Higher education, employers' monopsony power and the labour share in OECD countries

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Abstract: This paper examines the impact of higher education on the labour share. It is based on the following idea: as education offers adaptability skills, it should reduce employers' monopsony power and, therefore, increase the labour share. This idea is developed in a two-sector model with search unemployment and wage competition between employers to attract/keep workers. Using panel data for eleven OECD countries, we show that the proportion of higher educated in the population has a significant positive effect on the labour share: typically, an increase of one standard deviation in higher education induces a three point increase in the labour share. The other determinants of the labour share are compatible with the theoretical model. They include the capital-output ratio (-), minimum to median wage ratio (+), union density (+). We also find that the unemployment rate has a negative and significant impact on the labour share, which, together with the positive impact of higher education, is incompatible with a three-factor model where factors are paid their marginal products.

Keywords: Search frictions; Adaptability; Labour share; Macroeconomic panel data

JEL classification: E25; I20; J60

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1 Introduction

Human capital matters. However, its composition is probably as important as its level. The individual performance on the labour market as well as the impact of macroeconomic shocks dramatically depends on whether human capital is general or specific, that is whether one's skills can easily be transferred from a job to another or not. Several papers have thus recently argued human capital is more general in the US than in continental Europe (see e.g. Krueger and Kumar, 2002, and Wasmer, 2005). This helps explain the well established diverging paths in unemployment and/or wage inequality. It is also argued that higher education is more likely to provide general rather than specific human capital (see for instance Gould, Moav, and Weinberg, 2001, Aghion, Howitt and Violante, 2002, and Charlot, Decreuse and Granier, 2005). Those papers rely on the idea that higher education makes the workers more adaptable, while adaptability has become increasingly important in the development process. Those contributions have also examined the role of market frictions and labour market institutions in shaping the incentives to acquire general human capital (see Wasmer, 2005, or Charlot et al, 2005). However, a much less emphasized (though very intuitive) prediction of such models is that wages at given GDP should increase with higher education, as adaptability skills raise workers' outside opportunities. This paper investigates such a theoretical prediction, and confronts it to macro data. It also controls for alternative theories offering such a positive relationship between higher education and the labour share. Two main points are emphasized: employers derive some market power from workers' imperfect mobility on the labour market, while higher education may raise workers' mobility. Higher education therefore reduces employers' monopsony power and raises the labour share.

An example may be useful to broadly illustrate our ideas. Mathieu and Julien are two twin brothers. They have similar jobs in the same town. However, Mathieu spent two additional years at university, and he learnt English, while Julien, otherwise seemingly identical, can only speak French. After some years of job experience, one notices that Mathieu is paid fifteen percent more than Julien, although he never worked with English-speaking people. Why is it so? Likely because Mathieu's outside opportunities are higher than Julien's. Mathieu may have been contacted by other employers, or may have simply used the potential threat of searching a job in another company. Consequently, employers decided to raise his pay rate, in order to keep him or prevent other firms from poaching him. A general lesson stems from such an example. Higher education provides adaptability skills. Such skills are highly valued on modern labour markets, where workers' mobility over the technological space is reduced, so that employers have market power on wage determination. As a result, those who benefit from adaptability skills end up being paid more *at given output*: their skills lower employers' market power. Hence, the labour share should increase with the proportion of Mathieus in the workforce, i.e. with the proportion of higher educated.

Traditional human capital theory with perfectly competitive labour markets clearly explains wage inequality between workers with different educational background. More educated are better paid because they supply more skills, and competition between potential employers drives their wage towards (marginal) productivity. However, the theory has much less to say concerning the relationship between the labour share of income and the proportion of higher educated. In this paper, we complement the traditional view in two ways. On the one hand, we consider a frictional labour market. On the other hand, we emphasize the mobility skills offered by education.

When factors are paid their marginal products, the labour share only depends on relative factor uses

and there is no room for the story developed above. However, labour economists have recognized for long workers' mobility is imperfect: job requirements as well as workers' skills are heterogenous, between state or city mobility is reduced, information on vacancies is poor, and so on. As Stigler (1961) initially noticed, search frictions should provide employers with monopsony power. Modern monopsony models of the labour market are thus based on the idea that there is a continuum of potential employers, yet search frictions prevent the workers from moving instantaneously from one job to another[1]. For our purpose, the consideration of search frictions/monopsony power is very interesting: the labour share not only depends on relative factor uses, but also on the fundamentals of such monopsony power.

The idea that education provides the workers with adaptability skills is very widespread in the field of growth theory. Nelson and Phelps (1966) point out two essential dimensions of education: the ability to adapt to technological change and the ability to innovate[2]. Nelson and Phelps' notion of adaptability has been applied in many recent studies. In LLoyd-Ellis (1999), minimum skill levels are required to implement new but equiproductive technologies and workers differ in the range of technologies they can implement. Krueger and Kumar (2002) assume that general (by opposition to vocational) education reduces the probability that the workers suffer a loss of task-specific productivity following the introduction of a new technology. Aghion, Howitt and Violante (2002) assume that new technologies are sector-specific and workers must be adaptable to implement any such new technology. The longer the schooling period when young, the more likely it is that the worker can use the new technology when old. Importantly, adaptability skills are especially needed on frictional labour markets. Manning (2001) has an illuminating way to understand this point: small is beautiful in the competitive model, because scarcity is the essence of worship. Thus specific skills are important. However, the use of specific skills in frictional markets becomes eventual, and scarcity leads to long-term unemployment, sub-employment of skills, or lower than marginal product wage. It follows that workers have huge incentives to acquire general skills, which are more likely to be acquired through higher education.

The paper is composed of three parts. We first propose a theoretical model. Then, we provide estimates of the determinants of the labour share. Finally, we confront our empirical results to potential alternative models of the labour share.

Our setup can be depicted in more details as follows. We consider two sectors, each associated to a specific technology. Workers are either educated or not. Educated workers are more likely to be able to operate on both technologies than uneducated workers. Employers have some market power because of entry costs and search frictions. The search market is segmented by sector. Employers set the wage, while due to search frictions workers may receive either one or two job offers (one from each sector). If they receive only one job offer, they obtain no more than their reservation wage. If they receive two offers, employers enter Bertrand competition to attach labour services, and workers receive their full marginal product[3]. Consequently, the share of output accruing to labour rises with the proportion of job-seekers receiving two offers. Such a proportion depends on the state of activity (job availability, which in turn

[1] Those models successfully address major issues such as the extent of discrimination, wage heterogeneity for similar workers, the spike of the wage distribution at the minimum wage (see for instance Manning, 2001, for a survey).

[2] This view has received some support at the micro level, either from studies of US industries (Bartel and Lichtenberg, 1987), or plants (Dunne and Schmitz, 1995, Doms, Dunne and Troske, 1997).

[3] The fact wages result from Bertrand competition between employers has been investigated by Postel-Vinay and Robin (2002a, 2002b) in models with on-the-job search. Other models postulate firms post wages along with vacancies and commit to pay the posted wage (see, e.g. Burdett and Mortensen, 1998, or Acemoglu and Shimer, 2000).

depends on job profitability), as well as on workers' mobility between sectors. Here comes our view of education: given that the educated are more adaptable, they tend to prospect the two types of jobs. They are thus more likely to receive additional offers. At the macroeconomic level, the labour share is thus increasing in the share of educated. Our model predicts other determinants of the labour share: capital intensity, labour market institutions, and unemployment rate. As in the perfectly competitive model, the labour share should be affected by capital per worker, yet the actual sign of the relationship depends on whether capital and labour are substitutes (-) or complements (+). The unemployment rate should reduce the labour share as it means, other things being equal, that it is more difficult to benefit from several job offers. Labour market institutions like the minimum wage or union power have a positive impact on the labour share specific to monopsony models of the labour market. Those different predictions can be tested on macroeconomic data.

Our empirical analysis covers eleven OECD countries from 1970 to 2000. The variable of higher education is borrowed from Barro and Lee (2000): we use the share of tertiary educated, which corresponds to post-secondary schooling. We regress the labour share on the proportion of higher educated, different labour market variables, the unemployment rate, the capital to output ratio as a proxy of capital intensity, and the degree of openness. The regressions include country fixed effects and common time dummies. Typically, an increase of one standard deviation in higher education induces a three point increase in the labour share[4]. Once accounting for actual changes in higher education throughout our sample, we show that such changes have sustained the actual labour shares by 2 to 7 points. The US experienced a 3 point reduction in the labour share and France a 6 point. This divergence coincides with the actual difference in the contribution of education in these two countries that has pushed up the labour share by 6 points in the former and only by 3 points in the latter. The labour market variables have all the expected sign and are significant – the unemployment rate must be instrumented. Finally, the capital to output ratio has a negative impact, suggesting capital and labour are substitutes rather than complements. The magnitude of the impact, however, depends on whether the regression includes a control for technological change or not. For instance, it is very high when time dummies are omitted, but becomes insignificant once time dummies and an index of R&D investments are included[5]. Our interpretation is that technological change has raised firms' technological complexity, reducing workers' mobility, thereby increasing firms' monopsony power[6].

One may wonder whether such aggregate empirical evidence can be derived from an alternative theory of education and the labour market or not. We thus examine an alternative theoretical framework where output depends on three factors: educated labour, uneducated labour, and capital. The only assumption we make is that factors are paid their marginal products, which is consistent with various models of wage determination. We proceed in two steps. First, we wonder if the labour share can increase with the ratio of educated employment to uneducated employment. The answer is a timid yes, given that this implies strong restrictions on the set of possible substitutions between the different inputs. Second, we question if

[4] We also take into account the impact of higher education on the unemployment rate and capital to output ratio.

[5] In all these specifications, the coefficient associated to the proportion of higher educated is unchanged.

[6] This explanation is complementary to Acemoglu (2003), who argues European firms had incentives to develop capital-biased technologies, because wages were set too high. Such technological change can decrease the labour share in the medium run. We depart from this analysis in two ways. First, the change in labour share is not due to changes in output technology, but to increased employers' market power. Second, the impact on the labour share is not limited to the medium run and can take place in the longer run.

the labour share can increase with labour market institutions and decrease with the unemployment rate, given that it increases with higher education. The answer is a strong no. In such model, labour market institutions can only affect the labour share through changes in the relative employment rate of educated to uneducated workers. This ratio increases with the relative supply of educated workers. However, it is also positively correlated with the global unemployment rate (empirically, we show that a one point increase in global unemployment rate implies a .5 increase in the unemployment rate differential between educated and uneducated workers). Two major predictions follow. On the one hand, the impact of the unemployment rate has the same sign as the impact of the proportion of higher educated. Therefore, it must be positive, rather than negative. On the other hand, the impact of labour market institutions should not be significant if one controls for relative factor uses. These two predictions are not consistent with our empirical results which indicate the unemployment rate has a negative impact on the labour share, and labour market institutions have a positive impact on the labour share despite we control for relative factor uses. On the contrary, such predictions are in line with our theoretical model.

