Real Wage Inequality

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First Draft: May 2008
This Draft May 2009

Abstract. A large literature has documented a significant increase in the difference between the wage of college graduates and high school graduates over the past 30 years. I show that from 1980 to 2000, college graduates have experienced relatively larger increases in cost of living, because they have increasingly concentrated in metropolitan areas that are characterized by a high cost of housing. When I deflate nominal wages using a new CPI that allows for changes in the cost of housing to vary across metropolitan areas, I find that the difference between the wage of college graduates and high school graduates is lower in real terms than in nominal terms and has grown less. At least 22% of the documented increase in college premium is accounted for by differences in the cost of living. The implications of this finding for changes in well-being inequality depend on why college graduates sort into expensive cities. Using a simple general equilibrium model of the labor and housing markets, I consider two alternative explanations. First, it is possible that the relative supply of college graduates increases in expensive cities because college graduates are increasingly attracted by amenities located in those cities. In this case, the higher cost of housing reflects consumption of desirable local amenities, and there may still be a significant increase in well-being inequality even if the increase in real wage inequality is limited. Alternatively, it is possible that the relative demand for college graduates increases in expensive cities due to shifts in the relative productivity of skilled labor. In this case, the relative increase in skilled workers' standard of living is offset by the higher cost of living. The evidence indicates that changes in the geographical location of different skill groups are mostly driven by changes in their relative demand. I conclude that the increase in well-being disparities between 1980 and 2000 is smaller than the increase in nominal wage disparities that has been the focus of the previous literature.

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, and seminar participants at Berkeley Economics, Berkeley Haas, Chicago GSB, Collegio Carlo Alberto, Federal Reserve Board of Governors, IZA, Northwestern, San Francisco Federal Reserve, Stanford, UCLA, UC Santa Cruz, and UC Merced 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.

1 Introduction

A large literature in labor economics has documented a significant increase in wage inequality over the past 30 years.[1] Wage inequality is often measured as the difference between the wage of skilled and unskilled workers, or between the wage of workers at the top and the bottom of the wage distribution. The existing literature has proposed three broad classes of explanations for the increase in inequality: an increase in the relative demand for skills caused by skill biased technical change and product demand shifts across sectors with different skill intensities; a slowdown in the growth of the relative supply of skilled workers; and the erosion of labor market institutions, such as unions and the minimum wage, that protect low-wage workers.

In this paper, I re-examine 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 US, and I assess how existing estimates of inequality change when differences in the cost of living across locations are taken into account. I then discuss how to interpret these measures of real wage inequality when changes in amenities are different across cities.

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 the cost of housing between 1980 and 2000 and to the fact that much of the growth in the number of college graduates has occurred in cities that experience large increases in the cost of housing. 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.

Although the cost of housing varies substantially across metropolitan areas, changes in the cost of living are almost universally measured using the single *nation-wide* Consumer Price Index (CPI) computed by the Bureau of Labor Statistics (BLS). Changes in this official CPI are a weighted average of changes in the price of the goods in a representative consumption basket. The weights reflect the share of income that the average consumer spends on each good. Housing is by far the largest single item in the CPI, accounting for more than a third of the index.

To measure the wage difference between college graduates and high school graduates in *real* terms, I deflate nominal wages using a new CPI that allows for geographical differences. I closely follow the methodology that the BLS uses to build the official CPI, while allowing for increases in the cost of housing to vary across metropolitan areas. In some specifications, I also allow for the price of non-housing goods and services to vary across metropolitan areas.

The results are striking. First, I find that between 1980 and 2000, the cost of housing for college graduates grows much faster than cost of housing for high school graduates.

[1] A comprehensive survey is found in Katz and Autor (1999).

Specifically, in 1980 the difference in the average cost of housing between college and high school graduates is only 4%. This difference grows to 14% in 2000, or more than three times the 1980 difference. Second, 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. This finding does not appear to be driven by different trends in relative housing quality and is robust to a number of alternative specifications. Third, 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% in nominal terms and 51% 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. 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 general equilibrium model of the housing and labor markets. The model clarifies what happens to wages and costs of housing when a local economy experiences a shock to labor productivity or a change in local amenities. The model is a generalization of the Roback (1982) model, which is widely used by urban economists to study shocks to local economies. Like in Roback, in equilibrium workers and firms are indifferent between cities. But unlike Roback, housing supply is not necessarily fixed, so that productivity and amenity shocks are not necessarily fully capitalized into land prices. This is important, because it allows shocks to the relative demand and relative supply of skilled workers in a city to have different effects on the well-being of skilled and unskilled workers and landowners.

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 broad classes of 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.[2] 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. Increases in the relative supply of college graduates in a city should cause their relative wage to decline, or at least not to increase.[3]

Consistent with 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 on the importance of demand factors in driving variation in college share across cities, I present instrumental variable estimates of the relationship between changes in the college premium and changes in the college share obtained by instrumenting changes in the college share with a measure of arguably exogenous demand shocks. The instrument is a weighted average of nationwide relative skilled employment growth by industry, with weights reflecting the city-specific employment share in those industries in 1980. The 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 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

[2]See also Kahn (1999).

[3]This test is related to the test adopted by Katz and Murphy (1992) to understand nationwide changes in inequality.

of the two estimates is therefore informative about the relative importance of demand and supply shocks.

Overall, the empirical evidence is more consistent with the notion that relative demand shocks are the main force driving changes in the number of skilled workers across metropolitan areas. If this is true, it implies that the increase in well-being inequality between 1980 and 2000 is smaller than the increase in nominal wage inequality.

My results are related to a paper by Dan Black et al. (2007) which, along with earlier work by Dahl (2002), criticizes the standard practice of treating the returns to education as uniform across locations. They 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. In a related paper, Dan Black et al. (2009) argue that estimates of the wage differences between blacks and whites need to account for differences in the geographical location of different racial groups. They argue that accounting for geography changes the estimates of the speed of convergence between black and white earnings. They also develop a theoretical model to understand when estimates of black-white earnings gap can be used to infer welfare differences. In a series of recent papers on inequality, Robert Gordon (2009) and Gordon and Dew-Becker (2005, 2007 and 2008) argue that the magnitude of the increase in income inequality might have been overestimated and mention among the reasons the possible role of price changes faced by different income groups. They also propose an alternative measure of the gap between median income and productivity.[4]

My 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 findings point to an important role for the *local* component of these demand shifts. While in this paper I take these local demand shifts as exogenous, future research should investigate the economic forces that make skilled workers more productive in some parts of the country.[5] 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).[6] 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). Finally, the evidence in this paper is an example of general equilibrium effects undoing some of the effects of sector-specific shocks, a point made by Heckman et al (1998), among others.

The rest of the paper is organized as follows. In Section 2, I describe how the official CPI

[4]In two recent papers, Aguiar and Hurst (2007a and 2007b) focus on the role of differential changes in labor supply and leisure, by skill group.

[5]See for example Moretti (2004a and 2004b) and Greenstone, Hornbeck and Moretti (2007).

[6]Chen and Rosenthal (forthcoming) document that jobs are the key determinant of mobility of young individuals. Mobility of older individuals seems more likely to be driven by amenities.

is calculated by the BLS and I propose two alternative CPI's that allow for geographical differences across skill groups. In Section 3, I present estimates of nominal and real college premia. In Section 4, I present a simple model that can help interpreting the empirical evidence. In Section 5, I discuss the different implications of the demand pull and supply push hypotheses and present empirical evidence to distinguish the two. Section 6 concludes.

2 Cost of Living Indexes 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 (subsection 2.1). I then describe how the Bureau of Labor Statistics computes the official Consumer Price Index (subsection 2.2), and I propose two new measures of cost of living that account for geographical differences (subsection 2.3). 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 (subsection 2.4).

2.1 Changes in the Location of Skilled and Unskilled Workers

Throughout the paper, I use data from the 1980, 1990 and 2000 Censuses of Population.[7] The geographical unit of analysis is the metropolitan statistical area (MSA) of residence. Rural households in the Census are not assigned a 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 a 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% of workers has a college degree or more. The fraction of college graduates in Stamford is almost 5 times the fraction of college graduates in the city at the bottom on the distribution—Danville, VA—where only 12% of workers have a college degree. Other metropolitan areas in the top group include MSA's with an industrial mix that is heavy in high tech and R&D—such as San Jose, San Francisco, Boston and Raleigh-Durham—and MSA's 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 2 or 3 bedroom apartment—than metropolitan areas in the bottom panel. College

[7]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.

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 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 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 Moretti (2004) and Berry and Glaeser (2005).[8]

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 MSA's where housing is initially expensive.[9] 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 MSA's where housing has become more expensive.[10]

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.

2.2 The Official Consumer Price Index

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 Consumer Price Index 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 time t, and the weights reflect the share of income that the average consumer spends on each good at time

[8] 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 .460 (.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.

[9] 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 .0011 (.00006), indicating that a 100 dollar difference in the baseline monthly rent in 1980 is associated with a 4.7 percentage point increase in college share between 1980 and 2000.

[10] The regression yields a coefficient equal to .0003 (.00001).

t.[11]

Table 2 shows the relative importance of the main aggregate components of the CPI-U in 2000. The largest component by far is housing. In 2000, housing accounts for more than 42% of the CPI-U. The largest sub-components 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% and 14.9% of the CPI-U, respectively. The weights of all the other categories are 6% or smaller.

Although most households in the US 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 Verbugge, 2006; Bureau of Labor Statistics, 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.

2.3 Local Consumer Price Indexes

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 90th percentile of the distribution—is $894. This rental cost is almost 3 times higher than the rental cost for an equally sized apartment in Decatour, AL, the city at the 10th 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—one of the cities at the top of the distribution. The distribution of average rental costs and changes in average rental costs are shown in Figure 2.

