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Policy Insights from Quantile Regression**

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**Corrado Andini**

*Universidade da Madeira, CEEAplA and IZA*

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## ABSTRACT

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### **Tertiary Education for All and Wage Inequality: Policy Insights from Quantile Regression**

Wage inequality is a highly debated topic in policy and academic circles. Policy makers typically consider that a policy promoting the equalization of education levels among the individuals of a society – pushing everybody towards tertiary education – is a good strategy to fight wage inequality. Academics are more pessimistic. This article stresses that a policy of “tertiary education for all” does not necessarily reduce the overall level of wage inequality. It may reduce wage inequality due to differences in education levels among individuals, but it may also increase wage inequality due to differences in unobserved abilities among individuals.

**JEL Classification:** I24, I28, J31, C21

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**Corresponding author:**

Corrado Andini  
Universidade da Madeira  
Campus da Penteadá  
9000-390 Funchal  
Portugal  
E-mail: andini@uma.pt

## 1. Introduction

Education is widely seen as a source of individual development. Research has highlighted positive effects of education on several outcomes, including wages, employability, health, and well being. This is why the discourse of policy makers attributes the highest importance to an expansion of the education attainment of the population. For instance, Arne Duncan, a former U.S. Secretary of Education, explained in 2010 that President Obama saw as a priority for the United States to regain a position as world leader in college graduates.<sup>1</sup> This view is also expressed in a recent speech (March 2016) of another former U.S. Secretary of Education, John B. King Jr., on "Ensuring higher education for all".<sup>2</sup> On the other side of the Atlantic, it is well known that the European Commission is "supporting education and training in Europe and beyond".<sup>3</sup> Similarly, the World Bank recognizes that "education is fundamental for development and growth" in both advanced and developing countries.<sup>4</sup>

A policy promoting education can be implemented in two different forms: by targeting a specific group of individuals – for instance, providing incentives to high-school graduates to complete college education<sup>5</sup> – or by inducing all the individuals in a society to acquire more formal schooling, regardless of the level of education already achieved by each individual.

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<sup>1</sup> [http://www.realclearpolitics.com/articles/2010/08/09/interview\\_with\\_education\\_secretary\\_arne\\_duncan\\_106693.html](http://www.realclearpolitics.com/articles/2010/08/09/interview_with_education_secretary_arne_duncan_106693.html)

<sup>2</sup> <http://www.ed.gov/news/speeches/ensuring-higher-education-all>

<sup>3</sup> [http://ec.europa.eu/education/policy/strategic-framework/index\\_en.htm](http://ec.europa.eu/education/policy/strategic-framework/index_en.htm)

<sup>4</sup> <http://www.worldbank.org/en/topic/education>

<sup>5</sup> Policy makers typically see such a policy as an equality-of-opportunities measure: it is a way of ensuring that individuals from a low socio-economic status background have access to tertiary education.

In both cases, such a policy is able to shift the mean of the conditional wage distribution towards the right (see Section 2 for details).<sup>6</sup> That is, increasing the average education attainment of the labour force increases the wages of the labour-force members, on average.

Less known is that fact that education can affect not only the levels of wages but also the level of wage inequality in a society, in a direction which could be not desirable from a policy perspective. More education can, indeed, increase wage inequality.

Wage inequality is a relevant policy issue in many countries. Leaving aside institutional factors, which vary from one country to another, individuals have different wages for reasons that can be summarized in two main categories: different observed characteristics and different unobservable characteristics. For example, individuals can have different wages because they have different education levels (high school vs. college) – an observable characteristic; and they can have different wages because they have different innate (or genetic) abilities (making them more or less productive at work) – a characteristic which is not observable or difficult to observe.

The fact that high-school graduates have, on average, lower wages than college graduates is usually seen as an indication that a policy inducing an equalization of education levels – at the college level – across the individuals of a given society would reduce the wage inequality in that society. This is correct in the sense that such a policy

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<sup>6</sup> The conditional wage distribution is the distribution of wages resulting from individuals who are grouped by the same observed characteristic, for instance the education level.

would reduce the wage inequality due to differences in observed characteristics – the so-called *between-groups* wage inequality.