This paper is related to the literature on the determinants of the labour share. Studies of the labour share have known a renewal with Rodrik (1997), who argues that globalization hurts labour by eroding workers' bargaining power. Ortega and Rodriguez (2001) show that the degree of openness (usually defined as the ratio of exports plus imports to GDP) has a negative impact on labour shares. Harrison (2002) obtains similar results with alternative measures of globalization, like the degree of capital account openness. Blanchard (1997) and Acemoglu (2003) point out the role of firms' technological choices, that may have been incited to promote capital-augmenting technological progress. The literature has also focused on imperfections on the good market. The labour share typically decreases with firms' mark-up over marginal products. Blanchard (1997) and Blanchard and Giavazzi (2003) evoke the structural rise in such mark-ups as a potential cause of the decline in European labour shares – yet they immediately refute such explanation. Finally, there are papers examining the role played by labour market imperfections. Checchi and García-Peñalosa (2005) question the impacts of labour market institutions on income inequality in OECD countries. Among other results, they show that the minimum wage, union density and unemployment benefits positively affect the labour share. However, they explain such impact in a three-factor model where factors are paid their marginal productivity. Bentolila and Saint-Paul (2003) note that the so-called right-to-manage bargaining model has limited properties, as the firm finally chooses a point on the labour demand. Alternatively, they point out the efficient bargaining model, or the introduction of labour adjustment costs can move the firm out of her labour demand, and thus gives some explanatory power to labour market variables. Blanchard and Giavazzi (2003) explore a different route. They consider simultaneously monopolistic competition on the good market, and collective efficient wage bargaining. Monopolistic competition creates rents, while workers' bargaining power distributes such rents between firms and workers. As far as the working of the labour market is concerned, our paper differs more in philosophy than in facts. If we introduced our view of higher education in Blanchard and Giavazzi's model, higher education would increase the wage by raising workers' outside options in the bargaining game, thereby raising the labour share in the long run[7]. However, we included a measure of imperfect competition in our statistical analysis. It never revealed significant, casting some doubt on the

[7]Blanchard and Giavazzi do not especially focus on the labour share. However, they wonder in an extension of their model if it can explain the decrease in European labour shares observed since the beginning of the 1980s. They conclude that it could be attributed to an exogenous decline in workers' bargaining power.

actual impact of imperfect competition in the good market on the labour share.

The rest of the paper is composed of five sections. In section 2, we show how education can reduce firms' monopsony power in a two-sector model of search unemployment. We also discuss the various factors that can affect the labour share through extensions. In section 3, we present regression estimates of the labour share on the different factors suggested by the theory. In section 4, we consider potential alternative theories of the positive relationship between higher education and the labour share. Section 5 concludes.

2 Theoretical model

The main intuition of our model can be stated in a few words. Suppose that there are two types of workers: the educated and the uneducated. Workers are equally productive. However, educated workers are perfectly mobile, and thus manage to get the full marginal product of their contribution to output. Conversely, uneducated workers are attached to a single firm, and only get the monopsony wage, say 0. If labour is the only production factor, the labour share coincides with the proportion of educated workers in the workforce, i.e. it increases with this latter proportion.

Our model goes beyond this simple intuition to justify the links between firms' monopsony power and education, and to provide us with empirically convincing determinants of the labour share. In our model, monopsony power is originated by the combination of entry costs and search frictions, while education erodes monopsony power because it improves the scope of workers' skills. There are two sectors/technologies, the matching market is segmented by sector and education increases the number of technologies a worker can operate. Consequently, a more educated worker benefits from a larger number of expected job offers. It follows that firms' market power decreases with education, and there is a positive relationship between education and the labour share.

We proceed in two steps. First, we present the basic model. Then, we discuss several extensions.

2.1 The basic model

The model is static. There are two final goods entering preferences symmetrically. Each good is produced within an autonomous sector. There are a continuum of firms and workers.

2.1.1 Model environment

Each firm is endowed with a single job slot, which can be either active or inactive. To get an active job, the firm must first choose a technology (a sector) and pay the entry cost $\chi > 0$. This cost is a shadow cost involved by product market regulation[8] as in Blanchard and Giavazzi (2003). Once the cost is paid, the firm chooses capital size k, which unit rental price is r. In both sectors, the production function is the same. Output is produced by means of the technology $f(k)$; it is strictly increasing, strictly concave and satisfies the Inada conditions. In addition, $\alpha(k) = kf'(k)/f(k) \in (0,1)$ is the elasticity of output with respect to capital. To simplify, there is no irreversibility in capital choice: the firm can resell its capital without loss on the capital market. According to this assumption, everything happens as if firms

[8] Firms make superprofits in our model. It is implicit that such profits do not correspond to labour income.

were choosing capital after the worker is hired[9]. Inactive jobs cost nothing. We denote by n_i the number of active firms in sector i. As Blanchard and Giavazzi, we assume that the entry cost is proportional to output. This assumption is of no importance, but allows us to account for the fact that there is no clear empirical relationship between unemployment and the development level. Hence, the cost is worth $\chi = cf(k)$.

There is a mass 1 of workers who differ in two respects: education and mobility. First, workers are either educated or uneducated. Educated workers are in proportion $\pi \in [0,1]$. Second they are either mobile or immobile. Mobile workers can operate on both sectors, while the immobile are assigned (symmetrically) to either one of the two sectors. The proportion of mobile workers is $\sigma \in [0,1]$. For simplicity, the only role of education is to offer mobility skills. The proportion of mobile workers is thus larger among the educated than among the uneducated. Let q_π and $q_{1-\pi}$ be the proportion of mobile workers among, respectively, educated and uneducated workers; we have $q_\pi > q_{1-\pi}$. It follows that the overall proportion of mobile workers is $\sigma = q_\pi \pi + q_{1-\pi}(1-\pi)$. It is increasing in the proportion of educated.

Active jobs and job-seekers meet each other on the search market. It is segmented by technology, which means that matching takes place at the sector level. In each sector i, the total number of contacts M_i between firms n_i advertising sector-specific positions, and workers u_i seeking such jobs is determined by a constant-returns to scale matching technology, so that $M_i = M(u_i, n_i)$. Let $\theta_i = n_i/u_i$ denote market i specific tightness, and $m(\theta_i) = M(1, \theta_i)$ be the matching technology in intensive form. We assume that m is strictly increasing, strictly concave, with $m(0) = 0$, and $m(\theta) < \min\{1, \theta\}$ for all $\theta \geq 0$. Firm's and worker's probability of getting a contact on market i are then respectively given by $m(\theta_i)/\theta_i$ and $m(\theta_i)$. In addition, let $\eta(\theta) = \theta m'(\theta)/m(\theta) \in (0,1)$ be the elasticity of the matching technology with respect to vacancies.

There is no restriction on the number of sectors prospected by job-seekers, but the requirement workers can operate the underlying technology. Consequently, immobile workers only seek a job in one sector, while the mobile search on both sectors. It follows that the number of job-seekers is $u_i = \sigma + (1-\sigma)/2$ on each market.

Importantly, a worker may receive at most one offer from a given market. But mobile individuals may receive an additional offer from the other sector. As firms are bound to search on only one sector, they have at most one contact.

2.1.2 Equilibrium

Employers set the wage. Hence, if the contacted worker has no alternative option, the wage is $w = 0$. However, if the worker received another job offer, employers enter Bertrand competition for labour services. It follows that immobile workers always receive a wage equal to 0, while mobile workers may get the whole output. The probability that a mobile worker does not receive any such alternative offer is $1 - m(\theta)$. As sectors are perfectly symmetric, prices of the two final goods are equal in equilibrium and tightness is the same in each sector. We directly account for these facts, and normalize the common

[9] In the next subsection, we introduce capital choice irreversibility. Though the central message of the model is not altered, this gives birth to endogenous capital dispersion.

price to 1. The typical profit function is:

$$V = \max_k \left\{ -\chi + \frac{m(\theta)}{\theta} \left[\frac{1-\sigma}{1+\sigma} (f(k) - rk) + \frac{2\sigma}{1+\sigma} (1 - m(\theta)) (f(k) - rk) \right] \right\} \tag{1}$$

Grouping terms yields:

$$V = -\chi + \frac{m(\theta)}{\theta} \frac{1 - \sigma + 2\sigma(1 - m(\theta))}{1+\sigma} \max_k \{f(k) - rk\} \tag{2}$$

Hence, $f'(k) = r$. Capital owners manage to preserve their income and capital is paid its marginal product.

The number of firms adjusts so as to ensure profits are nil in equilibrium. Thus, tightness responds to profitability. In equilibrium, tightness is derived from the free entry condition ($V = 0$):

$$c = \frac{m(\theta)}{\theta} \left[1 - \frac{2\sigma m(\theta)}{1+\sigma} \right] (1 - \alpha(k)) \tag{3}$$

The latter equation defines tightness as a function of the entry cost χ (-), the elasticity of output with respect to capital (+), and the proportion of mobile workers σ (-). Sector-specific tightness thus decreases with the proportion of educated, reflecting the decline in profitability.

2.1.3 Labour share

Total output is

$$Y = (1-\sigma) m(\theta) f(k) + \sigma \left[2m(\theta)(1 - m(\theta)) + m(\theta)^2 \right] f(k)$$

while the total wage bill is

$$W = \sigma m(\theta)^2 (1 - \alpha(k)) f(k) \tag{4}$$

It follows that the labour share is

$$\text{LS} = [1 - \alpha(k)] \frac{\sigma m(\theta)}{1 + \sigma - \sigma m(\theta)} < 1 - \alpha(k) \tag{5}$$

Due to employers' monopsony power, the labour share is lower than the elasticity of aggregate output with respect to labour. It is increasing in tightness and education. Indeed, they both increase the probability of receiving offers from alternative sectors. It improves the average wage through Bertrand competition among potential employers. As tightness is decreasing in education, the overall impact of education seems ambiguous. Indeed,

$$\frac{d\text{LS}}{d\pi} = \underset{>0}{\frac{\partial \text{LS}}{\partial \pi}} + \underset{<0}{\frac{\partial \text{LS}}{\partial \theta}} \frac{d\theta}{d\pi} \tag{6}$$

However, the decline in tightness is not sufficiently strong to offset the direct effect. Indeed, we can write from (5):

$$\frac{\sigma m(\theta)}{1+\sigma} = \frac{\text{LS}}{1 - \alpha + \text{LS}}$$

The free entry condition (3) becomes:

$$c = \frac{m(\theta)}{\theta} \left[1 - 2\frac{\text{LS}}{1 - \alpha + \text{LS}} \right] (1 - \alpha(k)) \tag{7}$$

We know that equilibrium tightness is decreasing in education. Thus LS must increase with education for equality (7) to hold: in equilibrium, LS is thus increasing in the proportion of educated.

Equation (5) suggests the following empirical determinants of the labour share: capital intensity, sector-specific tightness and education. Sector-specific tightness is not available in the data. Rather, we use the unemployment rate. Indeed, the global unemployment rate is strictly decreasing in tightness and education. To show this, note that mobile workers' probability not to receive any offer is $(1-m(\theta))^2$. Similarly, immobile workers' probability not to receive any offer is $1-m(\theta)$. The global unemployment rate is thus

$$u = \sigma (1-m(\theta))^2 + (1-\sigma)(1-m(\theta)) \tag{8}$$

As tightness increases with employers' share in output, the unemployment rate is endogenous and should properly be instrumented in regressions.

2.2 Extensions

Our basic model predicts education should raise the labour share. In this sub-section, we consider several extensions. We first consider the role played by labour market institutions. Then we turn to the analysis of irreversible capital costs. We also discuss education as a production factor, and examine what happens when education simultaneously expands the quantity and the quality of prospected jobs. Finally, we examine the role played by firms' technological choices.

