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by

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January 10, 2008

Abstract

We study the evolution of the wage differentials between graduate (skilled) and non graduate (unskilled) workers in several european countries in the period that range from the beginning of the nineties to the beginning of this century. The starting point is that all european countries show an increasing relative supply of skilled workers but different behaviours of the wage differentials. The standard explanation for non decreasing differentials in the face of rising relative supply is that technological progress is skill biased. This in turn would imply that technological progress differs in its magnitude and effects across Europe. Our finding shows that what is relevant in the determination of the differentials it is the pace and intensity at which technological progress takes place. We turn then to institutions and we build a model of imperfect competition and wage bargaining which relate the differentials to the technological progress but also to several labour market institutions. The empirical analysis on this aspect reveal that employment rates of different groups as well as the union density and the generosity of unemployment benefits are indeed important and help in explaining the evolution of the wage differentials between skilled and unskilled workers.

1 Introduction

The notion that the wage differentials between skilled and unskilled depend on the technological change seems to be a consolidated fact. This relationship may

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vary in its magnitude through time and space, but most of the empirical analyses on this subject conclude that the skilled workers benefit relatively more from the progress in technology than the unskilled: what we observe then, is skill biased technological change (SBTC). Most of the evidence comes from the US, with Katz and Murphy (1992) being probably the first and most influential analysis and with several other papers confirming the presence of SBTC: Acemoglu (2001) is one of the most relevant, trying to endogenize SBTC, while Beaudry and Greene (2003) update the analysis of Katz and Murphy with more recent data. A smaller number of papers have appeared covering evidence from the rest of the world: works by Berman, Bound and Machin (1998) and Machin and Van Reenen (1998) tackles the consequences of technological change examining a larger groups of countries.

The basic idea for this relationship starts from the observation that the relative supply of skilled workers has been increasing in all industrial country and it is not usually accompanied by a decrease in the wage differentials. Since we do not observe a fall of the differentials while the factor becomes relatively more abundant, there must be something which is also increasing the labour demand for skilled. Several explanations are possible for this shift in the demand, but the one which seems to be confirmed by the above analysis is that (skill biased) technological change is the cause of the shift. The other possible explanations lay in the rise in the international commerce, which increased the competition with less developed countries and decreased low skilled wages, or on changes in the labour market conditions. The former has been widely studied but evidence of it has been hardly found while the latters did not receive much attention, with only a few articles focusing on them.

In this paper we focus on the wage gap between workers who hold a graduate degree (what we consider the skilled) and those who does not hold such a degree (the unskilled). This measure is similar to the one used in Katz and Murphy (1992) and Beaudry and Greene (2003) but has rarely been analysed outside US. We have data covering 10 European countries: Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Italy, Spain and UK, in a time span that range from the beginning of the nineties to the beginning of the new century. There are no official data that measures the ratio of wage of graduate and non graduate and we derive such values starting from surveys on workers: the British Household of Panel Studies for UK (BHPS), the German Socio Economic Panel for Germany (GSOEP) and the European Community Household Panel (ECHP) for the rest of the countries.

The differentials have an evolution quite different across those countries: in some they rise, in other decrease and in a few stay constant. Overall, the average ratio of the wages of the two groups of workers is quite comparable through the countries, ranging from 1.424 in Denmark to 1.756 in Spain (and Spain has a remarkable higher ratio than the rest of the countries). On the contrary, the relative supply of skilled workers is increasing in all country (with the partial exception of Ireland) but it greatly differs in its average level: from 0.11 in Austria to 0.77 in UK. Obviously this great variety is due to the differences in the participation rates to tertiary education but also in the differences that the

concept of "graduate degree" assumes in different countries.

The differences in the evolution of the wage differentials pose an interesting puzzle when compared to the common growth of relative supply. From our starting consideration on the role of technological change, there are a couple possible explanations to this behaviour: technological change does not happens at the same rate in different (through quite similar and near) countries so that using a common trend to measure it is misleading; 2) technological change happens at a similar rate, but its effects is different in different countries, being less (or non) biased in certain countries than in others; or 3) a combination of the two. To disentangle these possibilities is the first of our goals.

Obviously, the different evolutions may also be explained by the other factors. One of them is international trade, which we take into account in our analysis but that we not tackle in particular, as there are several papers on this subject that conclude that such effect is at the most feeble. On the contrary, we do focus on the role if institutions in the labor market, something that has hardly been done before. In particular we want to examine a context where wages are determined through union bargaining and we want to determine whether some elements like benefits generosity, employment protection and union density may, favoring some groups of worker over the other, help in explaining the evolution of the differentials.

The work is organized as follows: section two explains how we derived our data and briefly describes them, section three introduces a theoretical model which explain the determination of the differentials, both with and without the wage bargaining; section four presents the econometrical analysis, first focusing on the technological change and then adding also the institutions; section five concludes.

2 Data Description

The main variables we are interest in is the wage ratio between graduate and non graduate workers. There are no official data describing this variable so that we have to build it starting from national surveys on workers. What we need is basically a measure of the average wage for workers who hold at least a graduate degree (the skilled) and the average wage of the rest of the workers. The surveys which we use in our analysis are the BHPS (from 1991 to 2003), the GSOEP (from 1992 to 2003) and the ECHP (from 1994 to 2001) which contains data on income, education attainment and other demographic and economic information of individual workers.

For each workers we obtain a measure of his wage using the "current gross wage" variable and weighting it by the weekly working hours. We do not consider data on self employed to obtain a more comparable and trustworthy measure of wages. As for the data on education attainment, we rely on the International Standard Classification of Education (ISCED) and we consider him a graduate (and skilled) workers if he has an ISCED level of at least 5 (which is defined as first stage of tertiary education).

On principle we could simply calculate the average wage of skilled and unskilled in a given year in a given country, however we would like to remove from such a measure some possible compositional effects which may influence it but that are not particularly relevant for our analysis. In particular it is possible that the composition in terms of gender and working experience inside each group change over time, influencing the wage differential. Since we are not interested in variations due to compositional change we want to remove them. We proceed then to build a series of skill premium cleaned-up from these compositional effects: to do that we adopt the procedure presented in Katz and Murphy (1992), which we describe in what follows.

