New York, Boston, and San Francisco, where financial firms are concentrated. A third possible explanation is a localized change to the stock of physical capital, coupled with capital-skill complementarity.

Alternatively, it is possible that skilled workers move to expensive cities because the *relative supply* of skilled labor increases in expensive cities, as skilled workers are increasingly attracted by amenities located in those cities. For simplicity, I will model this scenario as a localized increase in amenities that are relatively more important for skilled workers. Glaeser and Tobio (2007) have a model that is based on a similar idea. Alternatively, one could assume that amenities are fixed, but the taste for those amenities increase; or both amenities and tastes are fixed, but amenities are a normal good, so that college graduates consume more of them than high school graduates (Gyourko, Mayer, and Sinai 2006).

<sup>25</sup> See also Berry and Glaeser (2005).

I consider a simple general equilibrium model of the labor and housing market that generalizes Roback (1982). Like in Roback, workers and firms are mobile and choose the location that maximizes utility or profits. But unlike Roback, the elasticity of local labor supply is not infinite, so that productivity and amenity shocks are not always fully capitalized into land prices. This allows shocks to the relative demand and relative supply of skilled workers to have different effects on the utility of skilled and unskilled workers.

The model is similar to the one discussed in Moretti (2011). In this section, I outline the basic assumptions and describe, informally, the key results. I refer to online Appendix A for the equations and all the details. I assume that each city is a competitive economy that produces a single output good that is traded on the international market at a fixed price. The indirect utility of workers in skill group  $s$  in city  $c$  is assumed to be

$$(3) \quad U_{sic} = w_{sc} - r_c + A_{sc} + e_{sic},$$

where  $w_{sc}$  is the nominal wage;  $r_c$  is the cost of housing; and  $A_{sc}$  is a measure of local amenities. Skilled and unskilled workers in a city compete for housing in the same housing market and therefore face the same price of housing. This allows a shock to one group to be transmitted to the other group through its effect on housing prices. While they have access to the same local amenities, different skill groups do not need to value these amenities equally, as  $A_{sc}$  has an index for skill group. The random term  $e_{sic}$  represents worker  $i$ 's idiosyncratic preferences for location  $c$ . A larger  $e_{sic}$  means that worker  $i$  is particularly attached to city  $c$ , holding constant real wage and amenities. (For example, being born in city  $c$  or having family in city  $c$  may make city  $c$  more attractive to a worker.)

I assume that there are two cities: Detroit and San Francisco. In equilibrium, the marginal worker needs to be indifferent between living in Detroit and San Francisco. This implies that each skill group local labor supply is upward sloping, with the slope that depends on the importance of preferences for location for that group. If idiosyncratic preferences for location are not very important (variance of  $e$  is small), then workers are very mobile, and the supply curve is relatively flat. If idiosyncratic preferences for location are very important (variance of  $e$  is large), then workers are rather immobile and the supply curve is relatively steep. This is a difference between the Rosen-Roback setting and this setting. In Rosen-Roback, all workers are identical, and always indifferent across locations. In this setting, the marginal worker is indifferent between locations, but there are inframarginal workers who enjoy economic rents.

Firms are assumed to be perfectly mobile, to be price takers, and to face a CRTS Cobb-Douglas technology. Capital is supplied at a fixed price set on the international market. The elasticity of housing supply varies across cities due to differences in geography and local land regulations. In cities where geography and regulations make it easy to build new housing, elasticity is high. In the extreme case, where there are no constraints to building new houses, supply elasticity is infinite.

*Relative Demand Shock.*—I begin by considering what happens to the equilibrium prices and quantities in the two cities when productivity of skilled workers



increases in San Francisco. Nothing happens to the productivity of unskilled workers in San Francisco and the productivity of skilled and unskilled workers in Detroit; and amenities are identical and fixed.

Because skilled workers in San Francisco have become more productive, their equilibrium nominal wage increases by an amount proportional to the productivity increase. Attracted by this higher productivity, some skilled workers leave Detroit and move to San Francisco. As a consequence, the cost of housing in San Francisco increases, while the cost of housing in Detroit declines. Thus, in San Francisco, real wages of skilled workers increase by an amount smaller than the increase in nominal wages.

This increase in the real wage of skilled workers is larger the more elastic housing supply is in San Francisco. Intuitively, a more elastic housing supply implies a smaller increase in housing prices in San Francisco, and therefore a larger increase in real wage, for a given increase in nominal wage. The increase in the real wage of skilled workers is also larger when the elasticity of local labor supply of skilled workers is smaller. Intuitively, lower elasticity of labor supply implies less mobility. With less mobility, a larger fraction of the benefit of the productivity shocks is capitalized in real wages. In the extreme case of no mobility (i.e., when the variance of the term  $e$  is infinite), the entire productivity shock is capitalized in the real wage of skilled workers. The increase in the real wage of skilled workers is larger when the elasticity of local labor supply of unskilled workers is larger. A higher elasticity of labor supply of unskilled workers implies that a larger number of unskilled workers move out in response to the inflow of skilled workers, so that the increase in housing costs is more limited. (All of these statements are derived formally in the online Appendix).

