Discussion: "A Quantitative Analysis of the Evolution of the U.S. Wage Distribution: 1970–2000" by Fatih Guvenen and Burhanettin Kuruscu

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1 Introduction

This intensely ambitious paper sits astride the rugged border between labor economics and macroeconomics, and from this vantage, offers a comprehensive and remarkably parsimonious explanation for perhaps *all* of the key stylized facts describing the evolution of U.S. wage levels and wage inequality over the three decades between 1970 and 2000. To say that it doesn't succeed completely at this goal is akin to saying that not all of Columbus' ships arrived intact to America. Success in such a sweeping endeavor is rarely complete, but we must nevertheless admire the effort.

In these comments, I first lay out what I see as the five key facts about U.S. wage structure with which this paper attempts to grapple, and that any unifying theory of wage inequality must accommodate. I then lay out the standard workhorse model often used by labor economists to interpret these facts. This framework, attributable to Jan Tinbergen, is sometimes referred to as the "Education Race" model, following the excellent book by Goldin and Katz, which takes its title from a quotation by Tinbergen. I then compare the Guvenen-Kuruscu model (GK, hereafter) to the Education Race framework and consider how each model fares in explaining the key facts. With this comparison, I hope to highlight where both the GK and Education Race models hit the mark or fall short. My goal is not to declare a winner—it is not clear that either model even receives a qualifying score—but to underscore which major facts are well understood and which remain elusive. I begin with the facts.

2 Key facts on U.S. wage inequality

There are five main facts about U.S. wage and skill structure with which GK grapple.[1]

2.1 Rising wage dispersion

A first is the rising unconditional dispersion of U.S. wages. Figure A1, reproduced from Autor, Katz and Kearney (2008, AKK hereafter), plots the evolution of the 90/10 log wage gap for male workers for the period 1963 through 2005. The series labeled CPS March Full-Time refers to log weekly earnings of full-time, full-year workers, while the series labeled CPS May/ORG hourly refers to log hourly earnings of all non-self-employed workers. The latter series, which is generally considered more accurate, does not unfortunately become available until 1973. Nevertheless, both series tell a comparable story for the period in which they overlap. Male wage dispersion is either flat or rising modestly in the 1970s, begins rising sharply in 1981, continues at a fairly torrid pace to 1988, and then increases at a slower (but non-zero) rate through the end of the sample period.[2] The net rise

[1] These are not the only facts that they confront. But in my view, they are the most robust and important.

[2] The rate of growth after 1988 differs between the two series, and there is not a definitive explanation for their divergence. See Lemieux (2006) and Autor, Katz and Kearney (2005, 2008) for discussion.

in 90/10 inequality in this time period is substantial. The May/ORG and March series imply rises of 36 and 47 log points respectively during 1973 through 2005, starting from a base of 121 log points.[3] Residual wage inequality—that is, the inequality of log wage earnings remaining after netting out the estimated effects of education, sex, and potential experience using cross-sectional wage regressions estimated separately by year—followed a similar trajectory, though at reduced amplitude.[4]

2.2 The rising, falling and then rising return to education

A second key fact is the dramatic fluctuations over four decades in the college/high-school log earnings gap, which I'll call the college premium for brevity. The evolution of this premium is depicted in Figure A.2. The composition-adjusted college premium rose from 40 log points to 47 log points between 1963 and 1971, then dropped back to 40 log points by 1981, before beginning a steep ascent, coincident with the rapid rise in 90/10 inequality. The premium rose by 14 log points between 1980 and 1989, by 10 additional log points between 1989 and 1999, and by an additional 2.5 log points between 1999 and 2005. Thus, similar to the 90/10, there was a sudden, spectacular rise in the college premium commencing in the early 1980s. This rise then decelerated but did not reverse starting in the late 1980s. Unlike the 90/10, however, the college premium actually declined in the 1970s, whereas the 90/10 merely plateaued.

2.3 Age group differences in the rising college premium

Equally noteworthy is that the rise in the college premium was greater for young workers, those with 0 to 10 years of potential experience, than for prime age workers with 20-29 years of potential experience. This pattern, shown in Figure A3 (from AKK), is found in the U.S., U.K. and Canada, and ingeniously interpreted by Card and Lemieux (2001b).

2.4 Rising real wages at the top, falling real wages at the bottom

A fourth fact of considerable consequence for the evolution of the U.S. wage structure is that absolute wages *fell* for some groups—most notably, less educated males. Figure A4 shows trends in real log weekly wages for males within five mutually exclusive education groups, ranging from high-school dropouts to those with post-college education, during the years 1963 through 2005. Wages for

[3] Autor, Katz, and Kearney (2008) show that the evolution of the 90/10 ratio is driven by two different trends. From 1979 to 1988, both 90/50 and 50/10 wage inequality increase rapidly. After 1988, 90/50 wage inequality continues its near-linear expansion path through 2005 (the end of their sample) whereas the 50/10 ratio plateaus in 1988 and then reverses somewhat thereafter. Thus, the deceleration in the growth of the 90/10 ratio is driven by a reversal of lower-tail inequality in combination with ongoing expansion of upper-tail inequality.

[4] Indeed, the comparable trajectory of residual and overall wage inequality in the CPS May/ORG series has led some researchers to conclude that these are really one phenomenon (see Lemieux, 2006). I say more about this below.

each group are normalized at zero in 1963, with subsequent data points representing the difference in real log wage levels between the current year and the 1963 baseline.

Real wage levels rose in unison for all 5 education groups from 1963 to 1973 and then stagnated in unison from 1973 to 1981. From that point forward, the course of real earnings diverged, with college-educated workers seeing modest to sizable gains, workers with some college experiencing modest losses, and workers with high school or lower education experiencing substantial losses.

AKK estimate that real, composition-adjusted wages of workers with less than a high school education fell by 15.7 log points between 1979 and 1995. Real wages of high school graduates dropped by 9.8 log points. Drops of this magnitude are unlikely to be fully explained by any plausible indexation bias in the Personal Consumption Expenditure inflator used by AKK.[5]

2.5 Boom and bust in college labor supply

A final key fact that is at the heart of labor economists' understanding of the evolution of wage inequality is the sharp deceleration in the growth of the relative supply of college graduates to the U.S. labor market in the early 1980s. This deceleration is evident in Figure A5, which plots the log relative supply of college versus non-college workers between 1963 and 2005 (see AKK for details of the construction of this index). College relative supply trends up at approximately 4.5 log points per year from 1963 to 1982, then discreetly and resolutely downshifts to approximately 2.0 log points per year from 1982 forward. This deceleration—which tellingly, occurred just when wage inequality began its rapid ascent—was a direct consequence of events that had occurred years earlier. College going rates declined in the U.S. in the mid-1970s, in response both to the following college wage premium and the end of the Vietnam war (Card and Lemieux, 2001a). This in turn implied a decline in the number of new college graduates 4 to 5 years later.