2.2.1 Labour market institutions and the fiscal wedge

Our first extension focuses on the minimum wage, unionization, and the fiscal wedge. Suppose that there is a minimum wage equal to $\beta f(k)$, with $\beta < 1-\alpha(k)$. The only change is that workers who receive just one offer are now paid the minimum wage rather than 0. The labour share is now:

$$\text{LS} = \beta + [1-\alpha(k)-\beta]\frac{\sigma m(\theta)}{1+\sigma-\sigma m(\theta)} \tag{9}$$

It is still increasing in education. It also directly increases with the minimum wage. However, the minimum wage also affects firms' profitability, thereby decreasing tightness. Indeed, the free entry condition now writes

$$c = \frac{m(\theta)}{\theta}\left[1-\frac{2\sigma m(\theta)}{1+\sigma}\right](1-\alpha(k)-\beta) \tag{10}$$

For similar reasons, the degree of unionization is likely to increase the labour share. Suppose for instance that unionized workers can collectively bargain their wage in case they do not receive alternative offers. Assuming Nash bargaining and zero outside options, the bargained wage is $\gamma(1-\alpha(k))f(k)$, where $\gamma \in (0,1)$ is union's bargaining power. The labour share then becomes:

$$\text{LS} = [1-\alpha(k)]\left\{\gamma + \frac{\sigma m(\theta)}{1+\sigma-\sigma m(\theta)}(1-\gamma)\right\} \tag{11}$$

It is still increasing in education. The previous discussion applies: union power has two impacts. The direct impact is positive, while the indirect impact due to a reduction in tightness is negative.

Finally, the fiscal wedge does not directly alter the labour share. However, it interacts with other labour market institutions so that it can increase the labour share. For instance, let τ be the (flat) payroll tax rate on the wage bill. If $\beta f(k)$ is the minimum wage, then $\beta f(k)(1+\tau)$ is employers' cost at the minimum wage. The labour share is thus

$$\text{LS} = \beta(1+\tau) + [1-\alpha(k)-\beta(1+\tau)]\frac{\sigma m(\theta)}{1+\sigma-\sigma m(\theta)} \tag{12}$$

The main implication of this discussion is the following. If an econometrician were to regress the labour share on the minimum wage, an index of union power, and the unemployment rate, she should find a positive impact of the two labour market institutions and a negative impact of the unemployment rate. This is a major difference with a model in which factors are paid their marginal product. In this latter case, labour market institutions only affect the labour share through their impact on unemployment rate – see Section 4.

2.2.2 Irreversible capital choices

Up to now we have assumed that capital can be resold at no cost, or, alternatively it is chosen after the wage is determined. We now consider irreversible capital costs. Such an irreversibility originates capital and wage dispersion[10]. However, the labour share is still likely to increase with higher education. Let Φ denote the symmetric sector-specific capital distribution. Firms' owners now maximize

$$\begin{aligned} V &= \max_{k} \left\{ V(k) = -rk + \frac{m(\theta)}{\theta} \left[\frac{1-\sigma}{1+\sigma} f(k) + \frac{2\sigma}{1+\sigma} (1 - m(\theta)) f(k) \right. \right. \\ &\quad \left. \left. + \frac{2\sigma}{1+\sigma} m(\theta) \int_{\widetilde{k}<k} \left[f(k) - f\left(\widetilde{k}\right) \right] d\Phi\left(\widetilde{k}\right) \right] \right\} \end{aligned} \tag{13}$$

The novelty comes from the third term within brackets. With probability $(m(\theta)/\theta) \times m(\theta) 2\sigma/(1+\sigma)$, the firm contacts a mobile worker and this worker receives an alternative offer from the other sector. Bertrand competition between employers ensures the worker is hired in the most productive job, and drives her wage to the output of the less productive job. The first-order condition yields

$$r = f'(k) \frac{m(\theta)}{\theta} \left\{ 1 - \frac{2\sigma m(\theta) [1 - \Phi(k)]}{1+\sigma} \right\} \tag{14}$$

The rental price of capital is equal to its marginal benefit, i.e. marginal productivity times the probability to fill the position. Given the latter probability depends on firm's ranking in the capital distribution, equation (14) defines the cdf of the equilibrium distribution of capital per worker. The lower bound k_0 and upper bound k_1 of the support of this distribution result from $\Phi(k_0) = 0$ and $\Phi(k_1) = 1$. This yields

$$r = f'(k_0) \frac{m(\theta)}{\theta} \left(1 - \frac{2\sigma m(\theta)}{1+\sigma} \right) = f'(k_1) \frac{m(\theta)}{\theta} \tag{15}$$

The upper-bound is decreasing in tightness, as tightness reduces the probability to contact a worker. The lower bound is decreasing in education as it raises the probability the worker gets an alternative offer. Given tightness is decreasing in education, education widens capital dispersion. Finally, the price of the scarce resource is $p = V = V(k)$ for all $k \in [k_0, k_1]$. In particular, $p = V(k_0)$, which yields $p = k_0 (1 - \alpha(k_0)) / \alpha(k_0)$.[11]

[10] This result is not new. In a model where firms set wages ex-ante (and commit to pay the posted wage) and workers may receive several offers at a time, Acemoglu and Shimer (2000) also obtain capital dispersion. In Postel-Vinay and Robin (2002a), there is Bertrand competition between employers, but workers can only receive one offer at a time. However, workers search on the job.

[11] The capital distribution is non-degenerate because irreversible capital choices would involve a discontinuity in the marginal benefit of capital investment at the equilibrium. Indeed, assume that there is a symmetric equilibrium k^*, and let us focus on the case where the firm contacts a worker who receives an alternative offer. If the firm sets $k = k^*$, she gets the marginal return $f'(k^*)$ with probability $1/2$, while she pays the marginal cost r in both cases. Her marginal profit is thus $1/2 f'(k^*) - r$. Now, if she invests slightly above k^*, she always hires the worker. In the limit case where k tends to k^*,

To compute the labour share, consider firms which invested $k \in [k_0, k_1]$. Output produced by such firms is:

$$y(k) = \frac{m(\theta)}{\theta} f(k) \left\{ 1 - \frac{2\sigma m(\theta)}{1+\sigma} [1 - \Phi(k)] \right\} \tag{16}$$

Using (14), we get

$$\alpha(k) y(k) = rk \tag{17}$$

Similarly, the total wage bill paid by such firms is

$$\omega(k) = \frac{m(\theta)}{\theta} \frac{2\sigma m(\theta)}{1+\sigma} \int_{\kappa \leq k} f(\kappa) d\Phi(\kappa) \tag{18}$$

In equilibrium, we have

$$\omega(k) = y(k) - rk - p = (1 - \alpha(k)) f(k) - p \tag{19}$$

The labour share is

$$\text{LS} = \frac{\int_k \omega(k) d\Phi(k)}{\int_k y(k) d\Phi(k)} \tag{20}$$

$$= \frac{\int_k \left[\frac{(1-\alpha(k))k}{\alpha(k)} - \frac{(1-\alpha(k_0))k_0}{\alpha(k_0)} \right] d\Phi(k)}{\int_k \frac{k}{\alpha(k)} d\Phi(k)} \tag{21}$$

The labour share is of course 0 when there are no mobile workers. Thus, it should increase with higher education. Intuitively, workers get better paid at given capital distribution. However, it turns out the result cannot be established in the general case. The reason is due to the fact that higher education also modifies capital choices. It raises the weight of firms located on the far left and far right of the distribution, so that dispersion rises. We thus consider the Cobb-Douglas case. When $\alpha(k) = \alpha$ for all k, it comes

$$\text{LS} = (1 - \alpha) \left[1 - k_0 / \overline{k} \right] \tag{22}$$

Hence, the labour share increases with education whenever the ratio of minimum capital investment to average capital decreases. Education widens capital dispersion, which suggests that the latter ratio should actually go down. Formally, we get

$$\overline{k}/k_0 = \frac{1-\alpha}{2-\alpha} \left(\frac{1+\sigma}{2\sigma m(\theta)} - 1 \right) \left[\left(1 - \frac{2\sigma m(\theta)}{1+\sigma} \right)^{\frac{2-\alpha}{\alpha-1}} - 1 \right] \tag{23}$$

It is increasing in the proportion π of higher-educated. It follows that the positive relationship between higher education and the labour share is not a pure artefact of the simple model. In the remaining of this section, we maintain the assumption of a perfect market for unused capital. Another learning of this second extension is that capital choice, and, consequently, average capital intensity, respond to profitability. Average capital intensity is thus endogenous to the labour share, and should be properly instrumented in econometric regressions.

her marginal profit is thus $f'(k^*) - r > 1/2 f'(k^*) - r$. This implies that there is no symmetric equilibrium. When capital choices are reversible, such a discontinuity does not occur, because the firm pays the rental price of capital if and only if she hires the worker.

2.2.3 Education as a production factor

For simplicity, our discussions assume that education only offers mobility skills. We now consider the case where education offers both mobility and productive skills. We suggest that the productive component of education is unlikely to originate a positive impact of higher education on the labour share.

Assume that education not only alters workers' mobility, but also improves their productivity. Hence, output produced by an educated worker (whether mobile or not) is $y = Af(k)$, with $A > 1$, while it is still $y = f(k)$ when the worker is uneducated. As individual productivity is heterogenous, it is no longer equivalent to choose capital before and after recruitment. To avoid useless complexity at this stage of the discussion, we assume that firms choose capital once the worker is known. Capital intensity depends on education according to

$$Af'(k_\pi) = r = f'(k_{1-\pi}) \tag{24}$$

Let i denote the education group, Y_i is total output produced by i-workers, while LS_i is the labour share accruing to such workers. The total labour share is:

$$\mathrm{LS} = \frac{Y_\pi}{Y_\pi + Y_{1-\pi}}\mathrm{LS}_\pi + \left(1 - \frac{Y_\pi}{Y_\pi + Y_{1-\pi}}\right)\mathrm{LS}_{1-\pi} \tag{25}$$

with

$$\mathrm{LS}_i = (1 - \alpha(k_i))\frac{q_i m(\theta)}{1 + q_i(1 - m(\theta))} \tag{26}$$

$$Y_\pi = \pi[1 + q_\pi(1 - m(\theta))]\, m(\theta)\, Af(k_\pi) \tag{27}$$

$$Y_{1-\pi} = (1-\pi)[1 + q_{1-\pi}(1 - m(\theta))]\, m(\theta)\, f(k_{1-\pi}) \tag{28}$$

Two important points should be noted. On the one hand, $Y_\pi/\pi > Y_{1-\pi}/(1-\pi)$. Output per educated individual is larger than output per uneducated. This results from two facts: educated are more productive (education is now a production factor), and their employment rate is higher (education still offers adaptability skills). On the other hand, LS_π and $\mathrm{LS}_{1-\pi}$ differ in two ways. First, educated are more mobile, which tends to imply that $\mathrm{LS}_\pi > \mathrm{LS}_{1-\pi}$. Second, $k_\pi > k_{1-\pi}$ means that $\alpha(k_\pi)$ and $\alpha(k_{1-\pi})$ are generally different, though the direction of this effect depends on the technology f. For instance, $\alpha(k)$ is strictly increasing (decreasing) with k when capital and labour are substitutes (complements) in output. Provided that this latter effect can be neglected with respect to the former (or has the same sign), we should have $\mathrm{LS}_\pi > \mathrm{LS}_{1-\pi}$, which we now assume.

