REASSESSING THE TRENDS IN THE RELATIVE SUPPLY OF COLLEGE-EQUIVALENT WORKERS IN THE U.S.: A SELECTION-CORRECTION APPROACH

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ABSTRACT

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A SELECTION-CORRECTION APPROACH

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Among better-educated employed workers, the fraction of full-time full-year (FTFY) workers is quite high and stable over time in the U.S. Among those with low education levels, however, this fraction is much lower and considerably more volatile. These observations suggest that the composition of unobserved skills is subject to sharp movements within low-educated employed workers, while the scale of these movements is potentially much smaller within high-educated ones. The standard college premium framework accounts for the observed shifts between education categories, but it cannot account for unobserved compositional changes within education categories. This thesis uses Heckman's two-step estimator on repeated Current Population Survey cross sections to calculate a relative supply series that corrects for unobserved compositional shifts due to selection in and out of the FTFY status. We find that the well-documented deceleration in the growth rate of relative supply of college-equivalent workers after mid-1980s becomes even more pronounced once we correct for selectivity. This casts further doubt on the relevance of the plain skill-biased technical change hypothesis. We conclude that what happens to the within-group skill composition for low-educated groups is critical for fully understanding the trends in the relative supply of college workers in the United States.

Keywords: Wage Inequality, Self-Selection, Relative Supply, SBTC, College Premium Equation.

ÖZ

ABD'DE ÜNİVERSİTE –EŞDEĞER ÇALIŞANLARIN GÖRELİ ARZ EĞİLİMLERİNİN YENİDEN DEĞERLENDİRİLMESİ:

SEÇİM YANLILIĞI DÜZELTME YAKLAŞIMI

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ABD'de çalışan yüksek eğitimli işgücü tam zamanlı tam yıl statü oranı oldukça yüksek ve istikrarlı seyretmektedir. Diğer yandan, düşük eğitim düzeyine sahip çalışanlar arasında, bu oran önemli zaman değişimleri sergilemektedir. Bu grup içerisinde, tam zamanlı tam yıl statüsündeki seçicilik daha düşük ve çok daha değişkendir. Bu durum, gözlenemeyen beceri kompozisyonlarındaki hareketlerin, yüksek eğitimli çalışanlar içerisinde daha yavaş, düşük eğitim düzeyine sahip çalışanlar içerisinde ise daha keskin olduğunu göstermektedir. Standart üniversite ücret getirisi analiz çerçevesi eğitim kategorileri arasındaki gözlenebilir değişiklikleri açıklayabilirken, bu kategorilerin kendi içerisindeki gözlenemeyen değişiklikleri açıklayamamaktadır. Bu çalışma, seçiciliği düzeltilmiş göreli arz serileri hesaplamak için Heckman iki aşamalı tahmin yöntemini kullanmıştır. Seçicilik düzeltildiğinde, üniversite-eşdeğer çalışanların göreli arzındaki büyüme oranının 1980'lerin ortalarından önce yazında belirtilenden çok daha keskin, bu tarihten sonra ise yazında belirtilenden çok daha yavaş olduğu, dolayısıyla göreli arzın büyüme oranındaki yavaşlamanın seçicilik düzeltmesinden sonra daha da belirgin hale geldiği bulunmuştur. Bu durum beceri yanlı teknolojik gelişme hipotezinin geçerliliğini sorgulamaktadır. Sonuç olarak, düşük eğitimli grupların kendi içindeki beceri kompozisyonunun, ABD'deki üniversite-eşdeğer işgücünün göreceli arz eğilimlerini anlamak açısından kritik olduğu sonucuna varılmıştır.

Anahtar Kelimeler: Ücret Eşitsizliği, Kendinden Seçim Yanlılığı, Nispi Arz, Beceri Yanlı Teknolojik Gelişme, Üniversite Ücret Getirisi

To My Beloved Father, ZEKİ ELİTAŞ

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CPS	Current Population Survey
SBTC	Skill Biased Technological Change
FTFY	Full-Time Full-Year

CHAPTER 1

INTRODUCTION

Our main purpose in this thesis is to provide a methodological contribution to the standard demand and supply framework used in explaining the widening wage inequality trends in the United States. The existing framework, we believe, needs some adjustments first to capture the unobserved compositional shifts within education categories due to selection in and out of the full-time full-year (FTFY) status and second to account for adjustments in quality of the labor force. For this purpose, we develop a method to revise the relative supply measure used in the literature in such a way that it corrects for these two points. Such a correction aids to document the nature and extent of the robustness issues that the mechanical treatment of "efficiency units" idea in the standard framework gives rise to. To achieve this goal, we use Heckman's two-step estimator on repeated Current Population Survey cross sections to calculate a relative supply series that corrects for self-selection into the FTFY status and we use the selection bias term to capture the unobserved compositional shifts within education categories, which, in turn, endogenizes the efficiency units. We, then, investigate the implications of these new results on the empirical analysis of U.S. wage inequality- including a reassessment of the skill-biased technological change (SBTC) hypothesis- using the selectivity-corrected relative supply series. We provide several interpretations to our selection-corrected estimates.

Many studies in the wage inequality literature have used simple formal canonical supply-demand models of the two factor constant elasticity of substitution (CES) human capital model to explain the widening wage structure in the United States.[1] The convention in this existing framework is to construct efficiency units of labor supply. A relative supply measure- also known as the relative supply index- is calculated by taking the ratio of college to high school efficiency labor supply units of FTFY workers. This measure is used to assess the trends in educational attainment in total and across various demographic groups. The wage inequality literature calculates efficiency units of labor supply by weighting total hours of work in a given year with relative real wages over "all" years in the sample period.[2] That is, the weights (or prices) are fixed. Efficiency labor supply units constructed using fixed weights capture the fact that an hour supplied by a relatively higher educated worker counts more than an hour supplied by a lower educated worker. This setup successfully captures the effect of the observed changes in the educational composition of the working population. For example, an increase in the fraction of college educated workers with a parallel decline in the fraction of lower educated workers implies an increase in the relative supply index. However, it has two deficiencies. First, it focuses on the labor hours supplied by only those who self-select into working FTFY status. FTFY is a choice variable and this procedure may bias the estimates. Second, it assumes that the relative efficiency of an hour worked by a college graduate versus an hour worked by a high school graduate is constant in the entire sample period (1967-to date). In other words, it fails to capture the fact that the relative effectiveness of the higher educated against the lower

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[1] See Katz and Murphy (1992), Murphy and Welch (1992), Autor, Katz and Krueger (1998), Katz and Autor (1999), Acemoglu (2002), Autor, Katz and Kearney (2008), and Acemoglu and Autor (2011) among many others.

[2] Examples include Katz and Murphy (1992), Autor, Katz, and Krueger (1998), Card and Lemieux (2001), Beaudry and Green (2005), Autor, Katz, and Kearney (2008) and Dustmann, Ludsteck, and Schonberg (2009). Several other papers, including Card and Dinardo (2002), use fixed *ad hoc* weights.

educated may change "over time". This "fixed-weight" assumption does not capture the potential changes in the efficiency units meaning that it ignores potential changes in the quality dimension.[3] If labor quality improves over time, the fixed-weight models underestimate the increase in the relative supply of college equivalents. If, on the other hand, labor quality deteriorates over time, increase in the relative supply is overestimated by these models. Therefore, the fixed-weight specification is not robust in that it misses a fair amount of economic phenomena that goes on in terms of quality adjustments.

The idea that assuming fixed efficiency labor supply units in the construction of the relative supply series may lead to miscalculations is related to Carneiro and Lee (2011) and Bowlus and Robinson (2012). Carneiro and Lee (2011) argue that time variation in school quality may be used as a proxy to endogenize the fixed efficiency units. They show that college quality has been declining over time; thus, an hour supplied by a worker received college education in, say, 1980s produces more output than an hour supplied by a worker received college education recently.[4] As a result, the fixed efficiency units setup over-estimates the growth rate of relative supply of college workers, which means that the slope of the SBTC trend has also been overestimated in the literature.

[3] See Bowlus and Robinson (2012). See also Browning, Hansen, and Heckman (1999) for an excellent review of the efficiency units literature.

[4] The literature has now reached a consensus that the "quality" of skilled workers relative to unskilled workers does change over time. However, there is no consensus on the direction of the change. The problem is that the definition of quality varies across studies. For example, Acemoglu (2002) documents that the relative productivity of college graduates has increased up to threefold from 1980 to 1990. The intuition is simple. Increased complementarity between high technology and skills is the driving force. This strand of the literature interprets the relative productivity of college graduates as the measure of quality. Carneiro and Lee (2011), at the other extreme, show that the relative quality of college education has declined between 1960 to 2000. Their measure of quality is the relative quality of college education.

Bowlus and Robinson (2012) show that estimating the changes in the efficiency units over time poses a serious challenge of identification. They find that both quality and quantity changes are important and should be accounted for. Our paper is similar to both of these papers in the sense that we also argue that ignoring time variation in the efficiency units may lead to miscalculations. Different from these literature, we obtain time variation through an explicit self-selection framework that allows for unobserved compositional changes within education categories.

The main idea behind our selectivity argument is that workers may be self-selecting into the FTFY status. Our starting point is the observation that most studies in the U.S. wage inequality literature focus on the full-time full-year (FTFY) workforce. In other words, the ones who potentially self-select into the FTFY status have been sampled. Among employed workers, selection into the FTFY status exhibits distinct trends between education categories after late 1960s to date. The fraction of the FTFY status among better-educated employed workers is quite high and stable-around 90 percent- over the data horizon. Among those with low education levels, on the other hand, the fraction of the FTFY status exhibits significant time variation. It is much lower and considerably more volatile. For example, among high-school dropouts, around 80 percent of the employed workers have had FTFY status in late 1960s, while the FTFY ratio has sharply gone down to 60 percent. Similar trends are also observed for other less-skilled workers, including the high school graduates and workers with some college education who earn less than the median wage. These observations suggest that the composition of unobserved skills is subject to sharp movements within low-educated employed workers, while the scale of these movements is potentially much smaller within high-educated ones. The standard college premium framework accounts for the observed shifts between education categories, but it cannot account for these unobserved compositional changes within education categories. These divergent patterns between low-and high-skill workers in terms of the labor supply patterns on the FTFY margin motivate this study.

These patterns raise concerns that the existing estimates may be missing some systematic components of the relative supply series that are relevant for wage inequality analysis. We are interested in the question how these two strong assumptions -first is that the efficiency units of labor supply is fixed over time that causes to miss the relative changes in the efficiency units of skilled versus unskilled labor hours and second is that the standard framework focuses only on the FTFY workforce that result in missing the systematic selection in and out of the FTFY status of low-skill workers- affect the estimates reported in the U.S. wage inequality literature. Both of these missing parts have economic content and, therefore, should be paid exclusive attention.

The first step in our analysis is to investigate if a significant selection bias exists or not. We employ a standard Heckman selection-correction procedure to model FTFY as a choice variable. We calculate a selection-corrected relative supply series. We then compare this corrected series with the uncorrected series. We provide evidence that ignoring FTFY status choice may bias the results. In particular, we find that selectivity is significant and that, under selection-correction, the rate of growth in the relative supply of college workers is even sharper before 1990s and it is even slower afterwards; that is, the deceleration is even more pronounced after correcting for selectivity. This suggests that unobserved compositional shifts arising from the time-varying FTFY choices of the low-skill workers should be accounted for.

At the second step, we investigate the sources of this bias. To perform this task, we take a deeper look at the composition of the Mills ratios across education and experience groups. Our goal, in this exercise, is to understand the main structure of self-selection into and out of the FTFY status over time. We use the inverse Mills ratios -the output from the selection correction procedure- and use them to as time-varying components of the efficiency units. In other words, we assume that the differential selection in and out of the FTFY status can describe how efficiency units move over time. We show that selectivity operates over the lower educated and less experienced workers. More precisely, we find that high-school dropouts and the workers with 0-9 years of experience select into the FTFY status until late

1980s and they select out afterwards. The same tendencies have been reported for the high-school graduates and the workers with 10-19 years of experience, in a much weaker sense though. This means that the direction of selectivity is reversed after mid-1980s. There are signs of selectivity also for the more skilled workers, but their patterns of selectivity are not altered over time; that is, they do not affect the trends in the relative supply. In other words, accounting for selectivity changes the trends in the relative supply of skills and the main source of these changes is the shift in the self-selection patterns of the low-skill workers. The intuition is as follows: low-skill workers are over-represented in the FTFY workforce before the 1990s and they are under-represented afterwards. Correcting for this pattern makes the trend in the relative supply of skills steeper before the 1990s and flatter after the 1990s. In terms of the SBTC hypothesis, this suggests the well-known deceleration observed in the relative supply of college workers after 1980s is even more pronounced after correcting for selectivity. This result casts further doubt on the relevance of the plain SBTC hypothesis. We conclude that what happens to the within-group skill composition for low-educated groups is critical for fully understanding the trends in the relative supply of college workers in the U.S..

That focusing on the FTFY workforce can be problematic in the analysis of inequality is new in the college premium literature, but it is originally introduced by Mulligan and Rubinstein (2008). The main idea is that workers may be self-selecting into the FTFY status and this may bias the result. They focus on the changes in women's self-selection into the FTFY status and proposes this mechanism as an explanation closing gender wage gap in the U.S. Our work concentrates on male workers and we document that there are systematic differences between the FTFY choices of the low-skill and high-skill workers. Specifically, we show that the FTFY fraction is stable for high-skill employed workers, while it fluctuates wildly for low-skill ones.

We then question what triggers the changes in the selectivity patterns of the low-skill workers. The fact that selection operates through the unobserved ability composition of the low educated suggests that we should focus on factors affecting the lower tail of the wage distribution should in seeking an explanation to the selectivity patterns. The real minimum wage is a good candidate. We propose that the interaction between the (endogenous) direction of technical change and the minimum wage laws is potentially the triggering mechanism.[5] Profit generating motives by producers endogenously determine the amount of innovative effort (i.e., R&D expenditures, patents etc.) to be devoted to different factors of production. These factors of production include skilled and unskilled labor. Thus, the direction of technical progress can lead to unskill-bias (e.g., England in the eighteenth and nineteenth centuries) or skill-bias (e.g., Unites States after World War II). Institutions (i.e., the non-market factors) can lead to amplification or attenuation of the strength of the technical change. To understand this mechanism better, think of the following example. Suppose that the relative supply of college workers grows at a constant rate. The government raises the level of real minimum wages permanently. This makes unskilled labor more expensive, triggering investments in skilled-labor favoring technologies. This raises the relative returns to college education leading the society to invest in college education at a faster rate. The reverse logic holds when real minimum wages are reduced permanently. The trends in real minimum wages in the U.S. perfectly fit the self-selection structure that we document. Our findings suggest that the movements in the real value of the minimum wage might have been the driving force behind the self-selection of low-skill workers into the FTFY status.[6]

The idea that the movements in the real minimum wage may have triggered substantial compositional changes in the workforce is closely related to Lemieux (2006). He argues that the trends in the real minimum wage can potentially generate compositional effects. Different from Lemieux (2006), we argue that the real value of the minimum wage may have led to compositional changes in the workforce that

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[5] See e.g., Acemoglu (1998).

[6] In Mulligan and Rubinstein (2008), the increased investment in women's human capital is the main triggering force behind the self-selection mechanism that has led to compositional changes.

affect the relative supply of college-equivalent workers in the U.S. In other words, we conclude that institutional changes- the real minimum wage- can affect wage inequality not only directly, but through its indirect effects on the relative supply of college workers.

The way we treat the real minimum wage also relates to the discussion of the effect of the real minimum wage on U.S. wage inequality in Autor, Katz, and Kearney (2008). They argue that movements in the real minimum wage cannot fully explain the trends in wage inequality, because the most of what happens to wage inequality is due to movements in the upper half of the distribution; but, the real minimum wage is mostly related to the lower half. We show that the real minimum wage also operates through its effect on the relative supply of college workers. As a result, one should also look at how the relative supply responds to institutional changes, rather than directly focusing on the wage outcomes. This is related to the endogenous technical change version of the SBTC hypothesis.[7]

The deceleration in the growth rate of the relative supply of college equivalent workers is argued to point out to a puzzle.[8] In terms of the mechanisms that the canonical college-premium equation features, the deceleration in the relative supply series brings together a puzzling deceleration in the relative demand for skilled workers starting in the early 1990s.[9] This is a consequence of the slowing of the growth of overall wage inequality. But, given the fact that computerized

[7] See e.g., Acemoglu (1998).

[8] See Acemoglu and Autor (2011), Card and Lemieux (2011), Ellwood (2002), and Freeman (1976) for a detailed documentation that contributes to this deceleration.

[9] See, for example, Autor, Katz and Kearney (2008), Autor, Katz, and Krueger (1998), and Katz and Murphy (1992), Carneiro and Lee (2011). Empirical results documented by Carneiro and Lee (2011) –setting education quality as the definition of quality- suggest that the slowdown may be worse than that predicted by the fixed-weight models.

technologies have been invested heavily during the 1990, the slowing of the SBTC trend posed a puzzle in the literature. The consensus in this literature is that the canonical supply-demand framework motivating the college-premium framework falls short of explaining the trends after early 1990s.

A strand of the literature, called the "revisionists", highlighted the importance of several institutional factors in explaining this puzzle. The real minimum wage is often pronounced as a key factor driving these results as we mention earlier. However, it is argued in the literature that fluctuations in the real minimum wage cannot fully explain these trends since the most of what happens to wage inequality is due to movements in the upper half of the distribution; but, the real minimum wage is mostly related to the lower half. However the argument we make that one should also look at how the relative supply responds to changes in the real minimum wage, rather than directly focusing on the wage outcomes since selection operates through the unobserved ability composition of the low educated and therefore the real minimum wage may themselves affects the evolution of the relative supply of college workers through unobserved compositional shifts shed light on this puzzle.

Apart from implying a puzzling deceleration in relative demand growth, the standard canonical supply-demand framework also fails to provide a satisfying explanation for the recent wage polarization structure in the U.S. since the late 1980s associated with polarization in skill demands. This recent pattern of wage changes, we believe, can be partially reconciled by a reinterpretation of the SBTC hypothesis along the line that gives more emphasize to a polarized wage structure.

Although, the fixed efficiency units idea is a good first approximation, it misses how the relative labor supply contributions of each education category evolve over time since it focuses exclusively on the FTFY workers without dealing with the potentially problematic issue we point out that the share of the FTFY status fluctuates within education categories over time, which suggests that there may be unobserved compositional shifts due to selection in and out of the FTFY status. This is particularly important for the point we make in this thesis. Accounting for these unobserved compositional changes can alter the estimated trends in the relative supply of college equivalent workers and, thus, can have implications on the analysis of wage inequality. All these arguments lead to the conclusion that the empirical findings in the literature are nonnegligibly sensitive to the construction of the relative supply measure. If fixed weights are used in the analysis, as did the canonical college premium framework, then both quality adjustments in the labor force and the effect of unobserved compositional shifts on wage inequality are ignored.

Our results confirm the fact that the literature neglects a number of substantive economic developments such as changing quality of the work force and composition of unobserved skills within low-educated employed workers that have taken place in the U.S. over the last four decades empirically. Using the standard latent variable selection-correction methods to control for selection in and out of the FTFY status-motivated by the observation that there are discrepancies in the labor supply decisions among different skill groups-, we find that the well-known deceleration observed in the relative supply of college-equivalent workers after mid-1980s is even more pronounced after correcting for selectivity which may have serious implications on wage inequality. We provide evidence that the uncorrected series of supply measure understate the substitutability of skilled and unskilled workers. This pattern also implies that the relative demand growth is stronger when the uncorrected series is used. This suggests that, when time-varying selection-corrected efficiency weights are used, the slowdown in the SBTC trend is more pronounced. In addition to that, we demonstrate that when we account for the substitutability of experience groups, the correction exercise makes the college and high-school workers more substitutable; therefore, leaves less room for SBTC trend to operate. The increase in substitutability is more pronounced for less-experienced while it is much less pronounced in high-experience groups. This suggests that the selectivity operates through the less-experienced workers.

We suggest that the following three points should perhaps be re-emphasized. First, that the deceleration in the relative supply series is more pronounced after correcting for selectivity suggests that the slowdown in the SBTC trend is even sharper, which makes the puzzle deeper. Second, the selectivity patterns do not explain the puzzle; instead, it offers a mechanism that amplifies the deceleration. Finally, the relative supply series can itself be affected from the institutional factors. We think that a full analysis of wage inequality requires a detailed examination of the productivity adjustments in the labor force rather than quantity adjustments only and unobserved compositional changes within education categories. There is more to be understood about the interactions between supply-demand conditions in the labor market and other nonmarket factors- i.e., the factors affecting labor quality and how they evolve over time. A more general human capital model is needed to understand these broader interactions and their implications on wage inequality.

The plan of the study will be as follows: Chapter 2 surveys the literature and reviews the theoretical framework by describing the environment of the college premium model, discussing the alternative theoretical settings and their implications. Chapter 3 presents technical details about the data used in the study and illustrates the historical evolution of some key variables. It explains the methodological framework, provides the details on the construction of our analysis samples, outlines how the relative supply measure is computed from the data, and explains how we calculate the selection-corrected relative supply series. Chapter 4 discusses shortcomings of fixed efficiency weight structure and proposes an exercise, with an empirical counterpart putting emphasize on the importance of the way of constructing weights in the analysis of wage inequality. Chapter 5 corrects the standard canonical skill premium framework used in the literature to account for the effect of unobserved compositional changes within education categories and discusses the implications of this selection-corrected model structure on the empirical analysis of wage inequality along with an in depth discussion of the potential effects of real minimum wages and several policy implications. Chapter 6 presents the concluding remarks. Finally, I complete with a synopsis of my future research directions.

CHAPTER 2

LITERATURE AND THEORETICAL FRAMEWORK

There is a large and expanding literature that documents and attempts to explain changes in the wage structure and earnings inequality in the U.S. over the past four decades. We survey this literature and discuss the possible explanations that have been offered for the increasing U.S. wage inequality including the role of that skill-biased technological change, changes in the labor market institutions and the role of globalization forces (trade) in section 2.1. Section 2.2 reviews the theoretical essence of the major studies in the literature and discusses the implications of the alternative model structures. We evaluate these models from both a theoretical and an empirical perspective. We start with a review of the models of the college premium and provide a detailed comparison of alternative theoretical settings in subsection 2.2.1 and 2.2.2. We extend the approach developed by Autor, Katz and Kearney (2008) using many alternative settings ranging from the simple Katz and Murphy (1992) model to the Card and Lemieux (2001) model of imperfect substitution. Then we discuss the role that various elasticity of substitution parameters play in these models in subsection 2.2.3. In subsection 2.2.4 the effect of the inclusion of the real minimum wages into the standard canonical skill premium equation is examined. Finally, in subsection 2.2.5, we introduce a simple selection-correction algorithm to account for the unobserved compositional changes due to selection in and out of the FTFY workforce.

2.1 Literature

After remaining relatively stable in the 1960s and 1970s, wage inequality among males increased substantially in the U.S. in the second half of the 1970s.[10] This trend continued in a rapid and monotonic fashion during 1980s, especially in the first half. The top grew most rapidly, the middle less rapidly, and the bottom the least of all. Since the late 1980s, there have been notably non-monotone changes in earnings levels across the earnings distribution. Inequality in the male earnings distribution has subsequently taken the form of polarization since then while upper- and lower-tail wage inequality have diverged with a continuing persistent rise in inequality in the upper half of the distribution and a slight reversal of inequality growth in the lower half of the distribution.

The majority of the increase in wage inequality since 1980 can be accounted for by rising educational wage differentials and residual wage inequality. Most of this spreading out of the wage structure has been attributed to an increase in the rate of growth of the relative demand for more skilled workers coming about from skill-biased technological changes and a re-organization of work driven by the spread of computer-based technologies. Increases in the supply of skills, from rising educational attainment of the U.S. work force also kept pace for most of the twentieth century, although skill-biased technological change has generated rapid growth in the relative demand for more-skilled workers for at least the past century. Since 1980, however, a sharp decline in skill supply growth driven by a slowdown in the rate of growth of educational attainment of successive U.S. born cohorts has been a major factor in the surge in educational wage differentials.

Wage inequality is defined as the differences in wages due to some measurable and immeasurable (or observable and unobservable) characteristics of earners. There can be mentioned about two types of wage inequality depending on the source of it. One is "between" inequality which is the wage inequality caused by differences in

[10] From this point on, whenever we mention wage inequality, it means male wage inequality.

observable skills and characteristics. It can be seen easily by comparing the wage distributions of individuals with different characteristics. Wage differentials between groups with different levels of education, for instance high school graduates vs. college graduates, or wage differentials between experience groups, such as workers with higher experience vs. workers with lower experience are the examples of "between" inequality. The wage inequality among individuals of the different sex, race, location or those working in the different occupation and industry also counted in this type of inequality. The other is, "within" or "residual" inequality showing the wage inequality among observationally equivalent workers. Even though these groups of individuals have seemingly similar observable characteristics such as age, education, experience, industry or occupation, usually one still observes wage dispersion that cannot be explained by their observed skills. Consider two workers of the same years of experience and education. If one these workers have some unmeasured skills that the other does not have, then a change in demand for these unmeasured skills the former worker have but the latter do not will result in higher wages for the former. Obviously, it is not an easy task to measure the effect of something that is unobservable or immeasurable. For one thing, we cannot argue that the data sets available to us give all the details about a person. Thus, even "narrowly defined groups" of similar characteristics might not be as similar as we expect. Levy and Murnane (1992) give standard data sets available to us as well as industry and plant specific characteristics as examples of unobservables that lead to within inequality. A generally accepted measure of within-group inequality is the inequality observed among ordinary least squares (OLS) residuals obtained from a Mincerian wage regression, due to their representation of unobserved skills and characteristics. [11]

[11] See Mincer (1974).

The evolution of the U.S. wage inequality- remaining quite stable in the 1950s and 1960s, widening rapidly during the 1980s, and "polarizing" since the late 1980s- has been occurred along three primary dimensions:[12]

1. Wage differentials by education showed a changing pattern from 1960s to the end of 1980s. The returns to education expressed as years of schooling increased during the 1960s, then fell during the 1970s, and rose sharply during the 1980s with a particularly sharp rise in the relative wages and earnings of college graduates. The average wage of a college graduate increased relative to the average wage of a high school graduate by over 15 percentage points from 1979 to 1988. (There was also a substantial increase in the gap between the returns to high school and elementary school). [13] The earnings of workers with a college (graduate) degree relative to non-college workers have increased rapidly and continuously since 1979. By contrast, the earnings of college only workers (those with a four-year college degree but without a graduate degree) relative to high school graduates rose rapidly from 1979 to 1987 and then reach a stable level. (The college/non college relative wages has continued to rise during the early 1990s, but at a slower rate than in the 1980s.) The wage gap between post-college educated and college educated workers has continued to expand rapidly since the late 1980s, while the growth in the wage gap between high school graduates and dropouts has diminished.

2. Experience differentials also expanded substantially from 1963 to 1987. The most dramatic increases in experience differentials occurred for less educated workers from 1979-1987. Wages of more experienced workers increased relative to the wages of younger workers for those with relatively low levels of education.

[12] See Bound and Johnson (1992), Levy and Murnane (1992), Murphy and Welch (1992), Katz and Murphy (1992), Katz and Autor (1999), and Acemoglu (2002) among many others.

[13] The changes in the college/high school wage ratio were greatest for the youngest workers in the 1970s and 1980s while it was greatest for prime age workers in the 1960s.

3. Wage dispersion within narrowly defined demographic and skill groups also expanded. The wages of individuals with similar characteristics such as education and experience (and even those working in the same occupation and industry) is much more unequal in the mid-1990s than two decades earlier.

As one can notice, the first two of these major facts refer to wage inequality "between" groups, while the last one is related to "within" or "residual" inequality. Within inequality has a significant importance in the debates over reasons accounted for the changes in the wage structure because of the difficulty of measuring it. Juhn, Murphy and Pierce (1993) conclude that the change in residual inequality explains a much higher portion of the changes in wage inequality than that of education, experience or other observable demographic characteristics. McCall (2000) argues the relationship between employment and market conditions and residual wage inequality. It suggests that residual inequality differs more widely across labor markets than across time and find that residual inequality tends to be highest in labor markets with flexible and insecure employment conditions. Another interesting finding of this study is that labor markets specializing in high technology industries apparently do not adopt higher levels of residual wage inequality. Another study emphasizing the importance of the residual inequality is Taber (2001). He confirms empirically that an increase in the demand for unobserved ability rather than an increase in the demand for skills accumulated in college play a major role in the growing college premium. Another research by Gould (2005) examines the link between increasing residual inequality and rising returns to cognitive skills. It also attempts to estimate the latent population distribution of unobservable skill within occupational sectors using selection-correction techniques. The findings show that sector-specific skills have played only a minor role in the inequality trends and that rising residual inequality is mostly characterized by an increasing importance of unobservable skill within occupations. The findings of Lemieux (2006) also have important implications with respect to the residual inequality argument. It demonstrates that composition effects linked to the secular increase in experience and education mostly account for the large fraction of the 1973-2003 growth in residual wage inequality. Therefore the role of unobserved skill prices in the overall growth in wage inequality should be reconsidered. Lemieux argues that the movements in the real minimum wage may have led to these compositional changes in the workforce. He suggests that movements in the real value of the minimum wage can be linked to the movements in the extent of residual inequality in the U.S. More specifically, he shows that the magnitude of residual inequality is negatively related to the real minimum wage.

The changing pattern of the wage structure and the fundamental causes of the change have been widely documented. Much debate, however, remains about the causes of this phenomenon than about the change itself. There are mainly three alternative explanations receiving much attention.

One class of explanations suggests that changes in the supply of and demand for skills are mainly responsible for the changes in the wage structure. First group of studies in this line attributes wage structure changes to an increased rate of growth of the relative demand for labor favoring more educated and more skilled workers over less educated and less skilled ones. The leading candidate explanation for these demand shifts is the skill-biased technological change hypothesis (SBTC), mainly associated with the increased use of computers and skill-intensive technologies in the workplace. It is argued that such technological changes associated with the computer revolution favored more skilled workers over the less skilled ones. Bound and Johnson (1992), Juhn, Murphy and Pierce (1993), Berman, Bound and Griliches (1994), Autor, Katz and Krueger (1998), and Acemoglu (2002) have been offered as explanations for this pattern.[14] The main argument in all of these studies is that the growth in the demand for workers with higher skills along with the use of new computer technologies is the main reason behind increasing wage inequality. Bound and Johnson (1992) point towards the shift in the skill structure of labor demand brought about by biased technological change. Juhn, Murphy and Pierce

[14] See also Levy and Murnane (1992) and Katz and Autor (1999) for a detailed review of this line of the literature. Katz and Autor (1999) also provide an overview of alternative approaches to modeling and measuring wage structure changes.

(1993) reveal that much of the increase in wage inequality, during the 1980s, was in the form of higher demand for more skilled workers and somewhat lower demand for the less skilled ones, the former having a more dominant effect.[15] The increase in the wage inequality favoring college graduates over high school graduates and new college graduates over older ones confirms this view. The increase in within inequality, as mentioned above, indicates that the workers with newly needed skills were also favored over the ones lacking of those skills. Berman, Bound and Griliches (1994) find that the change in the skill differential is closely correlated with technological change as measured by changes in computer intensity and capital, research and development facilities. Additional evidence confirming a positive relationship between computer use and the demand for more skilled workers came from Autor, Katz and Krueger (1998). They indicate that relative demand for college graduates grew strongly and persistently during 1940-1996 period and show that the rate of skill upgrading has been higher in industries which are more computer-intensive. Acemoglu (2002) suggests that most of the technological change in the 20th century has been characterized by skill-biased technological change, this kind of technological change has accelerated during the 1980s with the increased use of computers and demand for people with higher education and required skills increased, and the increase in wage inequality is closely related to an acceleration in this trend.

There are two distinct hypotheses related to the role and impact of skill-biased technological change in the literature.[16] The evidence on the impact of skill-biased

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[15] In parallel with the evidence for increasing wage inequality across skill groups, Juhn, Murphy and Pierce (1993) provide also an evidence for increasing wage inequality among workers with similar characteristics. ("within" or "residual " inequality). They reach a conclusion that a much higher proportion of the changes in the wage structure is explained by rising within (or residual) inequality rather than between inequality, inequality among workers with different education, experience, and other measured forms of skill.

[16] See Autor, Katz and Krueger (1998), Katz and Autor (1999), and Acemoglu (2002) for futher discussion on the subject.

technological change on recent wage structure changes is questioned in light of these two. The first is the “acceleration hypothesis”, which claims that the impact of technological change on the relative demand for more skilled labor accelerated during 1980s. It argues that this acceleration in the skill bias of technology, which, in turn, leads the acceleration in the demand for skills, is mainly responsible for the increasing wage inequality. Autor, Katz and Krueger (1998) provide some direct and indirect evidence in favor of this hypothesis. They find that within-industry demand growth accelerated from the 60s to the 70s and then kept at this higher level through the mid-90s. They also find a more accurate evidence that skill upgrading within detailed industries during the same period has concentrated in more computer-intensive industries. Acemoglu (2002) conclude that skill-biased technological change is likely to have accelerated over the past several decades based on the fact that returns to education rose over the past thirty years even though there is a rapid increase in the supply of skills. The second is the “steady-demand hypothesis”, which asserts that skill biased technological change has progressed in a continuous manner.[17] According to this hypothesis, it is the rate of the increase in the supply of skills explaining changes in inequality since the demand for skills increases at a steady rate. It says that the rapid increase in the supply of skills avoided wage inequality from rising before the 1970s in spite of what appears to be a skill-biased technological change. Since the growth of the supply of skills was as abrupt as the constant rate of skill biased technological change, inequality was relatively stable before the 1970s. The rapid increase in inequality after that period is then explained by a significant deceleration in the growth rate of the supply of skills rather than a major technological change inducing relative demand shifts.

Second group of studies in the line which is in support of the view emphasizing the importance of supply and demand factors in explaining changing wage structure consists of a supply related explanation. Evidence in favor of this explanation comes from a number of papers proposing that changes in the composition of labor

[17] It is named by Acemoglu (2002).

supply, specifically changes in the relative supplies of workers with high levels of education also play a role in explaining widening wage trends in the 1980s.[18] A comprehensive study is provided by Katz and Murphy (1992). They attribute increasing skill differentials in the 1980s and 1990s to a supply shifts coupled with a steady rate of growth in the relative demand. Important aspects of supply shifts are a remarkable increase in the supply of skills in the 1970s achieved by the labor market entry of relatively well educated baby boom cohorts, and a sharp slowdown of relative skill supply growth in the 1980s driven by a decline in the growth of educational attainment of successive cohorts. They conclude that this substantial deceleration in the growth rate of the supply of skills seems to be a crucial part of changes in the wage structure. Goldin and Katz (2007a) and (2007b) also argue that supply changes are critical regarding the changing pattern of wage structure and returns to skill. Both studies state that although skill-biased technological change has brought about a rapid growth in the relative demand for more skilled workers for at least the past century, the continuing large increase in the supply of skills more than kept pace for most the twentieth century. They suggest, since 1980s, however, relative demand shifts have not been particularly rapid. Instead, a marked slowdown in the growth rate of the supply of skills after this period has been a major dynamic affecting educational wage differentials.

Distinguishing supply shifts from demand shifts was a major step forward regarding supply based explanations. However, a distinguished work by Card and Lemieux (2001) deserve special attention in this group of explanations since they extend the standard supply and demand framework by introducing imperfect substitution between similarly educated workers in different age groups.[19] Introducing age

[18] The effects of the large increase in the labor force attachment of women, and the patterns of immigration, namely an increase in the supply of relatively low-skilled immigrants in the 1980s also contribute to a supply related explanation. See O'neil (1985), and Borjas, Freeman and Katz (1997) for a detailed argument , respectively.

[19] Many studies such as Katz and Murphy (1992), Katz and Autor (1999), Autor, Katz and Krueger (1998), and Autor, Katz and Kearney (2008) have used a simple supply and demand framework to

groups into the analysis rests on the observation that unlike what Mincer (1974) suggests- that the college premium increased steadily with age in 1960s- the college-high school wage gap trend in the last thirty years displays an increase for younger men while it has been stable or declining for older men. They argue that these changes have been driven by the recent slowdown in the growth rate of educational attainment in younger cohorts. That is; the fraction of skilled workers in each generation has been lower and lower starting with the cohorts born in early 1950s. Combining these two observations, they conclude that if similarly educated workers in different age groups are imperfect substitutes, the change in the age structure of the college premium can be related to the declining relative supply of college equivalents. Introducing imperfect substitution between young and old workers weakens the negative impact coming from the rise in the relative supply and creates an additional positive impact through age and cohort specific fixed effects. Therefore, they claim that the effect of the rise in the relative supply of college equivalents on wage inequality is not as strong as suggested. This result constitutes a crucial implication in terms of skill biased technological change hypothesis. That is, the rise in relative demand for college equivalents required to justify the increase in wage inequality is not as strong as suggested. In other words, the degree of skill biased technological change required to justify the increase in wage inequality does not display as strong an increasing trend as it is suggested in the papers favoring the skill biased technological change hypothesis. They, therefore, suggest that the role of technological change needs to be reconsidered. This idea has been influential in the existing wage inequality literature.

Another class of explanations for rising inequality, yet did not find as many supporters as the first one, focuses on the role of increasing volume of trade with developing countries. The main argument is that the expansion of trade with developing countries and increased import competition largely associated with large trade deficits in the 1980s have led to a sharp decline in manufacturing production

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analyze changes in wage differentials in the U.S.. In this standard theoretical model, the age groups under each skill category are used to be perfect substitutes.

employment and therefore a shift in relative demand against less skilled workers. It is also argued that the decline in manufacturing employment leads to the loss of wage premia paid to the blue collar workers in certain industries. Several studies have examined the impact of trade on the wage differential favoring the skilled. Wood (1995) argues that the opening of trade with less developed countries is the main cause of the deteriorating situation of unskilled workers. He utilize the factor content analysis, the common method in estimating the effects of trade on labor markets and find a strong evidence that trade with less developed countries raises the supply of less skilled workers in developed countries and therefore lowers their relative wages. Borjas and Ramey (1994) find that the trade deficit in durable goods and the average log wage differentials between college graduates and less educated keep the same pattern. Borjas and Ramey (1995) also find support for the argument that foreign competition in highly concentrated industries is strongly related to the increase in the returns to skills. Buckberg and Thomas (1996) also suggest that the increase in the durable goods trade deficit explains changes in the college/high school wage differentials. Bernard and Jensen (1997) claims that increases in employment at exporting industries contribute to the increase in relative demand for skilled labor in manufacturing and thereby explain the wage gap between high and low skilled workers. Many others, however, have argued that international trade is not important enough to account for a major determinant of increasing inequality. Lawrence and Slaughter (1993), and Krugman and Lawrence (1994) criticize the standard view that more trade with developing countries affects the skill premium by increasing the relative price of skill intensive good. They found almost no major change in these relative prices to account for the large increase in the skill premium. Burtless (1995) points out that the percentage of U.S. employment accounted for by trade affected manufacturing industries is too small to have a major impact on the wage structure. Berman, Bound and Griliches (1994) and Borjas, Freeman and Katz (1997) also emphasize the same point by indicating that trade has no effect on the relative supply of low skilled labor and the supply effect of trade is quite modest since the content of unskilled labor within in the U.S. imports is relatively small compared to the changes in the supply of skills. Topel (1997), as well, suggests that a trade-induced increase in the supply of unskilled workers does not seem to be a plausible factor explaining the changing wage structure.

To sum up, explanations based on relatively steady-trend relative demand growth for more skilled workers, an acceleration in the rate of skill-biased technological change, brought about in large part by the increased use of computer technology with the fluctuations in relative skill supplies, particularly a slowdown in the growth rate of the fraction of the workforce with high levels of education and arguments concentrated in the effects of increased international trade largely associated with large trade deficits in the 1980s shrinking the demand for the less skilled are supposed to be "traditional interpretation" of changes in the U.S. wage structure in which market forces of supply and demand are accounted for these changes. However, as we pointed out earlier, most evidence suggests that the trade argument is far from being the major cause of the changes in the wage structure. The effect of increased international trade on the US labor market has been relatively minor. Instead, supply and demand factors seem to matter in explaining the changing pattern of wages. Demand shifts from skill biased technological change and shifts in relative skill supplies appear to be much more significant factors in the growth of the U.S. wage inequality than trade's impact. For example, recent studies by Artuç and McLaren (2010) and Artuç, Chaudhuri, and McLaren (2010) suggest that the contribution of international trade to widening wage inequality is negligible and it can be easily dominated by other factors. Furthermore, Klein, Moser and Urban (2010) and Chakrabarti (2000) provide evidence that the effect of trade on wage inequality can be narrowing rather than widening.

A further explanation focuses on the importance of institutional factors in accounting for changes in the wage structure. Contrary to the "traditional" literature seeing wage inequality as a labor market phenomenon, non-market forces including the decline in unionization and erosion of the real value of the minimum wage are shown to be responsible for the widening wage inequality in this line of the literature.[20] One variant suggests that unions play an important role in wage determination both directly through collective bargaining and union threat effects on wages and indirectly by affecting government policies. It is argued that since unions have been found to have an equalizing effect on the wage distribution, the decline in union contract coverage has been as a possible cause of the widening wage gap. Blackburn, Bloom, and Freeman (1990) estimate that the decline in the proportion of the workforce that is unionized and the weakening role of many unions explain about 15 percent of the increase in the education-related wage gap in the 1980s. Dinardo and Lemieux (1995) also points out the role of declining union representation. Freeman (1993) examines the effects of de-unionization on the changes in the variance of log earnings of U.S. males from 1978 to 1988 and calculates that the decline in union density can explain approximately 20% of the rise in male earnings inequality from 1978 to 1988 and the declining union membership might account for as much as 40 percent of the rise in the college/high school wage differentials in the U.S.. Dinardo, Fortin and Lemieux (1996) also attempt to estimate the effects of de-unionization on overall wage inequality for US. Their results reveal that the decline in unionization from 1979 to 1988 can account for 10.7% of the 0.195 log point increase in the overall log wage differential for males. They argue that this decline contributes to a "declining middle" of the male wage distribution and explain one-third of the increase in the upper half wage differential and actually partially offsets other forces towards a widening of the lower half differential. Freeman (1996) argues that changes in collective bargaining institutions are the best explanation for the sharp differences in wage inequality between countries. Card (2001) also assesses the connection between declining importance of unions and widening wage inequality. Another variant focuses on the role played by the decline in the real value of the minimum wage in explaining the increase in wage inequality. The real value of the minimum wage fell considerably during the rise in wage inequality of the 1980s. Studies in this line mainly argue that

[20] There are additional institutional factors such as business fluctuations [Hoynes, Miller, and Schaller (2012)] and foreign outsourcing of less-skilled jobs [Feenstra and Honson (1999)] that can potentially diffuse into the process determining the relative demad for skills.

since the minimum wage sets a legal floor for the wage distribution and is likely to increase the wages of low-paid workers, the decline in its real value have led to increasing wage inequality, at least at the low-wage end of the distribution. Several studies, including Dinardo, Fortin and Lemieux (1996), Lee (1999) and Teulings (2003) provide evidence in support of this hypothesis. Dinardo, Fortin and Lemieux (1996) find that, in addition to supply and demand shocks and de-unionization, the decline in the real value of the minimum wage explains an important proportion of the increasing inequality, especially in the lower end of the wage distribution. They estimate that the drop in the real value of the minimum wage accounts for 25 percent of the 1979-1988 rise in wage inequality among men and this decline can account for most of the increase in the 50-10 log wage differential. Lee (1999) also argues that much of the rise in overall inequality over the last two decades is largely attributed to non-market factors, particularly declining real minimum wage. He finds a strong correlation between declining real minimum wage and declining relative earnings of low-wage workers. In a cross-state analysis of the minimum wage and wage inequality for the period 1979 to 1991, he shows that there is a strong relationship between the effective minimum wage and compression of the lower half of wage distribution across states, but modest impact on expansion in the upper half of the distribution. Teulings (2003) also suggests that the sharp decrease in real minimum wages observed in 1980s is held responsible for the rapid deterioration in the U.S. wage structure. He claims that the reduction in the minimum wage seems to be the main cause of the rise in wage dispersion in the lower half of the wage distribution in the U.S. during the1980s. Employing more recent data, several latest studies such as Card and Dinardo (2002) and Lemieux (2006) challenge the conclusions of “traditional” literature emphasizing a relative slowdown, even a stabilization in the growth of wage inequality over the last fifteen years. The starting point of this “revisionist” literature is the fact that wage inequality increased sharply in the 1980s and then stabilized in the 1990s, but the computer technology was observed to keep progressing. In other words, even though the skill-biased technological change continued to develop, the wage inequality did not keep pace with it. This relative slowdown, even a stabilization in wage inequality during 1990s, which appeared despite continuing improvement in technology, brought about some doubts over the validity of skill biased technological change hypothesis and showed that there is a weak time series relationship between technological change and wage inequality. “Revisionists” argue that much of the rise in inequality during 1980s is largely attributed to non-market factors, particularly declining real minimum wage and argues that the slowdown in the growth of wage inequality in the 1990s is inconsistent with the SBTC hypothesis. Card and Dinardo (2002) suggest that, in contrast to standard assumption conveyed in the literature, the SBTC hypothesis does not provide a plausible explanation for the evolution of the U.S. wage structure in the 1980s and 1990s. Instead, they characterize the rising U.S. wage inequality since 1980 as one-time “episodic” event of the early 1980s driven by nonmarket factors, mainly a falling real minimum wage, which is raised ground by the mid-1980s and did not recur.[21] They find a weak time series correlation between SBTC and wage inequality and therefore suggest that the validity of SBTC hypothesis is needed to be reconsidered. Lemieux (2006) also reaches a similar conclusion with Card and Dinardo (2002). He challenges the SBTC hypothesis suggesting that residual inequality declined in periods other than the 1980s and finds a close relation between trends in the real value of the minimum wage and residual wage inequality. He concludes that the rise of residual inequality in the 1980s was also an “episodic” event accounted for by declining value of the minimum wage and changing labor force composition effects linked to increasing education and experience of the work force.[22] Overall, this recent “revisionist” literature proposes that non-market factors, primarily the fall in the real minimum wages in 1980s, was an important contributor to rising inequality in the lower tail of the wage distribution. Although there is a

[21] They also mention about declining unionization and reallocation of labor brought by the 1982 recession as other factors contributing rising ineqaulity.