However, a policy pushing high-school graduates towards tertiary education – which I call "tertiary education for all" in this paper (somehow borrowing this expression from the former U.S. Secretary of Education, John B. King Jr.) – would not necessarily reduce the overall level of wage inequality because it may increase the wage inequality due to differences in unobservable characteristics of individuals – the so-called *within-groups* or *residual* or *conditional* wage inequality.

The next section will provide a brief discussion on the above two dimensions of wage inequality, in a simple two-graph theoretical framework.

## **2. A simple two-graph model**

Using data for the United States, Lemieux (2006) has established some stylized facts about the evolution of wage inequality from 1973 to 2003. First, overall wage inequality has increased. Second, residual wage inequality accounts for only a modest share of the growth in overall inequality. Third, residual and between-groups wage inequality generally move in tandem over time. Fourth, their increases are concentrated in the 1980s. Fifth, the group of workers for which residual wage inequality has grown most is formed by college-educated workers.

The standard explanations for the increase in the between-groups wage inequality in the U.S. can be provided in the context of Figure 1 (there are also other explanations related to institutional factors; I do not focus on these explanations here). As a matter of fact,

the average number of schooling years in the U.S. has increased from 10.78 in 1970 to 12.86 in 2005 (Barro and Lee, 2013)<sup>7</sup>, and the relative supply of college workers has shifted towards the right over time. However, this shift has not been sufficient to prevent a rise in the college premium (on the vertical axis) because of two additional structural changes: i) the rightward shift of the relative demand for college workers due to the skill-biased technological change, driven by the computer and internet revolution; and ii) the leftward shift of the relative labour supply of college workers due to an increase in immigration of unskilled labour force or to an increase in imports of goods with high unskilled labour content.

Thus, following Autor (2014) among others, a simple "supply and demand" model can explain a large share of the increase in the return to college education registered in the last 30 years in the U.S., i.e. the increase in the between-groups wage inequality, to which Lemieux (2006) has attributed most of the increase in the overall wage inequality.

In general, however, this type of "supply and demand" explanation – by focusing on how market forces affects the average college premium – is relatively silent on the impact of education on within-groups wage inequality, i.e. on the so-called ability return, depicted in Figure 2. This paper discusses this issue in greater detail.

### **3. Quantile-regression evidence**

A number of papers have investigated the impact of education on the between-groups dimension of wage inequality. The literature typically estimates a wage-schooling

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<sup>7</sup> The Barro-Lee estimate for 2010 is 13.18 years.

model using a mean-regression estimator. The fact that the coefficient of schooling is usually found to be positive and statistically significant is seen as evidence that more education implies higher wages, on average. That is, different education levels explain different wage levels, on average. If the schooling coefficient were zero, instead, differences in education levels among individuals would not explain differences in wages, on average.

In this sense, promoting an equalization of educational differences among individuals – pushing high-school graduates towards tertiary education – is a policy that reduces wage inequality because: i) on the one hand, it reduces the differences in education levels among individuals – the "composition effect"; and ii) on the other hand, it shifts the relative supply of college workers towards the right, reducing the wage return to college education – the "price effect" (see Figure 1).<sup>8</sup>

Unfortunately, however, such a policy may induce more wage inequality due to unobserved or unobservable characteristics of individuals. This article focuses on this specific aspect, which is rarely referred to in the policy debate though it is well known in academia. The evidence accumulated over the past 20 years suggests, indeed, that more education is associated with higher dispersion of the conditional wage distribution. That is, more education not only shifts the location of the conditional wage

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<sup>8</sup> A criticism to this view is that such a policy may induce a more-than-proportional rightward shift of the relative labour demand, raising the average college premium rather than reducing it. This is because a rightward shift in the relative supply of college workers may be a source of skill-biased technological progress, as emphasized by Acemoglu (2002). If this is the case, then the main argument of this paper – a policy of tertiary education for all may increase overall wage inequality – is, of course, reinforced.

distribution towards the right, but it also increases its dispersion (Figure 2). The evidence is typically based on an econometric technique called quantile regression.