What is the impact of A, the schooling effect on productivity? Formally,

$$\frac{d\mathrm{LS}}{dA} = \frac{dY_\pi/Y}{dA}(\mathrm{LS}_\pi - \mathrm{LS}_{1-\pi}) > 0 \tag{29}$$

This effect is positive because an increase in A raises the weight of mobile workers in output. At given labour share per education group, this increases the overall labour share. This suggests that the productivity effect of education should only have second-order impacts on the labour share *in our model*. Indeed, suppose that there is no effect of education on workers' mobility. Hence, $q_\pi = q_{1-\pi} = q$. Consider an increase in π. This yields

$$\frac{d\mathrm{LS}}{d\pi} = \frac{dY_\pi/Y}{d\pi}(\mathrm{LS}_\pi - \mathrm{LS}_{1-\pi}) \tag{30}$$

which has the sign of $\alpha(k_{1-\pi}) - \alpha(k_\pi)$. Hence, it only depends on the technology. In the absence of any impact of education on mobility, education only affects the labour share through changes in capital

intensity. There are two main implications. First, the impact of education can only be positive if capital and labour are complements in output. In Section 3, we show that capital intensity tends to decrease the labour share rather than to increase it, suggesting capital and labour are actually substitutes. Second, as far as the econometrician controls for capital intensity, higher education should not alter the labour share. Or, alternatively, if one gets a positive impact of higher education although capital intensity is among the regressors, she must deduce that higher education has an adaptability component and therefore tends to reduce employers' monopsony power.

2.2.4 Vertical vs horizontal heterogeneity

In this paper, we adopt the view that higher education allows one to adapt to different technologies of similar levels. Higher education, therefore, improves horizontal occupational mobility. However, several papers have suggested that higher education actually increases occupational mobility vertically, rather than horizontally. For instance, educated individuals have access to complex jobs, that are especially designed to them, and simple jobs, that everyone can occupy[12]. Whether mobility increases horizontally or vertically does not matter for our purpose. What accounts is the fact that job opportunities are more important for the educated than for the uneducated. To see this, it is necessary to slightly alter the model. The main change is the following: all individuals can work in sector 1, the old sector, while only the mobile can work in sector 2, the modern sector. To simplify, assume that the two goods are perfectly substitutable in consumers' preferences, so that they have the same price, normalized to one[13]. Profits are in each sector

$$\begin{aligned} V_1 &= \max_k \left\{ -\chi + \frac{m(\theta_1)}{\theta_1} \times \left[(1-\sigma)(f(k)-rk) + \sigma(1-m(\theta_2))(f(k)-rk) \right] \right. \\ &\quad \left. + \sigma m(\theta_2) \mathbb{E}_{k_2} \left(\max\{ f(k) - rk - f(k_2) + rk_2, 0 \} \right) \right. \qquad (31) \\ V_2 &= \max_k \left\{ -\chi + \frac{m(\theta_2)}{\theta_2} (1-m(\theta_1))(f(k)-rk) \right. \\ &\quad \left. + \frac{m(\theta_2)}{\theta_2} m(\theta_1) \mathbb{E}_{k_1} \left(\max\{ f(k) - rk - f(k_1) + rk_1, 0 \} \right) \right\} \qquad (32) \end{aligned}$$

Hence, $f'(k) = r$ in each sector. Free entry implies

$$c = \frac{m(\theta_1)}{\theta_1} \left[1 - \sigma + \sigma(1 - m(\theta_2)) \right] \left[1 - \alpha(k) \right] \qquad (33)$$

$$c = \frac{m(\theta_2)}{\theta_2} \left[1 - m(\theta_1) \right] \left[1 - \alpha(k) \right] \qquad (34)$$

Those equations define a unique equilibrium vector (θ_1, θ_2). Then, the labour share is worth

$$\text{LS} = \frac{\sigma m(\theta_1) m(\theta_2)}{m(\theta_1) + \sigma m(\theta_2) \left[1 - m(\theta_1) \right]} \qquad (35)$$

It is increasing in σ, the proportion of mobile workers. The positive impact of higher education on the labour share does not depend on whether educated workers have access to better jobs or similar jobs. What matters is that they have access to a larger set of opportunities, regardless the quality of such opportunities.

[12] See, e.g., Acemoglu (1999), and Albrecht and Vroman (2002) in matching models.

[13] As in the symmetric model, perfect susbtitutability between the two goods implies that the two types of workers are perfectly substitutable in final output. The positive impact of higher education on the labour share does not depend on this assumption, which is made for simplicity.

2.2.5 Technological complexity

Our final extension focuses on the role played by technological complexity. Education improves workers' adaptability. To a large extent, the value of adaptability is contingent on the skill requirements of the technology. In this extension, we discuss the impact of technological complexity, that raises productivity but also sector-specific skill requirements.

To make things simple, let $t \geq 0$ denote (exogenous) technological complexity. Technological complexity raises output according to $tf(k)$. However, it also reduces the proportion of mobile workers. We thus assume that $q_\pi = q_\pi(t)$ and $q_{1-\pi} = q_{1-\pi}(t)$ are both decreasing in t, with $q_\pi(t) > q_{1-\pi}(t)$ and $0 \geq q'_\pi(t) > q'_{1-\pi}(t)$ for all $t \geq 0$. Hence, education protects (at least partially) the transferability of skills between sectors against technological complexity. Those assumptions have two important implications. First, the labour share is decreasing in technological complexity. Indeed, technological complexity reduces the proportion σ of mobile workers, thereby decreasing average wage[14] at given output. It means that technological change reduces the labour share[15]. Second, capital intensity is now determined by $tf'(k) = r$. Capital per worker is thus increasing in technological complexity. But, technological complexity is difficult to observe, while capital intensity is not. Suppose that the econometrician has data concerning capital intensity, but no proxy for technological complexity. Then, the econometrician is likely to observe a negative impact of capital intensity on the labour share, reflecting the positive correlation between capital intensity and unobserved technological complexity.

2.2.6 From the theory to the empirical analysis

Three linearized relationships can be derived from our theoretical model: an equation for the labour share, and two equations which accounts for the endogeneity of the unemployment rate and capital intensity. Indeed, the labour share is a function $\text{LS}(k, u, \pi, \Gamma)$, while equilibrium unemployment rate and capital intensity are functions $u(\pi, \Gamma)$ and $k(\pi, \Gamma, r)$, where Γ is a set of exogenous parameters corresponding mainly to labour market institutions. In the neighborhood of some (π_0, Γ_0), we have

$$\text{LS} = \text{LS}_0 + \frac{\partial \text{LS}_0}{\partial u}(u - u_0) + \frac{\partial \text{LS}_0}{\partial k}(k - k_0) + \frac{\partial \text{LS}_0}{\partial \pi}(\pi - \pi_0) + \frac{\partial \text{LS}_0}{\partial \Gamma}(\Gamma - \Gamma_0) \tag{36}$$

$$u = u_0 + \frac{\partial u_0}{\partial \pi}(\pi - \pi_0) + \frac{\partial u_0}{\partial \Gamma}(\Gamma - \Gamma_0) \tag{37}$$

$$k = k_0 + \frac{\partial k_0}{\partial \pi}(\pi - \pi_0) + \frac{\partial k_0}{\partial \Gamma}(\Gamma - \Gamma_0) + \frac{\partial k_0}{\partial r}(r - r_0) \tag{38}$$

where $\text{LS}_0 = \text{LS}(k_0, u_0, \pi_0, \Gamma_0)$, $u_0 = u(\pi_0, \Gamma_0)$, and $k_0 = k(\pi_0, \Gamma_0, r_0)$. The different partial derivatives are unobserved and must be parametrically estimated assuming some noise in the above equations. The sign and significance of such parameters can be used to test the validity of our theory (thanks to the labour share equation), and to compute the global impact of higher education (through combining the various equations).

[14] At the same time, it increases tightness, but this is a second order effect.

[15] Acemoglu (2001) has a close analysis. He suggests that European firms have been incited to develop capital-biased technologies in response to wage rigidity. This may explain the observed decline in European labour shares since the early 1980s.

3 Empirical analysis

The purpose of this section is to investigate the empirical impact of higher education on the labour share. We use panel data covering OECD countries over the past three decades. The main result is that the labour share is increasing in higher education. This result is robust to different specifications and sensitivity tests. The other determinants of the labour share are in line with the theoretical model developed above: capital per worker (-), unemployment rate (-), union density (+), minimum to median wage ratio (+).

3.1 Data

The dataset only covers OECD countries. This allows to abstract from the role played by the development level, and its potential correlation with education. In addition, we can benefit from better and richer data, especially labour market data. There are eleven countries[16] over the period 1970-2000. The actual sample size is dictated by data availability. Our preferred estimates are achieved on yearly data to keep the maximum number of observations, but we also run regressions with data averaged over five-year periods to control for cyclical effects. The benchmark regressions are performed on 264 observations. Data sources are detailed in the Appendix.

3.1.1 Labour share

The dependent variable in the empirical analysis is the labour share. The analysis of labour share movements is awkward because it is very sensitive to the way we compute it. The basic definition used by the United Nations is simply the ratio of employee compensation to value-added (referred to as the 'naive measure' in the remaining). Several problems arise with the naive measure, particularly when we focus on international comparisons as documented by Gollin (2002). The most important one is the lack of the earnings of the self-employed workers in the numerator while the value-added created by such workers is part of the denominator. Neglecting this problem underestimates the labour share, and, given actual changes in self-employment among OECD countries, may alter the actual evolution of labour shares. Different methods have been envisaged to correct for this bias (see Daudey, 2005). The consensual method consists in assigning the same earnings to employed and non-employed workers.

$$\text{LS adjusted} = \frac{\text{compensation of employees}}{\text{VA}} \times \frac{\text{total workforce}}{\text{number of employees}} \tag{39}$$

We use data from the OECD Economic Outlook (2002), that are sufficiently detailed to establish several indicators of the sharing of value-added, naive or adjusted for the self-employed in the business sector. In the following, we mainly use the labour share adjusted for self-employed workers. However, we check the robustness of our results to alternative measures of the labour share in sub-section 3.3.

3.1.2 Education

The key explicative variable in this paper is the proportion of higher-educated. We use the updated Barro and Lee (2000) dataset, the most commonly used schooling data in empirical studies. It contains series for schooling attainment by combining census data and enrollment rates, both taken primarily

[16] Australia, Belgium, Canada, France, Ireland, Japan, Netherlands, New Zealand, Spain, United Kingdom, United States.

from UNESCO for a broad number of countries. The dataset provides estimates of educational levels attained and completed by persons over 25 – at five-year intervals for the years 1960-2000, in percentage of the total population. Educational levels are ranked in four levels: no schooling, primary schooling, secondary schooling and tertiary education. The proportion of higher educated is identified to the share of post-secondary educated in the total population[17]. The basic data are five-year averages. We linearly interpolate them to enter our annual dataset.

Figure 1 depicts the data. The proportion of higher educated increases in each country over the whole period of investigation. However, the bulk of the increase takes place at different dates. In addition, there is some substantial heterogeneity between countries: 53% of the Canadians are endowed with a tertiary education in 2000, while only 16% of the Spanish are in the same situation.

FIGURE 1

De la Fuente and Domenech (2000, 2002) document a number of suspicious features and inconsistencies in Barro-Lee data. They suggest that it contains substantial measurement error that leads to implausible time profiles. They construct a new database for OECD countries on educational attainments in conformity with the Barro and Lee classification, not based anymore on enrollment data but on various sources, as national census, surveys, statistics yearbooks and international publications. However, this latter database contains fewer observations than Barro and Lee. Our results are checked on it in sub-section 3.3.

3.1.3 Technological variables

Even though the focus is on education, the most consensual determinant of the labour share is certainly the capital to labour ratio. It is the only determinant of the labour share when capital and labour are paid their marginal product. To account for real growth, it is necessary to adjust labour with a labour productivity index. However, the computation of such an index involves the use of the labour share. Following Bentolila and Saint-Paul (2003), we rather consider the capital-output ratio. There is a one-to-one relationship between the capital-labour ratio k and the capital-output ratio κ. Indeed, $\kappa = k/f(k)$, which is increasing in k as f is strictly concave. The advantage of this formulation is that the capital-output ratio does not know an *a priori* upward trend. The capital-output ratio is obtained from the OECD Economic Outlook (2002) and is restricted to the business sector to be consistent with our measure of the labor share. In sub-section 3.3, we check if our results still hold when we consider the capital-output ratio in the whole economy.