[22] He states that compositional changes in the workforce have a more responsibility in changing inequality in the 1990s and early 2000s than in the 1970s and 1980s. Measurement errors are also mentioned to be another non-market factor contributing to rising wage inequality in the U.S.

consensus in the whole wage inequality literature that this episodic event did not affect the trends in upper-tail inequality, these non-market factors are now being taken more seriously in the study of wage inequality.

While the debate continues about the relative importance of market forces and institutional factors in accounting for changes in the wage structure, in a recent work, Autor, Katz and Kearney (2008) reevaluate the "traditional" and "revisionist" interpretations of rising inequality. They mainly argue that if the rising wage inequality was an episodic and nonrecurring event of the early 1980s determined by non-market forces as the "revisionist" literature claims, the main reason is likely to be falling minimum wages. On the other hand, if an increasing wage inequality is a marked and secular fact rather than one–time episode as the "traditional" line suggests, then there is need to explain it with a more fundamental factors such as supply and demand changes for skills. By this incentive, they reconciliate the "market" and "non-market" views. They find no support in favor of "revisionist" literature's claim that the increase in wage inequality was an episodic event of the early 1980s. They suggest that inequality in the upper half of the wage distribution grew continuously from 1980s up to the recent years. This persistent growth of wage dispersion in the upper half of the wage distribution over last twenty five years exhibits an ongoing, secular trend rather than showing an episodic characteristic. By contrast, inequality in the lower half of the distribution expanded rapidly in first half of the 1980s and then compressed thereafter. They claim that "revisionist" interpretation suggesting that the increase in wage inequality is caused by non-market forces- particularly a decline in minimum wages- cannot explain this diverging structure of wages, a continuing permanent growth in the upper half inequality with a little reversal of inequality growth in the lower half of the distribution. They find that the falling minimum wage is likely to be an important contributor to rising wage inequality only for the lower half of the wage distribution and only for the 1979-1987 period. However, it cannot provide a plausible explanation for the permanent growth in the upper half inequality and therefore is unlikely to provide a satisfying explanation for the bulk of inequality growth since the majority of inequality growth over the last two decades occurred in the upper half of the earnings distribution. The continuous rise in the upper half inequality seems to be related to the standard models focusing on both a secular growth in the relative demand caused by SBTC and movements in the relative supplies.[23] However, these models fail to provide a satisfying explanation for wage divergence since the late 1980s and find a puzzling slowdown in the growth of relative demand for college educated workers starting in the early 1990s. Furthermore, they suggest that these models are unable to provide an explanation for the "polarization" of employment which has been associated with a recent polarization of wage structure mentioned above. [24] Employment growth starts to polarize during the 1990s as employment shifts into high-wage and low-wage jobs at the expense of middle-wage jobs. Employment shares increase in low- and high-skill occupations while it decreases in middle- skill occupations, which lead to rapidly rising inequality in the upper half of the distribution but little falling inequality in the lower half of the distribution. They argue that this polarized structure of wage and employment growth observed in recent years implies that demand shifts have played a crucial role in explaining rising inequality of 1980s and the polarization that followed. In this context, they propose the reinterpretation of the skill-biased technological change hypothesis along a line that gives more emphasize to a polarized wage structure. They suggest that a more comprehensive version of the skill-biased technological change hypothesis along the lines developed by Autor, Levy, and Murnane (2003), Autor, Katz, and Kearney (2006), and Goos and Manning (2007)-

[23] See Katz and Murphy (1992) and Autor, Katz, and Krueger (1998) among many others.

[24] The "polarization" terminology is firstly used by Goos and Manning (2003) documenting employment polarization patterns for Britain. Acemoglu (1999) also finds employment growth polarization for U.S. from mid-1980s to early 1990s using more aggregated industry-occupation cells. Autor, Katz and Kearney (2006) and Goldin and Katz (2007a) also mention about the polarizing wage and employment structure of the U.S. labor market.

that gives importance to the role of information technologies- may help to understand the recent pattern of wage changes. [25]

What Autor, Katz and Kearney (2008) did was an important extension to the existing literature. However, there is a lack of this study since they did not take into account main criticisms that have been raised against the "traditional" literature regarding SBTC hypothesis. Remember that in the standard model of the "traditional" literature, the wage inequality is justified only by the SBTC hypothesis. However, Card and Lemieux (2001) criticizes this simple formulation in the "traditional" literature suggesting that the SBTC cannot be the only force generating wage inequality since it does not display as strong an increasing trend as it is suggested and should be re-emphasized. Therefore, they extend the standard "traditional" view by introducing imperfect substitution between different age groups. By doing so, the negative impact coming from the rise in relative supply on wage inequality is weakened and an additional positive impact through age and cohort–specific effects is created. Therefore, the degree of SBTC required to justify the increase in wage inequality is reduced and year effects that come from SBTC are complemented by age and cohort effects. This extension introduced by Card and Lemieux (2001) constitutes a rather "new" line and has been influential in the

[25] The ALM [Autor, Levy and Murnane (2003)] framework suggests that computerization- via raising demand for higher-educated workers; decreasing demand for middle-educated workers- can help explain the recent polarization of the U.S. labor market. They argue that computers strongly complement the non-routine (abstract) tasks of high-wage jobs, directly substitute for the routine tasks found in many traditional middle wage jobs, and have little impact on the non-routine manual tasks in relatively low-wage service jobs. Autor, Katz, and Kearney (2006) extend the ALM framework and provide evidence that declining computer prices may initially lead to monotonically increasing shifts in skill demand followed by non-monotonic shifts favoring the upper and lower at the expense of the middle of the wage distribution. See also Lemieux (2006) and Goldin and Katz (2007) on the subject. They both argue that a more nuanced view of skill biased technological change in which the computer task demand hypothesis gains importance may serve to explain many details of the recent wage polarization.

“traditional” wage inequality literature since then. This “new” setting focusing on re-evaluated SBTC will be basis for the contribution that this study suggests. We believe that the assessment of the “traditional” literature along this “new” line developed by Card and Lemieux (2001) and then present a unifying analysis by incorporating the “revisionist” literature through including the effect of the real minimum wages into the analysis will provide more accurate explanations and interpretations of changes in the U.S. wage structure.

Many studies in the wage inequality literature, since Freeman (1975) and Tinbergen (1975), have used simple formal canonical supply-demand models of the two factor constant elasticity of substitution (CES) human capital model to explain the widening wage structure in the United States.[26] This existing framework uses “fixed” efficiency units of labor supply in order to assess the trends in educational attainment in total and across various demographic groups in the wage inequality analysis. Efficiency units literature are well reviewed by Browning, Hansen, and Heckman (1999). They suggest that, while examining the deficiencies of Cobb-Douglas specification, labor is not homogeneous and an efficiency units assumption to adjust labor to homogeneous units is inconsistent with the evidence from factor markets.

This weighting procedure captures the basic “efficiency units" idea in the sense that an hour supplied by a relatively higher educated worker counts more than an hour supplied by a lower educated worker. In other words, it successfully captures the effect of the observed changes in the educational composition of the working population. However, efficiency labor supply units idea constructed using fixed weights has two deficiencies. One is that it fails to capture the fact that the relative effectiveness of the higher educated against the lower educated may change “over

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[26] See Katz and Murphy (1992), Murphy and Welch (1992), Autor, Katz and Krueger (1998), Katz and Autor (1999), Acemoglu (2002), Autor, Katz and Kearney (2008), and Acemoglu and Autor (2011), Card and Lemieux (2011), and Dustman, Ludsteck and Schoenberg (2009) among many others.

time”. In other words, it hinges on the view that the “quality” of skilled workers relative to unskilled workers does not change over time. If labor quality improves over time, the fixed-weight models underestimate the increase in the relative supply of college equivalents. If, on the other hand, labor quality deteriorates over time, the increase in the relative supply is overestimated by these models. Therefore, the fixed-weight specification is not robust in the sense that it misses a fair amount of economic phenomena that goes on in terms of quality adjustments and needs some adjustments to account for improvements in quality of the labor force.

The idea that assuming fixed efficiency labor supply units in the construction of the relative supply series may lead to miscalculations is related to Carneiro and Lee (2011) and Bowlus and Robinson (2012). Carneiro and Lee (2011) argue that time variation in school quality may be used as a proxy to endogenize the fixed efficiency units. They show that college quality has been declining over time; thus, an hour supplied by a worker received college education in, say, 1980s produces more output than an hour supplied by a worker received college education recently. As a result, the fixed efficiency units setup overestimates the growth rate of relative supply of college workers, which means that the slope of the SBTC trend has also been overestimated in the literature. Using time-varying weights rather than fixed weights, they suggest that the slowdown in the relative demand growth may be worse than that predicted in the literature by the fixed-weight models. Bowlus and Robinson (2012) state that heterogeneous demand and supply models used in the college premium literature has the standard identification approach -the standard efficiency units approach- which assumes either constant quantities or constant prices over time.[27] They address this identification problem in which relative payments are taken as relative prices which implicitly assumes that relative quantities are constant. They say that the assumption that the quantities associated with any observed education, experience or age groups are the same over time is a

[27] The term “quantity” used in Bowlus and Robinson (2012) paper refers to “quality” in our argument. They decompose the change in relative wages into two components as relative” price” and “quantity” while we do the same thing by naming them as “quantity” and “quality”, respectively.

very strong assumption that permits only changes in the skill price ratio determines the changes in the wage ratio. They show that relative changes in the quantity of efficiency units supplied are at least as important as relative price changes in explaining the path of the average college premium. A considerable part of the variation in the college premium is due to variation in the relative quantities associated with each observed education group. In other words, they claim that relative quantity changes are much more important than relative price changes in explaining the observed changes in relative wages. Overall, they propose that efficiency labor supply units constructed using fixed weights fail to capture the changes in the quality of the workforce.

The literature has now reached a consensus that the “quality” of skilled workers relative to unskilled workers *does* change over time. However, there is no consensus on the direction of the change. The problem is that the definition of quality varies across studies. One strand of the literature interprets the relative productivity of college graduates versus high-school graduates as the measure of quality. Acemoglu (2002) interprets weights as a measure of relative productivity of college educated workers, which increase in the U.S. over the last four decades. He documents that the relative productivity of college graduates has increased up to threefold from 1980 to 1990. The intuition is simple. This is due to increased quality of skilled workers over time and greater complementarity between high technology and skilled workers.[28] At the other extreme, however, Carneiro and Lee (2011) set the relative quality of college education as the definition of quality. They show that the relative quality of college education has declined between 1960 to 2000. Using decreasing weights in their analysis, they find that the fixed-weight assumption leads to an overestimation of the increase in wage inequality in the U.S. since it does not take into account the decline in the quality of college education over time. Their results imply that the effect of SBTC is much weaker than the revisionist literature suggest.

[28] See, for example, Autor, Levy and Murnane (2003).

The fixed-weight assumption, which is the standard assumption invoked in the literature, avoids the confusion regarding the choice of the quality measure, but it misses a number of substantive economic developments such as changing quality of the workforce. Therefore studies explaining widening wage structure based on rapid secular growth in the relative demand for skills attributable to skill-biased technological change and fluctuations in relative skill supplies based on canonical supply-demand models using fixed weights, used by Katz and Murphy (1992), Autor, Katz and Krueger (1998), and Autor, Katz and Kearney (2008), imply a puzzling slowdown in relative demand growth starting in the early 1990s. Autor, Katz and Kearney (2008) argue that there has been a slowdown in the relative demand growth in 1990s. Autor, Katz and Kearney (2008) conclude that the effect of SBTC on wage inequality is perhaps not as strong as Katz and Murphy (1992) estimates suggest. However, the role of this standard set of tools attributes to SBTC in the literature should be reconsidered by taking into account the quality improvements in the labor force. Maybe it is true that relative hours of work weighted by fixed efficiency wages display a slowdown after 1980s. However, one should investigate if the improvements in the quality of labor force compensate for this slowdown or not. These canonical supply-demand models also fail to provide a satisfying explanation for recent wage polarization in skill demands since the late 1980s. See Autor, Katz and Kearney (2006), Lemieux (2006), Goldin and Katz (2007), and Autor, Katz and Kearney (2008) among many studies.

The predictions of these fixed-weight models are challenged by a distinguished studies by Carneiro and Lee (2011) and Bowlus and Robinson (2012) as we have mentioned above. These mixed results leads to the conclusion that the empirical findings in the literature are nonneglibigly sensitive to the construction of the relative supply measure. How one constructs the relative supply measure determines the estimated slope of relative demand growth. The fixed-weight specification is not robust in that it misses a fair amount of economic phenomena that goes in terms of quality adjustments. On the other hand, if one abandons the fixed-weight assumption-which ignores all the quality adjustments-and uses varying weights in the analysis, then there is a problem regarding the choice of a quality measure. If one sets education quality as the definition of quality, as in Carneiro and Lee (2011), then the weights are decreasing which seriously downgrades the SBTC hypothesis. If, on the other hand, one adopts relative productivity of college educated workers as a measure of quality, as in Acemoglu (2002), then the story is reversed. With a purpose to show how it is important on the empirical findings the way one constructs weights, we perform an empirical exercise that adopts the relative productivity of college graduates versus high school graduates (labor productivity) as the definition of quality. [29] In this case, the weights are increasing which implies that SBTC still remains in existence with no change in its role and the Katz and Murphy (1992) trend is still relevant. All these arguments suggest that the construction of the relative supply measure is subject to problems in terms of "fixed efficiency units" which may have serious implications on wage inequality.

Second deficiency of the standard framework, we suggest, is that it focuses only on the FTFY workforce which misses the systematic selection in and out of the FTFY status of low-skill workers. The main idea behind our selectivity argument is that workers may be self-selecting into the FTFY status and this may bias the results. That focusing on the FTFY workforce can be problematic in the analysis of inequality is new in the college premium literature, but it is closely related to the selectivity argument studied by Mulligan and Rubinstein (2008). Their work focuses on the changes in women's self-selection into the FTFY status and proposes this mechanism as an explanation closing gender wage gap in the U.S. Our work concentrates on male workers and we document that there are systematic differences between the FTFY choices of the low-skill and high-skill workers. In their work, the increased investment in women's human capital is the main triggering force behind the self-selection mechanism that has led to compositional changes. We propose that the movements in the real value of the minimum wage have been the triggering force behind the self-selection of low-skill workers into the FTFY status.

[29] See Chapter 4.

Both of these missing parts of the standard college premium framework have economic content and, therefore, should be paid exclusive attention. Our main purpose in this thesis is to develop a method to revise the relative supply index in such a way that it corrects for these two points. This suggests that unobserved compositional shifts arising from the time-varying FTFY choices of the low-skill workers should be accounted for. In that respect, this study can be related to the particular papers we mention above in more detail as follows. As we said, the main idea is that workers may be self-selecting into the FTFY status is related by Mulligan and Rubinstein (2008). Our study is similar to both Carneiro and Lee (2011) and Bowlus and Robinson (2012) in the sense that we also argue that ignoring time variation in the efficiency units may lead to miscalculations. Different from these studies, we obtain time variation through an explicit self-selection framework that allows for unobserved compositional changes within education categories. The idea that the movements in the real minimum wage may have triggered substantial compositional changes in the workforce is closely related to Lemieux (2006). Similar to his work, we also discuss the potential effects of the real minimum wage on the composition of the workforce. Different from Lemieux (2006), we argue that the real value of the minimum wage may have led to compositional changes in the workforce that affect the relative supply of college-equivalent workers in the U.S. In other words, we say that real minimum wages have indirect as well as direct effects on the structure of the U.S. college premium. The way we treat the real minimum wage also relates to the discussion of the effect of the real minimum wage on U.S. wage inequality in Autor, Katz, and Kearney (2008). They argue that movements in the real minimum wage cannot fully explain the trends in wage inequality, because the most of what happens to wage inequality is due to movements in the upper half of the distribution; but, the real minimum wage is mostly related to the lower half. We show that the real minimum wage also operates through its effect on the relative supply of college workers. As a result, one should also look at how the relative supply responds to institutional changes, rather than directly focusing on the wage outcomes. This is related to the endogenous technical change version of the SBTC hypothesis of Acemoglu (1998).

2.2 Theoretical Framework

Many studies trying to explain changes in the wage structure in the U.S., at least since Freeman (1975) and Tinbergen (1975), have used a simple supply and demand framework as we mentioned above.[30] This methodology constructs a starting point of the present analysis in this section as well. We begin our analysis with this simple common framework in the literature which links wages to supply of and demand for skills. This framework relies on a simple aggregate production model. The standard practice is to drive a college premium (or college-high school wage gap) equation and carry out empirical analysis based on this equation. We first review the theoretical essence of the major studies in the wage inequality literature. We start with a review of the models of the college premium. We provide a detailed comparison of alternative theoretical settings. Then, we discuss the role that various elasticity of substitution parameters play in these models. After, we introduce real minimum wages to the model and finally discuss the selectivity argument.

2.2.1 Models of Aggregate Production

Existing research on the U.S wage inequality relies on a simple aggregate production model with two basic assumptions: (1) the aggregate production function is of the Constant Elasticity of Substitution (CES) form with two factors; college equivalent labor and high school equivalent labor, and (2) college and high school equivalents are paid their marginal products. The standard practice is to derive a college-premium (or college-high school wage gap) equation. The basic goal is to capture the movements in the wage premium paid to skills in the labor market. The labor market is assumed to consist of two types: the skilled and the unskilled. The former is defined by the college-equivalent workers and the latter by

[30] Katz and Murphy (1992), Murphy and Welch (1992), Autor, Katz and Krueger (1998), Katz and Autor (1999), Card and Lemieux (2001), and Acemoglu (2002) are other studies using an analysis that of supply and demand to examine the changes in wage differentials in the U.S.

the high school graduates. In this framework, the skill premium can be thought of as a proxy of how labor market values skills.[31]

The aggregate production function is of the following CES form: [32]

$$Y_t = A_t \left[\emptyset_t \, (a_t \, C_t)^{\frac{\sigma-1}{\sigma}} + (1-\emptyset_t) \, (b_t \, H_t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \qquad (2.1)$$

where Y_t represents the value of output, C_t and H_t are the quantities employed of college and high school equivalents at time t, A_t represents the Hicks neutral technical change, a_t and b_t correspond to skilled and unskilled labor augmenting technical change, $\emptyset_t$ is the time-varying weight parameter characterizing the work load allocated to skilled labor, and $\sigma \geq 0$ is the elasticity of substitution between college and high school equivalents.[33] Skill-neutral technical changes cause an increase in a_t and b_t by the same amount and skill-biased technical changes reflects increases in a_t / b_t or $\emptyset_t$.

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[31] See Acemoglu and Autor (2011) for an excellent discussion of the foundations of this framework.

[32] We compute college and high school equivalents following the existing literature. Workers with exactly a high school degree is assumed to have a unit of high school equivalent, workers with exactly a college degree is assumed to have a unit of college equivalent, workers in less than high school category is assumed to have less than a unit of high school equivalent, workers in college plus category is assumed to have more than a unit of college equivalent and workers with a some college degree is allocated between high school and college equivalents. The detailed explanation of this calculation is given in the next subsection when we argue wage determination and college premium. In the literature, it is a common approach to break the labor force into two broad educational groups. It is generally assumed that high school equivalents are "low-skilled" workers and college equivalents are "high-skilled" workers.

[33] In the literature, several versions of this setup is used to answer different questions. For example, Goldin and Katz (2007a, b) and Dustmann, Ludsteck, and Schönberg (2009) use a structure called the "two-step" production fuction which formulates the unskilled labor as another CES aggregate of low- and medium-skilled workers. We abstract from such versions.

There are two different settings we can consider C_t and H_t. First, different groups under each skill category are perfect substitutes. This is an assumption made by almost all studies in the wage inequality literature until the work Card and Lemieux (2001).[34] These studies analyze changes in educational wage differentials in the U.S. under the assumption that different groups with the same level of education are perfect substitutes in production. In other words, the average wage gap between college and high school workers is assumed to be invariant across different groups in each category of skills. Second, C_t and H_t have their own sub-categories consisting of different groups and these groups are imperfect substitutes. This idea is firstly introduced by Card and Lemieux (2001) suggesting that selection effects on relative quantities implied by cohort education patterns is crucial in explaining the path of the average college premium. They propose that there is a strong age pattern to the recent increase in the college wage gap. They raise criticism against the common idea in the literature that the path of the college wage gap should be the same for all ages since all ages would be subject to the same relative price changes. They show that the college–high school wage gap reflects different trends for different age groups with the same education level over time and suggest that most of the rise in the college-high school wage premium has been concentrated among younger workers starting from 1980s while very little change is observed for older ones. They explain this observed trend that the college premium is higher for cohorts born in early 1950s by cohort specific changes in the relative supply of college workers.

In Card and Lemieux (2001) model of imperfect substitution, C_t and H_t can be formulated with two CES subaggregates of high school and college workers:

[34] See Katz and Murphy (1992), Autor, Katz and Krueger (1998), Katz and Autor (1999), and Autor, Katz and Kearney (2008).

$$\mathrm{C_t} = \left[\sum_i \alpha_i\, C_{i,t}^{\frac{\eta_c - 1}{\eta_c}}\right]^{\frac{\eta_c}{\eta_c - 1}} \quad \text{and} \quad \mathrm{H_t} = \left[\sum_i \beta_i\, H_{i,t}^{\frac{\eta_h - 1}{\eta_h}}\right]^{\frac{\eta_h}{\eta_h - 1}}, \qquad (2.2)$$

where i indexes different age groups within each skill category, η_c and $\eta_h \geq 0$ represent partial elasticity of substitution between different age groups i with the same level of education, α_i and β_i are time-invariant weight parameters.

Different from the idea in the first model, a young college (or high school) graduate and an older one are now imperfect substitutes. C_t and H_t are no more observed supply measures in this formulation. They are theoretical constructs and are estimated from the age-group specific relative supply measures. The parameter $\eta_c \geq 0$ is the elasticity of the ratio of the college-graduate workers in different age groups with respect to the ratio of their marginal products. A similar definition holds for $\eta_h \geq 0$.

Introducing imperfect substitution between young and old workers into the analysis rests on the observation that unlike what Mincer (1974) suggests -that the college premium increased steadily with age in 1960s- the trends in college premium in the last thirty years displays an increase for younger men while it has been stable or declining for older men. This also differs from findings in the conventional setting that models education-related wage differentials by ignoring differences in the age distribution across skill categories. Card and Lemieux (2001) argue that these changes have been driven by the recent slowdown in the growth rate of educational attainment in younger cohorts. That is, the fraction of skilled workers an each new generation has been lower and lower starting with the cohorts born in early 1950s. This basic extension proposing imperfect substitution between young and old workers is crucial to understand how changes in relative supplies for different age groups affect skill premium. It helps explaining the changing trends in college wage premium through shifts in the intercohort trends of relative supply of highly educated workers.

This idea of imperfect substitutability between similarly educated workers in different age groups –or say imperfect substitutability between different groups-also has important implications regarding the SBTC hypothesis.[35] In the standard education-related wage differential model, the wage inequality is justified only by the SBTC hypothesis. Introducing imperfect substitution between different groups, however, weakens the negative impact coming from the rise in relative supply and creates an additional positive impact through age (experience) - and cohort- specific fixed effect. Therefore, the degree of SBTC required to justify the increase in wage inequality is reduced. In other words, SBTC cannot be the only force generating wage inequality since it does not display as strong an increasing trend as it is suggested. It cannot explain on its own the changing trends in college wage premium for different groups. The effects coming from SBTC should be complemented by age (experience) and cohort effects.[36] We will return to this point and discuss it in detail when we argue wage determination and the college premium in the next subsection.

2.2.2 Wage Determination and the College Premium

We now shift our focus to the determination of wages. We show how the college premium is calculated in these two different settings that we explain above.

Wages are determined based on the assumption that college and high school equivalents are paid their marginal products.

In the simple setup in which the different groups are perfect substitutes, the marginal product of high school equivalents is:

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[35] In Card and Lemieux (2001), different groups with same observable characteristics are "age groups". In this study, we mainly use "experience groups".

[36] Card and Dinardo (2002) also argue that SBTC cannot fully explain the differential trends in the college wage premium. The SBTC hypothesis suggests that all wage differentials will increase as a result of ongoing technical change. However, the existence of cohort effects in the returns structure- the fact that the college wage premium for young men has doubled while that for older men has remained almost the same- leaves little or no room for accelerating technical change.

$$\frac{\partial Y_t}{\partial H_t} = A_t(1-\emptyset_t) b_t^{\frac{\sigma-1}{\sigma}} \varphi_t \ H_t^{\frac{-1}{\sigma}} \tag{2.3}$$

where

$$\varphi_t = \left[\emptyset_t \ (a_t \ C_t)^{\frac{\sigma-1}{\sigma}} + (1-\emptyset_t) \ (b_t \ H_t)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}} \tag{2.4}$$

Similarly, the marginal product of college equivalents is

$$\frac{\partial Y_t}{\partial C_t} = A_t \ \emptyset_t \ a_t^{\frac{\sigma-1}{\sigma}} \ \varphi_t \ C_t^{\frac{-1}{\sigma}} \tag{2.5}$$

Setting the corresponding ratio of marginal products of the two groups equal to their wages and taking the natural logarithm yields the following skill-premium equation so that relative wages in year t, w_{ct}/w_{ht}, and relative supplies in year t, C_t/H_t satisfy the relationship:

$$ln\left(\frac{w_{c,t}}{w_{h.t}}\right) = ln\left(\frac{\emptyset_t}{1-\emptyset_t}\right) + \frac{\sigma-1}{\sigma} \ \ln\left(\frac{a_t}{b_t}\right) - \ln\left(\frac{C_t}{H_t}\right) \tag{2.6}$$

which can be arranged as

$$ln\left(\frac{w_{c,t}}{w_{h.t}}\right) = \frac{1}{\sigma}\left[D_t - \ln\left(\frac{C_t}{H_t}\right)\right] \tag{2.7}$$

where σ is the elasticity of substitution between college and high school equivalents and D_t is the time-varying skilled labor augmented relative demand shifts into a single variable measured in log units.[37]

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[37] $D_t = \sigma \ ln\left(\frac{\emptyset_t}{1-\emptyset_t}\right) + (\sigma-1)\ln\left(\frac{a_t}{b_t}\right)$. Shifts in A_t or equi-proportionate changes in a_t and b_t do not move D_t. As Autor, Katz, and Krueger (1998), Katz and Autor (1999) and Autor, Katz, and Kearney (2008) suggest, possible sources of demand shifts favoring college equivalents (D_t) are skill-biased technological change, non-neutral changes in the relative prices or quantities of non-labor inputs or product demand shifts.

If the relative supply of the two skill group is taken as exogenous, equation (2.7) implies that changes in the relative wage of high skilled workers (college premium) is determined by the combined effect of changes in the relative demand for college equivalents, D_t, changes in the relative supply of skilled workers, ln (C_t/H_t), and the elasticity of substitution between high school and college equivalents, σ.[38] The impact of relative demand measure on the change in the log college premium depends positively on the magnitude of the elasticity of substitution while the impact of changes in the relative supply depends inversely. The higher is σ, the lower the decrease in the college wage premium as a response to changes in the relative supply and the higher the relative demand effect required to explain changes in the relative wages.

We continue with the extended version of this traditional setup in which different age groups with the same level of education are imperfect substitutes. Following Card and Lemieux (2001) model of imperfect substitution, we can calculate the marginal product of high school equivalents in age group *i* as

$$\frac{\partial Y_t}{\partial H_{i,t}} = \frac{\partial Y_t}{\partial H_t} \times \frac{\partial H_t}{\partial H_{i,t}}$$

$$= A_t\,(1-\emptyset_t)\;b_t^{\frac{\sigma-1}{\sigma}}\;\varphi_t\;H_t^{\frac{-1}{\sigma}}\;\times\;\beta_i\,H_t^{\frac{1}{\eta_h}}H_{i,t}^{\frac{-1}{\eta_h}}$$

$$=\;A_t\,(1-\emptyset_t)\;b_t^{\frac{\sigma-1}{\sigma}}\;\varphi_t\,H_t^{\frac{\sigma-\eta_h}{\sigma\eta_h}}\;\times\beta_i\quad H_{i,t}^{\frac{-1}{\eta_h}} \qquad (2.8)$$

where

$$\varphi_t\;=\;\left[\emptyset_t\,(a_t\;C_t)^{\frac{\sigma-1}{\sigma}}+\;(1-\emptyset_t)\,(b_t\;H_t)^{\frac{\sigma-1}{\sigma}}\right]^{\frac{1}{\sigma-1}}$$

[38] There are also other factors affecting relative wages which is ignored in this setting such as efficiency wage premiums,rents or institutional wage floors. Bound and Johnson (1992) provides a theoretical framework including these factors as well.

Similarly, the marginal product of college equivalents in age group *i* as

$$\frac{\partial Y_t}{\partial C_{i,t}} = \frac{\partial Y_t}{\partial C_t} \times \frac{\partial C_t}{\partial C_{i,t}}$$

$$= A_t\ \emptyset_t\ \ a_t^{\frac{\sigma-1}{\sigma}}\ \varphi_t\ \ C_t^{\frac{-1}{\sigma}}\ \times\ \alpha_i\ C_t^{\frac{1}{\eta_C}}\ C_{i,t}^{\frac{-1}{\eta_C}}$$

$$=\ A_t\ \emptyset_t\ \ a_t^{\frac{\sigma-1}{\sigma}}\ \varphi_t\ C_t^{\frac{\sigma-\eta_C}{\sigma\eta_C}}\ \times \alpha_i\ \ C_{i,t}^{\frac{-1}{\eta_C}} \qquad (2.9)$$

Notice that the marginal product of labor for a given age-education category relies on both the group's own supply of labor and the total supply of labor in its education category.

Under the assumption that marginal products are equal to factor prices and $\eta_h = \eta_c = \eta$, equation (2.8) and (2.9) yields the following college premium equation in age group *i* in year t in the setting of imperfect substitution

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right) = \ln\left(\frac{\emptyset_t}{1-\emptyset_t}\right) + \frac{\sigma-1}{\sigma}\ln\left(\frac{a_t}{b_t}\right) + \ln\left(\frac{\alpha_i}{\beta_i}\right)$$

$$+\left[\frac{1}{\eta}-\frac{1}{\sigma}\right]\ln\left(\frac{C_t}{H_t}\right) - \frac{1}{\eta}\ \ln\left(\frac{C_{i,t}}{H_{i,t}}\right) \qquad (2.10)$$

which can be rewritten, analogous to (2.7), as

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right)\ = \frac{1}{\sigma}\left[D_t - \ln\left(\frac{C_t}{H_t}\right)\right] + \frac{1}{\eta}\left[\ln\left(\frac{C_t}{H_t}\right) - \ln\left(\frac{C_{i,t}}{H_{i,t}}\right)\right] +\ Z_i \qquad (2.11)$$

where Z_i represents skilled labor augmenting age-group specific relative demand shifts. Notice that (2.11) and (2.7) would be identical if the last two terms on the right-hand side of (2.11) were zero. Equation (2.11), different than equation (2.7), implies that the college wage premium in a specific age group depends on not only the relative supply of skilled workers $\left(\frac{C_t}{H_t}\right)$, but the age-group specific relative supply of skilled workers $\left(\frac{C_{i,t}}{H_{i,t}}\right)$ in year t. In that sense, Equation (2.11) can be thought as a more general form of equation (2.7). When $\frac{1}{\eta} = 0$, reflecting perfect substitutability across different age groups, equation (2.11) collapses to equation (2.7) in which the college premium relies only on the total relative supply of college equivalents. In the model of imperfect substitution, however, shifts in the age-group-specific relative supply is expected to affect the college wage premium depending on the magnitude of $\frac{1}{\eta}$, the partial elasticity of substitution between different age groups *i* with the same level of education.

When $\eta_h \neq \eta_c$, the college premium can be analyzed by jointly considering the earnings equations

$$\ln(w_{C,i,t}) = \ln(\emptyset_t) + \frac{\sigma - 1}{\sigma} \ln(a_t) + \ln(\alpha_i) + \left[\frac{1}{\eta_c} - \frac{1}{\sigma}\right] \ln(C_t) - \frac{1}{\eta_c} \ln(C_{i,t}) \tag{2.12}$$

and

$$\ln(w_{H,i,t}) = \ln(1 - \emptyset_t) + \frac{\sigma-1}{\sigma} \ln(b_t) + \ln(\beta_i) + \left[\frac{1}{\eta_h} - \frac{1}{\sigma}\right] \ln(H_t) - \frac{1}{\eta_h} \ln(H_{i,t}) \tag{2.13}$$

For the rest of the study, we assume that $\eta_h = \eta_c = \eta$ for simplicity. Next section discusses the role of the elasticity of substitution parameters σ, and η play in the pricing equations we formulate above in detail.

2.2.3 The Elasticity of Substitution

The elasticity of substitution parameter, σ, is important for the behavior of the skill premium when supply changes. Furthermore, depending on the value of the elasticity of substitution, one can observe the response of the skill premium to shifts in technology. Therefore, it has been a key element in the empirical analysis of wage inequality. There are a number of estimates using aggregate data that give a range of reasonable values regarding this parameter. The majority of these estimates are between σ=1 and 2.

Recall that in equation (2.7), the simple set up in which the age groups under each skill category are perfect substitutes, we have the parameter $\sigma \geq 0$ measuring the elasticity of the ratio of the college to high school equivalents with respect to the ratio of their marginal product. Equation (2.7) implies that the higher the elasticity of substitution between the two factors, the lower the effect of changes in relative skill supplies on the college premium and the higher must be the fluctuations in demand shifts (D_t) to explain any given time series of relative wages for a given time series of relative quantities. The impact of changes in relative skill supplies on relative wages relies inversely on the magnitude of the elasticity of substitution between the two skill groups. That is, keeping the relative demand component constant, a 1% increase in the relative supply of skilled workers lowers the college premium by $\frac{1}{\sigma}$%. The higher is σ between labor inputs, the lower the decrease in the college premium as a response to a unit increase in the relative supply of skills. We know that the relative supply of skills, $\left(\frac{C_t}{H_t}\right)$ have been steadily increasing in the major developed countries especially in last forty years. However, we do not observe a matching decline in the skill premium as a response to this increase. On the contrary, the earnings data reveal that the college premium has substantially increased throughout the past several decades. This is a contradiction. Thus, one immediately concludes that there must be a bigger effect in the opposite direction to satisfy the rise in the college premium materialized along with a rapid increase in relative proportion of highly skilled workers. The skill-biased technological change (SBTC) hypothesis kicks in at this point. It says that it is the increasing relative demand for skilled workers that avoids the college premium from decreasing as a response to the increase in the supply of skills. The literature formulates Equation (2.7) with this view in mind. That is, by definition, D_t represents skilled labor augmented relative demand shifts. The direction and the magnitude in the change in the college premium are determined by the net effect of the changes in relative demand and supply measures. Taking into account of this net effect, a various number of estimates for the elasticity of substitution between college and high school equivalents are suggested taking a value between 1 and 2. Even though a large uncertainty remains, the literature reaches a consensus that the typical estimate for σ is around 1.5 using data for both men and women. That is, a 1% increase in $D_t - \ln\left(\frac{C_t}{H_t}\right)$ leads to an approximately 0.6 % increase in the college wage premium.

As we said earlier, several criticisms have been raised against this simple formulation represented by equation (2.7) in the literature. The basic idea behind all these criticisms is that the SBTC cannot be the only factor generating wage inequality since it does not display as strong an increasing trend as it is suggested in the papers favoring the SBTC hypothesis. Remember that equation (2.11) reveals how the standard formulation in (2.7) is extended by the Card and Lemieux (2001) formulation taking into account the argument above. There are now two new terms: the difference between the usual relative supply and the age-group specific relative supply and the skilled labor augmenting age-group specific relative demand shifts. To provide a better intuition of the differences between the two models, we reformulate (2.11) as follows:

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right) = \frac{1}{\sigma} D_t + Z_i - \frac{\eta-\sigma}{\eta\sigma}\ln\left(\frac{C_t}{H_t}\right) - \frac{1}{\eta}\ln\left(\frac{C_{i,t}}{H_{i,t}}\right) \qquad (2.14)$$

Notice that, apart from σ, we now have another elasticity parameter, η ≥ 0 representing partial elasticity of substitution between different age groups *i* with the same level of education. The last term on the right-hand side says that increases in the age-group specific relative supply measure decreases the college wage premium. Higher η means that this effect is smaller. The data reveal that the growth rate in $\left(\frac{C_{i,t}}{H_{i,t}}\right)$ becomes smaller over time for younger men, which implies a decreased effect coming from the age-group specific relative supply of skills for younger workers. This is the first difference from the standard model.

The third term on the right hand-side characterizes the effect coming from the shifts in the relative supply of college equivalents. Different from (2.7), the coefficient of this term can even be positive if σ > η. That is, increased relative supply of skilled workers can increase age-group specific wage inequality if the elasticity of substitution between high- and low-skilled workers is larger than the elasticity of substitution between age-groups among similarly educated workers. This can happen only if age is a more important factor than education in the production technology. However, this is a highly unlikely setup in an aggregate production technology. Indeed, Card and Lemieux (2001) provide clear evidence that η > σ. In other words, similar to the first model, the relative supply of college equivalents is negatively related to wage inequality. To see the difference, we reparameterize the coefficients as follows:

$$\theta_1 = \frac{1}{\sigma} \quad \text{and} \quad \theta_2 = \frac{\eta-\sigma}{\eta\sigma} \tag{2.15}$$

The following proposition explains the relationship between θ_1 and θ_2.

Proposition 1. *θ_1 is always greater than θ_2. Moreover, the greater $\theta_1 - \theta_2$ is, the smaller η is.*

PROOF: Suppose, by contradiction, that $\theta_1 < \theta_2$. To have this contradiction satisfied, we need $\theta_1 < \theta_1 \frac{\eta-\sigma}{\eta}$, which implies that we need $1 < \frac{\eta-\sigma}{\eta}$. But, clearly, this cannot happen since $\sigma > 0$ and $\eta > 0$. This proves the first claim. To prove the second claim, observe that

$$\theta_1 - \theta_2 = \frac{1}{\sigma}\left[1 - \frac{\eta-\sigma}{\eta}\right] = \frac{1}{\eta}$$

as required.

Equation (2.14) can be rewritten in the following form:

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right) = \theta_1 D_t + Z_i - \theta_2 \ln\left(\frac{C_t}{H_t}\right) - (\theta_1 - \theta_2)\ln\left(\frac{C_{i,t}}{H_{i,t}}\right) \tag{2.16}$$

This equation communicates two important ideas:

1) The effect of the rise in the relative supply of college equivalents on wage inequality is not s strong as suggested. Consider the following example. Suppose $\ln\left(\frac{C_t}{H_t}\right)$ increase by h%. In the standard formulation, this reduces earnings inequality by θ_1 h%. If on the other hand, $\ln\left(\frac{C_{i,t}}{H_{i,t}}\right)$ increase by g% where $h > g$, the earnings inequality will decrease by $\theta_2 h + (\theta_1 - \theta_2) g$ percent in the Card and Lemieux (2001) setting. After simple algebra, it is easy to see that the effect in the Card and Lemieux (2001) setting is smaller than the effect in the standard setting. This result follows from the Proposition 1.[39]

2) The rise in relative demand for college equivalents required to justify the increase in wage inequality is not as strong as suggested. A smoother increase in the relative supply of high skills joined with the effect of the inclusion of skilled labor augmenting age-group specific relative demand shifts, Z_i, generates this result. Z_i includes age- and cohort-specific fixed effects and should be distinguished from SBTC.

Recall that equation (2.7) states that, in the standard model, the wage inequality is justified only by the SBTC hypothesis. However, the contribution by Card and Lemieux (2001) addressing the criticism raised against SBTC results in a very crucial conclusion, as shown above. That is, introducing imperfect substitution between age-groups *weakens* the negative impact coming from the rise in relative supply and *creates* an additional positive impact through age- and cohort-specific fixed effect. Therefore, the degree of "skill-biased" changes in technology required to rationalize the increase in wage inequality is reduced.

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[39] The estimates reported in Card and Lemieux (2001) are in the 4-6 range for η and 2-2.5 range for σ for young men. Card and Lemieux (2001) document that the estimate for σ becomes approximately 1.5 when the data is for men and women. This is similar to the estimates reported in the literature.

Card and Lemieux (2001) do not claim that SBTC was wrong. Instead, they argue that year effects that come from SBTC should be complemented by age and cohort effects. What we are going to do in the subsequent sections is to take this argument one step further and reconciliate it with the view of the literature favoring the importance of "non-market" forces in explaining wage inequality.

2.2.4 Incorporating the Minimum Wages

Up to this point, we have reviewed theories arguing that secular demand growth for more skilled workers driven by shifts in product demand, in combination with the fluctuations in relative skill supplies are responsible for changing wage structure. This "traditional" literature has been focused on "market" forces to analyze changes in wage differentials. The studies in this line suggest that much of the increase in wage inequality has been attributed to a rapid secular increase in the demand for skilled workers parallel to technological change accelerated during 1980s and a slowdown in the rate of growth in the supply of skilled workers.

On the contrary to the view of this "traditional" literature which propose a number of explanations for the observed changes in the wage structure, most of which can be characterized by "market" forces- supply and demand explanations -, we observe another line of the literature suggesting that the increase in the early 1980s is largely explained by other plausible factors. In this "revisionist" literature, "non-market" forces, particularly the falling real minimum wages are said to be the major cause of the rise in wage dispersion.[40] Many studies, including Dinardo, Fortin and Lemieux (1996), Lee (1999), Card and Dinardo (2002) and Lemieux (2006), argue that the rising U.S. wage inequality was a one-time "episodic" event in the early 1980s, which is mainly explained by falling real value of the minimum wages in the 1980s.[41] It is all common in these studies of this "revisionist" literature that there is

[40] Declining unionization and compositional changes in the labor force are other non-market factors that are believed to contribute to rising wage inequality.

[41] Lemieux (2006) also emphasizes that measurement errors and the mechanical labor force composition effects -besides declining real minimum wages- are among the other non-market factors

a strong time series correlation between the evolution of the real minimum wage and wage inequality. They propose that the erosion in the real value of the minimum wages accounts for much of the increase in wage inequality. Since the minimum wage is likely to increase the wages in the lower half of the wage distribution, this decline may be responsible for increased wage dispersion.

"Traditional" explanations based on interactions between relative demand growth for more skilled workers and fluctuations in relative skill supplies fall short to explain the slowdown in relative demand growth starting in the early 1990s. This is where the "revisionist" literature provides itself a supporting stand-point. The main argument of revisionists is the fact that wage inequality increased sharply in the 1980s but then stabilized in the 1990s despite the development of skill-biased technological change. In other words, even though the computer technology was observed to keep progressing, the wage inequality did not keep pace with it. This relative slowdown, even stabilization in wage inequality during 1990s, despite continuing improvement in technology, showed that there is a weak time series relationship between skill-biased technological change and wage inequality. These revisionist arguments point to the need for a serious reconsideration of the validity of SBTC hypothesis.

The role of non-market factors are started to be taken more seriously in the study of wage inequality as a result of the revisionist propositions. The literature reaches a consensus that a single factor, if it be skill-biased technological change or the minimum wage, cannot account for the full pattern of changing wage structure.[42]

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contributing to rising wage inequality in the U.S. It points out the importance of composition effects linked to increasing education and experience of the work force and states that composition effects have a more responsibility in changing inequality in the 1990s and early 2000s than in the 1979s and 1980s. See also Teulings (2003) and Card (2001) for other researches suggesting the importance of labor market institutions such as unions and minimum wages.

[42] In fact, revisionist explanations focusing on non-market factors especially minimum wages fail to account for the increasing wage inequality in the upper half of the distribution that has been the largest component of rising overall wage inequality since 1980. Falling minimum wages are likely to

Instead, it is concluded that both market forces- relative supply and demand shifts- and non-market forces- changes in real minimum wages- are important in explaining changes in wage inequality.

In order to perform an empirical analysis to analyze the reasons of the observed changing wage structure, therefore, it is useful to define a theoretical model that includes all of the major explanations. Thus, we provide a model that incorporates the separate contributions of changes in "market" and "non-market" factors to observed changes in overall wage dispersion.

Following Autor, Katz and Kearney (2008), we reconciliate the "market" and "non-market" views by introducing minimum wages into the standard skill premium equation (2.7). For the purpose we define the relative demand measure as

$$D_t = \beta_1 t + \beta_2 \ln(RMW_t) \qquad (2.17)$$

where t represents the SBTC trend and RMW denotes real minimum wages.[43] This structure says that the relative demand shifts that favor the skilled versus unskilled workers consist of two components: SBTC and changes in log real minimum wages, where the expected signs of β_1 and β_2 are positive and negative, respectively. Notice that this extension introduces yet another factor (real minimum

be an important contributor to rising wage inequality only for the lower half of the wage distribution. The continuous rise in the upper half inequality seems to be related to standard models focusing on both a secular growth in the relative demand caused by SBTC and movements in the relative skill supplies.