What we do is to group and weight data to obtain a homogeneous composition of workers so that the influences on wages of experience and gender is removed. To obtain this, we divide the sample into the two educational groups. For each group (skilled and unskilled) we pick out 6 classes of experience (0-2 years, 3-10, 11-20, 21-30, 31-40 and 41 and more), in turn divided by gender. Through this we obtain two matrices of 12 cells every year: each cell identified workers of a given gender and of a given experience. For each cell, and for each year studied, we calculate the average wage of skilled and unskilled workers using the current gross wage divided by the number of weekly working hours. The average wages per cell are assembled in two yearly values: one for skilled and one for unskilled. We then obtain the aggregate average wages as the weighted average of all the cells in a matrix. The weights are the same for all the years (allowing us to take away the compositional effects) and are computed as the average through time (for each single country) of the occupational rate (the share of workers belonging to that cell over the total workers) in each cell. Once we obtained the average wages for both kinds of workers we compute their ratio.

The other important variable that we need for our analysis is the ratio of labour supply between graduate and undergraduate workers. A simple measure of this would be the ratio of the total weekly hours worked between the skilled and the unskilled. However, we would like to aggregate quantities of work that are homogeneous in terms of efficiency units. Then, following the previous literature on this subject, we suppose that real wage is a measure of the efficiency of each unit. Once again we pick a country separately and we divide the workers into two matrices of 12 cells every year, as seen before. For each cell, and for each year studied, we calculate the sum of weekly hours worked by all the workers and the average wage. The supply of the skilled (or of the unskilled) is then obtained through a weighted aggregation of the total weekly hours in each cell of a given year. These weights are given by the ratio between the average through time of the wage of each cell over the average through time of the wage of a particular cell chosen as reference. Finally, we generate our time series of relative supply as the ratio between the annual supply of skilled and that of unskilled workers.

In all we obtain data on the following countries[1]: Austria (1995-2001), Bel-

[1]While ECHP survey covered also Luxembourg, Netherland and Sweden the quality of those data was not good enough to obtain a measure of wage differentials. In particular:

gium (1994-2001), Denmark (1997-2001), Finland (1996-2001), Germany (1992-2005), Greece (1994-2001), Ireland (1994-2001), Italy (1994-2001), Spain (1994-2001) and UK (1991-2003).

2.1 An overview of the data

We start showing the average share of skilled employed workers on total employed workers[2] in each country in the related years (figure 1.a).

The shares are quite different across the nations and range about 10% in Italy and Austria to the nearly 50% of Belgium and UK with an average across countries of 29,4%. Obviously such a variability is both due to the different participation of the population to the tertiary education and to differences in the exact definition of 'graduate degree' (and on how difficult and qualifying is obtaining it).

This wide variability is not met by a comparable phenomenon in the ratio between the wages of graduate and non graduate workers (see figure 1.b). This variable seems to be rather stable across the countries: from around 1.43 in Denmark and Belgium to 1.756 in Spain, with an average of 1.53. The general impression from a comparison of countries averages is that those countries with a lesser (greater) share of graduate workers do not display higher (lower) wage differential: countries with low relative supply, like Italy and Austria, have below average wage differentials, while those with high relative supply like UK and France has average differentials and quite high differential respectively. Only in Belgium a very high share of skilled workers correspond to one of the lowest wage differential. Overall, the negative relationship between differentials and relative supply does not to arise from a comparison among countries averages. In any case we are more interested in the evolution through time of these variables inside each country. The time patterns of the share of graduate is shown for each country in figure 2.

The patterns are clearly similar for most of the countries with an upward trend in the relative supply of graduate. The only exception is Ireland where this variable has been pretty much constant. Note that even if the increase in Austria and Italy seems visually modest, this is due to the scale of the graph (in Austria it rose from 8,66% to 11,95% and in Italy from 9,66% to 11,31%).

The same homogeneity of behaviour is not found in the evolution of the wage differentials (figure 3). Whereas almost all countries increased the share

data on Luxembourg do not cover gross income: the educational data on Netherland are clearly uncorrect (according to them only around 5% of workers achieved more than primary education) and data on Sweden cover to too few years. Things are different for Portuguish data which are complete enough to calculate their wage differentials. However the result is completely out of scale with an average value of the wage ratio above 3 whereas the average of the other countries is around 1.52. We do not know whether this is due to the quality of data or if they reflect the real portuguish situation, but in order not to comprimise this analysis we prefer not to use them.

[2]The measure is given by the total weighted work hours of skilled workers over total work hours of all the employed workers. The weights allow us to measure efficients units of labour, as explained above.

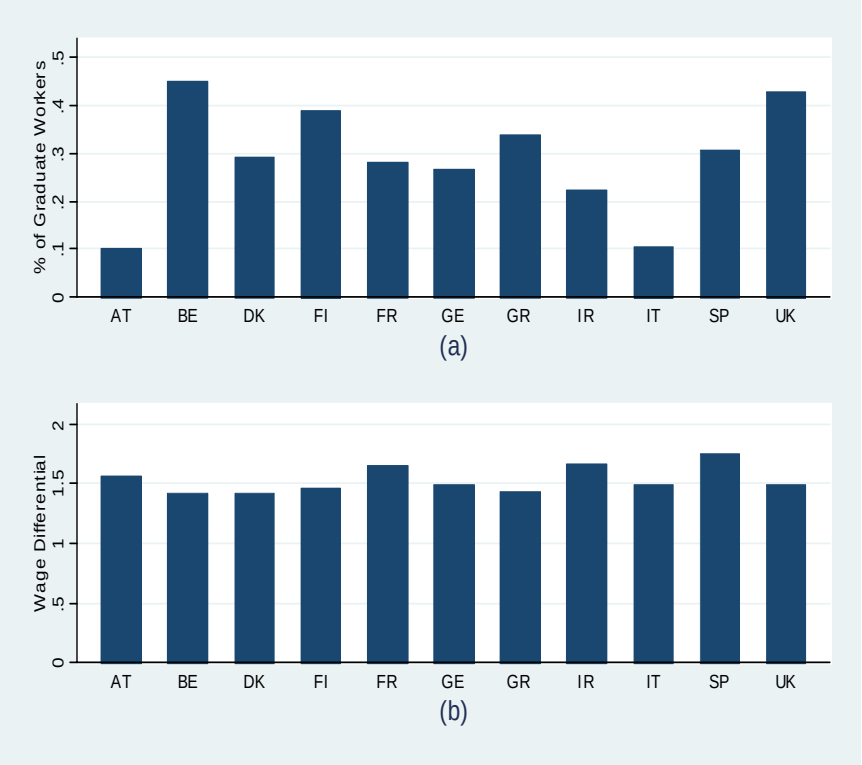

Figure 1: (a) Share of workers holding a graduate degree. (b) Skilled-Unskilled Wage Ratio

of skilled work, the wage differential shows a variety of patterns. In Austria, Belgium, Denmark and Finland is increasing, in France, Ireland, Spain and UK is decreasing while in Germany and Italy it does not have a clear trend.