3.1.4 Labour market variables

From the OECD Labour Force Statistics, we obtain the unemployment rate, the minimum to median wage ratio, the union membership index, and the tax wedge.

TABLE 1

[17] The UNESCO classification (International Standard Classification of Education, ISCED) divides education in 6 categories. "Higher education" englobes levels 4, 5 and 6, where level 4 corresponds to post-secondary non-tertiary education, level 5 corresponds to first stage of tertiary education, and level 6 corresponds to second stage of tertiary education.

3.1.5 Other variables

We mainly consider two other variables: openness, and product market power.

As recalled in the introduction several papers focus on world globalization – proxied by openness, capital account liberalization, trade liberalization (see Ortega and Rodriguez, 2002, and Harrison, 2002). Such papers provide evidence of a negative relationship between globalization and labour shares, probably driven by the fall in workers' bargaining power. In order to ensure the robustness of our empirical results, we include such a measure of globalization. We choose two proxies: the most standard, the degree of openness, derived from Penn World Tables (6.1) and defined as exports plus imports divided by GDP, and the Capital Account Openness Index (CAOI) computed by Brune et al (2001). For each country, the CAOI only records two observations over time. Hence, we only use it in our sensitivity analysis.

The focus of our analysis is on labour market distortions. But previous theoretical studies have shown that product market imperfections tend to reduce the labour share (see Blanchard, 1997). However, as previously indicated by Nickell (1997) and Bentolila and Saint-Paul (2003), it seems impossible to obtain measures of product market competition that are sufficiently consistent to be added to our regressions. One way to deal with this problem is to use some proxy variables. We use the degree of product market regulation constructed by Nicoletti et al (1999).

Descriptive statistics for the core variables used in our regressions are shown in Table 1.

3.2 Estimation methodology

Formally, let i denote the country and t the period. We aim to estimate the following equation

$$\mathrm{LS}_{it} = a_i^0 + a_t^1 + a^2\pi_{it} + a^3 k_{it} + a^4 LMI_{it} + a^5 u_{it} + a^6 X_{it} + \varepsilon_{it} \tag{40}$$

where a_i^0 is a country-specific dummy, a_t^1 is a period dummy, LMI is a vector of (two) labour market institutions and X is a vector other relevant variables. The validation of our model requires $a^2 > 0$, $a^4 > 0$, $a^5 < 0$, while a^3 can either be positive, negative, or not significant. It is also important to account for the potential endogeneity of the unemployment rate u_{it}. In addition, we must estimate the following auxiliary regressions:

$$u_{it} = b_i^0 + b_t^1 + b^2\pi_{it} + b^3 LMI_{it} + \varepsilon'_{it} \tag{41}$$

$$k_{it} = d_i^0 + d_t^1 + d^2\pi_{it} + d^3 LMI_{it} + \varepsilon''_{it} \tag{42}$$

The global effect of higher education must be positive, so that $a^2 + a^3 d^2 + a^5 b^2 > 0$.

We proceed in two steps. First we estimate equation (40), then we estimate equations (41) and (42) through auxiliary regressions.

3.2.1 Estimation of the labour share

The model (40) is estimated by means of fixed-effects regressions[18]. The results are shown in Table 2.

[18] We have also performed random-effect estimations. Most of the coefficients have opposite signs, a typical case of the Simpson's paradox. The choice of the fixed-effect model is then confirmed by the Hausman test, which rejects the null hypothesis of independence of country-specific fixed effects.

TABLE 2

Column a depicts our benchmark regression. In column b, we have added the fiscal wedge among the regressors, but at the price of losing more than one hundred observations. Columns c accounts for the possible endogeneity of regressors. Following our theoretical model, the unemployment rate and the capital-output ratio are treated as potentially endogenous, while we assume that variables resulting from political or social choices – the minimum wage and the degree of unionization, education – and the degree of openness are exogenous. We instrument both the capital-output ratio and the unemployment rate by their first and second lags[19]. Column c presents a 2SLS regression, while column d presents a GMM estimation. They have almost identical results.

The results can be commented along five dimensions.

First, the proportion of higher educated (HIGH) has a positive and significant coefficient in all the regressions we performed, whether we account for the possible endogeneity of regressors or not. It indicates that an increase of one standard deviation in the proportion of the population with post-secondary education increases the labour share by about three points, neglecting changes in unemployment rate and capital to output ratio. This positive impact of higher education is of course the cornerstone of our empirical analysis. Yet it is not sufficient to validate the assertion that higher education erodes employers' monopsony power. We must also validate the other predictions of our model.

Second, concerning the labour market institutions, the degree of unionization (UNION) and the minimum wage (MINMED) have a positive and significant coefficient. The unemployment rate (UNR) has a negative coefficient, yet it is not significant in our benchmark regression. It is not surprising considering the fact (discussed in the previous section) that the unemployment rate is potentially endogenous to the labour share. Accordingly, in the IV estimations, the coefficient associated to the unemployment rate becomes significant. The negative impact of unemployment rate together with the positive impacts of labour market institutions are key features of our monopsony model.

Third, the parameter associated to the capital-output ratio has a significant and negative sign. This result departs from Checchi and Garcia-Peñalosa (2005) but it is in accordance with former estimates by Bentolila and Saint-Paul (2003) who find, with the help of data per sector, a negative sign for almost all countries but one. It suggests that the elasticity of substitution between capital and labour is larger than one[20].

TABLE 3

An alternative interpretation is based on our extension on technological complexity. If changes in capital intensity reflect changes in technological complexity, the regression may well overestimate the actual impact of capital intensity. To account for this possibility, we have made additional regressions,

[19] It reveals extremely difficult to find exogenous variables correlated with the unemployment rate. At the theoretical level, it is possible to show that corporate taxation does not affect the labour share, yet it reduces tightness. We used the corporate tax rate as an instrument, but the null hypothesis of exogeneity was rejected by the standard tests.

[20] Suppose that output is given by $Y = (K^{\nu} + L^{\nu})^{\frac{1}{\nu}}$. Factors are complements (respectively substitutes) if $\nu < 0$ ($\nu > 0$). The elasticity of output with respect to labour is $1 - \alpha(k) = (1 + (K/L)^{\nu})^{-1}$. Its derivative with respect to K/L has the sign of $-\nu$.

presented in Table 3. Column a reports our basic fixed-effects regression. In column b, we have omitted the capital-output ratio. This corresponds to the Cobb-Douglas case. Most coefficients are not affected, except for the unemployment rate and the degree of openness which become significant. In column c, we have omitted the time dummies, it does not alter qualitatively our results. However, the coefficient associated to the capital-output ratio is multiplied by 2 (in absolute value). The fact that the coefficient of the capital-output ratio is magnified by the absence of dummies, suggests that the time dummies may capture technological change. This leads us to inspect the coefficients associated to the time dummies in column a. Figure 2 thus reveals a strongly negative time trend.

FIGURE 2

In column d, we have included a proxy for technological complexity. We have chosen the ratio of R&D spending to GDP, which is not available before 1980 – we lose three countries and more than half of the observations (116). As such a ratio is unlikely to alter firms' contemporaneous technological choices, we have built a stock variable defined by the five-year average of the ratio. The coefficient attached to this variable is significant and negative. It means that a one standard deviation increase in the ratio of R&D spending to GDP induces a 3 point decrease in the labour share. The capital-output ratio is no longer significant. However, the coefficients associated to the time dummies still define a negative trend.

Finally, in Table 2, the coefficient associated to OPEN has a negative sign. It is not significant in basic regressions, while it becomes significant in IV regressions. This result is in accordance with Harrison (2002), and Ortega and Rodriguez (2002), who find a negative and significant impact of globalization variables on labour shares.

3.2.2 Auxiliary regressions and quantitative implications

To compute the global effect of higher education on the labour share, we need to account for its impacts on unemployment rate and capital to output ratio. We thus estimate equations (41) and (42) by means of fixed effects regressions reported in Table 4.

TABLE 4

Those regressions highlight the negative impacts of higher education on the unemployment rate and capital to output ratio. The former effect is due to the larger job-finding rate benefiting to the higher educated. The latter effect is explained in the model with capital choice irreversibility by the lower marginal return to capital investment at given output. As the unemployment rate and the capital to output ratio negatively impact the labour share, these results strengthen our claim: an increase in the proportion of higher educated does raise the labour share.

Noteworthy, the LMI have a positive impact on the unemployment rate. Yet the parameter associated to the minimum wage becomes not significant once the fiscal wedge has been introduced among the regressors. Similarly, the LMI negatively affect the capital to output ratio. It can be explained in our model with commitment in capital choice. There, capital investment responds to vacancy profitability, and

the LMI reduce such a profitability. The fiscal wedge raises both the labour share and the unemployment rate, in accordance with our discussion in sub-sub-section 2.2.1.

Finally, the real interest rate has a negative but not significant impact on the capital to output ratio.

Given the actual magnitude of changes in the proportion of higher educated, one can easily compute from such estimates the contribution of higher education to the evolution of the labour share in each country of our sample. In Table 5, the second column depicts the actual change in labour share from 1970 to 2000 in each country of our sample. The third column reports the actual change in the proportion of higher educated. The last columns report the predicted impact of such a change on the labour share for each specification, accounting for alterations in unemployment rate and capital to output ratio.

TABLE 5

The actual decline in the labour share would have certainly been much larger if educational attainment had not been expanding. According to our benchmark regression – fourth column – the massive increase in higher education raised the labour share by 2.6 to 10.3 points. The figures are a bit larger when the fiscal wedge is included – fifth column – and a bit lower in the IV estimations – final column. This heterogeneity reflects differences in country-specific changes in the proportion of higher educated. Interestingly, this helps to explain the diverging trends in labour shares observed in Continental Europe, on the one hand, and in Anglo-Saxon countries, on the other. Consider France and the United States for instance: the United States experienced a three-point reduction in the labour share and France a six point. This divergence is actually lower than the actual difference in the contribution of education in these two countries (6.5 to 10 points in the US, and only 3.5 to 5.5 points in France).

3.3 Robustness

In this sub-section, we test whether the robustness of the relationship between higher education and the labour share persists when we use different variables (for the labour share, higher education and openness). Results are reported in Table 6.

Let us begin with the time dimension. Our estimations are based on annual data. Such data may be subject to cyclical fluctuations that can affect the results. Even though we have included year dummies to protect our data from biases induced by exogenous shocks, it seems cautious to test the robustness of our results for different time periods. We run equation (40) with all variables on five year averages in spite of annual data. Obviously, the sample becomes extremely small (36 observations). The results reported in column a show that the coefficient of higher education does not change much and stays highly significant.

TABLE 6

We also reestimate the model with different definitions and sources for the labour share, education and other measures of the capital-output ratio and the degree of openness. First, we focus on the measure of the dependent variable, the labour share. Columns b to d report estimates of the coefficient on higher

education with the labour share adjusted or not, measured at the factor cost or at the market price. All estimations show that the coefficient on higher education is positive and significant (except for the naive measure at market prices). Second, we focus on education. We replace the proportion of higher educated from the Barro and Lee dataset by the same variable from the de la Fuente and Domenech dataset. Results reported in column e are almost unchanged. Third, we test whether results change when we use a second source for the capital-output ratio. We use the STAN database, which provides the ratio for the whole economy rather than for the business sector only (column f). Even if the sample becomes very small (87 observations), the replacement of the measure for the capital-output ratio does not modify the role of education. We do the same for the degree of openness. We use the capital account openness index computed by Brune et al (2001). The coefficient associated to this variable is negative and significant (column g). This strengthens the idea globalization erodes the labour share through increased capital mobility. In column h, a last variable is added to our regression: the index of stringency of anticompetitive product market competition (PMR), from Nicoletti et al (1999). Only one regression is reported here, but we have introduced this index in a number of specifications. The result is always the same: PMR is not significant. It could be due to the poor quality of the index – a lot of observations are repeated year after year – and the small sample size – introducing it reduces the sample from 264 to 150 observations.