### 3.1 What is a quantile regression?

Economists usually suppose that (log) individual wages are a linear function of education, labour-market experience, and experience squared, according to a model called "the Mincer equation", in honour of Jacob Mincer (Mincer, 1974). The coefficient of the education variable in this model is called the "return to schooling" or the "return to education".

For many years, since the birth of the Mincer equation in 1974, economists have been looking at the coefficients of this equation as constant across individuals. More recently, however, a number of authors have started to consider them as heterogeneous across individuals.

The view of these coefficients as random variables is crucial to allow the use of the Mincer equation as a model able to predict the impact of a covariate, such as education, not only on the mean but also on the shape – and thus on the dispersion – of the conditional wage distribution. In particular, under mild assumptions, it is possible to estimate the wage returns to education across quantiles of the conditional wage distribution associated to different quantiles of the conditional distribution of individual abilities.<sup>9</sup>

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<sup>9</sup> This is the distribution of abilities resulting from individuals who are grouped by the same observed characteristics, including the education level.

If these returns are found to be increasing along the conditional wage distribution, this means that education increases the within-groups wage inequality, i.e. the "ability return" (Figure 2), defined as the wage premium that a high-ability individual earns relative to a low-ability individual, holding all the other individual characteristics constant – including the education level.

That is, additional education produces wage increases that are higher for individuals with higher ability index. In this sense, a policy of "tertiary education for all" – while reducing the differences in wages due to different education levels – increases the differences in wages due to different ability levels.

### 3.2 What does the quantile-regression evidence tell us?

The returns to education are generally found to be positive along the quantiles of the conditional wage distribution. This means that education is beneficial, in terms of higher wages later in life, for both low and high ability individuals. The debate is on whether the returns to education are increasing along the quantiles of the conditional wage distribution, or not.

The evidence can be divided in three groups of studies:

- Those using cross-sectional data, either for one country or for a group of countries, but assuming education to be exogenous;
- Those using cross-sectional data and dealing with the endogeneity of education;
- Those using panel data.

There is, however, a fourth group of studies which uses quantile-regression techniques to look at the impact of education on unconditional, rather than conditional, quantiles of the wage distribution. As we shall see, despite education is assumed to be exogenous, they complement earlier research in a way that strengthens policy conclusions.

### *3.2.1 First group of studies*

The first estimates of the wage returns to schooling across quantiles of the conditional wage distribution can be found in *Econometrica* (Buchinsky, 1994). The study has analyzed data on male workers from the U.S. March Current Population Survey, in all years between 1964 and 1988, suggesting that there are typically higher returns at upper quantiles.

A different study has analyzed data on both male and female workers in Portugal (*Quadros de Pessoal*) in 1982 and in 1994, suggesting that the schooling returns are positive at all quantiles as well as higher at higher quantiles. In addition, the tendency for education to be more rewarded at upper quantiles has sharpened from 1982 to 1994 (Machado and Mata, 2001).

Other authors have explored data on both male and female workers in Portugal (*Quadros de Pessoal*) in 1982, 1986 and 1992. The effect of education on wages is found to be heterogeneous across quantiles of the conditional wage distribution. The returns are higher for the individuals located at higher positions in the conditional wage distribution, though minor exceptions are found for tertiary education. The labour force does not seem to be reasonably described by a constant average schooling return. The

return to an additional year of schooling at the 90th quantile is twice as big as the one at the 10th quantile (Hartog et al., 2001).

Another study has presented evidence based on data for British male workers, extracted from the Family Expenditure Survey in the years of 1980, 1985, 1990 and 1995.

According to the authors, there is clear evidence that the returns to education are larger for individuals at the top of the conditional wage distribution compared to those at the bottom, though the profiles look flat around the middle range of the distribution (Harmon et al., 2003).