If we still have in mind the basic model which explain the magnitude of the wage gap on the base of the scarcity of skilled workers we find ourself with much left unexplained. Not only the basic inverse relationship between relative wages and relative supply is not confirmed in several cases but moreover the same phenomenon produce different outcomes. Even if we introduce the effect of technology and the demand shift it may produce, it is quite clear that the demand shift was different in different countries so that the technological change cannot be seen as a common trend (or if the technological change was the same, it produced different effects). To solve this puzzle is the aim of the next sections.

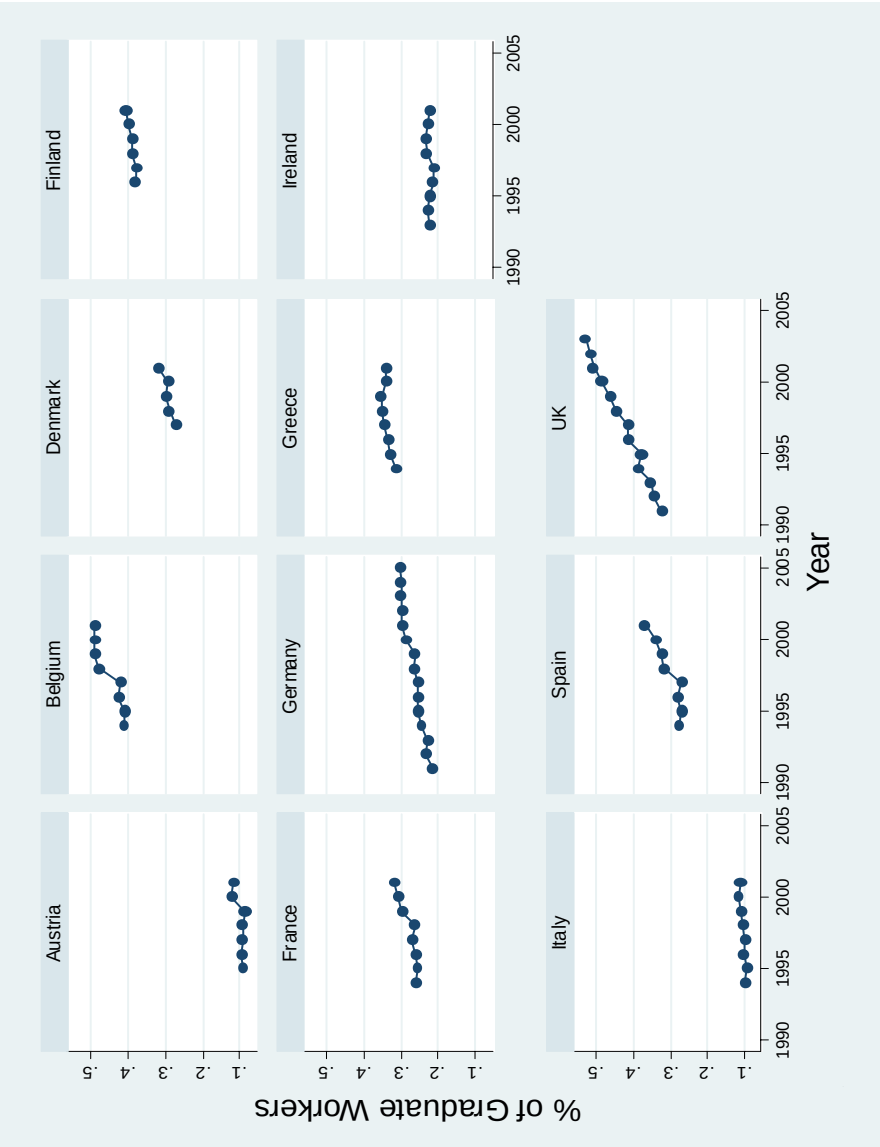

Figure 2: The evolution of the relative supply of skilled labour in the European countries