[43] Note that there may be additional institutional factors- other than real minimum wages- that can potentially diffuse into the process determining the relative demand for skills. These factors include, but not limited to, business cycles and foreign outsourcing of jobs with low skill requirements. For simplicity and for the purpose of compliance with Autor, Katz and Kearney (2008) (our benchmark paper), we focus on real minimum wages as the only institutional factor driving demand for skills.

wages) trying to reduce the burden that falls on the SBTC term and changes the estimates of the elasticity of substitution between skill categories. [44]

Then, the final simple skill premium equation that we estimate becomes

$$\ln\left(\frac{w_{C,t}}{w_{H,t}}\right) = \beta_0 + \beta_1 t + \beta_2 \, ln(RMW_t) + \beta_3 \, ln\left(\frac{C_t}{H_t}\right) + \varepsilon_t \qquad (2.18)$$

where β_0 is a constant, β_1 and β_2 are coefficients of SBTC trend *t* and RMW, which are expected to be positive and negative, respectively. ε_t is the error term, and β_3 provides an estimate of 1/σ, where σ is the elasticity of substitution between high school and college equivalents.

Notice that the college premium is determined by the combined effect of the relative demand shifts that favor the skilled versus unskilled workers depending on two components- SBTC and changes in log real minimum wages-, the relative supply measure, and the elasticity of substitution between high school and college equivalents.

The inclusion of the real minimum wages into the standard skill premium equation is crucial first to understand the implications of the existing modeling practices for interactions among real minimum wages and supply and demand conditions in the labor market and second to develop a coherent economic interpretation of why the real minimum wage is regarded as an important element in the analysis of wage inequality.

Incorporating the effect of the real minimum wages into the standard analysis is one step. However, we aim to take the analysis one step further. For this purpose, we extend the approach developed by Autor, Katz and Kearney (2008) by reconciliating it with the Card and Lemieux (2001) model of imperfect substitution.

[44] Autor, Katz and Kearney (2008) find that σ is around 1.6, slightly above the results reported in the literature.

It is well-known that the college premium has significantly varied by age/experience groups over recent decades, with the rise in the skill gap concentrated among less experienced workers in the 1980s [Autor, Katz, and Kearney (2008)]. The return to college education has increased much more substantially since 1980 for younger workers than for older ones. Card and Lemieux (2001) utilize these differences to construct a model in which workers with similar education but with different experience levels enter as imperfect substitutes into the production technology as we mention earlier. We now examine these changing trends across cohort-specific relative supplies by estimating regression models for the college/high school wage premium by experience group.

Remember that Card and Lemieux (2001) proposes that the SBTC cannot be the only force generating wage inequality since it does not display as strong an increasing trend as it is suggested. So it extends the standard formulation in (2.7) by introducing imperfect substitution between different age groups. Recall that equation (2.14) is the extended version of the standard equation in (2.7).

We now examine these changing trends across cohort-specific relative supplies by estimating regression models for the college/high school wage premium by experience group. Our concern is to incorporate the effect of the real minimum wages into the analysis developed by Card and Lemieux (2001) suggesting a reinterpretation of the SBTC hypothesis. For this purpose, we introduce the effect of the real minimum wages into the extended formulation in (2.14). The relative demand parameter, D_t we are considering now is the one defined in equation (2.17). Thus, the final extended skill premium equation that we estimate becomes:

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right) = \beta_0 + \beta_1 t + \beta_2\, ln(RMW_t) + Z_i + \beta_3\, ln\left(\frac{C_t}{H_t}\right) + \beta_4\left(\frac{C_{i,t}}{H_{i,t}}\right) + \varepsilon_{i,t} \tag{2.19}$$

where i indexes experience groups, β_0 is a constant, and $\varepsilon_{i,t}$ is the error term. β_1 represents an estimate for the time trend and β_2 gives an estimate of RMW. $1/\beta_3$

provides an estimate of σ, the aggregate elasticity of substitution between high school and college equivalents. Accordingly, $1/\beta_4$ provides an estimate of η, the partial elasticity of substitution between different experience groups *i* with the same level of education meaning that shifts in the experience-group-specific relative supply is expected to affect the college wage premium depending on this magnitude. We interpret the role that different elasticity of substitution parameters plays in the pricing equations we formulate above and discuss how introducing imperfect substitution between similarly educated workers in different experience/age groups changes the conclusions of the standard demand and supply models in the literature assuming perfect substitutability among workers above.

Card and Lemieux (2001) calculates $\ln\left(\frac{C_{i,t}}{H_{i,t}}\right)$ where *i* indexes age groups. We do the same exercise where *i* indexes experience groups in order to be able to comply with Autor, Katz and Kearney (2008) and compare our results with their findings. Trends and results related with age groups also reported, though. Notice that this unified model includes both the effect coming from real minimum wages and age (experience) and cohort effects which is a product of the assumption of imperfect substitution between different groups. Therefore, there are now two forces reducing the degree of SBTC required to justify the increase in wage inequality.

2.2.5 Incorporating Selectivity

Our main purpose in this thesis is to develop a method to revise the relative supply index in such a way that it corrects for the unobserved compositional shifts due to selection in and out of the FTFY status as we mentioned above. For this purpose, we use Heckman's two-step estimator to calculate a selectivity-corrected relative supply series. In other words, we correct for self-selection into the FTFY status and we use the selection bias term (i.e., the inverse Mills ratios) to capture the unobserved compositional shifts within education categories, which, in turn, endogenizes the efficiency units.

This section introduces this simple selection-correction algorithm to account for the unobserved compositional shifts within education categories. Let w* denote the real hourly wages received by a worker under the FTFY status. The empirical wage equation can be characterized simply as

$$\ln(w_i^*) = x_i'\beta^* + \epsilon_i^* \tag{2.20}$$

where ϵ is normally distributed with zero mean and non-zero variance σ^2 and it is i.i.d across individuals. The binary variable D_i describes the labor force status of the workers in the sample. $D_i = 1$ if the worker has a FTFY status and $D_i = 0$ otherwise (i.e., if the worker is employed, but has a part-time part-year, part-time full-year, or full-time part-year status). The FTFY wage $\ln(w_i^*)$ is observed only if $D_i = 1$ and is latent otherwise. In fact, a wage is observed under part-time and /or part-year status, but it is not the FTFY wage and, therefore, we assume that the FTFY wage is latent even though the worker is employed part-time and/or part-year.

To formulate the choice, the worker is assumed to observe two offers: one for the FTFY job ((ln(w_i^*)) and the other for a non-FTFY job ((ln(w_i)). He chooses D_i = 1 if $\ln(w_i^*) > \ln(w_i)$ and $D_i = 0$ if $\ln(w_i^*) <= \ln(w_i)$. Let the latent wage equation be $\ln(w_i) = x_i'\beta + \epsilon$. Then, the first-step (choice) regression can be formulated as (i subscripts are suppressed)

$$\begin{aligned} \mathbb{P}[D = 1 \mid x, z \mid &= \mathbb{P}[\ln(w^*) > \ln(w) \mid x, z] \\ &= \mathbb{P}[\eta > z'\gamma] \\ &= \Phi\left({z'\gamma}/{\sigma_\eta} \right) \end{aligned} \tag{2.21}$$

where x is the restricted version of the z (i.e., the choice equation has one more variable than the outcome equation), $\gamma = \beta^* - \beta$, $\eta = \epsilon^* - \epsilon$, σ_η and is the standard deviation of η . The second-step (outcome) equation is therefore

$$\mathbb{E}[\ln(w^*) \mid \ln(w^*) > \ln(w)] = x'\beta^* + {\sigma^*}/{\sigma_\eta}\, \lambda\left(-{z'\gamma}/{\sigma_\eta}\right) \qquad (2.22)$$

where σ^* is the covariance between ϵ^* and η and λ is the inverse Mills ratio. The selection-corrected version can either be estimated via the full-information maximum likelihood method or the two-step estimator developed by Heckman (1979). Without selection correction, the estimated wage equation becomes

$$\mathbb{E}[\,\ln(w^*) \mid x\,] = x'\beta^* \qquad (2.23)$$

The term

$$\Lambda = {\sigma^*}/{\sigma_\eta}\, \lambda\left(-{z'\gamma}/{\sigma_\eta}\right) \qquad (2.24)$$

is the component of the FTFY wages due to the correlation between the unobserved determinants of choices and outcomes. We let this term represent the evolution of the unobserved compositional factors derived by self-selection in and out of the FTFY status.

Let $\widehat{\Lambda}_i$ denote the predicted inverse Mills ratio multiplied by its estimated coefficient. To calculate these predicted values, we run separate year-by-year regressions for each of the six education categories that we utilize and, at the end, we obtain a predicted value $\widehat{\Lambda}^J_{i,t}$ for each worker *i* in the education category *J* at each year *t*. We use the predicted inverse Mills ratios to adjust the fixed efficiency weights -that is to be formulated in the next chapter- in such a way that we obtain time varying weights that can account for the effect of unobserved compositional shifts on efficiency units. The fixed weight is just a mean relative wage estimated by the OLS. We just mechanically incorporate the mean relative inverse Mills ratio's to capture what is going on selection-wise. To achieve this goal, we employ the following formula

$$\overline{w}_t^J = \overline{w}^J + \left(\int_{I_J} \widehat{\Lambda}_{\mathrm{i,t}}^{\mathrm{J}}\, \mathrm{dF}_{\mathrm{J,t}}\,(i) \Big/ \int_{I_{HSG}} \widehat{\Lambda}_{\mathrm{i,t}}^{\mathrm{HSG}}\, \mathrm{dF}_{\mathrm{HSG,t}}\,(i) \right) \tag{2.25}$$

Then we use these time varying efficiency weights to calculate the relative supply measure. Notice that there is no time aggregation across relative inverse Mills ratios, which enables us to capture the time variation in efficiency units due to selectivity.

CHAPTER 3

DATA AND METHODOLOGY

In this chapter we summarize the basic changes in the U.S. wage structure over the last four decades and explain the standard methodology in estimating the college high school wage gap. Before going into a detailed analysis of U.S. wage inequality, we first explain the data in detail in section 3.1. Section 3.1.1 is reserved for understanding the main characteristics of our wage-earner sample. As we will see in the subsequent chapters, a significant part of the wage inequality is related to the personal characteristics. Then we document the historical evolution of the U.S. wage structure from 1967 to 2009 in section 3.1.2 to constitute the basis for our later analysis. We try to explain where our motivation stems from for the further analysis with the help of these observations. Finally, in section 3.2 we discuss the methodological construct and provide the details on the construction of our analysis samples.

3.1 Data

We use the March Annual Social and Economic Supplement (ASEC) of the Current Population Survey (CPS) data for earning years 1967 to 2009 (referring to raw March files from 1968 to 2010). Since data of a given year is published the next year and labeled with the year of publication, the survey data in one year actually belongs to the year before. Taking this into account, we address the actual year that the data belongs to whenever we mention years. We choose 1967 as the starting year because the content of the survey changed in 1967.

The CPS is a monthly survey conducted among the civilian, non-institutional population in every state of the United States and the District of Columbia. The survey data is collected monthly by interviewing about 60,000 households. Each household is interviewed once a month for four months in turn every year, then interviewed again during the same four months next year. The survey is designed to collect detailed information on employment, earnings, and hours of work in the U.S. It also provides information on a variety of demographic characteristics of the population including age, sex, race, marital status, number of children, area of living, and educational attainment. Over time, supplemental inquiries on special topics have been added to the survey for particular months. Among these supplemental surveys, the ASEC which constitutes a primary source of detailed information on income and work experience, is the most widely used in the literature. The labor force and work experience data from this survey are used to profile the U.S. labor market.

The CPS data contain three different records: household, family, and person. Each row in the data matrix consists of one of these records while each column characterizes one digit. Therefore, a person's record is reported in the corresponding row by the columns that are determined via the length of the related statistic. The way that the data is arranged can be described as follows. The record for a household is followed by a family record which in turn is followed by each person's record in that family. Then, related subfamilies, unrelated subfamilies, and non-relatives are recorded as family records, followed by person records under each category. Once the data regarding every family under the same household is collected, a new household record begins. In this study, we utilize only person records. Household and family records are linked to person records whenever necessary.

Our data involves male workers of age 16 to 64 with 0 to 39 years of potential labor market experience. Years of potential labor market experience are calculated by the formula age minus assigned years of education minus 6. We have limited our sample to full-time, full-year workers defined as those who worked at least 35 hours per week and 40-plus weeks in the previous year. We also exclude from the sample those living in group quarters, working part year due to school, retirement, or military service, self-employed or working without pay.

The wage measure that we use is the average weekly wages and salary income.[45] The annual wage and salary income entries in the March CPS are reported in a top coded single variable before March 1987. The top coded values are rearranged by multiplying 1.5 with the reported maximum value of the variable for the corresponding years. However, wage and salary incomes start to be reported in two separate earnings variables: primary and secondary earnings after 1987. Therefore, we impute the top coded values as 1.5 times the maximum top coding value separately for primary and secondary earnings after this year. After correcting for top coding, these values are summed to calculate total wage and salary income. Then the annual wage and salary incomes are deflated to 2000 values using the personal consumption expenditure (PCE) deflator from National Income and Product Accounts (NIPA). Full-time weekly wage and salary income is computed as the natural logarithm of annual earnings divided by the number of weeks worked during the reference year. We drop from the sample workers with weekly earnings below half of the real minimum wage in 1982 ($67/week in 1982 dollars or $112/week in 2000 dollars).

One important point in computation of weekly wages is that number of weeks worked during the reference year start to be reported as its exact number only after 1975. Before this year, number of weeks worked entry is given as a value from 1 to

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[45] All the calculations in the analysis of the next chapter, subsection 4.2 are carried out by using hourly wages instead of weekly wages for the purpose of compliance with Lemieux (2006) which my intended future research will rely on when investigating the effect of unobserved compositional shifts within educational categories on the magnitude of residual wage inequality and how the sources of residual wage inequality change after correcting for selectivity. The basic trends we will demonstrate in this section are still based on weekly wages. Since the sample we utilize consists of full-time/full-year employed men for the whole period, the use of weekly or hourly wages does not make any difference at this point. It does not alter the main trends.

7 denoting a number of weeks in each group. Therefore, in order to recode the actual number of weeks worked for the previous years to create data in harmony with post 1975, we calculate an average number of weeks for each category using values for 1975, 1976, and 1977, weighted by March Supplement Weights. We use an imputed measure of weeks worked: 22.2 for 14-26 weeks category, 34.4 for 27-39 weeks category, 43.3 for 40-47 weeks category, 48.3 for 48-49 weeks category and 51.9 for 50-52 weeks category.

The definition of data on educational attainment experiences a few changes in its coding within our period of analysis. However, the crucial change occurs in 1991. Before this year, two different questions in the survey provide data on education variable, one is the highest grade or year of regular school attended and other is whether that grade (year) is completed or not. An individual's educational attainment is assumed to be his or her last fully completed year of education. If an individual did not complete his or her last year of school, the years of education are considered without that year. However, beginning in 1991, the survey starts to collect data on educational attainment by combining the two questions mentioned above into the question that ask the highest level of school or degree received. This change in coding means that educational attainment variable starts to focus on the degree received rather than the years of education. In the revised description of the new variable, several years of education of the lower grade levels are grouped into a single category while some new categories start to be used and college degrees begin to be recorded by type. Since the new question revision allows for a more accurate definition of educational attainment, the comparison of the data collected before 1991 with the one belong to subsequent years becomes a bit tricky. In order to make a precise comparison of educational categories across years, we use the general approach proposed in the literature. We construct five different categories of educational attainment. Individuals who have fewer than 12 years of completed schooling are defined as high school dropouts (less than high school category). High school graduates are considered to be those having 12 years of completed schooling. Those with any schooling beyond 12 years and less than 16 completed years are classified in some college category. College graduates are assumed to complete 16 years of schooling while those having more than 16 years of education are counted as college plus graduates.

As we mention above, we calculate years of potential labor market experience for each person. While doing that, we use the average years of completed schooling derived from the revised educational attainment data following Park (1994). It suggests that calculating potential experience in this way is one of the best options to handle with the revised education variable. Using the CPS data described above, we basically construct two samples: one is a wage sample representing college-high school log relative weekly wages overall and by age and experience groups, and the other is relative supply measure, again overall and by age and experience groups. Our wage sample contains average weekly wages for high school and college graduate categories in each year from 1967 to 2009. The logarithm of the ratio of the average weekly wage of college graduates to the average weekly wage of high school graduates provides us college-high school log relative weekly wages.

3.1.1 An Overview of the Data

Table 3.1 presents information concerning the weekly earnings and the demographic details of the sample in addition to the information about education and experience from the CPS data for the years 1968, 1980, 1990, 2000 and 2008.

The mean age of the sample records a decline at first in the 1980s and 1990s, and starts to increase afterwards. The period of "baby boom", reflecting the sudden increase in births in the U.S. immediately after the Second World War which reached its peak level in the 1960 provides an explanation of this observed trend in the mean age. Babies who were born during this demographic boom affected the average and median age of the working population starting from late 1960s. Around 1980s and 1990s, the trend is changed as baby boomers grow towards their middle age.[46]

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[46] The implications of this trend for the future constitute a line of work that is gaining interest. See Baker (2001).

The share of white people in the sample has been decreasing over time. The migration from South and Central American countries, as well as the increased number of people who left their ex-communist homes to live in the U.S. within the last decade and half is most likely responsible for this trend.

Table 3.1 Descriptive Statistics

	1968		1980		1990		2000		2008	
	n=68.809		n=80.998		n=78.223		n=85.360		n=101.813	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
Weekly Pay	756.84	453.08	837.64	495.10	855.15	593.54	1015.10	948.35	1041.58	1002.42
Demographics										
Age	37.43	10.54	36.15	10.68	36.77	9.91	38.54	10.20	39.58	10.75
White	0.91	0.29	0.89	0.31	0.87	0.34	0.85	0.36	0.83	0.38
Married	0.95	0.21	0.72	0.45	0.66	0.48	0.62	0.48	0.60	0.49
SMSA St.	0.70	0.46	0.66	0.47	0.65	0.48	0.70	0.46	0.72	0.45
Education										
Less than HS	0.31	0.46	0.17	0.37	0.11	0.32	0.11	0.31	0.09	0.29
High School	0.39	0.49	0.40	0.49	0.39	0.49	0.32	0.47	0.31	0.46
Some Coll.	0.14	0.35	0.19	0.39	0.22	0.42	0.27	0.45	0.26	0.44
College Grad.	0.10	0.29	0.14	0.34	0.17	0.37	0.20	0.40	0.22	0.42
Post Coll.	0.07	0.25	0.11	0.31	0.11	0.31	0.10	0.30	0.12	0.32
Experience and Age										
0<=E<=9	0.24	0.42	0.31	0.46	0.24	0.43	0.21	0.40	0.21	0.40
10<=E<=19	0.27	0.44	0.30	0.46	0.36	0.48	0.29	0.45	0.26	0.44
20<=E<=29	0.27	0.44	0.21	0.41	0.24	0.43	0.30	0.46	0.27	0.44
30<=E<=39	0.23	0.42	0.18	0.38	0.14	0.35	0.17	0.38	0.23	0.42
25<=A<=34	0.30	0.46	0.35	0.48	0.35	0.48	0.28	0.45	0.27	0.44
35<=A<=44	0.28	0.45	0.25	0.43	0.31	0.46	0.32	0.47	0.28	0.45
45<=A<=54	0.25	0.43	0.19	0.39	0.19	0.39	0.25	0.43	0.27	0.44
55<=A<=64	0.05	0.21	0.06	0.23	0.05	0.22	0.06	0.24	0.09	0.29

3-year averages are given, centered on the specified year. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

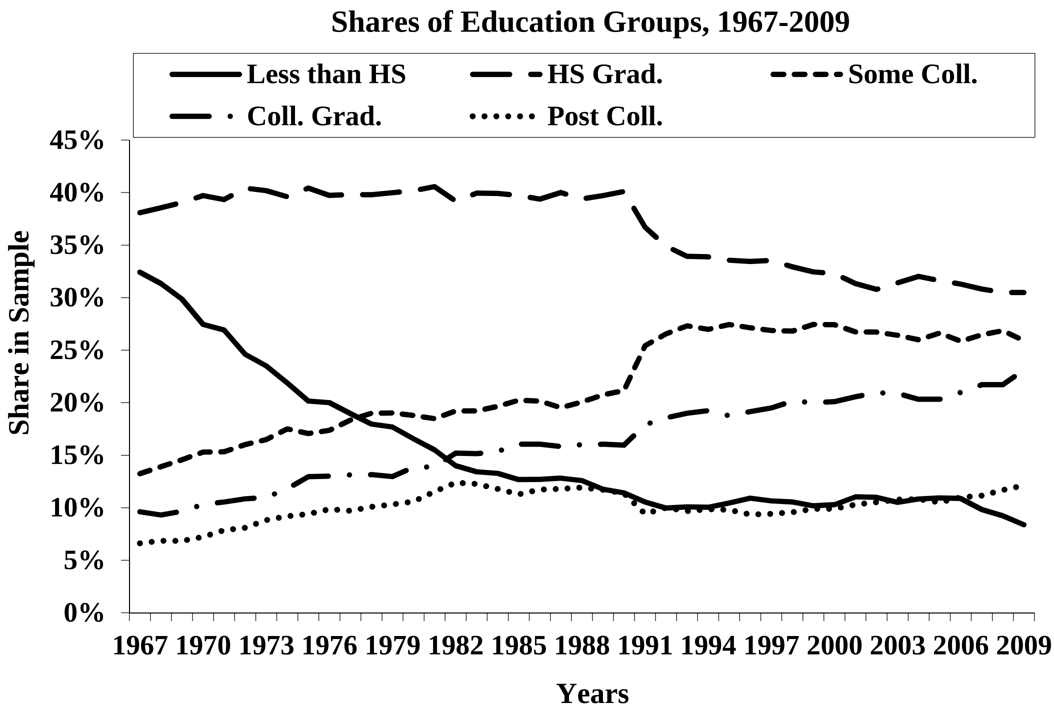
The fraction of the married males in the sample also has fallen constantly over time. It decreases from about 90% in 1968 to 60% in 2008, pointing to a great social transformation in the country in this time period, especially in the 1980s and 1990s.

The shares of education groups are also reported in the table. We see a decrease in both groups regarding the share of high school and less than high school degree from 1968 to 2008 while the latter is always stays below that of former. The share of high school remains level around 1980s and 1990s and start to decrease in 2000s while the share of lower degree holders display a sharp decline around 1980s and seems to have constantly dropped after that. The decline in the proportion of people who have lesser degree than high school is much sharper, from 31% to 9%. The share of high school graduates, on the other hand, represents a relatively softer decrease, from 39% to 31%. The share of people with some college education shows a continuous increase except one point decline in recent years. However, the share of this group stays above those of college and post-college for all periods. The share of people with an exact college degree and post college degree increased consistently throughout the sample period while it has more than doubled for a former group.

Since we will be mentioning about the educational attainment quite a bit, it is worth spending some more time on this subject. Figure 3.1 provides a closer look to the trend of all 5 education categories in our sample, allowing us to see a much more comprehensive representation of educational attainment in the U.S. for the 43 years time span.

The share of low education group (less than high school graduate) decreases from the beginning of the period (about 30%) to the mid-90s (about 10%) and stays there. They lose about 2/3 of their share and become the smallest of all other four categories by far.

The share of high school graduates constitutes the biggest group of the entire sample. It remains level until 1990 around 40% and then it declines in a matching progress with the some college group afterwards. After this decline, it stays the same with a minor fluctuation in the very beginning of the 2000s.



Shares of five education groups in the wage-earner sample. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.1 Shares of Education Groups in the Sample

The matching movement observed in high school and some college lines (and partly in college line) indicates that some people who formerly had been in the high school category increase their educational attainment and has moved to the category of some college and college degree after 1990. This trend is still powerful when we look at the last year of our sample period with the college graduate group is now mostly in charge rather than some college group.

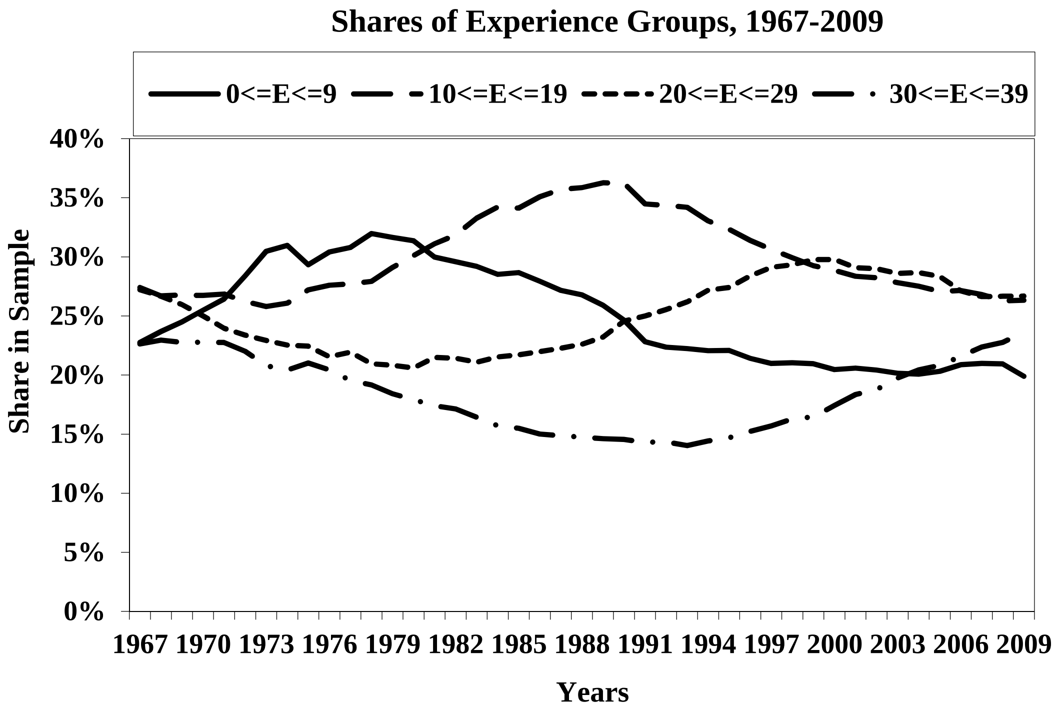
Share of some college graduates has been increasing until 1990 and then it abruptly jump off in 1991. This sudden increase is most likely to be a product of the change in educational attainment coding. After 1991, the share of this group remains level.

The share of college graduates keeps increasing from the beginning of our data with a slight jump in 1990. The share of people with post college education tracks the same pattern with college graduate line until 1982. After that year, however, the former starts to decrease while the latter keeps on increasing. Around 1990, the decline is noteworthy in the post college group. However, beginning from the 2000s it started to increase again to the end of the period.

Table 3.1 also shows the shares of males with different potential labor market experiences. The data indicate that the composition of males who have less than 9 years of experience (including 9) is increased from 24% in 1967 to 31% in 1980. In 1990s, it draws back to its initial level 24%, and keeps decreasing in 2000 and after. The share of those with 10-19 (including 19) years of experience increased in 1980s and 1990s and then displayed a sudden decrease in 2000 from 36% in 1990 to 29% in 2000. In recent years, the share is less than its initial level in 1967. Those with 20-29 (including 29) years of experience reached its highest level in 2000. In 2009, the share is exactly the same with its level in the beginning. The percentage of people with 30-39 (including 39) years of experience has decreased in 1980 and 1990 and then increase in 2000 and 2009.

Figure 3.2 examines the shares of potential labor market experience in detail. One can notice that the movements of shares of different experience groups are closely related with those of the education groups. It makes sense since experience has accumulated over time. Under the assumption of work continuity, those who entered the labor force at some point actually remained in for a long time thereafter. Therefore, a person who enters to the labor force in 1967 would have build up 10 additional years of work experience by 1977 and passes from the lowest experience group to the second lowest one.

The group with the lowest experience, the persons with 9 years or less potential labor market experience reach its highest level in 1980 with around 30%. This group has the largest share among others from the beginning of the period until the late 1980s. After then, it starts to fall and never recovers again. The share of the 10-19 years of experience starts to increase in the mid1970s.



*Shares of four experience groups in the wage-earner sample***.** *Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.*

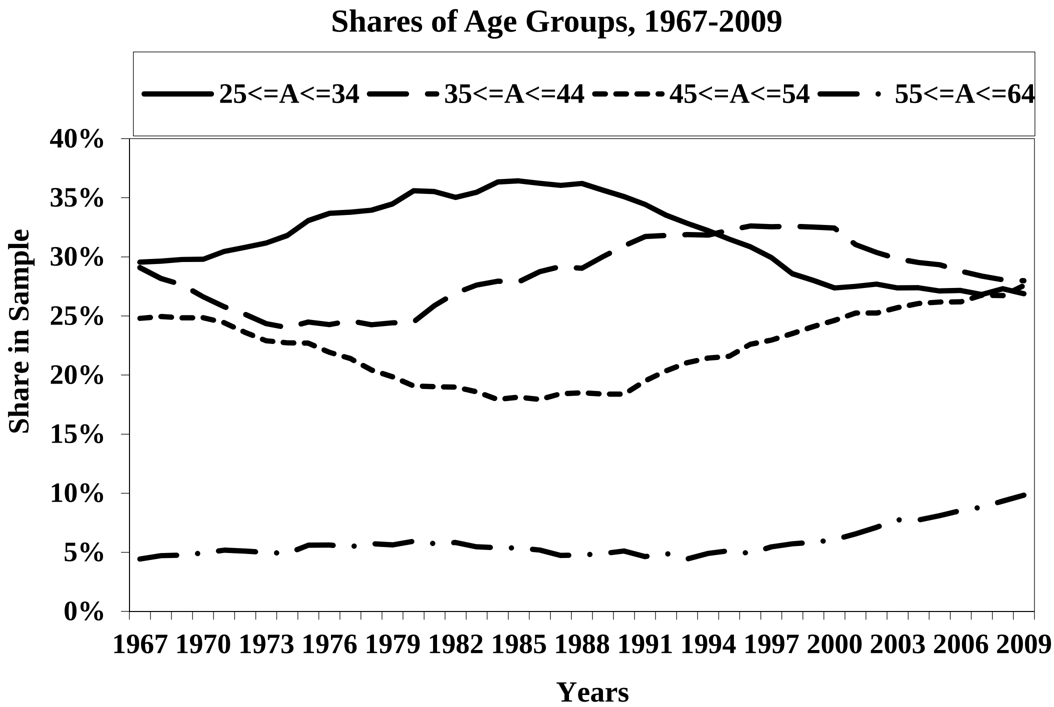
Figure 3.2 Shares of Experience Groups in the Sample

This increase continues until the beginning of the 1990s. Around these years, it constitutes the highest share of all groups. Then it begins to fall steadily to the end of the period. Share of those with 20-29 years of experience represents a declining pattern until 1983. After that year, their share starts to rise. Around 2000s, they become the biggest of all experience categories by far, although it seems that their share tends to fall after the year 2006. The fourth group, those with 30-39 years of experience has shown a long-term decrease until the very beginning of 1990s. After then, the increase in their share gains speed and in 2000s it accelerates even more.

As we said earlier, one can notice that the movements of shares of these groups are closely related with each other. We see that while the first group with 9 years or less experience starts to decrease in share, the share of second group with 10-19 years of experience begin to increase. Similarly, when this second experience group loses their share, the share of the third group of women with 20-29 years of experience initiates to rise. It is not surprising since with each passing year, experience has mounted. That's why the first group has the largest share at the beginning of 1980s, whereas those in the second group and third group achieve an increase in their share around 1990s. The timing of these transitions should be kept in mind for our later arguments in wage inequality.

One can reveal some key suggestions by looking at the individual paths of these shares and also the timing of these transitions. The sudden increase in the population caused by baby-boom period affects these changeovers with no doubt. Because, someone was born during this demographic boom around the mid-1950s would be in the work force by the mid-1970s, taking place in the lowest experience group. After 10 years, around 1980s, these people would take place in the second lowest experience group with 10 years of experience. Similarly, they would have 20 years of experience during the mid-1990s. This is certainly consistent with our rising and falling points in the figure.

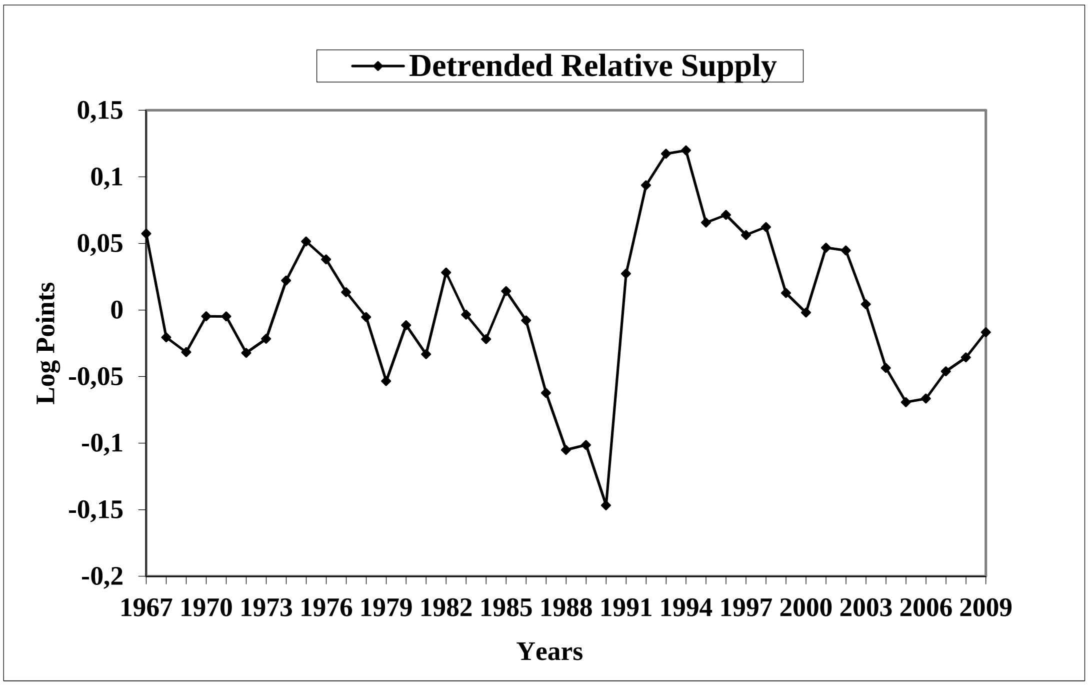
The distribution of our sample over age groups is given in Figure 3.3. The first age group including those with the age of 25-34 has been increasing until 1990s. It decreased after then until 2000s and stayed more or less the same to the end of the period. The second age group, people with the age of 35-44, has exactly the same share with the first group at the beginning of the period. It lost ground after that until the mid-70s, kept level to the end of 1970s and started to increase in 1980s to 2000s when it started to decline again. 45-54 age group has been decreasing with few fluctuations throughout 1980s and begins to rise afterwards while the oldest age group, 55-64, remains level until 2000 and then increase.



Shares of four age groups in the wage-earner sample. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.3 Shares of Age Groups in the Sample

Figure 3.4 shows the college/ high school relative supply over 1967 to 2009 deviated from a linear time trend. The figure reveals that the relative supply of college graduates grows with few fluctuations in the 1970s and 1980s (especially years 1975 and 1982) compared to 1960s. The growth in the relative supply indicates a remarkable slowdown after 1985 which comes to an end in 1990. After then, it rebounds again and reaches its maximum level in the mid-1990s. These fluctuations in the growth rate of relative supply accompanied by a secular trend growth in the relative demand for college graduates explains a lot about the evolution of college/ high school wage premium over four decades.

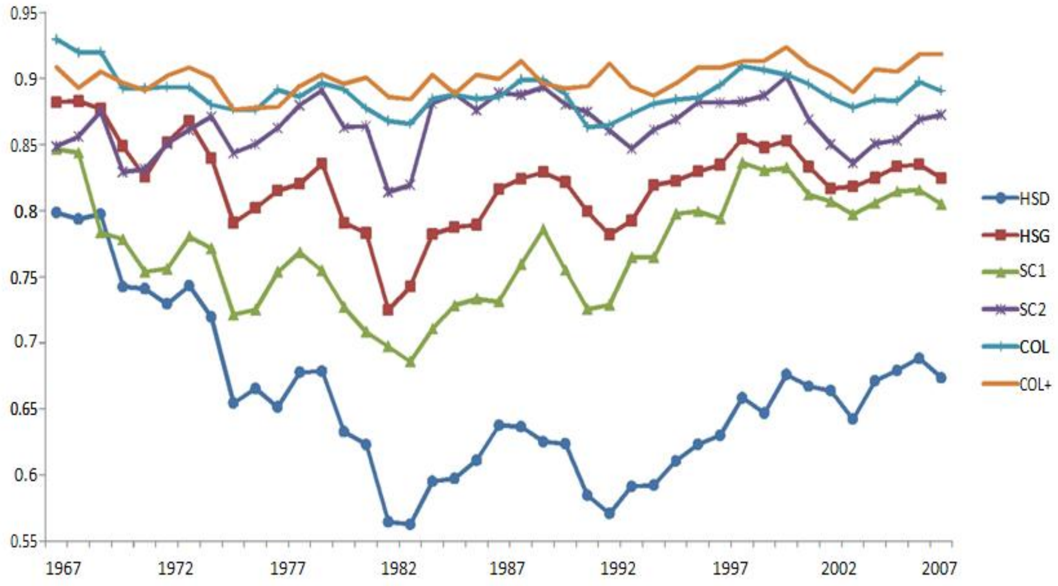


The detrended supply series are residuals from OLS regression of the log relative supply on a constant and a linear time trend. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.4 Detrended College/High School Relative Supply

The next and the last figure of this section motivates why we perform the selection-correction exercise. Our starting point is the observation that most studies in the U.S. wage inequality literature focus on the FTFY workforce. In other words, the ones who potentially self-select into the FTFY status have been sampled. However, Figure 3.5 reveals an important piece of information on the fraction of FTFY workers. It shows that among employed workers, selection into the FTFY status exhibits distinct trends between education categories after late 1960s to date.

As it can be clearly seen in the figure, we observe a lot of variation in the FTFY fraction among low-skill workers, whereas the FTFY fraction among the high-skill workers is quite stable. This variability is potentially due to discrepancies in the labor supply decisions among different skill groups.



Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.5 Fractions of FTFY Workers by Education Category

The fraction of the FTFY status among high-skill workers stays in a narrow range around 90 percent over the data horizon. The fraction of the FTFY status among low-skill workers, on the other hand, exhibits significant time variation. For example, among high-school dropouts, around 80 percent of the employed workers have had FTFY status in late 1960s, while the FTFY ratio has sharply gone down to 60 percent and made a double-dip in 1982 and 1992. Then it has picked up and reached to 70 percent in 2007. Similar trends are also observed for other less-skilled workers, including the high school graduates and workers with some college education who earn less than the median wage. This suggests that the selectivity operates for low-educated workers. We also observe that, among the low educated, the fraction of the FTFY status declines until mid-1980s and it picks up afterwards. This means that the direction of selectivity is reversed after mid-1980s.

These observations suggest that the composition of unobserved skills is subject to sharp movements within low-educated employed workers, while the scale of these movements is potentially much smaller within high-educated ones. These divergent patterns between low-and high-skill workers in terms of the labor supply patterns on the FTFY margin motivate this study. These patterns raise concerns that the existing estimates may be missing some systematic components of the relative supply series that are relevant for wage inequality analysis.

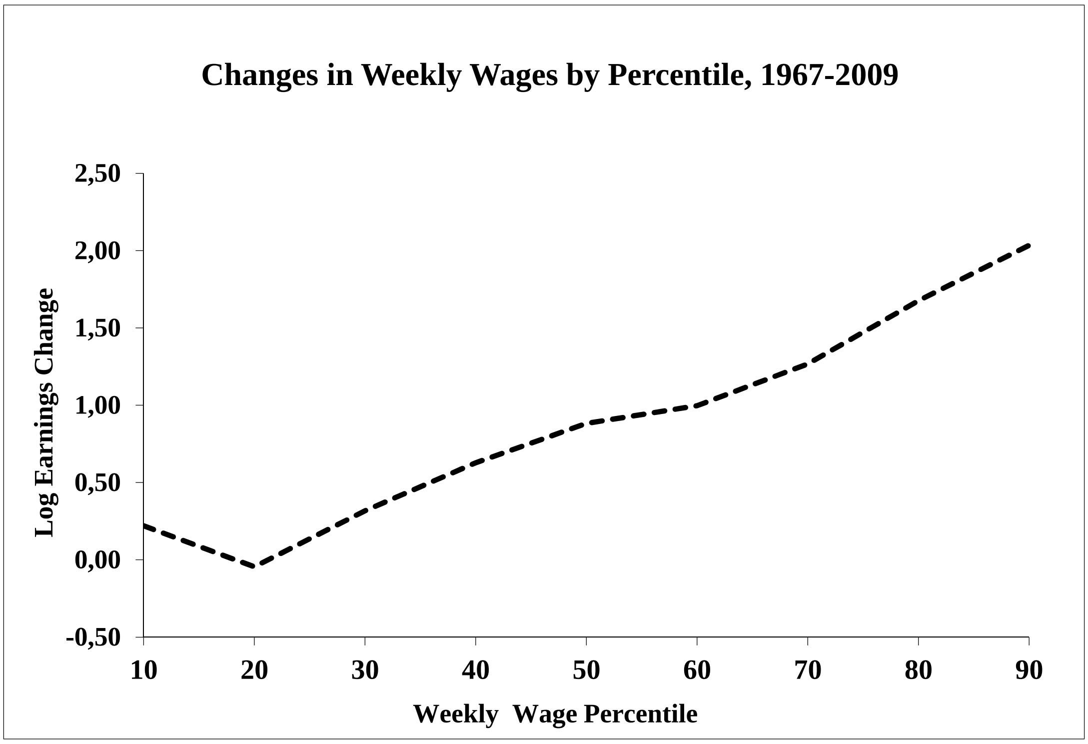
We believe that accounting for selectivity changes the trends in the relative supply of skills and the main source of these changes is the shift in the self-selection patterns of the low-skill workers. The intuition is as seen in the figure 3.5: low-skill workers are over-represented in the FTFY workforce before the 1990s and they are under-represented afterwards.

We suggest that the standard college premium framework accounts for the observed shifts between education categories, but it cannot account for these unobserved compositional changes within education categories. Therefore, we use the standard latent variable selection-correction methods to control for these unobserved compositional shifts due to selection in and out of the FTFY status.

3.1.2 Evidence on Wage Inequality

Now it is time to see how these characteristics of the wage earner sample mentioned above are related to wage inequality. We begin displaying basic wage structure facts in Figure 3.6. The figure plots the change in log real weekly wages by percentile for males from 1967 to 2009. It is clearly seen from the figure that there is a considerable expansion in the wage inequality with the 90th percentile earns by more than 55% relative to 10th percentile. The figure also shows a linear and monotone increase of the whole wage distribution above around the 20th percentile.

Wages may show different patterns at different points of a distribution. Therefore, it is very helpful to look at different percentiles of a wage distribution in order to obtain a more detailed picture. Based on the log weekly wages, Figure 3.7 plots the change in 90th, 50th (median) and 10th percentiles in U.S. over forty years. In order to make an understandable comparison, we index the values as 1967=100.

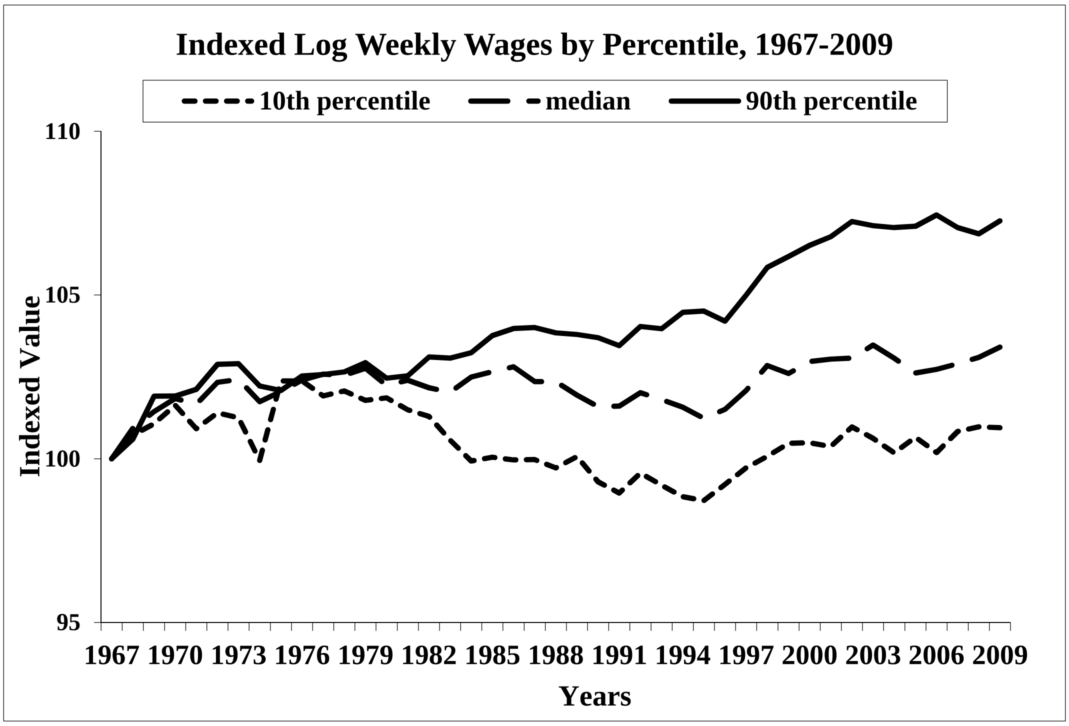


Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.6 Changes in Log Real Weekly Wage by Percentile

We can see from Figure 3.7 that, 10th percentile starts to decline in real terms at the beginning of 1980s and actually goes below its initial level after 1982. It is noteworthy that in the second half of the 1990s, it began to recover on account of economic environment which saw an increase in demand for all sorts of workers. It seems to catch up with the 1967 level at the end of the period.