Also relevant was the end of the Baby Boom. For most of the 20th century, new cohorts entering the labor market were significantly more educated than the cohorts that were retiring, and hence the average education of the working population rose steeply with each wave of entry and retirement. By 1982, the last of the Baby Boom cohorts had entered the labor market, and when smaller cohorts followed, the rate of increase in educational attainment of the workforce slowed. These two forces—declines in college-going and the end of the Baby Boom influx—led to a sharp deceleration in the supply of new college graduates.[6]

[5] Note that the PCE is thought to overstate inflation by less than the more commonly used Consumer Price Index.

[6] Another possibility is that young Americans were influenced by Richard Freeman's classic 1976 book, *The Overeducated American*, which documented that the college premium had fallen and estimated that the net social return to further rises in college enrollment were probably negative. Thus, Richard Freeman may be personally responsible for the epochal rise in U.S. wage inequality—for which a generation of researchers (myself among them) owe him thanks.

3 The 'Education Race' model

Before discussing the subtle and novel GK explanation for these five facts, it is useful to consider the benchmark model widely used in labor economics.[7] This framework starts with a CES production function for aggregate output with two factors, college equivalents (c) and high school equivalents (h):

$$Q_t = \left[\alpha_t \left(\theta_{H,t} N_{ct}\right)^{\rho} + (1-\alpha_t)\left(\theta_{L,t} N_{ht}\right)^{\rho}\right]^{1/\rho}, \tag{1}$$

where N_{ct} and N_{ht} are the quantities employed of college equivalents (skilled labor) and high-school equivalents (unskilled labor) in period t, $\theta_{H,t}$ and $\theta_{L,t}$ represent skilled and unskilled labor augmenting technological change, α_t is a time-varying technology parameter that can be interpreted as indexing the share of work activities allocated to skilled labor, and is ρ a time invariant production parameter. Skill-neutral technological improvements raise and $\theta_{H,t}$ and $\theta_{L,t}$ by the same proportion. Skill-biased technological changes involve increases in $\theta_{H,t}/\theta_{L,t}$ or α_t. The aggregate elasticity of substitution between college and high-school equivalents is given by $\sigma = 1/(1-\rho)$.

Under the assumption that college and high-school equivalents are paid their marginal products, we can use equation (1) to solve for the ratio of marginal products of the two labor types yielding a relationship between relative wages in year t, w_{ct}/w_{ht}, and relative supplies in year t, given by

$$\ln\left(w_{ct}/w_{ht}\right) = \ln\left[\alpha_t/\left(1-\alpha_t\right)\right] + \left[(\sigma-1)/\sigma\right]\ln\left(\theta_{H,t}/\theta_{L,t}\right) - 1/\sigma \ln\left(N_{ct}/N_{ht}\right). \tag{2}$$

This equation can be rewritten as

$$\ln\left(w_{ct}/w_{ht}\right) = (1/\sigma)\left[D_t - 1/\sigma \ln\left(N_{ct}/N_{ht}\right)\right], \tag{3}$$

where D_t indexes relative demand shifts favoring college equivalents and is measured in log quantity units.

The impact of changes in relative skill supplies on relative wages depends inversely on the magnitude of aggregate elasticity of substitution between the two skill groups. The greater is σ, the smaller the impact of shifts in relative supplies on relative wages and the greater must be fluctuations in demand shifts (D_t) to explain any given time series of relative wages for a given time series of relative quantities. Changes in D_t can arise from (disembodied) skill-biased technological change, non-neutral changes in the relative prices or quantities of non-labor inputs, and shifts in product demand.

This model is sometimes called the Education Race model after Jan Tinbergen, who envisaged the evolution of the education premium as reflecting a race between education and technology. In the

[7] The lineage of this explanation runs through Katz and Murphy (1992), Autor, Katz and Krueger (1998), Katz and Autor (1999), Card and Lemieux (2001b), Acemoglu (2002), Autor, Katz and Kearney (2008), and Goldin and Katz (2008).

Tinbergen view, technology is constantly exerting outward pressure on one blade of the Marshallian scissors (represented by D_t), while schooling is pushing outward on the other blade (represented by N_{ct}/N_{ht}). So long as these two forces move in parallel, that is $\Delta D_t \simeq \Delta\left[1/\sigma \ln\left(N_{ct}/N_{ht}\right)\right]$, wage inequality (here, the return to education) is stable. When demand moves outward faster than supply, $\Delta D_t > \Delta\left[1/\sigma \ln\left(N_{ct}/N_{ht}\right)\right]$, wage inequality rises, and vice versa when supply moves outward faster than demand.

This stylized and stripped down model is surprisingly powerful.[8] Following the approach of Katz and Murphy (1992), one can directly estimate a version of equation (3) to explain the evolution from 1963 to 2005 of the overall log college/high school wage differential series shown above. The dependent variable in this model, $\ln\left(w_{ct}/w_{ht}\right)$, is directly observed, as is one of the two explanatory variables, $\ln(N_{ct}/N_{ht})$. Rather than modeling unobserved demand shifts, D_t, one can proxy for them using a simple time trend (represent the outward thrust of demand in the spirit of Tinbergen's education race). Specifically, one may fit the equation:

$$\ln\left(w_{ct}/w_{ht}\right) = \gamma_0 + \gamma_1 t - \gamma_2 \ln(N_{ct}/N_{ht}) + \varepsilon_t \tag{4}$$

where γ_t provides an estimate of $1/\sigma$.

Fit using OLS to the 43 data points on the college premium and college relative supplies above, we obtain the following estimates for equation (4):

$$\ln\left(w_{ct}/w_{ht}\right) = \underset{(0.037)}{0.043} + \underset{(0.001)}{0.018 \times t} - \underset{(0.046)}{0.411 \times \ln\left(w_{ct}/w_{ht}\right)}, \quad R^2 = 0.93.$$

Three noteworthy features of this estimate are: the fit is surprisingly good (note the R-squared); secular relative demand shifts favoring college labor are quite important, as seen in the time trend; shifts in relative supply play a critical role in explaining movements in the college wage premium. Note also that the our estimate of $\hat{\gamma} = 0.411$ implies that $\hat{\sigma} \simeq 2.4$, which is within the bounds of standard estimates of the college/high school substitution elasticity.[9]

Figure A6 provides a glimpse of why this simple model works so well. This figure plots the detrended college/high-school wage differential against the detrended college/high-school relative supply series (where detrending simply means removing an OLS fitted linear time trend from each series). These series appear near mirror images of one another—and in particular, the inflexion point in the supply series appears 'separated at birth' from the inflexion point in the wage premium series. It is difficult (at least for me) to look at this figure and conclude that relative supplies of educated labor

[8] Though it should be stressed that sophisticated versions of this model are successfully applied by, among others, Card and Lemieux (2001a), Acemoglu, Autor and Lyle (2004), Carneiro and Lee (2008) and Goldin and Katz (2008).

[9] Standard estimates range from 1.0 to 2.5 (Katz and Autor, 1999). The estimate here is on the high side because we impose linearity of the time trend in log relative demand. If we allow a bit more flexibility, the estimates of σ fall towards approximately 1.7, which is closer to the estimates of Katz and Murphy (1992), as well as many subsequent authors.

do *not* play a central role in the determination of wage inequality (at least as measured by the college premium).