In the first group of studies, a special relevance can be attributed to an article that has provided empirical evidence for the mid-1990s using data on male workers from 16 countries, suggesting a robust stylized fact: the education returns are higher for individuals at the top of the ability distribution, conditional on their observable characteristics. The implication is that education has a positive impact on within-groups wage inequality (Martins and Pereira, 2004).

The above studies have generally focused on males to minimize sample selection problems arising from females (who show stronger self-selection into the labour market). However, an important study has presented return estimates which are corrected for selection bias using data on females from the U.S. March Current Population Survey for the years of 1968, 1973, 1979, 1986, and 1990. The evidence suggests that the returns at the lower quantiles for the younger females are higher than those at upper quantiles at the beginning of the sample period, but lower at the end. For

older females, the returns seem to be higher at upper quantiles during the whole sample period (Buchinsky, 2001).

Additional studies have adopted both a single-country perspective (for instance, looking at Turkey, Spain, Austria, United Kingdom, Germany, Italy, and United States) as well as a multi-country approach (looking at a variety of European countries).<sup>10</sup>

Overall, the evidence in the first group of studies supports the idea that education increases within-groups wage inequality.

### *3.3.2 Second group of studies*

The second group of studies include articles addressing the issue of the endogeneity of schooling in a quantile-regression framework.

The standard quantile-regression approach – while allowing for individuals to be different in terms of unobserved abilities – does not allow for individual ability to be correlated with schooling, i.e. education is assumed to be exogenous.

Some authors have challenged this assumption (Arias et al., 2001). They have presented an instrumental-variable method to obtain consistent estimates of the schooling returns when education is endogenous (i.e. potentially correlated with ability). Using data for

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<sup>10</sup> Tansel and Bodur (2012) for Turkey, Budría and Moro-Egido (2008) for Spain, Fersterer and Winter-Ebmer (2003) for Austria, Gosling et al. (2000) for the United Kingdom, Fitzenberger and Kurz (2003) for Germany, Naticchioni et al. (2010) for Italy, Lemieux (2006) and Angrist et al. (2006) for the United States, Prieto-Rodriguez et al. (2008), Budría (2010), and Budría and Pereira (2011) for a variety of European countries.

1991, 1992, 1993 and 1995 from the Annual Twins Festival in Twinsburg Ohio, the authors have tested to what extent there is evidence of heterogeneity in the schooling returns and argued that individuals with higher abilities have higher returns – a result consistent with the idea of a complex interaction between education and unobserved abilities in the production of earnings. The estimated coefficients are found to be never below the level of 9 percent, with peaks up to 13 percent at the top of the conditional wage distribution.

The above approach is interesting because it tries to disentangle the effect of education on within-groups wage inequality from that of ability on education, which biases the estimation of the former.

A similar approach has been used in a work analyzing Portuguese data from the 2001 wave of the European Community Household Panel (Andini, 2008). The results provide additional support to the view that education is a source of within-groups wage dispersion in Portugal. Indeed, when the total impact of schooling on conditional wage inequality is measured as the difference between the return at the 90th quantile and the return at the 10th quantile, this difference is likely to range between the 4% estimated using the standard quantile regression and the 26% estimated by means of instrumental variables.

An alternative approach to deal with the endogeneity of schooling – based on a control function – has been proposed by Lee (2004), who has suggested that the return to schooling is higher at the lower quantiles, using a sample of U.S. men born between 1930 and 1939 from the 1980 Census.

A similar approach has been adopted in another study (Andini, 2010a). It is argued that, depending on the order of the control function, the total impact of schooling on within-groups wage inequality ranges from 5.1% to 7.4% for Portugal. This suggests the presence of increasing returns, being in contrast with the U.S. evidence.

Nevertheless, the above evidence for the United States is consistent with that presented by another article (Chernozhukov and Hansen, 2006), again using the 1980 Census, in which the authors have proposed a different estimator for quantile regression with endogenous education. The returns are found to be decreasing in the quantile index as the latter increases towards the middle of the distribution, remaining stable in the upper part. This suggests that the largest gains are obtained by those at the lower tail of the conditional earnings distribution – a result consistent with the idea that individuals with high unobserved ability earn higher wages regardless of their education, while people with low ability benefit more from the education training.