Although the shock has increased productivity only in San Francisco, in equilibrium the real wages of skilled workers increase in Detroit as well, because of mobility. Of course, the increase in real wages in San Francisco is larger than the increase in real wages in Detroit. This is not surprising. While labor mobility causes real wages to increase in Detroit following a shock in San Francisco, real wages are not fully equalized because mobility is not perfect, and only the marginal worker is indifferent between the two cities in equilibrium. With perfect mobility, real wages are completely equalized.

What happens to the wage of unskilled workers? Because their productivity is fixed, their nominal wage does not change. However, housing costs increase in San Francisco and decline in Detroit. As a consequence, the real wage of unskilled workers in San Francisco decreases. Effectively, unskilled workers compete for scarce housing with skilled workers, and the inflow of new skilled workers in San Francisco hurts inframarginal unskilled workers through higher housing costs. Marginal unskilled workers leave San Francisco, since their real wage is higher in Detroit. Inframarginal unskilled workers (those who have a strong preference for San Francisco over Detroit) opt to stay in San Francisco, even if their real wage is lower. For the same reason, the real wage and utility of inframarginal unskilled workers in Detroit increases.<sup>26</sup>

<sup>26</sup> Firms are indifferent between cities because they make the same profits in both cities. While labor is now more expensive in San Francisco, it is also more productive there. Because firms produce a good that is internationally traded, if skilled workers weren't more productive, employers would leave San Francisco and relocate to Detroit.

In sum, the model illustrates that the relative demand shock creates winners and losers. Skilled workers in both cities and landowners in San Francisco benefit from the productivity increase. Inframarginal unskilled workers in San Francisco are negatively affected, and inframarginal unskilled workers in Detroit are positively affected. The exact magnitude of the changes in utility for skilled and unskilled workers and for landowners crucially depends on which of the three factors—skilled labor, unskilled labor, or land—is supplied more elastically at the local level. Specifically, the incidence of the shock depends on the elasticities of the labor supply of the two groups and the elasticities of housing supply in the two cities. Moretti (2011) provides a detailed discussion of the incidence and welfare consequences of relative demand shocks.

*Relative Supply Shock.*—I now turn to the opposite case, where the number of skilled workers in San Francisco increases because the relative supply of skilled workers in San Francisco increases. Specifically, I consider what happens when San Francisco becomes relatively more desirable for skilled workers compared to Detroit. I assume that the productivity of both skilled and unskilled workers, as well as the amenity level in Detroit, do not change.

Unlike the case of demand, here the nominal wage of skilled workers in San Francisco and Detroit remains unchanged. Attracted by the better amenity, some skilled workers move from Detroit to San Francisco and some unskilled workers leave San Francisco to go to Detroit. On net, population and housing costs increase in San Francisco and decline in Detroit.

Real wages of skilled workers decline in San Francisco and increase in Detroit. This reflects the compensating differential for the better amenity in San Francisco. Like for the case of demand shocks, a supply shock generates winners and losers. Here inframarginal skilled workers benefit from the improvement in amenities. While the utility gain is larger for inframarginal skilled workers in San Francisco, inframarginal skilled workers in Detroit are also made better off, even if there is no change in amenity there. On the other hand, inframarginal unskilled workers in San Francisco are made worse off by the increase in housing prices. Similarly, inframarginal unskilled workers in Detroit are made better off by the decline in local housing prices.

*Implications.*—The model has several implications that are useful in guiding the interpretation of the empirical findings. First, the model clarifies the relationship between changes in relative wages and changes in relative utility in the two scenarios. *For a given nationwide increase in the nominal wage gap between skilled and unskilled workers*, the demand pull hypothesis implies a more limited increase in utility inequality, while the supply push hypothesis implies a larger increase in utility inequality.

More specifically, in the demand pull scenario, the nominal wage difference between skilled and unskilled workers averaged across the two cities increases.<sup>27</sup>

<sup>27</sup> This average is a weighted average reflecting the size of the two cities.

The utility difference between skilled and unskilled workers averaged across the two cities also increases, but by an amount smaller than the increase in the nominal wage gap. It is possible to show that the larger is the increase in housing costs experienced by skilled workers relative to unskilled workers, the smaller is the increase in average utility experienced by skilled workers relative to unskilled workers.<sup>28</sup>

The intuition is simple. The benefits of a higher nominal wage for skilled workers are in part eroded by the higher cost of housing in the cities where the new skilled jobs are created. Thus, the relative utility of skilled workers does not increase as much as their relative nominal wage. Put differently, if college graduates move to expensive cities like San Francisco and New York because of increases in the relative demand for college graduates in these cities, and not because they particularly like living in San Francisco and New York, then part of the benefit of higher nominal wages is offset by the higher cost of living. In this case, the increase in their real wage and utility level is smaller than the increase in their nominal wage.