Log weekly wages at the 90th percentile tells another story than that of 10th percentile. After an initial jump around 1970s, it keeps level until 1980s. After then, it increases until 1987. After remaining steady at this level for a long time with few fluctuations, it makes a jump during the mid-90s. We see a second jump in late-90s that ends in 2003. After then, it looks like stable with minor fluctuations to the last year of our analysis.



Three percentiles of log weekly wages indexed to 1967=100. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

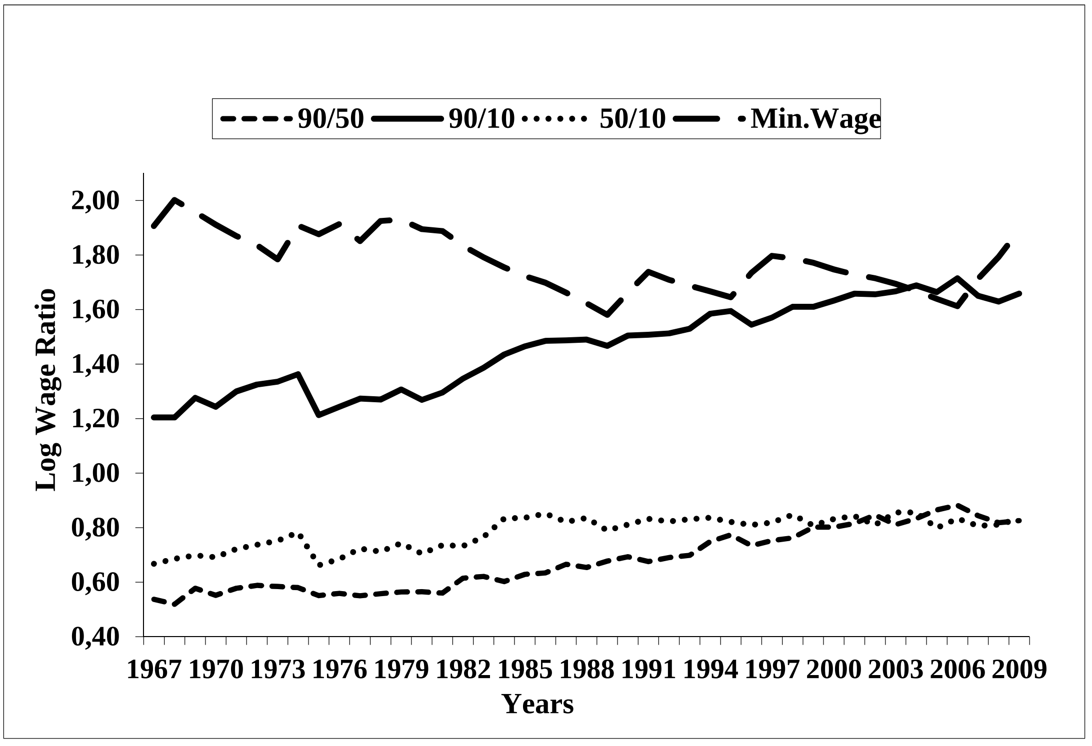
Figure 3.7 Indexed Log Weekly Wages by Percentile

The noteworthy thing here is that while the 90th percentile seems to increase and 10th percentile decreases in real terms, the 50th percentile (median) keeps a stable pattern especially after early 1970s. Another important thing to notice is that 90th percentile and the 50th percentile go close to each other until the mid-80s, but then they start spreading from each other again in the second half of 1980s. There is an apparent divergence especially during the second half of the 1990s. However, they both keep their distance with the 10th percentile during this time period.

Overall, one can clearly notice from the figure that the gap between all these three measures starts to expand after the 1980s. The gap between 50th and 10th percentiles represents rather a stable course while the gap between 50th and 90th percentiles displays a more divergent pattern especially after the beginning from 1990s. From mid-1970s until the 1990s, the gap between 50th and 10th percentile increases and then stabilizes. The gap between 50th and 90th percentile, starts expanding after mid-1980s, especially during the 1990s. The gap between 90th and

10th percentile starts to grow after the first half of the 1980s and slowed down during but keep increasing around the mid-1990s.

In Figure 3.7, we look at the individual paths of selected percentiles letting us to make comparisons between their relative positions. Now it is time to evaluate how wage inequality evolves over time. Figure 3.8 represents the difference between 90th-10th, 50th-10th and 90th-50th percentiles of log weekly wages and the movements in real minimum wages.



Differences of 90th, 50th and 10th percentiles of log wages for each year. The minimum wage is reported in log 2005 values. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.8 Differences of Log Wage Percentiles

The difference of log weekly wages at the 90th and 10th percentile is a standard measure of overall wage inequality. It has been increasing since the mid-1970s with a few fluctuations. The most remarkable increase seems to be around the 1980s. It is increasing around mid-1990s but at a slower rate than 1980s. It looks to have stabilized after a jump around 2007 to the end of the period.

The difference between 50th and 10th percentiles, which corresponds to the inequality at the lower half of the distribution, more or less follows the same path as that of 90-10 difference until 1980s. Likewise 90-10 percentile difference, it has been increasing until the mid-1970s with a few fluctuations. After then, it reaches at a level that has been kept more or less the same until today.

The 90-50 difference, which is the inequality in the upper half of the distribution, maintains a rather stable path until the 1980s. It is so because; as we said earlier, 90th and 50th percentiles more or less match each other until that year. It then demonstrates an increasing trend which continues until 2007. It becomes larger than then the 50-10 difference after 2005 for the only time in our range of years. This trend seems to come to an end with the year 2007. The 90-50 difference grows faster during the second half of the 1990s. We notice that the level of 90-50 difference is much higher than its 1967 level, when we come to 2000s.

We also see from the figure that the log real minimum wage values experienced a distinctive decline during the mid-1980s in line with the jump in the 50-10 difference at the same period. Therefore one can say that one of the reasons for the stability of inequality in the bottom part of the distribution in the recent years may be the increases in minimum wages during the 1990s which kept the real value relatively stable.

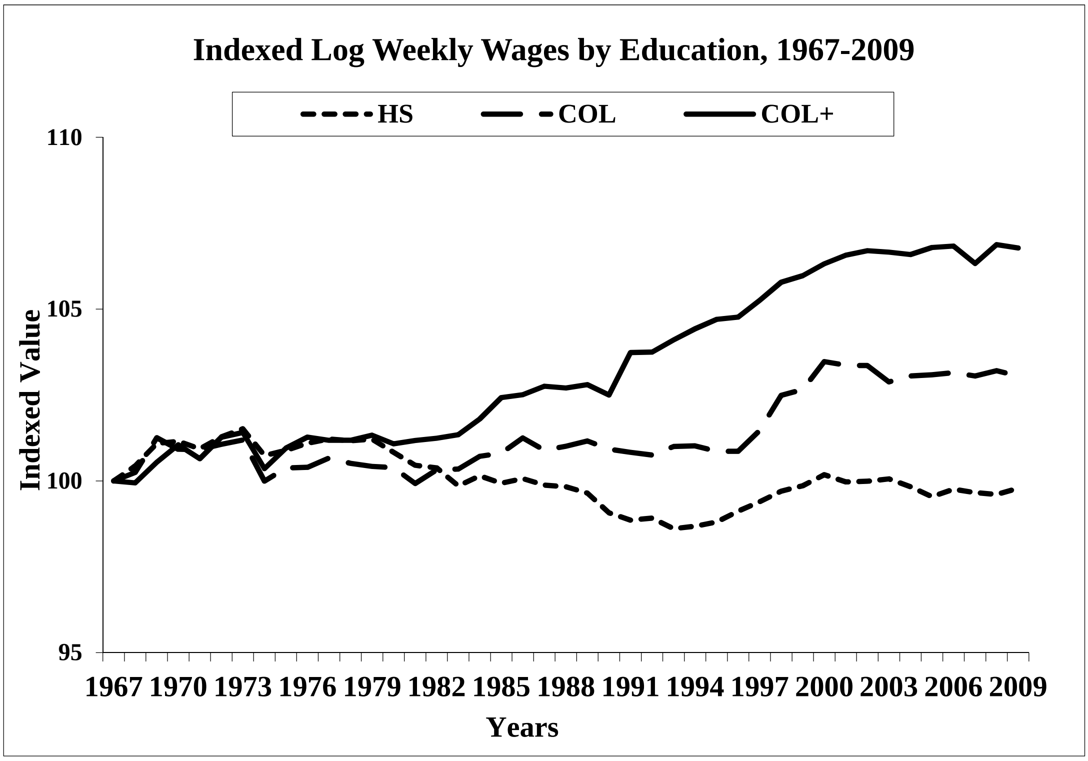
The trend in real minimum wages as the figure shows is particularly important for the point we make in this thesis. When searching for an answer what triggers the changes in the selectivity patterns of the low-skill workers that are demonstrated in Figure 3.5, we come up with the idea that the movements in the real minimum wage may have triggered these substantial compositional changes in the workforce. Based on the observation that selection operates through the unobserved ability composition of the low educated, we suggest that one should focus on factors affecting the lower tail of the wage distribution should in seeking an explanation to the selectivity patterns. We suggest that trends in the real minimum wage can potentially generate compositional changes in the workforce that affect the relative supply of college-equivalent workers in the U.S. The trends in real minimum wages as clearly seen in the figure perfectly fit the self-selection structure that we document.

The 90-50 difference (upper-half inequality) and 50-10 difference (lower-half inequality) can be thought as two pieces that add up to create an overall inequality, which is the 90-10 difference. It is observed from the figure that the 90-10 difference and 50-10 difference grows parallel in 1970s and 1980s while the 90-50 difference remains almost unchanged for these years. Therefore, one can suggest that an increase in overall wage inequality during these years is a result of increased inequality in the lower half of the distribution. The significant increase in 90-10 difference until the mid-1980s was fueled by increased dispersion in both halves of the distribution. After then, however, the composition of wage inequality seems to have changed. The dispersion in the lower part of the distribution stayed quite stable while the dispersion in the upper part has been increasing. Therefore, the 90-10 difference was a result of the dispersion in the upper half after this period. Overall, we can say that until the mid-1980s, overall inequality is mostly related to the lower-half inequality while it is mostly a product of the upper-half inequality ever since.

Figure 3.9 shows another piece of evidence regarding between-group wage differentials. Indexed log weekly wages earned by three different education groups are reported in the figure. The first thing we notice that the individual paths of high school, college and college plus line grows similar to those of paths of 10th, 50th and 90th percentile lines in Figure 3.7. These similar paths support the argument that most of the increase in wage inequality since 1980 can be accounted for by rising educational wage differentials.

When we put these two figures together, what we see is that the path of log weekly wages in the 90th percentile line which represents the top of the distribution, especially after 1990s, corresponds exactly to the path of wages earned by college plus educated. It is a very important observation in the sense that 90th percentile line which implicitly supposed to be identical to that of college line now (after

1990s) starts to represent the post college line. This fact points to an important change in the wage inequality pattern of the U.S.

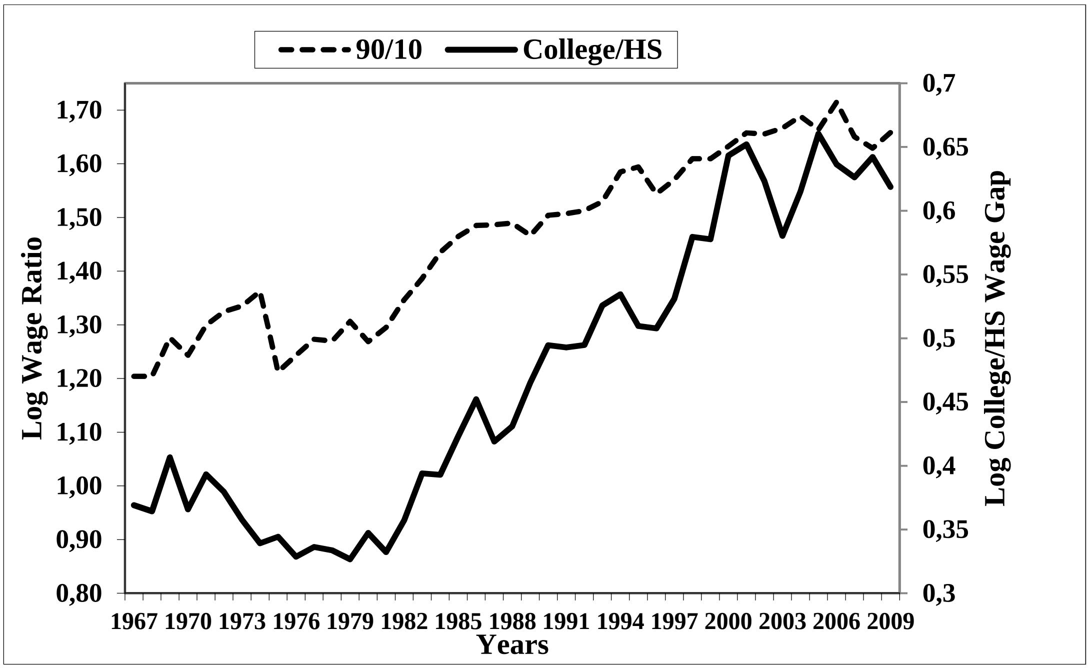


Log weekly wage of three education categories indexed to 1967=100. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.9 Indexed Log Weekly Wages by Education

Figure 3.10 demonstrates the evolution of two important measures of wage inequality to get a better picture: the 90/10 overall wage inequality and college/high school log wage premium. We see a modest increase in the overall wage inequality during the 1970s while a significant decline is observed in the college/high school wage gap during the same period and then a rapid recovery during the 1980s in both. These divergent patterns suggest a key fact about the growth of wage inequality that it cannot explained by a single factor.

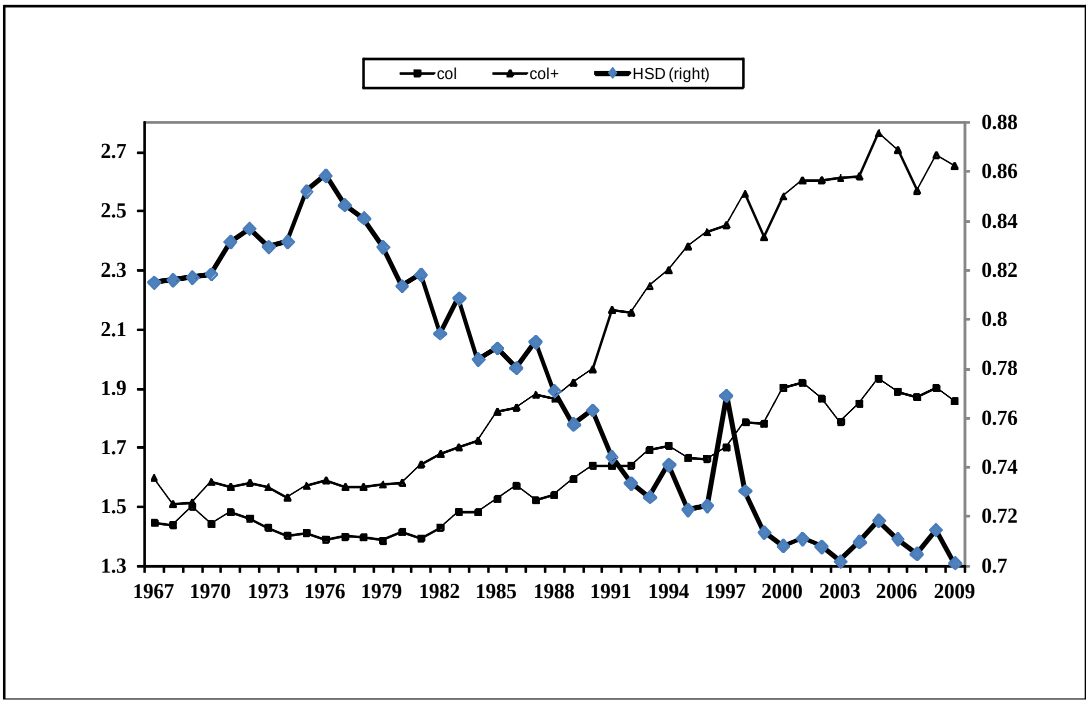
Figure 3.11 plots the trends in relative real wages earned by high school dropouts (HSD), college graduates (COL), post college graduates (COL+). Wages are calculated relative to the wages of high school graduates. High school dropouts are reported on the right axis. Obviously, under the assumption that workers are paid their marginal products, the productivity of higher educated workers versus the lower educated ones improves at an increasing rate. The extent and characteristics of these improvements are clearly documented in the literature. For example, Mincer (1997) finds that the natural logarithm of wages is increasingly convex in years of education. To be concrete, the rate of increase in the wages of workers in the college-plus category relative to college graduates is faster than the rate of increase in the wages of college graduates relative to high school graduates, which in turn, is faster than the rate of increase in wages of high school graduates relative to high school dropouts.



Calculations are based on the March CPS. The college/high school wage premium series shows a fixed weighted ratio of college to high school wages. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.10 Two Measures of Wage Inequality: College/High School Premium and 90/10 Overall Inequality

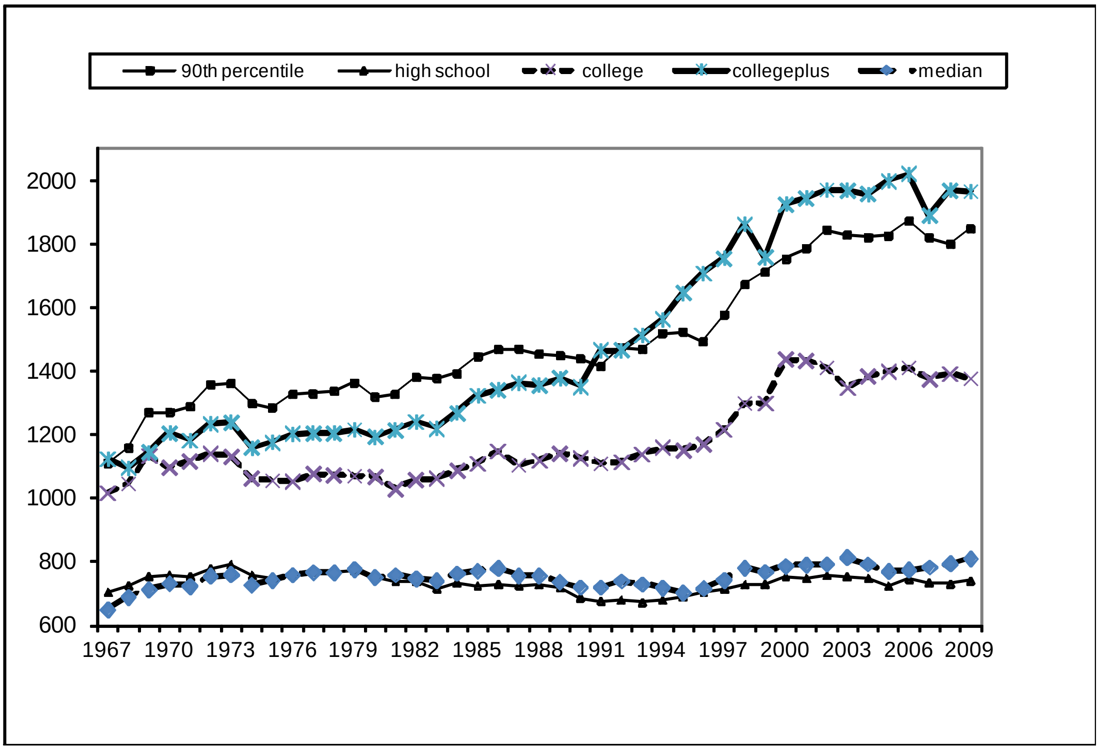
Figure 3.12 provides us to make another important comparison that real wages, and therefore real productivities, increase differently across different education categories. Notice that the average real wage paid to the college-plus category has increased so rapidly that it cruises well above the 90th percentile real wages following the cross-over in early 1990s. We have emphasized this point also in Figure 3.9. We believe that the recent increase in wages at the top of the distribution and therefore the recent wage inequality especially in the upper tail of the distribution are closely related to this sudden increase in wages earned by the college-plus category.



Wages are calculated (from the March CPS) relative to the wages of high-school graduates. High-school dropouts are reported on the right axis. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.11 Weekly Wages by Education

This cross-over indicates an important change in the wage inequality pattern as we said before. Equating wages to marginal products, which is the standard assumption invoked in the literature, it tells us that there are certain quality improvements of the workforce in recent years which should be taken into account in the wage inequality analysis. Of course, changing relative prices may not fully reflect changes in quality. But this trend certainly shows us that something goes on in terms of wages that is related to the productivity. Since we take "productivity" as our measure of “quality”, this point constitutes an important empirical insight and motivation in our analysis. We will return this point later.



Real wages (in levels) are calculated from the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.12 Weekly Wages by Percentile and Education

Before completing our discussion about the nature and evolution of wage inequality, it is also important to look at another aspect of wage inequality that has been debating in the U.S. for a long time. Figure 3.13 displays within (residual) inequality trends among the workers with similar observable characteristics such as education and experience over 1967 to 2009. We have constructed 3 groups of workers based on their years of potential labor market experience: those with 9 years or less experience, 0<=E<=9, those with between 10 and 19 years of experience including 19, 10<=E<=19, and those with between 20 and 29 years of experience including 29, 20<=E<=29. We have also constructed 4 subgroups of workers according to their educational attainment: <HS represents workers who have education less than high school degree, HS represents high school graduates

and no more education, College represents workers with a 4-year college graduates, and college plus represents higher levels than that.

We classify each experience group according to their education attainment. We calculate the change in wages by percentile within these groups for the periods: 1967-1980, 1980-1990 and 1995-2009. Each rows in the figure displays the same time period for 3 different experience levels. When calculating the percentiles, we take the averages of the last 2 years of the time period. For instance, 1967-2009 change is the difference of the average 2008 and 2009 from that of 1967 and 1968.

The first three figures in the first row show that workers with college and college plus degree not only gain better wages in 1967 than in 2009, their earnings is also better than those of high school graduates on all percentiles. (Except for the Exp9 group where they gain more than less than high school graduates after the 20th percentile). Therefore one can say that there is increased wage inequality that stems from the educational differences. One can also observe from the figure that there is an increase in wage inequality among all education groups themselves except less than high school degree. The wage inequality among the college, college plus and high school graduates themselves increased as higher percentiles gaining more than lower percentiles. This provides an evidence of within inequality among workers with similar education and experience profiles. This trend is especially strong for those in a college plus group whose experience level are greater than 10 years.

Those with a college degree and between 10-19 years of experience also earn more in higher percentiles than lower percentiles. The same cannot be said for those with less than high school degree. It seems like they gain less than 1967 except for the highest 5th or 10th percentiles.

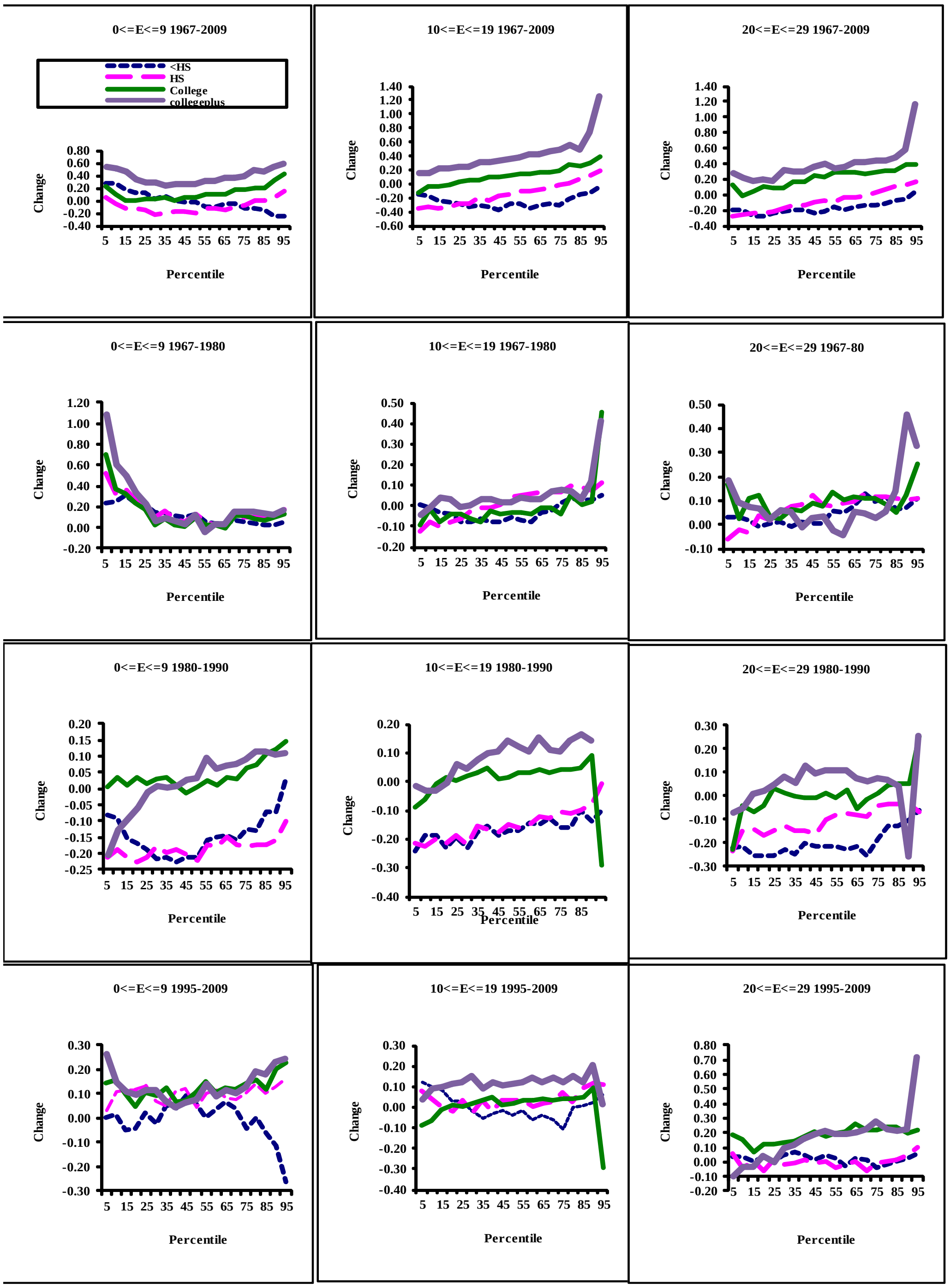
The figures for 1967-1980 period does not provide a clear picture about regards to within inequality, however one can observe that there is an increase in lower half-inequality for the high school graduates who have between 10-19 and 20-19 years of experience.

1980-1990 period which indicates wage inequality in our earlier analysis as well as in the literature reveals that there is an increase in inequality forced by college and college plus graduates earning more than both of the other two groups. Furthermore high school graduates gain more than those with less than high school degree especially in upper percentiles.

The figures for 1995-2009 period reveals that the earnings of college and post college graduates rise more than those of the high school graduates in each experience group. This is the case especially for the workers with higher experience. The upper-half inequality seems to grow within high school, college and post college categories especially for those having between 0-9 and 10-19 years of experience. Although the between inequality picture is not that clear for this period as it is in 1980-1990 period, one can see it is still observable especially in the upper tail of the distribution. There is also a noticeable increasing within inequality in the upper percentiles.

One can also compare Figure 3.13 with Figure 3.1 and 3.2. From the earlier figures, we observe that the share of college and post college graduates in the wage-earner sample is more or less stable for the 1980-1990 period. Accordingly, Figure 3.13 shows that the college and post college graduates gained the highest earnings over the other groups in this period most likely as a result of rising demand and stable supply.

Another way of getting an idea about the change in within inequality is by observing regression residuals which partly shows the effects of unobservable characteristics on wage differentials. A wider dispersion in the distribution of regression residuals reflects the growth in within-group inequality. Table 3.2 represents the 90-10, 90-50, and 50-10 percentile differences for 5-year intervals (except the last period). The first panel shows these differences for log weekly wages from the empirical data. The second panel displays difference of residual wages at these percentiles from the residual distribution from a wage regression.



Calculations are based on the March CPS. Change in percentiles of wage distribution between two years. The change is calculated as the difference of corresponding percentile between two points in time. 2-year pooled data is used to avoid measurement error. The legend is given only for the first figure. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 3.13 Within Inequality

The last panel represents how much of the values in the first panel can be explained by the values in the second panel. In other words, it displays how the residual inequality (within-group inequality) can be compared to the inequality values from the empirical data.

Table 3.2 Residual Inequality

LOG WEEKLY WAGES								
Percentile	1968	1975	1980	1985	1990	1995	2000	2009
90-10	1.23	1.27	1.29	1.46	1.49	1.57	1.63	1.64
90-50	0.54	0.56	0.56	0.62	0.68	0.75	0.81	0.82
50-10	0.68	0.71	0.73	0.84	0.81	0.82	0.83	0.82
std	0.52	0.53	0.53	0.58	0.60	0.64	0.66	0.68
WEEKLY WAGE RESIDUALS								
Percentile	1968	1975	1980	1985	1990	1995	2000	2009
90-10	0.96	0.98	1.03	1.11	1.14	1.21	1.25	1.27
90-50	0.45	0.45	0.48	0.52	0.53	0.57	0.61	0.62
50-10	0.41	0.42	0.43	0.46	0.47	0.51	0.53	0.54
std	0.41	0.42	0.43	0.46	0.47	0.51	0.53	0.54
% OF CHANGE EXPLAINED BY RESIDUALS								
Percentile	1968	1975	1980	1985	1990	1995	2000	2009
90-10	78%	77%	80%	76%	76%	77%	76%	77%
90-50	82%	81%	85%	83%	78%	76%	76%	76%
50-10	60%	59%	59%	55%	58%	62%	64%	66%
std	79%	79%	81%	79%	79%	79%	80%	79%

Calculations are based on the March CPS. The residuals are obtained from a regression of log weekly wages on a quadratic of experience, education dummies for less than high school, high school graduate, some college, college graduate, and post college degree and demographic dummies such as married, white, metropolitan area and living in the south. All regressions are 3-year pooled regressions centered on the indicated year except 2009, which is a 2-year pooled regression of 2008 and 2009. The sample consists of full-time/full-year employed men for the 1967-2009 period.

It is clearly seen from the table that there is a strong within inequality trend. The last panel reveals that the residual distribution seems to explain about 3/4 of the inequality in the empirical data. The overall inequality summarized by the 90-10 wage difference and the upper half inequality summarized by the 90-50 wage difference point the highest match with the residual wages in 1980. For the lower half inequality, the best match seems to be in 2009. One can also notice that the fraction of 90-10 difference explained by the residuals have not changed that much since 1980. However, we also observe that the portion of 90-50 inequality explained by wage residuals has declined while the portion of 50-10 inequality has increased.

These two reverse effects are probably responsible for this observed trend in 90-10 difference. The table provides evidence that there is an increase in within inequality in the lower half of the distribution while it decreases in the upper part.

3.2 Methodology and Construction of Data

In Chapter 4 and 5, we will discuss alternative methodologies which differentiate from that in the standard supply-demand framework. The construction of data used in inventing this methodology is explained in this subsection.

Our concern in a framework determining college wage premium is to explain relative wage changes by the help of the rate of growth of the relative supply- both aggregate and group-specific- and the relative demand for college graduates across time periods.

We follow earlier work by Katz and Murphy (1992) and Katz and Autor (1999). We calculate appropriate measures for relative wages, relative supplies, and relative demand shifts. We use the overall college/high school wage ratio as our relative wage measure. The college/high school wage ratio is calculated as the ratio of the average weekly wages of workers with exactly a college degree (i.e., sixteen years of education) to the average weekly wages of those with exactly a high school degree (i.e., twelve years of education).[47]

[47] Data section contains more details on the construction of our relative wage measure. All wages are deflated by the implicit price deflator for personal consmption expenditures.

Relative demand shifts, D_t is represented by a simple linear time trend and real minimum wages. [48]

The key construct in the traditional college premium analysis is the variable describing the aggregate supply of college equivalent workers relative to the supply of high school equivalent workers. This variable is called the relative supply measure. The conventional relative supply measure used in the wage inequality literature is calculated as follows. There are five education categories in our sample: high school dropouts (HSD), high school graduates (HSG), some college (SC), college graduates (COL), and post college graduates (COL_+). In our notation, $J \in$ {HSD, HSG, SC, COL, COL_+}. Two more general education categories are constructed from these five categories: “high school equivalents” and “college equivalents”. [49] The efficiency units of labor supply are calculated for each of these five categories in order to construct these two broad skill categories. The construction of “college equivalent” and “high school equivalent” labor supplies are as follows. High school dropouts are covered in the high school category while post college graduates are covered in the college category. Workers in some college category are allocated between the high school and college categories on the basis of their relative wages. The total supply of “high school” and “college” equivalents are weighted sums of hours worked by the different groups. According to this, the aggregate high school equivalent labor supply is defined as the total efficiency units of labor supplied by high school graduates (total hours worked by high school graduates), plus the total efficiency units of labor supplied by high school dropouts (total hours worked by high school dropouts weighted by average wage of this group relative to high school graduates), plus a fraction of the hours of workers with

[48] Following Autor, Katz and Kearney (2008), we formulate the relative demand measure as $D^t = \beta_1 t + \beta_2 \ln (RMW_t)$, where *t* represents the skill-biased technological change (SBTC) trend and RMW denotes real minimum wages deflated by the personal consumption deflator.

[49] This is the convention in constructing relative supply measure in the wage ineqaulity literature. See among studies Katz and Murphy (1992), Katz and Autor (1999), Card and Lemieux (2001), Acemoglu (2002), Card and Dinardo (2002), and Autor, Katz and Kearney (2008).

some college (total hours supplied by a share of some college workers weighted by average wage of this group relative to high school graduates). Similarly, the aggregate college equivalent labor supply is described as the total efficiency units of labor supplied by college graduates (total hours worked by college graduates weighted by average wage of this group relative to high school graduates), plus the total efficiency units of labor supplied by college-plus workers (total hours supplied by post college workers weighted by average wage of this group relative to high school graduates), plus the remaining fraction of the hours of workers with some college (total hours supplied by the corresponding share of those with some college weighted by average wage of this group relative to high school graduates). The way that we allocate those with some college between high school and college equivalents is as follows: workers in the some college category are sorted on the basis of their weekly wages in each year. We assign those who earns below the median wage as high school equivalents.[50] Similarly the workers receiving above the median wage are merged to college equivalents.

We denote the labor supplies of high school equivalents and college equivalents by *H* and *C*, respectively. Roughly speaking, *H* and *C* are calculated by aggregating the hours supplied for the respective categories weighted by the "efficiency units". In other words, it is a standard measure of relative supply calculated in "efficiency units" for each education category by weighting total hours of work in a given year with the relative real wages averaged over "all" years in the sample period.[51]

We formulate the computation of efficiency units as follows:

$$J_t = \overline{w}^J h_t^J \quad , \tag{3.1}$$

[50] Some studies use mean rather than median. But the choice of the division criterion is not critical at all for the results.

[51] See Katz and Murphy (1992), Autor, Katz and Kearney (2008), Autor, Katz, and Krueger (1998), Card and Lemieux (2001), Beaudry and Green (2005), Autor, Katz and Kearney (2008) and Dustmann, Ludsteck, and Schönberg (2009). Papers including Card and Dinardo (2002) use fixed *ad hoc* weights.

where J_t denotes the education category that the calculation is carried out for, h_t^J is the total hours of work for the education category *J* at time *t*, and

$$\bar{w}^J = {}^1\!/_T \sum_{t=1}^{T} \left(\int_{I_J} \ln w_{i,t}^J \, \mathrm{dF_{J,t}}\,(i) \Big/ \int_{I_{HSG}} \ln w_{i,t}^{HSG} \, \mathrm{dF_{HSG,t}}\,(i) \right), \tag{3.2}$$

Here $\ln w_{i,t}^J$ is the log real wage for individual *i*, $i \in I_J$, belonging to the category *J* at time *t*, *t* =1, …, *T*, where *T* is the length of the sample period and I_J is the support for the relevant population in the corresponding education category. $\mathrm{F_{J,t}}(i)$ describes the cumulative distribution function (cdf) of individual-level wage observations at time *t*. Note that the weight is calculated relative to the real mean wage among the benchmark education category, which is high school graduates (HSG), at time *t*. To put it differently, the fixed weight $\bar{w}^J$ is incorporated to capture the fact that higher educated workers supply larger efficiency labor units per unit of time than the lower educated workers do. That is, the efficiency units of labor supply are calculated by multiplying the total hours of supply with this fixed weight. Based on this logic, one can simply construct

$$H_t = \sum_{J=HSD,HSG,SC1} J_t \quad \text{and} \quad C_t = \sum_{J=SC2,COL,COL+} J_t \tag{3.3}$$

The natural logarithm of the amount of supply of college equivalents, C_t, relative to supply of the high school equivalents, H_t, yields our college-high school log relative supply indicator.[52]

[52] It is important to note that Card and Lemieux (2001) formulates ln (C_t/H_t) as a theoretical construct based on the imperfect substitutability assumption across age groups. However, they calculate ln $(C_{i,t}) / H_{i,t})$ in the way we describe in Chapter 2, where *i* indexes the age groups. We do the same exercise where *i* indexes the experience groups in accordance with Autor, Katz and Kearney (2008). Trends related with age groups also reported in Figure (4.3).

We would like to emphasize at this stage that all the calculations are carried out for the workers reporting a FTFY status.[53]

In this study, our main focus is on the efficiency units, $\overline{w}^J$. Under this formulation, there are five efficiency units coefficients, one for each education category. The one for the HSG category is 1 due to the normalization described above. These coefficients capture the standard idea that the labor units supplied by skilled workers per unit of time is larger than the labor units supplied by unskilled workers per unit of time. This logic has been frequently used in many different contexts in our discipline.

Note that efficiency units of our labor supply measure have two components: “quantity” and “price”. The “quantity sample” refers to total hours of work of all workers in each five education category (high school dropouts, high school graduates, workers with some college, college graduates, and college plus graduates) for each year. In order to construct the “quantity” sample, we first calculate total hours of work of all workers in each education category. Total annual hours are computed by multiplying the imputed weeks worked by the usual weekly hours for each worker in each year and then sum them up over all workers in each education category. The second part of the relative supply measure, “price sample", on the other hand, is derived by constructing fixed-weight wage indices -relative real weekly wages averaged over “all” years in each education category. To do so, average weekly wages for each education group in each year is calculated, firstly. Then, these average weekly wages for each education group in each year are normalized by the average weekly wages of high school graduates -the benchmark education category in our study. This normalization provides a relative wage

[53] It is also important to note that Card and Lemieux (2001) formulates $\ln\left(\frac{C_t}{H_t}\right)$ as a theoretical construct based on the imperfect substitutability assumption across age groups. However, they calculate $\ln\left(\frac{C_{i,t}}{H_{i,t}}\right)$ in the way we describe, where *i* indexes the age groups. As we point out earlier, the idea is that different age groups are assumed to have different efficiency units of supply, reflecting a weighted average of supply of workers for each age group.

measure for a given group in each year. These normalized relative wage values (derived from a “price sample") are used as weights that are merged to total hours of worked (derived from a “quantity sample"), which in turn creates an “efficiency units" measure of labor supply. In the literature, these relative wages are calculated based on a “fixed-weight” wage index for a given education category. The “efficiency units” measure of labor supply is then provided by weighting the total hours worked in each year-that is total labor supplied- by this fixed-weight wage index. Calculations based on a fixed-weight imply that “price” component is not allowed to change over the sample. This means that shifts in the total efficiency units of labor supply comes only from the “quantity” component.

This standard assumption invoked in the literature is very strong and inconsistent with the data, we believe. Although, the fixed efficiency units idea is a good first approximation, it misses how the relative labor supply contributions of each education category evolve over time. This is particularly important for the point we make in this paper. We mainly argue that the share of the FTFY status fluctuates within education categories over time, which suggests that there may be unobserved compositional shifts due to selection in and out of the FTFY status. The literature focuses exclusively on the FTFY workers without dealing with this potentially problematic issue. Accounting for these unobserved compositional changes can alter the estimated trends in the relative supply of college equivalent workers and, thus, can have implications on the analysis of wage inequality. We will argue the problems arising from the fixed-weight specification in detail in the following chapters and describe a simple empirical framework that can be used to correct for these unobserved compositional shifts.

CHAPTER 4

A ROBUSTNESS ANALYSIS OF THE ESTIMATED TRENDS IN THE RELATIVE SUPPLY OF COLLEGE EQUIVALENTS: THE ROLE OF WEIGHTS

So far we have provided a detailed comparison of alternative theoretical settings and mentioned about the standard methodology and the construction of main variables in the estimation of the college high school wage gap used in the literature. In this chapter we propose an extension to the existing literature by attempting to make a methodological contribution to the theoretical model and discuss the potential gains from extending the canonical skill premium model in the way we propose. We show how we differentiate from the existing canonical supply-demand models in terms of the construction of the relative supply measure (construction of the “efficiency units”). Then we present our results with this new methodology and compare them with the results in the existing wage inequality literature.

We mention earlier that the standard framework in college-premium analysis has two deficiencies. This chapter is mainly related with one of these defects, namely “fixed-efficiency units” idea which ignores potential changes in the quality of the workforce. The existing framework, we believe, needs some adjustments to account for improvements in quality dimension. For this purpose, we develop an alternative weighting procedure- which is “time-varying” rather than “fixed”- which the wage inequality literature relies on- to document the nature and extent of the robustness issues that the fixed weight assumption gives rise to. In that sense, this chapter provides an example regarding the importance of the way of constructing weights. We show, in this chapter, how the main predictions of the standard model change upon relaxing the assumptions on the relative supply index, i.e. that the predictions of the model can be stronger or weaker depending on how we relax the fixed efficiency units assumption.

This chapter proceeds as follows. Section 4.1 emphasizes possible problems arising from using fixed efficiency units as weights. Section 4.2 describes our weighting procedure and demonstrates how we contribute to the existing methodology. We argue that some adjustments are needed in the simple supply-demand framework to account for changes in quality. Section 4.2 presents the estimates of the college premium equation derived using this new methodology developed in section 4.2 and shows the implications of these new results of this alternative model structure on the empirical analysis of wage inequality. We use the standard empirical tools used in the literature to reevaluate the interaction between the college premium and the supply-demand conditions in the labor market. A unifying analysis is presented to incorporate the effect of the imperfect substitution and the effect of the real minimum wages into the analysis. Section 4.4 discusses the results.

4.1 Problems with Fixed-Efficiency Units

Efficiency labor supply units constructed using "fixed" weights capture the fact that an hour supplied by a relatively higher educated worker counts more than an hour supplied by a lower educated worker. This setup successfully captures the effect of the observed changes in the educational composition of the working population. For example, an increase in the fraction of college educated workers with a parallel decline in the fraction of lower educated workers implies an increase in the relative supply index. However, it assumes that the relative efficiency of an hour worked by a college graduate versus an hour worked by a high school graduate is constant over time. This assumption fails to capture that the relative effectiveness of the higher educated against the lower educated may change "over time". In other words, the fixed-weight assumption hinges on the view that the "quality" of skilled workers relative to unskilled workers does not change over time. If this assumption is correct, then it must be the case that the quality of a college graduate relative to a high school graduate, say, in 1970 is the same as that in 2010. But this is hardly the case. Therefore, we say that the “fixed-weight” assumption ignores potential changes in the quality of the workforce. Specifically, if labor quality improves over time, the fixed-weight models underestimate the increase in the relative supply of college equivalents. If, on the other hand, labor quality deteriorates over time, increase in the relative supply is over estimated by these models. Therefore, the fixed-weight specification is not robust in that it misses a fair amount of economic phenomena that goes on in terms of quality adjustments.

The literature has now reached a consensus that the “quality” of skilled workers relative to unskilled workers *does* change over time. However, there is no consensus on the direction of the change. The problem is that the definition of quality varies across studies. To put it differently, if one abandons the fixed-weight assumption- which ignores all the quality adjustments- and uses varying weights (or prices) in the analysis, then there is a problem regarding the choice of a quality measure, i.e., which definition of quality one should use. If one sets “education quality” as the definition of quality then the weights are decreasing which seriously downgrades the SBTC hypothesis [Carneiro and Lee (2011)]. If, on the other hand, one adopts the “relative productivity” of college graduates versus high school graduates as the definition of quality, then the weights are increasing which implies that SBTC still remains in existence with no change in its role and the Katz and Murphy (1992) trend is still relevant. [Bowlus and Robinson (2012)].

In other words, how we relax the fixed efficiency units assumption directly affects the predictions of the standard model. Relative efficiency of college workers might have declined or increased in the U.S. after 1960s, depending on how we “conceptualize” the term efficiency units. If this term reflects “quality of college education", then the related literature documents that the quality of college education has deteriorated in the U.S.; therefore, the efficiency units should be declining which implies that the fixed-weight assumption leads to an overestimation of the increase in wage inequality in the U.S. If, on the other hand, it reflects productivity, then the relative productivity of college workers have improved over time; therefore, the efficiency units should be increasing suggesting the opposite story about wage inequality compared to the one above.