The model need not be this simple, however. One important extension developed by Card and Lemieux (2001) considers a generalization where workers of different experience levels within the same educated group are imperfect substitutes for one another. This extension implies, with few additional assumptions, that when the supply of college graduates decelerates, as occurs in the U.S. in the 1980s, the college premium will rise more rapidly for young than old workers—which is the pattern that we see in Figure A3.

Before discussing the potential applicability of the education race model to the key facts above, I compare and contrast it with the GK model. As it turns out, they have almost nothing in common.

4 The Guvenen-Kuruscu model

GK start with a production function that looks familiarly like the Katz-Murphy model. In particular, the GK aggregate production function can be written as:

$$Q_t = Z\left[\left[(\theta_{H,t}N_{ct})^{\rho} + (\theta_{L,t}N_{ht})^{\rho}\right]^{1/\rho}\right],$$

where Z is a neutral productivity shifter, and the rest is equivalent to equation (1). The parameterization of this model that they study, however, is one where $\rho \to 1$, which implies that $\sigma \to \infty$. In other words, high and low-skilled labor are perfect substitutes.

Due to this perfect substitutability, the earlier equation (2) for wage inequality becomes simply:

$$\ln(w_{ct}/w_{ht}) = \ln(\theta_{H,t}/\theta_{L,t}). \tag{5}$$

Here, the demand for skills is completely elastic. The pure skilled wage premium is determined only by the state of technology, represented by $\theta_{H,t}/\theta_{L,t}$. While the Katz-Murphy model had three central ingredients—the relative supply of skills, the location of the relative demand curve, and the elasticity of substitution between skill groups in relative demand—the GK model features only one of these components, the relative demand curve, which might aptly be called a relative demand plateau, since supply movements have no effect on the equilibrium price of skill.

Despite this utter parsimony, the model generates rich dynamics for, among other things, the measured college/high-school wage premium, the inequality of earnings within and between skill groups, and even the relative supply of skill. How is this accomplished? The answer is heterogeneity, and lots of it. There is heterogeneity in endowments, heterogeneity in learning capabilities, heterogeneity in investment windows, and heterogeneity in beliefs about the state of nature. These numerous sources of heterogeneity, combined with some strong assumptions on the evolution of $\theta_{H,t}/\theta_{L,t}$, give rise to a rich (almost bewildering) array of predictions, some of which fit the data quite well.

GK do an excellent job in explicating the model's many moving parts, and I won't attempt to improve on their work. I will instead name the main actors and discuss their roles. Following that, I compare how the model stacks up against the Tinbergen setup in explaining the key facts.

4.1 The Big Bang

The one and only forcing variable in the GK model is an unanticipated shock to the trajectory of the skill price, $\theta_{H,t}/\theta_{L,t}$. The growth rate of $\theta_{H,t}/\theta_{L,t}$ discontinuously rises in 1970 and then reverts to its prior trend in 1995. It is this shock, combined with the abundant sources of heterogeneity in the model, that leads to the dynamics. These dynamics work through three channels:

1. Price effect. When $\theta_{H,t}/\theta_{L,t}$ rises, this immediately raises inequality by amplifying pre-existing differences in skill stocks.

2. Investment effect. A rise in skill prices stimulates further skill investments. In the GK model, workers partly or fully withdraw from the labor force to invest in human capital. In the short run, this lowers observed wages since the most able workers are those who most reduce labor supply to enable them to make the largest investments.

3. Quantity effect. Over the longer term, the investment effect leads to greater human capital stocks (denoted by l^j). Wages rise as workers accumulate skills and as they slow their rates of investment (i.e., as steady state skill targets are achieved).

Of these three channels, the investment effect is the most critical. Following Becker (1964), workers acquire skills in the GK model in large part through investment in on the job skill acquisition (OJT for short). Workers may dedicate up to 50 percent of their work hours to OJT, reducing their effective labor supply and contemporaneous earnings accordingly. If a worker wants to invest more than 50 percent of his time in OJT, he 'enrolls in college,' and invests full time for at least two years, at which point he is labeled a college graduate for purposes of the simulation.

Concretely, if worker a is twice as skilled as worker b, and a spends 50 percent of his work hours investing in human capital while b spends none, they earn the same net wage. Since the return to skill investments rises with the price of skill, an unanticipated rise in the skill price may initially *reduce* observed wages and then raise them. This occurs if the investment response—greater OJT in response to higher skill prices—dominates the price effect, i.e., higher skill prices directly raising wages.

4.2 Heterogeneity in investment responses

If all workers were identical, shocks to skill price would have homogeneous effects on wages. In the GK model, wage effects are anything but homogenous. Heterogeneity enters through its interaction with each of the four channels below:[10]

1. Heterogeneity in learning ability. Perhaps the central source of heterogeneity in the model is cross-worker variation in learning ability, A^j. This parameter in large part determines a workers' optimal investment path. Workers with lower A implicitly pay a higher price for acquiring skills, and hence invest less in them. Most critically, given an unanticipated shock to the value of human capital (θ_H), workers with higher A optimally increase their human capital investments by more, which greatly affects their earnings profile over the life cycle. The greater the extent of investment, the more that wages fall in the short run (due to lower effective labor supply) and the more they rise in the long run (due to higher prices and greater skills accumulation)—with both effects amplified by higher A.

2. Heterogeneity in labor. For reasons that elude me, GK also posit the presence of worker heterogeneity in raw labor endowment, l^j, with an assumed correlation of 1.0 between A and l. Thus, more able workers have an absolute advantage in *both* labor and human capital intensive tasks. When high A workers differentially raise OJT in response to an increase in θ_H, average wages in the economy fall by even more than would occur if A and l were uncorrelated (i.e., since the workers who reduce their effective labor input the most are also the most productive).

3. Heterogeneity in age. Workers in the model spend a finite career of 45 years in the labor force, so older and younger workers face different investment horizons. An unanticipated rise in the skill premium induces a greater investment response among the young than the old, leading to relatively larger reductions in effective labor supply among young workers, which are then rewarded with higher earnings later in life.

4. Heterogeneity in beliefs. Given that the key exogenous force in the model is an unanticipated shock to skill prices, workers' investment responses to this shock will depend upon how rapidly and accurately they perceive the shock, and how long they believe it will last. GK consider a few scenarios for the evolution of beliefs, but in practice, these variations do not turn out to be empirically important.

[10] There is also initial heterogeneity in human capital stocks even prior to the 'Big Bang,' and this is amplied by the 'price effect' as detailed below.

In summary, the operative channels influencing wage inequality are in almost all senses different from the Tinbergen framework. In GK, the only macroeconomic factor is the skill price—all wage dynamics arise from microeconomic responses (observed and unobserved) to this price. In the Tinbergen framework, skill demand—though not its price—is exogenous, and the supply responses that follow are probably fairly viewed as endogenous (though Tinbergen offers no explicit model for this). The skill price, in turn, is determined by the intersection of the two blades of the Marshallian cross. Heterogeneity in microeconomic responses to skill demand are simply not part of the model, though they are not in any sense at odds with it.