By contrast, in the supply push scenario, the utility difference between skilled and unskilled workers averaged across the two cities increases more than the nominal and real wage difference between skilled and unskilled workers averaged across the two cities. Intuitively, if college graduates move to expensive cities like San Francisco and New York because improvements in amenities raise the relative supply of college graduates there, and not because of labor demand, then there may still be a significant increase in utility inequality, even if the increase in real wage inequality is limited. In this case, increases in the cost of living in these cities simply reflect the increased attractiveness of these cities to skilled workers and represent the price to pay for the consumption of desirable amenities.

Second, the equilibrium described above suggests a simple empirical test to distinguish between the two cases. If relative demand shifts are responsible for the geographical reallocation of labor, we should see that in equilibrium cities that experience large increases in the relative number of skilled workers (in the model: San Francisco) also experience increases in the relative nominal wage of skilled workers. By contrast, if relative supply shifts are responsible for the geographical reallocation of labor, we should see that in equilibrium cities that experience an increase in the relative number of skilled workers experience no change in the relative nominal wage of skilled workers.<sup>29</sup>

Third, it is important to point out that while the focus of the paper is on inequality related to labor market outcomes, the broader welfare consequences of the demand and supply shocks depend not just on changes in relative wages, but also on which of the two education groups originally owns the land in the cities that benefit from

<sup>28</sup> To see this, consider the population-weighted average across the two cities of the change in the skilled-unskilled nominal wage difference and compare it with the population-weighted average across the two cities of the change in the skilled-unskilled utility difference.

<sup>29</sup> One might have expected that an increase in the relative supply of factor of production in a city should cause a *decline* in its equilibrium relative price. Why, in the model, does the nominal wage of skilled workers in San Francisco remain constant following an increase in the relative supply of skilled workers? This is due to the endogenous reaction of capital. Because capital is supplied with infinite elasticity at a fixed interest rate, nominal wages do not move in San Francisco because capital flows to San Francisco and leaves Detroit, thus offsetting the effect of changes in labor supply in the two cities. In a model without capital, nominal wages of skilled workers decline in San Francisco following an increase in their supply.

the demand and supply shocks. In the model, some landowners benefit from the demand and supply shocks (namely those in San Francisco), while others are hurt (namely those in Detroit). The relevant empirical question in this respect is which of the two skill groups owns more of the land in the neighborhoods where land prices are raised by the inflow of new residents in cities that experience positive skill-biased shocks, and the neighborhoods that are abandoned by the outflow of residents in cities that experience negative shocks. This is an important but complicated question. A full empirical treatment of this issue is beyond the scope of this paper and is left for future research.

A useful feature of the model is that it illustrates when a nondegenerate equilibrium is possible. After a shock that makes one group more productive or one city more attractive to a group, both groups are still represented in both cities. This conclusion hinges upon the assumption of a less than infinite elasticity of local labor supply. In the absence of individual preferences for location, no unskilled worker would remain in San Francisco, and the equilibrium would be characterized by complete geographic segregation of workers by skill level. This is not realistic, since in reality we never observe cities that are populated by workers of only one type.

#### IV. Interpreting the Evidence: Demand Pull or Supply Push?

I now present empirical evidence that seeks to determine whether relative demand or relative supply shifts, or a combination of the two, drive changes in the geographical location of different skill groups. The analysis above suggests that the demand pull and the supply push hypotheses have similar predictions for equilibrium housing costs. Under both hypotheses, cities that experience large increases in the share of college graduates should also experience large increases in housing costs.

But the demand pull and supply push hypotheses have different predictions for wage changes. Under the demand pull hypothesis, cities that experience large increases in the share of college graduates should experience large increases in the equilibrium relative wage of college graduates. By contrast, under the supply push hypothesis, there should be no positive relationship between increases in the share of college graduates and changes in the equilibrium relative nominal wages. Intuitively, increases in the relative demand of a factor of production in a city should result in increases in its equilibrium relative price there. Increases in the relative supply of factor of production in a city cannot cause an increase in its equilibrium relative price. A similar idea is used in Katz and Murphy (1992) to explain *nationwide* changes in relative wages.

It is important to highlight that the two hypotheses are not mutually exclusive, since it is possible that cities experience both demand and supply shocks. It is also possible that relative demand shifts endogenously generate relative supply shifts, and vice versa. For example, an increase in the relative demand for skilled labor in a city may result in an increase in the number of college educated residents in that city, and this, in turn, may result in increases in the local amenities that are attractive to college graduates, such as good schools, good theaters, good restaurants, etc. Alternatively, an increase in the supply of skilled workers in a city may generate

agglomeration spillovers that lead to increases in the productivity of firms and workers in that city (Moretti 2004, 2011). Similarly, Desmet and Rossi-Hansberg (2009) propose a model of the localization of service and manufacturing industries with agglomeration economies that can generate both supply shifts and demand shifts.

I present two pieces of empirical evidence. First, I look at the OLS relationship between changes in the college share and changes in the college premium across US metropolitan areas. Second, to shed more light on whether relative supply shifts are important, I use an instrumental variable strategy.