Linking this confusion -the choice of a quality measure- to the estimates of the trends in wage inequality produces mixed results. These mixed results leads to the conclusion that the estimates produced by the canonical college-premium framework are nonnegligibly sensitive to the assumptions on the relative supply index, the key object in the analysis of the college premium. In particular, this framework does not offer a systematic way that can help us determine toward which direction we should relax this assumption. In other words, it does not provide a systematic way to account for the time-series evolution of the efficiency units of labor supply. We believe that this fragility is a weak spot in the college premium analysis and is a source of empirical non-robustness which has important implications for the analysis of wage inequality.

Our main purpose in the next section, therefore, is to relax this assumption and see how the predictions of the basic framework change. These predictions can be grouped under three headings: (1) predictions regarding the trends in the supply of skills, (2) predictions regarding the SBTC trend, and (3) parameter estimates.

4.2 Relative Supply Index: Constructing Varying Weights

Remember that the existing wage inequality literature calculates the efficiency units of labor supply assessing the trends in educational attainment in total and across various demographic groups using the formula as we provided above:

$$J_t = \overline{w}^J h_t^J \tag{4.1}$$

We have said that the “efficiency units” of labor supply in equation (4.1) consists of two components: “quantity” and “price”. Our main focus is on the construction of “price” sample. This point is directly related to the contribution of this chapter and how we differentiate from the existing literature.

In order to construct the "price" sample, wages in each earning cells in each education category in each year are normalized to a relative wage measure by dividing each cell by the wage of the benchmark education category. Let us call the resultant wages as "adjusted wages". We then use these adjusted wages (normalized relative wages) as weights that are merged to the total hours of work, which in turn creates the "efficiency units".

The above formula tells us that, the standard literature calculates the "price" sample by simply calculating real wages over "all" years in the sample period. In other words, the literature calculates a "fixed-weight" wage index- relative real wages averaged over "all" years in each education category- to construct a "price sample". Thus, the mean wage for each education category is the only measure of relative productivity. To do so, average weekly wages for each education category in each year are calculated. Then these average wages are deflated by the average weekly wages of high school graduates- the benchmark education category. The average of these calculated wages through time yields a fixed-weight wage index for a given education category. Therefore, the efficiency units of labor supply for each education category are then provided by weighting the total hours of work in a given year - total labor supplied- with relative wages averaged over "all" years in the sample period- the "fixed-weight" wage index for each education category-. Notice that this fixed-weight specification in the literature does not allow that "price" component to change over the sample. Therefore, the shifts in the total efficiency units of labor supply come only from the "quantity" component.

Maybe it becomes clearer if one looks at the Figure 4.1. Let us assume that these are the adjusted wages computed by deflating the average weekly wages in each education category by the average weekly wages of high school graduates- the benchmark education category. The common approach is to drive a relative wage measure- a single "weight"- that is going to be used in the calculation of the relative supply measure. If these adjusted wages are averaged over all years in the sample period as it is done in the standard calculations in the literature, then the resultant wage index will be a "fixed-weight". This fixed weight captures the fact that higher educated workers supply larger efficiency labor units per unit of time than the lower educated workers do. In other words, the calculated weight for high school dropouts will obviously be less than that calculated for high school graduates. (i.e., $w_{HSD} < 1$). Or similarly, the weight for college graduates will be greater than that of either high school graduates or some college degree. (i.e., $w_{COL} > 1$)

	HSD	HS	SC	COL	COL+
1967	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
2009	-	1	-	-	-
$\overline{w}^J \Rightarrow$	-	1	-	-	-

Figure 4.1 Calculating Adjusted Wages by Education Categories

However, this formulation fails to fully capture the improvements in the quality of the workforce as we discuss earlier. In other words, efficiency labor supply units constructed using fixed weights is incorporated to capture the fact that higher educated workers supply larger efficiency labor units per unit of time than the lower educated workers do as Figure 3.9 suggests. However, it fails to capture the fact that the "relative effectiveness" of the higher educated against the lower educated may change over time.

This is particularly important for the point we make in this chapter. We believe that the standard framework using fixed-weight specification needs some adjustments to account for improvements in quality of the labor force. For this purpose, we relax the fixed-weight assumption and reconstruct the relative supply measure by introducing alternative weighting schemes into the analysis which are "time-varying" rather than "fixed" to overcome the problems related to the quality improvement issue to document the nature and extent of the robustness issues that the fixed-weight assumption gives rise to. Our ultimate goal is to perform the thought experiment "what if the weights were time-varying" rather than "fixed" to arrive at strong conclusions such as one approach dominates the other.

The measure of quality is labor productivity in our study. This view is in line with Acemoglu (2002) and Bowlus and Robinson (2012) in the sense that it interprets weights as a measure of relative productivity of college educated workers, which increase in the U.S. over the last four decades. Again, equating wages to marginal products, which is the standard assumption invoked in the literature, we conclude that quality improvements should be taken into account in analyses of wage inequality. Of course, changing relative prices may not fully reflect changes in quality. But, we follow the convention in the literature and calculate changes in efficiency units using changes in relative real wages.

We relax the fixed-weight assumption by using two alternative weighting procedures. First, we directly use relative wages year by year. Obviously, if one places the fixed-weight assumption to the one extreme, the other extreme is clearly the year-by-year weighting assumption. Second, as an intermediate case, we calculate weights by taking five-year moving averages of relative wages.

We construct J_t in two alternative setting as follows:

$$J_t = w_t^J h_t^J \tag{4.2}$$

and

$$J_t = w_t^{J,[5]} h_t^J \quad (4.3)$$

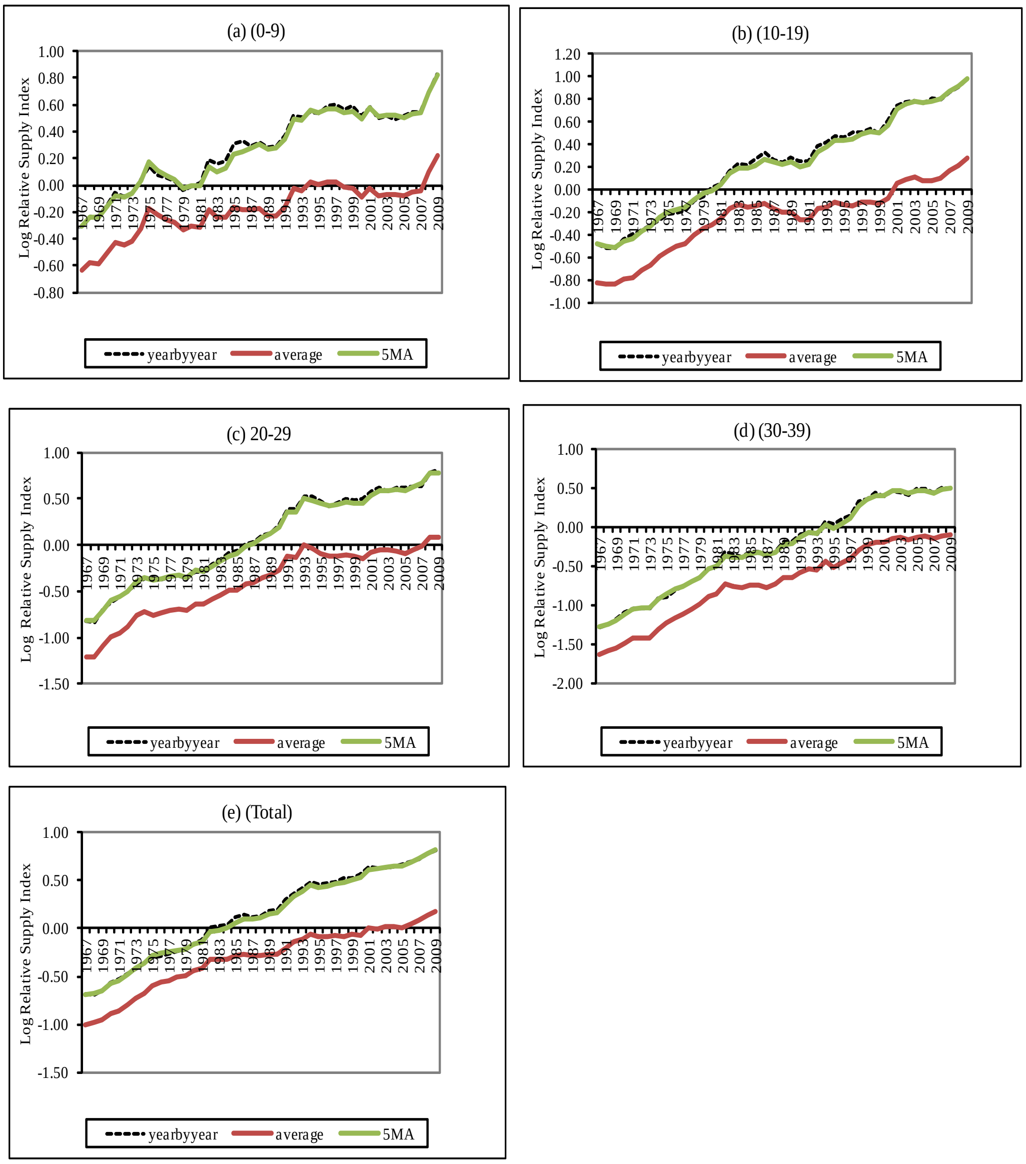
where $w_t^{J,[5]}$ is the five-year moving average for the relative real wages in category *J*. Formally, $w_t^{J,[5]} = \left(1/5\right)\sum_{k=t-4}^{t} w_k^J$. The first setting uses year-by-year relative wages, whereas the second setting uses five-year moving averages for the relative wages as the weights. The weighting procedure for the first four years is as follows: a weight for the first year takes its own value -1967-, a weight for the second year is calculated using two-year averages -1967 and 1968-, a weight for the third year is calculated using three-year averages -1967, 1968, and 1969-, and similarly a weight for the fourth year is calculated using four-year averages -1967, 1968, 1969, and 1970-. Therefore, we have no loss of observations. The difference between our setting and the calculations carried out in the literature is straightforward. The literature assumes that the "price" is fixed over the sample period and the variation comes only from the "quantity" side. This means that the calculations based on fixed weights, by construction, do not allow the total efficiency units of labor supply to increase- except through hours- if the demographic composition of the workforce does not shift. In our setting however, both "price" and "quantity" may vary. This captures quality adjustments in the time-series dimension.

Figure 4.2 and 4.3 compares our calculations based on the formula (4.2) and (4.3) against the findings in the literature based on the formula (4.1). The two figures display educational attainment trends measured by the relative supply of college equivalents by experience and age groups, respectively.

What Figure 4.2 and 4.3 together communicates can be summarized as follows:

1. The increase in the relative supply of college equivalents is underestimated in the literature for the whole sample. (For different age and experience groups).

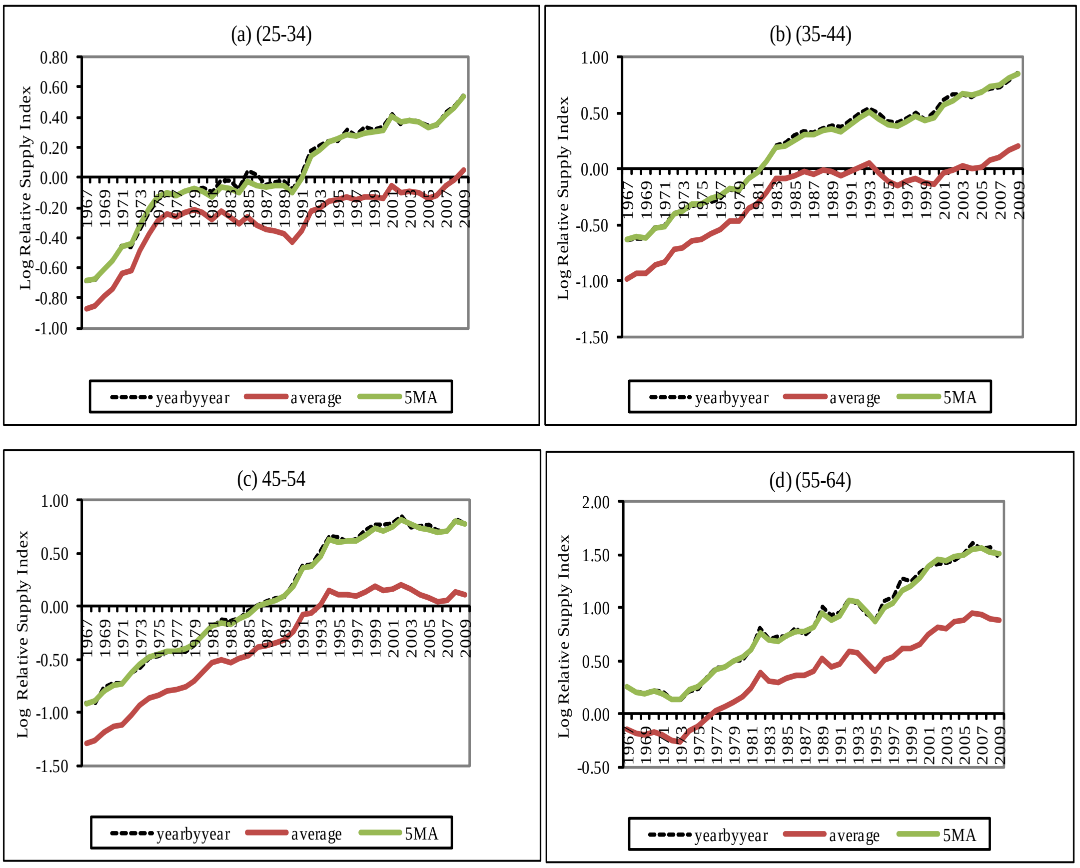
2. Contrary to the impression conveyed by the recent wage inequality literature [see, for example, Autor, Katz and Kearney (2008)], there is not an abrupt slowdown in the growth rate of the relative supply of college equivalents during the 1980s when we look at the whole sample.



Panels (a), (b), (c), and (d) plot the trends for experience groups 0-9, 10-19, 20-29, and 30-39, respectively. Panel (e) plots the aggregate trend. "5MA", "yearbyyear", and "average" mean that the relative supply index is calculated by using five-year moving averages, year-by-year wages, and average over all years, respectively. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 4.2 Educational Attainment Trends in the United States Measured by the Log Relative Supply of College Equivalents (Experience)

3. The Card and Lemieux (2001) result that the educational attainment displays a slowdown for the baby boomers still holds but to a significantly lesser extent. [See Figure (4.3)]



Panels (a), (b), (c), and (d) plot the trends for age groups 25-34, 35-44, 45-54, and 55-64,, respectively. "5MA", "yearbyyear", and "average" mean that the relative supply index is calculated by using five-year moving averages, year-by-year wages, and average over all years, respectively. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 4.3 Educational Attainment Trends in the United States Measured by the Log Relative Supply of College Equivalents (Age)

4. There appears a second slowdown wave for the experience group 0-9 and for the age group 25-34 starting around 1995 [see Panel (a) in both figures]. This second wave joined with the first wave-which is currently affecting the middle-age and

middle-experience group [see Panel (c) in both figures]-seems to start a slowdown in educational attainment measured in terms of the time-varying weights (see Panel (e) in Figure 4.2). But it is still early to make a judgement on this because of the increasing trends in other age and experience groups.

Now it is time to calculate the magnitude of this underestimation in the relative supply of college equivalents. Let $\ln\left(\frac{C_t^*}{H_t^*}\right)$ denote the relative supply measure that we calculate using five-year moving averages (time-varying weights) and $\ln\left(\frac{C_t}{H_t}\right)$ denote the traditional relative supply measure calculated using fixed weights. To calculate the magnitude of the underestimation, we employ the following formula:

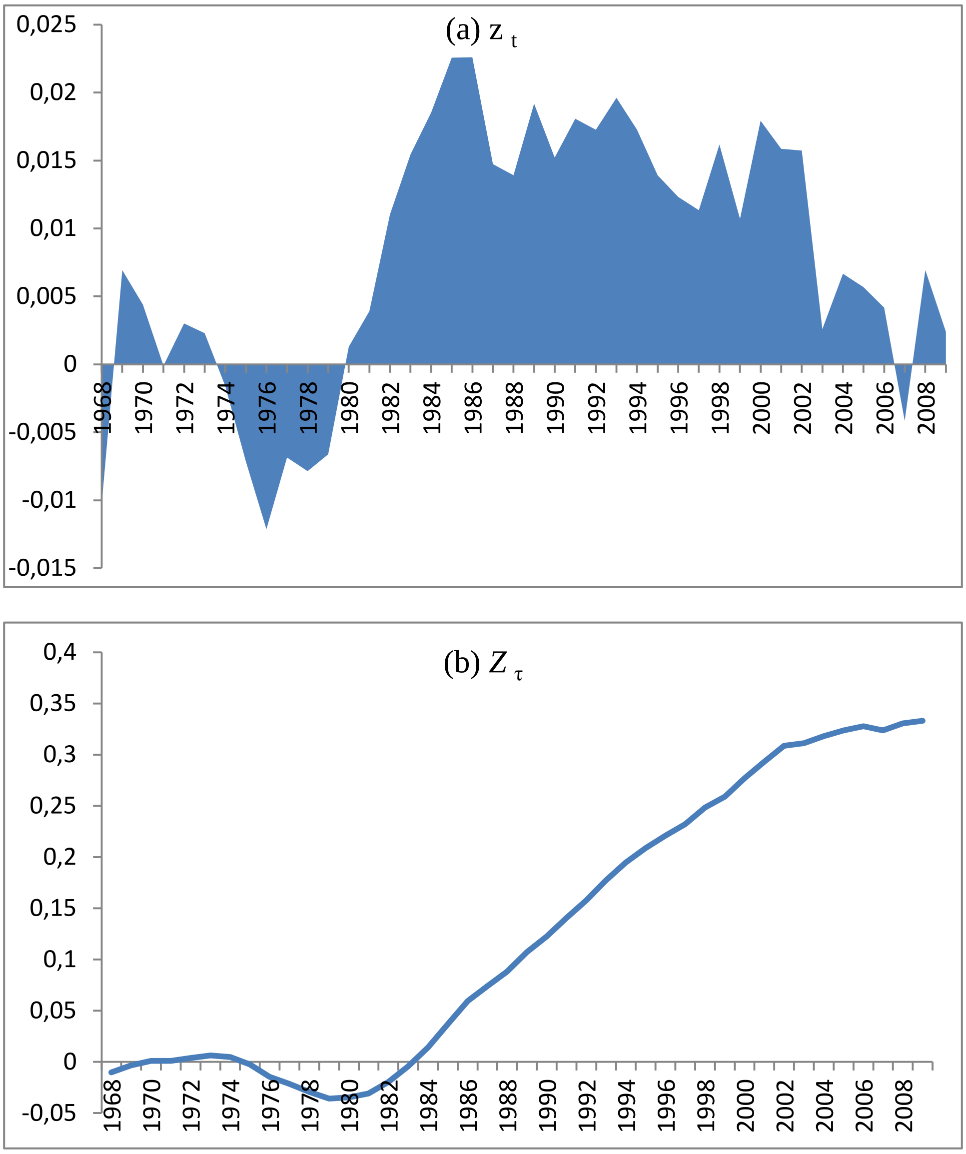
$$z_t = \left[\ln\left(\frac{C_t^*}{H_t^*}\right) - \ln\left(\frac{C_{t-1}^*}{H_{t-1}^*}\right)\right] - \left[\ln\left(\frac{C_t}{H_t}\right) - \ln\left(\frac{C_{t-1}}{H_{t-1}}\right)\right] \quad (4.4)$$

The magnitude of the cumulative underestimation, Z, can be calculated by summing z_t over the sample period. That is,

$$Z = \lim_{\tau \to T} Z_\tau \text{, where } Z_\tau = \sum_{t=1}^{\tau} z_t \quad (4.5)$$

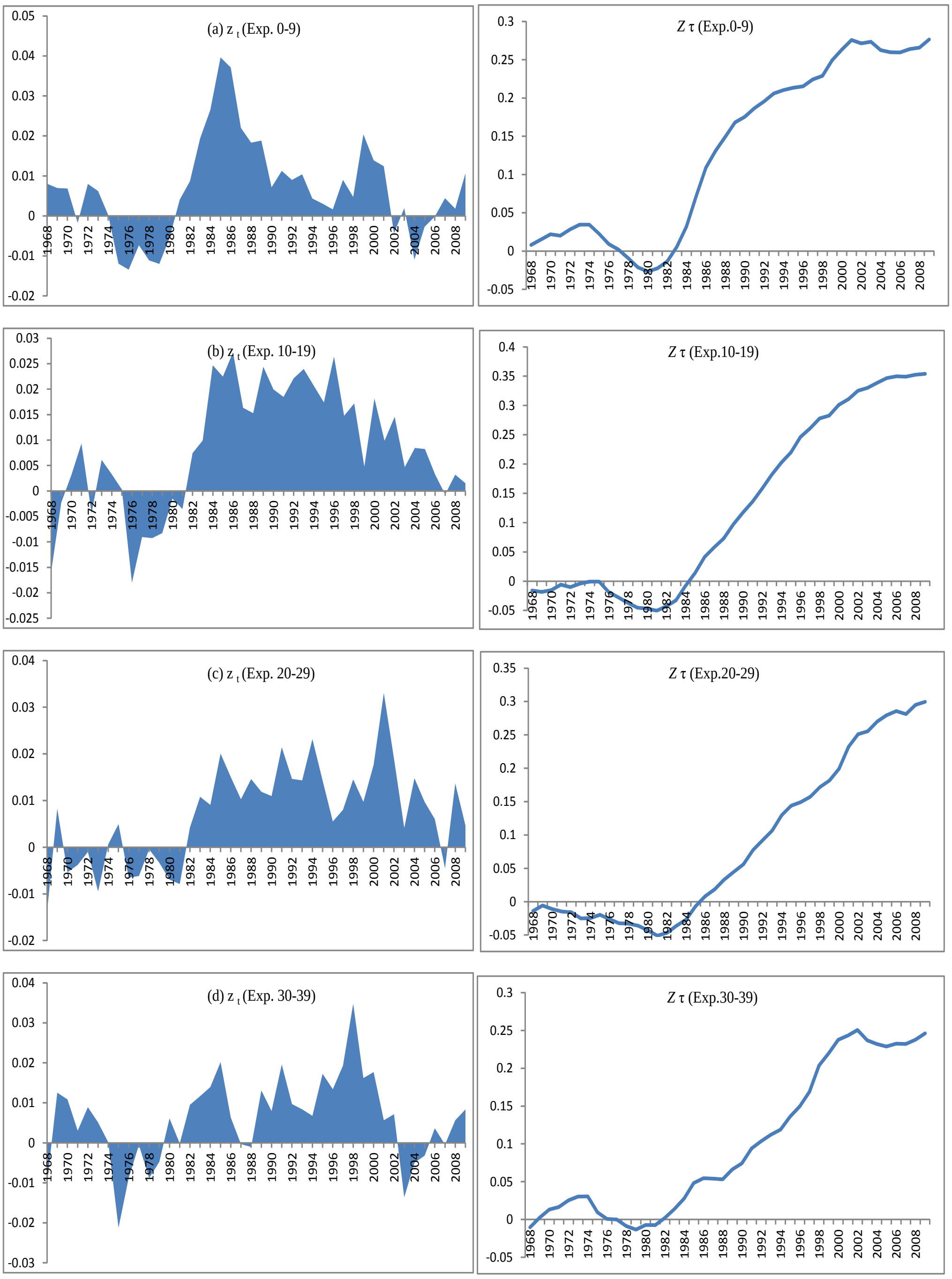
Figure (4.4) plots the evolution of z_t and Z_τ for the sample period. The left panel reveals that the difference between our measure and the measure used in the literature has opened up early in 1980s. Obviously, the difference has gotten smaller over time and it is even negative in 2007 (see the result 4 above for an explanation.) The right panel shows that, in total, the traditional measure underestimates the increase in the relative supply of college equivalents at a magnitude of 33%. These results provide *prima facie* evidence that the construction of the relative supply measure is sensitive to the specification of the efficiency units. Therefore, it is obvious from these results that the standard canonical demand supply framework in the literature utilizing relative supply measure calculated using fixed weight specification underestimates the increase in the relative supply of college equivalents by more than 30%, which may have serious implications on wage inequality.

Figure 4.5 plots the evolution of z_t and Z_τ for the sample period for each of four experience groups separately. Panels (a), (b), (c), and (d) plot the trends 0-9, 10-19, 20-29, and 30-39 years of experience groups, respectively. The left four panels reveal that the difference between our measure and the measure used in the literature is distinctive for each of four experience groups for the period 1980s to 2000s. The only exception here is the 30-39 years of experience group, in which the difference is insignificant around 1987. One can also notice that, after 1980s, the difference has never became negative for the 10-19 years of experience group, and only slightly negative for 20-29 years of experience group around 2006. The other important thing is that the distribution of the difference is similar and much more smoother in 10-19 and 20-29 experience groups. For the experience groups, 0-9 and 30-39, it has a more skewed pattern. The right four panels, on the other hand, show that the traditional measure underestimates the increase in the relative supply of college equivalents at a magnitude of 27%, 35%, 29%, and 24%, for 0-9, 10-19, 20-29, and 30-39 years of experience groups, respectively. The observed cumulative difference is higher in 10-19 and 20-29 years of experience groups. This fact is also consistent with the trends depicted in Figure 4.2 and 4.3 since these experience groups implicitly correspond to age groups 35-39 and 45-49. Figure (4.6) plots the evolution of z_t and Z_τ for each of four age groups. Panels (a), (b), (c), and (d) plot the trends for age groups 25-34, 35-44, 45-54, and 55-64, respectively. The bottom four panels display that the traditional measure underestimates the increase in the relative supply of college equivalents at a magnitude of 30%, 30%, 29%, and 23%, for 25-34, 35-44, 45-54, and 55-64 age groups, respectively. That pattern together with the trends in upper panels is almost the same as in our experience groups.



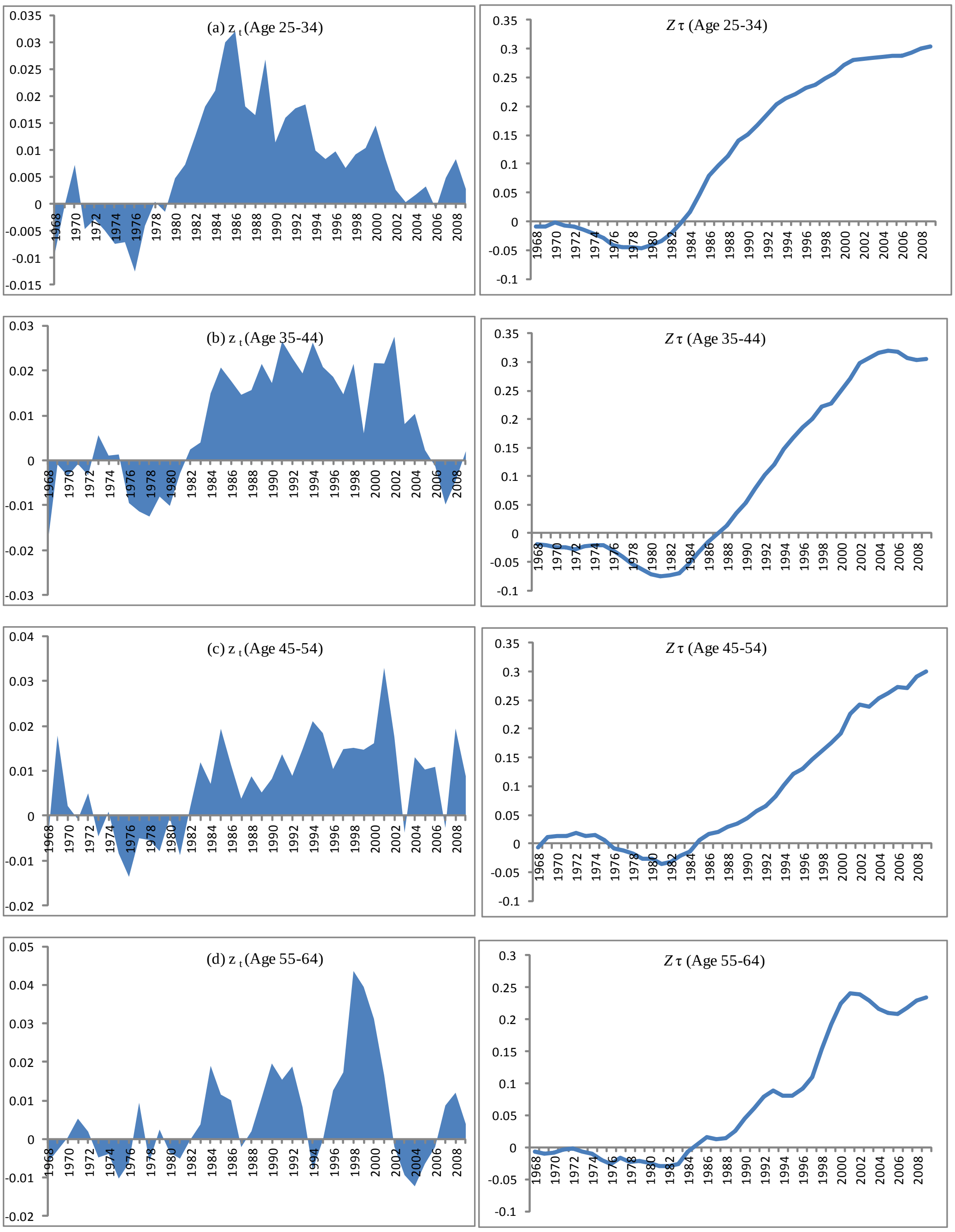
Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 4.4 The Difference Between Our Relative Supply Measure (with five-year moving averages) and Traditional Relative Supply Measure



Panels (a), (b), (c), and (d) plot the trends for experience groups 0-9, 10-19, 20-29, and 30-39, respectively. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 4.5 Cumulative Differences Between Two Supply Indexes by Potential Experience Group



Panels (a), (b), (c), and (d) plot the trends for experience groups 0-9, 10-19, 20-29, and 30-39, respectively. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 4.6 Cumulative Differences Between Two Supply Indexes by Potential Age Group

4.3 Estimates

Now it is time to investigate the implications of the underestimation of the increase in the relative supply of college equivalents on the empirical analysis of wage inequality. We use the standard empirical tools used in the literature to reevaluate the interaction between the college premium and the supply-demand conditions in the labor market. To pursue this goal, we estimate the standard skill-premium equation first using the traditional relative supply measure, then our version of the relative supply measure- the one that we calculate using five-year moving averages of wages- as the explanatory variable long with other standard variables.[54]

Recall the simple skill premium equation that we estimate is the following:

$$\ln\left(\frac{w_{C,t}}{w_{H,t}}\right) = \beta_0 + \beta_1 t + \beta_2\, ln(RMW_t) + \beta_3\, ln\left(\frac{C_t}{H_t}\right) + \varepsilon_t \qquad (4.6)$$

The key issue is the formulation of $ln\left(\frac{C_t}{H_t}\right)$. To make sure that we avoid a potential endogeneity problem-that the explanatory variable can be written as a linear combination of the dependent variable- we use (4.3) in our regression. Again, to kill the issue of endogeneity, we calculate the five-year moving averages at time t by taking the average from $t-1$ to $t-5$. That is, we use $w_{t-1}^{J,[5]} = \left({}^{1}/_{5}\right)\sum_{k=t-5}^{t-1} w_k^J$ as the weight at time t. Such a formulation gives us time-varying weights which are exogenous. Our estimates of the Equation (4.6) are reported in Table 4.1.

The first column reports the estimates using the relative supply specification (4.1) - relative supply specification uses “fixed weights”- for the 1967-2009 period. Consistent with the estimates reported in Card and Lemieux (2001) and Autor, Katz and Kearney (2008), our analysis yields an estimated elasticity of substitution of 2.26 (1/0.443) and an estimated trend growth in the wage gap of 1.9 % per annum.[55]

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[54] Using year-by year wages may impose a potential endogeneity problem which we avoid by using “lagged” five-year moving averages.

[55] The typical estimate for σ is around 2-2.5 for men and 1.5 for men and women in the literature.

The second column- which we estimate using the relative supply specification (4.3) representing relative supply identification using 5-year moving average "time-varying" weights - gives an estimated elasticity of substitution 1.97 (1/0.509) and an estimated trend growth in the wage gap of 2.6 % per annum.

Table 4.1 Regression Models for the College/High School Log Wage Gap, 1967-2009

	Dependent variable: Log College/High School Wage Gap			
	[1]	[2]	[3]	[4]
Constant	-0.083*	-0.028	0.153	0.319
	(0.046)	(0.082)	(0.141)	(0.206)
Time	0.019***	0.026***	0.018***	0.022***
	(0.001)	(0.005)	(0.002)	(0.005)
Log Relative Supply(old)	-0.443***		-0.417***	
	(0.054)		(0.055)	
Log Relative Supply(new)		-0.509**		-0.443**
		(0.128)		(0.129)
Log real minimum wage			-0.091*	-0.131*
			(0.052)	(0.072)
Observations	43	43	43	43
R-squared	0.94	0.87	0.94	0.88
Adj. R-squared	0.93	0.87	0.93	0.87

*Standard errors are reported in parentheses. Each column represents an OLS regression of the fixed-weighted and time-varying weighted college/high school wage differential on the indicated variables, respectively. Real minimum wage is deflated by the personal consumption expenditure deflator. ***, **, and * refer to 1%, 5%, and 10% significance levels, respectively.*

These results have very important implications. One is that the elasticity of substitution between high school and college equivalents, σ, is lower when the one uses time-varying weights in the calculation of relative supply measure. In other words, fixed weights overstate the substitutability of skilled and unskilled workers. This result is consistent with the argument we have made earlier that the fixed-weight specification fails to capture the quality improvements in the labor force over time. In other words, using efficiency labor supply units constructed using fixed weights in the analysis, as it has done in the literature, causes the underestimation of the increase in the relative supply of college equivalents which results in such a pattern we show above. This result is suggestive in the sense that the "quality" improvements should be taken into consideration in the analysis rather than "quantity" adjustments only as it is done in the literature. The other crucial result that we find is that how one constructs the relative supply measure determines the estimated slope of relative demand growth. Our calculations suggest a stronger secular growth trend in the relative demand for skills than what the literature reports. The relative demand growth is much stronger when time-varying weights are used as it can be clearly seen from the table. Surprisingly, a trend growth with a magnitude of 2.6 % is perfectly consistent with the estimates reported by Katz and Murphy (1992), which was for the 1963-1987 period.

Our analysis suggest that when one restructures the relative supply measure using increasing weights, the CES human capital model yields significantly higher SBTC estimates. The stronger time trend associated with the relative supply specification using time-varying weights indicates the fact that a larger relative demand push via the so called SBTC is required to justify the widening wage structure in the U.S. That is, increased wage gap is justified by a higher relative demand growth when one uses increasing weights rather than fixed weights. More precisely, the growth rate of relative demand for skills that our calculations suggest is 0.07% (0.04% when real minimum wages are incorporated) greater than the calculations reported using fixed weights. This is a contradiction as we have pointed out before. The literature has recently reached a consensus that there is a puzzling deceleration in relative demand growth for college equivalents in the U.S starting in the early 1990s.[56] Such a slowdown does not appear in our calculations, as it is obvious from the table, since we take into account quality adjustments, a significant bulk of which have taken place after 1990s. These results show that the role that the standard set of tools attributes to SBTC is understated in the literature. This is not a statement that the extent of SBTC should actually be greater than what the literature suggests. What we point out is a serious confusion. Autor, Katz and Kearney (2008) conclude

[56] See, for example, Katz and Murphy (1992), Autor, Katz, and Krueger (1998) and Autor, Katz and Kearney (2008).

that the effect of SBTC on wage inequality is perhaps not as strong as Katz and Murphy (1992) estimates suggest. We show that the Katz and Murphy (1992) estimates, which are based on data for 1963 to 1987 period, still holds when one takes into account the quality improvements in the labor force. Maybe it is true that relative hours of work weighted by fixed efficiency wages display a slowdown after 1980s. However, the improvements in the quality of labor force compensate for this slowdown and, as a result, the Katz and Murphy (1992) SBTC trend is still relevant when increasing weights are used.

The role of minimum wages is examined in the third and the fourth columns. Natural logarithm of the real minimum wage has additionally explanatory power as suggested by Card and Dinardo(2002) and Autor, Katz and Kearney (2008). But the inclusion of this variable does not alter our main conclusion that the literature underestimates the relative demand growth. As the estimates suggest, in this case, the magnitude of this underestimation is 0.04 % per annum. Thus, our conclusion is robust to the inclusion of non-market (i.e., institutional) factors.

Going back to the Carneiro and Lee (2011) study and comparing their insight with the results presented above, we plot Figure 4.7 to simply diagnose the problem. The problem is the definition of the quality, altering which totally flips the predictions. As in Carneiro and Lee (2011), if one sets education quality as the definition of quality, then the weights are decreasing (the blue line) which seriously downgrades the SBTC hypothesis. If, on the other hand, one adopts the relative productivity of college graduates versus high-school graduates as the definition of quality, then the weights are increasing (the red line) which implies that SBTC still remains in existence with no change in its role.

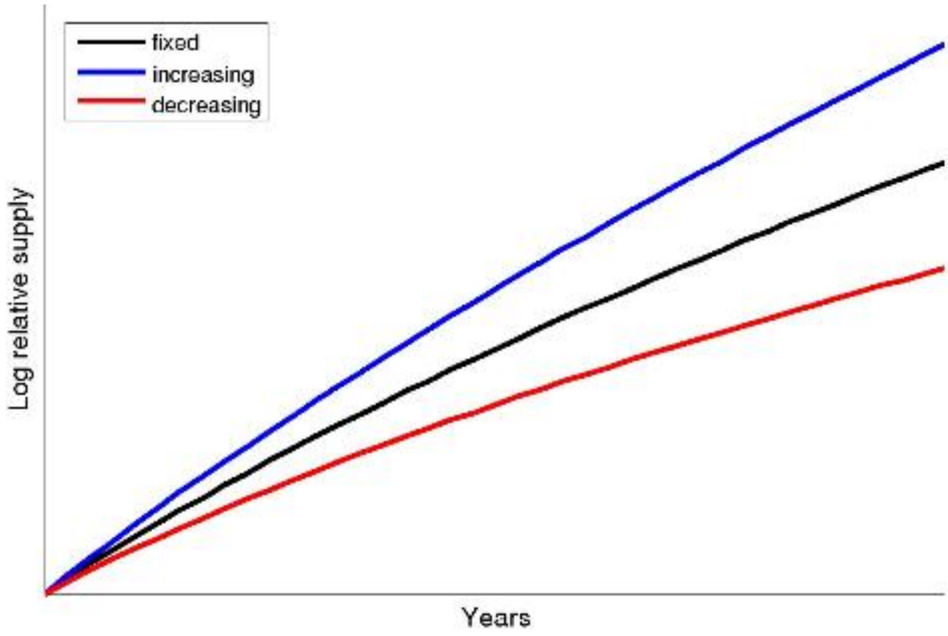


Figure 4.7 Sketch of the Trends in Relative Supply of College Graduates Under Alternative Weighting Assumptions

We earlier mention that changes in the college/high school wage premium differ across age/experience groups. This pattern can clearly be seen in Figure 4.8. Panel A in the Figure 4.8 gives the evolution of the college/high school wage gap while Panel B and C gives the college/high school relative supply by using fixed-weights and time-varying weights, respectively for younger workers (those with 0-9 years of potential labor market experience) and older workers (those with 20-29 years of potential labor market experience). The college/high school wage gap has increased to a large extent for younger workers (those having less experience) since 1980s than it did for older workers (those having more experience) as shown in Panel A. Consistently, both Panel B (fixed-weighted) and C (varying-weighted), regardless of the measurement of efficiency labor supply units, depicts that the college/high school relative supply has showed a much more slowdown for younger workers than older ones in the mid to late 1970s and stagnated throughout the 1980s and 1990s. This point that the workers who have similar educational attainment but different ages or experience are imperfect substitutes and therefore relative supply shifts across age-groups (cohort-specific relative skill supplies) is expected to affect the changes in the college/high school wage premium by age/experience is also emphasized by Card and Lemieux (2001).

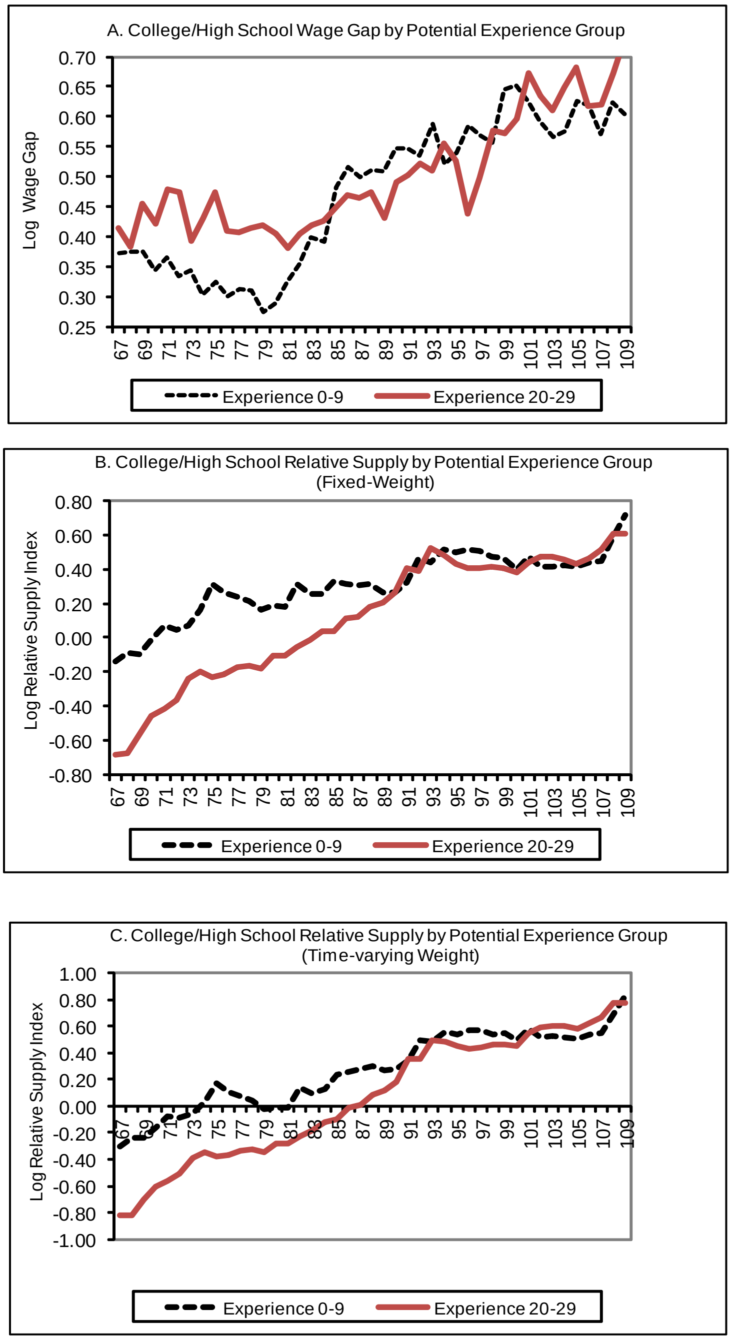
We now examine these changing trends across cohort-specific relative supplies by estimating regression models for the college/high school wage premium by experience group. For this purpose we extend the simple specification in Equation (4.8) to contain own experience group-specific relative skill supplies.

Recall that we estimate the extended skill premium equation:

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right) = \beta_0 + \beta_1\left[ln\left(\frac{C_{i,t}}{H_{i,t}}\right) - ln\left(\frac{C_t}{H_t}\right)\right] + \beta_2\, ln\left(\frac{C_t}{H_t}\right) + \beta_3 D_t + \delta_i + \varepsilon_{i,t} \quad (4.7)$$

Remember that we interpret the role that different elasticity of substitution parameters plays in the pricing equations we formulate above and discuss how introducing imperfect substitution between similarly educated workers in different experience/age groups changes the conclusions of the standard demand and supply models in the literature assuming perfect substitutability among workers when we argue the theoretical framework in detail in Chapter 2.

The results are given in Table 4.2. The estimates in the first two columns show the effects of both aggregate and group-specific relative supplies on the changes in the college/high school wage premium in which relative supply indexes are calculated using fixed weights. The resulted estimates of the aggregate elasticity of substitution in Table 4.2 are bigger than our estimates from the aggregate models reported in Table 4.1. Remember our specification in Table 4.1 which does not assume imperfect substitutability across age/experience groups in the construction of the relative supply index yields an estimated aggregate elasticity of substitution of 2.26 (1/0.443). On the other hand, Table 4.2 in which we calculate the relative supply index that assumes imperfect substitution across experience groups, reports the estimated aggregate elasticity of substitution as 3.17 (1/0.315). (Card and Lemieux (2001) reports an estimate of aggregate elasticity of substitution equal to 2.07 and 3.05 in two different specifications both of which assume the imperfect substitution while the latter includes a dummy variable for 1980.



The college/high school log relative supply index is the natural logarithm of the ratio of college equivalent to high school equivalent labor ssupply unitsin each year. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 4.8 Log Relative College/High School Wage and Supply by Potential Experience Groups

Autor, Katz and Kearney (2008) reports similar estimates of aggregate elasticity of equal to 1.66 in different specifications, one assumes perfect and the other assumes imperfect substitutability). The second thing with the first two columns is that the resulted estimate of the partial elasticity of substitution across experience groups is around 3.33. (This result is similar to Autor, Katz and Kearney (2008) estimate which is around 3.55 but rather lower than the estimates in Card and Lemieux (2001) which is around 4.80). These resulted own-group relative substitution estimates in the first two columns explain the effect of the slower relative college supply growth in the less experienced group on larger wage increases in this group relative to the group with more experience in Figure 4.8.