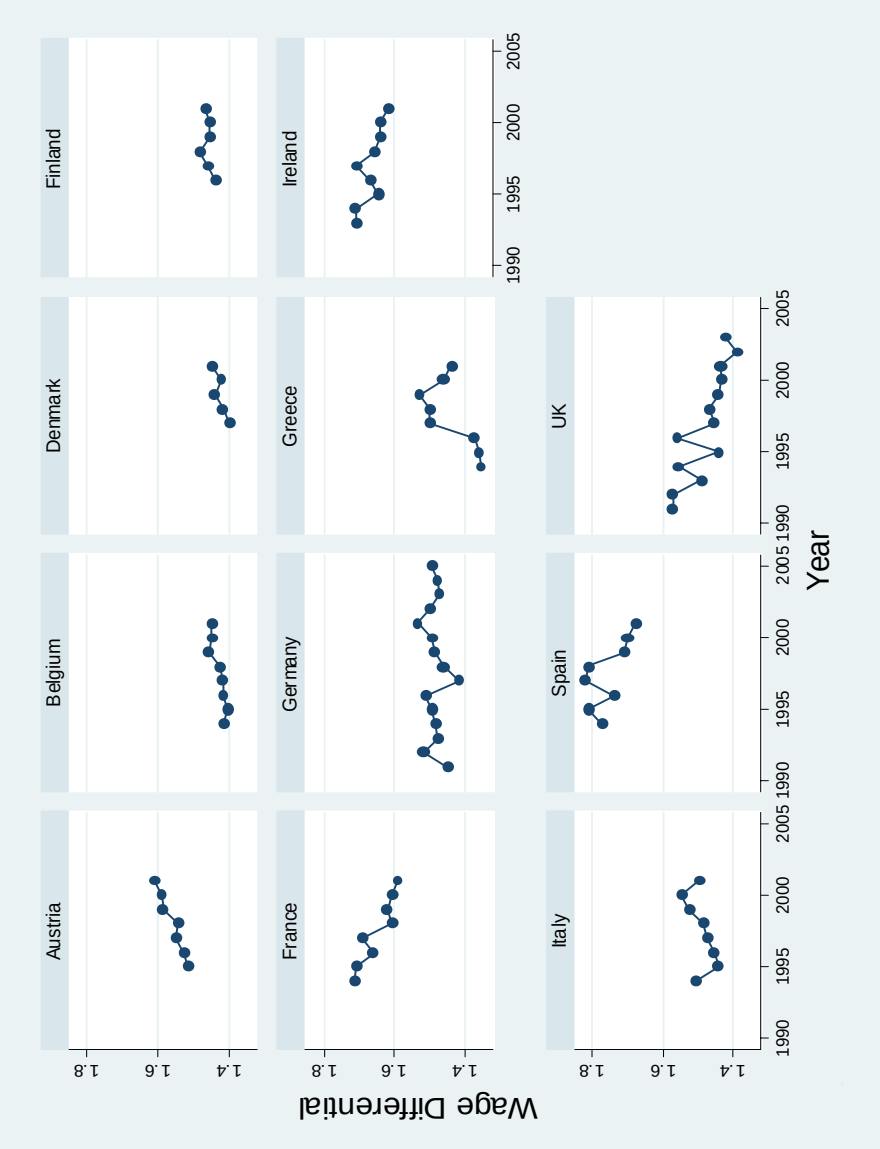

Figure 3: The evolution of the wage differentials in the European countries

3 Theoretical Model

We want give a theoretical foundation to the relationship between the wage differentials, the relative supply and the technological change. To do that we start building a model of perfect competition and we move then to a model of imperfect competition and wage bargaining.

3.1 Perfect competition

We assume that the production function[3] is given by

$$Y = \alpha(aS)^{\gamma} + (1-\alpha)(bU)^{\gamma} \tag{1}$$

where S is the quantity of skilled labour, U the quantity of unskilled labour, a and b are two productivity parameters and α measures how the two factors are aggregated. The parameter γ determines the returns to scale, which are the same for both factors: we assume diminishing return so that $\gamma < 1$. We imagine that S and U are exogenous variables.

Firms are operating in perfect competition so that wages are set equal to marginal productivity:

$$\frac{dY}{dS} = w_s = \alpha\gamma a(aS)^{\gamma-1} \tag{2}$$

$$\frac{dY}{dU} = w_u = (1-\alpha)\gamma b(bU)^{\gamma-1}. \tag{2a}$$

It follows that the relative wages w_s/w_u is

$$\frac{w_s}{w_u} = \frac{\alpha a^{\gamma}(aS)^{\gamma-1}}{(1-\alpha)b^{\gamma}(bU)^{\gamma-1}} \tag{3}$$

or, we if we call w^R the logarithm of the above ratio:

$$w^R = \log\frac{w_s}{w_u} = \frac{\alpha}{(1-\alpha)} + \gamma\frac{a}{b} + (\gamma-1)\frac{S}{U}. \tag{4}$$

This is what we will refer to as the wage differentials: from the equation above we can state that as long as the parameters are constant, the relative wage is solely determined by the relative supply. If, following an increase in the relative supply S/U we do not observe a decrease in the wage ratio, then the parameters must have changed, that is, a shift in demand has occurred. It is quite obvious that both the parameter a and b should increase through time as an effect of the technological change, however, this is not enough to modify the relative wages. As long as the ratio a/b is constant the change in productivity has no effects on the differentials. Instead if one of the parameter grow at an

[3] We choose this particular functional form to allow tractability of the problem when, later, we introduce wage bargaining. As long as we stick to the perfect competition framework, we could have adopted standard Cobb-Douglas and CES function obtaining similar results.

higher rate than the other, then this affects the wage differentials and we observe biased technological change.

We can imagine that technological level (and its change) may be measured, in a given period t, by the variable T_t then we can write (4) as

$$w^R = C + \rho T_t + \sigma R_t \tag{5}$$

where C is a constant and R_t is the exogenous relative supply at time t. If the parameter $\rho > 0$ then the technological change is biased in favor of the skilled, while if it is zero, we do not observe any effect of technology. One of the obvious problem is the measurement of T_t: this is usually approximated by a time trend. Under this interpretation, the technology level keeps increasing at a constant rate and if $\rho > 0$, at each increase of the technology level the productivity of skilled workers grows more than those of the unskilled. The explanation that is usually brought forth for this is that skilled workers are better in exploiting more complex technologies, so that their reward for their skills grows with the technological level. In any case the adoption of a time trend to approximate the technological level is probably a too simple approach: we will propose different ways to measure T_t in the section 4 and see how they perform empirically.

3.2 Imperfect competition and wage bargaining

We want now to examine the role of institutions in the labour market in order to understand how they could affect the wage differentials. To do that we introduce wage bargaining but, in order to make the problem analytically tractable, we try to keep the model as simple as possible. We imagine now that there are two kind of firms i and j, which use only skilled and unskilled labour respectively:

$$Y_i = (aS)^\gamma \tag{6}$$

$$Y_j = (bU)^\gamma \tag{6a}$$

and which operate in monopolistic competition facing the following demand:

$$Y_i^D = \theta p_i^{-\varepsilon} \tag{7}$$

$$Y_j^D = \theta p_j^{-\varepsilon} \tag{7a}$$

where p_i are the relative prices, ε the elasticity of demand and θ an index of aggregate demand. The latter two parameters are the same for both kind firms.

The workers are organized in a union which bargains on the wages of both groups. The aim of the union is maximising its utility Θ which is given by the a weighted sum of the relative surplus of wage over the outside options z_s and z_u :

$$\Theta = \lambda \left(\frac{w_s - z_s}{z_s} \right) + \left(\frac{w_u - z_u}{z_u} \right) \tag{8}$$

where λ is the relative importance given by the union to the unskilled workers. An higher λ implies that the union cares relatively more about the unskilled and will try to favour them during the bargaining.