In Figure 2, I show the empirical relationship between the equilibrium college share and the equilibrium college premium across US metropolitan areas, both in the 2000 cross section and in changes between 1980 and 2000. Demand pull would predict a positive slope, while supply push would predict zero slope. Note that the relationship in the figure is *not causal*. Rather, it is an *equilibrium* relationship between the relative number of college graduates and their relative wage. This is in contrast with earlier work, including my own, that seeks to establish the *causal* effect of increases in college share on wages, and therefore estimates different specifications.<sup>30</sup>

The figure shows a positive association between the college share and the college premium across US metropolitan areas, both in levels as well as in changes. Columns 1 and 2 in Table 10 quantify the corresponding regression coefficients. The level of observation is the metropolitan area. The dependent variable is the city-specific college premium, defined as the city-specific difference in the log of hourly wage for college graduates and high school graduates, conditional on all the controls used in the regressions (a cubic in potential experience, year effects, gender and race). Models are weighted by city size. The coefficient for the specification in column 2 is positive and statistically significant: 0.388 (0.057). This evidence is consistent with demand factors playing a significant role in driving variation in college share across cities. This conclusion is consistent with Berry and Glaeser (2005), who argue that demand factors play a more important role than supply factors in explaining the sorting of skilled workers across US metropolitan areas.

These findings indicate that demand shifts are important, but do not rule out that supply shifts are also present. One possibility is that relative supply shifts generate relative demand shifts. For example, it is in principle possible that college graduates seek to be near other college graduates,<sup>31</sup> and that firms locate where workers are and adopt technology that favors workers that are in plentiful supply (Acemoglu 1998; Beaudry, Doms, and Lewis 2008). Over time, cities that experience increases in the relative supply of college graduates will also experience increases in their

<sup>30</sup> For example, in Moretti (2004), I try to establish the causal effect of increases in college share on wages. The econometric specification adopted here differs from the specification there, because in Moretti (2004) the econometric model seeks to *control for* shocks to the relative demand of skilled labor. To this end, I include in the regressions as controls several variables in order to absorb changes in the relative demand for college graduates. I also use instrumental variables to further control for relative demand shocks. By contrast, in this paper, I engage in a completely different exercise. I do not seek to hold constant demand shocks. Instead, I am interested in establishing the role played by demand shocks in affecting changes in college share across cities. What I am measuring in Figure 2 and Table 10 is the relationship between the wage gap and the college share, inclusive of any human capital spillover.

<sup>31</sup> This could be due to amenities, such as restaurants, arts and theater, or thickness of labor market for dual career couples (Costa and Kahn 2000) or human capital spillovers where they learn from other college graduates.