The third and fourth columns in Table 4.2 show the effects of both aggregate and group-specific relative supplies on the changes in the college/high school wage premium in which relative supply indexes are calculated using time-varying weights. The resulted estimate of the aggregate elasticity of substitution is equal to 4.13 (1/0.242) where we find the corresponding estimate in our specification which assumes perfect substitutability across age/experience groups as 1.97 (1/0.509). Remember that in Table 4.1 we find that the aggregate elasticity of substitution were lower when the one uses time-varying weights in the calculation of relative supply measure. However, it becomes higher now in the specification which assumes imperfect substitution across experience groups (it increases from 1/0.315=3.17 to 1/ 0.242=4.13). This is also true for the own-group elasticity between experience groups. It is now higher for specification using time-varying weights (it increases from 1/0.300=3.33 to 1/0.266=3.75).

Overall, as the first four columns display, the specification which uses relative supply indexes calculated using time-varying weights yields higher estimates for both the aggregate and group-specific elasticity of substitution in all experience group regressions. This result is not coherent with our results in Table 4.1.

Table 4.2 Regression Models for the College/High School Log Wage Gap by Potential Experience Group, 1967-2009

						Potential Experience Groups						
	All Experience Groups					**0-9 yrs**		**10-19 yrs**		**20-29 yrs**		**30-39 yrs**
Own supply minus aggregate supply	-0.300***	-0.296***	-0.266***	-0.262***		0.188	0.266*	-0.317***	-0.499***	0.201**	0.405***	-0.075
	(0.035)	(0.033)	(0.042)	(0.041)		(0.111)	(0.125)	(0.072)	(0.113)	(0.073)	(0.083)	(0.093)
Aggregate supply (old)	-0.315***	-0.353***				-0.169*		-0.568***		-0.377***		-0.017
	(0.042)	(0.042)				(0.070)		(0.057)		(0.058)		(0.084)
Aggregate supply (new)			-0.242***	-0.296***			-0.182		-0.720***		-0.423***	
			(0.064)	(0.066)			(0.109)		(0.122)		(0.084)	
Log real minimum wage		-0.134***		-0.118**		-0.296***	-0.289***	-0.101	-0.084	0.001	0.010	-0.154**
		(0.037)		(0.043)		(0.066)	(0.070)	(0.051)	(0.072)	(0.051)	(0.057)	(0.053)
Time	0.0139***	0.0143***	0.0130***	0.0142***		0.0126***	0.0144**	0.0213***	0.0297***	0.0128***	0.0162***	0.002
	(0.001)	(0.001)	(0.002)	(0.002)		(0.002)	(0.004)	(0.002)	(0.004)	(0.002)	(0.003)	(0.003)
Constant	0.243***	0.475***	0.245***	0.429***		0.673***	0.595***	0.256*	0.044	0.257**	0.176	0.689***
	(0.025)	(0.069)	(0.046)	(0.082)		(0.118)	(0.132)	(0.095)	(0.138)	(0.090)	(0.106)	(0.154)
Observations	172	172	172	172		43	43	43	43	43	43	43
R-squared	0.80	0.81	0.74	0.74		0.91	0.91	0.94	0.94	0.85	0.82	0.69

*Standard errors are reported in parentheses. Each column represents an OLS regression of the fixed-weighted and time-varying weighted college/high school wage differential on the indicated variables, respectively. Real minimum wage is deflated by the personal consumption expenditure deflator. The first two columns also include dummy variables for the four potential experience group used in the table. ***, **, and * refer to 1%, 5%, and 10% significance levels, respectively.*

However, the resultant estimates of both aggregate and partial elasticity of substitution in regression models separately estimated by the potential experience groups give us the same results with Table 4.1. The college wage premium for those with 10-19 and 20-29 years of experience seems more sensitive to aggregate relative skill supplies than that for those with more experience. The real minimum wage has the explanatory power in explaining the wage gap for those with 0-9 years of experience. The own-group relative skill supplies appear to be effective in 10-19 years of experience group in explaining the wage premium. The aggregate elasticity of substitution is lower in the specification using time-varying weights than those in the specification using fixed weights in all separate regressions. Therefore our argument that fixed weight specification overstates the substitutability of skilled and unskilled workers is still valid as these estimates in separate models show. The effect is stronger again for those 10-19 and 20-29 years of experience. The results indicate that the effect of the increase in the relative supply of college equivalents in explaining the wage gap across experience groups is underestimated by fixed-weight models used in the literature.

In fact, the results presented in Table 4.2 point out another problem with using relative supply measures constructed under the fixed-weight assumption in the standard education premium equation. That is it produces mixed signals when one incorporates experience groups into the regression equation. We focus on the particular case that experience groups are imperfect substitutes. The results presented in Table 4.1 assume the extreme case: they are perfectly substitutable. As we document in detail, such a model yields the result that SBTC is stronger with increasing weights, while it is weaker with decreasing weights.

When we incorporate imperfectly substitutable experience groups into the regression equation [like AKK (2008)] we observe two rather surprising results. First, with increasing weights, experience groups become better substitutes, which swamps the rise in productivity differences and produce the result that SBTC is weaker. Second, with decreasing weights, experience groups become worse substitutes, which works in favor of a stronger SBTC and produces the result that SBTC is stronger.

Clearly, these two results are strikingly divergent, which makes the fixed-weight assumption even more questionable. The intuition is as follows: when weights are increasing, the difference that the experienced workers make in the production process is offset by the relatively more productive young workers, who are more educated and equipped than the older ones. As a result, experience groups become better substitutes. This, in turn, makes the college and high school equivalents more substitutable since older and less educated workers are now more substitutable with younger and more educated ones. The reverse is true with decreasing weights.

4.4 Concluding Remarks

In this chapter, we propose a theoretical framework, with an empirical counterpart, to address the problems stemming from the mechanical treatment of “quality" (or prices) in the canonical education premium equation. This model endogenizes the quality measure for two purposes: to account for the changes in the price of the relative supply of college equivalents and to provide a reanalysis of the earnings inequality trends in the U.S.

The patterns that we provide in this chapter suggest that the estimates produced by the canonical college-premium framework are nonnegligibly sensitive to the assumptions on the relative supply index, the key object in the analysis of the college premium. In particular, we argue that this framework does not offer a systematic way to account for the time-series evolution of the efficiency units of labor supply. This fragility is a source of empirical non-robustness and has important implications for the analysis of wage inequality. We show how the main predictions of the standard model change upon relaxing the assumptions on the relative supply index.

We provide evidence that constructing the relative supply measure is subject to problems related to “efficiency units” which may have serious implications on wage inequality. We argue that at least as equally sensible relative supply measure as the ones used in the literature produce significantly different results. We show that using fixed weights rather than increasing weights underestimates the rise in wage inequality. We first provide evidence that the growth in the relative supply of college equivalents calculated using increasing weights is substantially higher than what the literature reports using fixed weights. We find that the literature may be underestimating the increase in the relative supply of college equivalents by more than 30%. In addition to that, we demonstrate that how one constructs the relative supply measure determines the estimated slope of relative demand growth. We find that, when one uses time-varying weights rather than fixed-weights, the CES model produces inconsistencies in justifying the changing wage gap with a changing trend growth. Our calculations suggest a stronger secular growth trend in the relative demand for skills than what the literature reports. If fixed weights are used in the analysis, as did the literature, then quality adjustments in the labor force are ignored and the role of the standard set of tools attributes to skill-biased technological change (SBTC) is understated. We provide evidence that when one restructures the relative supply measure using increasing weights, the CES human capital model yields significantly higher SBTC estimates. That is, increased wage gap is justified by a higher relative demand growth via so called SBTC, when one uses increasing weights rather than fixed weights. The result is intuitive. Labor markets favor skilled versus unskilled workers at an increasing rate. This is due to increased quality of skilled workers over time and greater complementarity between high technology and skilled workers. This is a contradiction, because the literature has recently reached a consensus that there is a puzzling deceleration in relative demand growth for college equivalents in the U.S. Such a slowdown does not appear in our calculations. We argue that the improvements in the quality of labor force compensate for this slowdown and, as a result, the SBTC trend still remains in existence with no change in its role when one adopts the relative productivity of college graduates versus high school graduates as the definition of quality, as we perform in this study, -when increasing weights are used in other words-. On the other hand, when the weights are decreasing the flip side of this story holds as in

Carneiro and Lee (2011) which suggest that the slowdown may be worse than that predicted by the fixed-weight model.

Our results provide evidence that the standard models used in the existing wage inequality literature neglect a number of substantive and important economic developments such as systematic changes in the quality of the work force that have taken place in the U.S. over the last four decades. Therefore, studies explaining widening wage structure based on rapid secular growth in the relative demand for skills attributable to skill-biased technological change and fluctuations in relative skill supplies based on canonical supply-demand models using fixed weights should be reassessed to include the implications of these productivity adjustments in the labor force. Our results are suggestive in the sense that a full analysis of wage inequality requires a detailed examination of these quality adjustments in the labor force rather than quantity adjustments only. We argue that recent changes in the U.S. wage inequality should be analyzed within the framework of more comprehensive models that is corrected for the important measurement issues in the operation of the existing modeling. There is more to be understood about the interactions between supply-demand conditions in the labor market and other nonmarket factors- i.e., the factors affecting labor quality and how they evolve over time. A more general human capital model is needed to understand these broader interactions and their implications on wage inequality. Dealing with these problems manually, as we did here, provides valuable insights but it is still an incomplete strategy to fully resolve the issues. In what follows, we sketch out a strategy using which we plan to deal with the problems we summarize above. We conjecture that an endogenously determined quality variable can resolve the problems we point out.

CHAPTER 5

A SELECTION CORRECTION APPROACH

So far we have demonstrated that the empirical findings documented in the wage inequality literature are nonnegligibly sensitive to the construction of the relative supply measure. We provide evidence that constructing the relative supply measure is subject to problems related to efficiency units and show that at least as equally sensible relative supply measure as the ones used in the literature produce significantly different results.

The existing framework using fixed weight specification has some defects and therefore needs some adjustments to account for unobserved compositional changes due to selection in and out of the FTFY status. We believe that recent changes in the U.S. wage inequality should be analyzed within the framework of a more comprehensive model that is corrected for the important measurement issues in the operation of the existing modeling. Our main purpose in this chapter is to develop a method to revise the relative supply measure in such a way that it controls for these changes within education categories. For this purpose, we use the standard latent variable selection-correction methods. At the first step, we calculate a selection-corrected relative supply series in order to investigate if a significant selection bias exists or not. At the second step, we use the selection bias term to investigate the sources of this bias. These two steps provide us endogenous efficiency units. We then argue what triggers these changes in the selectivity patterns. After, we reanalyze the trends in U.S. wage inequality using the selectivity-corrected relative supply series. Finally, we provide several interpretations to our selection-corrected estimates.

This chapter proceeds as follows. Section 5.1 explains the main idea behind our selectivity argument. It discusses our motivation to develop a method that corrects for the unobserved compositional shifts. In section 5.2, we confirm the conjecture expressed in Section 5.1 empirically and present the estimates of the college premium equation derived using the selectivity-corrected relative supply series. Section 5.3 and 5.4 provides an in depth discussion of the potential effects of real minimum wages and several policy implications. Section 5.5 discusses the results.

5.1 Selectivity Argument

The standard college premium framework capturing the basic “efficiency units” idea successfully captures the effect of the observed changes in the educational composition of the working population. However, it has two deficiencies as we point out earlier. First, it focuses on the FTFY workforce and second, the efficiency units of labor supply is fixed over time. The former misses the systematic selection in and out of the FTFY status of low-skill workers. The latter, on the other hand, misses the relative changes in the efficiency units of skilled versus unskilled labor hours. We believe that both of these missing parts have economic content and, therefore, should be paid exclusive attention.

Our starting point is the observation that the ones who potentially self-select into the FTFY status have been sampled by most studies in the U.S. wage inequality literature. The main motivation why we perform the selection-correction exercise was given in Figure 3.5. We observe a lot of variation in the FTFY fraction among low-skill workers, whereas the FTFY fraction among the high-skill workers is quite stable. In particular, among better-educated employed workers, the fraction of full-time full-year workers is quite high and stable -around 90 percent -over time in the U.S. Among those with low education levels, however, this fraction is much lower and considerably more volatile, moving within the range of 62-82 percent for high school dropouts and 75-88 percent for high school graduates. These observations suggest that the composition of unobserved skills is subject to sharp movements within low-educated employed workers, while the scale of these movements is potentially much smaller within high-educated ones. In other words, there are systematic differences between the FTFY choices of the low-skill and high-skill workers. This variability is potentially due to discrepancies in the labor supply decisions among different skill groups.

These divergent patterns between low- and high-skill workers in terms of the labor supply patterns on the FTFY margin raise concerns that the existing estimates may be missing some systematic components of the relative supply series that are relevant for wage inequality analysis since the standard college premium framework accounts for the observed shifts between education categories, but it cannot account for unobserved compositional changes within education categories.

Remember that the standard literature calculates the "efficiency units" of labor supply by using the fixed weight, $\overline{w}^J$, given in Equation (5.3). Again, remember that this fixed weight is incorporated to capture the fact that higher educated workers supply larger efficiency labor units per unit of time than the lower educated workers do. That is, it captures the standard idea that the labor units supplied by skilled workers per unit of time is larger than the labor units supplied by unskilled workers per unit of time. Although, the fixed efficiency units idea is a good first approximation, it misses how the relative labor supply contributions of each education category evolve over time as it cannot capture the fluctuations in the share of the FTFY status within education categories over time, which suggests that there may be unobserved compositional shifts.

Accounting for these unobserved compositional changes, we believe, will alter the estimated trends in the relative supply of college equivalent workers. Therefore, we develop a simple empirical framework that can be used to correct for these unobserved compositional shifts. We use Heckman's two-step estimator to calculate a selectivity-corrected relative supply series that controls for these unobserved compositional changes due to selection in and out of the FTFY status. We achieve this as follows:

Remember the term

$$\Lambda = {\sigma^*}/{\sigma_\eta}\, \lambda \left(-{z'\gamma}/{\sigma_\eta}\right) \qquad (5.1)$$

is the component of the FTFY wages due to the correlation between the unobserved determinants of choices and outcomes. We let this term represent the evolution of the unobserved compositional factors driven by self-selection in and out of the FTFY status.

Let $\widehat{\Lambda}_i$ denote the predicted inverse Mills ratio multiplied by its estimated coefficient. To calculate these predicted values, we run separate year-by-year regressions for each of the six education categories that we utilize and, at the end, we obtain a predicted value $\widehat{\Lambda}^J_{i,t}$ for each worker *i* in the education category *J* at each year *t*.

We use these predicted inverse Mills ratios to capture the unobserved compositional shifts within education categories, which, in turn, endogenizes the efficiency units. In other words, we use them to adjust the fixed efficiency weights in such a way that we obtain time varying weights that can account for the effect of unobserved compositional shifts on efficiency units. To achieve this goal, we employ the following formula:

$$\overline{w}^J_t = \overline{w}^J + \left({\int_{I_J} \widehat{\Lambda}^J_{i,t}\, dF_{J,t}\,(i)} \Big/ {\int_{I_{HSG}} \widehat{\Lambda}^{HSG}_{i,t}\, dF_{HSG,t}\,(i)} \right) . \qquad (5.2)$$

Notice that the “fixed weight” formulated as:

$$\overline{w}^J = 1/_T \sum_{t=1}^{T} \left(\int_{I_J} \ln w_{i,t}^J \, \mathrm{dF_{J,t}}\,(i) \Big/ \int_{I_{HSG}} \ln w_{i,t}^{HSG} \, \mathrm{dF_{HSG,t}}\,(i) \right) \tag{5.3}$$

in the standard framework is now replaced by the "selectivity-corrected time varying weights" formulated in the above equation (5.2).

The fixed weight, $\overline{w}^J$, is just a mean relative wage estimated by the OLS. We just mechanically incorporate the mean relative inverse Mills ratio's to capture what is going on selection-wise. In other words, we obtain time variation in efficiency units due to selectivity through an explicit self-selection framework that allows for unobserved compositional changes within education categories. That is represented by time varying weights, $\overline{w}_t^J$.

Then we use these time varying efficiency weights to calculate the relative supply measure. The next section provides a detailed presentation of our estimates along with a careful comparison of the results with and without selection-corrected relative supply series.

5.2 Estimates

We first compare the estimated relative supply series with and without selectivity. The version with no selection-correction is identical to the estimates provided by Autor, Katz, and Kearney (2008). The selection-corrected version controls for self-selection in and out of the FTFY status. To calculate the selection-corrected series, we run the algorithm described above: basically, we run year-by-year regressions for each of the education category. Then we use the predicted inverse Mills ratios to adjust the efficiency units in a way to correct for selectivity.

Figure 5.1 compares the relative supply series with and without selection-correction for the whole sample. The dashed line plots the corrected series, while the solid line plots the uncorrected series. Clearly, the corrected series is steeper than the uncorrected series before 1982. After 1982, however, it is flatter. We start our discussion with the uncorrected series. The relative supply of college equivalent workers has risen steadily after the World War II, until early 1980s. This means that each cohort of workers entering the labor market has boasted a proportionately higher relative rate of college education than the preceding cohort. Three factors are

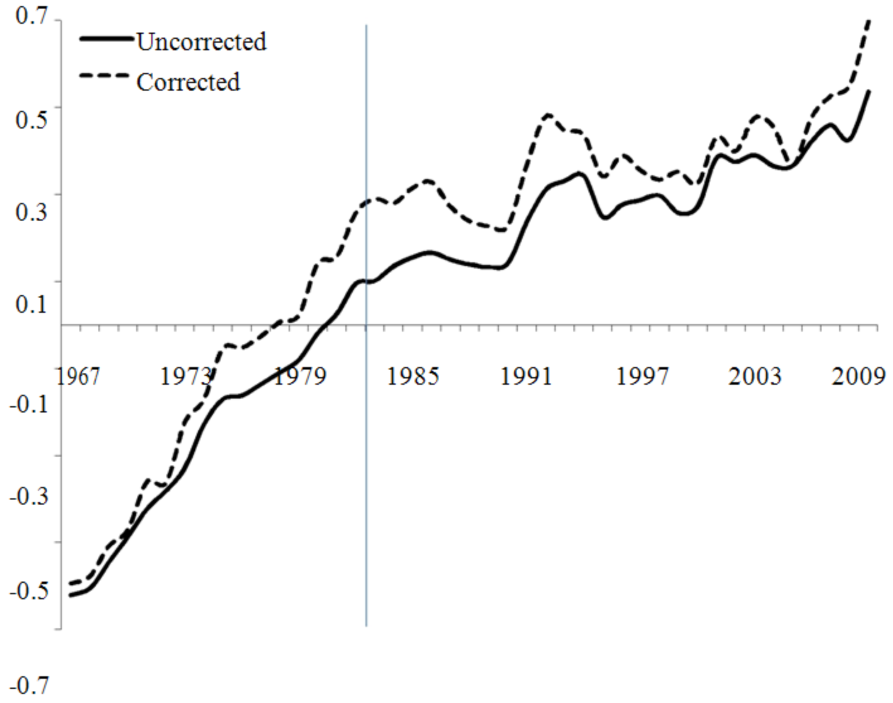


Figure plots the aggregate trend. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 5.1 Uncorrected Versus Corrected Relative Supply Series

documented to contribute the deceleration in the growth rate of the relative supply index.[57] First, the Vietnam War inflated college education, because it induced males to defer military service by college enrollment [Card and Lemieux (2001)]. Second, the overinvestment in college education in 1970s drived the net social return to college enrollment after high school to negative levels, which eventually induced a deceleration in the growth rate of college education [Freeman (1976)]. Finally, the

[57] See Acemoglu and Autor (2011) for details.

baby boom (entering) cohorts were larger and more educated than the exiting cohorts and this led to an increase in the stock college-educated workers, while the smaller cohorts of post-baby-boomers have only had a small impact on the stock of education in the society [Ellwood (2002)].

This deceleration in the uncorrected series is argued to point out to a puzzle. In terms of the mechanisms that the canonical college-premium equation features, the deceleration in the relative supply series brings together a puzzling deceleration in the relative demand for skilled workers. This is a consequence of the slowing of the growth of overall wage inequality. But, given the fact that computerized technologies have been invested heavily during the 1990, the slowing of the SBTC trend posed a puzzle in the literature. The consensus in this literature is that the canonical supply-demand framework motivating the college-premium framework falls short of explaining the trends after early 1990s. A strand of the literature, called the “revisionists”, highlighted the importance of several institutional factors in explaining this puzzle. The real minimum wage is often pronounced as a key factor driving these results. However, Autor, Katz, and Kearney (2008) argues that fluctuations in the real minimum wage cannot fully explain these trends since it cannot account for what happens to the 90/50 gap, which is an important component of the overall wage inequality.

The corrected series tell a somewhat different story. We still observe a decline in the growth rate of the relative supply of skills after 1982. But the growth rate until 1982 is sharper and the deceleration after 1982 is more pronounced. This is because of the selection-correction procedure we follow. The motivation is provided in Figure 3.5, which plots the fraction of the FTFY workers among all employed workers by each education category. The data reveal that the fraction of the FTFY status is quite stable around 90 percent among the high-educated employed workers. In other words, better-educated workers tend to work full-time full-year and this tendency does not vary a lot over time.

For lower-educated workers, however, the fraction of FTFY exhibits a time-varying pattern. In particular, we observe that the fraction of FTFY status declines until 1982 and it picks up thereafter. To interpret these trends, it is instructive to think of distributions of unobserved ability (or productivity) for each education category. FTFY status is a choice and a change in the fraction of the FTFY status can be related systematic changes in the distribution of unobserved skills over time. To understand the structure of selectivity, suppose that the demand for part-time and/or part-year jobs is constant over time. When the demand for college education high, there is will be an increased transition from high-school to college education among those who prefer to work FTFY. These are the more able guys and they are the ones who are more likely to succeed in college. As a result, as the FTFY fraction goes down among the low-educated, the mean unobserved ability also goes down.

This explanation suggests that the uncorrected series underestimate the growth rate of the relative supply series before 1982. The reason is that the skill gap should be higher in this period after correcting for selectivity. The opposite logic should hold after 1982; that is, a rise in the FTFY status among low-educated workers suggests that the more able ones among FTFY status choose to stay low educated (due to decreased demand for college education). As a result, the deceleration in the relative supply series is even more pronounced after correcting for self-selection due to choices in and out of the FTFY status.

Trends shown in Figure 5.2 also confirm the argument that selectivity operates through the low-educated employed workers. As the figure clearly shows, the difference between uncorrected and corrected series are much more distinct for low-educated groups. Therefore, trends for low-educated groups, namely HSD, HSG, and SC1 accounts for the aggregate trend in new series -steeper before mid-1980s and flatter afterwards- in Figure 5.1. [58]

[58] Notice that these series are not reported in logs units and they do not represent relative supply series. They are actual supply units with and without selectivity. That is the reason why uncorrected series are well above the corrected series. When one takes the natural logarithms of each series, it will look like just as Figure 5.1.

Panels (a), (b), (c), (d),(e, and (f) plot the trends both in uncorrected and corrected relative supply series for education categories HSD, HSG, SC1, SC2, COL, and COL+, respectively. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 5.2 Uncorrected Versus Corrected Actual Supply of Hours by Education Categories

Trends here reinforce the idea that self-selection patterns of the low-educated workers into the FTFY status are responsible for the aggregate new trends in the relative supply of skills. In other words, the fact that low-educated workers especially high-school dropouts are over-represented in the FTFY workforce before the 1990s and they are under-represented afterwards causes the rate of growth in the relative supply of college equivalents be even sharper before 1990s and even slower afterwards.

We find that selectivity is significant and that, under selection-correction, the rate of growth in the relative supply of college-equivalent workers is even sharper before 1990s and it is even slower afterwards; that is, the well-documented deceleration is even more pronounced once we correct for selectivity. This casts further doubt on the relevance of the plain skill-biased technical change hypothesis. We conclude that what happens to the within-group skill composition for low-educated groups is critical for fully understanding the trends in the relative supply of college workers in the United States. This suggests that unobserved compositional shifts arising from the time-varying FTFY choices of the low-skill workers should be accounted for.

The next step is to investigate the implications of the selectivity-corrected relative supply series on the empirical analysis of wage inequality. We use the standard empirical tools used in the literature to reevaluate the interaction between the college premium and the supply-demand conditions in the labor market. We estimate the standard skill-premium equation first using the uncorrected relative supply measure, then the selectivity-corrected relative supply measure as the explanatory variable long with other standard variables to see how the correction exercise affects the estimates that the college premium equation yields.

Remember our simple college premium equation

$$\ln\left(\frac{w_{C,t}}{w_{H,t}}\right) = \beta_0 + \beta_1 t + \beta_2 \, ln(RMW_t) + \beta_3 \, ln\left(\frac{C_t}{H_t}\right) + \varepsilon_t \qquad (5.4)$$

Our estimates of the above equation are reported in Table 5.1. The first column reports the estimates using the uncorrected relative supply series for the 1967 to 2009 period. The estimated elasticity of substitution is 2.75 (1/0.363) and the estimated trend growth in the wage gap is 1.5% per annum. These are in line with the literature.

Table 5.1 Regression Models for the College/High School Log Wage Gap, 1967-2009

Dependent variable: Log College/High School Hourly Wage Gap				
	[1]	[2]	[3]	[4]
Constant	0.125**	0.191***	0.309***	0.312***
	(0.021)	(0.013)	(0.100)	(0.097)
Time	0.015***	0.013***	0.015***	0.013***
	(0.001)	(0.001)	(0.001)	(0.001)
Log Relative Supply (uncor.)	-0.363***		-0.390***	
	(0.043)		(0.044)	
Log Relative Supply(cor.)		-0.268***		-0.277***
		(0.029)		(0.030)
Log real minimum wage			-0.103*	-0.065
			(0.055)	(0.052)
Observations	43	43	43	43
R-squared	0.92	0.92	0.92	0.92
Adj. R-squared	0.91	0.92	0.92	0.93

*Standard errors are reported in parentheses. Each column represents an OLS regression of the college/high school wage differential calculated with both uncorrected and corrected relative supply series on the indicated variables, respectively. Real minimum wage is deflated by the personal consumption expenditure deflator. ***, **, and * refer to 1%, 5%, and 10% significance levels, respectively.*

The second column -which we estimate using the selection-corrected relative supply series- gives an estimated elasticity of substitution 3.73 (1/0.268) and an estimated trend growth in the wage gap of 1.3% per annum. Thus, the uncorrected series understate the substitutability of skilled and unskilled workers. This pattern also implies that the relative demand growth is stronger when the uncorrected series is used. This suggests that, when the selection-corrected weights are used, the slowdown in the SBTC trend is more pronounced.

The role of minimum wages is examined in the third and the fourth columns. The natural logarithm of the real minimum wage has additional explanatory power as suggested by Card and Dinardo (2002) and Autor, Katz, and Kearney (2008). But the inclusion of this variable does not alter our main conclusion that the literature overestimates the relative demand growth. Thus, our conclusion is robust to the inclusion of non-market (i.e., institutional) factors.

It is well-known that the college premium has significantly varied by age/experience groups over recent decades, with the rise in the skill gap concentrated among less experienced workers in the 1980s [Autor, Katz, and Kearney (2008)]. The return to college education has increased much more substantially since 1980 for younger workers than for older ones. Card and Lemieux (2001) utilize these differences to construct a model in which workers with similar education but with different experience levels enter as imperfect substitutes into the production technology as we mention earlier. We now examine these changing trends across cohort-specific relative supplies by estimating regression models for the college/high school wage premium by experience group. For this purpose we estimate the extended skill premium equation to contain own experience group-specific relative skill supplies.

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right) = \beta_0 + \beta_1 t + \beta_2\, ln(RMW_t) + Z_i + \beta_3\, ln\left(\frac{C_t}{H_t}\right) + \beta_4\left(\frac{C_{i,t}}{H_{i,t}}\right) + \varepsilon_{i,t} \quad (5.5)$$

We run this regression for both corrected and uncorrected aggregate series. Table 5.2 presents the estimates for regressions in which experience groups are pooled and Tables 5.3 - 5.4 presents the results for separate regressions for each experience category. Table 5.2 shows that both own-group and aggregate relative supply indices have significant effects on the college premium. Estimates for both the aggregate elasticity of substitution the partial elasticity of substitution between experience groups are larger than the aggregate estimates presented in Table 5.1 This suggests that accounting for the substitutability of experience groups can potentially alter the results.

Estimates by experience groups (separately) are reported in Tables 5.3 – 5.4 and they communicate important messages. First, for almost all experience groups, the correction exercise makes the college and high-school workers more substitutable; therefore, leaves less room for SBTC trend to operate. The increase in substitutability is more pronounced for less-experienced group (i.e. for workers with 0-9 and 9-19 years of experience). The effect is much less pronounced in high-experience groups. This suggests that the selectivity operates through the less-experienced workers. These results help to understand the sources of the bias stemming from self-selection into and out of the FTFY status over time. In other words, a deeper look at the composition of the Mills ratios across education and experience groups helps us to get the main structure of self-selection.

Table 5.2 Regression Models for the College/High School Log Wage Gap by Potential Experience Groups, 1967-2009

Dependent variable: Log College/High School Hourly Wage Gap by Potential Experience Groups				
Pooled Regressions				
	[1]	[2]	[3]	[4]
Constant	0.210** *	0.256***	0.371***	0.376***
	(0.019)	(0.013)	(0.093)	(0.093)
Time	0.012***	0.011***	0.012***	0.010***
	(0.001)	(0.001)	(0.001)	(0.001)
Aggregate Relative Supply (uncor.)	-0.262***		-0.286***	
	(0.039)		(0.041)	
Aggregate Relative Supply (cor.)		-0.194***		-0.203***
		(0.028)		(0.029)
Own Minus Aggregate Relative Supply	-0.040***	-0.040***	-0.042***	-0.042***
	(0.014)	(0.014)	(0.015)	(0.015)
Log real minimum wage			-0.090*	-0.064
			(0.051)	(0.050)
Observations	172	172	172	172
R-squared	0.70	0.70	0.71	0.71
Adj. R-squared	0.70	.069	0.71	0.70

*Standard errors are reported in parentheses. Each column represents an OLS regression of the college/high school wage differential calculated with both uncorrected and corrected relative supply series on the indicated variables, respectively. Real minimum wage is deflated by the personal consumption expenditure deflator. ***, **, and * refer to 1%, 5%, and 10% significance levels, respectively.*

As the results reveal, selectivity operates over the lower educated and less experienced workers. More precisely, we find that high-school dropouts and the workers with 0-9 years of experience select into the FTFY status until late 1980s and they select out afterwards. The same tendencies have been reported for the high-school graduates and the workers with 10-19 years of experience, in a much weaker sense though. There are signs of selectivity also for the more skilled workers, but their patterns of selectivity are not altered over time; that is, they do not affect the trends in the relative supply. In other words, accounting for selectivity changes the trends in the relative supply of skills and the main source of these changes is the shift in the self-selection patterns of the low-skill workers.

Table 5.3 Regression Models for the College/High School Log Wage Gap by Potential Experience Groups, 1967-2009 (Separate Regression for (0-9) and (10-19) Experience Group)

Dependent variable: Log College/High School Hourly Wage Gap by Potential Experience Groups				
	[0-9]		[10-19]	
	[1]	[2]	[3]	[4]
Constant	0.715***	0.673***	0.453***	0.448***
	(0.154)	(0.156)	(0.137)	(0.137)
Time	0.014***	0.012***	0.018***	0.015***
	(0.002)	(0.002)	(0.002)	(0.001)
Aggregate Relative Supply (uncor.)	-0.291***		-0.526***	
	(0.072)		(0.060)	
Aggregate Relative Supply (cor.)		-0.211***		-0.369***
		(0.047)		(0.042)
Own Minus Aggregate Relative Supply	0.073	-0.025	-0.250***	-0.172***
	(0.108)	(0.118)	(0.078)	(0.076)
Log real minimum wage	-0.320***	-0.249***	-0.183***	-0.130*
	(0.090)	(0.088)	(0.075)	(0.073)
Observations	43	43	43	43
R-squared	0.89	0.88	0.90	0.90
Adj. R-squared	0.88	0.87	0.89	0.89

*Standard errors are reported in parentheses. Real minimum wage is deflated by the personal consumption expenditure deflator. ***, **, and * refer to 1%, 5%, and 10% significance levels, respectively.*

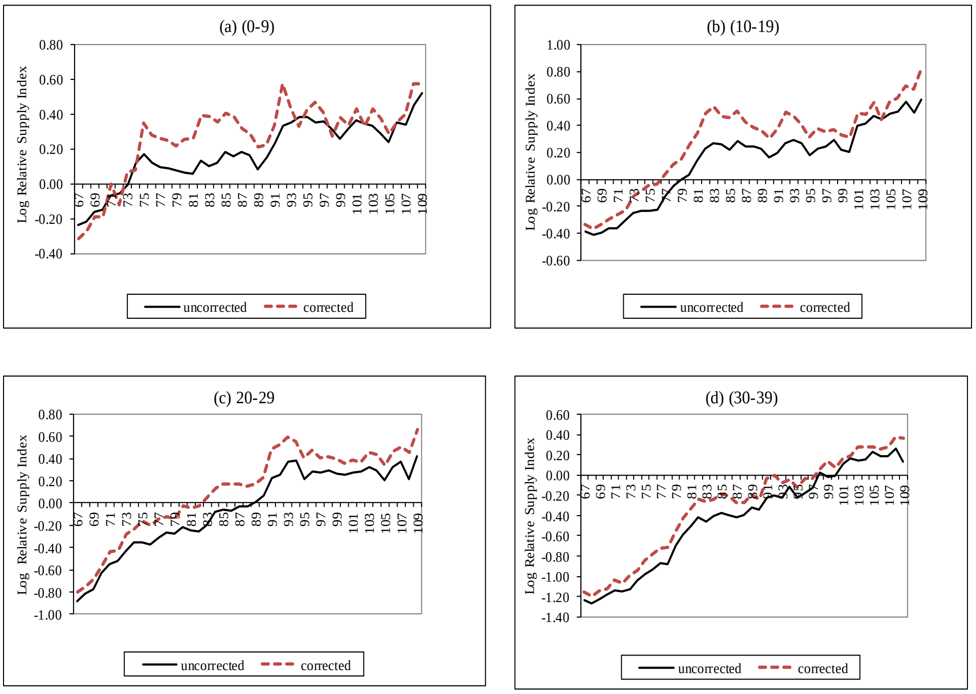
The intuition is as follows as we described above: low-skill workers are over-represented in the FTFY workforce before the 1990s and they are under-represented afterwards. Correcting for this pattern makes the trend in the relative supply of skills steeper before the 1990s and flatter after the 1990s. As a result, the deceleration in the relative supply of skills is sharper under selection correction.

Table 5.4 Regression Models for the College/High School Log Wage Gap by Potential Experience Groups, 1967-2009 (Separate Regression for (20-29) and (30-39) Experience Group)

Dependent variable: Log College/High School Hourly Wage Gap by Potential Experience Groups				
	[20-29]		[30-39]	
	[1]	[2]	[3]	[4]
Constant	0.018	0.036	0.479***	0.464***
	(0.140)	(0.140)	(0.166)	(0.170)
Time	0.011***	0.010***	0.003	0.003
	(0.001)	(0.001)	(0.002)	(0.002)
Aggregate Relative Supply (uncor.)	-0.214***		-0.060	
	(0.061)		(0.073)	
Aggregate Relative Supply (cor.)		-0.162***		-0.048
		(0.043)		(0.055)
Own Minus Aggregate Relative Supply	-0.091	-0.084	0.091	0.063
	(0.079)	(0.075)	(0.088)	(0.093)
Log real minimum wage	0.120	0.131*	0.02	-0.020
	(0.078)	(0.077)	(0.084)	(0.082)
Observations	43	43	43	43
R-squared	0.79	0.80	0.44	0.44
Adj. R-squared	0.78	0.79	0.43	0.43

*Standard errors are reported in parentheses. Each column represents an OLS regression of the college/high school wage differential calculated with both uncorrected and corrected relative supply series on the indicated variables, respectively. Real minimum wage is deflated by the personal consumption expenditure deflator. ***, **, and * refer to 1%, 5%, and 10% significance levels, respectively.*

Figure 5.3 reveals trends in the uncorrected relative supply compared to the trends in the corrected relative supply for potential experience groups. Trends here also confirm the above argument that selectivity operates through the lower educated and less experienced workers. Panel (a) reveals the fact that the workers with 0-9 years of experience select into the FTFY status until late 1980s and they select out afterwards. The same tendencies have been reported for the workers with 10-19 years of experience, in a much weaker sense though as can be seen in Panel (b). There are signs of selectivity also for the more skilled workers, but their patterns of selectivity are not altered over time; that is, they do not affect the trends in the relative supply.



Panels (a), (b), (c), and (d) plot the trends both in uncorrected and corrected log relative supply series for experience groups 0-9, 10-19, 20-29, and 30-39, respectively. Calculations are based on the March CPS. The sample consists of full-time/full-year employed men for the 1967-2009 period.

Figure 5.3 Uncorrected Versus Corrected Relative Supply Series by Potential Experience Groups

Therefore we find empirically that the increase in substitutability is more pronounced for less-experienced group (i.e. for workers with 0-9 and 9-19 years of experience) and the effect is much less pronounced in high-experience groups.

The observation that selection operates through the unobserved ability composition of the low educated and low-skilled suggests that one should focus on factors affecting the lower tail of the wage distribution should in seeking an explanation to the selectivity patterns. We argue that trends in the real minimum wages can potentially generate these observed compositional effects. Our findings suggest that changes in minimum wage laws may be the driving force behind the selectivity patterns of the low-skill workers. We propose that the interaction between the (endogenous) direction of technical change and the minimum wage laws is potentially the triggering mechanism. As we explain earlier, profit generating motives by producers endogenously determine the amount of innovative effort to be devoted to different factors of production including skilled and unskilled labor. Thus, the direction of technical progress can lead to unskill-bias or skill-bias. Institutions can lead to amplification or attenuation of the strength of this technical change. The trends in real minimum wages in the U.S. perfectly fit the self-selection structure that we document.

Since the real value of the minimum wage may have led to compositional changes in the workforce that affect the relative supply of college-equivalent workers, we conclude that it can affect wage inequality not only directly, but through its effect on the relative supply of college workers. In other words, we say that the real minimum wages have indirect as well as direct effects on the structure of the U.S. college premium. As a result, one should also look at how the relative supply responds to institutional changes, rather than directly focusing on the wage outcomes. This is related to the endogenous technical change version of the SBTC hypothesis [see, e.g., Acemoglu (1998)].

Therefore, we think that the following three points should perhaps be re-emphasized. First, that the deceleration in the relative supply series is more pronounced after correcting for selectivity suggests that the slowdown in the SBTC trend is even sharper, which makes the puzzle deeper. Second, the selectivity patterns do not explain the puzzle; instead, it offers a mechanism that amplifies the deceleration. Finally, the relative supply series can itself be affected from the institutional factors.

5.3 A Non-Identification Result

There is a large literature on the association between the level of real minimum wages and the degree of wage inequality [see, e.g., Dinardo, Fortin, and Lemieux (1996) and Lee (1999)]. The main argument is as follows. As the level of real minimum wages goes up, the distance between high wage earners and low wage earners tends to get smaller, as a result, wage inequality should go down. This is a simple mechanical story and is documented to hold in the U.S.

We argue above that there are unobserved compositional shifts within education categories and the trends in these shifts coincide with the trends in the real minimum wages in the U.S. Since we document that these compositional shifts affect the relative supply of college workers, the findings that we report implies that the real minimum wages may have an indirect effect on the relative supply of college workers. In other words, the institutional factors may themselves affect the evolution of the relative supply index through unobserved compositional shifts. This second-order effect is ignored in the literature (although Lemieux (2006) briefly mentions the possibility of such a second-order effect).

These second-order effects may bring together a non-identification result in the college-premium framework. Suppose that the relative supply of skills can be expressed as a linear function of several explanatory variables including the real minimum wages. This linearity assumption is standard in empirical labor economics. Under this assumption, it is not possible to directly identify the effect of real minimum wages on college premium. The reason is that the direct mechanical effect of real minimum wages on skill premium is confounded with the second-order effect operating through the relative supply.

To be precise, let's assume that the relative supply series can be written as a linear function of the real minimum wages and a vector of other explanatory variables as follows:

$$\ln\left(\frac{C_t}{H_t}\right) = a_0 + a_1 RMW_t + a_2 X_t + \nu_t \tag{5.6}$$

Plugging this equation into the college premium equation and taking the partial derivative of the dependent variable with respect to the real minimum wage give us the compound effect $\beta_2 + a_1$ rather than onlyβ_2. In other words, β_2 will be a biased estimator of the effect of the real minimum wage on college premium. The bias reflects the changes the relative supply of skills as a response to the changes in the real minimum wage.

This result suggests that both the simple and the extended college premium formulas given by the Equation (2.18) and (2.19) may not be the ideal way to estimate the causal effect of the real minimum wage on inequality. That is, it may not be possible to directly see the effect of real minimum wages on wage inequality using the college premium equation under the assumption of linearity of relative supply series in real minimum wages. This is a potential non-identification result. Therefore the existing results about real minimum wages in this literature should be cautiously interpreted.

5.4 Policy Implications

The empirical college-premium literature rests on the assumption that the relative supply of college workers is only a function of the observed compositional shifts between education categories. For example, an observed increase in hours supplied by college graduates relative to high school graduates will be recorded as an increase in the relative supply of college workers. We argue that the effect of observed compositional shifts between educational categories is not the only source of shifts in the relative supply of college-equivalent workers. Unobserved compositional changes within education categories can also affect the relative supply of skills. Moreover, we show that failing to account for these second class of compositional changes can have considerable effects on the wage inequality estimates.

We argue that the institutional (or non-market) factors, which definitely have direct effects on wage inequality, can also have indirect (or second-round) effects on wage inequality through the unobserved compositional changes. For instance, as argued above, an increase in the real minimum wage is expected to compress the wage structure, all else equal. But an increase in the real minimum wage can also lead to decreased residual demand for college education. This decreased demand would lead some skilled individuals, who would normally go to college, to stop schooling after high school. This tendency, in turn, would push the relative supply down, only if the analyst accounts for the unobserved shifts.

The real minimum wage is not the only non-market factor that can generate these second-order effects. Factors including business fluctuations, foreign outsourcing of less-skilled jobs, and changes in international trade patterns can also induce unobserved compositional shifts.

This finding has some positive implications that would lead to policy recommendations. To be precise, the government should be aware that any institutional change that is expected to affect wage inequality directly may also have second-order effects that operate through quality adjustments within education categories. On the minimum wage example, the model we propose predicts that a decline in real minimum wages will likely to lead to a decline in the average quality of the stock of high school educated workers. These unobserved quality adjustments may have further effects not only on wage inequality but on labor phenomena such as search frictions, mismatch, and sorting. We conclude that a systematic account of quality adjustments within education categories is needed to fully assess the link between institutional factors and wage inequality. Our model is only a first attempt toward this direction.

5.5 Concluding Remarks

We argue that the canonical college premium framework has two defects. First, it focuses on the labor hours supplied by only those who self-select into working full-time full-year. FTFY is a choice variable and this procedure may bias the estimates. Second, it assumes fixed efficiency units of labor supply. In other words, it assumes that the relative efficiency of an hour worked by a college graduate versus an hour worked by a high school graduate is constant in the entire sample period (1967- to date). This assumption ignores potential changes in the quality dimension.

We are interested in the question how these two strong assumptions affect the estimates reported in the U.S. wage inequality literature. Therefore, in this chapter, we employ a standard Heckman selection-correction procedure to model FTFY as a choice variable. We find that ignoring this choice may bias the results. In particular, we find that the fraction of FTFY workers have stayed constant -around 90 percent- for high-educated workers along the data horizon, while it significantly fluctuates over time for the low-educated. This suggests that the selectivity operates for low-educated workers. We also show that, among the low educated, the fraction of the FTFY status declines until mid-1980s and it picks up afterwards. This means that the direction of selectivity is reversed after mid-1980s. Therefore, we conclude that what happens to the within-group skill composition for low-educated groups is critical for fully understanding the trends in the relative supply of college workers in the United States.

We then use the inverse Mills ratios -the output from the selection correction procedure- and use them to as time-varying components of the efficiency units. In other words, we assume that the differential selection in and out of the FTFY status can describe how efficiency units move over time. A new relative supply series is constructed that corrects for unobserved compositional shifts due to selection in and out of the FTFY status. We find that the standard model underestimates the relative supply series before 1990s and overestimates afterwards. In other words, correcting for this pattern makes the trend in the relative supply of skills steeper before the mid-1980s and flatter afterwards. This suggests that the relative efficiency of college units increased until mid-1980s and it declines later. In terms of the SBTC hypothesis, this suggests the well-known deceleration observed in the relative supply of college workers after 1980s is even more pronounced after correcting for selectivity. This result casts further doubt on the relevance of the plain SBTC story.

Then we ask what may be triggering the changes in selectivity patterns. We propose that the movements in the real value of the minimum wage have been the triggering force behind the self-selection of low-skill workers into the FTFY status. In particular, we think that the interaction between the (endogenous) direction of technical change and the minimum wage laws is potentially the triggering mechanism. In other words, institutional changes affect wage inequality not only directly, but its indirect effects on the relative supply of college workers. As a result, we conclude that it is also important to account for the response of the relative supply to institutional changes rather than directly focusing their effects on the wage outcomes.