Although the cost of living varies substantially across metropolitan areas, wage and income are typically deflated using a single, nation-wide deflator, such as the CPI-U calculated by the BLS. The use a nation-wide deflator is particularly striking in light of the fact that more than 40% of the CPI-U is driven by housing costs (Table 2), and that housing costs vary so much across locations (Figure 2). To investigate 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 Bureau of Labor Statistics uses to build the official Consumer Price Index, but I generalize two of its assumptions.

Local CPI 1. First, I compute a CPI that allows for the fact that the cost of housing varies across metropolitan areas. Specifically, I measure the cost of housing faced by an

[11] 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".

individual in metropolitan area c as the average of the monthly cost of renting a 2 or 3 bedroom apartment among all renters in area c. Consistent with BLS methodology, I assign the cost of housing to homeowners in a metropolitan area based on the relevant average monthly rent. 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 workers in the same city, irrespective of their own individual housing cost and irrespective of whether they rent or own.

Following the BLS methodology, I then take the properly weighted sum of the cost of housing—with the average across cities normalized to 1 in 1980—and non-housing consumption—normalized to 1 in 1980. The weights are the weights used by BLS in the relevant year. The cost of non-housing consumption is assumed to be the same for all individuals in a given year and is obtained by subtracting changes in the cost of housing from the nationwide CPI-U computed by the BLS:

$$\text{CPI Non-Housing} = (\text{CPI-U}/(1-w)) - (w/(1-w))\text{Housing} \tag{1}$$

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.[12] I call the resulting local price index "Local CPI 1".

A limitation is that I use the same consumption shares for all individuals in a given year, irrespective of their skill group. The use of fixed shares may in principle result in biased estimates of Local CPI 1, since different skill groups are exposed to different price changes and therefore they may adjust their housing share differently. While it is possible that, in any given year, the consumption share differ across skill groups, the BLS only publishes nation-wide shares. The use of fixed shares for all individuals within a year should lead me to *underestimate* the fraction of the college premium explained by cost of living for two reasons. First, the demand for housing is not very elastic and the share of income spent on housing is likely to be higher in more expensive cities. For example, the share of income spent on housing in New York is likely to be higher than the share of income spent on housing in Indianapolis, everything else constant. Indeed, Lewbel and Pendakur (forthcoming) document that a housing price increase of 10 percent results in a 0.63 percentage points higher housing share,

[12] In practice, my measure of rent is the "gross monthly rental cost" of the housing unit. 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". The weights are the BLS weights for the relevant year for "Shelter" and "Fuel and Utilities". Since the basket is updated periodically the weights vary over time. The weight for year 2000 is 0.381 (see Table 2). The weight in 1980 is .355 and in 1990 is .356. 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.

everything else constant. Second, it is possible that substitution effects may vary by skill level and income level. Lewbel and Pendakur find that high income individuals substitute less than low income individuals in the face of an increase in the price of housing. Both arguments indicate that I am probably underestimating the importance of changes over time in housing costs for college graduates, and that my estimates of the fraction of the college premium explained by the cost of living should probably be considered a lower bound.

Local CPI 2. In CPI 1, changes in the cost of housing can vary across localities, but changes in the cost of non-housing 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 costs are higher and therefore the cost of many goods and services is higher. For example, a slice of pizza or a hair cut are likely to be more expensive in New York city than in Indianapolis, since it is more expensive to operate a pizza restaurant or a barber shop in New York city than Indianapolis.[13]

In a second departure from the standard BLS CPI, I propose an index that allows for both the cost of housing and the cost of non-housing consumption to vary across metropolitan areas. Systematic, high quality, city-level data on the price of non-housing good and services are not available for most cities over a long time period. The BLS releases a local CPI for some metropolitan areas. This local CPI is far from ideal. First, it is available only for a limited number of MSA's. Of the 315 MSA's in the 2000 Census, the metropolitan-level CPI is made available by the BLS only for 23 MSA's in the period under consideration. Second, 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 non-housing 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 non-housing costs (NHP_{ct}):

$$\mathrm{BLS}_{ct} = w\mathrm{HP}_{ct} + (1 - w)\mathrm{NHP}_{ct} \tag{2}$$

where w is the CPI weight used by BLS for housing. Non-housing costs can be divided in two components:

$$\mathrm{NHP}_{ct} = \pi\mathrm{HP}_{ct} + v_{ct} \tag{3}$$

where $\pi\mathrm{HP}_{ct}$ is the component of non-housing 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 non-housing goods and services. I use the small sample of MSA's for which a local BLS CPI is available to estimate π.[14] I then impute the systematic component of non-housing costs to all MSA's, based on their housing

[13] The cost of leasing a store is certainly higher in New York; labor costs are also likely to be higher in New York, since workers need higher wages to live in New York.

[14] To do so, I first regress changes in the BLS local index on changes in housing costs: $\Delta\mathrm{BLS}_{ct} = \beta\Delta\mathrm{HP}_{ct} + e_{ct}$. Estimating this regression in differences is necessary because BLS_{ct} is normalized to 1 in a given year.

cost: $E(\text{NHP}_{ct}|\text{HP}_{ct}) = \hat{\pi}\text{HP}_{ct}$. Finally, I compute "Local CPI 2" as a properly weighted sum of the cost of housing, the component of non-housing costs that varies with housing ($\hat{\pi}HP_{ct}$), and the component of non-housing costs that does not vary with housing. I use as weights the weights used by BLS in the relevant year.

Local CPI 2 is more comprehensive than Local CPI 1 because it includes local variation in both housing and non-housing costs, but it is has the limitation that non-housing costs are imputed. For this reason, in the next Section I present separate estimates for Local CPI 1 and Local CPI 2. Moreover, I show how my estimates change when I compute Local CPI 2 using data on non-housing prices taken from the Accra dataset, which is collected by the Council for Community and Economic Research. The Accra dataset is available for most cities and therefore does not require any imputation, but, for each city, it has a much smaller sample size and therefore is more noisy.

2.4 Differences in the Cost of Living Experienced by Skilled and Unskilled Workers

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 3 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% more than the cost of housing for the average high school graduate. This gap grows to 11% in 1990 and reaches 14% by 2000. Column 4 indicates that housing costs for high school and college graduates increased between 1980 and 2000 by 127% and 147%, respectively.

The third panel shows "Local CPI 1", normalized to 1 in 1980 for the average household. The panel shows that in 1980 the overall cost of living experienced by college graduates is only 2% higher than the cost of living experienced by high school graduates. This difference increases to 6% by 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 non-housing 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 non-housing goods and services is allowed

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 β, I can calculate $\hat{\pi} = \frac{\hat{\beta}-w}{1-w}$. Empirically, $\hat{\beta}$ is equal to .588 (.001) and $\hat{\pi}$ is equal to .35 in 2000.

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

The relative increase in the cost of housing experienced by college graduates between 1980 and 2000 can be decomposed into a part due to geographical mobility and a part 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=high school or college), can be written as

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

where ω_{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: a part due to the the change in the share of workers in each city, given 2000 prices ($\sum_c (\omega_{jc2000} - \omega_{jc1980}) P_{c2000}$); and a part 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 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% 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% is due to the second component (larger cost increase in cities that have many college graduates in 1980).

3 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, I show estimates of the college premium in nominal and real terms, by year. I also discuss to what extent differences in the cost of housing may reflect differences in the quality of housing.

(a) Main Estimates. Model 1 in the top panel of Table 4 estimates the conditional <u>nominal</u> wage difference between workers with a high school degree and workers with college or more, by year. Estimates in columns 1 to 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, years dummies, a cubic in potential experience, and dummies for gender and race. Estimates in columns 5 to 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.

My estimates in columns 1 to 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% in 1980 and rises to 60% 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 4 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 .60 in nominal terms and only .53 in real terms when Local CPI 1 is used as deflator. The difference is smaller—.51 percentage points—when Local CPI 2 is used as 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% 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% of the increase in conditional wage inequality between college and high school graduates between 1980 and 2000 (column 4).[15]

[15] One might be concerned about unobserved differences in worker quality. Models in Table 4 control for standard demographics, but not for worker ability. Ability of college graduates and high school graduates may vary differentially across metropolitan areas. Without knowing the exact type of selection, one can only speculate on the type of bias that may be caused by the failure to account for unobserved heterogeneity. Note that what matters in this respect is not the mere presence of cross-sectional differences across cities in the relative average ability of college graduates and high school graduates. Neither is the mere fact that the relative average ability of college graduates and high school graduates may vary over time differently in different cities. What matters is whether 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 housing prices in that city. If the average unobserved ability of college graduates relative to high school graduates

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 deflator. After conditioning on MSA fixed effects, cost of living differences account 22% 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).

In Table 5 I present the results from several alternative specifications. I begin in the top panel by using an alternative source of non-housing costs data to compute Local CPI 2. Specifically, I compute Local CPI 2 using data on non-housing prices from the Accra dataset collected by the Council for Community and Economic Research.[16] The Accra data have both advantages and disadvantages when compared to the BLS local price index. On one hand, the Accra data are available for a much larger set of cities. 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.[17] Moreover, the sample size for each good and city is quite small and the set of cities covered changes over time. With these limitations in mind, I follow the same methodology used to compute Local CPI 2, but use Accra data instead of the local BLS for non-housing goods.

In the second panel, 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 re-estimate the baseline model where the dependent variable is wage per hour worked or spent commuting. (I calculate hourly wage by summing number of hours worked and time spent commuting.) In the third panel, I show estimates based on a sample that includes all wage and salary workers 25-60, irrespective of the number of weeks worked in the previous year. In the fourth panel, I show estimates that include workers born outside the US. In the bottom panel I drop rural workers (i.e. those who are not assigned an MSA).