Using the same estimator but a different instrument and dataset – namely, a cross-sectional sample of males from the U.S. National Longitudinal Survey of Youth in 1976 – other authors have found a U-shaped pattern for the schooling returns along quantiles of the conditional wage distribution, with the return at the median quantile – around 3% – being much lower than in the tails (Chernozhukov et al., 2007).

A further study – using a different estimator, an instrument based on compulsory schooling reforms, and pooled data for several countries from the 2001 wave of the European Community Household Panel – has found that education is a brake on conditional wage inequality rather than a source (Brunello et al., 2009).

Overall, the evidence in this second group of studies is mixed: the impact of education on within-groups wage inequality depends on the country, the data, the instrument, the population affected by the instrument, the estimator used, and a variety of other factors.

### *3.2.3 Third group of studies*

In the third group of studies, those using panel data, we can – in principle – distinguish among three possible approaches:

- Allowing for the persistence of wages in a quantile-regression context;
- Controlling for individual time-invariant heterogeneity;
- Considering both the above dimensions.

Some authors have proposed a version of the Mincer equation where past earnings play the role of additional explanatory variable. This can be due to several factors including a) imperfect adjustment between human-capital productivity and wages, b) wage bargaining when the unemployment benefit of the worker depends on his/her past wage, and c) persistence of productivity shocks.<sup>11</sup> Using panel data on a sample of male workers extracted from the U.S. National Longitudinal Survey of Youth, for the years between 1980 and 1987, it has been shown that a static approach (where past wages are not controlled for) does not provide the same answer as a dynamic approach to the question of how education affects within-groups wage inequality. While the static approach suggests a positive effect in line with the first group of studies, the dynamic approach suggests a negative impact (Andini, 2007).

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<sup>11</sup> For example, see Andini (2009), Andini (2010b) and Guvenen (2009).

The above result, however, looks limited to the case of U.S. young male workers. When more representative data for Spain (Andini, 2009) and Portugal (Andini, 2010b) are used – despite still related to the male labour force only – both the static and the dynamic approach point in the direction of a positive impact. In particular, the evidence is based on data from the European Community Household Panel and refers to the years between 1994 and 2001.

The studies controlling for individual time-invariant heterogeneity are rather scant, and the body of evidence is still too small to comment on it here.

To the best of my knowledge, there are no papers which combine wage dynamics and individual fixed effects in a quantile regression for schooling returns, which is, however, an interesting field for future research.

Overall, the existing papers using panel data – though limited in number – point in the direction of higher returns at upper quantiles, i.e. education increases within-groups wage inequality.

#### *3.2.4 Fourth group of studies*

To summarize, the main policy message from the above groups of studies is that education has a positive effect on within-groups wage inequality. This is not unanimous, but still most of the existing evidence points in this direction. Thus, on the one hand, a policy equalizing education differences among individuals – at the college

level – is likely to reduce the between-groups wage inequality;<sup>12</sup> on the other hand, the same policy is likely to increase the inequality within groups.

Less known are, instead, the answers to the questions: Which is the prevailing effect? Does a policy of "tertiary education for all" reduce the overall level of wage inequality? Unfortunately, it is difficult to find definitive answers in the above three groups of studies. Nevertheless, the research has made major advances in the last few years and the evidence based on more recent studies complements earlier research in a way that strengthens policy conclusions, as shall be argued below.

For example, some authors have proposed a procedure which uses quantile regression to decompose the change in the unconditional wage distribution<sup>13</sup> over a period of time in several factors contributing to that change: namely, changes in the characteristics of the working population, changes in the returns to these characteristics, and residual changes. Analyzing the change in the shape of the wage distribution in Portugal (*Quadros de Pessoal*) from 1986 to 1995, they have suggested that the observed expansion of education levels has contributed decisively towards higher inequality of earnings (Machado and Mata, 2005).