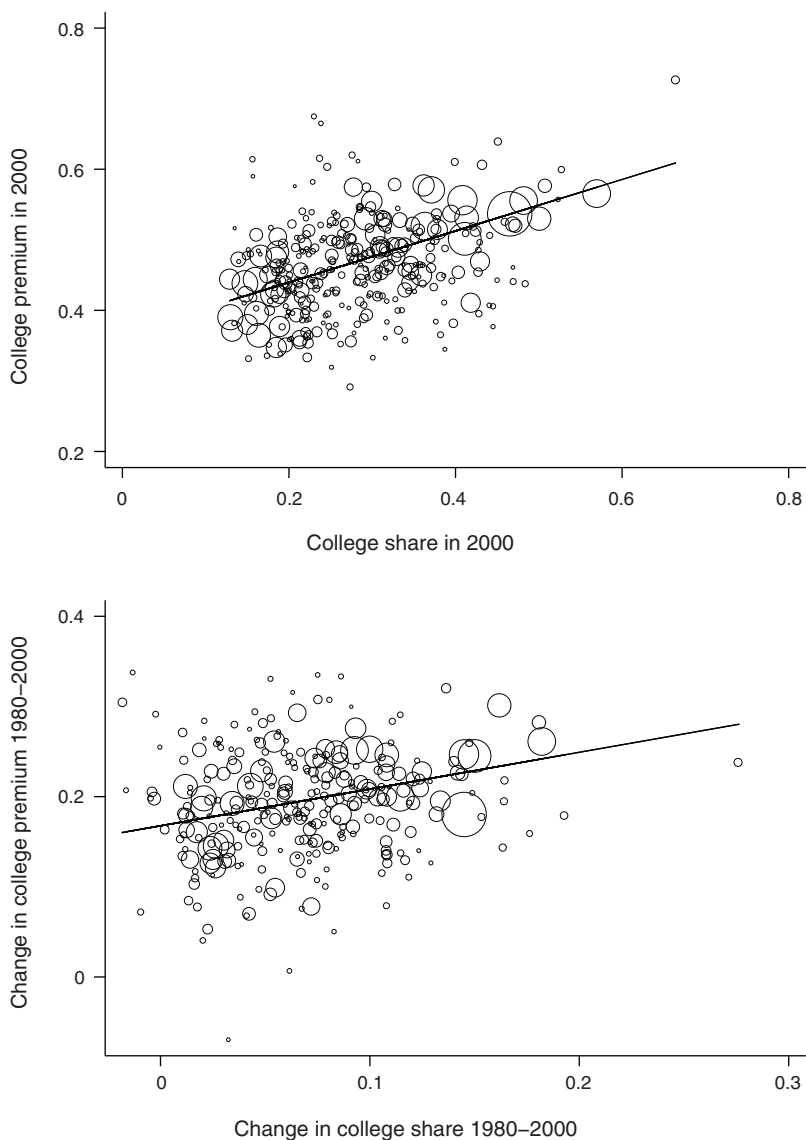


FIGURE 2. SHARE OF COLLEGE GRADUATES AND COLLEGE PREMIUM, BY CITY

*Notes:* The top panel plots estimates of the city-specific college premium in 2000 against the share of college graduates in 2000. The bottom panel plots the 1980–2000 change in college premium against the 1980–2000 change in the share of college graduates.

relative demand. To shed more light on the timing of demand and supply shifts, I have looked at 1980–1990 and 1990–2000 separately. Models similar to the one in Table 10 reveal that the correlation between relative wage changes and quantity changes was weak in 1980–1990 and became pronounced in 1990–2000.<sup>32</sup> Although

<sup>32</sup> More precisely, the coefficient on change in college share for the 1980–1990 period is  $-0.035$  (0.088). The coefficient on change in college share for the 1980–1990 period is  $0.520$  (0.107).

TABLE 10—THE RELATION BETWEEN SHARE OF COLLEGE GRADUATES AND COLLEGE PREMIUM

	2000		1980–2000	
	cross section		change	
	OLS	OLS	IV	
	(1)	(2)	(3)	
College share	0.375	0.388	0.371	
	(0.031)	(0.070)	(0.106)	
$R^2$	0.30	0.10		

*Notes:* Standard errors in parentheses. The dependent variable in column 1 is the city-specific college premium, defined as the city-specific difference in the log of hourly wage for college graduates and high school graduates conditional on gender, a cubic in potential experience, race, and year. The dependent variable in columns 2 and 3 is the change in the city-specific college premium. Entries are the coefficient on college share in column 1 and change in college share in columns 2 and 3. All models are weighted by city size.

several models may generate this pattern, this is consistent with the hypothesis that supply shifts were the “first mover” and were later followed by endogenous skill-biased productivity shifts.

As a more direct piece of evidence on whether relative supply factors play a role in driving variation in college share across cities, I use observable shocks to the relative demand of skilled labor as an instrumental variable for college share. This IV estimate isolates the effect on the college premium of changes in the college share that are driven exclusively by changes in relative demand. Put differently, the instrumental variable estimate establishes what happens to the college premium in a city when the city experiences an increase in the number of college graduates that is driven purely by an increase in the relative demand for college graduates. By contrast, the OLS estimate above establishes what happens to the college premium in a city when the city experiences an increase in the number of college graduates that may be driven by either demand or supply shocks. The comparison of the two estimates is therefore informative about the relative importance of demand and supply shocks.

To isolate relative demand shocks, I use as an instrument the weighted average of nationwide relative employment growth by industry, with weights reflecting the city-specific employment share in those industries:

$$(4) \quad \text{Change in Relative Demand in City } c = \sum_s \eta_{sc} (\Delta E_{Hs} - \Delta E_{Ls}),$$

where  $\eta_{sc}$  is the share of jobs in industry  $s$  in city  $c$  in 1980;  $\Delta E_{Hs}$  is the nationwide change between 1980 and 2000 in the log of number of jobs for college graduates in industry  $s$  (excluding city  $c$ );  $\Delta E_{Ls}$  is a similar change for high school graduates. If relative employment of skilled workers in a given industry increases (decreases) nationally, cities where that industry employs a significant share of the labor force will experience a positive (negative) relative shock to the labor demand of skilled workers (Katz and Murphy 1992).

The first-stage relationship between demand shocks and changes in college share is shown graphically in Figure 3. The figure shows that in cities that experience an increase in the relative demand of college graduates, the share of college graduates increases, and the relationship appears fairly tight. The regression coefficient