5 Confronting the evidence

I now return to the five key facts.

5.1 Rising wage dispersion

In the Tinbergen model, an increase in skill prices—reflecting a relative demand shift for college relative to non-college workers (H vs L) that outstrips the growth of supply—raises wage dispersion through two channels: an increase in the college wage gap, and a rise in 'within-group' inequality among H and L workers. This latter 'residual channel' arises through the interaction between rising prices and heterogeneity in productivities among workers who have similar nominal credentials (college or non-college).

While demand and supply play equal (and opposite) roles in the Tinbergen model, much analysis of U.S. wage inequality attributes most of the *fluctuations* in relative wages over recent decades to movements in relative supply. As Katz and Murphy (1992) first demonstrated, one can go a very long way towards explaining the evolution of the U.S. wage structure simply by overlaying the accelerations and decelerations in the growth rate of relative supply of college-educated labor on a smoothly trending outward shift in relative demand.

In GK, by contrast, there is no economic distinction between within- and between-group inequality since all skills are perfect substitutes; although some workers are labeled college and others non-college, this distinction is quantitative not qualitative, reflecting depth of skill rather than type of skill. Moreover, given perfect skill substitutability and perfectly elastic labor demand, fluctutations in the aggregate supply of skills have no impact on inequality.[11].

But wage dispersion enters this model through so many other doorways that one hardly misses the supply channel. A positive shock to skill prices raises inequality through the price channel, lowers

[11] Labor demand is perfectly elastic because this is a one good economy with constant returns to scale production that uses two perfectly substitutable factors, l and h. Thus, there is neither diminishing marginal rate of substitution in production nor diminishing marginal utility in consumption.

it initially through the investment channel, and then raises it again through the quantity channel. What's the net effect? Clearly, it will depend on model parameters, at least in the short run—though in the long run, the effect must be positive.

Which framework (Tinbergen, GK) does a better job with the facts? The key virtue of GK, in my view, is that it's capable of generating different time paths for 'between-group' and within-group inequality—this despite the fact that both are responding to the same causal force. (I place 'between group' in ellipses here because the distinction between college and non-college groups is nominal.) In particular, within-group inequality—inequality among those labeled either college or non-college—may rise initially following the price shock, reflecting heterogeneity in the investment response to changing skill prices (as well as the interaction between heterogeneity in skill endowments and changing skill prices). Between-group wage inequality—the mean wage gap between workers labeled college and non-college—may initially fall due to greater investment responses among more skilled workers.

This additional richness comes with costs and benefits. One cost, as above, is that the definition of college versus non-college workers has no economic counterpart in the model's underpinnings; college and high-school wages are set by the same pair of prices.[12] Thus, absent unmeasured heterogeneity in l, h, and effective labor supply, there would be no between-group inequality in the model.

A second cost is a complexity. As the discussion above underscores, with so many heterogeneity dynamics in the model—I count five parameters in Table 1 that measure heterogeneity—one suspects that almost anything could happen under the right parameterization. This complexity allows heterogeneity in the GK model to do the work done by labor supply in the Tinbergen model, but at considerable loss in transparency.

Perhaps the overriding consideration, however, is whether the rich dynamics of the model help it to better explain the data. The answer to this question turns on whether overall and residual inequality follow a different time trajectory than the college wage gap, which is a phenomenon that GK's simulation predicts, or whether they do not, as the Education Race model predicts. As it turns out, this is a contested fact in the literature.

Using data from the March CPS, Katz and Murphy (1987), Juhn, Murphy and Pierce (1993), Katz and Autor (1999), Acemoglu (2002), and AKK (2005, 2008) find that there is a gap of one decade between the rise of the college premium, commencing in the 1980s, and the rise of overall and residual inequality commencing in the 1970s. This suggests that these are distinct phenomena. In contrast, Lemieux (2006), reiterating earlier conclusions from DiNardo, Fortin and Lemieux (1996), finds that the path of the college gap and overall and residual inequality follow a similar trajectory

[12] In the Education Race framework, there is a distinct college wage and a distinct non-college wage. Of course, there may also be within-group heterogeneity in the skills of college and non-college workers. But college and non-college skills are not linear syntheses of one another.

in the May/ORG CPS (as distinct from the March CPS). This leads Lemieux to argue that these different dimensions of inequality are not truly distinct.[13]

To date, the difference in timing between the rise of between and within-group inequality in the March and May/ORG CPS has not been adequately explained (cf. Lemieux, 2006, and AKK, 2005 and 2008, for discussion). A dispassionate reader would certainly be justified in accepting Lemieux's unifying view of wage inequality, particularly because it has the appeal of parsimony. Indeed, despite my published conclusions to the contrary, I have been increasingly persuaded by Lemieux's view.

Surprisingly, strong countervailing evidence against the more parsimonious view is uncovered in a recent paper by Kopczuk, Saez and Song (forthcoming). Using consistent Social Security earnings samples from 1973 through 2004 (arguably a more authoritative data source than the March or May/ORG CPS), they show that the Gini coefficient for male and pooled-gender (though not female) annual inequality started rising sharply in 1970, plateaued briefly from 1977 through 1980, rose even more steeply from 1980 through 1988, then grew more slowly through the end of their series in 2004. These patterns match the timing of overall and residual inequality in the March CPS, but they are at odds with the May/ORG CPS.

Based on Kopczuk et al's analysis of the Social Security data, I must conclude that the best evidence now favors the view that the timing of between-group versus overall inequality is distinct. And this in turn favors the GK model since it can do something that the Education Race model cannot, which is to explain this difference in timing. The fact that GK can rationalize this fact does not make the explanation correct—but it's a good start. For those keeping score at home, I award this round to GK.

5.2 The rising, falling and then rising return to education

The crowing success of the Education Race model is its ability to explain the fluctuating college premium over numerous decades merely by positing a steady outward shift in relative demand, a stable (and plausible) elasticity of substitution between college and non-college labor, and a set of sharp secular shifts in the growth rate of college supply. Figure A7 (from AKK) replicates the famous Katz and Murphy (1992) implementation of the Education Race model for the years 1963 through 1987 (i.e., the years available to Katz and Murphy) and then extending the model's predictions out of sample through 2005. The model does an exemplary job of fitting the data through 1992, though somewhat over-predicts the subsequent growth of the college premium. Goldin and Katz (2008) further demonstrate that this model does an impressive job in explaining skill premiums over a much longer

[13] Lemieux also argues that part of the rise in residual inequality in the 1990s can be explained by the changing composition of the U.S. labor force. See Lemieux (2006) and Autor, Katz and Kearney (2005) for discussion.

time period, 1915 - 2005. Notably, this model neither presumes nor requires a sudden, unanticipated shock to skill demand. Its goodness of fit arises exclusively through movements in observable prices and quantities overlaid on a time trend.