TABLE 7

As a final sensitivity test, we would like to ensure that the positive impact of higher education is not an artefact of aggregation between countries. We thus run eleven regressions, one for each country. Results are reported in Table 7. We observe that all countries but one have a positive coefficient, and that 7 over 11 countries report significant coefficients.

4 Alternative theories

This section addresses the important question of potential alternative theories. We proceed in three steps. First, we consider a general production technology with three factors paid their marginal products. We examine the (restrictive) conditions under which the resulting labour share can increase with the share of higher educated. Second, we show the three-factor model is unable to predict a positive impact of labour market institutions and higher education together with a negative impact of the unemployment rate. Third, we turn to another potential model, based on imperfect competition on the good market, and wage bargaining on the labour market. In such a model, education can increase the labour share through majoring workers' outside options. Actually, this model is very close to our model where firms are endowed with local monopsony power.

4.1 The three-factor model: theoretical aspects

Suppose that output is produced by means of three inputs: capital K, educated workers H, and uneducated workers L. Hence, $Y = F(K, H, L)$, where F is a neoclassical technology. Factors are paid their marginal products:

$$r = F_K(K, H, L),\ w_H = F_H(K, H, L),\ w_L = F_L(K, H, L) \tag{43}$$

where w_H (w_L) is the wage of (un)educated workers. The labour share is

$$\text{LS} = 1 - \frac{rK}{F(K,H,L)} \tag{44}$$

Let $\widetilde{\pi} = H/(H+L)$ be the proportion of educated *among employed workers*, $k = K/(H+L)$ be capital per worker, and $f(k,\widetilde{\pi}) = F(k,\widetilde{\pi},1-\widetilde{\pi})$ output in intensive form. It follows that

$$\text{LS} = 1 - \frac{kf_k(k,\widetilde{\pi})}{f(k,\widetilde{\pi})} \tag{45}$$

We address two questions. First, can we derive from equation (45) a labour share regression in which the impact of the proportion of educated is positive? Second, given some additional restrictions, can we expect an increase in the proportion π of educated *among the workforce/population* has a positive effect on the labour share?

In the neighborhood of some $(k_0,\widetilde{\pi}_0)$, we get

$$\text{LS} \approx \delta_0 + \delta_1 k + \delta_2 \widetilde{\pi} \tag{46}$$

What is the expected sign of parameter $\delta_2 = \partial \text{LS}(k_0,\widetilde{\pi}_0)/\partial\widetilde{\pi}$? Answering such a question in the general case reveals too difficult. We thus focus on nested production functions, and more particularly on nested CES technologies. The main idea consists in grouping two factors within a single class, then considering output as a function of the resulting class and the third input. Formally, let (x_1,x_2,x_3) be the input vector, and let G denote the class formed by inputs x_1 and x_2. We get

$$F(x_1,x_2,x_3) = F(G(x_1,x_2),x_3) \tag{47}$$

We more especially consider

$$G(x_1,x_2) = (x_1^\rho + x_2^\rho)^{1/\rho} \tag{48}$$

$$F(G,x_3) = (G^\nu + x_3^\nu)^{1/\nu} \tag{49}$$

The parameter $1/(1-\rho)$ is the intra-class elasticity of substitution between x_1 and x_2, while the parameter $1/(1-\nu)$ is the inter-class elasticity of substitution between G and x_3. Importantly, $1/(1-\nu)$ is not the elasticity of substitution between x_1 and x_3 or x_2 and x_3. However, Duffy, Papageorgiou and Perez-Sebastian (2004) show an important relationship between such elasticities. Let ε_{ij} be the elasticity of substitution between inputs i and j in the three-factor production function. Then[21],

$$\forall i,j \in \{1,2\},\ i \neq j,\ \varepsilon_{ij} < \varepsilon_{i3} \Leftrightarrow \nu < \rho \tag{50}$$

Given some empirically relevant knowledge on ε_{KH} and ε_{KL}, property (50) provides us with the possibility to tell whether the different conditions on ρ and ν compatible with a positive impact of higher education are empirically plausible or not. Table 8 depicts the three possible cases (see appendix 6.3).

Table 8: Higher education and the labour share in the three-factor model

[21] There are different ways to measure the elasticities of substitution in a three-factor production function. The two most famous are the direct elasticity and the Allen elasticity. The set of inequalities (50) holds in both cases.

Specifications	(1)	(2)	(3)
Output Y	$[(H^\rho + L^\rho)^{\frac{\nu}{\rho}} + K^v]^{\frac{1}{\nu}}$	$[(K^\rho + H^\rho)^{\frac{\nu}{\rho}} + L^\nu]^{\frac{1}{\nu}}$	$[(K^\rho + L^\rho)^{\frac{\nu}{\rho}} + H^\nu]^{\frac{1}{\nu}}$
Restrictions	$\varepsilon_{KL} = \varepsilon_{KH}$	$\varepsilon_{LK} = \varepsilon_{LH}$	$\varepsilon_{HK} = \varepsilon_{HL}$
Q1 - Labour share equation	$\frac{\partial \text{LS}}{\partial \widetilde{\pi}} < 0$ iff $\nu (w_H - w_L) < 0$	$\frac{\partial \text{LS}}{\partial \widetilde{\pi}} < 0$ if $\rho < 0 < \nu$	$\frac{\partial \text{LS}}{\partial \widetilde{\pi}} < 0$ if $\nu < 0 < \rho$
Q2 - Global effect	$\frac{d\text{LS}}{d\pi} = 0$	$\frac{d\text{LS}}{d\pi} \gtreqless 0$	$\frac{d\text{LS}}{d\pi} \gtreqless 0$

Each column corresponds to a particular specification and each specification proceeds to a restriction on the elasticities of substitution between the different inputs. For instance, in specification (1), the elasticity of substitution between capital and labour does not differ across education groups. Lines Q1 examine the likelihood of a positive relationship between higher education and the labour share in the labour share regression. Line Q2 proceeds to a similar exercise, yet it concerns the global effect of the proportion of higher educated in the workforce/population on the labour share. To do so, we need additional information on price determination. As in our model, we assume that the interest rate is given. The information displayed by lines Q1 and Q2 suggests that the three-factor model may predict a positive relationship between the labour share and higher education, yet such prediction requires strong restrictions on the elasticities of substitution between the different inputs.

On the one hand, lines Q1 show that popular cases previously investigated in the literature imply $\partial \text{LS}/\partial \widetilde{\pi} < 0$. In specifications (2) and (3), the proportion of educated *reduces* the labour share when capital and educated labour are complements, and both are substitutes to uneducated labour. This restriction is a typical case of the so-called capital-skill complementarity phenomenon initially studied by Griliches (1969), and emphasized by Hamermesh (1993).

On the other hand, specification (1) may predict a positive impact of the proportion of educated on the labour share in the labour share regression. Indeed, one must see w_H and w_L as wage rates per efficient unit of labour (H and L incorporating education-specific productivity parameters), hence the sign of $\nu (w_H - w_L)$ is ambiguous. However, line Q2 shows that the global impact on the labour share of the relative supply of educated workers cannot be positive in specification (1). In this specification, the labour share only depends on the interest rate, so that $d\text{LS}/d\pi = 0$.

4.2 The three-factor model: empirical aspects

The previous sub-section argues that it is possible to find production functions compatible with a positive impact of higher education in the following regression:

$$\text{LS} = \delta_0 + \delta_1 k + \delta_2 \widetilde{\pi} + \varepsilon \tag{51}$$

where ε is the vector of residuals. However, we do not perform such regression. Rather, we estimate

$$\text{LS} = \delta_0' + \delta_1' k + \delta_2' \pi + \delta_3' u + \delta_4' LMI + \varepsilon' \tag{52}$$

There are two main differences. On the one hand, we consider π, the proportion of educated workers in the population/workforce, rather than $\widetilde{\pi}$, the proportion of educated workers among employed workers. On the other hand, we add the unemployment rate u and two labour market institutions (minimum wage to median wage ratio, and degree of unionization) to the set of regressors. Importantly, the three-factor

model predicts the signs of δ_2' and δ_3' must be the same, while, to a lesser extent, the parameters δ_4' should not be significant.

To show this, note that the proportions of educated among the employed and among the workforce/population are related by:

$$\begin{aligned}\widetilde{\pi} &= \frac{\pi(1-u_H)}{\pi(1-u_H)+(1-\pi)(1-u_L)} \\ &= \left[1+\frac{1-\pi}{\pi}\frac{1-u_L}{1-u_H}\right]^{-1} \\ &\approx \left[1+\frac{1-\pi}{\pi}(1-\Delta u)\right]^{-1}\end{aligned}$$

where u_H and u_L are the unemployment rates of educated and uneducated workers, and $\Delta u \equiv u_L - u_H$ is the unemployment rate differential. Therefore, $\partial\widetilde{\pi}/\partial\pi > 0$ and $\partial\widetilde{\pi}/\partial(\Delta u) > 0$. Back to the labour share, we have in the neighborhood of some $(k_0, \pi_0, \Delta u_0)$,

$$\text{LS} \approx \delta_0'' + \delta_1'' k + \delta_2'' \pi + \delta_3'' \Delta u \tag{53}$$

where $\delta_2'' = (\partial \text{LS}/\partial\widetilde{\pi})(\partial\widetilde{\pi}/\partial\pi)$ and $\delta_3'' = (\partial \text{LS}/\partial\widetilde{\pi})(\partial\widetilde{\pi}/\partial\Delta u)$ have the same sign. From the latter equation, labour market institutions and unemployment rate cannot directly affect the labour share. Moreover, our regressions include the capital intensity k and the proportion of educated in the population π among the regressors. It follows that labour market institutions and unemployment rate can only affect the labour share through changes in the unemployment rate differential Δu.

Let us start with the unemployment rate. A tentative guess suggests that it should be positively correlated with the unemployment rate differential. The OECD provides homogenous data concerning unemployment rates by education level since 1997. We have performed several regressions of the unemployment rate differential on the unemployment rate. The results are shown in Table 9.

TABLE 9

The relationship between the unemployment rate differential and unemployment rate is unambiguously positive: a one point increase in unemployment rate translates into a half point increase in the unemployment rate differential. Put otherwise, an increase in the unemployment rate differential is captured in our regression by an increase in unemployment rate. A major prediction follows: *In regression (52), the parameter δ_3' must have the sign of parameter δ_2' according to the three-factor model, while δ_3' must be negative and δ_2' must be positive according to our monopsony model.* Our empirical analysis shows that $\delta_2' > 0$ and $\delta_3' < 0$. These results are in accordance with our model, yet they cannot be explained by the three-factor model.

Now, consider the labour market institutions. Both the minimum wage to median wage ratio should disproportionately alter the uneducated unemployment rate, thereby increasing the unemployment rate differential. Thus, they should impact the labour share in the same direction than the proportion of educated. This is in accordance with our estimates, which report a positive impact of the minimum to median wage ratio, a positive impact of union density, together with a positive impact of the proportion of educated. The point is that the unemployment rate is likely to concentrate most of the unemployment rate

differential between education groups. In such case, labour market institutions should not be significant in the regressions. By contrast, our model distinguishes the positive direct effect of such institutions from their negative indirect effect that is incorporated into the impact of the unemployment rate.