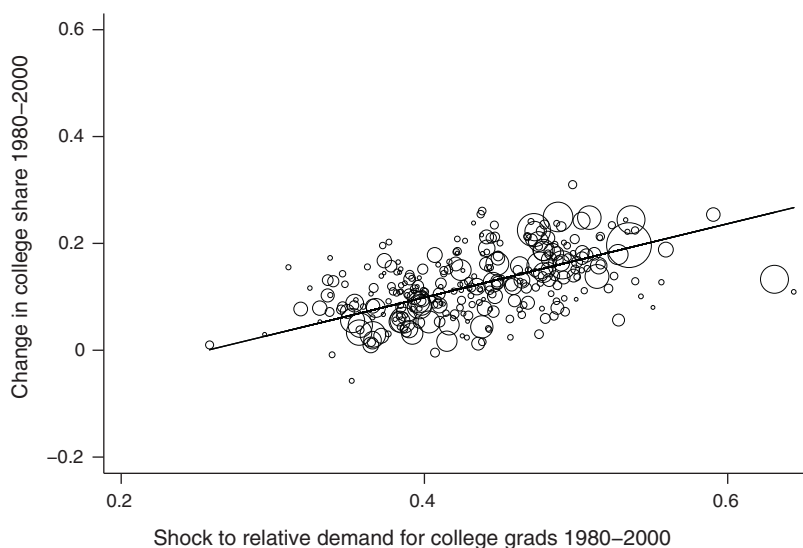


FIGURE 3. SHARE OF COLLEGE GRADUATES AND RELATIVE DEMAND SHOCKS, BY CITY

*Notes:* The panel plots changes in the share of college graduates 1980–2000 on the  $y$ -axis against 1980–2000 shocks to the relative demand of college graduates due to 1980 differences in industry mix on the  $x$ -axis. Shocks to the relative demand are defined in equation (4).

is 0.42(0.02). The instrumental variable estimate, in column 3 of Table 10, is 0.371 (0.106), and is remarkably close to the OLS estimate. The similarity between the OLS and the IV estimates suggests that the increase in the college premium in a city caused by a demand shock (IV estimate in column 3) is not very different from the empirical correlation between the college share and the college premium that is observed in the data (OLS estimate in column 2). This finding casts some doubt on the hypothesis that changes in college share were first driven by relative supply shifts followed by endogenous shifts in relative demand. At the same time, however, the evidence cannot completely rule out the possibility that relative demand shifts were endogenously followed by relative supply shifts.

I have also estimated a regression of changes in college share on the demand index (i.e., the first stage) conditioning on changes in amenities. The idea is to see how sensitive is the coefficient on the demand index to the inclusion of measures of amenities. First, I condition on changes in the amenity index proposed by Albouy (2011). This model has the advantage of capturing, in principle, all the amenities in a city. But some of the amenities are likely to depend on changes in college share. For example, changes in the amenity index could reflect changes in crime rates and cultural amenities in a city. And these changes could occur as a response to an increase in the local share of skilled workers, if the demand for safety or cultural amenities is relatively stronger for skilled workers. Conditioning on the change in the amenity index has a rather limited effect on the coefficient on the demand index. The point estimate changes from 0.422 (0.04) to 0.419 (0.040). (Not surprisingly, the coefficient on the amenity index is positive and highly significant: 0.392 (0.085).)



Second, I condition on a vector of clearly exogenous observable amenities: heating and cooling degree days, number of sunny days, precipitation, humidity, latitude longitude, an indicator for whether the city is on the ocean, an indicator for whether the city is on a lake, the average slope and the difference between maximum altitude and minimum altitude, the degree of urban sprawl in 1976, and an index of road density. While these amenities are clearly fixed, it is, in principle, possible that the demand for these amenities varies over time differently for different skill groups. The vector of amenities is jointly statistically significant. Conditioning on this vector of amenities significantly lowers the coefficient on the demand index from 0.422 (0.04) to 0.277 (0.043). But the point estimate remains large and statistically significant. Third, I include Albouy's index of amenities in 1980. This model is informative if the type of amenities that people valued in 1980 have not changed over time, but the demand for such amenities has changed differently for college graduates and high school graduates. Conditioning on the 1980 amenity index has virtually no effect on the coefficient on the demand index: from 0.422 (0.04) to 0.428 (0.044).

Overall, I conclude that relative demand shifts were probably more important than supply shifts in determining the geographical location of different skill groups in this period. At the same time, I want to emphasize that I cannot rule out that endogenous supply shifts also played a significant role. In the end, this leads me to conclude that the increase in utility inequality between 1980 and 2000 was smaller than previously thought based on nominal wages, but the exact magnitude of the change in utility inequality remains unknown.

It is important to clarify what this finding implies for the role of amenities in worker location decisions. My finding does *not* imply that amenities do not affect worker location decisions in general. Amenities are clearly an important determinant of where people decide to live. Furthermore, my finding does *not* imply that amenities do not affect location decisions of skilled and unskilled workers differently. It is possible that the relative importance of certain amenities (cultural amenities, school quality, crime, restaurants) is different for different skill groups. What my finding implies is that the *change over time* in the *difference* between skilled and unskilled workers in relevant local amenities played a less important role in driving differential changes in the geographical location of skilled and unskilled workers in the period 1980–2000 than the *change over time* in the relative labor demand. This would be true, for example, if the amenities that matter for skilled and unskilled workers have changed in a similar way within each city in this period. This would also be true if the amenities that matter for skilled workers have changed differently from the amenities that matter for unskilled workers, but this differential change is similar across metropolitan areas in the United States.