As for the firms, they are orgainized in a confederation that bargains with the union trying to maximise the profits of both kind of firms (π_i and π_j respectively); its objective function is:

$$\Pi = \pi_i + \pi_j = (p_i Y_i - w_s S) + (p_j Y_j - w_u U)\,. \tag{9}$$

The two parties (the union and the confederation of firms) bargain over the wage and the firms are then free to set the amount of labour that they desire (as in the right to manage model of bargaining): this means that the solution of the bargaining must lay on the labour demand of firms, which is obtained imposing the condition $\frac{d\pi_i}{dS} = 0$ for firms i and $\frac{d\pi_j}{dU} = 0$ for firms j. We obtain the labour demands maximizing the profits with respect to employment, their equations are given by:

$$S = \left(\frac{w_s}{K \mu a \gamma} \right)^{\frac{1}{\gamma\mu - 1}} \frac{1}{a} \tag{10}$$

$$U = \left(\frac{w_u}{K \mu b \gamma} \right)^{\frac{1}{\gamma\mu - 1}} \frac{1}{b} \tag{10a}$$

where $\mu = \frac{\varepsilon - 1}{\varepsilon}$ and $K = \theta^{-\varepsilon}$.

The solution of the bargaining is given by the couple of real wage which maximise the Nash Maximandum which takes in consideration parties' utility, subject to conditions (10) and (10a):

$$\begin{cases} (w_s, w_u) = \underset{w_s, w_u}{\arg\max} \Theta^{\beta} \Pi^{1-\beta} \\ S = \left(\frac{w_s}{K \mu a \gamma} \right)^{\frac{1}{\gamma\mu - 1}} \frac{1}{a} \\ U = \left(\frac{wu}{K \mu b \gamma} \right)^{\frac{1}{\gamma\mu - 1}} \frac{1}{b} \end{cases} \tag{11}$$

where β is barganing power of the union and it ranges from 0 to 1. Inserting equation (8) and (9) in the above problem and imposing the conditions (10) and (10a) we have

$$\begin{aligned} (w_s, w_u) = \underset{w_s, w_u}{\arg\max} & \left[\lambda \left(\tfrac{w_s - z_s}{z_s} \right) + \left(\tfrac{w_u - z_u}{z_u} \right) \right]^{\beta} * \\ & \left[\left(\tfrac{1}{\mu\gamma} \right)^{\frac{\gamma\mu}{\gamma\mu - 1}} K^{\frac{1}{1 - \gamma\mu}} (1 - \gamma\mu) \right]^{1-\beta} \left[\left(\tfrac{w_s}{a} \right)^{\frac{\gamma\mu}{\gamma\mu - 1}} + \left(\tfrac{w_u}{b} \right)^{\frac{\gamma\mu}{\gamma\mu - 1}} \right]^{1-\beta}. \end{aligned} \tag{12}$$

The above deals the following conditions:

$$\frac{\partial(\Theta^{\beta}\Pi^{1-\beta})}{\partial w_s} = \frac{\beta\lambda}{z_s}\Theta^{\beta-1}\Pi^{1-\beta} - a^{\frac{\gamma\mu}{1-\gamma\mu}}\left(\frac{K}{\mu\gamma}\right)^{\frac{1}{\gamma\mu-1}} w_s^{\frac{1}{\gamma\mu-1}}\Pi^{-\beta}\Theta^{\beta-1} = 0 \quad (13)$$

$$\frac{\partial(\Theta^{\beta}\Pi^{1-\beta})}{\partial w_s} = \frac{\beta\lambda}{z_s}\Theta^{\beta-1}\Pi^{1-\beta} - a^{\frac{\gamma\mu}{1-\gamma\mu}}\left(\frac{K}{\mu\gamma}\right)^{\frac{1}{\gamma\mu-1}} w_s^{\frac{1}{\gamma\mu-1}}\Pi^{-\beta}\Theta^{\beta-1} = 0 \quad (13a)$$

which allows us to easily obtain the ratio between the wages of the two groups:

$$\frac{w_s}{w_u} = \left(\frac{a}{b}\right)^{\gamma\mu}\left(\frac{1}{\lambda}\frac{z_s}{z_u}\right)^{1-\gamma\mu} \quad (14)$$

and, taking logs, we have:

$$w^R = \gamma\mu\log\frac{a}{b} + (1-\gamma\mu)\log\frac{z_s}{z_u} + (\gamma\mu-1)\log\lambda. \quad (15)$$

The relative wage has a component similar to the case of perfect competition, as it still depends on the ratio of the productivity parameters, but it now depends also on the outside options and on the preferences of union. We can still assume that the ratio a/b is related to the technology and we can imagine that the ratio between the reservation wages depends on the probability of each group of finding a job and on the generosity of unemployment benefits. The preference of the unions may be related to union density if it is true that larger unions promote wage compression. In anycase it is worth to note that the bargaining power of the union does not enter, at least directly, directly in the wage ratio; the same is true of the relative supply which is now endogenous. We will better discuss this relationships in the following part, where we try to find a way to measure these variables.

4 Empirical analysis

In this part we turn to the empirical evidence on wage differentials and we look for a confirmation of the above models. We start from the first one, focusing on the role of technological change and we move then to the second, introducing the institutions. In both the cases, before estimating the models, we discuss which are reasonable proxies for some of variables we are interested and which should be, in the light of the models we presented above, their role in the determination of wage differentials.

4.1 Technological Change

According to the first model we presented, the relative wages depends on the relative supply of skilled workers and on a variable which measure the relative

productivity of skilled with respect to unskilled workers: this variable should be related to the technological progress. If we add a country specific constant we can estimate the following model:

$$w_{i,t}^R = C + c_i + \rho T_{i,t} + \sigma R_{i,t} + \varepsilon_{i,t}$$

where $w_{i,t}^R$ is the log-ratio between skilled and unskilled wage in country i, $R_{i,t}$ the relative supply of skilled workers (measured in log) and $T_{i,t}$ the technological variable; C and c_i are the constant terms with the latter being country specific.