Another major progress has been due to the introduction of the unconditional quantile regression by Firpo et al. (2009), which has allowed us to go at the roots of the problem and to estimate the impact of education on unconditional quantiles of the wage

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<sup>12</sup> Even if the "price effect" is ambiguous as stressed by Acemoglu (2002), the "composition effect" is still at work (the policy reduces education differences between groups; in the limit, it creates one single educational group – the college graduates).

<sup>13</sup> This is the distribution of wages as it is, regardless of individual characteristics.

distribution. In particular, an important analysis for 32 countries conducted by two OECD researchers (Fournier and Koske, 2012) has shown that an increase in the number of college graduates implies a change in the composition of the workforce in a way in which wages become more dispersed. Similar results are found in Alejo et al. (2014) and Ghosh (2014).

#### **4. Conclusions**

As a matter of fact, the average number of schooling years has increased in most countries during the last 50 years (Barro and Lee, 2013). Wage inequality has shown a similar pattern in numerous countries, including the United States where better data are available and measures of inequality are more reliable.

An increase of the average number of schooling years in a society can be due either to an increase in the average number of schooling years of all members of a society – say high-school graduates earn a college degree and college graduates get a doctorate – or to an increase in the average number of schooling years in a specific group of a society – say high-school graduates only. The latter is the "tertiary education for all" policy discussed in this paper.

With a policy promoting a universal expansion in education, the educational differences across individuals in a society may not decrease as a result of the policy – and they may even increase. Thus, policy makers willing to fight wage inequality should not promote such a universal approach.

A different story is when public support is given to a specific group of the population such as high-school graduates to complete college education. This policy is likely to reduce educational differences across individuals in a society as well as the college return (the latter is not unanimous), thus reducing the between-groups wage inequality. The drawback is that such a policy may increase the within-groups wage inequality, i.e. the ability return. Knowing which of the two effects is prevailing is still a controversial research question. This makes it difficult to provide a clear policy advice.

As a matter of fact, the education return is found to be increasing along quantiles of the conditional wage distribution – corresponding to ability quantiles – in a variety of countries. The implication is that, if more high-school graduates get a college degree, the dispersion of the conditional wage distribution widens. Putting it differently, the dispersion of the wage distribution, conditional on the observed characteristics of the individuals in a country (gender, work experience, tenure, industry, occupation, marital status, and so on), is higher when everybody has a college degree than when everybody has a high-school diploma.

This research result, which is supported by extensive (though not unanimous) empirical evidence – as we have seen – has a policy implication: "tertiary education for all" will increase the average wage of the individuals affected by the policy, but such a policy is not necessarily useful to fight wage inequality. The policy reduces the wage differences between the high-school graduates and the college graduates by increasing the relative supply of college graduates and reducing the college premium (the latter is not unanimous). Yet, at the same time, it increases the wages differences among individuals

with different abilities since high-ability individuals benefit more than low-ability individuals.

My personal view is that a policy of "tertiary education for all" is likely to increase the overall level of wage inequality, increasing the within-groups wage inequality by more than it reduces the between-groups wage inequality. This is not in contrast with the Lemieux's view (2006)<sup>14</sup> because this paper analyzes the effect of the policy under the *ceteris paribus* hypothesis, i.e. independently of shifts in the relative labour demand that may eventually take place. In addition, my view is supported by recent OECD research using unconditional quantile regression, which suggests a positive effect of education on overall wage inequality.

In sum, policy makers should be aware that a policy trade-off (to deal with) is likely to exist: college education for all can reduce wage inequality by reducing differences in education levels among individuals and the price at which the market rewards these differences, but it can also increase wage inequality by favouring individuals with higher ability more than those with lower ability.

As usual with any policy, there are pros and cons to be put on the scales. The pros and cons of the policy analyzed in this paper can be summarized as follows:

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<sup>14</sup> As stressed above, Lemieux suggests that the within-groups wage inequality accounts for only a modest share of the overall inequality growth, at least in the United States.