## V. Conclusions

Because of their different geographical distribution, college graduates and high school graduates have experienced different increases in the cost of living over the past 30 years. One contribution of this paper is to document that, as a consequence, the conditional difference between the wage of college graduates and of high school

graduates is significantly lower in real terms than in nominal terms, and has grown less. In 2000, the level of the college premium is 60 percent in nominal terms and only 51 percent in real terms. More importantly, the *increase* in the college premium between 1980 and 2000 in real terms is significantly smaller than the increase in nominal terms. Specifically, at least 22 percent of the documented increase in the college premium between 1980 and 2000 is accounted for by differences in the cost of living.

The implications of this empirical finding for disparities in well-being depend on the reasons for the increase in the share of college graduates in expensive cities. Using a simple general equilibrium model of the labor and housing markets, I consider two broad classes of explanations. Under a demand pull hypothesis, the *relative demand* of college graduates increases in expensive cities because of localized skill-biased technical change or other demand shocks. In this case, college graduates move to expensive cities because the jobs for college graduates are increasingly located in those cities, and not because they particularly like living in those cities. The increase in their utility level is smaller than the increase in their nominal wage due to a higher cost of living. Under a supply push hypothesis, the *relative supply* of college graduates increases in expensive cities because college graduates are increasingly attracted by amenities located in those cities. The increase in the cost of living in those cities reflects the attractiveness of the cities to skilled workers and is the price for the consumption of desirable amenities. In this case, there may still be a significant increase in utility inequality, even if the increase in real wage inequality is limited. Of course, the two hypotheses are not mutually exclusive, and it is possible that cities experience both demand and supply shocks.

To determine whether the variation in the relative number of college graduates across cities is driven by relative demand or relative supply shocks, I analyze the equilibrium relationship between changes in college premium and changes in the share of college graduates across metropolitan areas. Consistent with demand shocks playing an important role, I find a positive association between changes in college premium and changes in college share. Cities that experience large increases in the fraction of college graduates also experience large increases in the relative wage of college graduates.

This evidence is an important corollary to the already widely recognized notion that relative labor demand shifts have generated increased nominal wage inequality at the national level. But my evidence highlights that nationwide shifts in labor demand are the product of highly heterogeneous localized shifts. Some cities have experienced large shifts, while others have not. Thus, in order to understand why the relative demand of skilled workers has increased nationwide, we need to understand first why the relative demand of skilled workers has increased in some cities but not in others.

This paper leaves open the question of what ultimately causes the local relative demand shocks. In my theoretical setting, I take these shocks as exogenous. Future research should focus on exactly what generates the localized relative demand shifts that make college graduates more productive in some parts of the country. Localized skill-biased technical change is a potential explanation, as long as it is enriched by a theory of why demand shocks occur in some cities and not in others.

Beaudry, Doms, and Lewis (2008) and Berry and Glaeser (2005) propose realistic models and intriguing empirical evidence. Models with human capital spillovers or agglomeration spillovers also have the potential to explain localized demand shifts (Moretti 2004a, b, 2011; Greenstone, Hornbeck, and Moretti 2010). An alternative explanation centers on shifts in product demand across industries that have different skill intensities (Buera and Kaboski 2009). For example, industries like finance and high tech, which are skill intensive and are located in expensive coastal metropolitan areas, have been expanding during the 1980s and 1990s. Future research should determine the role of the local industrial mix in driving differential labor demand shifts for skilled and unskilled workers.

A second conclusion of the paper is that the increase in well-being disparities between 1980 and 2000 is significantly smaller than we previously thought, based on the existing literature.<sup>33</sup>

It is important to clarify that the exact magnitude of the increase in well-being disparities remains unknown. While my findings suggest that the increase in the difference in well-being between skilled and unskilled workers is smaller than we may have thought, a full account of well-being disparities is difficult to accomplish here for at least two reasons. First, my analysis does not take into consideration features of jobs other than wages. Hamermesh (1999) shows that the amount of workplace disamenities (such as risk of death or workplace injury) born by low-skill workers increased more than the amount of workplace disamenities born by high-skill workers during the 1980s. This differential change implies a larger increase in well-being inequality than the one measured ignoring workplace disamenities, although this bias is likely to be limited for the typical worker.<sup>34</sup>

Second, this paper leaves open the question of how changes in housing wealth affect the relative welfare of skilled and unskilled homeowners. Consistent with the previous literature on inequality, the main focus of this paper is on differences between skilled and unskilled workers that are caused by labor market changes. However, the broader distributional consequences of the demand and supply shocks depend not just on changes in relative wages, but also on changes in wealth, as discussed above. Changes in the price of housing have the potential to affect the relative wealth of different skill groups depending on who originally owns the land in the cities that are affected by the demand and supply shocks. A full empirical treatment of this issue is complicated and is beyond the scope of this paper.

## APPENDIX

Here, I describe in more detail how I compute Local CPI 1 and Local CPI 2. As I mention in the main text, I follow closely the BLS methodology, and take the properly weighted sum of changes in the cost of housing and nonhousing consumption.

<sup>33</sup> My results have the potential to explain, at least in part, an outstanding puzzle in the inequality literature. Despite the increase in the return to education, the rate of growth in the number of college graduates is still low relative to earlier periods. The fact that their real wage has not increased as much as previously thought may explain why the number of college graduates has not increased as much as one would have expected.