We could use several proxies to measure T, and depending on which we choose, we imply a different mechanism that links technology to the relative productivity: in any case, should the ρ be significantly different from zero this would indicate the presence of biased technological progress (skill-biased for $\rho > 0$).

The first way to approximate the technological progress is through a linear trend. That would imply that technological progress happens at a steady pace that is the same in all the countries and that has the same effect across them. We test the above model with a fixed effect estimator and the result are given in the column (i) of table 1.

The results clearly shows that a common time trend is not present. This was not unexpected because we already noticed that while the relative supply of skilled workers was increasing almost everywhere, the wage differentials were having different evolutions in different countries, so that they could not be experiencing a common trend. We also find that the coefficient of the relative supply is negative (though significant only at the 10%), which is line from what our theoretical model predicted.

If we still believe that technological progress is relevant in explaining the evolution of wage differentials, we need then a variable that can measure the differences in the technology in each nation. Our next attempt is to measure the technological level as the cumulated sum through the years of the R&D expenditure over the GDP. In practice we normalize to zero the technological level in a base year (1990 in our case) and we imagine that $T_{i,t} \equiv \sum_{y=1990}^{t} R\&D_{i,y}$ where $R\&D_{i,y}$ indicate the expenditures in year y. Obviously it is possible that the starting technological level is different in different in nations but such (likely) case would be captured by the country specific constant and would not be a problem. We present the results in column (ii) of table 1. Once again, the technological variable is not statistically significant, suggesting that the technological level on itself does not imply a bias toward a certain category of workers.

We turn then to a different approach and we imagine that the relevant factor is the intensity of the technological change. We can then measure the technological variable directly through the R&D expenditure, in practice we set $T_{i,t} \equiv R\&D_{i,t}$. The results of the estimation (column (iii), table 1) are much better than in the previous case as the intensity of the change seems

	(i) Technological Trend	(ii) Technological Level	(iii) Intensity of Technological Change
	Wage Differentials	**Wage Differentials**	**Wage Differentials**
Relative Supply	-0.075*	-0.074***	-0.079***
	(0.038)	(0.028)	(0.016)
Time Trend	0.001		
	(0.002)		
Cumulated R&D		0.004	
		(0.006)	
R&D			0.200***
			(0.037)
Constant	0.340***	0.365***	1.162***
	(0.050)	(0.018)	(0.149)
Observations	93	85	85
Number of ID	11	10	10
R-squared	0.08	0.14	0.38
Standard errors in parentheses.	* significant at 10%; ** significant at 5%; *** significant at 1%		

Table 1: Regressions for the wage differentials in the perfectly competititive case

to be strongly correlated to the relative wages. The interpretation is that the technological bias comes from the pace of the progress, not from the progress itself. Under this view, skilled workers seems to be quicker to adapt so that they take advantage in rapid changes in technology. This finding is indeed interesting and allow us to identify in the intensity of technological change one of the driving force in the evolution of wage differentials between skilled and unskilled. The relationship between intensity and differentials can also be seen plotting the change in the wage differentials against the change in R&D expenditures measured as the log ratio of the final and initial values in each country (figure 4).

Obviously this is only an intuitive representation of the relationship, as it neglect the evolution of the variable and focus only on the first and last values. Nonetheless the relationship is striking clear and positive with countries with growing R&D expenditures having an increase in wage differentials and vice-versa. The figure also explains the division in groups of countries that we made in the previous section: Austria, Belgium, Denmark and Finland had increasing differentials and are in the top right of the figure with R&D expenditures

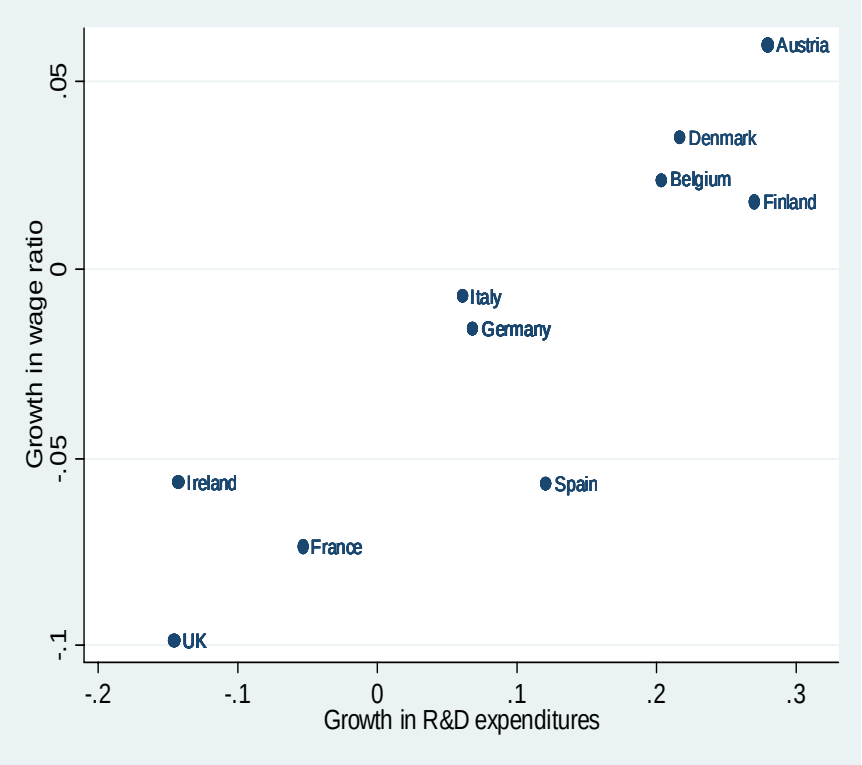

Figure 4: Growth of Wage Ratio against Growth of R&D expenditures

increasing as well. Germany and Italy are in the centre, with stable differentials and RD. Finally, in the bottom left we find France, Ireland and UK with decreasing differentials and RD: only Spain remains partly out of this description, with a slightly increase in RD but falling differentials. Note also that according to the above figure, a costant R&D would be associate to decreasing differentials: this is not a real issue because the graph is neglecting the effect of relative skilled supply that was increasing througout the period in nearly all countries.