In general, estimates in Table 5 are not very different from the baseline estimates in Table 4. The inclusion of workers with less than 48 weeks of work in panel 3 results in a slightly larger percent of the nominal increase in inequality being accounted for by differences in cost of living.[18]

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grows more (less) in expensive cities compared to less expensive cities, then the estimates of the real college premia in Table 4 are biased downward (upward).

[16]The data were generously provided by Emek Basker. Basker (2005) and Basker and Noel (2007) describe the Accra dataset in detail.

[17]Only 48 goods have prices that are consistently defined for the entire period under consideration. The BLS basket includes more than 1000 goods.

[18]I have performed several 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

(b) Differential Changes in Housing Quality. A concern is the possibility that the 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. One 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 quality of the kitchen or 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[19], 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 can not completely rule out the possibility of unmeasured quality differences, here 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

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 4. When I estimate separate models for male and females, results are generally similar. When I estimate separate models for workers with less than 20 years of experience and workers with more than 20 years of experience, I find that the college premium seems to be smaller, and to have grown less—both in nominal and real terms—for workers with higher levels of potential experience. Estimates where the dependent variable is the log of weekly or yearly earnings are also generally consistent with Table 4. Finally, my estimates are not very sensitive to the exclusion of outliers (defined as the top 1% and the bottom 1% of each year's wage distribution).

[19] Although my measure of housing cost is the average rent for apartments with a fixed number of bedrooms, exact square footage may vary.

the last 3 months.[20]

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 6 are generally similar to the corresponding baseline estimates based on the Census reported in Table 4.[21] 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 re-estimate 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 6 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 6 indicates that controlling for a rich vector of observable quality differences results in differences between nominal and real college premium that are slightly larger than the baseline differences.

(c) Alternative Measures of Local Cost of Living. My estimates above are based on a definition of cost of living where the housing component of cost of living varies only by metropolitan area. In Appendix Table A1 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. 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

[20] 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.

[21] Unlike Table 4, 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 4.

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 2 or 3 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 non housing good and services. Estimates in Appendix Table 1 indicate that, relative to Table 4, a larger share of the increase in nominal wage differences appears to be accounted for by cost of living differences.[22]

4 A Simple Framework

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 well being inequality? Not necessarily, because changes in real wages do not necessarily equal changes in well-being. In this Section, I use a simple general equilibrium model to investigate the implications of my empirical findings for changes in well-being disparities. The implications are different depending on the reasons for the increase in the share of college graduates in expensive cities. I consider two broad class of explanations for such an increase. 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. In this case, a higher cost of housing reflects consumption of local amenities. Since this consumption arguably generates utility, the increase in utility disparity is larger than the increase in real wage disparity. Under a demand pull hypothesis, the relative demand of college graduates increases in expensive cities because their relative productivity increases there so that firms located in these cities increasingly seek to hire skilled labor. This can be due to localized skill-biased technical change or positive shocks to the demand faced by industries that employ college graduates and are located in expensive cities (for example, high tech, finance, etc.). In this case, a higher cost of housing does not reflect better amenities, and the increase in utility inequality is smaller than the increase in nominal wage inequality.

To formalize these two alternative hypotheses, I consider the simplest possible general equilibrium model of the labor and housing market. The model is a generalization of the Roback (1982) model and has two types of workers, skilled and unskilled. Like in Roback,

[22] A limitation of Local CPI 4 is that while I allow for within-metropolitan area differences in the type of housing consumed by workers belonging to different skill groups, I assign the same price of non-housing consumption to all groups. In reality, it is possible that different skill groups consume different types of non-housing goods. An additional concern is the possibility of differential changes in the unmeasured quality of housing for college graduates and high school graduates. I have repeated the analysis of Table 6 and found results that are generally similar.

in equilibrium workers and firms are indifferent between cities. But unlike Roback, housing supply is not necessarily fixed, so that productivity and amenity shocks are not necessarily 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.

4.1 Assumptions and Equilibrium

Assume that there are two cities: Detroit (city a) and San Francisco (city b). Each city is a competitive economy that produces a single output good y which is traded on the international market, so that its price is the same everywhere and set equal to 1. There are two types of workers: skilled workers (type H) and unskilled workers (type L).

I assume that workers and firms are perfectly mobile. This implies that in equilibrium workers need to be indifferent between living in Detroit and San Francisco. Similarly, firm profits need to be equalized across locations. Since in my empirical analysis I focus on long run changes (over a 20 year period), this assumption does not appear to be unrealistic. For simplicity, I also assume no human capital externalities and that the owners of land and capital live abroad.

I first focus on the case where skilled and unskilled workers in the same city work in different firms and live in different neighborhoods. This amounts to assuming away imperfect substitution between skilled and unskilled workers and the effect that shocks to skilled workers have on unskilled workers. This assumption greatly simplifies the analysis. Later, I show that results generalize when I relax this assumption. The production function for firms in city c that hire skilled workers is Cobb-Douglas with constant returns to scale:

$$\ln y_{Hc} = X_{Hc} + hN_{Hc} + (1-h)K_{Hc} \tag{4}$$

where N_{Hc} is the log of the number of skilled workers hired in city c; $c = a, b$; K_{Hc} is the log of capital and X_{Hc} is a productivity shifter. If firms are price takers and labor is paid its marginal product, the log of the wage of skilled workers, w_{Hc}, is

$$w_{Hc} = X_{Hc} - (1-h)N_{Hc} + (1-h)K_{Hc} + \ln h \tag{5}$$

Equation 5 represents the labor demand for skilled labor in city c. I assume that there is an international capital market, so that capital is infinitely supplied at price i. In equilibrium demand for capital is equal to its supply:

$$X_{Hc} - hK_{Hc} + hN_{Hc} + \ln(1-h) = \ln i \tag{6}$$

To keep things simple, I do not consider worker labor supply decisions and I assume that each worker provides one unit of labor. Similarly, I assume that each worker consumes one unit of housing. The indirect utility of skilled workers in city c is

$$U_{Hc} = w_{Hc} - r_{Hc} + A_{Hc} \tag{7}$$

where r_{Hc} is the cost of housing in city c in the neighborhoods where skilled workers live, and A_{Hc} is a local amenity.

In equilibrium it has to be the case that workers have the same level of utility in San Francisco and Detroit. This implies that skilled labor in San Francisco is supplied with infinite elasticity at the wage level

$$w_{Hb} = w_{Ha} + (r_{Hb} - r_{Ha}) - (A_{Hb} - A_{Ha}) \tag{8}$$

and that the (inverse of) the demand curve for housing in San Francisco is

$$r_{Hb} = (w_{Hb} - w_{Ha}) + r_{Ha} + (A_{Hb} - A_{Ha}) \tag{9}$$

An increase in the cost of housing in San Francisco or in the wage in Detroit lowers the supply of skilled workers in San Francisco. An increase in the cost of housing in Detroit or an increase in the amenity in San Francisco increases the supply of workers there.

I assume that the supply of housing is

$$r_{Hc} = z + k_c N_{Hc} \tag{10}$$

The slope parameter, k_c, represents how elastic the supply of housing is in city c. I assume that this parameter is exogenously determined by geography and local land regulations. In cities where geography and regulations make it is easy to build new housing, k_c is small. In the extreme case where there are no constraints to building new houses, the supply curve is horizontal, and k_c is zero. In cities where geography and regulations make it difficult to build new housing, k_c is large. In the extreme case where it is impossible to build new houses, the supply curve is vertical, and k_c is infinite.[23] Finally, I assume that the number of workers in the economy is fixed.

In period 1, the two cities are identical. Equilibrium in the labor market for skilled workers is obtained by equating equation 5 and 8. Equilibrium in the housing market for skilled workers is obtained by equating equation 9 and 10. Because of the assumptions on the technology, profits are always zero, so that firms are indifferent between cities. The labor and housing markets for unskilled workers are similar. For example, the city-level production for firms that hire unskilled workers is $y_{Lc} = X_{Lc} N_{Lc}^{h} K_{Lc}^{1-h}$.

4.2 Demand Pull

I consider two scenarios. In the first scenario, the productivity of skilled workers increases relative to the productivity of unskilled workers in San Francisco. Nothing happens to the productivity of unskilled workers in San Francisco and the productivity of skilled and unskilled workers in Detroit. In other words, the relative demand for skilled labor increases in San Francisco. The amenities in the two cities are identical and fixed.

[23] Equation 10 ignores the durability of housing–i.e. the fact that once built, housing does not depreciate quickly (Glaeser and Gyourko, 2001).

Formally, I assume that in period 2, the productivity shifter for skilled workers in San Francisco is higher than in period 1: $X_{Hb2} = X_{Hb1} + \Delta$, where $\Delta > 0$ represents a positive, localized, skill-biased productivity shock. I have added subscripts 1 and 2 to denote periods 1 and 2. The dot-com boom experienced by the San Francisco Bay Area is arguably an example of such 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) in San Francisco in the second half of the 1990s.