## Pros

- The policy can be targeted to a specific group of the population, the high-school graduates who would have not enrolled in college education otherwise
- The policy reduces the between-groups wage inequality by reducing educational differences among individuals in a society
- The individuals affected earn higher wages, on average, as a result of the policy
- The policy is beneficial for both low and high ability individuals because the wage return to education is positive for both groups

## Cons

- Low ability individuals benefit less from the policy because the wage return to education is lower for them
- The policy reduces the average college premium by shifting the relative supply of college graduates towards the right (this "price effect" is controversial)
- The policy increases the within-groups wage inequality because the wage return to education is increasing along the conditional wage distribution
- The policy is likely to increase the overall level of wage inequality because it increases the inequality within groups by more than it reduces the inequality between groups

To conclude, a number of studies have documented the positive effects of education on later outcomes, including wages. This is why policy makers attribute the highest importance to the attainment of the highest level of education for all the members of a society. This paper has highlighted the existence of a trade-off in the link between education and earnings. The policy of promoting the college graduation of individuals

who would have not graduated otherwise – a policy of "tertiary education for all" – can be beneficial for the individuals affected in terms of higher wages later in life, on average. However, such a policy can increase the overall level of wage inequality in the society.

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Figure 1. The effect of the policy on the between-groups wage inequality

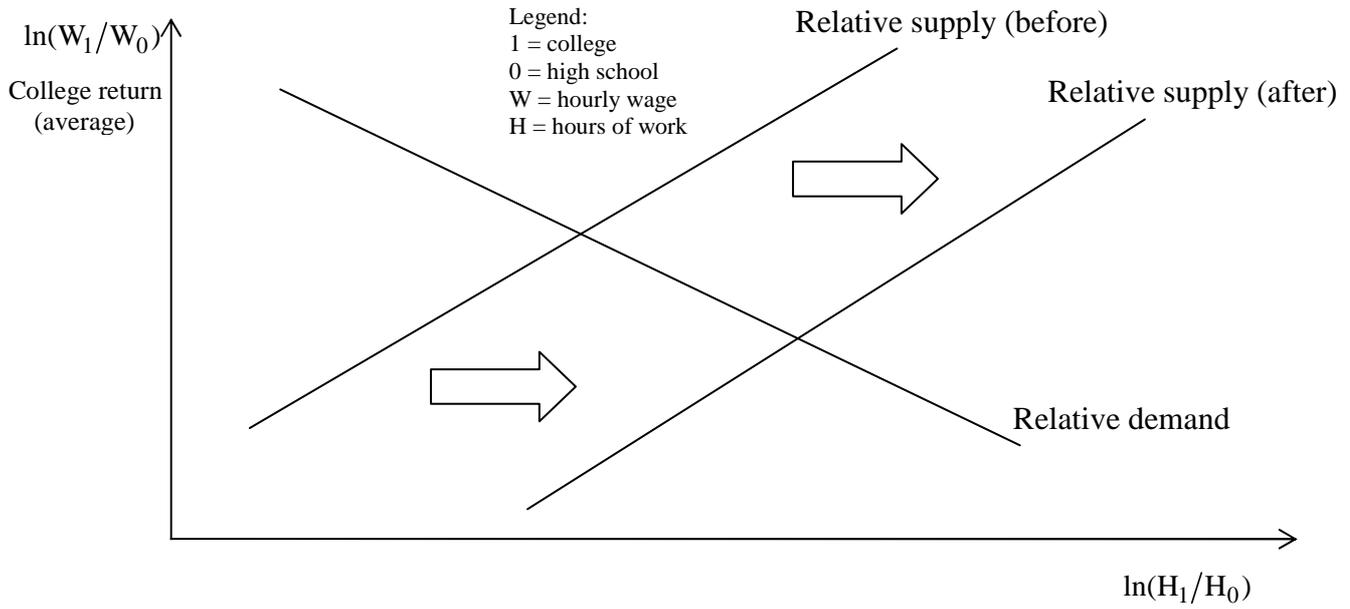


Figure 2. Effect of the policy on the within-groups wage inequality