To better explore this relationship, to analyse differences across countries and to check how robust our specification is, we allow now for the technological effect due to the RD intensity to differ across country. This allows us to determine whether the magnitude (and the sign) of the skill bias is the same in different countries. We proceed in estimating

$$w_{i,t} = C + c_i + \alpha R_{i,t} + \beta_i T_{i,t} + \varepsilon_{i,t}$$

where the coefficient β_i is specific to country i. This specification comes with some problems as the number of independent variables is rather high with respect to the number of observations so that our estimates cannot be very

efficient. Nonetheless this is still gives a first idea of the differences across countries. We present the results in table 2: in it for each country, we present the coefficient associated to their R&D expenditures.

It is easy to see that most of the countries, once we have taken into account the standard errors, have coefficients that are reasonably close to each other. The exceptions are France which has a higher coefficient, Finland which is a bit lower than the average and Spain which has a negative (but not significant) coefficients. The latter case is the only result that create some concerns as it does not find a explanations in the theory (unless, of course, we suppose that in Spain we observe unskilled biased technology). A possible explanation for this, may come from the fact that Spanish labour market was undergoing several changes in the period of analysis, with a strong increase in the flexibility of it. Given the reforms Spain went under, it is likely that new entrant workers ended up having fixed term contracts in contrast to the incumbents workers which mostly had permanent contract. The combination of the fact that the new entrants have an higher share of skilled (due to an increase in tertiary education attainment) if compared to the incumbents and that fixed term job are generally less paid than permanent one, may explain the decline in the wage differential. From a statistical point of view we can test the equality of the coefficients: the results (which are reported in table 2) indicates that we have to refuse the equality of the coefficients when we consider also Spain, but we cannot refuse it for all the rest of the countries.

This far we have neglected the effect of international commerce on the wage differentials. While we did not introduce a formalized model we discussed before that competition from less developed countries may induce a reduction of the non skilled wage and thus increase the differentials. To control for this we introduce in the regression a measure of the international competition. The simplest way to do this is to simply consider the share of imports of good and service other the GDP. We use this measure in regression (i) of table 3 but we fail to find a significant effect of international competition.

Obviously the share of imports is a crude approximation: what in we need in fact is a measure of the international competition only from the less developed countries. We proceed then to build a much more accurate measure which we have called adjusted imports. This variable is given by the total imports from non developed countries[4] less the imports of mineral fuels (oil, carbon and gas) from those countries and it should be able to capture the competition that unskilled intensive goods suffer because of international commerce. The results of using this variable is given[5] in regression (ii) of table 3. While the sign of this variable is, as we should expect, positive, it is still not significant: even when properly measured, competition from less developed countries does not seem to be relevant.

[4]This is obtained subtracting from total imports the imports from Euro-15 countries, Australia, Japan, New Zeland, Norway, Switzerland and US. While some minor developed country are still present, their impact should be negligible.

[5]We were able to construct the adjusted imports only for the years after 1994. This explain the reduction in the observations.

	Wage Differentials
Relative Supply	-0.057**
	(0.026)
Austria	0.268***
	(0.081)
Belgium	0.267**
	(0.108)
Denmark	0.201*
	(0.119)
Finland	0.041
	(0.076)
France	0.657***
	(0.245)
Germany	0.197*
	(0.109)
Ireland	0.249*
	(0.137)
Italy	0.482**
	(0.214)
Spain	-0.241
	(0.150)
UK	0.301*
	(0.160)
Constant	1.360***
	(0.181)
Observations	85
Number of Countries	10
R-squared	0.54
Test for equality of all but the Spanish coefficient	F(8, 64) = 1.44 Prob > F = 0.1979

Standard errors in parentheses.
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2: Regression with country specific coefficients for technological change

	(i) **Imports**	(ii) **Adjusted Imports**
	Wage Differentials	**Wage Differentials**
Relative Supply	-0.065***	-0.070**
	(0.02)	(0.029)
R&D	0.216***	0.158***
	(0.04)	(0.05)
Imports	-0.033	
	(0.03)	
Adjusted Imports		0.010
		(0.03)
Constant	1.207***	1.02***
	(0.15)	(0.028)
Observations	85	73
Number of ID	10	10
R-squared	0.392	0.404
Standard errors in parentheses.	* significant at 10%; ** significant at 5%; *** significant at 1%	

Table 3: Regression with controls for the international commerce

4.2 The role of Institutions

We now turn to evaluate how institutions can affect the wage differentials. In our theoretical discussion we introduce the mechanism of wage bargaining and we concluded that in such a context the relative supply is not relevant (as it is not exogenous) and the wage differential should depend from the relative productivity of workers (which might be related to technological progress) but also on the reservation wage (which depends on the employment possibilities and on unemployment benefits) and the preferences of unions. In general, these factors should be relevant only if they differs across our two groups while it is well likely that some institutions, or at least labour legislation, it is the same for both the groups. In all, we are going to use the following variables: employment rates of skilled and unskilled (which measure the probabilities of finding a job), replacement ratio (RR) and benefits duration (BD) (which determines the generosity of unemployment benefits) and the overall[6] union density (UD) and employment protection level (EPL) (which can be thought to be a proxy

[6]In principle there could exist an exact measure of union density for each group, but we do not have such data nor we know any possible source for it.

of overall bargaining power and possibly of the unions preference)[7]. On the contrary, starting from the survey we are using, we can build a measure for the employment rate of the two different groups.

In any case, even when the institution and the variable measuring it, are they same, we have reason to believe that it may have different effects on the reservation wages and bargaining power of the two groups: in what follow we describe the variables and we explain what effect we should expect.

Employment rates should measure the employment opportunity of a worker and it is the only variable which can be effectively measured distinguishing between the skilled and unskilled. We obtain it from the surveys and, for each group (graduate and non graduate) is given by the number of workers that are employed over the sum of them plus those workers that declare being unemployed and searching for a job. The effect of this variable should be quite clear: when the employment rates of a certain group are high it means that it is easy to obtain a job for people belonging to that group so that their outside option should be better. We measure differences in the employment opportunities through the ratio of the employment rate of the skilled and those of the unskilled and we expect that this variable has a positive effects on wage differentials.