CHAPTER 6

CONCLUSION

The college premium in the U.S. has increased substantially after the late 1970s until early 1990s. Researchers investigating the sources of this increase have built their analyses on a framework featuring the interactions between the relative demand for skills and the relative supply of skills. This “market" framework has been influential in explaining the U.S. data until the early 1990s, as, in this period, the relative supply of college-equivalent workers has increased sharply and steadily, which implies a similar upward trend in the relative demand. This phenomenon is hypothesized as the existence of a steady technological progress- the skill-biased technical change (SBTC) - in the U.S. labor markets, corresponding to a shift in the relative demand for labor favoring the skilled over unskilled. Based on this definition, the SBTC is associated with increased investment in computerized technologies.

After early 1990s, however, the rate of increase in the relative supply of college-equivalent workers has slowed down, which is accompanied by a parallel slowdown in the rate of increase in college premium. According to the canonical college-premium equation, the relative demand for skilled workers has also slowed down after the early 1990s in the U.S. This is in stark contrast with the story linking

SBTC to computer investments. In fact, the computer investments have continued to grow even more rapidly during the 1990s, while the college-premium equation says the opposite. The emerging consensus in the literature is that the pure \market" explanation fails to fully capture the evolution and the determinants of college premium in the U.S. As an alternative explanation, the decline in real minimum wages is argued to account for how wage inequality evolves after early 1980s in the U.S. Finally, Autor, Katz, and Kearney (2008) show that the real minimum wage indeed affects the college premium, but it seems to operate mostly on the lower tail of the wage distribution, although the developments in wage inequality after 1990s mostly affected from what happens on the upper tail. As a result, the real minimum wage cannot fully account for the deceleration. Other factors such as business fluctuations [Hoynes, Miller, and Schaller (2012)] and foreign outsourcing of less-skilled jobs [Feenstra and Hanson (1999)] are also argued to affect the trends in college premium. These findings have led the literature toward the conclusion that market and non-market factors jointly determine the college premium.

The key construct in the traditional college premium analysis is the variable describing the sup-ply of college equivalent workers relative to the supply of high school equivalent workers. This variable is called the relative supply index. Roughly speaking, the supply of college-equivalent workers is calculated from the aggregate hours supplied by full-time full-year (FTFY) workers sorted into the following three education categories weighted by the mean wage- in the entire data horizon- for the corresponding education category: (i) workers with graduate education (COL+), (ii) college graduates (COL), and (iii) some college education (SC2) who earn more than the median wage within the some college category. The supply of high school equivalent workers, on the other hand, is calculated from the aggregate hours worked by workers sorted in the remaining three education levels weighted by the mean wage-in the entire data horizon-for the corresponding education category: (i) high school dropouts (HSD), (ii) high school graduates (HSG), and (iii) workers with some college education (SC1) who earn less than the median wage within the some college category. The ratio of these two aggregates gives the relative supply of college-equivalent workers.

The weighting procedure captures the basic “efficiency units" idea in the sense that an hour supplied by a relatively higher educated worker counts more than an hour supplied by a lower educated worker. This setup successfully captures the effect of the observed changes in the educational composition of the working population. But it has two deficiencies: first, it focuses on the labor hours supplied by only those who self-select into working full-time full-year (FTFY). FTFY is a choice variable and this procedure may bias the estimates. Second, it assumes fixed efficiency units of labor supply. In other words, it assumes that the relative efficiency of an hour worked by a college graduate versus an hour worked by a high school graduate is constant in the entire sample period. This assumption ignores potential changes in the quality dimension.

We are interested in the question how we develop a method to revise the relative supply measure in such a way that it corrects for these two strong assumptions in the wage inequality literature. Our starting point is the observation that most studies in the U.S. wage inequality literature focus on the full-time full-year (FTFY) workforce. In other words, the ones who potentially self-select into the FTFY status have been sampled. Among employed workers, selection into the FTFY status exhibits distinct trends between education categories after late 1960s to date. The fraction of the FTFY status among high-skill workers stays in a narrow range around 90% over the data horizon. The fraction of the FTFY status among low-skill workers, on the other hand, exhibits significant time variation. For example, among high-school dropouts, around 80% of the employed workers have had FTFY status in late 1960s, while the FTFY ratio has sharply gone down to 60% and made a double-dip in 1982 and 1992. Then it has picked up and reached to 70% in 2007. Similar trends are also observed for other less-skilled workers, including the high school graduates and workers with some college education who earn less than the median wage. These divergent patterns between low-and high-skill workers in terms of the labor supply patterns on the FTFY margin motivate this study.

These patterns raise concerns that the existing estimates may be missing some systematic components of the relative supply series that are relevant for wage inequality analysis. The first step in our analysis is to investigate if a significant selection bias exists or not. We calculate a selection-corrected relative supply series. We then compare this corrected series with the uncorrected series. We find that selectivity is significant and that, under selection-correction, the rate of growth in the relative supply of college workers is even sharper before 1990s and it is even slower afterwards; that is, the deceleration is even more pronounced after correcting for selectivity. This suggests that unobserved compositional shifts arising from the time-varying FTFY choices of the low-skill workers should be accounted for.

At the second step, we investigate the sources of this bias. To perform this task, we take a deeper look at the composition of the Mills ratios across education and experience groups. Our goal, in this exercise, is to understand the main structure of self-selection into and out of the FTFY status over time. We show that selectivity operates over the lower educated and less experienced workers. More precisely, we find that high-school dropouts and the workers with 0-9 years of experience select into the FTFY status until late 1980s and they select out afterwards. The same tendencies have been reported for the high-school graduates and the workers with 10-19 years of experience, in a much weaker sense though. There are signs of selectivity also for the more skilled workers, but their patterns of selectivity are not altered over time; that is, they do not affect the trends in the relative supply. In other words, accounting for selectivity changes the trends in the relative supply of skills and the main source of these changes is the shift in the self-selection patterns of the low-skill workers. The intuition is as follows: low-skill workers are over-represented in the FTFY workforce before the 1990s and they are under-represented afterwards. Correcting for this pattern makes the trend in the relative supply of skills steeper before the 1990s and flatter after the 1990s. As a result, the deceleration in the relative supply of skills is sharper under selection correction. In terms of the SBTC hypothesis, this suggests the well-known deceleration observed in the relative supply of college workers after 1980s is even more pronounced after correcting for selectivity. This result casts further doubt on the relevance of the plain SBTC story.

We then question what triggers the changes in the selectivity patterns of the low-skill workers. We think that the interaction between the (endogenous) direction of technical change [see, e.g., Acemoglu (1998)] and the minimum wage laws is potentially the triggering mechanism. Profit generating motives by producers endogenously determine the amount of innovative effort (i.e., R&D expenditures, patents etc.) to be devoted to different factors of production. These factors of production include skilled and unskilled labor. Thus, the direction of technical progress can lead to unskill-bias or skill-bias. Institutions (i.e., the non-market factors) can lead to amplification or attenuation of the strength of the technical change. To understand this mechanism better, think of the following example. Suppose that the relative supply of college workers grows at a constant rate. The government raises the level of real minimum wages permanently. This makes unskilled labor more expensive, triggering investments in skilled-labor favoring technologies. This raises the relative returns to college education leading the society to invest in college education at a faster rate. The reverse logic holds when real minimum wages are reduced permanently. The trends in real minimum wages in the U.S. perfectly fit the self-selection structure that we document. We conclude that the real minimum wage can affect wage inequality not only directly, but through its effect on the relative supply of college workers.

We suggest that the following three points should perhaps be re-emphasized. First, that the deceleration in the relative supply series is more pronounced after correcting for selectivity suggests that the slowdown in the SBTC trend is even sharper, which makes the puzzle deeper. Second, the selectivity patterns do not explain the puzzle; instead, it offers a mechanism that amplifies the deceleration. Finally, the relative supply series can itself be affected from the institutional factors.

We think that a full analysis of wage inequality requires a detailed examination of the productivity adjustments in the labor force rather than quantity adjustments only and unobserved compositional changes within education categories. There is more to be understood about the interactions between supply-demand conditions in the labor market and other nonmarket factors- i.e., the factors affecting labor quality and how they evolve over time. A more general human capital model is needed to understand these broader interactions and their implications on wage inequality.

FUTURE RESEARCH

There are two directions that I would like to follow in conducting future research on the ideas developed in this thesis. The first one is to investigate the effect of unobserved compositional shifts within educational categories on the magnitude of residual wage inequality. And the second is to construct a hedonic model of labor supply, in which relative supply of skills can be drived from a supply-demand framework based on pricing of human characteristics with multi-dimensional heterogeneity.

Lemieux (2006) is the most recent and the breakthrough paper in the U.S. residual wage inequality literature. He defines residual wage inequality as the variance of the residuals in a standard empirical wage equation (i.e., in a regression of log wages on schooling and experience). By plotting the estimated trends in this residual variance, he documents that residual wage inequality has increased substantially over time in the United States. He then develops a variance decomposition method to analyze and understand the sources of the increase in residual wage inequality. This study also potentially suffers from the same selectivity problem as the college-premium literature; that is, the focus is on full-time full-year (FTFY) workers. One can employ the standard selection-correction methods (similar to the one I use in this thesis) to correct for selectivity in and out of the FTFY status and then analyze the trends in residual wage inequality. Based on our finding that the selectivity is significant, especially for low-educated workers, I conjecture that correcting for selectivity can at least partially change the results documented by Lemieux. A further question is how the sources of residual wage inequality change after correcting for selectivity. I do not perform these exercises in this thesis, because the residual wage inequality literature works with May CPS, whereas I use the March CPS. I plan to answer these questions in future research.

As I document in the thesis, the way the college-premium literature constructs the relative supply series is ad hoc and mechanical. Based on this observation, my thesis criticizes the treatment of human capital in this literature. In my future research, I plan to develop an alternative human capital model that endogenizes the trends in the relative supply series. One way to follow is to construct a hedonic model of human capital. Hedonic wage models are based on pricing multi-dimensional human characteristics. I conjecture that it should be possible to construct a relative supply series by constructing human capital from multi-dimensional personal characteristics and then estimate the weights of this hedonic model to fully characterize the evolution of the relative supply of skills. Such a framework will provide a non-monotonic evolution of weights over time and it will capture the substantive economic developments that the traditional fixed-weight assumption does not.

I briefly sketch out the new framework as follows. The price of the relative supply measure is actually a hedonic price. To employ the principles of hedonic models, it is required to specify a good to be priced. That good is the relative supply of college equivalents in our framework. It is a combination of three main factors: (1) the actual hours supplied by college equivalents and high school equivalents, (2) the cohort-specific unobserved variables for both groups, and (3) a luck component independent of the first two factors. The hedonic relative supply measure, by definition, is a combined variable and the content of this combination comes from a simple optimization problem. The hedonic price is called the “implicit" price in the literature, since it jointly values a bundle of variables. The pricing equation values this hedonic good and it provides a good representation of the time-varying quality measure. The actual hours worked are no longer weighted by wages. Instead, the weights come from an economic model, and they price out the observed, unobserved, and shock components of the relative supply. The theoretical structure of our model will be similar to Ekeland, Heckman, and Nesheim (2004), which builds on the well-known hedonic model pioneered by Tinbergen (1956) and Rosen (1974).

One potential limitation with March CPS is that we observe each worker only once over time, therefore it may not be straightforward to control for individual-level heterogeneity in this framework. Working with PSID or NLSY can resolve these complications. Again, I will try to answer these questions in my future research.

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APPENDICES

APPENDIX A

HECKMAN'S SAMPLE SELECTION MODEL

Recall that the empirical wage equation used is the following:

$$\ln(w_i^*) = x_i'\beta^* + \epsilon_i^*$$

where ϵ is normally distributed with zero mean and non-zero variance σ^2 and it is i.i.d across individuals. Explanatory variables used in the logit consist of a full set of indicators for age and education, plus interactions between education and a quartic in age. Dependent variable is log hourly wages. The excluded restriction for probit model is marital status.

The term

$$\Lambda = {}^{\sigma^*}/_{\sigma_\eta} \lambda \left(-{}^{z'\gamma}/_{\sigma_\eta} \right)$$

is the component of the FTFY wages due to the correlation between the unobserved determinants of choices and outcomes.

Let $\widehat{\Lambda}_i$ denote the predicted inverse Mills ratio multiplied by its estimated coefficient. To calculate these predicted values, we run separate year-by-year regressions for each of the six education categories that we utilize and, at the end, we obtain a predicted value $\widehat{\Lambda}_{i,t}^J$ for each worker i in the education category J at each year t.

Here is the outcome table showing year by year predicted inverse Mills ratios, their estimated coefficients and interaction of these two for each education group:

		HSD	HSG	SC1	SC2	COL	COL+
1967	**lambda**	-0.272	-0.037	-0.373	0.242	-0.621	-0.405
	mills ratio(mean)	0.262	0.179	0.284	0.169	0.107	0.158
	interaction	**-0.071**	**-0.007**	**-0.106**	**0.041**	**-0.066**	**-0.064**
1968	**lambda**	-0.272	-0.047	-0.340	0.049	-0.239	-0.339
	mills ratio(mean)	0.253	0.168	0.182	0.144	0.123	0.164
	interaction	**-0.069**	**-0.008**	**-0.062**	**0.007**	**-0.030**	**-0.056**
1969	**lambda**	-0.279	-0.077	-0.347	-0.014	-0.213	-0.357
	mills ratio(mean)	0.250	0.170	0.343	0.124	0.119	0.154
	interaction	**-0.070**	**-0.013**	**-0.119**	**-0.002**	**-0.025**	**-0.055**
1970	**lambda**	-0.057	-0.156	-0.413	-0.023	-0.871	0.104
	mills ratio(mean)	0.320	0.218	0.420	0.156	0.164	0.157
	interaction	**-0.018**	**-0.034**	**-0.174**	**-0.004**	**-0.143**	**0.016**
1971	**lambda**	-0.266	-0.083	-0.421	-0.023	-0.278	0.112
	mills ratio(mean)	0.321	0.243	0.433	0.164	0.159	0.174
	interaction	**-0.085**	**-0.020**	**-0.183**	**-0.004**	**-0.044**	**0.019**
1972	**lambda**	-0.241	-0.072	-0.003	0.187	-0.345	-0.424
	mills ratio(mean)	0.327	0.216	0.319	0.151	0.164	0.157
	interaction	**-0.079**	**-0.015**	**-0.001**	**0.028**	**-0.056**	**-0.067**
1973	**lambda**	-0.409	-0.265	-0.460	0.200	-0.239	-0.045
	mills ratio(mean)	0.312	0.204	0.424	0.151	0.169	0.139
	interaction	**-0.128**	**-0.054**	**-0.195**	**0.030**	**-0.041**	**-0.006**
1974	**lambda**	-0.363	-0.039	-0.486	0.102	-0.370	-0.386
	mills ratio(mean)	0.341	0.239	0.470	0.133	0.177	0.171
	interaction	**-0.124**	**-0.009**	**-0.229**	**0.014**	**-0.066**	**-0.066**
1975	**lambda**	-0.392	-0.300	-0.414	-0.033	-0.292	-0.545
	mills ratio(mean)	0.420	0.308	0.452	0.187	0.191	0.193
	interaction	**-0.165**	**-0.092**	**-0.187**	**-0.006**	**-0.056**	**-0.105**
1976	**lambda**	-0.364	-0.289	-0.394	-0.034	-0.290	-0.323
	mills ratio(mean)	0.407	0.289	0.436	0.159	0.195	0.188
	interaction	**-0.148**	**-0.084**	**-0.172**	**-0.005**	**-0.057**	**-0.061**

1977	**lambda**	-0.381	-0.302	-0.423	-0.043	-0.277	-0.416
	mills ratio(mean)	0.406	0.277	0.426	0.155	0.175	0.209
	interaction	**-0.155**	**-0.084**	**-0.180**	**-0.007**	**-0.048**	**-0.087**
1978	**lambda**	-0.426	-0.334	-0.423	-0.008	-0.329	-0.415
	mills ratio(mean)	0.375	0.273	0.402	0.144	0.187	0.186
	interaction	**-0.160**	**-0.091**	**-0.170**	**-0.001**	**-0.062**	**-0.077**
1979	**lambda**	-0.403	-0.309	-0.338	0.113	-0.260	-0.337
	mills ratio(mean)	0.375	0.255	0.340	0.136	0.170	0.163
	interaction	**-0.151**	**-0.079**	**-0.115**	**0.015**	**-0.044**	**-0.055**
1980	**lambda**	-0.427	-0.319	-0.443	-0.025	0.165	-0.365
	mills ratio(mean)	0.449	0.311	0.472	0.165	0.173	0.171
	interaction	**-0.192**	**-0.099**	**-0.209**	**-0.004**	**0.029**	**-0.062**
1981	**lambda**	-0.417	-0.297	-0.429	-0.008	-0.323	-0.301
	mills ratio(mean)	0.460	0.312	0.462	0.156	0.196	0.163
	interaction	**-0.192**	**-0.093**	**-0.198**	**-0.001**	**-0.063**	**-0.049**
1982	**lambda**	-0.386	-0.333	-0.440	-0.019	-0.353	-0.323
	mills ratio(mean)	0.526	0.390	0.490	0.223	0.213	0.184
	interaction	**-0.203**	**-0.130**	**-0.216**	**-0.004**	**-0.075**	**-0.060**
1983	**lambda**	-0.382	-0.389	-0.502	-0.033	-0.294	-0.233
	mills ratio(mean)	0.512	0.372	0.528	0.202	0.209	0.186
	interaction	**-0.196**	**-0.145**	**-0.265**	**-0.007**	**-0.061**	**-0.043**
1984	**lambda**	-0.389	-0.344	-0.482	-0.027	-0.322	-0.325
	mills ratio(mean)	0.473	0.314	0.478	0.152	0.187	0.160
	interaction	**-0.184**	**-0.108**	**-0.230**	**-0.004**	**-0.060**	**-0.052**
1985	**lambda**	-0.446	-0.381	-0.455	-0.030	-0.326	-0.281
	mills ratio(mean)	0.480	0.318	0.454	0.134	0.181	0.182
	interaction	**-0.214**	**-0.121**	**-0.206**	**-0.004**	**-0.059**	**-0.051**
1986	**lambda**	-0.426	-0.389	-0.449	-0.028	-0.254	-0.285
	mills ratio(mean)	0.464	0.327	0.436	0.154	0.184	0.168
	interaction	**-0.198**	**-0.127**	**-0.196**	**-0.004**	**-0.047**	**-0.048**
1987	**lambda**	-0.379	-0.324	-0.473	-0.028	-0.323	-0.335
	mills ratio(mean)	0.430	0.286	0.440	0.137	0.188	0.172
	interaction	**-0.163**	**-0.093**	**-0.208**	**-0.004**	**-0.061**	**-0.058**
1988	**lambda**	-0.319	-0.295	-0.422	-0.024	-0.296	-0.341
	mills ratio(mean)	0.436	0.269	0.388	0.130	0.165	0.155
	interaction	**-0.139**	**-0.079**	**-0.164**	**-0.003**	**-0.049**	**-0.053**

1989	**lambda**	-0.443	-0.327	-0.449	-0.034	-0.258	-1.226
	mills ratio(mean)	0.448	0.263	0.378	0.127	0.170	0.170
	interaction	**-0.199**	**-0.086**	**-0.170**	**-0.004**	**-0.044**	**-0.209**
1990	**lambda**	-0.361	-0.352	-0.452	-0.015	-0.366	-1.337
	mills ratio(mean)	0.455	0.282	0.421	0.144	0.187	0.191
	interaction	**-0.164**	**-0.099**	**-0.190**	**-0.002**	**-0.068**	**-0.255**
1991	**lambda**	-0.409	-0.381	-0.336	-0.026	-0.396	-0.410
	mills ratio(mean)	0.511	0.313	0.391	0.150	0.221	0.182
	interaction	**-0.209**	**-0.119**	**-0.131**	**-0.004**	**-0.087**	**-0.075**
1992	**lambda**	-0.378	-0.384	-0.484	-0.024	-0.352	-0.383
	mills ratio(mean)	0.518	0.332	0.468	0.148	0.215	0.158
	interaction	**-0.196**	**-0.127**	**-0.227**	**-0.004**	**-0.076**	**-0.060**
1993	**lambda**	-0.211	-0.305	-0.453	-0.025	-0.288	-0.336
	mills ratio(mean)	0.461	0.308	0.415	0.163	0.195	0.176
	interaction	**-0.097**	**-0.094**	**-0.188**	**-0.004**	**-0.056**	**-0.059**
1994	**lambda**	-0.218	-0.256	-0.454	-0.032	-0.322	-0.354
	mills ratio(mean)	0.476	0.267	0.407	0.164	0.197	0.191
	interaction	**-0.104**	**-0.068**	**-0.185**	**-0.005**	**-0.063**	**-0.068**
1995	**lambda**	-0.350	-0.314	-0.444	-0.033	-0.246	-1.176
	mills ratio(mean)	0.445	0.267	0.364	0.135	0.188	0.181
	interaction	**-0.156**	**-0.084**	**-0.162**	**-0.005**	**-0.046**	**-0.213**
1996	**lambda**	-0.317	-0.286	-0.434	-0.027	-0.190	-0.114
	mills ratio(mean)	0.434	0.254	0.357	0.128	0.189	0.155
	interaction	**-0.137**	**-0.073**	**-0.155**	**-0.003**	**-0.036**	**-0.018**
1997	**lambda**	-0.212	-0.192	-0.449	0.073	-0.132	-1.198
	mills ratio(mean)	0.393	0.248	0.377	0.141	0.172	0.162
	interaction	**-0.083**	**-0.048**	**-0.170**	**0.010**	**-0.023**	**-0.194**
1998	**lambda**	-0.154	-0.253	-0.433	-0.002	-1.244	-0.133
	mills ratio(mean)	0.366	0.226	0.335	0.137	0.148	0.153
	interaction	**-0.056**	**-0.057**	**-0.145**	**0.000**	**-0.184**	**-0.020**
1999	**lambda**	-0.326	-0.298	-0.412	-0.026	-0.210	-0.372
	mills ratio(mean)	**0.383**	**0.234**	**0.310**	0.123	0.158	0.154
	interaction	**-0.125**	**-0.070**	**-0.128**	**-0.003**	**-0.033**	**-0.057**
2000	**lambda**	-0.138	-0.271	-0.429	-0.034	-0.231	-1.443
	mills ratio(mean)	0.351	0.226	0.331	0.110	0.160	0.142
	interaction	**-0.048**	**-0.061**	**-0.142**	**-0.004**	**-0.037**	**-0.205**

2001	**lambda**	-0.221	-0.246	-0.432	0.012	-0.182	-2.072
	mills ratio(mean)	0.382	0.248	0.370	0.161	0.176	0.160
	interaction	**-0.084**	**-0.061**	**-0.160**	**0.002**	**-0.032**	**-0.332**
2002	**lambda**	-0.186	-0.207	-0.566	-0.023	-0.254	-2.693
	mills ratio(mean)	0.376	0.266	0.304	0.176	0.183	0.159
	interaction	**-0.070**	**-0.055**	**-0.172**	**-0.004**	**-0.047**	**-0.428**
2003	**lambda**	-0.255	-0.239	-0.490	-0.026	-0.289	-0.260
	mills ratio(mean)	0.403	0.264	0.296	0.175	0.195	0.184
	interaction	**-0.103**	**-0.063**	**-0.145**	**-0.005**	**-0.056**	**-0.048**
2004	**lambda**	-0.258	-0.185	-0.454	-0.026	-0.167	-0.272
	mills ratio(mean)	0.360	0.253	0.384	0.155	0.187	0.156
	interaction	**-0.093**	**-0.047**	**-0.175**	**-0.004**	**-0.031**	**-0.043**
2005	**lambda**	-0.339	-0.297	-0.431	-0.028	-1.279	-2.130
	mills ratio(mean)	0.335	0.242	0.345	0.155	0.175	0.148
	interaction	**-0.114**	**-0.072**	**-0.149**	**-0.004**	**-0.224**	**-0.316**
2006	**lambda**	-0.244	-0.250	-0.474	-0.028	-0.177	-2.307
	mills ratio(mean)	0.337	0.239	0.387	0.128	0.165	0.133
	interaction	**-0.082**	**-0.060**	**-0.183**	**-0.004**	**-0.029**	**-0.307**
2007	**lambda**	-0.291	-0.275	-0.460	-0.022	-0.225	-2.200
	mills ratio(mean)	0.370	0.257	0.382	0.144	0.166	0.135
	interaction	**-0.108**	**-0.071**	**-0.176**	**-0.003**	**-0.037**	**-0.297**
2008	**lambda**	-0.251	-0.315	-0.471	-0.019	-0.316	-0.175
	mills ratio(mean)	0.444	0.305	0.364	0.163	0.197	0.152
	interaction	**-0.111**	**-0.096**	**-0.172**	**-0.003**	**-0.062**	**-0.027**
2009	**lambda**	-0.388	-0.239	-0.495	-0.032	-0.235	-0.199
	mills ratio(mean)	0.548	0.386	0.467	0.227	0.232	0.166
	interaction	**-0.212**	**-0.092**	**-0.231**	**-0.007**	**-0.054**	**-0.033**

APPENDIX B

TIME SERIES PROPERTIES OF CORRECTED AND UNCORRECTED SERIES

Unit Root Test:

Null Hypothesis: uncorrected series has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.066102	0.5490
Test critical values:	1% level	-4.192337	
	5% level	-3.520787	
	10% level	-3.191277	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(FW)
Method: Least Squares
Date: 01/01/02 Time: 00:07
Sample (adjusted): 1968 2009
Included observations: 42 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
FW(-1)	-0.130601	0.063212	-2.066102	0.0455
C	-0.020288	0.032860	-0.617414	0.5406
@TREND(1967)	0.002240	0.001553	1.442127	0.1572

R-squared	0.166012	Mean dependent var	0.025753
Adjusted R-squared	0.123244	S.D. dependent var	0.037420
S.E. of regression	0.035038	Akaike info criterion	-3.796004
Sum squared resid	0.047879	Schwarz criterion	-3.671884
Log likelihood	82.71608	Hannan-Quinn criter.	-3.750509
F-statistic	3.881637	Durbin-Watson stat	1.919802
Prob(F-statistic)	0.029014		

Null Hypothesis: D(FW) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on AIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.102623	0.0000
Test critical values:	1% level	-4.198503	
	5% level	-3.523623	
	10% level	-3.192902	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(FW,2)
Method: Least Squares
Date: 01/01/02 Time: 00:09
Sample (adjusted): 1969 2009
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(FW(-1))	-1.044669	0.171184	-6.102623	0.0000
C	0.048431	0.014808	3.270709	0.0023
@TREND(1967)	-0.000973	0.000525	-1.852569	0.0717

R-squared	0.495891	Mean dependent var	0.001580
Adjusted R-squared	0.469359	S.D. dependent var	0.050958
S.E. of regression	0.037121	Akaike info criterion	-3.678930
Sum squared resid	0.052362	Schwarz criterion	-3.553547
Log likelihood	78.41807	Hannan-Quinn criter.	-3.633273
F-statistic	18.69028	Durbin-Watson stat	1.900564
Prob(F-statistic)	0.000002		

Null Hypothesis: corrected series has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 4 (Automatic - based on AIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.311114	0.4181
Test critical values:	1% level	-4.219126	
	5% level	-3.533083	
	10% level	-3.198312	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(HW)
Method: Least Squares
Date: 01/01/02 Time: 00:10
Sample (adjusted): 1972 2009
Included observations: 38 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
HW(-1)	-0.205494	0.088916	-2.311114	0.0276
D(HW(-1))	-0.099802	0.165507	-0.603009	0.5509
D(HW(-2))	0.197449	0.163414	1.208275	0.2361
D(HW(-3))	-0.038185	0.168230	-0.226982	0.8219
D(HW(-4))	-0.380182	0.178463	-2.130310	0.0412
C	0.025964	0.040931	0.634321	0.5305
@TREND(1967)	0.002508	0.002110	1.188254	0.2438

R-squared	0.296227	Mean dependent var	0.027591
Adjusted R-squared	0.160013	S.D. dependent var	0.064714
S.E. of regression	0.059311	Akaike info criterion	-2.647215
Sum squared resid	0.109052	Schwarz criterion	-2.345554
Log likelihood	57.29708	Hannan-Quinn criter.	-2.539886
F-statistic	2.174713	Durbin-Watson stat	1.791644
Prob(F-statistic)	0.072584		

Null Hypothesis: D(HW) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=9)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-6.420632	0.0000
Test critical values:	1% level	-4.198503	
	5% level	-3.523623	
	10% level	-3.192902	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(HW,2)
Method: Least Squares
Date: 01/01/02 Time: 00:15
Sample (adjusted): 1969 2009
Included observations: 41 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(HW(-1))	-1.102900	0.171774	-6.420632	0.0000
C	0.057443	0.023291	2.466299	0.0183
@TREND(1967)	-0.001083	0.000877	-1.234234	0.2247

R-squared	0.521492	Mean dependent var	0.003224
Adjusted R-squared	0.496307	S.D. dependent var	0.090478
S.E. of regression	0.064214	Akaike info criterion	-2.582846
Sum squared resid	0.156689	Schwarz criterion	-2.457462
Log likelihood	55.94833	Hannan-Quinn criter.	-2.537188
F-statistic	20.70676	Durbin-Watson stat	1.842288
Prob(F-statistic)	0.000001		

So both uncorrected and corrected series are I(1).

AR(1) Test:

Source	SS	df	MS				
						Number of observations	42
						F (1,40)	998.22
Model	3.749	1	3.749			Prob > F	0.000
Residual	0.150	40	0.004			R-squared	0.9615
Total	3.899	41	0.095			Adj R-squared	0.9605
						Root MSE	0.06128
	Coef.	Std. Err.	t	P>ItI	[95 % Conf. Interval]		
Corrected series							
L1.	0.944	0.030	31.59	0.000	0.883	1.004	
Constant	0.040	0.011	3.72	0.001	0.018	0.061	

Source	SS	df	MS				
						Number of observations	42
						F (1,40)	2703.8
Model	3.409	1	3.409			Prob > F	0.000
Residual	0.050	40	0.001			R-squared	0.9854
Total	3.459	41	0.084			Adj R-squared	0.9851
						Root MSE	0.03551
	Coef.	Std. Err.	t	P>ItI	[95 % Conf. Interval]		
Uncorrected series							
L1.	0.957	0.018	52	0.000	0.920	0.994	
Constant	0.026	0.005	4.82	0.000	0.015	0.038	

So both uncorrected and corrected series are AR(1).

APPENDIX C

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Elitaş, Zeynep
Nationality: Turkish (TC)
Date and Place of Birth: 9 February 1980, Ankara
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EDUCATION

Degree	**Institution**	**Year of Graduation**
BS	Gazi University Economics	2002
High School	Ayrancı Anadolu High School, Ankara	1998

WORK EXPERIENCE

Year	**Place**	**Enrollment**
2004- Present	METU Department of Economics	Teaching and Research Assistant

FOREIGN LANGUAGES

Advanced English

FIELDS OF INTEREST

Microeconomics, Labor Economics, Microeconometrics, Wage dynamics, Search and Matching Models.

HONORS AND AWARDS

Undergraduate Merit Award, *Turkish Economic Association* (*TEK*), 2002.

Graduated with a Top Honor from Faculty of Economics and Administrative Sciences, Gazi University, 2002.

WORK IN PROGRESS

"A Note on the College-Premium Framework", with Hakan Ercan and Semih Tümen.

"Reassessing the Trends in the Relative Supply of College-Equivalent Workers in the U.S.: A Selection-Correction Approach", with Hakan Ercan and Semih Tümen.

PRESENTATIONS

2004

11th Annual Conference of the Multinational Finance Society (MFS), July, İstanbul, Turkey.

2011

Anadolu International Conference in Economics (EconAnadolu 2011), June, Eskişehir, Turkey.

2012

26th Annual Conference of the European Society of Population Economics (ESPE 2012), June, Bern, Switzerland.

APPENDIX D

TURKISH SUMMARY

Amerika Birleşik Devletleri'nde (ABD), üniversite eğitimine sahip kişiler (yüksek becerili) ile lise eğitimine sahip kişiler (düşük becerili) arasındaki ücret farklılıkları, 1970'lerden sonra 1990'ların başlarına kadar önemli ölçüde artmıştır. Bu artışın kaynaklarını inceleyen araştırmacılar, analizlerini becerilerin nispi arz ve talebi arasındaki etkileşimleri içeren bir çerçeve üzerine inşa etmişlerdir. Bu çerçeve, ücret farklılıklarını açıklamada "piyasa" yanlı açıklamalara temel teşkil etmiş olup, 1990'ların başlarına kadar ABD verilerini açıklamada etkili olmuştur. Bu dönem üniversite-eşdeğer işgücü (bir lisans veya yüksek lisans derecesi sahipleri ile üniversite eğitimlerini yarıda bırakmış ve ortalama ücret seviyesinin üzerinde ücret alanlar) nispi arzının keskin ve giderek arttığı ve bunun da nispi talepte benzer bir artış eğilimi ima ettiği bir dönemdir. Bu olgu, ABD işgücü piyasalarında, nitelikli işgücünü niteliksiz lehine destekleyen nispi talep kaymasına karşılık gelen sürekli bir teknolojik ilerlemenin-beceri yanlı (eğilimli) teknolojik değişimin (SBTC-BYTD)- varlığı olarak hipotize edilmiştir. Bu tanıma göre, beceri yanlı teknolojik değişim, bilgisayar donanımlı teknolojilere artan yatırım ile ilişkilidir.

Ancak, 1990'ların başından sonra üniversite-eşdeğer işgücü nispi arzındaki artış oranı, üniversite ücret getirisi (college premium) artış oranında paralel bir yavaşlamaya eşlik ederek, yavaşladı. Kanonik (standart) üniversite ücret getirisi denklemine göre, nitelikli işçiler için göreli (nispi) talep de, 1990'lardan sonra yavaşladı. Bu durum, bilgisayar donanımlı yatırımlar ile beceri yanlı teknolojik değişimi ilişkilendiren hikaye ile şiddetli bir biçimde tezat içindedir. Üniversite ücret getirisi denklemi tersini söylüyorken, gerçekte bilgisayar yatırımları, 1990'larda daha da hızla büyümeye devam etmiştir. Literatürde gelişmekte olan uzlaşma, yukarıda adı geçen saf “piyasa" faktörü açıklamasının ABD'de gözlenen üniversite ücret getirisi evrimini ve belirleyicilerini açıklamada başarısız olduğu yönündedir. Alternatif bir açıklama olarak, 1980'lerin başlarından bu yana ücret eşitsizliğinin nasıl geliştiğini açıklamada, reel asgari ücretlerdeki düşüşün rolü tartışılmıştır. Nihayet, Katz ve Kearney (2008) çalışmalarında, reel asgari ücretin gerçekten üniversite ücret getirisini etkilediğini ancak bunun çoğunlukla ücret dağılımının alt kısmında faaliyet gösterip, 1990'lardan bu yana ücret eşitsizliği gelişmelerini esas olarak etkileyen dağılımın üst kısmını o kadar da etkilemediğini göstermişlerdir. Sonuç olarak, reel asgari ücret değişimleri yavaşlamayı tam olarak açıklayamaz. İş çevrimleri (dalgalanmaları) [Hoynes, Miller ve Schaller (2012)] ve daha az vasıflı işlerde dış kaynak kullanımı [Feenstra ve Hanson (1999)] gibi diğer faktörlerin de üniversite ücret getirisi eğilimlerini etkilediği tartışılmaktadır. Bu bulgular, ücret farklılıkları yazınını, piyasa ve piyasa dışı faktörlerin ortaklaşa üniversite ücret getirisini belirlediği yönünde etkilemiştir.

Standart üniversite ücret getirisi analizinde, temel değişken üniversite-dengi (eşdeğeri) işgücü ile lise-dengi (eşdeğeri) işgücünün göreli arzını belirleyen değişkendir. Bu değişken nispî arz endeksi (değişkeni) olarak isimlendirilmektedir. Üniversite-eşdeğer işgücü arzı tam zamanlı tam yıl (FTFY-TZTY) işgücü tarafından, aşağıdaki üç eğitim kategorisinin ilgili eğitim kategorisindeki ortalama ücret ile ağırlıklandırılmış olarak arz edilen toplulaştırılmış çalışma saati olarak hesaplanmaktadır: (i) yüksek lisans eğitimli (COL +) çalışanlar, (ii) lisans dereceli çalışanlar (COL) ve (iii) üniversite eğitimini tamamlamamış, bir lisans derecesi almamış ve medyan ücretin üstünde ücret kazanan çalışanlar (SC2). Diğer taraftan, lise-eşdeğeri işgücü arzı ise, benzer olarak, geride kalan diğer üç eğitim grubu kategorisindeki işgücünün ağırlıklandırılmış toplam çalışma saati ile hesaplanmaktadır: (i) bir lise diplomasına sahip olamayanlar (HSD), (ii) lise mezunları (HSG) ve (iii) üniversite eğitimini tamamlamamış, bir lisans derecesi almamış ve medyan ücretin altında ücret kazanan çalışanlar (SC1). Bu iki toplamın oranı üniversite-eşdeğer işgücünün nispî arzını vermektedir.

Yazında geçerli olan ve bu şekilde hesaplanan bir ağırlıklandırma prosedürü, görece yüksek eğitimli işçi tarafından arz edilen bir saatlik çalışmanın, daha düşük eğitimli işçi tarafından arz edilen bir edilen bir saatlik çalışmadan daha fazla olduğu anlamına gelen temel "verimlilik üniteleri (birimleri)" (efficiency units) fikrini açıklamaktadır. Başka bir deyişle, bu hesaplama yöntemi, belli bir zaman süreci içinde bir işçi tarafından sürekli bir üretim teknolojisi için üretilen miktarın soyut bir ölçüsü olan "verimlilik birimleri" fikrini, çalışan nüfusun eğitim kompozisyonunda gözlenen değişikliklerin etkisini açıklayabilmesi bağlamında yakalayabilmektedir. Fakat, bu hesaplama yönteminin iki eksikliği söz konusudur. Birincisi, bu yöntem yalnızca veri setindeki tam zamanlı tam yıl çalışanlar üzerinde yoğunlaşmaktadır. Diğer bir deyişle, bu yöntem yalnızca tam zaman tam yıl statüsü içerisine seçim yanlılığında bulunmuş çalışanları örneklem olarak almaktadır. İkincisi, bu yöntem doğası itibariyle, verimlilik birimlerinde zaman içerisinde meydana gelen olası değişiklikleri yakalayamamaktadır. Diğer bir deyişle, yöntem üniversite eğitiminin lise eğitimine göreli verimliliğinin zaman içerisinde değişebileceğini hesaba katmamaktadır. Bunun nedeni, işgücü arzının verimlilik birimleri hesaplanırken, toplam çalışma saatinin (arzının) göreli reel ücretlerin tüm örneklem dönemindeki ortalaması ile ağırlıklandırılmasıdır. Başka bir deyişle, toplam işgücü arzı, "sabit" bir ağırlıkla hesaplanmaktadır. Dolayısıyla, yazındaki bu "sabit verimlilik birimleri" hesaplaması, nitelikli işgücünün niteliksiz işgücü karşısındaki göreli verimliliğini sabit kabul etmekte ve bunun örneklem dönemi boyunca değişmediğini varsaymaktadır.

Bu çalışmanın amacı, mevcut yazında ücret eşitsizliği eğilimlerini açıklamakta yaygın olarak kullanılan standart arz ve talep çerçeveli analize metodolojik bir katkı sağlamaktır. Mevcut çerçeve, yukarıda belirtilen iki önemli eksikliğe sahip olması nedeniyle, işgücü statüsündeki yanlı seçimlerin sonucu olarak eğitim kategorileri içerisinde gözlemlenemeyen kompozisyonel değişiklikleri yakalamak ve işgücü kompozisyonundaki verimlilik (kalite) değişim ve gelişimlerini hesaba katmak adına kimi düzenlemelere ihtiyaç duymaktadır. Bu amaçla, tez, yazında varolan göreli arz hesaplama yöntemini yeniden gözden geçirmekte ve belirtilen eksiklikleri düzeltecek şekilde yeni bir yöntem geliştirmeyi amaçlamaktadır. Böyle bir düzeltme, standart çerçevedeki "verimlilik üniteleri" fikrinin mekanik uygulamasının sebebiyet verdiği sağlamlık sorunların niteliğini ve kapsamını belgelemek için faydalı olacaktır. Bu amaçla, çalışmada tam zamanlı tam yıl çalışma statüsündeki yanlı seçimden kaynaklanan tutarsız tahmine neden olmamak için, Heckman'ın (1979) iki aşamalı tahmin yöntemi kullanılmıştır. Heckman iki aşamalı tahmin yöntemi ile gözlemlerin yanlı (bias) tahmini ortadan kaldırılarak, yanlı olmayan ve düzeltilmiş göreli arz serileri oluşturulmuş ve Ters Mills Oranları kullanılarak, eğitim kategorileri içerisindeki gözlemlenemeyen değişiklikler yakalanmıştır. Bu, verimlilik birimlerini sabit ve dışsal olmaktan çıkarıp, içsel hale getirmiştir. Daha sonra, oluşturulan bu yeni ve seçiciliği-düzeltilmiş (selection-corrected) göreli arz serilerinin ücret eşitsizliğinin ampirik analizindeki ve bu analiz sonuçlarının beceri yanlı teknolojik değişimin yeniden değerlendirilmesi bağlamındaki etkileri araştırılmıştır.

Yukarıda da belirtildiği gibi, çalışmadaki yanlı seçicilik argümanı ardındaki ana fikir, işgücünün tam zamanlı tam yıl statüsü içerisinde seçilebilecek olmasıdır. Yine daha önce belirttiğimiz gibi, mevcut yazındaki çalışmaların büyük çoğunluğu, bu seçicilik argümanını gözardı ederek, tam zamanlı tam yıl çalışan işgücüne odaklanmıştır. Oysa ki, istihdam edilen çalışanlar içerisinde, tam zamanlı tam yıl statüsüne yanlı seçicilik durumu, eğitim kategorileri bazında 1960'lardan günümüze farklı eğilimler sergilemektedir. Tüm veri seti içerisinde, çalışan iyi eğitimli işgücü tam zamanlı tam yıl statü oranı oldukça yüksek ve istikrarlı- yüzde 90'ın üzerinde- seyretmektedir. Diğer yandan, düşük eğitim düzeyine sahip çalışanlar arasında, bu oran önemli zaman değişimleri sergilemektedir. Bu grup içerisinde, tam zamanlı tam yıl statüsünü seçicilik daha düşük ve çok daha geçicidir. Örneğin, lise diplomasına sahip olmayan çalışan grup içerisinde, 1960'ların sonlarında yüzde 80 olan TZTY statü oranı, hızla yüzde 60'lara inmiştir. Benzer eğilimler, medyan ücretten daha az kazanan ve lisans diplomasına sahip olmayan grup ve lise mezunu çalışanları da dahil olmak üzere diğer daha az vasıflı işgücü için de gözlenmiştir. Bu gözlemler, gözlenmeyen becerilerin kompozisyonunun, yüksek eğitimli olanlar içinde potansiyel olarak çok daha küçük iken, düşük eğitimli çalışan işçilerin içinde keskin hareketlere tabi olduğunu göstermektedir. Standart üniversite ücret getirisi analizi, eğitim kategorileri arasındaki gözlenebilir değişimleri hesaba katabilirken, bu kategorilerin kendi içerisinde tam zamanlı tam yıl seçiminden kaynaklanan gözlenemeyen kompozisyonel değişimleri gözardı etmektedir. İşte düşük ve yüksek becerili işgücü arasındaki tam zamanlı tam yıl seçim marjı ile ilişkili bu çok farklı trendler bu çalışmayı teşvik etmiştir.

Bu gözlemler mevcut tahminlerin nispî arz serisinin ücret eşitsizliğinin analizi için önemli olan bazı sistematik bileşenleri açısından eksik olabileceği ile ilgili kaygılara yol açmaktadır. Biz bu iki güçlü varsayımın- işgücü arzının verimlilik birimlerinin sabit olması ve dolayısıyla yüksek becerili işgücünün düşük becerili işgücü karşısındaki göreli üstünlüğünün zaman içerisinde değişebileceğinin gözardı edilmesinin ve yalnızca tam zamanlı tam yıl çalışan işgücünün örneklem olarak alınmasının yarattığı yanlı ve tutarsız tahminlerin- kayıp parçalar olduklarını, ekonomik olarak anlam ifade ettiklerini, ücret eşitsizliği mevcut yazınındaki tahminlerde sistematik eksiklikler yarattıklarını ve bu nedenledir ki özel bir ilgi ile yeniden ele alınmaları gerektiklerini önermekteyiz.

Analizin ilk aşamasında, anlamlı bir seçim yanlılığı var olup olmadığı araştırılmaktadır. Bu amaçla, tam zamanlı tam yıl çalışma statüsünü bir tercih (seçim) değişkeni olarak modelleyecek biçimde Heckman iki aşamalı tahmin yöntemi uygulanmıştır. Seçiciliği-düzeltilmiş göreli arz serilerini, düzeltilmemiş yanlı seriler ile karşılaştırılmıştır. Elde edilen sonuçlar, tam zamanlı tam yıl seçimini gözardı etmenin sonuçları yanlı (bias) hale getirdiğini kanıtlamıştır. Sonuçlar, seçiciliğin anlamlı olduğunu ve seçicilik düzeltilmesi koşulu altında, üniversite-eşdeğer işgücü göreli arzındaki büyüme oranının 1990'lardan önce yazında belirtilenden çok daha keskin ve bu tarihten sonrasında ise yazında belirtilenden çok daha yavaş olduğunu, dolayısıyla göreli arzın büyüme oranındaki yavaşlamanın seçicilik düzeltmesinden sonra daha da belirgin hale geldiğini göstermiştir. Bu da, düşük becerili işçilerin zamanla değişen tam zamanlı tam yıl statüsü seçimlerinden kaynaklanan gözlenmeyen bileşimsel değişimlerin hesaba katılması gerektiğini ortaya koymaktadır.