GK's explanation for the rising-falling-rising college wage premium is more subtle, but, to my eye, less credible. As a starting point, they invoke *ex cathedra* an unexpected acceleration in skill demands that starts in 1970 and ends in 1995—presumably because this appears to fit the data (notice that it is a few years prior to 1995 where the Katz-Murphy model 'wants' more wage inequality than it gets). Under the baseline scenario, workers do not anticipate the acceleration in skill prices in 1970. But once the Big Bang hits, workers forecast its deceleration 25 years later.[14] These assumptions do not make for a promising start.

The mechanism whereby the positive price shock leads to initially falling college wages is the investment channel as above: more skilled workers reduce their effective labor supply through OJT—or they exit the labor force to enroll in college—thereby depressing the observed wages of college versus non-college workers. This idea has solid roots in Becker's Human Capital model, but it is hard to reconcile with the facts. As the authors candidly admit (section 4.4), the fall in the college premium in the U.S. during the mid 1970s was met with a *fall* in college enrollments—opposite to the model's predictions. While the model can rationalize the fall in college *wages* (rather than enrollments) as reflecting an unmeasured rise in OJT, it is not particularly credible that workers unobservably increased on-the-job skills investments while observably deciding that school-based skill investments were not worthwhile.

5.3 Age group differences in the rising college premium

There is, however, another important empirical regularity that GK capture through the nuances of their model: the measured college premium rose by considerably more for the young than the old during the 1980s, as shown in Figure A3. GK's model offers an elegant explanation: facing the same skill price shock in the 1970s, young workers made larger skill investments than older workers, since they had more remaining work years in which to garner the returns. Accordingly, by 1980, they had greater human capital than older workers possessing similar nominal education levels. Hence the college wage gap rose by more for the young than the old in the 1980s as the investment effect abated and the quantity effect took hold.

While this is ingenious, a simple extension to the education race model offered by Card and Lemieux (2001b) does at least as well with these facts, and taxes credulity less. A deceleration in

[14] Though GK consider more plausible learning processes, all of them have the feature that workers forecast a deceleration at some future point, which seems a bit odd. (Why wouldn't priors give further accelerations and decelerations equal weight?)

college production will induce greater scarcity of young than old college workers. If, plausibly, workers of different age groups within an education group are imperfect substitutes, this will cause the college wage premium to rise by more for young than old workers when the college crunch hits.

This slowdown in experience-group relative supplies is shown in Figure A8. The relative supply of young college workers (0 to 9 years of experience) falls off sharply in 1975, while the relative supply of older college workers (20 to 29 years of experience) does not decelerate until 1995. Comparing Figure A3 (the college gap by experience group) with Figure A8 shows a clear correspondence: the experience group specific college premium rises when experience group specific relative supply decelerates. This parsimonious explanation fits the data well, so this round goes to Tinbergen.[15]

5.4 Rising real wages at the top, falling real wages at the bottom

One of the least well understood facts about U.S. wage inequality is the rapid fall in real wages for less educated workers during the 1980s. What explains this fall?

The Education Race model has trouble with this fact. Given that there was no increase in the relative supply of low-skilled workers during this period depressing the low-skilled wage—just the opposite—the Education Race model leaves only one remaining channel for low-skill wages to fall while high-skill wages are rising: an absolute decline in θ_L, implying a form of 'skill-destroying' technical change.[16]

Is this plausible within the confines of the simple two-factor model? Not especially. Technical change that is massively biased in favor of high-skilled workers and against low-skilled workers would have to offer substantial TFP gains for it to dominate the existing technology and hence be adopted (Krugman, 2000). But U.S. productivity growth was torpid at the time that wage inequality was soaring. This makes it hard to tell a credible story within this simple model that can rationalize these wage declines—though many have tried.[17]

[15] Perhaps most persuasively, Card and Lemieux (2001b) document that the rise in the college premium among the young commenced five years later in the U.K. in the U.S., which is exactly as predicted because the slowdown in relative supply of young college workers also started five years later in the U.K.

[16] Given gross complementarity between H and L workers ($\sigma > 1$), as is suggested by all available evidence, an increase in θ_H holding constant θ_L raises wage inequality *and* raises the wages of L workers (due to q-complementarity). Thus, L wages can only fall if θ_L falls. And θ_L must fall farther still if either H or θ_H is rising, since both raise earnings of L workers. Note that under the parameterization in equation (1), one could also interpret the decline in L wages to indicate that that α_t fell, so a larger share of tasks was allocated to H than L workers. This is a distinction without a difference, however, since $\theta_{L,t}$ and $\theta_{H,t}$ can always be redefined to include α_t.

[17] Of course, many sophisticated (and more credible) alternative explanations have been offered. Greenwood and Yorukoglu (1997) is a brave and early effort. Acemoglu (1999) offers a model in which rising skill supplies cause firms to endogenously adopt a strongly skill complementary technology in lieu of a comparatively skill neutral technology that was appropriate when skills were scarce. Beaudry and Green study a setting in which a rise in skill supplies causes capital starvation in the low-skill intensive sector, causing low-skill wages to fall. Unfortunately, the rapidly falling U.S. minimum wage during the 1980s does not offer a credible explanation for falling low-skill wages since the minimum was set too low to be relevant for almost all male workers in this period (Autor, Manning and Smith, 2009). Levy and Temin

In the GK model, the fall in the real wage of less-skilled workers works through three channels. A first is skill-destroying technical change. GK posit that during the Big Bang (1970 through 1995), θ_L trends downward at about one-half of a percent a year. Offsetting this, GK assume that factor neutral TFP grows at 1.5 percent per year—so raw labor productivity is rising (in net). The observed fall in real wages is therefore not purely mechanical, though the decline in θ_L helps it along.

The second channel operating against low-skill wages is the investment effect; an increase in OJT means that low-skill wages (which are already afflicted with slowing productivity growth) are further depressed by a rise in OJT and concomitant reduction in effective labor supply.

Finally, the assumed perfect correlation between raw labor endowments and learning ability means that the low-skill workers who reduce effective labor supply the most are those with the highest ability. This magnifies the wage losses stemming from rising OJT. In net, real wages of college workers stagnate and non-college wages fall during the initial years of the Big Bang.

This explanation for falling real wages is no more or less satisfying than the earlier explanation for a falling then rising college premium in the 1970s and 1980s, respectively. If one accepts the implication that the 1970s was a period of dramatically increased investment in human capital on the job (but not in school), then the explanation for falling wages at the bottom and stagnating wages at the top is coherent and ingenious. If one rejects this implication, then the explanation is less appealing.

It appears hard to deny that the real earnings power of low-skill workers fell during the 1970s and 1980s—not just their effective labor supply. High school dropout rates, non-employment, criminal participation and incarceration rose among low-skilled workers and low-income families during these decades. This is hard to square with the view that the 1970s was a renaissance for skills investment among the less educated.

Neither the Education Race nor the GK model can, in my view, be declared a winner on this score. They are coequals in defeat.

5.5 Boom and bust in college labor supply

The boom and then bust in the supply of new college graduates depicted in Figure A5 can arguably be rationalized by either model. In the Education Race model, the fluctuations in college supply seem largely to follow the trajectory of the college premium, though of course with a built-in delay of four or more years (i.e., the time it takes to earn a college degree).[18]

(2007) offer a richer institutional explanation for the evolution of low- and high-skilled wages.

[18] Indeed, Freeman's (1976) book, which arguably caused the college skill shortage, also predicted its reversal. Using a 'cobweb' model, Freeman predicted that the supply response to the falling wage premium would overshoot the mark, leading the wage premium to rebound.

In the GK model, the rise in college attainment is also a response to changes in skill prices. But here the fit is less good. GK predict a brief dip and then accelerating rise in college supply from 1970 to 2000. The crucial deceleration of college supply in the early 1980s is not predicted by their model, as is seen in Figure 13 of their paper. Of course, this is not a serious problem for the GK model since the realized college premium is independent aggregate supplies. For the Education Race model, however, the supply deceleration is both a logical response to the falling wage premium and a leading causal force in the subsequent rise of wage inequality.

6 Conclusion

If I have done my job well, I have made a solid case that we do not have a perfectly satisfactory explanation of the key facts surrounding the rise of U.S. wage inequality. The most successful models explain between-group inequality well, within-group inequality less well, and real wage levels least of all. In particular, the canonical Education Race model is a major success on the first front, a partial success on the other, and a failure on the third. The GK model is at its best where the canonical model has weak footing—in particular, in explaining the disparate timing of rising between versus within-group inequality. Is the GK model a standalone explanation for all of the major facts? Clearly not. Nor is it probably intended to be. For example, I doubt the authors would wish to argue that skill supplies have no effect on prices—only that one can shut down this channel and still get rich results. The question that only time can answer is whether the GK model provides enough additional points of contact between theory and data to drive analysis and understanding forward. If yes, the paper will clearly have moved the frontier. And if not, this work will remain admirable for its ambition and its craft.

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Figure A1. The Evolution of Male 90/10 Log Wage Inequality, 1963 through 2005.
Source: Autor, Katz and Kearney (2008).

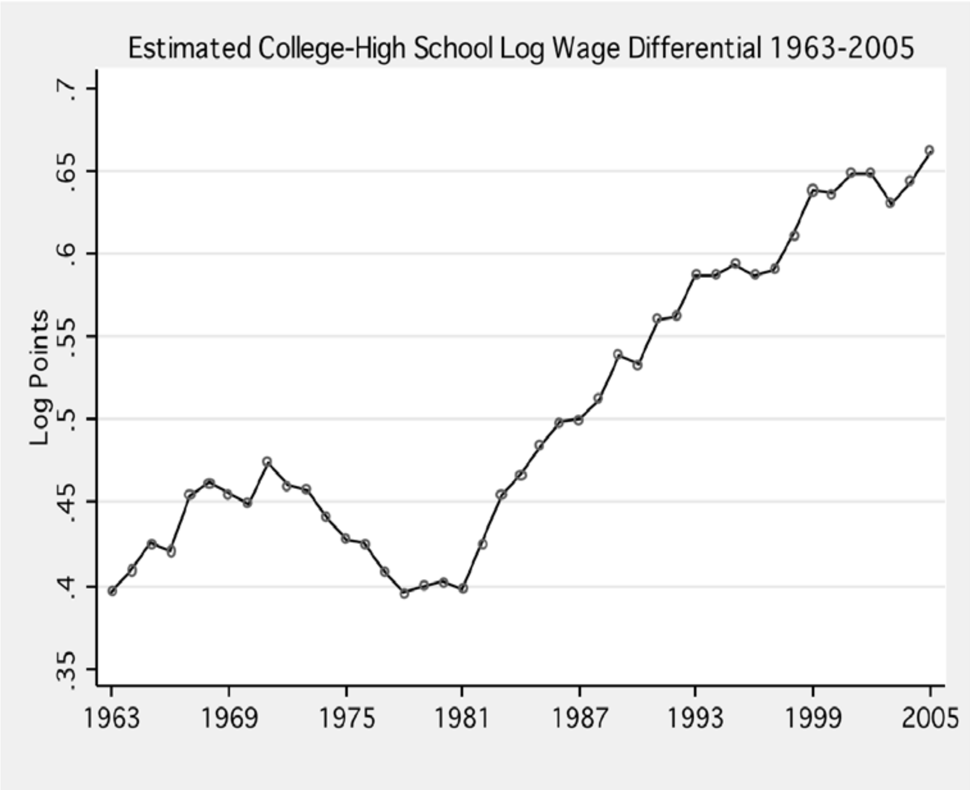

Figure A2. The Evolution of the College/High-School Wage Gap, 1963 through 2005. Source: Autor, Katz and Kearney (2008).

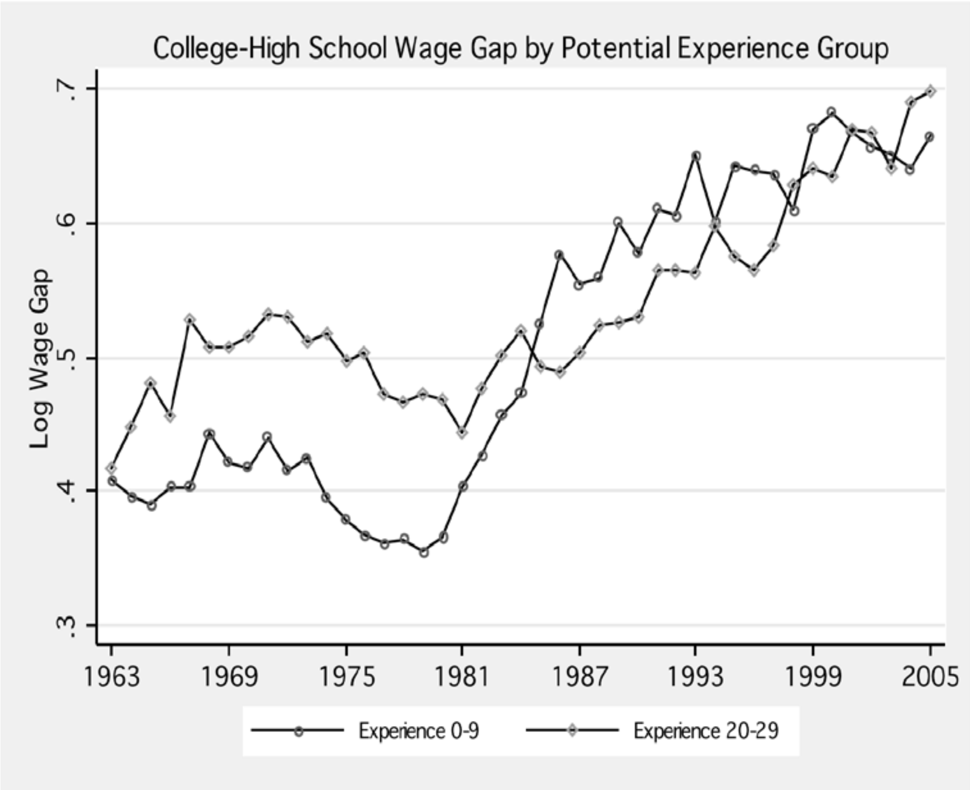

Figure A3. The Evolution of the College/High-School Wage Gap among Inexperienced and Experienced Workers, 1963 through 2005. Source: Autor, Katz and Kearney (2008).

