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A note on the college-premium framework

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Abstract

This paper demonstrates 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.

Key words: College premium equation, wage inequality, relative supply, skill biased technological change (SBTC).

JEL codes: E24, I24, J24, J31.

1. Introduction

The US college premium has increased substantially after 1960s. Researchers investigating the sources of this increase have built their analyses on a framework featuring the interactions between the relative demand for

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skills and the relative supply of skills. After 1960s, the relative supply of college-equivalent workers has increased, implying 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 US labor markets, corresponding to a shift in the relative demand for labor favoring the skilled over unskilled.[1] This "market" framework has been influential in explaining the US data.[2]

The key construct in this literature is the variable describing the supply of college equivalent workers relative to the supply of high school equivalent workers. This variable is called the relative supply index. It is the ratio of college-equivalent hours supplied to the high school- equivalent hours supplied, where the hours are weighted by the mean wages for each education category. The mean wage in each category is calculated over the entire data horizon. 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. But the efficiency units are fixed; that is, this framework fails to capture the potential changes in the efficiency units over time. Our main purpose in this paper 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.

We show that the predictions of the model can be stronger or weaker depending on how we relax the fixed efficiency units assumption. Relative efficiency of college workers might have declined or increased in the US 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 US [Carneiro and Lee (2011)]; therefore, the efficiency units should be declining. If, on the other hand, it reflects productivity, then the relative productivity of college workers have improved over time [Bowlus and Robinson (2012)]; therefore, the efficiency units should be increasing. Most importantly, we argue that the existing theories does not provide a systematic way that can help us determine toward which direction we should relax this assumption. We conclude that this is a weak spot in the college premium analysis and is a source of non-robustness.

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[1] See Davis and Haltiwanger (1991), Mincer (1991), Katz and Murphy (1992), Krueger (1993), and Autor, Katz, and Krueger (1998) for different versions of this hypothesis. See also Katz and Author (1999), Violante (2008), and Acemoglu and Autor (2011) for extensive surveys of the related literature.

[2] The points where this framework fails to explain the data are summarized by Autor, Katz, and Kearney (2008).

The plan of the paper is as follows. Section briefly describes the basic framework and the construction principles of the relative supply index. Section 3 discusses the main sources of non-robustness and provides an example. Section 4 concludes.

2. The model

2.1. The canonical college-premium framework

Existing research on the U.S. wage inequality relies on a simple aggregate production model with two basic properties: (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.[3] The standard practice is to derive a college-premium (or college-high school wage gap) equation and perform empirical analysis based on this 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 the high school graduates. In this framework, the skill premium can be thought of as a proxy of how the labor market values skills.

The aggregate production model is of the following CES form:

$$Y_t = A_t \quad \emptyset_t \quad a_t C_t^{\frac{\sigma-1}{\sigma}} + \quad 1 - \emptyset_t \quad b_t H_t^{\frac{\sigma-1}{\sigma} \quad \frac{\sigma}{\sigma-1}} \tag{2.1}$$

where Ct and Ht are college and high school equivalents employed at time t, At is the Hicks- neutral technical change, at and bt respectively correspond to skilled and unskilled labor- augmenting technical change, φt 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. Wages are determined based on the assumption that college and high school equivalents are paid their marginal products. We first calculate the marginal products of Ct and Ht using the production function described by Equation (2.1), then we equate wages to the corresponding marginal products and, finally, we take the ratio of these two decision rules. Taking the natural logarithms of this final ratio yields the following skill-premium equation:

$$ln \frac{w_{c,t}}{w_{h.t}} = ln \frac{\emptyset_t}{1-\emptyset_t} + \frac{\sigma-1}{\sigma} \ln \frac{a_t}{b_t} - \ln \frac{C_t}{H_t} \tag{2.2}$$

[3] See, for example, Katz and Murphy (1992), Katz and Autor (1999), Autor, Katz, and Krueger (1998), Card and Lemieux (2001), and Autor, Katz, and Kearney (2008).

which can be arranged as

$$ln\ \frac{w_{c,t}}{w_{h.t}} = \frac{1}{\sigma}\ D_t - \ln\ \frac{C_t}{H_t} \tag{2.3}$$

where Dt collapses the time-varying skilled labor augmented relative demand shifts into a single variable measured in logs [Katz and Murphy (1992) and Autor, Katz, and Kearney (2008)]. Equation (2.3) says that college premium is determined by the combined effect of the relative demand measure, Dt , the relative supply measure, ln(Ct /Ht), and the elasticity of substitution between high school and college equivalents, σ.

Following Autor, Katz, and Kearney (2008), we formulate the relative demand measure as

$$D_t = \beta_1 t + \beta_2 \ln\ RMW_t \tag{2.4}$$

where t represents the SBTC trend and RM W denotes real minimum wages.[4] This structure says that the relative demand shifts that favor the skilled against unskilled workers have two components: SBTC and changes in log real minimum wages, where the expected signs of β1 and β2 are positive and negative, respectively. Thus, the final equation that we estimate becomes

$$\ln\ \frac{w_{C,t}}{w_{H,t}} = \beta_0 + \beta_1 t + \beta_2\ ln\ RMW_t + \beta_3\ ln\ \frac{C_t}{H_t} + \varepsilon_t \tag{2.5}$$

where ε_t is the error term and β3 provides an estimate of 1/σ.[5]

The key problem is the formulation of ln (Ct /Ht), the relative supply measure, which we describe next.

2.2. Relative supply index

The conventional relative supply measure used in the wage inequality literature is constructed as follows. The supply of college-equivalent workers is calculated from the aggregate hours supplied by employed workers in 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

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4 The U.S. federal minimum wage is deflated by the personal consumption deflator.