How the Equilibrium Changes. Attracted by higher labor demand, skilled workers move to San Francisco. The number of skilled workers in San Francisco increases by

$$N_{Hb2} - N_{Hb1} = \frac{\Delta}{k_a + k_b} \tag{11}$$

The number of skilled workers in Detroit declines by the same amount. What happens to wages and rents? In San Francisco, the nominal wage of skilled workers increases by an amount Δ equal to the productivity increase

$$w_{Hb2} - w_{Hb1} = \Delta \tag{12}$$

while rents increase by a fraction of Δ:

$$r_{Hb2} - r_{Hb1} = \frac{k_b}{k_a + k_b}\Delta \tag{13}$$

In Detroit, nominal wages for skilled workers do not change.[24] Because of the decline in the number of workers, the cost of housing in Detroit declines:

$$r_{Ha2} - r_{Ha1} = -\frac{k_a}{k_a + k_b}\Delta \tag{14}$$

In equilibrium workers are indifferent between cities. Real wages and utility of skilled workers increase by the same amount in San Francisco and Detroit:

$$(w_{Hb2} - r_{Hb2}) - (w_{Hb1} - r_{Hb1}) = (w_{Ha2} - r_{Ha2}) - (w_{Ha1} - r_{Ha1}) = \frac{k_a}{k_a + k_b}\Delta \tag{15}$$

Firms are also indifferent between cities. Because of the assumptions on technology, firms have zero profits in both cities. While skilled labor is now more expensive in San Francisco, it is also more productive there. Because firms produce a good that is internationally traded,

[24] This may look surprising at first. Given that the supply of skilled workers has declined, and that the demand curve is downward sloping, one might expect an increase in wages of those workers who stay in Detroit. Indeed, this would be true in a model without capital. But in a model that includes capital, the amount of capital increases in San Francisco ($K_{Hb2} - K_{Hb1} = \frac{\Delta}{k_a + k_b}$) and decreases in Detroit ($K_{Ha2} - K_{Ha1} = -\frac{\Delta}{k_a + k_b}$). This capital flow off-sets the decline in labor supply in Detroit, so that there is no change in the wage in Detroit.

if skilled workers weren't more productive, employers would leave San Francisco and relocate to Detroit.

Who Benefits? In this model, the benefit of the increase in workers' productivity, Δ, is split between workers and landowners. The fraction of Δ that goes to workers depends on the relative elasticity of housing supply in the two cities. To see this, note that the change in real wages in equation 15 depends on k_a and k_b, which are the elasticities of supply of housing in Detroit and San Francisco. Two special cases are of interest.

1. In the extreme case where the supply of housing in San Francisco is perfectly inelastic ($k_b = \infty$), all the benefit of the productivity increase goes to landowners in San Francisco. Workers' utility does not change. This case is the one described in Roback (1982). Housing costs and nominal wages in San Francisco increase by the same amount Δ. Because the supply of housing is fixed, the number of skilled workers in San Francisco can not change. Since there is no migration from Detroit to San Francisco, nothing happens to labor or housing prices in Detroit. (Another special case where all the rent resulting from the productivity shock accrues to landowners in San Francisco is when the elasticity of supply of housing in Detroit is infinite so that $k_a = 0$.)

2. At the other extreme is the case where the elasticity of supply of housing in San Francisco is infinite ($k_b = 0$). In this case, all the benefit of the productivity increase goes to workers. Real wages in San Francisco and Detroit grow by Δ. Landowners in San Francisco are indifferent, while landowners in Detroit experience a loss equal to Δ due to the decline in demand for housing. (Another special case where all the rent resulting from the productivity shock accrues to workers is when the housing supply in Detroit is perfectly inelastic so that $k_a = \infty$.)

Distribution of the Shocks. Consistent with the empirical evidence in Section 3, in the demand pull scenario the nominal wage averaged across the two cities increases for skilled workers.[25] Furthermore, this increase is larger than the increase in the real wage averaged across the two cities for skilled workers, unless in period 1 skilled workers in San Francisco have much lower productivity than skilled workers Detroit.[26] In other words, for localized skill biased demand shocks to be consistent with my empirical evidence in Section 3, these shocks can not be concentrated in cities with a small initial share of college graduates. Consistent with this notion, Figure 1 has shown that increases in the number of college graduates are more concentrated among cities that have a large initial share of college graduates. Also consistent with this notion, 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

[25] This increase is equal to $\frac{\Delta(2X_{Hb}+hNk_a-2X_{Ha}+h\Delta)}{h(k_b+k_a)N}$.

[26] Formally, $X_{Ha} < X_{Hb} + (h\Delta)/2$.

with a higher than average initial share of college graduates and cost of housing. Similarly, Berry and Glaeser (2005) show evidence consistent with a model of urban agglomeration where the number of entrepreneurs is a function of the number of skilled people working in an area. If skilled people are more likely to innovate in ways that employ other skilled people, this creates an agglomeration economy where skilled people want to be around each other.

Before proceeding, it is important to highlight that the model in this Section focuses on the case where the housing market for skilled workers is separated from the housing market for unskilled workers in the same city. This assumption has the advantage of making the model very simple and transparent. It has the disadvantage that skilled and unskilled workers in a city do not compete for the same set of houses, and therefore shocks to the relative demand or supply of skilled workers have no effect on unskilled workers in the city. I also assume that the labor supply in each city is infinitely elastic. In Appendix 1, I show that the the qualitative results of the model hold when the housing market is integrated—i.e. skilled and unskilled workers in a city compete for the same set of houses—and the labor supply in a city is not infinitely elastic but is upward sloping.[27]

4.3 Supply Push

In the case of demand pull described above, the number of skilled workers in San Francisco increases because the relative demand of skilled workers increases. 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 more desirable for skilled workers relative to Detroit. I assume that in period 2, the amenity level increases in San Francisco: $A_{Hb2} = A_{Hb1} + \Delta'$, where $\Delta' > 0$ now represents the improvement in the amenity. I assume that the productivity of both skilled and unskilled workers, as well as the amenity level in Detroit, do not change.[28]

How the Equilibrium Changes Like for the case of demand pull above, $\frac{\Delta'}{k_a+k_b}$ skilled workers move from Detroit to San Francisco. As before, the cost of housing increases in San Francisco (by the amount in equation 13) and declines in Detroit (by the amount in equation

[27]Another assumption of the model is that skilled and unskilled workers are employed by different firms. The model generalizes to the case where skilled and unskilled worker can work in the same firm. In this case, the productivity of unskilled workers may increase when the number of skilled workers in the same firm increases because of complementarities between skilled and unskilled labor.

[28]For simplicity, I have assumed that supply shocks are driven by increases in amenities for given tastes. Glaeser and Tobio (2007) have a model that makes a similar assumption. Alternatively I could assume that (i) amenities are fixed, but the taste for those amenities increase; or (ii) 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).

14). Also, similar to before, the nominal wage in Detroit does not change.

A key difference with the case of demand pull is that the nominal wage of skilled workers in San Francisco remains unchanged. This may be surprising at first. While one expects wage *increases* in response to demand increases (this is exactly what happens in subsection 4.2), one expects wage *decreases* in response to supply increases. Why nominal wages do not decline in San Francisco after it has become more attractive? After all, skilled workers should be willing to pay a compensating differential in the form of lower nominal wages to live in the more desirable city. Indeed, this is what the Roback (1982) model would predict. But the Roback model ignores the endogenous reaction of capital. In a model with capital, nominal wages do not move in San Francisco because capital flows to San Francisco and leaves Detroit, offsetting the changes in labor supply in the two cities.[29] Workers in both cities experience an increase in utility equal to $\frac{k_a}{k_a+k_b}\Delta'$. The two special cases described in subsection 4.2 apply to this scenario as well. As mentioned above, in Appendix 1, I discuss a more general model where the housing market is integrated, and labor supply in a city is not infinitely elastic. The results are similar.

Distribution of the Shocks. In this scenario, the mean nominal wage across the two cities increases for skilled workers only if improvements in amenities are concentrated in cities with high initial wages for skilled workers. The intuition is simple. Under the supply push hypothesis, the nominal wage of skilled workers in San Francisco and Detroit does not change. However, if San Francisco has higher nominal wages to begin with, the shift of skilled workers from Detroit to San Francisco results in higher mean nominal wage across the two cities for skilled workers. In other words, for the supply push scenario to be consistent with the nationwide increase in nominal wage inequality documented in Section 3, cities that experience increases in the relative supply of college graduates in the 1980-2000 period need to be cities with high initial nominal wages in 1980.

5 Interpreting the Evidence: Demand Pull or Supply Push?

5.1 Different Implications for Inequality

The analysis in subsections 4.2 and 4.3 suggests that *for a given nation-wide increase in the nominal wage gap*, the demand pull hypothesis implies a more limited increase in utility inequality, while the supply push hypothesis implies a larger increase in utility inequality.[30]

[29] The amount of capital increases in San Francisco by $K_{Hb2} - K_{Hb1} = \frac{\Delta'}{k_a+k_b}$ and decreases in Detroit by $K_{Ha2} - K_{Ha1} = -\frac{\Delta'}{k_a+k_b}$.

[30] The ratio of the increase in worker's utility over the increase in mean nominal wage across the two cities is $\frac{Nk_a h}{2(X_{Hb}-X_{Ha})+h(Nk_a+\Delta)}$ for the demand pull case and $\frac{Nk_a h}{X_{Hb}-X_{Ha}}$ for the supply push case. It is clear that the latter is larger than the former.

The intuition is simple. 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 increase in nominal wage is offset by the higher cost of living. In this case, the increase in their utility level is smaller than the increase in their nominal wage.

On the other hand, 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.

It is important to note 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 viceversa. 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 turns 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 2004a, 2004b).

It is also important to point out that, while the focus of the paper is on wage inequality, 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 the demand and supply shocks. In the model, some landowners benefit from the demand and supply shocks (namely those in San Francisco), while other are hurt (namely those in Detroit). The relevant empirical question in this respect is which of the two skill groups owns the land in the marginal neighborhood that is gentrified by the inflow of college graduates in cities that experience positive shocks and the marginal neighborhood that is abandoned by the outflow of college graduates from cities that experience negative shocks. A full empirical treatment of this issue is beyond the scope of this paper and is left for future research.