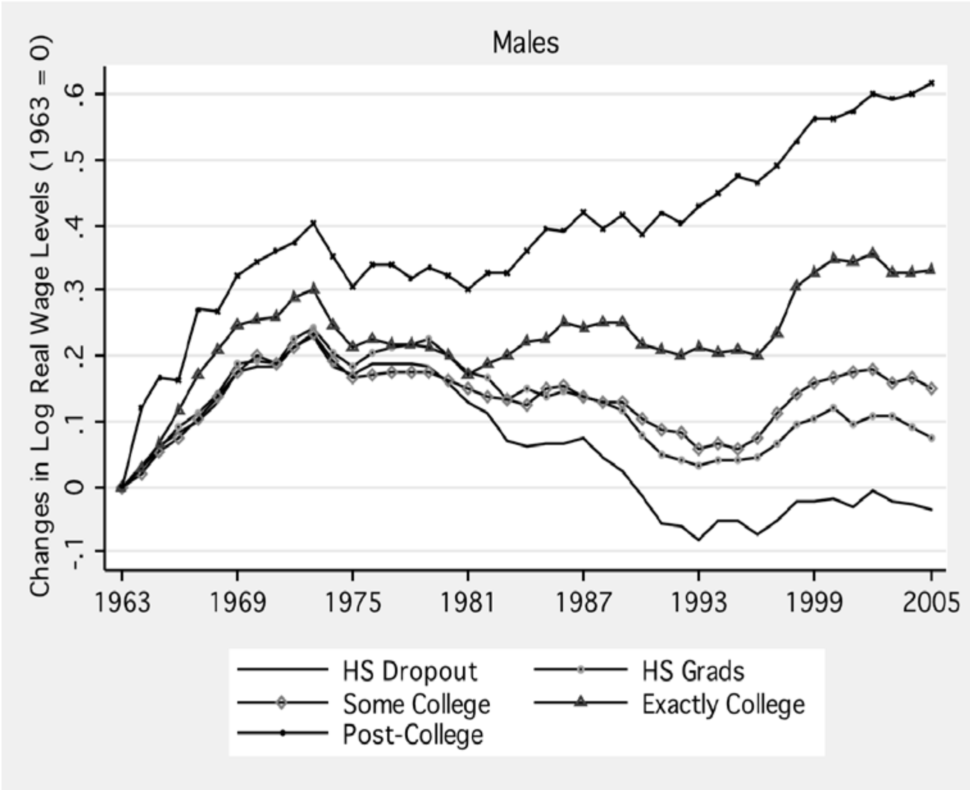

Figure A4. Indexed Changes in Real Male Wages by Educaton Group, 1963 through 2005 (1963=100). Source: Autor, Katz and Kearney (2008).

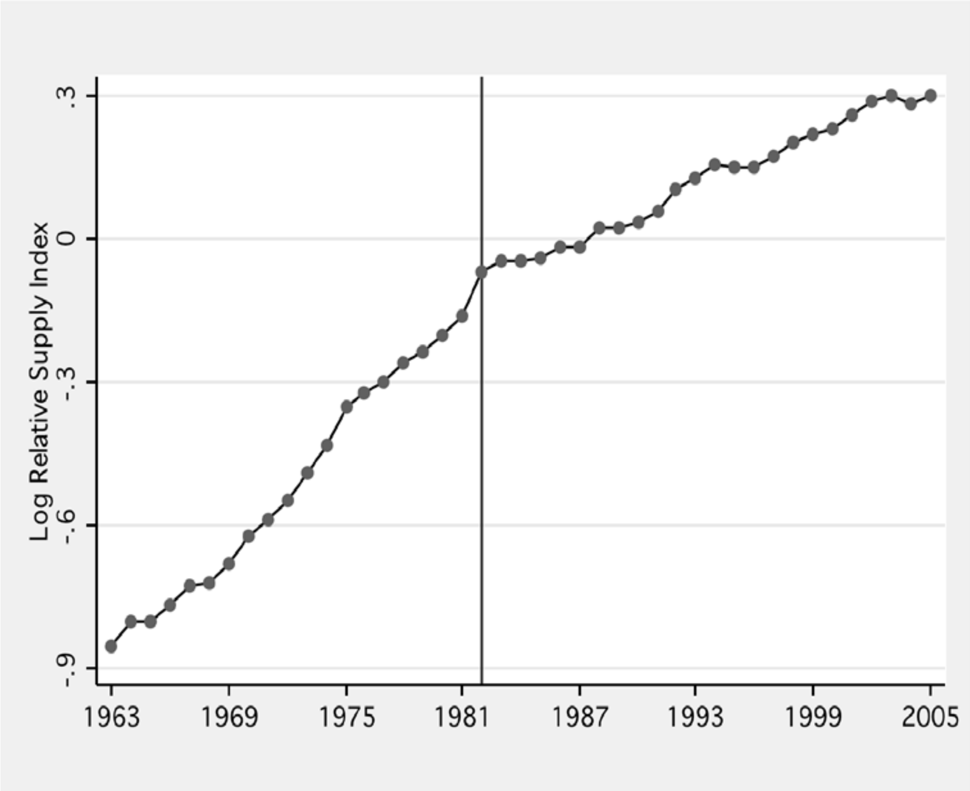

Figure A5. Log Relative Supply of College Equivalent Labor, 1963 through 2005.
Source: Autor, Katz and Kearney (2008).