4.3 Accounting for imperfect competition on the good market

One may consider another story relating the labour share to labour market institutions and higher education. This story builds on Blanchard and Giavazzi (2003). They introduce monopolistic competition on the good market. This originates rents that must be divided between firms and workers. The share of rents accruing to labour depends on bargaining structures – labour market institutions – and status quo positions. The latter are affected by the generosity of unemployment compensation and, more generally, the magnitude of outside options. In turn, such options should decline with the unemployment rate. Such a general canvas offers a framework in which the unemployment rate and the labour market institutions affect the labour share.

Now, suppose that education offers adaptability skills that improve workers' employment perspectives. This means education raises workers' outside options at given output. Consequently, education should increase the share of rents obtained by the workers, and, therefore, the labour share.

This mechanism is very close to the one we examine in this paper. Both have in common labour is not paid its marginal product. As far as the data are concerned, we did not find any significant impact of our proxy for imperfections on the good market.

5 Conclusion

This paper suggests that higher education should increase the labour share, because it appreciates workers' mobility skills, and therefore reduce employers' monopsony power over wage setting. We proceed in two steps. First, the main thesis is developed in a two-sector model with heterogenous workers where monopsony power originates from search frictions on the labour market. Higher education affects the number of technologies a worker can operate, and thus the number of sectors she can prospect as a job seeker, and the potential number of job offers she may receive. Hence, higher education raises wage competition among employers, which implies the labour share is increasing in the proportion of higher educated. Second, we confront the theory to OECD data covering the period 1970-2000. We identify higher education to tertiary education as defined in the Barro and Lee (2000) dataset. Typically, an increase of one standard deviation in higher education induces a three point increase in the labour share. This result appears robust to various issues like endogeneity bias and alternative data sources. The other determinants of the labour share include the capital to output ratio (-), the minimum to median wage ratio (+), the unemployment rate (-), and union density (+). Those results are compatible with our model, while they are inconsistent with a three-factor model where factors are paid their marginal products.

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6 Appendix

6.1 Construction of the labour shares

From OECD definitions (Economic Outlook Statistics and Projections, 2002), we can compute:

$$\begin{aligned}
\text{LS mp} &= \frac{\text{WSSS}}{\text{GDP}} \\
\text{LS fc} &= \frac{\text{WSSS}}{\text{GDP - TIND + TSUB}} \\
\text{LS mp adj} &= \frac{\text{WSSS (1+ (ES / (ET - ES)))}}{\text{GDP}} \\
\text{LS fc adj} &= \frac{\text{WSSS (1+ (ES / (ET - ES)))}}{\text{GDP - TIND + TSUB}}
\end{aligned}$$

where:

WSSS = Compensation of employees, at current prices, national currency

GDP= Value added at market prices, current prices, national currency.

TIND = Net indirect taxes

TSUB = Subsidies

ES = Number of self-employed

ET= Total employment

6.2 Other data sources and definitions

- CAOI: Capital Account Openness Index (CAOI); unit: Varying between 0 (fully closed) and 9 (fully open).

  The index is based on nine categories of capital account transactions: (1) payments from invisible transactions; (2) proceeds from invisible transactions; (3) inward controls on money market transactions; (4) outward controls on money market transactions; (5) inward controls on credit operations; (6) outward controls on credit operations; (7) inward controls on foreign direct investment and real estate; (8) outward controls on foreign direct investment and real estate; (9) and controls on provisions and operations of commercial and credit institutions. Each category is coded as either having significant restrictions ("closed") or not ("open"). The index is the sum of the scores for the dummy variables in each of these categories. Data are available for two sub-periods: 1973-1979 and 1990-1999.

  Source: Brune, N., Garrett, G., Guisinger, A., and Sorens, J., 2001.The political economy of capital account liberalization. Working Paper, Yale University and UCLA

- HIGHDOM: Percentage of higher school attained in population over age 25

  Source: Educational Attainment levels in the OECD, 1960-1995, De la Fuente and Domenech, 2001, version 2.1

- HIGH: Percentage of higher school attained in total population; five years average, interpolated to obtain annual data

  Source: Barro, R. J. and Lee J.W., 2000. International Data on Educational Attainment: Updates and Implications (CID Working Paper no. 42)

- INTEREST: Real interest rate = T-Bill-CPIant, where T-Bill is a short-term debt obligation issued by the US Treasury at a discount under competitive bidding, with a maturity of up to one year, and CPIant is the expected Consumer Price Index one-year ahead forecast formed from a univariate ARMA(1,1) process

  Source: International Fund Statistics, 2005

- KYT: Ratio of real capital stock on value-added at market price;

  Source : value-added at market price (GDPD) comes from ISDB (OECD) at 1990 prices and 1990 PPA (US$)

- KY: Ratio of capital stock in business (KBV) on GDP in private sector (GDPBV)

  Source : OECD Economic Outlook, vol. 2002/2.

- MINMED: Ratio of the minimum on the median wage

  Source : OECD Labour Force Statistics database

  data available at http://www1.oecd.org/scripts/cde/members/lfsdataauthenticate.asp.

- OPEN: Index = (Imports+Exports) / real GDP (Laspeyres); unit : % of 1996 price

  Source : Heston, A., Summers, R. and Aten, B., Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002

- PMR: Global index of stringency of anticompetitive product market regulation; unit: varying between 0 and 6 from least to most stringent

  Source : OECD Employment Outlook, 2002.

- R&D: Total national spendings in research and development, in five years average lags; unit: % of GDP

  Source: Eurostat, http://epp.eurostat.cec.eu.int, (June 2005)

- TAX WEDGE: Total tax wedge including employer's social security contributions; unit: average rate in %

  Source: OECD, 2005.

- UNION: Union membership index; Specific studies and if does not available, administrative data

  Source : OECD Labour Force Statistics database.

- UNR: Unemployment rate; unit: %

  Source: OECD Labour Force Statistics database.

6.3 Higher education and the labour share in the three-factor model

In this Appendix, we compute the labour share in the different cases shown by Table 8.

6.3.1 Specification (1): $Y = F(G(L, H), K)$

Output is:

$$Y = [(L^\rho + H^\rho)^{\frac{\nu}{\rho}} + K^\nu]^{\frac{1}{\nu}} = (L + H) f(k, \widetilde{\pi}) \tag{54}$$

with

$$f(k, \widetilde{\pi}) = [((1 - \widetilde{\pi})^\rho + \widetilde{\pi}^\rho)^{\frac{\nu}{\rho}} + k^\nu]^{\frac{1}{\nu}} \tag{55}$$

Each input is paid its marginal product:

$$w_H = f(k, \widetilde{\pi})^{1-\nu} \left((1 - \widetilde{\pi})^\rho + \widetilde{\pi}^\rho\right)^{\frac{\nu}{\rho}-1} \widetilde{\pi}^{\rho-1} \tag{56}$$

$$w_L = f(k, \widetilde{\pi})^{1-\nu} \left((1 - \widetilde{\pi})^\rho + \widetilde{\pi}^\rho\right)^{\frac{\nu}{\rho}-1} (1 - \widetilde{\pi})^{\rho-1} \tag{57}$$

$$r = f(k, \widetilde{\pi})^{1-\nu} k^{\nu-1} \tag{58}$$

The labour share is:

$$\text{LS} = 1 - \frac{k^\nu}{((1 - \widetilde{\pi})^\rho + \widetilde{\pi}^\rho)^{\frac{\nu}{\rho}} + k^\nu} \tag{59}$$

It follows that:

$$\frac{\partial \text{LS}}{\partial \widetilde{\pi}} \overset{sign}{=} \nu \left[w_H - w_L\right] \tag{60}$$

When r is given, we obtain:

$$\text{LS} = 1 - r^{-\frac{\nu}{1-\nu}} \tag{61}$$

6.3.2 Specification (2): $Y = F(G(K, H), L)$

Output is:

$$Y = \left[(K^\rho + H^\rho)^{\frac{\nu}{\rho}} + L^\nu\right]^{\frac{1}{\nu}} = (H + L) f\left(k, \widetilde{\pi}\right) \tag{62}$$

where

$$f\left(k, \widetilde{\pi}\right) = \left[(k^\rho + \widetilde{\pi}^\rho)^{\frac{\nu}{\rho}} + (1 - \widetilde{\pi})^\nu\right]^{\frac{1}{\nu}}$$

Factors are paid their marginal product:

$$w_H = f\left(k, \widetilde{\pi}\right)^{1-\nu} \left(k^\rho + \widetilde{\pi}^\rho\right)^{\frac{\nu}{\rho}-1} \widetilde{\pi}^{\rho-1} \tag{63}$$

$$w_L = f\left(k, \widetilde{\pi}\right)^{1-\nu} (1 - \widetilde{\pi})^{\nu-1} \tag{64}$$

$$r = f\left(k, \widetilde{\pi}\right)^{1-\nu} \left(k^\rho + \widetilde{\pi}^\rho\right)^{\frac{\nu}{\rho}-1} k^{\rho-1} \tag{65}$$

The labour share is:

$$\text{LS} = 1 - \frac{k^\rho}{k^\rho + \widetilde{\pi}^\rho + (1 - \widetilde{\pi})^\nu (k^\rho + \widetilde{\pi}^\rho)^{1-\frac{\nu}{\rho}}} \tag{66}$$

The derivative of LS with respect to $\widetilde{\pi}$ is:

$$\frac{d\text{LS}}{d\widetilde{\pi}} \overset{sign}{=} \rho \widetilde{\pi}^{\rho-1} \left[1 + (1 - \widetilde{\pi})^\nu z^{\frac{-\nu}{\rho}}\right] - \nu (1 - \widetilde{\pi})^{\nu-1} z^{\frac{-\nu}{\rho}} \left[z + (1 - \widetilde{\pi}) \widetilde{\pi}^{\rho-1}\right] \tag{67}$$

where $z = k^\rho + \widetilde{\pi}^\rho$. The two terms in brackets are strictly positive. Therefore $\partial LS / \partial \widetilde{\pi} < 0$ if $\rho > 0 > \nu$.