The replacement ratio measures the share of the past wage that an unemployed worker receive when is out of work and entitled to unemployment benefits. It follows that this variable should be more relevant in the determination of reservation wage for the group whose past wage are on average higher, which in our case should be the skilled: the relationship between RR and the wage differential should then be positive.

The duration of unemployment benefits measures the maximum length of the unemployed benefit. The same reasoning we made for the reservation wage should be true for the benefit duration: however, it must be stressed that the group which shows higher employment probability could take less advantage of a long duration. Since in our case the skilled have almost always an higher probability, the final effect is dubious.

Union density is the percentage of workers that are members of a union. This variable is usually associated to the bargaining power of union, which in our model should have no effect on the wage ratio. However, there is evidence that unions are able to compress wages, so that the effect could be negative, even if there is no clear evidence that this compression happens also in the differentials between graduate and non graduate. On the other side we can think of at least two reason why its effect should be positive: first of all the bargained wage depends on the outside options and it may possible that bargaining power amplify the differences in the starting position, so that the group of worker with better outside option gain more from a high bargaining power. However, our theoretical model failed to capture such interaction. In addition there may be a relation between the union density and the composition of the members: it is likely that when only few workers belongs to unions, those members belong to the unskilled group (that probably forms the core of the unions) while the

[7]The source of data for RR, UD and EPL is OECD; for BD is Nickell (2006).

relative number of skilled members increase with the increase of union density. Then we could observe a shift in the preferences of the union (from the unskilled to the skilled) as its density increase. The overall effect is then uncertain.

The employment protection level is an artificial variable that measure the rigidity of the labour market. It should not directly affect the wage but it is possible that high protection increase the bargaining power of workers making them less likely to be fired when too high bargained wages generate an excess in the number of employers. As discussed above, a stronger bargaining power may promote wage compression but it might also amplify the differences in the outside options of the groups. This mechanism is in anycase dubious so its effect on the differentials is uncertain.

Now that we have introduced the variables we use, we perform the estimation of the following equation:

$$w_{i,t} = C + c_i + \alpha e_{i,t} + \beta T_{i,t} + \gamma_1 RR_{i,t} + \gamma_2 BD_{i,t} + \gamma_3 UD_{i,t} + \gamma_4 EPL_{i,t} + \varepsilon_{i,t}$$

and we show the results in column (i) of table 4 (we do not have data on institutions of Greece, so we omitted it from the regression).

The estimation are quite in line with what we would expect. They confirm that the ratio of employment rate as well as the replacement ratio have a positive effects on the differentials. On the contrary, the duration of benefits has a negative effect, implying that skilled workers tend to take less advantage of benefits that last long periods. The result on union density seems to negate that unions induce wage compression, at least between the skilled and unskilled; on the contrary the employment protection level is not relevant. As we discussed before, a possible explanation for the positive effect of union density is that the composition and the preferences of unions shift to favour the skilled as the union density increase. The other possibility, that is, that is an amplifying of the outside options of the groups is less likely, because in that case EPL should be significant as well, something which we excluded.

Since we saw earlier that Spain has a different coefficient for R&D from the rest of countries we allow in regression (ii) for this difference. The results do not change much and we also find out that the coefficient for Spain, while still negative, is not statistically different from the others (though the result is borderline): it is possible that the introduction of the institutions helped in explaining part of the Spanish uniqueness.

Finally, the R&D expenditures are still significant, confirming once again the fact that the skill bias originate from the intensity of the technological change. Even if we do not produce here the results for reason of space, we also tried to run regressions were we used the cumulated R&D expenditure as a measure of the technological progress together with all the above institutions: the results showed once again this variable is not significant; finally, we also tried to control for the international competition but we obtained non significant estimation.

	(i) Common R&D coefficient	(ii) Different R&D coefficient for Spain
	Wage Differentials	Wage Differentials
Employment Rate Ratio	0.326***	0.22*
	(0.106)	(0.125)
R&D	0.197***	0.207***
	(0.042)	(0.042)
R&D for Spain		-0.056
		(0.169)
Raplacement Ratio	0.212***	0.201***
	(0.047)	(0.052)
Benefits Duration	-0.092**	-0.102***
	(0.037)	(0.038)
Union Density	0.12**	0.101**
	(0.047)	(0.047)
Employment Protection Level	0.02	0.0234
	(0.053)	(0.032)
Constant	0.031	0.041
	(0.263)	(0.260)
Observations	75	75
Number of Countries	10	10
R-squared	0.51	0.54
Test for the equality of the Spanish R&D coefficient		F(1,58) = 2.61 Prob > F = 0.1114

Standard errors in parentheses * significant at 10%; ** significant at 5%; *** significant at 1%

Table 4: Regressions for the wage differentials in the imperfectly competititive case

5 Conclusions

In this paper we have examined the evolution of the wage differentials between skilled (graduate) and unskilled (non graduate) workers in several european countries in a period that stretch from the beginning of the nineties to the beginning of this century. The main stylized fact for that period is that while all european countries saw a rise in the relative supply of skilled workers, the evolution of the wage differentials was widely different across the countries. This behaviour suggested not only that a simple supply and demand scheme is lacking in explaining the evolution of the differentials but also that the adoption of a common technological trend is not enough to identify the effect of technological changes. In the first part of our work we analysed the relationship between technological progress and the wage differentials and we find out that the intensity of technological change, measured through the R&D expenditures, seems to be the (technological) driving force of the wage differentials. The interpretation of this result is that skilled workers are more able to adapt to the change of technology so that they take advantage of periods of intense progress. The different degree of R&D across Europe helps us to explain the differences in the evolution of the differentials. We also tried to take into account the effect of international competition of less developed countries, building what we believed a good measure of it: the results seems to neglect any effect of this factor.

We turned then to the labour market institutions, first presenting a simple theoretical model and then testing it with data. The introduction of institutions shifts the attention to the analysis of the outside option of workers and how institutions may interact with it. The impression is that as skilled workers have better outside options, then stronger institutions may magnify this and increase the wage differentials. The overall results is that institutions have indeed a relevant role in the determinations of wage differentials and that partly unexpectely, they do not produce wage compression between skilled and uskilled workers.

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