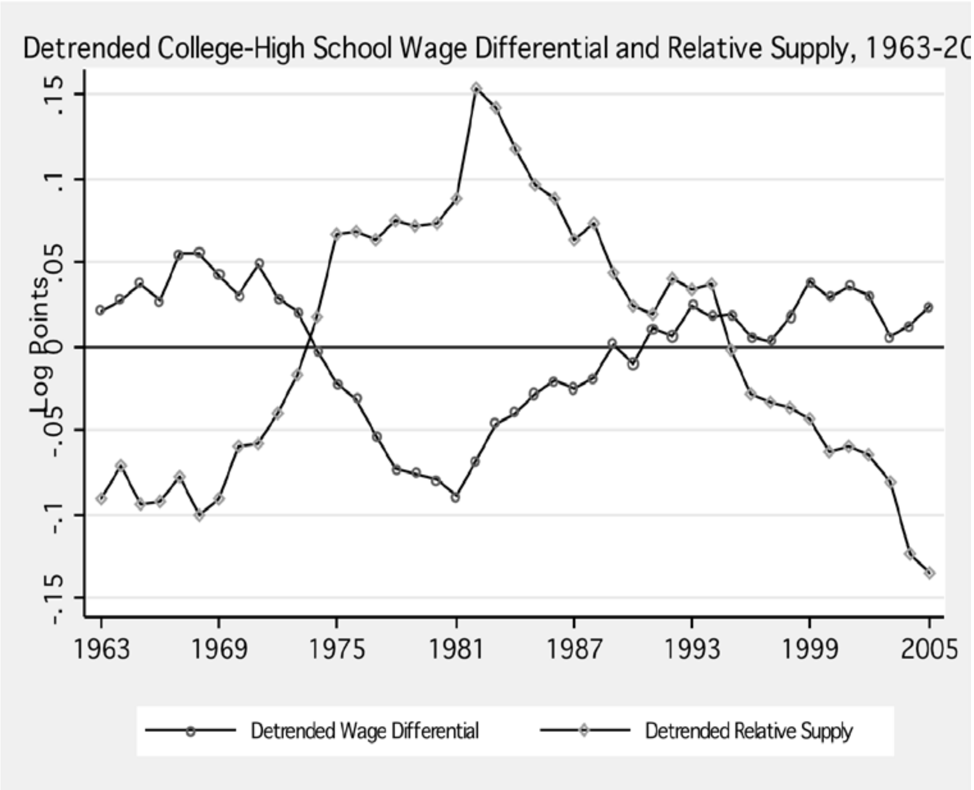

Figure A6. Detrended Measures of Supply and Wage Differentials, 1963 through 2005. Source: Autor, Katz and Kearney (2008).

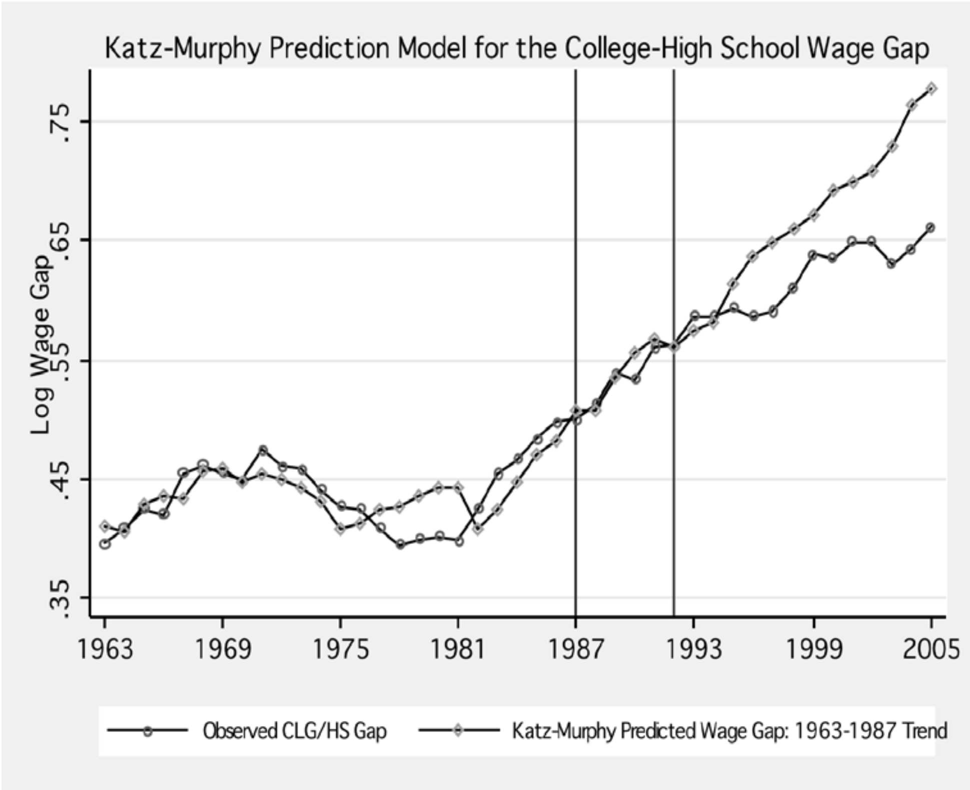

Figure A7. Observed and Predicted College/High-School Log Wage Gap based on Katz-Murphy (1992) fit of Education Race Model for Years 1963 through 1987 and Projected Out of Sample to 2005. Source: Autor, Katz and Kearney (2008).

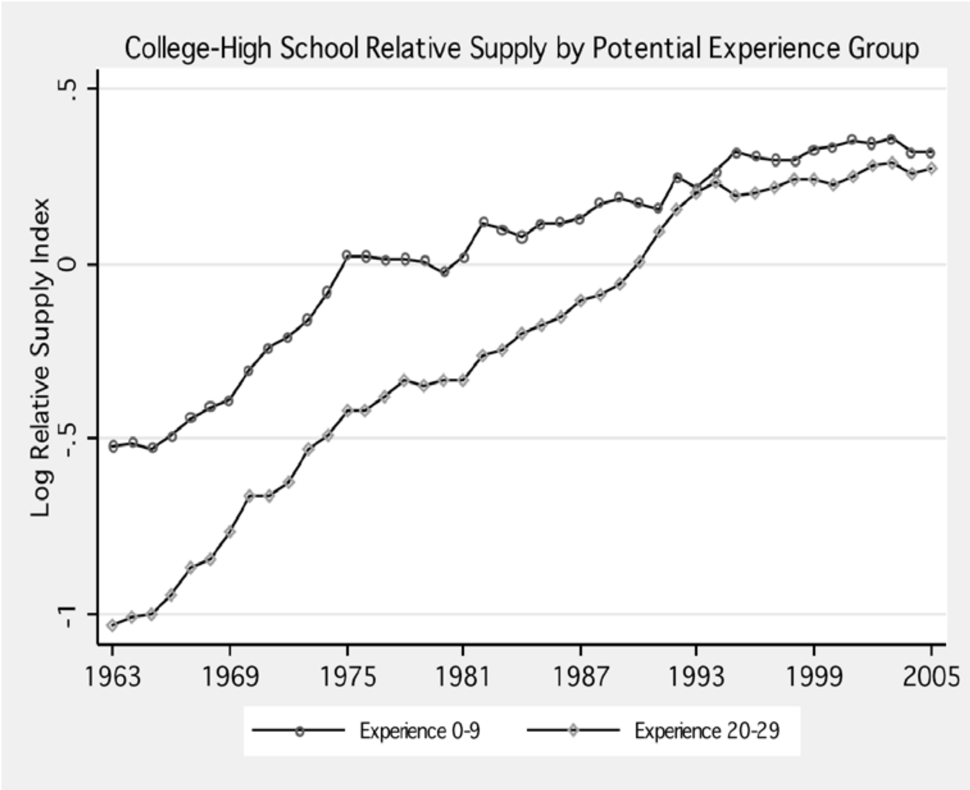

Figure A8. The Evolution of College/High-School Relative Supply among Inexperienced and Experienced Workers, 1963 through 2005. Source: Autor, Katz and Kearney (2008).