5 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 to comply with the literature, we focus on real minimum wages as the only institutional factor driving demand for skills.

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.[6] 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". The ratio of these two aggregates gives the relative supply of college-equivalent workers. To understand the basic logic, it is possible to simply consider the main mechanism as follows. We formulate

$$J_t = \overline{w}^J h_t^J \tag{2.6}$$

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

$$w^J = \frac{1}{T} \sum_{t=1}^{T} \frac{\int_{I_J} \ln w_{i,t}^J \, dF_{J,t}(i)}{\int_{I_{HSG}} \ln w_{i,t}^{HSG} \, dF_{HSG,t}(i)} \tag{2.7}$$

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. $F_{J,t}(i)$ 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 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

$$H_t = \sum_{J=HSD,HSG,SC1} J_t \text{ and } C_t = \sum_{J=SC2,COL,COL+} J_t \tag{2.8}$$

Finally, the relative supply measure is constructed by calculating the ratio C_t / H_t and, then, taking the natural logarithm of this ratio to get $\ln(C_t / H_t)$.

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6 Katz and Murphy (1992) and Autor, Katz, and Kearney (2008) explain the construction of this index in great detail.

3. Discussion

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 show that the growth in the relative supply of college equivalents calculated using time-varying weights is substantially higher than what the literature reports using fixed weights. Using the March CPS data for 1967 to 2009 period, we find that the cumulative increase in the relative supply of college equivalents have been underestimated by more than 30%. We then investigate the implications of this underestimation on the analysis of wage inequality. 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 along with other standard variables.[7]

Our analysis suggests that, in our version, a larger relative demand push via the so called skill-biased technical change (SBTC) is required to justify the widening wage structure in the United States. 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. Autor, Katz, and Kearney (2008) argue that there has been a slowdown in the relative demand growth in 1990s. Such a slowdown does not appear in our calculations because we take into account quality adjustments, a significant bulk of which have taken place after 1990s. Our estimates of the Equation (2.5) are reported in Table (1).

The first column reports the estimates using the relative supply specification (2.6) for the 1967 to 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.[8] The second column—which we estimate using the relative supply specification—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. Thus, fixed weights overstate the substitutability of skilled and unskilled workers. This pattern also implies that the relative demand growth is much stronger when time-varying weights are used. Surprisingly, a trend growth

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[7] Using year-by-year wages may impose a potential endogeneity problem which we avoid by using "lagged" five-year moving averages. See Section 3 for details.

[8] The typical estimate for σ is around 2-2.5 for men and 1.5 for men and women.

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. Autor, Katz, and Kearney (2008) report a slowdown in relative demand growth starting in early 1990s. We show that, when time-varying weights are used, there is no slowdown in SBTC and the Katz and Murphy (1992) trend is still relevant. This is because of the quality adjustments in the labor force—which occured mostly after 1990s—rather than quantity adjustments only.

Table 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.

The role of minimum wages is examined in the third and the fourth columns. 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 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.

These patterns suggest that the estimates reported in the literature are sensitive to the con- struction method of the relative supply measure. When we use time-varying weights, the CES human capital model yields significantly higher SBTC estimates. 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. The wage inequality literature does not take into account these improvements. We conclude that, when one uses time-varying weights rather than fixed weights, increased wage gap is justified by a higher trend growth. But, this is contradictory, since the literature argues—using the same methods—that the SBTC story cannot be highly relevant.

4. Concluding remarks

Explanations for the widening wage structure in the United States are based on the canonical two factor CES human capital model. The key object in this model is the relative supply index, which is built on the assumption that the efficiency units of labor supply are fixed. We argue that the fixed efficiency units specification is not robust in the sense that it misses a fair amount of economic phenomena that goes on in terms of quality adjustments in the work force. We conclude that how one relaxes this assumption to construct alternative relative supply measure determines the estimated slope of relative demand growth.

Our analysis is suggestive in the sense that full analysis of wage inequality requires a de- tailed examination of these quality adjustments. 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.

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Özet

Üniversite ücret prim yapısı üzerine bir değerlendirme

Bu çalışma, mevcut yazında kabul gören standart üniversite ve eşdeğeri işgücü ile lise ve eşdeğeri işgücü ücret getirisi analizi sonucunda üretilen tahminlerin, bu ikisinin analizinde temel değişken olan göreli arz endeksi hesaplaması varsayımlarına ihmal edilemez ölçüde duyarlı olduğunu göstermektedir. Mevcut göreli işgücü arzı hesaplama yöntemi, yüksek eğitimli işgücünün düşük eğitimli işgücü karşısındaki göreli verimliliğini sabit kabul etmekte ve bu oranın örneklem dönemi boyunca değişmediğini varsaymaktadır. Bu varsayım, verimlilik birimlerinde zaman içerisinde meydana gelmesi olası değişiklikleri gözardı etmektedir. Bu varsayıma dayandırılarak hesaplanan işgücü göreli arzı da, doğal olarak, verimlilik birimlerinin zaman serisi gelişimine ilişkin sistematik bir yöntem sunamamaktadır. Mevcut yöntemdeki bu kırılganlık, ampirik sağlamlılığı tehdit etmekte ve ücret eşitsizliği analizi çerçevesinde önemli çıkarımlara yol açmaktadır. Bu çalışma, mevcut yöntemdeki varsayımlar zayıflatıldığı takdirde mevcut standart modelin başlıca tahminlerinin ne şekilde değişeceğini göstermektedir.

Anahtar kelimeler: Üniversite ücret prim denklemi, ücret eşitsizliği, göreli arz, beceri yanlı teknolojik gelişme.

JEL kodları: E24, I24, J24, J31.