5.2 Demand or Supply? Empirical Evidence

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 in subsections 4.2 and 4.3 suggests that the demand pull and the supply push hypotheses have similar predictions for 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 relative nominal wage of college graduates. Under the supply push hypothesis, there should be no relationship between increases in the share of college graduates and changes in the relative nominal wages. Intuitively, increases in the relative demand of a factor of production in a city should result in increases in its relative price there. Increases in the relative supply of factor of production in a city should cause its relative price to decline, or at least not to increase.

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. The finding of a positive coefficient indicates that relative demand shifts are important, but does not rule out the existence of relative supply shifts. Second, to shed more light on whether relative supply shifts are important, I use an instrumental variable strategy.

(1) First, in Figure 3, I show the empirical relationship between the college share and the 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. 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 7 quantify the corresponding regression coefficients. 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: .388 (.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. While Figure 3 and Table 7 indicate that demand factors are important, they can not rule out that supply shocks are also present.

It is important to point out that the relationship between college premium and college share is *not causal*. Rather, it is an *equilibrium* relationship. 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 estimate different specifications.[31] What I am measuring in Figure 3

[31] 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

and Table 7 is the relationship between the wage gap and the college share, inclusive of any human capital spillover.

(2) The evidence above suggests that demand factors are important, but does not rule out that supply factors are also present. As a second piece of evidence that may shed more light on whether relative supply factors play any 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:

$$\text{Change in Relative Demand in City c} = \sum_s \eta_{sc}(\Delta E_{Hs} - \Delta E_{Ls}) \tag{16}$$

where η_{sc} is the share of jobs in industry s in city c in 1980; ΔE_{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); ΔE_{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 4. 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 is .42(.02), with R^2 of .44. This means that at least 44% of the variation in changes in college share can be attributed to *observable* demand shocks. (Of course, there are other demand shocks that are not captured by the instrument.)

The instrumental variable estimate, in column 3 of Table 7, is .371 (.106) and is remarkably close to the OLS estimate. The similarity between the OLS and the IV estimates

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.

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). In other words, most of the empirical correlation between the college share and the college premium that is observed in the data seems to be driven by demand shocks.

6 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% in nominal terms and only 51% 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% 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 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. I also present an instrumental variable estimate obtained by instrumenting changes in college share with a measure of arguably exogenous relative demand shocks.

The weight of the evidence seems consistent with the notion that changes in the geographical location of different skill groups are mostly driven by changes in their relative demand. I conclude that the increase in well-being disparities between 1980 and 2000 is smaller than the increase in nominal wage disparities that has been the focus of the previous literature.[32]

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 and 2004b; Greenstone, Hornbeck and Moretti, 2007). 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 that 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.

In interpreting the findings of this paper, three points are worth highlighting. First, consistent with the previous literature on inequality, the main focus this paper is on *wage* differences. 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. 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 beyond the scope of this paper.

Second, my analysis does not take into consideration features of jobs other than wages. Hamermesh (1999) shows that the amount of workplace disamenties (such as risk of death or workplace injury) born by low skill workers increased more than the amount of workplace disamenties born by high skill workers during the 1980's. This differential change implies a larger increase in well-being inequality than the one measured ignoring workplace disamenties, although the bias is likely to be limited for the typical workers.

Finally, the return to college is but one measure of wage inequality. Although it has received much attention in the literature on inequality, future research should determine

[32]My results have the potential to explain 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.

whether the results in this paper extend to other measures of inequality.

7 Bibliography

Aguiar, Mark and Erik Hurst "The Increase in Leisure Inequality", mimeo (2007a).

Aguiar, Mark and Erik Hurst, "Measuring Trends in Leisure: The Allocation of Time Over Five Decades", Quarterly Journal of Economics (2007b).

Autor, David, Lawrence F. Katz and Alan B. Krueger, 1998. "Computing Inequality: Have Computers Changed The Labor Market?," The Quarterly Journal of Economics, MIT Press, vol. 113(4), pages 1169-1213, November

Bayer, Patrick, Robert McMillan, and Kim Rueben "An Equilibrium Model of Sorting in an Urban Housing Market" NBER Working Paper 10865

Bayer, Patrick, Shakeeb Khan, Christopher Timmins "Nonparametric Identification and Estimation in a Generalized Roy Model", NBER Working Paper 13949

Bayer, Patrick, and Christopher Timmins "Estimating Equilibrium Models of Sorting Across Locations" Economic Journal, March 2007

Bayer, Patrick, and Robert McMillan "Racial Sorting and Neighborhood Quality," NBER Working Paper 11813

Basker, Emek "Selling a Cheaper Mousetrap: Wal-Mart's Effect on Retail Prices", JUE 2005, which uses the average prices of drugstore items in selected cities for 1982-2002 and

Baum-Snow Nathaniel and Ronni Pavan Inequality and City Size Brown University, mimeo, 2009.

Beaudry, Paul, Mark Doms and Ethan Lewis "Should the PC be Considered a Technological Revolution? City Level Evidence from 1980-2000", mimeo (2008)

Black, Dan, Natalia Kolesnikova, and Lowell J. Taylor, "Earnings Functions When Wages and Prices Vary by Location", Journal of Labor Economics, 2009.

Black, Dan, Natalia Kolesnikova, and Lowell J. Taylor, Local Price Variation and Labor Supply Regional Economic Development 4(1) October 2008 2-14.

Black, Dan, Natalia Kolesnikova, and Lowell J. Taylor, "Why Do So Few Women Work in New York (and So Many in Minneapolis)? Labor Supply of Married Women Across U.S. Cities" Federal Reserve Bank of St Louis Working Paper (2007)

Black, Dan, Natalia Kolesnikova, and Lowell J. Taylor, S. Sanders, and M. Wessel A Divergent View on Black-White Earnings Convergence, Mimeo, University of Chicago (2009).

Blanchard Olivier Jean and Lawrence F. Katz, 1992. "Regional Evolutions," Brookings Papers on Economic Activity, Economic Studies Program, The Brookings Institution, vol. 23(1992-1), pages 1-76.

Blundell, R, L. Pistaferri and I. Preston, "Consumption inequality and partial insurance"

American Economic Review 2008

John Bound and George Johnson, Changes in the structure of wages in the 1980s: an evaluation of alternative explanations, American Economic Review 82 (1992).

Bound, John and Holzer, Harry J, 2000. "Demand Shifts, Population Adjustments, and Labor Market Outcomes during the 1980s," Journal of Labor Economics, University of Chicago Press, vol. 18(1), pages 20-54, January.

Buera, Francisco J. and Joseph P. Kaboski "The Rise of the Service Economy", NBER Working Paper No. 14822 (2009)

Bureau of Labor Statistics, "Handbook of Methods", June 2007.

Chen, Tong and Stuart S. Rosenthal "Local Amenities and Migration Over the Life Cycle: Do People Move for Jobs or Fun?" Journal of Urban Economics, forthcoming.

Dora L. Costa and Matthew E. Kahn, 2000. "Power Couples: Changes In The Locational Choice Of The College Educated, 1940-1990," The Quarterly Journal of Economics, MIT Press, vol. 115(4), pages 1287-1315, November.

Dahl, Gordon "Mobility and the Return to Education: Testing a Roy Model with Multiple Markets," Econometrica, Vol. 70, No. 6, pp. 2367-2420, (2002).

Glaeser, E, Gyourko, J. and R. Saks (2005) Why Have Housing Prices Gone Up? American Economic Review, forthcoming

Glaeser, E. and C. Berry, "The Divergence of Human Capital Levels across Cities" Harvard Institute of Economic Research Discussion Paper Number 2091 (2005)

Goldin Claudia and Lawrence F. Katz, 2007. "Long-Run Changes in the U.S. Wage Structure: Narrowing, Widening, Polarizing," NBER Working Papers 13568, National Bureau of Economic Research, Inc

Gordon, Robert "Has the Rise in American Inequality Been Exaggerated?" forthcoming in Challenge, May-June 2009. Longer version presented at ASSA Meetings, San Francisco CA, January 3, 2009.

Gordon, Robert and Ian Dew-Beker "Controversies About the Rise of American Inequality: A Survey", NBER WP 13982, 2008.

Gordon, Robert and Ian Dew-Beker "Selected Issues in American Inequality". Brookings Papers on Economic Activity, 2007, no. 2, pp. 169-92.

Gordon, Robert and Ian Dew-Beker Where Did the Productivity Growth Go? Inflation Dynamics and the Distribution of Income, Brookings Papers on Economic Activity, vol. 36 (2005, no. 2), pp. 67-150 . NBER Working Paper 11842, December 2005.

Gottschalk, Peter and Robert Moffitt (1994), The Growth of Earnings Instability in the U.S. Labor Market, Brookings Papers on Economic Activity, No. 2, 217-272.

Gottschalk, Peter and Robert Moffitt "Trends in the Transitory Variance of Earnings in the United States", Economic Journal, March 2002

Greenstone M., R. Hornbeck and E. Moretti "Identifying Agglomeration Spillovers: Evidence from Million Dollar Plants", University of California, Berkeley (2007).

Grogger, Jeff "Changes in College Skills and the Rise in the College Wage Premium." Journal of Human Resources 30, no. 2, Spring 1995, 280-310.

Gyourko, Joseph, Christopher Mayer, and Todd Sinai. Superstar Cities, Mimeo, The Wharton School, Revised, June 2006

Gyourko, Joseph "Housing Supply," Wharton Real Estate Center Working Paper, August 2008

Hamermesh, Dan "Demand for Labor," in International Encyclopedia of the Social and Behavioral Sciences, Pergamon Press, 2001.

Hamermesh, Dan "Changing Inequality in Markets for Workplace Amenities," Quarterly Journal of Economics, November 1999.

Hamermesh, Dan "A General Model of Dynamic Labor Demand," Review of Economics and Statistics, November 1992.

Heckman James, Lance Lochner and Christopher Taber, 1998. "Explaining Rising Wage Inequality: Explanations With A Dynamic General Equilibrium Model of Labor Earnings With Heterogeneous Agents," Review of Economic Dynamics, vol. 1(1), pages 1-58, January.

Heckman and Scheinkman "The Importance of Bundling in a Gorman-Lancaster Model of Earnings Author" Review of Economic Studies, 1987, 54 (2)

Jappelli, T. and L. Pistaferri, "Consumption and Income Inequality" (2008)

Kahn Matthew E., 1995. "A Revealed Preference Approach to Ranking City Quality of Life," Journal of Urban Economics, Elsevier, vol. 38(2), pages 221-235, September.

Kahn, Matthew E. 2005. "Estimating Housing Demand With an Application to Explaining Racial Segregation in Cities," Journal of Business and Economic Statistics, American Statistical Association, vol. 23, pages 20-33, January.

Kahn, Matthew E., 1999. "Climate consumption and climate pricing from 1940 to 1990," Regional Science and Urban Economics, Elsevier, vol. 29(4), pages 519-539, July.

Katz, Lawrence F and Murphy, Kevin M, 1992. "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," The Quarterly Journal of Economics, MIT Press, vol. 107(1), pages 35-78, February.

Katz L. and D. Autor "Changes in the Wage Structure and Earnings Inequality", Handbook of Labor Economics, Ashenfelter and Crad, Eds, Elsevier (1999).

Keane, M. R. Moffitt and D. Runkle ”Real Wages Over the Business Cycle: Estimating the Impact of Heterogeneity with Microdata” Journal of Political Economy, December 1988.

Krupka Douglas J. and Kwame Donaldson, “Wages, Rents and Heterogeneous Moving Costs,” IZA Discussion Papers 3224, Institute for the Study of Labor (2007)

Krupka, Douglas J. “Location-Specific Human Capital, Location Choice and Amenity Demand,” IZA Discussion Papers 2987, Institute for the Study of Labor (IZA) (2007).

Lewbel, Arthur and Krishna Pendakur, 2008, ”Tricks with Hicks: The EASI Implicit Marshallian Demand System for Unobserved Heterogeneity and Flexible Engel Curves.”, American Economic Review, forthcoming.

Lockner, Lance and Christopher Taber, 1999. “Human capital formation and general equilibrium effects” Fiscal Studies, Institute for Fiscal Studies, vol. 20(1), pages 25-40.

Moffitt, R., D. Ribar and M. Wilhelm ”The Decline of Welfare Benefits in the U.S.: The Role of Wage Inequality” Journal of Public Economics, June 1998

Moretti, Enrico “Estimating the Social Return to Higher Education: Evidence From Longitudinal and Repeated Cross-Sectional Data” Journal of Econometrics 121(1-2) (2004a)

Moretti, Enrico “Workers’ Education, Spillovers and Productivity: Evidence from Plant-Level Production Functions” American Economic Review 94(3) (2004b)

Roback, Jennifer “Wages, rents and the quality of Life”, Journal of Political Economy, 90-6, pp. 1257-1278 (1982)

Roback, Jennifer “Wages, Rents and Amenities: Differences Among Workers and Regions”, Economic Inquiry, 26-1, pp. 23-41 (1988).

Poole R., F. Ptacek and R. Verbrugge “The treatment of Owner-Occupied Housing in the CPI” (2006), Office of Price and Living Conditions, Bureau of Labor Statistics.

Shapiro, Jesse, ”Smart cities: Quality of life, productivity, and the growth effects of human capital” Review of Economics and Statistics, May 2006

Shapiro, Jesse ”Urban growth in the 1990s: Is city living back?” Journal of Regional Science, February 2003.

Appendix 1

In this appendix I change two assumptions of the model in Section 4. In Section 4, I assume that the housing market for skilled workers is separated from the housing market for unskilled workers in the same city. I also assume that labor supply in a city is infinitely elastic. Here I consider the case where the housing market is completely integrated—i.e. skilled and unskilled workers in a city compete for the same set of houses—and labor supply in a city is not infinitely elastic but rather upward sloping.

Assume that the indirect utilities of skilled and unskilled workers in city c are, respectively: $U_{Hic} = w_{Hc} - r_c + A_{Hc} + \epsilon_{ic}$ and $U_{Lic} = w_{Lc} - r_c + A_{Lc} + \epsilon_{ic}$, where ϵ_{ic} is i.i.d and $\epsilon_{ic} \sim U[-s, s]$. This utility differs from Section 4 in two respects. First, the cost of housing is now the same for skilled and unskilled workers living in city c: r_c. This implies that skilled and unskilled workers face the same housing market within a city, and that shocks to the relative demand or supply of skilled workers will affect unskilled workers in the city through housing costs. Second, the term ϵ_{ic} allows for idiosyncratic preferences for a city. All the other assumptions remain unchanged.

A skilled worker chooses to live in city b if $w_{Hb} - r_b + A_{Hb} + \epsilon_{ib} > w_{Ha} - r_a + A_{Ha} + \epsilon_{ia}$. A similar expression holds for unskilled workers. If there are N unskilled workers and N skilled workers in the economy, the inverse labor supplies of the skilled and unskilled workers in city b are, respectively:

$$w_{Hb} = \frac{N_{Hb}}{q} - \frac{N}{2q} + w_{Ha} - r_a + r_b \tag{17}$$

and

$$w_{Lb} = \frac{N_{Lb}}{q} - \frac{N}{2q} + w_{La} - r_a + r_b \tag{18}$$

where $q = N/2s$. Unlike Section 4, labor supply is upward sloping.

Demand Pull. Consider what happens when the productivity of skilled workers increases relative to the productivity of unskilled workers in San Francisco, and nothing happens to the productivity of skilled and unskilled workers in Detroit. Some skilled workers move from Detroit to San Francisco:

$$N_{Hb2} - N_{Hb1} = \frac{q(q(k_a + k_b) + 1)}{h(2q(k_a + k_b) + 1)}\Delta \tag{19}$$

where I have added subscripts 1 and 2 to denote periods 1 and 2. Some unskilled workers leave San Francisco for Detroit:

$$N_{Lb2} - N_{Lb1} = -\frac{q^2(k_a + k_b)}{h(2q(k_a + k_b) + 1)}\Delta \tag{20}$$

As in Section 4, both total population and the fraction of skilled workers in San Francisco (Detroit) increase (decrease). As before, the nominal wage of skilled workers in San Francisco increases

$$w_{Hb2} - w_{Hb1} = \frac{\Delta}{h} \tag{21}$$

The wage of unskilled workers in San Francisco and the wage of skilled and unskilled workers in Detroit does not change. Rents in San Francisco increase by

$$r_{b2} - r_{b1} = \frac{k_b q}{h(1 + 2q(k_a + k_b))}\Delta \tag{22}$$

while rents in Detroit decline by

$$r_{a2} - r_{a1} = -\frac{k_a q}{h(1 + 2q(k_a + k_b))}\Delta \tag{23}$$

As in Section 4, it is possible to show that the difference between the nominal wage of skilled workers averaged across the two cities and the nominal wage of unskilled workers averaged across the two cities increases. Furthermore, such an increase is larger than the increase in the difference between the real wage of skilled workers averaged across the two cities and the real wage of unskilled workers averaged across the two cities.[33]

Supply Push. Consider now what happens when San Francisco becomes more desirable for skilled workers relative to Detroit because the amenity that attracts skilled workers increases there. The productivity of both skilled and unskilled workers, as well as the amenity level in Detroit, do not change. The number of skilled workers who move from Detroit to San Francisco is

$$N_{Hb2} - N_{Hb1} = \frac{q(q(k_a + k_b) + 2)}{2q(k_a + k_b) + 1}\Delta' \tag{24}$$

The number of unskilled workers who leave San Francisco to Detroit is

$$N_{Lb2} - N_{Lb1} = -\frac{q(q(k_a + k_b) - 1)}{2q(k_a + k_b) + 1}\Delta' \tag{25}$$

The nominal wages of skilled and unskilled workers do not change. Rents in San Francisco increase by

$$r_{b2} - r_{b1} = \frac{(q(4k_b - 2k_a) - 1)}{2(1 + 2q(k_a + k_b))}\Delta' \tag{26}$$

while rents in Detroit decline by

$$r_{a2} - r_{a1} = -\frac{(q(4k_a - 2k_b) - 1)}{2(1 + 2q(k_a + k_b))}\Delta' \tag{27}$$

As before, the difference between the nominal wage of skilled and unskilled workers averaged across the two cities increases more than the difference between the real wage of skilled and unskilled workers averaged across the two cities, if the elasticity of housing supply in San Francisco is not much larger than the elasticity of housing supply in Detroit.

[33] As before, this is true if the elasticity of housing supply in San Francisco is not much larger than the elasticity of housing supply in Detroit.

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
Metropolitan Areas with the Largest College Share in 2000				
Stamford, CT	.58	.26	1109	759
San Jose, CA	.48	.15	1231	892
Washington, DC/MD/VA	.48	.08	834	532
Boston, MA-NH	.45	.17	854	556
San Francisco-Oakland-Vallejo, CA	.44	.12	1045	724
Ann Arbor, MI	.43	.02	724	417
Columbia, MO	.43	.06	485	239
Raleigh-Durham, NC	.42	.12	669	427
Fort Collins-Loveland, CO	.42	.10	693	419
Trenton, NJ	.41	.14	776	494
Metropolitan Areas with the Smallest College Share in 2000				
Ocala, FL	.15	.02	514	285
Williamsport, PA	.15	.04	434	229
Lima, OH	.15	.05	444	226
Hickory-Morgantown, NC	.15	.02	486	286
Johnstown, PA	.14	.01	370	165
Flint, MI	.14	.01	481	217
Vineland-Milville-Bridgetown, NJ	.13	.01	617	368
Mansfield, OH	.13	.01	460	242
Visalia-Tulare-Porterville, CA	.13	.00	495	270
Danville, VA	.12	.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 2 or 3 bedroom apartment.

Table 2: Relative Importance of the Main Aggregate Components in the BLS Consumer Price Index (CPI-U)

Housing	42.7%	
Shelter		32.8%
Fuels 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%	

Notes: Entries are the share of the main aggregate components of the CPI-U. For more disaggregated categories see Appendix 4 in Chapter 17 of the Bureau of Labor Statistics's "Handbook of Methods" (2007).

Table 3: Changes in the Cost of Living, by Education Group

	1980 (1)	1990 (2)	2000 (3)	Percent Increase 1980-2000 (4)
Official CPI				
High-School	1	1.53	2.02	102%
College	1	1.53	2.02	102%
Percent Difference	0	0	0	
Monthly Rent				
High-School	247	432	563	127%
College	259	491	642	147%
Percent Difference	4%	11%	14%	
Local CPI 1				
High-School	0.99	1.49	1.95	96%
College	1.01	1.58	2.07	105%
Percent Difference	2%	4%	6%	
Local CPI 2				
High-School	0.98	1.57	2.04	108%
College	1.01	1.71	2.22	119%
Percent Difference	3%	7%	9%	

Notes: Monthly rent refers to the rent paid for a two or three bedroom apartment. 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 non-housing goods and services.

Table 4: 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)
Model 1								
Nominal Wage Difference	.40	.53	.60	.20	.35	.47	.53	.18
	(.011)	(.012)	(.013)		(.007)	(.006)	(.007)	
Model 2								
Real Wage Difference - Local CPI 1	.38	.48	.53	.15	.37	.46	.52	.15
	(.010)	(.008)	(.008)		(.008)	(.006)	(.007)	
Percent of Nominal Increase Accounted for by Cost of Living				25%				17%
Model 3								
Real Wage Difference - Local CPI 2	.37	.45	.51	.14	.37	.46	.51	.14
	(.009)	(.008)	(.008)		(.008)	(.006)	(.007)	
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 to 8 also include MSA fixed effects. Sample size is 5,024,221.

Table 5: Additional Specifications

	1980	1990	2000	1980-2000 Increase	Percent of Nominal Increase Accounted for by Cost of Living
	(1)	(2)	(3)	(4)	(5)
Model 1: ACCRA Non-Housing Prices					
Nominal Wage Difference	.40	.53	.60	.20	
	(.015)	(.009)	(.010)		
Real Wage - ACCRA price Index	.39	.48	.54	.15	25%
	(.012)	(.006)	(.006)		
Model 2: Include Commuting Time					
Nominal Wage Difference	.40	.54	.60	.20	
	(.010)	(.009)	(.011)		
Real Wage - Local CPI 1	.38	.48	.53	.15	25%
	(.008)	(.006)	(.007)		
Real Wage - Local CPI 2	.37	.45	.51	.14	30%
	(.008)	(.007)	(.007)		
Model 3: Include Workers with Less Than 48 Weeks					
Nominal Wage Difference	.43	.57	.62	.19	
	(.009)	(.010)	(.012)		
Real Wage - Local CPI 1	.42	.52	.56	.14	26%
	(.008)	(.007)	(.008)		
Real Wage - Local CPI 2	.41	.49	.53	.12	37%
	(.007)	(.007)	(.007)		
Model 4: Include Immigrants					
Nominal Wage Difference	.40	.54	.61	.21	
	(.011)	(.012)	(.013)		
Real Wage - Local CPI 1	.39	.49	.55	.16	24%
	(.010)	(.009)	(.010)		
Real Wage - Local CPI 2	.38	.46	.52	.14	33%
	(.010)	(.010)	(.010)		
Model 5: Only Urban Workers					
Nominal Wage Difference	.40	.52	.60	.20	
	(.011)	(.008)	(.010)		
Real Wage - Local CPI 1	.39	.49	.55	.16	20%
	(.010)	(.007)	(.007)		
Real Wage - Local CPI 2	.38	.47	.53	.15	25%
	(.010)	(.007)	(.007)		

Notes: Standard errors clustered by metropolitan area in parentheses.

Table 6: Nominal and Real Conditional Earnings Difference Controlling for Quality of Housing, by Year - American Housing Survey

	1980	1990	2000	1980-2000 Increase	Percent of Nominal Increase Accounted for by Cost of Living
	(1)	(2)	(3)	(4)	(5)
Nominal Earnings Difference	.37	.47	.56	.19	
	(.019)	(.008)	(.010)		
Real Earnings Difference - Not Controlling for Quality					
Real Earnings - Local CPI 1	.36	.45	.52	.16	15%
	(.010)	(.006)	(.010)		
Real Earnings - Local CPI 2	.35	.44	.51	.16	15%
	(.013)	(.006)	(.010)		
Real Earnings Difference - Controlling For Quality					
Real Earnings - Local CPI 1	.35	.43	.50	.15	21%
	(.012)	(.007)	(.012)		
Real Earnings - Local CPI 2	.34	.42	.49	.15	21%
	(.014)	(.009)	(.014)		

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 3 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).

Table 7: The Relation between Share of College Graduates and College Premium

	2000 Cross-section	1980-2000 Change	
	OLS	OLS	IV
	(1)	(2)	(3)
College Share	.375	.388	.371
	(.031)	(.070)	(.106)
R^2	.30	.10	

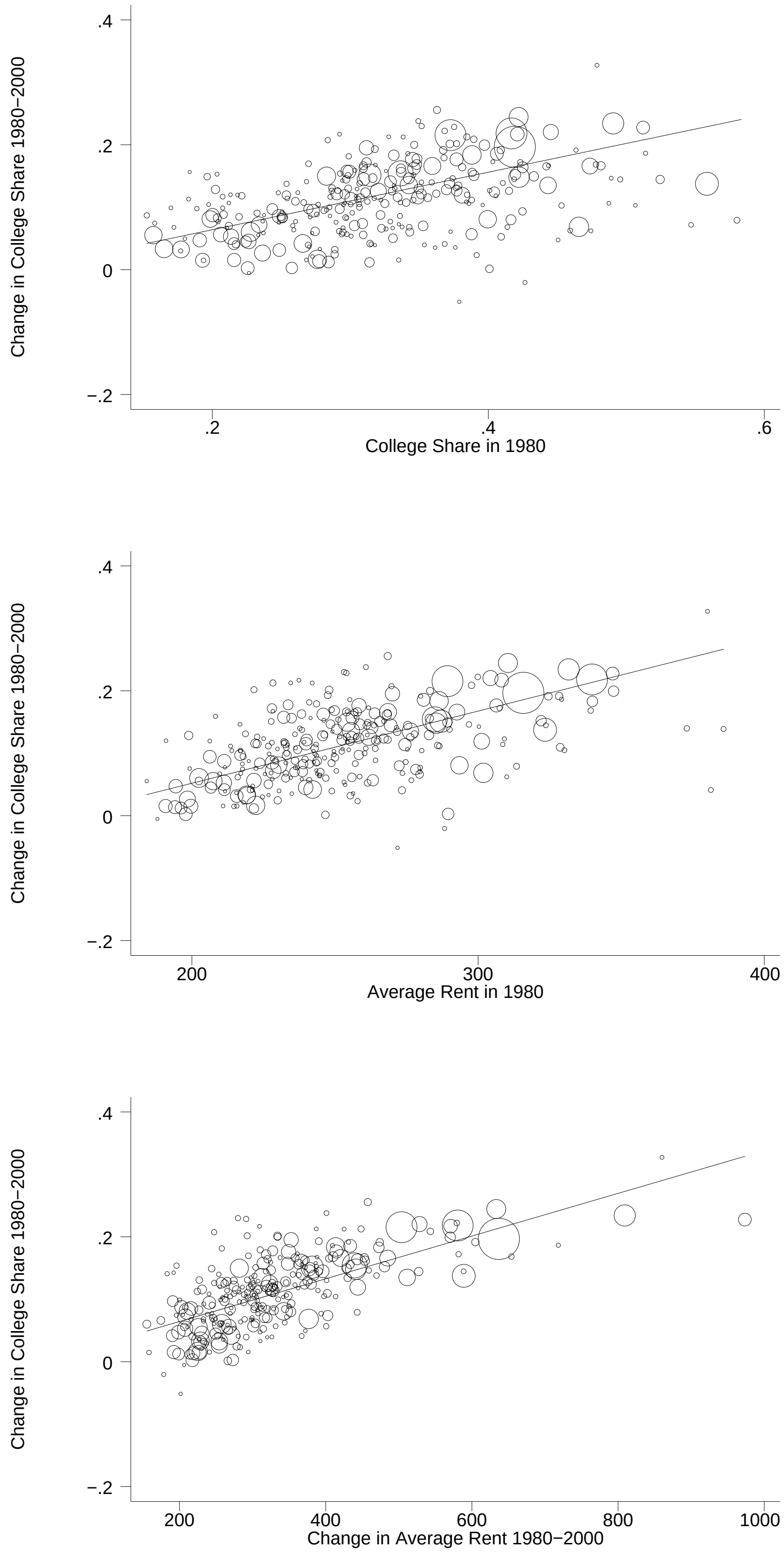
Notes: Standard errors in parentheses. The dependent variable in column 1 is the city-specific college premium, defined as the city-specific difference in the log of hourly wage for college graduates and high school graduates conditional on gender, a cubic in potential experience, race and year. The 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.

Appendix Table 1. Estimates Based on an Alternative Definition of Rental Cost

	1980	1990	2000	1980-2000 Increase	Percent of Nominal Increase Accounted for by Cost of Living
	(1)	(2)	(3)	(4)	(5)
Nominal Wage Difference	.39	.53	.59	.20	
	(.008)	(.012)	(.013)		
Real Wage - Local CPI 3	.32	.41	.44	.12	40%
	(.006)	(.005)	(.004)		
Real Wage - Local CPI 4	.28	.34	.38	.10	50%
	(.006)	(.006)	(.005)		

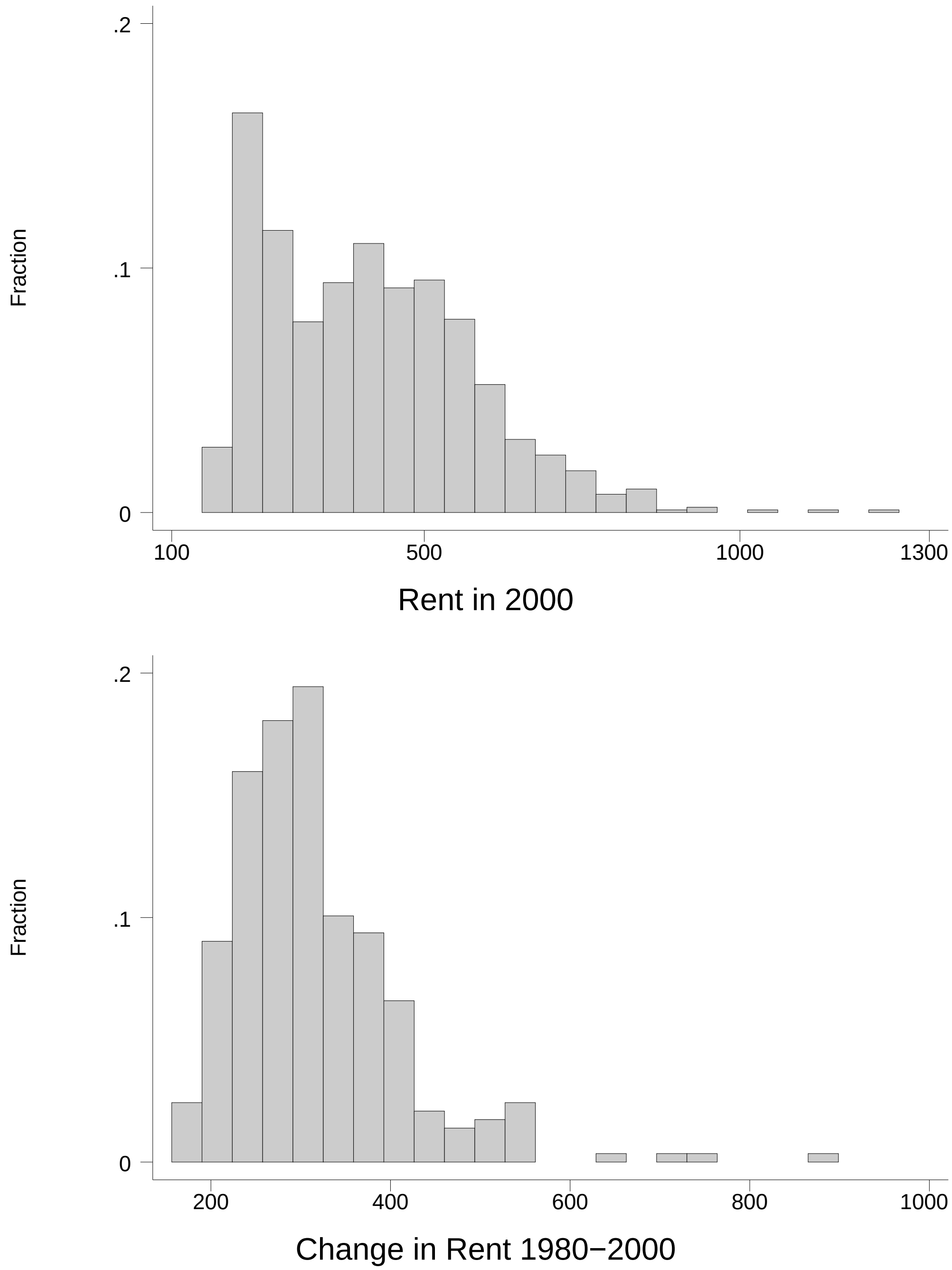
Notes: Standard errors clustered by metropolitan area in parentheses. The dependent variable in the first row is the log of nominal hourly wage. The dependent variable in the second and third row is the log of real hourly wage, where real hourly wage is the ratio of nominal wage and Local CPI 3 or Local CPI 4. In Local CPI 3 and 4, housing costs are allowed to vary by metropolitan area, skill group, race and number of children in the household. Local CPI 3 only uses local variation in cost of living that arises from variation in cost of housing. (The difference with Local CPI 1 is that in Local CPI 1 cost of housing varies only by MSA, while in Local CPI 3 cost of housing varies by MSA, education group, race and number of children.) Local CPI 4 uses local variation both in cost of housing and cost of non housing good and services. (The difference with Local CPI 2 is that in Local CPI 2 cost of housing varies only by MSA, while in Local CPI 4 cost of housing varies by MSA, education group race and number of children.) All models include dummies for gender and race, a cubic in potential experience, and year effects. Sample size is 4,920,703.

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



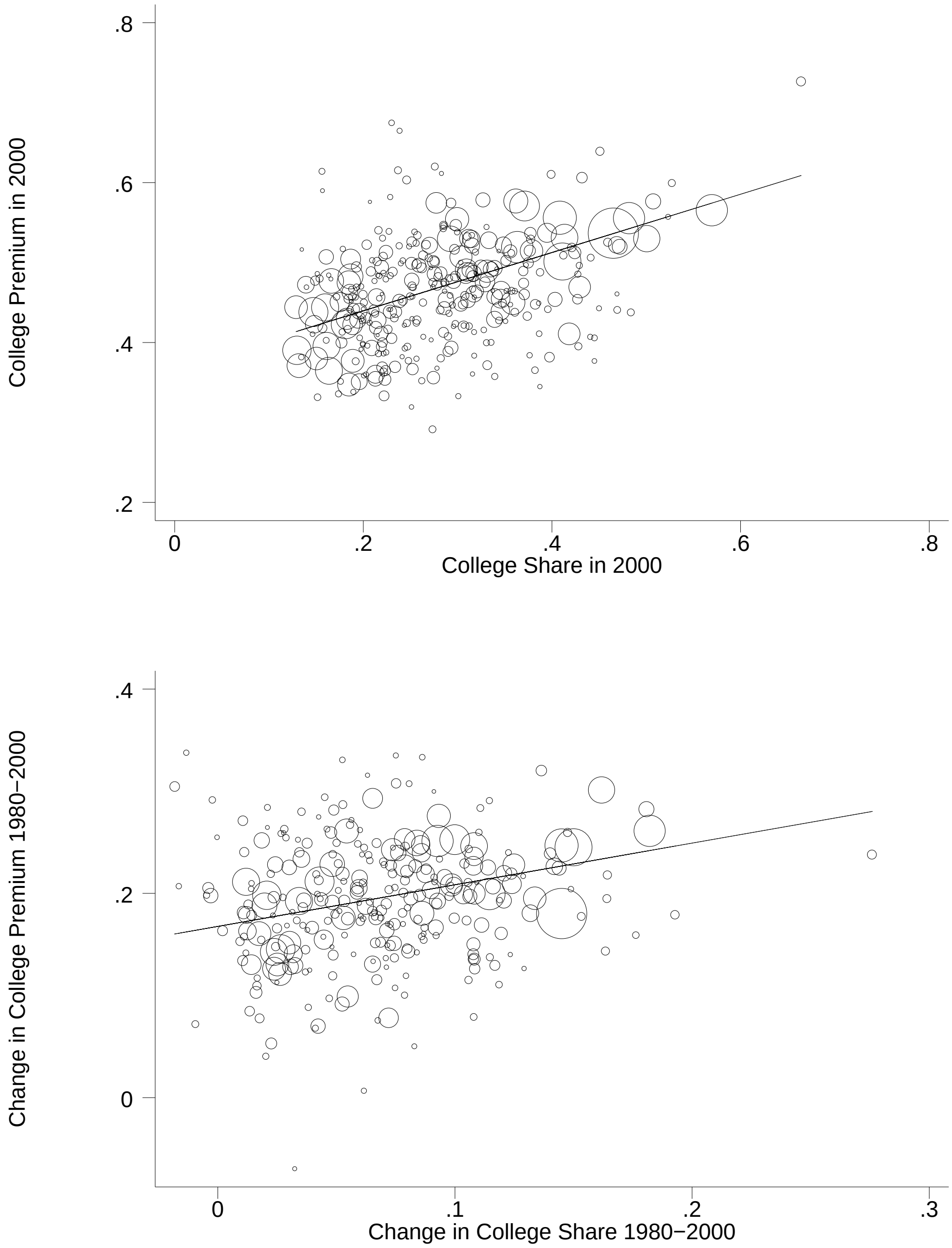
Notes: Average rent is the average monthly rental price of a two or three bedroom apartment.

Figure 2: The Distribution of Average Rental Costs Across Metropolitan Areas: 2000 Cross-Section and 1980-2000 Change



Notes: The top panel shows the distribution of the average cost of renting a 2 or a 3 bedroom apartment in year 2000. The bottom panel shows the distribution of the changes between 1980 and 2000 in the average cost of renting a 2 or a 3 bedroom apartment.

Figure 3: 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.

Figure 4: 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 16.