<sup>34</sup> Similarly, Pierce (2001) finds that from 1981 to 1997 the increase in compensation inequality exceeded the increase in wage inequality by 15 percent.

Cost of housing is measured either using rental costs or housing prices. In the first case, my measure of rent is the “gross monthly rental cost” of the housing unit. I limit the sample to two or three bedroom rental units. This includes contract rent plus additional costs for utilities (water, electricity, gas) and fuels (oil, coal, kerosene, wood, etc.). This variable is considered by IPUMS as more comparable across households than “contract rent,” which may or may not include utilities and fuels. The Department of Housing and Urban Development (HUD) also uses the “gross monthly rental cost” measure of rent to calculate the federally mandated “Fair Market Rent.”<sup>35</sup>

The housing costs relevant for a worker living in metropolitan area  $c$ , whether he rents or owns, is the average of the monthly cost of renting a two or three bedroom apartment among all renters in area  $c$ . When cost of housing is measured using housing prices, I use the property value reported by homeowners of two or three bedroom single family houses. In this case, the housing costs relevant for a worker living in metropolitan area  $c$  are then the average of housing values reported by all homeowners of two or three bedroom homes in area  $c$ .

Note that measured changes in cost of housing do not reflect the change in rental cost or changes in property values at the individual level. Instead, measured changes in cost of housing reflect an average for the local housing market, irrespective of an individual own housing cost and irrespective of whether she rents or owns.

As weights, in my baseline specifications I use the expenditure shares that the BLS uses to compute the official CPI. Since the basket is updated periodically, the BLS weights vary by year. One concern is that housing expenditure shares may vary across metropolitan areas because of differences in housing prices. Additionally, it is possible that housing expenditure shares vary across skill groups if preferences are non-homothetic. I address these possibilities as follows.

First, I consider the possible differences in expenditure shares across metropolitan areas. Since housing costs vary across cities, it is, in principle, possible that the share of income spent on housing also varies, as consumers adjust their consumption bundles to local prices. Empirically, the demand for housing is not very price elastic, and the share of income spent on housing appears to be higher in more expensive cities. In a recent *American Economic Review* paper, Lewbel and Pendakur (2009) find that a housing price increase of 10 percent results in a 0.63 percentage point *higher* housing share, everything else constant. If this is true, it implies that the share of income spent on housing in expensive cities like New York is higher than the share of income spent on housing in less expensive cities like Indianapolis, everything else constant. Because college graduates are overrepresented in expensive cities like New York and underrepresented in less expensive cities like Indianapolis, this should increase the housing share of college graduates relative to high school graduates, everything else

<sup>35</sup> Rents are imputed for top-coded observations by multiplying the value of the top code by 1.3. Results do not change significantly when no imputation is performed or when I multiply the value of the top code by 1.4. For Local CPI 1, the cost of nonhousing consumption is obtained by subtracting changes in the cost of housing from the nationwide CPI-U computed by the BLS:

$$(5) \text{ CPI Nonhousing} = (\text{CPI-U}/(1 - w)) - (w/(1 - w)),$$

where “housing” is the average nationwide increase in cost of housing (from census data), and  $w$  is the BLS housing weight in the relevant year.

constant. (In this case, the use of constant housing shares across cities would lead me to *underestimate* the effect that cost of living adjustments have on wage inequality.)

Second, I consider the possibility that housing price elasticity vary by skill level (or income level). Lewbel and Pendakur (2009) find that high-income individuals substitute less than low-income individuals in the face of an increase in the price of housing. This should further increase the housing share of college graduates relative to high school graduates, everything else constant.

Third, I consider the possibility of non-homothetic preferences. Most empirical studies find that housing is a normal good, with an income elasticity just below 1 when income is measured as permanent income.<sup>36</sup> If this is true, the share of income spent on housing should be slightly lower for college graduates than high school graduates.

To account for these possibilities, I have replicated my results using different expenditure shares for different cities and different skill groups in different years. In particular, I use available estimates in the literature of price elasticity and income elasticity to impute shares that vary as a function of local housing prices and individual income. For housing, I assume a permanent income elasticity equal to 0.85, which is the midpoint in the range of estimates provided by Polinsky and Ellwood (1979). I also assume that the percent difference in permanent income between skilled and unskilled workers is 40 percent in 1980, 53 percent in 1990, and 60 percent in 2000. (These figures reflect estimates of the nominal college premium.) To allow for differences across cities as a function of local housing prices, I use estimates of demand elasticity from Lewbel and Pendakur (2009).

As I discuss in the main text, estimates of the college premium based on expenditure shares that vary by MSA, skill group, and year are similar to the ones obtained using BLS shares that vary only by year. Overall, using a common housing share for all individuals within a year appears not to be a bad approximation. This is consistent with what is reported by Baum-Snow and Pavan (2009), who find that expenditure shares are generally similar across cities of different size (and therefore different price level).

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