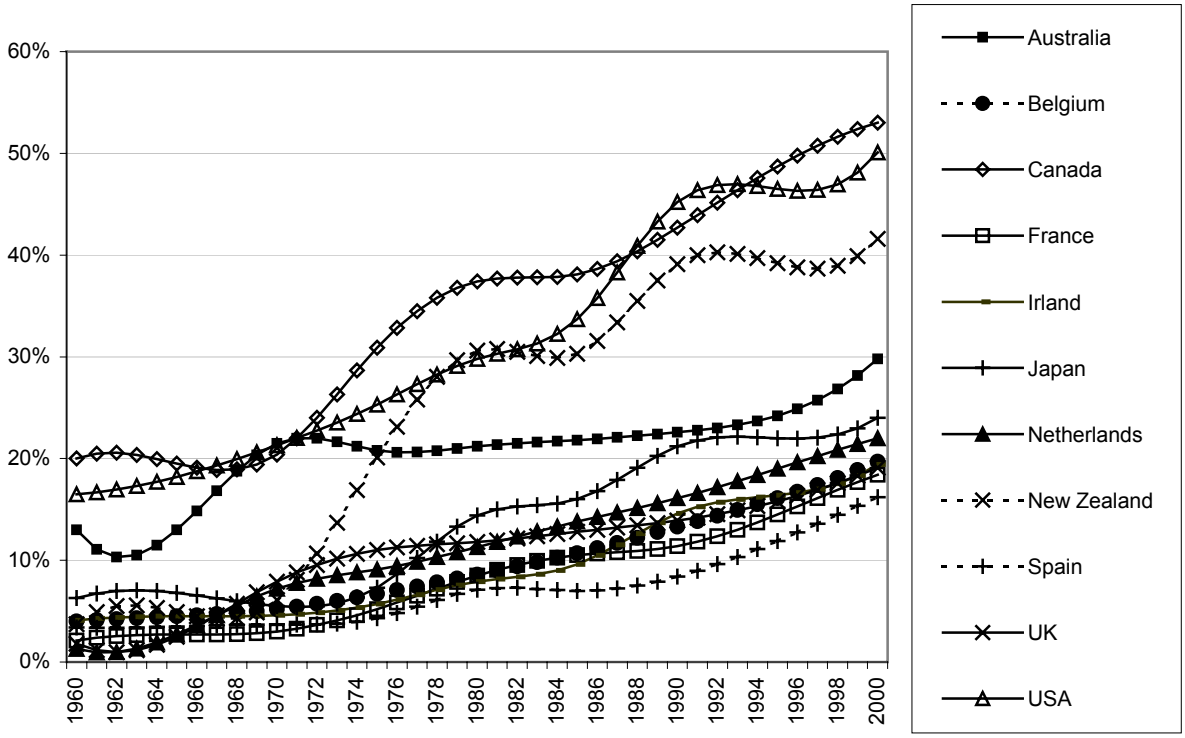
6.3.3 Specification (3): $Y = F(G(K, L), H)$

Output is

$$Y = [(K^\rho + L^\rho)^{\frac{\nu}{\rho}} + H^\nu]^{\frac{1}{\nu}} \tag{68}$$

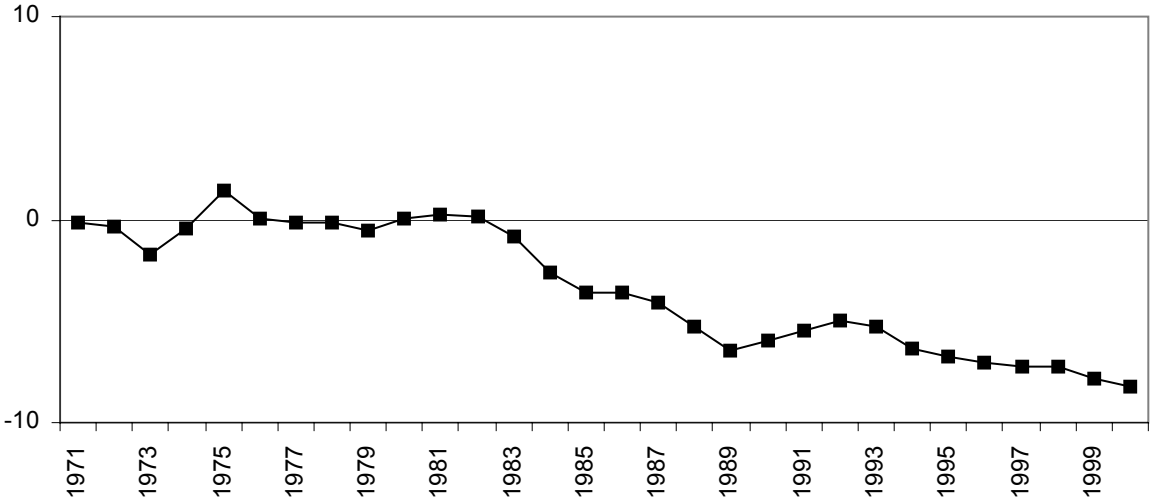
The analysis is similar to specification (2). We get $\partial LS / \partial \widetilde{\pi} < 0$ if $\nu > 0 > \rho$.

Figure 1: Share of population with post-secondary education



Sources: Barro and Lee dataset, interpolated over 5-years

Figure 2: Time dummies



Notes: Are reported the time dummies for the regression of Table 2, column (a).

Table 1: Descriptive statitics of the main variables

Variables	Obs	Mean	Std. Dev.	Min	Max
Labour shares in business					
LS mp	264	53.102	3.900	40.111	60.211
LS mp adjusted	264	63.222	4.784	49.287	79.388
LS fc	250	59.245	3.726	45.840	65.654
LS fc adjusted	250	70.232	4.438	56.327	83.334
Education					
High level attainment from B&L (HIGH)	264	21.585	12.629	2.692	53
High level attainment from D.F.& D (HIGH DF&D)	201	21.909	10.274	5.704	48.02
Labour market					
Unemployment rate (UNR)	264	6.823	3.660	.076	18.436
Unionization (UNION)	264	30.524	14.522	7.4	69.1
Minimum to median wage ratio (MINMED)	264	47.424	10.350	28	65
Tax wedge	185	35.391	6.790	24.3	46.114
Other variables					
Research and Development in %GDP (R&D)	116	1.917	.678	.41	2.844
Capital/Output ratio in business (KY)*	264	32.503	8.482	21.801	54.228
Openness degree (OPEN)*	264	17.983	12.880	3.261	69.693
Capital Account Openness Index (CAOI)*	264	4.159	3.027	0	8
Real interest rate (INTEREST)	193	3.130	2.880	3.936	9.437

Note: for sources and/or calculations see Appendix.

Table 2: Regression results, basic specifications

	(a)	(b)	(c)	(d)
Estimation method	Fixed Effects	Fixed Effects	IV/2SLS	GMM
HIGH	0.226***	0.262***	0.088***	0.090***
	[0.047]	[0.069]	[0.030]	[0.030]
KY	-0.230***	-0.187**	-0.275***	-0.259***
	[0.074]	[0.082]	[0.083]	[0.081]
MINMED	0.085***	0.026	0.106***	0.110***
	[0.030]	[0.044]	[0.035]	[0.035]
OPEN	-0.005	-0.01	-0.124**	-0.126***
	[0.070]	[0.066]	[0.048]	[0.048]
UNION	0.164***	0.112***	0.190***	0.187***
	[0.026]	[0.026]	[0.021]	[0.021]
UNR	-0.045	-0.167*	-0.253*	-0.281**
	[0.095]	[0.099]	[0.132]	[0.127]
TAX WEDGE		0.250***		
		[0.081]		
Period dummies	Yes	Yes	Yes	Yes
Observations	264	185	252	252
Countries	11	11	10	10
R-squared	0.77	0.81		
Hansen-Sargan			0.207	0.268

Notes: Robust standard errors in brackets

* significant at 10%; ** significant at 5%; *** significant at 1%

Hansen-Sargan is a test of overidentifying restrictions, P-value is reported

Table 3: Role of the capital-output ratio

	(a)	(b)	(c)	(d)
Estimation method	Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
HIGH	0.226***	0.239***	0.123***	0.262***
	[0.047]	[0.048]	[0.030]	[0.063]
KY	-0.230***		-0.495***	0.043
	[0.074]		[0.059]	[0.105]
MINMED	0.085***	0.063**	0.116***	0.318***
	[0.030]	[0.030]	[0.030]	[0.108]
OPEN	-0.005	0.112*	-0.281***	-0.401***
	[0.070]	[0.061]	[0.040]	[0.086]
UNION	0.164***	0.123***	0.264***	0.426***
	[0.026]	[0.023]	[0.022]	[0.050]
UNR	-0.045	-0.207**	0.136*	-0.264***
	[0.095]	[0.082]	[0.069]	[0.094]
R&D				-4.782**
				[2.288]
Period dummies	Yes	Yes	No	Yes
Observations	264	264	264	116
Countries	11	11	11	8
R-squared	0.77	0.76	0.65	0.91

Notes: Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Auxiliary regressions

	UNR	UNR	KY	KY
HIGH	-0.130***	-0.133**	-0.389***	-0.343***
	[0.037]	[0.057]	[0.044]	[0.066]
MINMED	0.079***	0.138***	0.131***	0.119**
	[0.024]	[0.033]	[0.028]	[0.045]
INTEREST			-0.005	-0.068
			[0.049]	[0.071]
UNION	0.007	0.01	0.095***	0.077***
	[0.016]	[0.017]	[0.017]	[0.021]
TAX WEDGE		0.137**		0.215**
		[0.057]		[0.093]
Period dummies	Yes	Yes	Yes	Yes
Observations	352	266	193	151
Countries	18	18	9	9
R-squared	0.57	0.31	0.71	0.52

Notes: Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5: Contribution of education to labour share movements (in points)

Country	Observed ΔLS	Observed ΔHIGH	Contribution FE	Contribution FE + tax wedge	Contribution IV
Australia (1980-2000)	-2.9	8.6	2.7	3.0	2.0
Belgium (1975-2000)	-5.9	13.6	4.3	4.7	3.1
Canada	0.0	32.6	10.3	11.4	7.4
Spain (1980-2000)	-8.3	9.1	2.9	3.2	2.1
France	-6.1	15.4	4.9	5.4	3.5
UK	-0.8	11.2	3.5	3.9	2.6
Irland (1971-2000)	-22.7	14.7	4.6	5.1	3.3
Italy	-7.0	12.1	3.8	4.2	2.8
Japan (1975-2000)	-13.9	16.7	5.3	5.8	3.8
Netherlands	-9.0	14.8	4.7	5.2	3.4
New Zealand (1972-2000)	-8.6	31	9.8	10.8	7.1
USA	-3.2	28.8	9.1	10.0	6.6

Table 6: Sensitivity analysis

	Time sensitivity				Measure sensitivity						
	sub-periods			5 years	Labour shares			HIGH			
	1970-1980	1980-1990	1990-2000	av.	LS mp	LS fc	LS fc adj.	DF&D	KY	Openness	Oil price
HIGH	0.043	0.365***	0.091*	0.197**	0.057	0.171***	0.362***		0.331***	0.119**	0.249***
	[0.053]	[0.110]	[0.068]	[0.087]	[0.038]	[0.045]	[0.064]		[0.097]	[0.048]	[0.053]
HIGH DF& D								0.212***			
								[0.081]			
KY in the whole economy									0.431		
									[1.755]		
CAOI										-0.566***	
										[0.108]	
Real oil price											0.285*
											[0.148]
Observations	78	84	102	59	143	130	130	201	164	264	244
Countries	7	9	11	11	9	8	8	9	7	11	11
R-squared	0.37	0.73	0.65	0.77	0.66	0.68	0.71	0.70	0.67	0.80	0.78

Table 7: Estimations country by country

Countries	HIGH	Standard errors	Observations	R-squared
Australia	0.149	[0.601]	26	0.68
Belgium	-0.655	[0.403]	31	0.92
Canada	0.167**	[0.070]	35	0.47
France	2.645***	[0.358]	36	0.93
Italy	0.001*	[0.429]	40	0.90
Japan	1.336***	[0.206]	36	0.88
Netherlands	0.477*	[0.495]	32	0.91
New Zealand	0.251	[0.247]	29	0.80
Spain	1.675	[1.326]	20	0.87
UK	2.692***	[0.860]	31	0.57
USA	0.062*	[0.034]	41	0.91

Notes:* significant at 10%; ** significant at 5%; *** significant at 1%
R-squared is the within-R-squared.
MINMED has been removed from regressions in order to obtain more observations

Table 9: Unemployment rate and unemployment rate differential

	(a) pooled OLS	(b) Fixed Effects	(c) Fixed Effects
U_L-U_H	0.398***	0.461***	0.502***
	[0.041]	[0.052]	[0.052]
Period dummies	No	No	Yes
Observations	220	220	220
Countries	31	31	31
R-squared	0.30	0.30	0.39

Notes : Standard errors in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%