İkinci aşamada, yukarıda belirtilen seçim yanlılığının kaynakları araştırılmaktadır. Bu görevi gerçekleştirmek için, eğitim ve tecrübe (deneyim) grupları arasındaki ters Mills oranları kompozisyonuna daha derin bir göz atılmıştır. Bunla amaçlanan, zaman içerisindeki tam zamanlı tam yıl statüsü kendiliğinden seçiminin ana yapısını anlamaktır. İki aşamalı tahmin yönteminin ikinci aşamasından gelen Ters Mills oranları, verimlilik birimlerinin içsel hale getirilmesinde kullanılan zaman-değişkenli ağırlıklar olarak kullanılmışlardır. Diğer bir deyişle, tam zamanlı tam yıl seçimlerindeki diferansiyel etkiler, verimlilik birimlerinin zaman içerisinde nasıl hareket ettiğini tanımlayabilmektedir. Bu aşamada elde edilen sonuçlar, tam zamanlı tam yıl çalışma statüsündeki kendinden seçim yanlılığının daha az eğitimli ve daha az tecrübeli işgücü üzerinden faaliyet gösterdiğini kanıtlamaktadır. Sonuçlar, lise diplomasına sahip olmayan ve 0-9 yıl arasında potansiyel işgücü piyasası tecrübesine sahip olan çalışanların 1980’den önce tam zamanlı tam yıl statüsü içerisinde aşırı temsil edildiklerini, bu tarihten sonra ise seçim yanlılığının dikkate alınmadığını göstermiştir. Aynı eğilimler, çok daha zayıf bir biçimde de olsa, lise mezunu ve 10-19 yıllık işgücü piyasası tecrübesine sahip çalışanlar için de rapor edilmiştir. Bu durum, yanlı seçiciliğin yönünün 1980'li yılların ortalarından sonra tersine döndüğü anlamına gelir. Daha vasıflı (nitelikli) işçiler için de seçicilik belirtileri vardır, ancak bu gruptaki seçicilik trendleri zamanla çok değişmiş değildir; yani, nispî arz eğilimlerini etkilememektedir. Diğer bir deyişle, seçiciliğin dikkate alınması becerilerin nispi arz eğilimlerini etkilemektedir ve bu eğilimlerin ana kaynağı düşük becerili işgücünün yanlı seçimlerindeki eğilimlerden kaynaklanmaktadır. Tüm bu sonuçların gerisindeki öngörü, yazındaki çerçevede düşük becerili işgücünün tam zamanlı tam yıl çalışma statüsü açısından 1980’lerin ikinci yarısından önce aşırı temsil edilmesi ve bu tarihten sonra ise yetersiz temsil edilmesidir. Seçiciliği düzeltilmiş göreli arz serileri ile yapılan analizler, becerilerin göreli arzını- düzeltilmemiş serilere kıyasla- 1990’lardan önce daha dik, bu tarihten sonra ise daha yatay olarak tahmin etmektedir. Diğer bir deyişle, yazında sıkça vurgulanan üniversite dengi işgücünün göreli arzındaki düşüş, düzeltilmiş seriler söz konusuyken daha belirgindir. Bu bağlamda, düzeltilmemiş göreli arz serileri, yüksek becerili işgücü ile düşük becerili işgücü ikamesini gerçekte olduğundan daha az göstermektedir. Bu bulgu, aynı zamanda göreceli talep artışının düzeltilmemiş arz serileri kullanıldığında daha güçlü olduğunu ima eder. Dolayısıyla, bu sonuç, beceri yanlı teknik değişim hipotezinin uygunluğuyla ilgili şüphe doğurmaktadır. Sonuç olarak, düşük eğitimli grupların kendi içindeki beceri kompozisyonunun, ABD'deki üniversite-eşdeğer işgücünün göreceli arz eğilimlerini anlamak açısından kritik olduğu sonucuna varılmıştır.

Bundan sonraki aşamada, düşük beceri işçilerin seçicilik eğilimlerindeki değişiklikleri tetikleyen nedenler sorgulanmıştır. Seçim yanlılığının düşük eğitimli grupların gözlenmeyen beceri kompozisyonu üzerinden işlediği gerçeği, seçicilik eğilimleri için bir açıklama arayışında, ücret dağılımının alt kısmını etkileyen faktörlere odaklanmak gerektiğini göstermektedir. Bu bağlamda, reel asgari ücretler bu mekanizmayı açıklamada iyi bir adaydır. Bu çalışma, içsel teknolojik değişim ve asgari ücret yasaları arasındaki etkileşimin yönünün potansiyel tetikleme mekanizması olduğunu önermektedir. Üreticiler tarafından kullanılan kâr yaratıcı motifler, endojen olarak üretim farklı üretim faktörlerine atanacak yenilikçi çabaların miktarını belirlemektir (örneğin, Ar-Ge harcamaları, patent vb). Bu faktörler nitelikli ve niteliksiz işgücünü içermektedir. Böylece, teknik ilerlemenin yönü, niteliksiz-yanlı (örneğin, on sekizinci ve on dokuzuncu yüzyıllarda İngiltere) ya da nitelik-yanlı (örneğin, İkinci Dünya Savaşı'ndan sonra Amerika Birleşik Devletleri) durumlara yol açabilir. Kurumlar (yani, piyasa dışı faktörler) teknik değişimin gücünü büyütme veya zayıflatma yönünde rol oynayabilir. Bu mekanizmayı daha iyi anlamak için, şu örnek faydalı olacaktır: Varsayalım ki, üniversite dengi işgücü nispî arzı sabit bir oranda büyüyor olsun ve politika yapıcılar reel asgari ücret seviyesini sürekli olacak bir biçimde yükseltmiş olsun. Bu durum, nitelikli işgücü lehine olan teknolojilere yatırımları tetiklerken, niteliksiz işgücünü daha pahalı hale getirir. Bu da, toplumun üniversite eğitimine olan yatırımını daha hızlı bir oranda yükselterek, üniversite eğitiminin göreceli getirisini yükseltir. Bu durumun tam tersi, reel asgari ücretler sürekli bir şekilde düşürüldüğü zaman geçerlidir. Bu bağlamda, ABD'deki reel asgari ücret eğilimleri, öngörmüş olduğumuz tam zamanlı tam yıl seçim yanlılığı ile mükemmel bir şekilde örtüşmektedir. Bu bulgunun dışında, analizler göstermiştir ki, reel asgari ücretlerdeki dalgalanmalar ücret eşitsizliğini yalnızca direk olarak etkilememekte, bunun yanında üniversite eşdeğer göreli arzını da etkilediği için, bu kanalla da ücretler üzerinde dolaylı bir etki yaratmaktadır. Bu durum politika yapıcılar açısından önem taşımaktadır. Zira piyasa dışı faktörlerin- çalışmada vurgulandığı üzere reel asgari ücretlerin- dolaylı, ikincil etkileri de araştırılmalıdır. Bu bulgu mevcut yazında daha önce vurgulanmamış bir noktaya işaret etmektedir ve bu açıdan büyük önem taşımaktadır.

Sonuç olarak, bu çalışma sırasıyla belirtilen şu üç noktanın tekrar araştırılması ve değerlendirilmesini önermektedir. Birincisi, mevcut yazında belirtilen göreli arz düşüşü, seçim yanlılığını düzelttikten sonra hesaplanan arz indeksi söz konusuyken daha belirgindir. Bu sonuç, beraberinde beceri yanlı teknolojik gelişme eğilimindeki düşüşün daha keskin olduğu ve dolayısıyla, yazında bu yönde belirtilen bilmecenin aslında daha da derin olduğu sonucunu doğurmaktadır. İkinci olarak, çalışmada öngörülen yanlı seçim eğilimleri belirtilen muammayı açıklamaktan ziyade, bu durumu daha da güçlendirici bir faktör olarak ortaya çıkmaktadır. Sonuncu olarak, yukarıda belirtildiği gibi, göreli arz serileri kurumsal faktörlerden-piyasa dışı faktörlerden- etkilenmektedir. Bu bağlamda, anlamlı bir ücret farklılığı analizi yapabilmenin yolu işgücünü etkileyen niceliksel faktörlerin dışında, eğitim kategorilerinin kendi içerisinde oluşan ve gözlenemeyen kompozisyonel ve niteliksel faktörleri de hesaba katmaktan geçmektedir. Dolayısıyla, işgücü verimliliğini anlamada kullanılan ve piyasa ve piyasa dışı faktörleri içeren arz-talep etkileşim çerçevesi bağlamında araştırmaya açık yeni alanlar bulunmaktadır. Tüm bu bahsedilen etkilerin ücret eşitsizliği üzerindeki etkisini analiz edecek daha genel bir beşeri sermaye modeline ihtiyaç vardır.

ABD işgücü piyasalarındaki ücret eşitsizliği eğilimleri ve bunun temel nedenleri geniş bir biçimde belgelenmiştir. Bu değişimlerin kendisinden ziyade, değişimlerin kaynakları daha ayrıntılı incelenen bir konu olmuştur. Ücret farklılıklarını açıklayan başlıca üç değişik açıklama mevcuttur.

Birinci grup açıklamalar, ücret yapısındaki değişiklikler için arz ve talepte meydana gelen değişikliklerin sorumlu olduğunu vurgulamaktadırlar. Bu gruptaki çalışmalar, ücret farklılıklarının, daha eğitimli ve daha vasıflı işgücü lehine olan göreceli talep artışından kaynaklandığını ileri sürmektedirler. Yukarıda belirtilen beceri-yanlı teknolojik gelişme hipotezi, bu ilk grup yazının temel açıklayıcısıdır. Bilgisayar devrimi ile ilişkili teknolojik değişimlerin daha vasıflı işgücüne olan talebi artırdığı ileri sürülmektedir. Bu ilk grup çalışmalar arasında, Bound ve Johnson (1992), Katz ve Murphy (1992), Juhn, Murphy ve Pierce (1993), Berman, Bound ve Griliches (1994), Berman, Bound ve Griliches (1994), Borjas, Freeman ve Katz (1997), Goldin ve Katz (2007a, 2007b), Autor, Katz ve Krueger (1998), Katz ve Autor (1999), Card ve Lemieux (2001), ve Acemoglu (2002) örnek gösterilebilir. Tüm bu çalışmalardaki temel argüman, teknolojik ilerleme sayesinde nitelikli işgücüne olan talebin arttığı, bunun da artan ücret eğilimlerinin gerisindeki neden olduğudur.

İkinci gruptaki çalışmalar, her ne kadar ilk grup açıklamaları kadar taraftar bulamamış ve daha az yaygın olarak Kabul görmüş olsalar da, gelişmekte olan ülkeler ile ticaret hacminin artmasının rolü üzerinde durmuşlardır. Bu gruptaki çalışmaların temel argümanı, 1980'li yıllarda gelişmekte olan ülkelerde artan ticaret ve büyük ticaret açıkları ile ilişkili olarak artan ithalat rekabetinin imalat üretimi istihdamını düşürdüğü ve dolayısıyla da daha az vasıflı işçilere karşı göreceli talep kaymasına neden olduğudur. Bu sayede, daha vasıflı işgücü ile daha az vasıflı işgücü arasında ücret farklılıkları gözlenmiştir. Bu grup çalışmalar arasında, Lawrence ve Slaughter (1993), Berman, Bound ve Griliches (1994), Borjas ve Ramey (1994), Krugman ve Lawrence (1994), Burtless (1995), Wood (1995), Buckberg ve Thomas (1996), Bernard ve Jensen (1997), Borjas, Freeman ve Katz (1997), ve Topel (1997) ve daha birçokları sayılabilir.

Üçüncü ve son grup çalışmalar ise, ücret farklılıklarını açıklamada birinci grup çalışmaların aksine, kurumsal- piyasa dışı- faktörlerin önemini vurgulamışlardır. Bu çalışmalar, arz ve talep etkileşimlerini içeren piyasa faktörlerinden ziyade, sendikalaşma değişimleri yahut reel asgari ücretlerdeki dalgalanmaların, başka bir deyişle, piyasa dışı faktörlerin, ücret farklılıkları üzerinde etkili olduğunu ileri sürmüşlerdir. Bu yazındaki bir grup çalışma, sendika faaliyetlerinin önemini vurgulamaktadır. Blackburn, Bloom, ve Freeman (1990), Freeman (1993), Dinardo ve Lemieux (1995), Dinardo, Fortin ve Lemieux (1996), Freeman (1996), ve Card (2001) bunlara örnek teşkil etmektedir. Bu yazındaki ikinci grup çalışmalar da daha önce belirtildiği gibi, reel asgari ücretlerin etkilerini vurgulamaktadırlar. Dinardo, Fortin ve Lemieux (1996), Lee (1999), Teulings (2003), ve Lemieux (2006) bu grup çalışmalardandır. Genel olarak, bu son çalışmalar, "revizyonist" yazın olarak adlandırılmaktadır ve piyasa dışı bu faktörlerin, temel olarak 1980'lerde reel asgari ücret seviyesinde görülen düşüşün, ücret dağılımının alt seviyesindeki yükselen eşitsizliğin önemli bir belirleyicisi olduğu öne sürülmektedir. Her ne kadar ücret eşitsizliği yazınında, bu epizodik olayın ücret dağılımının üst seviyelerini etkilemediği kabul görse de, belirtilen bu kurumsal faktörlerin ücret eşitsizliği analizinde giderek daha fazla ciddiye alınması bu çalışmaların bir sonucudur.

Ücret farklılıklarının piyasa faktörlerinden kaynaklandığı ileri süren birinci grup "geleneksel" yazın ile piyasa dışı faktörlerin önemini vurgulayan "revizyonist" yazın arasında tartışmalar devam ederken, Katz ve Kearney (2008) çalışması bu iki grup yazını yeniden değerlendiren ve daha da önemlisi bunları birleştirici bir şekilde yorumlayan ve analize dahil eden bir çalışma ortaya koymuştur. Çalışma sonucunda, "revizyonist" yazının iddiası lehinde -ücret eşitsizliği artışının 1980'lerin başında meydana gelen epizodik bir olay olduğu - destek bulunamamış ve 1980'lerden itibaren günümüze kadar ücret dağılımının üst kısmında artış gösteren eşitsizliğin bir defalık gerçekleşen epizodik bir olay olmadığı ve aksine "geleneksel" yazının belirttiği gibi bu artışın kalıcı ve devam eden bir süreç olduğuna dair bulgular gözlenmiştir. Fakat çalışmada belirtilen bir diğer husus da, "geleneksel" yazının 1990'ların başında gözlenmeye başlayan ve bir muamma-bilmece- olarak adlandırılan göreli talepteki artış oranının düşüşünü açıklayamamasıdır. Bu tez, bu anlamda da önemli bir vurgu yapmaktadır. Mevcut yazının göz ardı ettiği husus olan kurumsal faktörlerin dolaylı ve ikincil etkiler yarattığı ve bu etkilerin incelenmesi gerektiği gerçeği, belki de bu muamma için bir açıklama teşkil edebilir.

Ücret farklılıkları ve kaynaklarını araştıran yazının standart kanonik arz-talep modelinden faydalandığı ve bu modeldeki göreli arz hesaplama yönteminin “sabit verimlilik birimleri” kullandığı daha önce belirtilmişti. Göreli arz serilerinin hesaplanmasında sabit işgücü verimlilik birimlerinin kullanılması varsayımının yanlış hesaplamalara yol açabileceği fikri, yazında Carneiro ve Lee (2011) ile Bowlus ve Robinson (2012) çalışmaları ile oldukça ilintilidir. Carneiro ve Lee (2011), eğitim kalitesinde zaman içerisinde meydana gelen değişimlerin sabit verimlilik ünitelerini içselleştirme konusunda bir araç olarak kullanılabileceklerini savunmuştur. Bu bağlamda, son yıllarda ABD’de düşüş eğiliminde olan üniversite eğitimi kalitesi göreli arz hesaplamalarında toplam saate ilişkilendirilecek bir ağırlık ölçütü olarak sunulmaktadır. Bu da, ağırlıkların azalan olması sonucunu doğurmaktadır. Bu koşul altında, diğer bir deyişle, azalan ağırlıklarla hesaplanan göreli arz serileri, sabit verimlilik birimlerinin göreli arz artış oranını ve dolayısıyla da tahmin edilen beceri yanlı teknolojik gelişme eğilimi artış oranını, olduğundan daha fazla tahmin etme eğilimine sahip olduğunu söylemektedir. Öte yandan, ağırlıklandırma ölçüsü Bowlus ve Robinson (2012) çalışmasında olduğu gibi, artan işgücü verimliliği olarak kabul edilirse, bu defa, artan ağırlıklarla hesaplanacak olan yeni arz serileri, beceri yanlı teknolojik gelişme eğilimi artış oranını, yazında belirtilenden daha az tahmin etme eğilimine sahip olacaktır. Dolayısıyla, bu noktada ağırlık birimi veya diğer bir deyişle işgücündeki kalite göstergesi olarak seçilecek ölçüt önem kazanmaktadır. Eğer bu ölçüt, eğitim kalitesi olursa, ağırlıklar azalan olacak ve bu da beceri yanlı teknolojik gelişme hipotezini olduğundan daha fazla vurgulamaya yol açacaktır. Tersine, eğer bu ölçüt, işgücü verimliliği olursa, bu defa, ağırlıklar artan olacak ve beceri yanlı teknolojik gelişme hipotezini olduğundan daha az vurgulanacaktır. Bu nokta eldeki çalışmanın vurgusu açısından çok önemlidir. Bu çalışma, mevcut yazının hangi ağırlıklandırma yönteminin seçilmesi gerektiği konusunda herhangi bir önermede bulunamadığını ve bu anlamda da zayıflık teşkil ettiğini vurgulamaktadır. Bu zayıflığı gidermek için, eldeki çalışma, daha önce de belirtildiği gibi seçim yanlılığını hesaba katarak geliştirilecek bir ağırlıklandırma yöntemi ile içsel verimlilik birimleri oluşturulacak ve bu da büyük ölçüde belirtilen sorunları çözecektir.

Mevcut yazındaki hesaplama yönteminde belirtilen ikinci eksiklik olan, tam zamanlı tam yıl statüsünde çalışmanın yanlı olabileceği konusu ise Mulligan ve Rubinstein (2008) çalışması ile oldukça ilgilidir. Bu çalışma, kadınların tam zamanlı tam yıl işgücüne katılım seçimi ile ilgilenmektedir ve bu seçimin kompozisyonel etkiler yaratmak suretiyle daralan kadın-erkek ücret farklarını açıklayabileceğini savunmaktadır. Eldeki çalışma, aynı şekilde erkeklerin tam zamanlı tam yıl çalışma statüsündeki yanlılığı hesaba katması açısından Mulligan ve Rubinstein (2008) çalışması ile benzerlik göstermektedir. Belirtilen çalışmada, bu kompozisyonel etkilerin belirleyicisi olarak kadın işgücünün beşeri sermayesine artan yatırım gösterilmiştir. Bizim çalışmamızda ise, bu çalışmadan farklı olarak, reel asgari ücrette meydana gelen dalgalanmalar, düşük becerili işgücünün seçim yanlılığı dolayısıyla yarattığı kompozisyonel etkileri açıklayan mekanizma olarak ileri sürülmüştür.

Bu iddia, mevcut yazındaki Lemieux (2006) çalışması ile ilintilendirilebilir. Lemieux (2006) çalışması, asgari ücretin reel değerindeki hareketlerin ABD'deki rezidüel ücret eşitsizliğindeki hareketlerle bağlantılı olabileceğini savunmaktadır. Bu çalışmaya benzer olarak, eldeki çalışma da, reel asgari ücretin işgücü kompozisyonu üzerindeki potansiyel etkilerini tartışmaktadır. Fakat Lemieux (2006) çalışmasından farklı olarak, biz bu hareketlerin göreli arz eğilimlerini de etkilemek suretiyle, ücret farklılıkları üzerinde doğrudan bir etki dışında, dolaylı bir etki de yaptığını savunmaktayız.

ABD'deki ücret eşitsizliği mevcut analizi iki temel varsayımlı basit bir toplulaştırılmış üretim modeli üzerine kuruludur. Bu varsayımlar: (1) toplam üretim fonksiyonu iki faktörlü- üniversite eşdeğer ve lise eşdeğer işgücü- Sabit İkame Esnekliği (CES)'ne sahiptir, ve (2) bu iki gruba marjinal verimlilikleri düzeyinde ödeme yapılır. Standart uygulama işgücü piyasasında becerilerine ödenen ücret hareketlerini yakalamak için bir üniversite-lise ücret farkı denklemi elde etmektir.

Sabit İkame Esnekliği'ne sahip iki üretim faktörlü toplulaştırılmış üretim fonksiyonu aşağıdaki gibi ifade edilir:

$$Y_t = A_t \left[\emptyset_t \, (a_t \, C_t)^{\frac{\sigma-1}{\sigma}} + \, (1 - \emptyset_t) \, (b_t \, H_t)^{\frac{\sigma-1}{\sigma}} \right]^{\frac{\sigma}{\sigma-1}}, \qquad \text{(A.1)}$$

Bu denklemde, Y_t üretim değerini, C_t ve H_t sırasıyla üniversite-eşdeğer ve lise-eşdeğer işgücü miktarını göstermektedir. Bu denklemden ilk olarak üniversite-eşdeğer ve lise-eşdeğer işgücünün marjinal verimlilikleri hesaplanmaktadır. Daha sonra, bu iki gruba ilişkin ücretler, bu hesaplanan marjinal verimliliklere eşitlenmek suretiyle, bu iki karar kuralları oranları hesaplanır. Daha sonra, bu oranın doğal logaritması alınarak, aşağıdaki beceriye dayalı nispi ücret pozisyonu denklemi oluşturulur:

$$ln\left(\frac{w_{c,t}}{w_{h.t}}\right) = ln\left(\frac{\emptyset_t}{1-\emptyset_t}\right) + \frac{\sigma-1}{\sigma} \ln\left(\frac{a_t}{b_t}\right) - \ln\left(\frac{C_t}{H_t}\right) \qquad \text{(A.2)}$$

Yukarıdaki bu denklem şu şekilde düzenlenebilir:

$$ln\left(\frac{w_{c,t}}{w_{h.t}}\right) = \frac{1}{\sigma}\left[D_t - \ln\left(\frac{C_t}{H_t}\right)\right] \qquad \text{(A.3)}$$

Burada, zaman-değişkenli göreli talep değişikliklerini ve σ parametresi, üniversite-eşdeğer işgücü ile lise-eşdeğer gücü arasındaki ikame oranını temsil etmektedir.

Yazındaki Autor, Katz ve Kearney (2008) çalışması takip edilmek suretiyle, zaman-değişkenli göreli talep ölçüsü olan, D_t şu şekilde ifade edilebilir:

$$D_t = \beta_1 t + \beta_2 \ln(RMW_t) \qquad \text{(A.4)}$$

Yukarıdaki denklemde, t parametresi beceri yanlı teknolojik gelişmeyi ifade ederken, RMW parametresi reel asgari ücret trendini göstermektedir. Dolayısıyla göreli talep, iki etkinin birleşimidir: beceri yanlı teknolojik gelişme ve reeal asgari ücretlerdeki değişimler.

Dolayısıyla, tahmin edilecek nihai basit nispi ücret denklemi şu şekildedir:

$$\ln\left(\frac{w_{C,t}}{w_{H,t}}\right) = \beta_0 + \beta_1 t + \beta_2\, ln(RMW_t) + \beta_3\, ln\left(\frac{C_t}{H_t}\right) + \varepsilon_t \qquad (A.5)$$

Denklemdeki β_0 parametresi sabit bir katsayı, β_1 and β_2 sırasıyla beceri yanlı teknolojik gelişmeyi ve reel asgari ücret düzeyini gösteren katsayılardır. ε_t hata terimi ve β_3 parametresi ise yüksek becerili işgücünün, düşük becerili işgücüne oranını gösteren ikame oranının tersini (1/σ) vermektedir.

Göreli ücret denklemi, yaş ve deneyim grupları arasında ciddi değişiklikler gösterir. [Card and Lemieux (2001)]. Bu bağlamda mevcut yazımdaki Autor, Katz, ve Kearney (2008) çalışmasını takip edecek olursak, yukarıdaki ücret denklemi, farkı deneyim gruplarını da içerecek şekilde aşağıdaki gibi modifiye edilebilir. Bu denklem çalışmada tahmin edilecek nihai kapsamlı nispi ücret denklemini vermektedir:

$$\ln\left(\frac{w_{C,i,t}}{w_{H,i,t}}\right) = \beta_0 + \beta_1 t + \beta_2\, ln(RMW_t) + Z_i + \beta_3\, ln\left(\frac{C_t}{H_t}\right) + \beta_4 \left(\frac{C_{i,t}}{H_{i,t}}\right) + \varepsilon_{i,t} \qquad (A.6)$$

Tahmin edilecek olan bu iki denklemdeki temel sorun, göreli arz indeksinin (ölçüsünün) nasıl hesaplanacağıdır. Bu çalışma işte tam da bu noktada, mevcut literatürden farklı bir bakış açışı ve yöntem geliştirmektedir.

Ücret eşitsizliği yazınında genel olarak kullanılan geleneksel nispi arz ölçüsü şöyle hesaplanmaktadır. Beş tane eğitim kategorisi mevcuttur: lise diplomasına sahip olmayanlar (HSD), lise mezunları (HSG), üniversiteye girmiş ancak bir lisans diploması sahibi olmayanlar (SC), lisans mezunları (COL), ve lisans üstü mezunları (COL+). Üniversiteye girmiş ancak bir lisans diploması sahibi olmayanlar iki alt kategoriye ayrılmaktadır: SC1 and SC2. SC1 bu grup içerisinde olup, medyan ücretin altında ücret alanları ifade ederken, SC2 medyan ücretin üzerinde bir ücret alan grubu ifade etmektedir. Çalışmadaki notasyon şu şekildedir: , J Є {HSD, HSG, SC, COL, COL_+}. Bu belirtilen altı kategoriden, iki tane genel eğitim kategorisi oluşturulmaktadır: lise-eşdeğer işgücü: (HSD + HSG + SC1) ve üniversite-eşdeğer işgücü: (SC2 + COL + COL+). Bu iki oranın birbirine bölümünün logaritmik değeri göreli arzı vermektedir. Bu oran da toplam çalışma saatleri ile çarpılarak verimlilik birimlerini oluşturmaktadır.

Bu birimlerin mevcut yazındaki hesaplama yönteminin sabit verimlilik birimleri varsayımına dayandığını daha önce belirtmiştik. Bu hesaplama aşağıdaki formülasyonla ifade edilebilir:

$$J_t = \overline{w}^J h_t^J \quad \text{(A.7)}$$

Denklemde, J_t ilgili eğitim kategorisini, h_t^J J eğitim kategorisinde ve t zamanındaki toplam çalışma saatini göstermektedir.

$$\overline{w}^J = {}^1\!/_T \sum_{t=1}^{T} \left(\int_{I_J} \ln w_{i,t}^J \, \mathrm{dF}_{\mathrm{J,t}}(i) \Big/ \int_{I_{HSG}} \ln w_{i,t}^{HSG} \, \mathrm{dF}_{\mathrm{HSG,t}}(i) \right) \quad \text{(A.8)}$$

Burada, $\ln w_{i,t}^J$ logaritmik reel saatlik ücreti, T örneklem periyodunu, $\mathrm{F}_{\mathrm{J,t}}(i)$ kümülatif dağılım fonksiyonunu göstermektedir. Bu denklemden anlaşılması gereken en önemli nokta, toplam çalışma saatinin "sabit" bir ağırlık olan, $\overline{w}^J$ ile çarpılmasıdır. Bu mantığa dayanarak, C_t ve H_t değişkenlerini sırasıyla şu şekilde hesaplayabiliriz:

$$H_t = \sum_{J=HSD,HSG,SC1} J_t \quad \text{ve} \quad C_t = \sum_{J=SC2,COL,COL+} J_t \quad \text{(A.9)}$$

Bu çalışmada, ana odak, daha önce de belirttiğimiz gibi verimlilik birimleridir, $\overline{w}^J$. Yukarıdaki formülasyondan da anlaşılacağı üzere, verimlilik üniteleri, iki farklı bileşeden oluşmaktadır. Bunlar, "fiyat" ve miktar" bileşenleridir. Miktar bileşeni, her bir eğitim kategorisindeki toplam çalışma saatidir. Fiyat bileşeni ise, her bir eğitim grubundaki reel ortalama ücretin (tüm yılların ortalaması), lise mezunu grubundaki (çalışmadaki çapa eğitim grubu) ortalama ücrete bölünmesiyle elde edilen "sabit" bir bileşendir. İşte bu sabit bileşen, yıllar içerisinde değişiklik göstermemesi bağlamında, nitelikli işgücünün niteliksiz karşısındaki göreli konumunun değişebileceğini hesaba katmamaktadır. Oysa ki, gerçekte, bu oran yıldan yıla değişiklik gösterebilmektedir. Başka bir deyişle, örneğin, 1970 yılı için hesaplanacak nitelikli/niteliksiz işgücü arzı, 2005 yılı için hesaplanacak orandan açıkça farklı olmalıdır. Oysaki mevcut yazındaki bu sabit verimlilik birimleri varsayımı, bu olguya izin vermemekte ve dolayısıyla da gerçeği yansıtmamaktadır. Bu sayede hesaplanan göreli arz, işgücündeki kalite değişimlerini, bu nedenle, yansıtmayacak ve ücret analizinde ciddi sorunlara neden olacaktır.

Sonuç olarak, sabit verimlilik birimleri varsayımı, belki iyi bir ilk yaklaşımdır, fakat göreli işgücü arzındaki komposizyonel değişimlerin zaman içerisinde nasıl geliştiğini gözardı etmektedir. Bu çalışma, tam zamanlı tam yıl seçimlerini hesaba katarak, bu hesaplama yöntemini düzeltmekte ve böylece verimlilik ünitelerini içsel hale dönüştürmektedir.

Bu dönüştürme aşağıda belirtilen basit Heckman (1979) iki aşamalı tahmin yöntemi uygulanarak gerçekleştirilmiştir. Eğer w* tam zamanlı tam yıl çalışmadaki reel saatlik ücret düzeyini gösterirse, ampirik ücret denklemi aşağıdaki şekilde ifade edilebilir:

$$\ln(w_i^*) = x_i'\beta^* + \epsilon_i^* \qquad \text{(A.10)}$$

Buradaki ikili değişken, D_i tam zamanlı tam yıl statüsünü göstermektedir. Tam zamanlı tam yıl ücret düzeyi, $\ln(w_i^*)$ yalnızaca $D_i = 1$ olduğunda gözlenmektedir. Seçimi formülleştirmek için, çalışanın iki teklif gözlemlediği varsayılmaktadır: tam zamanlı tam yıl çalışma statüsü ve diğer statüler (tam zamanlı yarı yıl, yarı zamanlı yarı yıl, yarı zamanlı tam yıl).

Bu durumda, birinci aşama regresyonu aşağıdaki gibi olacaktır:

$$\mathbb{P}[D = 1 \mid x, z \mid= \mathbb{P}[\ln(w^*) > \ln(w) \mid x, z]$$

$$= \mathbb{P}[\eta > z'\gamma]$$

$$= \Phi\left({z'\gamma}/{\sigma_\eta} \right) \qquad \text{(A.11)}$$

İkinci aşama regresyonu ise şu şekildedir:

$$\mathbb{E}[\ln(w^*) \mid \ln(w^*) > \ln(w)] = x'\beta^* + \sigma^*/\sigma_\eta \, \lambda\left(-z'\gamma/\sigma_\eta\right) \quad \text{(A.12)}$$

O halde seçiciliği-düzeltilmemiş tahmini ücret denklemi şudur:

$$\mathbb{E}[\ln(w^*) \mid x] = x'\beta^* \quad \text{(A.13)}$$

Dolayısıyla, aşağıdaki terim:

$$\Lambda = \sigma^*/\sigma_\eta \, \lambda\left(-z'\gamma/\sigma_\eta\right) \quad \text{(A.14)}$$

tam zamanlı tam yıl çalışma seçiminin göreli arzı nasıl etkilediğini gösterecektir. Başka bir deyişle, bu terim, seçim yanlılığının sebep olduğu gözlenemeyen kompozisyonel değişiklikleri yakalamamızı sağlayacaktır.

$\widehat{\Lambda}_I$ parametresinin tahmin edilen ters Mills oranları ile onun tahmini katsayısının çarpımını gösterdiği varsayılırsa, bu tahmin edilen ters Mills oranları, aynı zamanda gözlemlerin yanlı (bias) tahminini ortadan kaldırmak amacıyla kullanılmaktadır. Başka bir deyişle, bu oranlar ağırlıklandırmada kullanılacak içsel değişkenlere işaret ederler. Bu sayede, seçim yanlılığının göreli arzı nasıl etkilediği bu oranlar yardımıyla hesaplanabilecektir. İçsel olarak oluşturulan ağırlık ölçüsü aşağıdaki gibi ifade edilebilir:

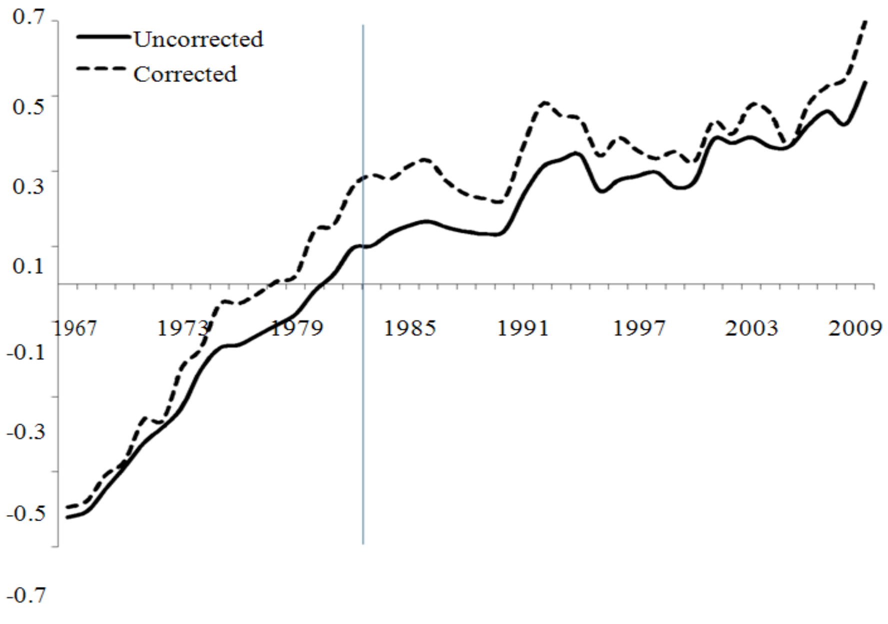
$$\overline{w}_t^J = \overline{w}^J + \left(\int_{I_J} \widehat{\Lambda}_{i,t}^{J} \, dF_{J,t}(i) \Big/ \int_{I_{HSG}} \widehat{\Lambda}_{i,t}^{HSG} \, dF_{HSG,t}(i) \right) \quad \text{(A.15)}$$

Bu formülden de anlaşılacağı üzere, verimlilik birimleri artık sabit değil, zamanla değişkenlik gösteren bir yapıya kavuşturulmuştur. Ters Mills oranları bu değişkenliği yakalamak için kullanılmaktadır.

Bu yöntemle düzeltilmiş tahmin sonuçlarını vermeden önce, veri setini kısaca tanımlamak faydalı olacaktır. Çalışmada, 1967-2009 yıllarını kapsayacak biçimde ABD yıllık mevcut nüfus araştırma anketi Mart verisi (CPS March Data) kullanılmıştır. Analizler yalnızca erkek nüfus için yapılmış olup, yaş 16-64 yaş arasında sınırlandırılmış ve 0 ile 39 yıllık potansiyel işgücü piyasası deneyimine sahip olan çalışan nüfus seçilmiştir. Kendi hesabına çalışanlar,emekliler, askerlik vazifesini icra edenler veri setinden çıkarılmış, yalnızca ücretli çalışanlar analize dahil edilmiştir.

Eğitim yılları ve potansiyel işgücü deneyimleri hesaplanırken, kodlamada yıllar içerisinde meydana gelen değişiklikler göz önüne alınmış, bunlar için gerekli düzeltmeler mevcut yazın izlenerek yapılmıştır. Veri seti üç ayrı kayıttan oluşmaktadır: kişi, aile ve hanehalkı. Tüm bu kayıtlar kişi bazında toplanarak analiz gerçekleştirilmiştir.

Aşağıdaki şekil, seçiciliği-düzeltilmemiş göreli arz serisi ile seçiciliği-düzeltilmiş arz serisini 1967-2009 yılları için karşılaştırmaktadır:



Şekil A.1 Seçiciliği Düzeltilmemiş (Uncorrected) ve Düzeltilmiş (Corrected) Nispi Arz Serileri

Çizgili seri, düzeltilmiş seriyi gösterirken, düz seri düzeltilmemiş seriyi ifade etmektedir. Şekilden de açıkça görüleceği üzere, seçiciliği düzeltilmiş seri, 1982 yılından önce eski seriden daha dik şekilde hareket etmektedir. Bu yıldan sonra ise, düzeltilmiş seri, eski seriye kıyasla daha düz hale gelmektedir. Öncelikle düzeltilmemiş arz serilerini yorumlamak faydalı olacaktır. Üniversite eşdeğer göreli arz serileri İkinci Dünya Savaşı'ndan sonra, 1980'lerin başlarına kadar düzenli bir biçimde artmıştır. Bu artış oranının düşüşüne etki eden üç faktörden söz edilebilir. Birincisi, Vietnam Savaşı, erkek nüfusun askerlik görevini ertelemesine vesile olarak, üniversite eğitimini artırmıştır [Card and Lemieux (2001)]. İkincisi, 1970'lerde gözlenen üniversite eğitimine aşırı yatırım, bunun getirisini düşürmüş ve dolayısıyla da üniversite eğitiminin artış oranını düşürmüştür [Freeman (1976)]. Son olarak, savaş sonrası işgücüne katılan yeni kohortlar, mevcut kohortlardan daha eğitimli ve daha çok oldukları için, üniversite mezun stoku artmıştır [Ellwood (2002)].

Seçiciliği düzeltilmiş seriler ise şunları işaret etmektedir: Eski seride olduğu gibi burada da, 1982 sonrasında işgücü göreli arzının artış oranında bir düşüş söz konusudur. Fakat artış oranı bu tarihten önce hızlı bir seyir izlerken, bu tarihten sonra düşüş belirginleşmiştir. Bu durum, çalışmada izlenmiş olan yanlılık düzeltme yönteminden kaynaklanmaktadır. Daha önce de belirtildiği gibi, tam zamanlı tam yıl çalışma seçimleri veri setinde farklılık göstermektedir. Bu seçim oranı yüksek becerili işgücü arasında zaman içerisinde çok fazla değişiklik göstermemekle beraber, düşük becerili işgücü arasında ise ciddi biçimde farklılık göstermektedir. 1980'li ve 1990'lı yılların başlarında, bu grup için, yanlılık oranı gözle görülür biçimde azalmıştır. Bu seçim yanlılığının gözlenemeyen beceri dağılımına etkisini anlamak için, başka bir deyişle, yanlılığın yapısını anlamak için, sıradaki örneği vermek anlamlı olacaktır. Üniversite eğitimine olan talep yüksek olduğunda, tam zamanlı tam yıl çalışan işgücü içerisinde, lise eğitimden üniversite eğitimine artan şekilde bir geçiş olacaktır. Bu geçişi gerçekleştirebilenler, görece daha yetenekli olanlar ve dolayısıyla üniversite eğitiminde daha başarılı olabilecek olanlardır. Dolayısıyla, düşük becerili grup içerisinde tam zamanlı tam yıl çalışma oranı düşerken, aynı zamanda bu grup içerisindeki gözlenemeyen ortalama beceri de düşüş gösterecektir.

Bu açıklama, düzeltilmemiş serilerin 1982'den önce göreli arzdaki artış oranını olduğundan daha az tahmin ettiği anlamına gelmektedir. Bunun nedeni, bu tarihten önce, nitelikli işgücü ile niteliksiz işgücü arasındaki beceri açığının düzeltilmiş seriler kullanıldıktan sonra daha yüksek olması gereğidir. Tersi bir mantık, bu tarihten sonra geçerlidir. Başka bir deyişle, 1982 sonrasında tam zamanlı tam yıl çalışma statüsünün düşük becerili işgücü arasında artmış olması, bu grup içerisindeki görece daha yetenekli çalışanların yine bu grupta kalmış olmayı tercih etmelerinin bir sonucudur. Bu toplu eğilim, tek tek eğitim ve deneyim kategorilerine bakıldığında da kendini göstermektedir. Burada gözlenen eğilimler, seçim yanlılığının düşük becerili ve düşük deneyim grubundaki işgücü üzerinden çalıştığı fikrini desteklemektedirler.

Aşağıdaki tabloda düzeltilmiş ve düzeltilmemiş serilerin kullanıldığı tahmin sonuçları gösterilmektedir.

Tablo A.1 Üniversite/Lise Logaritmik Ücret Farkı Regresyon Modeli, 1967-2009

Bağımlı Değişken: Üniversite/Lise Saatlik Ücret Farkı Logaritmik Değeri				
	[1]	[2]	[3]	[4]
Sabit	0.125**	0.191***	0.309***	0.312***
	(0.021)	(0.013)	(0.100)	(0.097)
Zaman Trendi	0.015***	0.013***	0.015***	0.013***
	(0.001)	(0.001)	(0.001)	(0.001)
Log. Nispi Arz (uncor.)	-0.363***		-0.390***	
	(0.043)		(0.044)	
Log. Nispi Arz (cor.)		-0.268***		-0.277***
		(0.029)		(0.030)
Log. reel asgari ücret			-0.103*	-0.065
			(0.055)	(0.052)
Gözlem Sayısı	43	43	43	43
R-kare	0.92	0.92	0.92	0.92
Uyarlanmış R-kare	0.91	0.92	0.92	0.93

Birinci sütun, seçiciliği düzeltilmemiş seriler kullanılarak yapılan tahminleri raporlamaktadır. Tahmin edilen ikame tahmini esnekliği 2.75 (1/0.363) ve tahmini talep büyüme trendi yıllık % 1.5 'dir. Bu sonuçlar, yazındakilerle uyumludur.

İkinci sütun ise seçiciliği düzeltilmiş serilerle hesaplanan tahminleri göstermektedir. Tahmin edilen ikame esneklik katsayısı 3.73 (1/0.268) ve tahmini yıllık talep büyüme trendi % 1.3’tür. Sonuçlar göstermektedir ki, düzeltilmemiş seriler, nitelikli işgücü ile niteliksiz işgücü ikamesini olduğundan daha az tahmin etmektedir. Dolayısıyla, düzeltilmemiş seriler kullanıldığında, göreceli talep artış hızı daha güçlü olacaktır. Bu demektir ki, seçiciliği düzeltilmiş ağırlıklar kullanıldığında, beceri yanlı teknolojik gelişme eğilimindeki yavaşlama trendi daha belirgin olarak gözlenmektedir.

Reel asgari ücretin modele etkisi, son iki sütunda gösterilmiştir. Anlaşılacağı üzere, bu hareketlerin açıklayıcı gücü vardır. Fakat bunların modele dahil edilmesi, ana sonucu değiştirmemektedir. Dolayısıyla, tahmin sonuçları, piyasa dışı faktörlerin modele dahil edilmesine sağlamlılık göstermektedir.

Sonuç olarak, daha önce de belirtildiği üzere, mevcut yazında kabul edilen göreli arz düşüşü, seçiciliği düzeltilmiş serilerle daha belirgin hale gelmiştir. Bu durum, beceri yanlı teknolojik gelişme artış oranındaki düşüşü daha derin hale getirmekte ve bu bilmecenin açıklanması için gelecekteki çalışmalara zemin hazırlamaktadır. Buna ek olarak, seçicilik yanlılığının düşük becerili ve az deneyimli gruplar vasıtasıyla faaliyet göstermesi, ücret dağılımının alt kesimini ilgilendiren piyasa dışı faktörlerin önemini artırmakta ve bunların yarattığı etkilerin daha detaylı incelenmesini zorunlu kılmaktadır. Göreli arz değişimlerini içsel bir biçimde yansıtacak şekilde geliştirilecek bir beşeri sermaye modeli, çalışmada belirtilen mevcut yazındaki eksikliklerin giderilmesine önemli ölçüde katkı sağlayacaktır.

APPENDIX E

TEZ FOTOKOPİSİ İZİN FORMU

ENSTİTÜ

Fen Bilimleri Enstitüsü	
Sosyal Bilimler Enstitüsü	X
Uygulamalı Matematik Enstitüsü	
Enformatik Enstitüsü	
Deniz Bilimleri Enstitüsü	

YAZARIN

Soyadı : ELİTAŞ
Adı : ZEYNEP
Bölümü : İKTİSAT

TEZİN ADI (İngilizce): REASSESSING THE TRENDS IN THE RELATIVE SUPPLY OF COLLEGE-EQUIVALENT WORKERS IN THE U.S.: A SELECTION-CORRECTION APPROACH

TEZİN TÜRÜ : Yüksek Lisans [ ] Doktora [X]

1. Tezimin tamamından kaynak gösterilmek şartıyla fotokopi alınabilir. ☐

2. Tezimin içindekiler sayfası, özet, indeks sayfalarından ve/veya bir bölümünden kaynak gösterilmek şartıyla fotokopi alınabilir. ☐

3. Tezimden bir bir (1) yıl süreyle fotokopi alınamaz. X

TEZİN KÜTÜPHANEYE TESLİM TARİHİ: