Job Polarization and Labor Market Institution*

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Abstract

This paper studies changes in job opportunities in European countries (Italy, Spain, France, Greece, Belgium and the UK). According to the recent literature, the technological change and the routinization process have *polarized* the labor market of advanced economies: employment has shifted toward very high-wage and low-wage jobs, and wages have grown faster at the extremes of the earning distribution. We find that in continental Europe, differently from the US and the UK, the fall in the share of middling paid occupations has not come with an increase in the share of low-paid employment. While the previous literature has studied the effects of routinization on a perfect competitive labor market, we proposes a theoretical model to study the effects of a technological shock on a unionized economy. Therefore, we analyze the joint effect of the technology and institutions on the labor market changes. By accounting for the collective bargaining process, our model may fit continental Europe better than the previous ones and can explain the observed cross-country heterogeneity. Moreover, our framework highlisgts the emergence of the low-skill unemployment as an alternative to employment polarization.

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1 Introduction

The recent literature on the labor markets changes presents, by one hand, a clear evidence for the US, and to the other hand, conflicting evidence relative to the Europe. Since the end of the Eighties, the US labor market has been characterized by a clear polarization pattern, with employment growth concentrated in high-paid professional and managerial jobs and low-paid personal service jobs, whereas employment in average-paid production and office jobs has been declining.[1] In relation to Europe some authors show an employment polarization pattern (Goos et al.,2009), while others reveal a massive occupational upgrading (Oesch et al, 2010).
Using data by Eurostat, we focus on the main European countries and we find that almost everywhere there has been a fall in the share of hours worked in middling paid jobs and an increase in the share of highest paid jobs in last 15 years. Hence, this change in job opportunities, which closely reminds to the US one, can be considered as a global answer to some shock which has hit labour market of developed economies. As far as lowest paid jobs are concerned, results are quite heterogeneous among European countries, but overall the employment structure has not polarized, but there has been a sort of *occupational upgrading* with a decline in job opportunities in lowest and middling qualified occupations and an increase in highest qualified occupations.

We explain observed cross-country differences in job polarization trends building a model whose main elements are:

- the presence of a technological shock. Indeed, among the different possible explanations[2] of the polarization phenomenon, the technological motive, related to the nuanced theory of skill-biased technological change, seems to be the most convincing one (Autor, 2010; Goos et al., 2009b), also for Europe (Goos et al., 2009b).

- the role of labor market institutions. The technological change, whatever its relevance, is always embedded in a given institutional enviroment and in an institutional history (Levy et al., 2007). The latter point acquires even more importance in the continental Europe, where

[1] Wright and Dwyer, 2003; Autor et al. 2008; Goos and Manning, 2007.

[2] There are other possible explanations of the polarization phenomenon (see Autor, 2010 for a review). Those related to the demand side of the labor market focus on the consequences of computerization and offshoring of middle-skilled routine tasks, that were formerly performed by middle-skilled workers. Looking at the supply side, job polarization may result from changes in the available supply of skills.

the wage structure is more rigid than in the US because of the strength of labor market institutions, which are able to mitigate the effects of market forces (Krugman, 1994; OECD, 1994; Blau and Kahn, 1996).

One of the novelties of the paper is that the theoretical analysis considers simultaneously the two previous elements, studying their joint action and providing a complete analysis. Indeed, up to now, the literature has examined separately the effect of the technological change and of the institutions on the employment and wage structure.

Our model analyzes the impact of the techological change on wages and employment in different parts of the wage distribution accounting for the presence of unions. The latter sets the highest possible wage compatible with a certain employment objective and then the firm chooses its labor demand (Blanchard and Summers, 1986). The size of the union's employment target is crucial to determine the effects of the technological change on the labor market.

The labor market enviroment, characterized by some institutional rigidities, clearly differentiates the model from our theoretical point of reference, that is the framework of Autor et al. (2006). They propose a nuanced version of the skill-biased technological change in a competitive framework, that is appropriate for the US case.

The contribution of our analysis is twofold.

First, the model predicts both employment polarization and occupational upgrading, depending on the union behaviour. Therefore, it is able to explain the patterns of countries very different in terms of labor market institutions, like US and Italy, as shown in the last part of the paper. Indeed, the model shows that the technological change induces (i) a reduction of wages and employment in routine labor tasks, typically replaced by computer capital; (ii) an increase in wages and employment in abstract labor tasks that are complements to computers; (iii) some heterogeneous results in the manual labor market, depending on the union employment target. When the union protects only its current members (*insiders*) there emerges a positive effect on manual wages and no change in manual employment; we have an uncertain effect on manual wages and a positive one on manual employment when unions care about the entire manual labor supply. According to this model, labor market institutions have avoided employment growth in low-paid jobs by maintaining a high level of manual wage.

From this wage effect derives the second important and new result of the theoretical analysis: when institutions play a role, the technological change may generate unemployment. Therefore, unemployment seems to be the European alternative to employment polarization, as suggested by the analysis

in the last paragraph of the paper. It reveals that the share of hours worked in lowest paid jobs is negatively correlated with national employment rate. This evidence suggests that European upgrading may hide a lower creation of new job opportunities.

A number of studies are related to this work. First, as noted above, we build on Autor et al.'s model (2006). However, in contrast with this contribution, we consider a more complicated institutional setting, and we emphasize the interaction between the technological change and different institutional enviroments. Our work is also related to the papers that study the recent wage and employment pattern of US and Europe (Goos et al., 2007; Dustman et al. (2007)). In particular Goos et al. (2009) focus on the entire European labor market, showing an employment polarization pattern. Moreover, the authors demonstrate that the routinization is the main explanation of this pattern. Most closely related to the current studys perspective is the paper of Oesch et al. (2010), that analyzes different possible explanations (routinization, labor supply shock and the role of institutions) for the employment pattern of four European coutries. They show a massive occupational upgrading and conclude that both technological change and institutions play a role in explaining this pattern. Our findings confirm theirs with the value added of the theoretical analysis. Moreover, from the empirical point of view, we consider more countries and use a more homogeneous dataset.
The paper is also related to the literature on the effects of institutions on the labor market (Nickell, 1997; Di Nardo et al., 1996; Acemoglu, 2001; Levy et al., 2007). These studies underline that institutions like union, employment protection legislation, and minimum wage have an impact on the wage dispersion and, therefore, can make the creation of low-skill jobs more difficult. None of the previous papers integrate, in a theoretical framework, the technological and the institutional elements to explain the labor market patterns of the western economies, which is the main focus of this article. The different explanations are generally considered separately and from an empirical point of view.

The paper is organized as follows: in Section 2 we show the employment pattern of some European countries. In Section 3 we describe our theoretical model and in Section 4 we empirically verify the main predictions of the model. Finally, we conclude in section 5 .

2 Change in Job Opportunities in Europe

The literature does not present a unique evidence about the pattern of the European employment structure. Some authors (Goos et al., 2009) reveals that the polarization trend has been crucial in Europe as well as in the US. Goos et al. (2009), focusing on a limited range of high-, middling- and low paid jobs, found that the share of worked hours in middling paid jobs has declined by over 7 percentage points from 1993 to 2006, while the share in high paid and low paid has increased respectively by 6.2 and 1.6 percentage points.

However, a recent paper by Oesch et al. (2010) revealed a massive occupational upgrading in European countries.

We try to solve this puzzle focusing on six of the major European countries: France, Greece, Italy, Spain, Belgium and the UK. We use data collected by Eurostat which comes from national labor force surveys. This dataset is homogeneous in terms of sample strategies and uses some harmonized definitions for the major aggregates of the labor force. Even the classification of occupations is uniform across countries and over time. This choice, differently from Oesch et al. (2010), makes our results strictly comparable across countries and over time. We restrict our analysis to employed workers from 15 to 74 years old, regardless of whether they are filled by wage-earners, self-employed workers or employers. We exclude workers hired in agriculture because of problems in data quality.

Tables 1 and 2 show which are the occupations which have experienced the highest decline and the highest increase in the employment shares. In every country but Italy the deeper decrease has concerned middling paid jobs: clerks and crafts. In Italy the employment share has sharply decreased for low skilled workers hired in the trade sector. Furthermore, in every country the employment shares of high skilled workers (managers and associate professionals) are the more growing ones.

We evaluate changes in the employment structure by distinguishing occupations using the 1 digit International Standard Classification of Occupations (ISCO). Thus, we have 8 different groups of occupations and we determine the skill requirement of every group using the average number of years of schooling of workers.[3] Finally, we rank this groups according to their skill requirements at the beginning of the period (1993). In our analysis the rank-

[3]We derive this information from the individual highest educational degree.

Country	Occupation	Change in Empl. Sh.
BE	Metal and machinery	-3.0
ES	Office clerks	-4.6
FR	Office clerks	-4.0
GR	Other craft and trades workers	-4.3
IT	Models, salespersons and demonstrators	-6.1
UK	Office clerks	-3.5

Table 1: Occupations with the largest increase in the employment share. Source: Eurostat, 1993-2008.

Country	Occupation	Change in Empl. Sh.
BE	Other professionals	2.7
ES	Other associate professionals	4.7
FR	Corporate managers	6.5
GR	Other associate professionals	2.1
IT	Managers of small enterprises	6.0
UK	Teaching professionals	2.2

Table 2: Occupations with the largest decline in the employment share. Source: Eurostat, 1993-2008.

ing is fixed over time. We test the assumption that ranking does not change a lot over time using the Sperman's correlation between the ranking of 1 digit ISCO occupations at the beginning and at the end of the period in each country. These correlations are very strong, spanning from 0.90 in Portugal to 1 in Spain[4]. Hence, we find stability in the occupational skill structure. On the other side, in principle, this ranking could be different across countries; this is not a problem since the analysis aims at comparing the evolution of *good* and *bad* jobs in each country and not at tracing the evolution of the same occupations across countries.[5] Regardless, the occupational skill structure is very similar in our six countries.

Figure 1 shows that the employment share has declined in middling paid jobs in every country; the fall is particularly deep in Italy (6.3 percentage points for craft and related trades workers). Furthermore, all countries have experienced a growth in the average of the highest skilled occupations. Again,

[4]Even the correlations between the ranking of 2 digits ISCO occupations at the beginning and at the end of the period are strong: they span from 0.93 in he UK to 0.99 in Greece and Belgium.

[5]See Oesch et al., 2010.

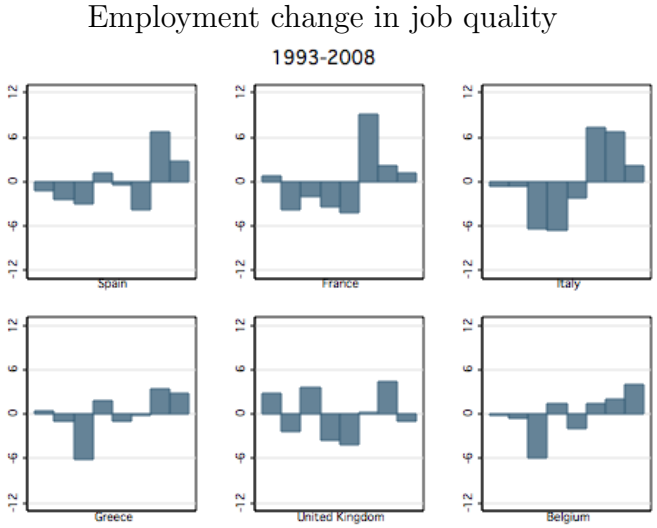

Figure 1: Changes in employment shares by occupation. Source: Eurostat, 1993-2008.

this growth is particularly significant in Italy, where the employment shares of legislators, senior officials, managers and professionals has increased by 7 percentage points from 1993 to 2008; in France the share of legislators, senior officials, managers by 9.2 points.

At the bottom of the skill rank we do not observe any significant change in employment shares everywhere but in the UK, where the share of employment in elementary occupations has grown by 1.8 percentage points. In the same occupational group we find a weak increase in France and Greece and a decline in Italy, Belgium and Spain. Thus, job expansion in Europe in last 15 years has been clearly biased towards high-paid jobs occupations, since we observe that employment has grown most at the top of the occupational skill ranking and has decreased in mid-range and lowest paid occupations.

Unlike Goos et al. (2009a), the overall pattern appear more similar to an upgrading trend that to a polarization trend. This evidence is consistent to what Oesch et al. (2010) found for Spain, Germany, United Kingdom and Switzerland.

3 The Theoretical Model

The European pattern does not seem to be consistent with the simple routinization hypothesis studied for a perfect competitive labor market (Autor et al., 2006). Hence, we propose a theoretical model that analyzes the

impact of the technological diffusion on wages and employment in a labor market characterized by the presence of the union.

Following the simple framework of Autor et al. (2006), technological diffusion is embodied by an exogenous decline in the real price of computers and similar technologies. Indeed, the decrease of computing power price has been the main responsible factor of computer diffusion in productive processes.

We study an economy with three different groups of workplace tasks: abstract (A), routine (R) and manual (M). These groups roughly correspond to high-, intermediate- and low-skilled jobs. The technological shock hits in a different way the workers hired in these three activities (Levy and Murname, 2004). In particular, we assume that: (i) computer capital is a close substitute for human labor in routine cognitive and manual activities.[6]; (ii) routine tasks are complements of abstract tasks (e.g., coordination activities and problem solving) and probably, to some extent, also of manual activities.

Aggregate output is produced using the Cobb-Douglas production function:

$$Y = L_A^{\alpha}(L_R + K)^{\beta}L_M^{\gamma} \tag{1}$$

where $\alpha, \beta, \gamma \in (0, 1)$ and $\alpha + \beta + \gamma = 1$. Only workers can perform abstract and manual tasks (L_A, L_M), while routine tasks can be done either by workers (L_R) or by computer capital (K). K is measured in efficiency units and is elastically supplied to routine tasks at price ρ per efficiency unit.

The first innovative contribution of this framework is the labor market environment, characterized by some rigidities related to the union activity[7], and the possibility to analyze the effects of the technological shock in this particular institutional setting.

We assume that the abstract and routine labor market are perfectly competitive, while in the manual labor market, employment and wages depend on the interaction between the union and the firm. The union's goal is to reach in the manual labor market the highest possible wage compatible with

[6]The substituitability assumption is reasonable given that routine tasks (such as bookkeeping, clerical work and repetitive production tasks) are sufficiently well defined that they can be carried out successfully by either a computer executing a program or, alternatively, by workers. Moreover, Autor et al. (2003) deeply analyze this issue and provide empirical support to this theoretical assumption.

[7]The union activity strictly influences the presence and the behaviour of other labor market institutions, as the employment protection legislation and the dual labor market. The latter are, for the most part, the result of the union policies. Therefore, it is reasonable to study the union behaviour in order to evaluate, in a general way, the role played by labor market institutions.

a certain employment target[8]. This target (L_M^*) is a function of the number of union members, L_M^I, (employed workers at the moment of the bargaining process) and of the total labor supply for this task, S_M. The choice of this specific union objective function is in line with the insider-outsider approach commonly adopted by European unions .
The union employment target is:

$$L_M^* = \phi L_M^I + (1-\phi)S_M, \tag{2}$$

where $\phi \in (0,1)$ represents the weight assigned to L_M^I. If ϕ is equal to one, then $L_M^* = L_M^I$ and so the union cares only about insider workers. If $\phi < 1$, the employment target depends also on S_M. The union sets the wage level that equalizes L_M^* to its expectation on the demand of the firm, $E(L_M)$.

The wage definitions for abstract, routine and manual workers are different, depending on the functioning of the corresponding market. While abstract and routine workers are paid at their marginal productivity, the manual wage depends on the interaction between union and representative firm. Once the union has set the wage level, manual employment L_M is chosen by the firm according to its labor demand function that is determined in order to maximize its profit:

$$L_M = \left(\frac{\gamma L_A^{\alpha}(L_R+K)^{\beta}}{w_M}\right)^{\frac{1}{1-\gamma}}. \tag{3}$$

When no shock hits the economy, $L_M^* = E(L_M) = L_M$, and we obtain w_M from equations (2) and (3). The manual wage differs according to the value of ϕ. In particular, if union cares only about its current members ($\phi = 1$), we have:

$$w_M = \gamma L_A^{\alpha}(L_R+K)^{\beta} L_M^{I\gamma-1}. \tag{4}$$

When $\phi < 1$:

$$w_M = \gamma L_A^{\alpha}(L_R+K)^{\beta}[\phi L_M^I + (1-\phi)S_M]^{\gamma-1}. \tag{5}$$

[8]It is reasonable to treat separately the three labor markets since the bargaining process sets labor conditions for every industrial sector and worker qualification. The assumption according to which the routine labor market is competitive is not binding. Our results stay valid even if the wage setting process in the routine market is equal to the one in the manual market. Indeed, the substitutability between routine workers and computers forces unions to set a routine wage equal to the marginal productivity of the routine input; otherwise no worker would be employed in routine tasks and -whatever it is- the union employment target would not be satisfied.

In this economy, there are many income-maximizing workers. Each of them is endowed with a vector of three skills, one for each production task ($E_i = (a_i, r_i, m_i)$). College-graduate workers are endowed with one efficiency unit of abstract skill ($E_i = (1, 0, 0)$) that is inelastically supplied to abstract tasks. Every non-graduate worker has one efficiency unit to supply to manual tasks and cannot perform abstract tasks. Moreover, non-graduate workers are characterized by η efficiency units of routine skill, with η being a continuous variable distributed on the unit interval ($\eta \in (0, 1)$) with positive probability mass at all points. Therefore, non-graduate workers have the endowment vector $E_i = (0, \eta, 1)$ and can choose to supply their efficiency units to either manual or routine tasks.

Individual supply choices of the non-graduate workers with respect to the sector to work in are determined by a self-selection rule. According to it, workers select themselves into one specific task given their ability, the wage levels and the probability of being hired in each task. Each worker maximizes his expected wage per efficiency unit, where weights are computed taking into account the probability to be hired in each sector.
Let w_R and w_M be the wage paid to routine and manual tasks per efficiency unit; then, each worker will compare w_M and ηw_R. The higher the value of η is, the more likely it is that the worker chooses a routine job. Furthermore, supply choices depend on the probability of having a job in the two sectors. Since the routine market equilibrium is equal to the competitive outcome, at the equilibrium, no worker will be an involuntarily unemployed. In the manual market, the probability of being employed depends on ϕ. Only when $\phi = 0$ there is certainly no unemployment. A more restrictive employment target ($\phi > 0$) implies a lower probability of finding a job in the manual sector (since the union protects mainly who already work in this sector) and therefore a lower manual labor supply.
With probability $(1 - \phi)$ the worker finds a job in the manual sector and gets w_M; with probability ϕ she does not work and obtains zero wage. The manual labor supply is function of the ratio between the expected wage in the manual and routine sector, $\frac{w_M}{\eta w_R}$, and of the probability $1 - \phi$ to find a job in the manual sector.

$$S_M = \lambda \frac{w_M}{\eta w_R}(1 - \phi) + \sigma X \tag{6}$$

where X represents other possible relevant characteristics.
Now we study in more details the behaviour of the labor supply function.

- $\frac{\partial S_M}{\partial \frac{w_M}{\eta w_R}} = \alpha(1-\phi) > 0$, the higher the relative wage the higher the labor supply in manual sector

- $\frac{\partial S_M}{\partial \phi} = \frac{(1-\phi)}{\eta w_R}\frac{\partial w_M}{\partial \phi} - \frac{w_M}{\eta w_R}$. The sign of this derivative is not clear. Indeed two different effects act simultaneously. The stricter the union employment target, the higher the manual wage bargained by the union for a given S_M(*wage effect*). On the other hand, when ϕ is higher it is more difficult to find a job in the manual sector (*employment effect*). If $\phi < 1 - [\frac{w_M}{\eta w_R}\frac{1}{\frac{\partial \frac{w_M}{\eta w_R}}{\partial \phi}}]$ the *manual effect* prevails on the *employment effect* and so $\frac{\partial S_M}{\partial \phi} > 0$.

- $\frac{\partial^2 S_M}{\partial \frac{w_M}{\eta w_R}\partial \phi} = -\phi < 0$. This derivative implies that workers are more sensitive to changes in the relative wages when ϕ is low.

Also routine labor supply is function of relative wage and union behaviour: $S_R(\frac{w_M}{\eta w_R};\phi)$. We have $\frac{\partial S_R}{\partial \frac{w_M}{\eta w_R}} < 0$, the higher the relative wage the lower the labor supply in routine sector; $\frac{\partial S_R}{\partial \phi} > 0$ if the *manual effect* matters less than the *employment effect*. In this case the higher the weight assigned to union members the higher the labor supply in manual sector. The second cross partial derivative is $\frac{\partial^2 S_R}{\partial \frac{w_M}{\eta w_R}\partial \phi} > 0$ and says that an increase in relative wages induces a deeper reduction in S_R when ϕ is low.

The timing of the model with respect to the manual sector is the following:

- the union defines its employment target and simultaneously the firm sets the labor demand function;
- then interaction between the specific union employment target and the labor demand function leads to the manual wage;
- workers take their labor supply decision;
- the employment level is set.

Now we consider the effects of a positive shock on the labor market, paying attention to the manual sector. In particular, the exogenous force that hits the economy is the reduction of the computer price, ρ.

Let first consider what is the effect on the routine sector. Since computer capital is a perfect substitute for routine labor input, $w_R = \rho$, and, consequently, a decline in ρ reduces w_R on a one-to-one basis. With downward-sloping factor demand curves ($R'(\rho) < 0$), the decline in ρ raises the demand

for routine tasks. This increase in the demand for routine tasks leads to an increase in the abstract and manual labor demands because of the existing complementarities. Both computer capital and routine labor inputs are potentially able to satisfy this additional routine demand, but the self-selection rule implies that it will be, at least partially, satisfied by computer capital . In fact, when ρ declines, the ratio between manual and routine wages increases and some workers will decide to switch from routine to manual tasks (Autor et al., 2006). These workers are those having the lowest values of η. Since the shock reduces S_R, the employment in routine tasks declines. A worker's decision to supply labor is related to the ease of finding a job in each sector; thus, the magnitude of the labor supply change will depend on the value of the parameter ϕ. Noteworthy is that the less restrictive the employment target is (the lower ϕ is), the greater the reduction in S_R will be.

In the manual sector the effect of the reduction in ρ depends on the union policy and on the predictability of the shock. If the union does not expect the increase in the manual demand, then $L_M^* = E(L_M) < L_M$, and whatever the value of ϕ, the manual employment increases. Actually, it is reasonable to assume that the union can anticipate technological shocks.[9] Then, the resulting wage embodies the shock, and the employment level coincides with the union expectation. In this case, the effects on the manual labor market crucially depend on ϕ. When $\phi = 1$, an increase in the manual supply (due to the decline of ρ) does not affect the union employment target because the changes in the labor supply derived by the workers' choices are not taken into account by the union, that considers only unionized workers (already employed in this sector). When $\phi < 1$, an increase in S_M leads to a positive effect on manual employment; in this case union considers also what happens on the supply side of the market and therefore its employment target is adjusted to take the change of S_M into account. Indeed we have $-\frac{\partial L_M^*}{\partial \rho} = -(1-\phi)\frac{\partial S_M}{\partial \rho} > 0$.
The second cross partial derivative is $-\frac{\partial L_M^*}{\partial \rho \partial \phi} = -[(1-\phi)\frac{\partial S_M}{\partial \rho \partial \phi} - \frac{\partial S_M}{\partial \rho}] < 0$. Therefore, the higher ϕ is, the lower the effect of the computer price decline on manual employment, to the limit that when $\phi = 1$, the increasing labor supply does not play any role.

In order to analyze the effects of a decline in computer price on wages, we differentiate the three wage equations with respect to $-\rho$. As far as the

[9]This assumption is reasonable for all those economies a bit far from the technological frontier (as Italy). Indeed, these economies generally face a given shock some years later than the US, so they expect the technological innovations and their consequences on the labor market.

routine wage is concerned, our result is obvious and strictly related to the substitutability between computers and routine workers:

$$-\frac{\partial w_R}{\partial \rho} = -1. \tag{7}$$

The impact of the technological diffusion on w_M has to be studied separately when $\phi = 1$ and $\phi < 1$. By differentiating equation (4), we get:

$$-\frac{\partial w_M}{\partial \rho} = -\beta\gamma L_A^{\alpha} R^{\beta-1} \frac{\partial R}{\partial \rho} L_M^{\gamma-1}. \tag{8}$$

This derivative is positive; therefore, the union is able to obtain a higher wage level after the technological shock. Since for this value of ϕ manual employment does not change, a higher demand for manual tasks - due to factor complementarities - leads only to a higher wage level. Therefore, when the union cares only about employed workers, the technological shock leads to an increase in w_M, and the wage structure tends to polarize to the detriment of manual employment growth[10].

When $\phi < 1$, we differentiate (5), getting:

$$\begin{aligned} -\frac{\partial w_M}{\partial \rho} = {} & \gamma(1-\gamma)(1-\phi) L_A^{\alpha} R^{\beta} [\phi L_M^I + (1-\phi) S_M]^{\gamma-2} \frac{\partial S_M}{\partial \rho} + \\ & - \beta\gamma L_A^{\alpha} R^{\beta-1} \frac{\partial R}{\partial \rho} [\phi L_M^I + (1-\phi) S_M]^{\gamma-1}. \end{aligned} \tag{9}$$

The effect of the technological spread on w_M is not clear: two opposite effects act simultaneously. On one side, complementarities would induce a manual wage increase. On the other side, the workers' shift induces an increase in S_M due to the self-selection rule. Therefore, it tends to decrease manual wage. The final outcome depends on the prevailing force. The supply side effect depends on ϕ: (i) when ϕ is high, fewer workers shift to manual tasks, (ii) the higher ϕ is, the weaker the increase in manual employment and (iii) the higher ϕ is, the more demand-side shocks are transferred to wages. While according to (i) and (ii) a restrictive employment target implies a lower supply-side effect, (iii) makes the supply-side effect stronger when ϕ is high.

An interesting consideration arises from this result: the reduction of ρ

[10]Note that the observed wage, in the case of routine tasks, may differ from the wage paid per efficiency unit of routine task input. Observed routine wages are affected by composition. As workers self-select out of routine tasks, the remaining routine workers have above-average routine skills, meaning that the observed routine wage can either rise or fall as ρ declines.

has a different impact on the manual labor market according to the weight that labor market institutions assign to manual labor supply. Therefore, the presence of union can affect the way the technological shock acts. In this framework, it is possible to observe both wages and employment polarization as in Autor et al.'s (2006) perfect competitive framework in the situation in which the union's behavior is more *market oriented* ($\phi \neq 1$): indeed, in this case, an increase in the manual labor supply has a positive effect on manual employment.

Finally, in the abstract labor market the wage unambiguously increases:

$$-\frac{\partial w_A}{\partial \rho} = -\alpha L_A^{\alpha-1}[\beta R^{\beta-1}\frac{\partial R}{\partial \rho}L_M^{\gamma} + \gamma R^{\beta} L_M^{\gamma-1}\frac{\partial L_M}{\partial \rho}] > 0. \tag{10}$$

This is due to the increase in the demand for abstract tasks (due to the complementarity between routine and abstract input), which is not followed by a countervailing labor supply. Therefore, the computerization process implies a higher w_A.

Proposition 1 *Given the weight ϕ that the union assigns to its members, the technological shock induces:*

- *employment polarization only if $\phi < 1$. Otherwise, with $\phi = 1$, the positive demand side shock is only transferred to the wage level and the manual employment does not change.*

- *wage polarization*

The second important contribution of our analysis is that, in this setting, when $\phi > 0$ involuntary unemployment emerges. As long as manual wage is higher than that of perfect competition, manual employment is lower than manual labor supply. Indeed, independently on the value of ϕ (for $\phi \neq =$) , when the technological shock occurs the manual labor supply increases but the magnitude of the employment target change is not the same amount. That is, the increase of the union employment target, that determines the employment level, is not sufficient to compensate the higher manual labor supply. Therefore, when ρ declines, unemployment (defined as $U_M = S_M - L_M^*$) emerges, as shown by the following derivative:

$$-\frac{\partial U_M}{\partial \rho} = -[\frac{\partial S_M}{\partial \rho} - (1-\phi)\frac{\partial S_M}{\partial \rho}] = -[\frac{\partial S_M}{\partial \rho}\phi] > 0 \tag{11}$$

The (11) shows that unemployment increases after the technological shock. Indeed, when $\phi > 0$, the union transfers the most part of the positive demand

shock that hits the manual sector to the insiders' wage, instead of allowing an empoyment increase proportional to the demand and supply shock. The union, by bargaining for a high level of low-skilled wage, decreases inequality in the lower tail of the earning distribution, at the cost of an increasing number of unemployed workers. From this we derive the following.

Remark 1 *Low-skilled unemployment seems to be an alternative to employment polarization. Indeed, when the technological transformation hits an economy where the union acts, the emergence of unvolontary unemployment can occur.*

Now we study how the unemployment varies when the strictness of the union employment target changes.
The second cross partial derivative has not a clear sign[11]. This is due by the simultaneous presence of the *wage* and *employment effect*. When $\phi < -\frac{\frac{\partial S_M}{\partial \rho}}{\frac{\partial S_M}{\partial \rho \phi}}$ the *wage effect* is bigger than the *employment effect* and a positive and monotone relationship between ϕ and the unemployment in the manual sector emerges. In this case, a greater transfer of the technological shock on the manual wage occurs. Consequentely, there is a bigger increase of w_M that has a strong positive effect on S_M, which more than compensate the lower increase of S_M due to the more difficulty to find a job in the manual sector.

Proposition 2 *If $\phi > 0$, the technological shock will lead to involuntary unemployment of low-skilled individuals. Indeed, the supply increase in the manual sector is not fully absorbed by the market because the variation of the union employment target has lower magnitude. For some values of ϕ, there is a positive and monotone relationship between the strictness of the union employment target and the unemployment level.*

Our insight is that as the technological shock spreads and the reduction of the computer price is greater, the ratio $\frac{\partial w_M}{\partial w_R}$ increases even more and this effect is stronger when ϕ is higher. Indeed, the strenght of the shock is such that the situation for routine workers worsens a lot and so, with higher probability, they will move to the manual sector. At the same time, when ϕ increases, the manual wage bargained by the union is so high to play, in the supply function, a positive role bigger than the negative one due to the more difficulty to find a job. Therefore, we expect that when the shock is strong, the stricter the union employment target is the greater the unemployment growth is (*wage effect* bigger than the *employment effect*).

[11] $-\frac{\partial U_M}{\partial \rho \partial \phi} = -[\frac{\partial S_M}{\partial \rho \partial \phi}\phi + \frac{\partial S_M}{\partial \rho}]$

4 More Evidence on Europe

The theoretical model provides some predictions on the effects of the technological shock on the employment and wage structures depending on country-specific institutions. In this section we are going to verify how those predictions fit real data. Unfortunately, both technological change and labor market policies are variables with a lot of measurement problems; thus, this analysis could not aim at verifying some causal relationship, but only to show whether theoretical predictions are reliable from a quantitative point of view.

First, we want to verify Proposition 1. It states that: i) the strenght of labor market institutions should avoid employment polarization. Indeed, the more labor market institutions protect their members, the more wages for low-skilled jobs tend to be high, to the detriment of low-skill employment. Conversely, when the labour market is more competitive, employment shares will polarize; ii) the technological shock should lead to a polarization of the wage structure.
To analyze this first issue, we will compare the European and the US labor markets: these areas are similar in terms of technological diffusion, but they are different from an institutional point of view. In particular, the collective bargaining process in many European countries may have a crucial role in determining the wage level, and thus it may influence the effects of the implementations of new technologies on the employment structure.

Then, we want to verify Proposition 2, according to which where the institutions prevent the low-skill employment growth, we should find a statistical correlation between the lack of the employment polarization and the unemployment rate.

4.1 The Setting

Now we provide some information that make clear the different institutional settings of US and Europe.
The US economy experienced in the 1990s a period of massive investment in information and communication technology (ICT), fueled by strong computer price declines. Analogous information on the European countries is quite limited, due to the lack of reliable measures of ICT capital stock. Bugamelli and Pagano (2004), using microdata on Italian manufacturing firms, suggest a measure of capital stock that includes hardware, software and communication equipment. They show a delay in Italian ICT accumulation with respect to US manufacturing of about 8 years and find a positive correlation at the firm level between ICT investment and reorganization. Despite the delay

and the different magnitude of the computerization process in some European countries and in the US, according to the World Bank from 1991 to 2004 the number of PCs grew by 588% in Italy, 499% in Germany, 561% in France, 381% in the United Kingdom.

In order to analyze the consequences of these pressures on the labor market, we have to focus on differences in the institutional setting of these countries. It is difficult to define precisely what are labor market institutions. We can consider either: (i) labor taxes, (ii) law and regulations covering employees' rights, (iii) trade unions and the structure of wage bargaining.

As far as labor taxes are concerned, OECD compares the shares of employee earnings taken by governments in different countries through taxation by calculating the difference between labor costs to the employer and the net take-home pay of the employee, including any cash benefits from government welfare programs. According to these data, the total tax wedge for a single individual without children with an average income in 2008 was equal to 30.1% in the US and 46.5% in Italy, 52.0% in Germany and 49.3% in France. Thus, total rates in continental Europe are significantly higher than in the US.

Furthermore, laws referring to the treatment of employees by companies (which include working hours, annual leave, health and safety, employee representation rights, employment security and compensation insurance) presents strong cross-country heterogeneity with a higher level of regulation in southern Europe. All these features are strictly related to the labor cost and may have additional effects on productivity; that is why many papers looked at the relationship between the institutional setting of the labor market and the overall economic performance, focusing mainly on unemployment and growth.[12]

Finally, the unionization rate in 2004 was about 30% in Europe and 11.5% in the US. This evidence shows that the European labor market is cleraly more affected by the union acrivity than the US one. Indeed, many European countries have their wages determined by collective agreements which are negotiated at the plant, firm, industry or national level. In many of these countries, even if the number of union members is low, most workers have their wage set by union agreements: union pay is legally extended to cover non-union firms or workers. In particular, the wages of Italian workers are determined through a national agreement.[13]. Three major confederations

[12]See Nickell and Layard (1999) for a review.

[13]For details on the Italian labor market see Brandolini et al. (2001), Erickson and Ichino (1995), Brandolini et al. (2006).

of sectoral unions (CGIL, CISL and UIL), characterized by different political inspirations, represent Italian workers. On the other side, all private industrial employers are represented by a single association (Confindustria) that has traditionally played the leading role in bargaining. Other similar associations represent employers in the other main sectors. This agreement sets minimum contractual wages for employees at different skill levels in each industry, covering both unionized and non-unionized workers. Higher wages can be negotiated at the firm level for a single worker or a group of workers. Typically, sectoral contracts last approximately three years. Italian confederations of sectoral unions act quite crosswise among sectors and so their politics and their behavior are similar in different sectors. Collective agreements set wages by differentiating according to a skill ranking system. The law divides employers into four categories: blue-collars, white-collars, *quadri*, [14] and managers. The nature of the occupation, whether manual or intellectual, traces the border between blue-collar workers and the other categories, while the amount of directive responsibility traces the distinctions among the highest categories.

4.2 Prediction 1: Wage Polarization

Given the institutional characteristics of US and European labor markets, we expect that the continental European case is consistent with our theoretical predictions relative to a high value of ϕ, while the US case to the one with a lower level of ϕ. According to our model, under the technological shock both in continental Europe and in the US there should be a polarization pattern in wages. As far as employment is concerned, we should observe a clear polarization pattern only in the US and an upgrading pattern in Europe.
The first evidence consistent with this prediction is provided in Section 2, where it is showed that continental European countries, differently from the US and the UK, have had an upgrading in job opportunities.
We test the Proposition 1 in more detail focusing on two countries: Italy and the US. Our source of data for Italian wages is the WHIP[15]. It is a database of individual work histories, based on Italian social security institute (INPS) archives. The reference population is made up by all the people, Italian and foreign, who have worked in Italy even for only a part of their working career. A large representative sample has been extracted from this

[14]White-collar workers with directive responsibilities.

[15]The *Work Histories Italian Panel*, created by the center for employment studies *Laboratorio R. Revelli*. See http://www.laboratoriorevelli.it/whip.

population: the sampling coefficient is about 1:180 for a dynamic population of 370,000 people. These data are collected through 20 surveys carried out yearly over the period 1985-2004. The dataset provides information on employees with working experience in Italian private sector. On average, we have 65,000 labor relationships per year. Around 67% of employee labor relationships concern blue-collars, 32% white-collars, and 1% managers. The above dataset allowed us to obtain information about real individual weekly wages expressed in Euros: their values are obtained by dividing the annual earnings by the number of weeks worked. These nominal values are then transformed into real terms using a price deflator.

Data on the US hourly wages (based on annual earnings divided by hours worked in the previous calendar year) come from the CPS March Samples (Autor et al. 2006).

Once collected, these data are used to observe the changing nature of inequality in different parts of the wage distribution. Figure 2 plots the annual average growth of real earnings by wage percentile.[16] On the whole, in the last decades very low wages and very high wages have been the ones that have grown the most both in the US and in Italy. What emerges is a clear wage polarization pattern. This evidence is very striking: despite the difference in the average wage growth in the two countries, the shapes of the curves are very similar. In particular, in both countries lowest wages have grown 1 log point more that median wages.

To summarize, figures 1 and 2 plot the changes in wages and employment in Italy, showing a clear polarization pattern for wages and no convexification in employment. The correspondence between our theoretical predictions when $\phi = 1$ and the Italian trends may suggest that labor market institutions in Italy have mainly protected employed workers, leading to a huge increase in manual wages to the detriment of manual employment. In other words, the increase in the demand of manual work induced by computerization - which in a competitive world would have had a positive effect on both wage and employment - has raised only manual wages. The US case - where both wages and employment have polarized - is consistent with our predictions when $\phi < 1$.
This evidence is in line with the structure of the Italian and US labor markets, with more institutional rigidieties the former and more competitive di latter. Moreover, the analysis of these two different labor markets highlights the capability of the theoretical analysis to explain the wage and employment

[16]From the 3rd to the 97th percentile.

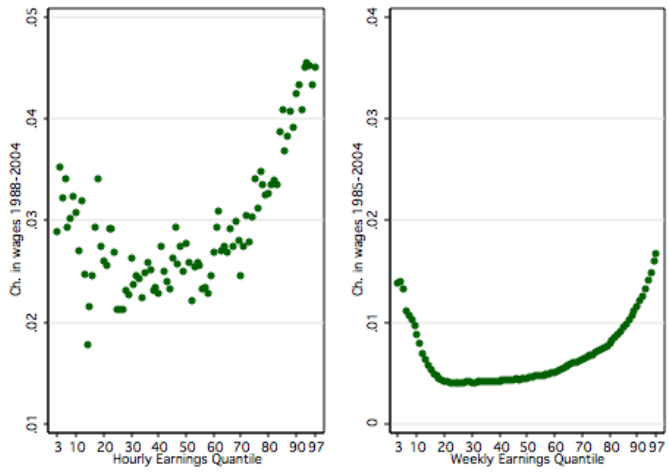

Figure 2: Annual average change in log wages by percentile. Source: WHIP and CPS (Autor et al. 2006).

pattern of countries with heterogeneous institutional enviroment.

4.3 Predictions 2: Involontary Unemployment

In our theoretical framework the labor market institutions, which tend to protect their insiders, create unemployment of low-skilled individuals avoiding the supply pressure on low-skilled wages. This effect is mitigated by the fact that a *strict* employment policy (high value of ϕ) can oppose the fall in routine employment[17] [18].

In this section we want to verify whether the theoretical prediction, according to which the unemployment is an alternative to job polarization, finds an empirical counterpart in the European case.

Firstly, we want to check whether there is any relationship between the characteristics of labour market institutions and the job opportunities of low-skilled workers. This analysis is important given that the relationship

[17]The bigger the value of ϕ, the lower the probability of finding a manual job and, therefore, the lower the shift of workers from R to M when ρ declines.

[18]In a competitive market, the drawbacks of computerization impact: (i) on routine workers who decide to stay in R even with a lower wage per efficiency unit and (ii) on manual workers - when the increase in manual labor supply is greater than the increase in the labor demand -; in a non-competitive market, routine workers have to pay all the drawbacks of the technological shock: in terms of wage if they stay in R and in terms of employment if they move.

between unemployment and polarization, pointed out in Proposition 2, is a consequence of the rigidities induced by the intistitutions.
We use the employment protection legislation (EPL)[19] index elaborated by OECD as a proxy of the strictness of the union policy. The effects on the job structure are measured by the difference of the employment shares of low-skilled and middling-skilled jobs (crafts and related trade workers, plant and machine operators and assemblers). The higher this difference, the more polarized is the employment structure.

EPL index and the share of low-quality jobs

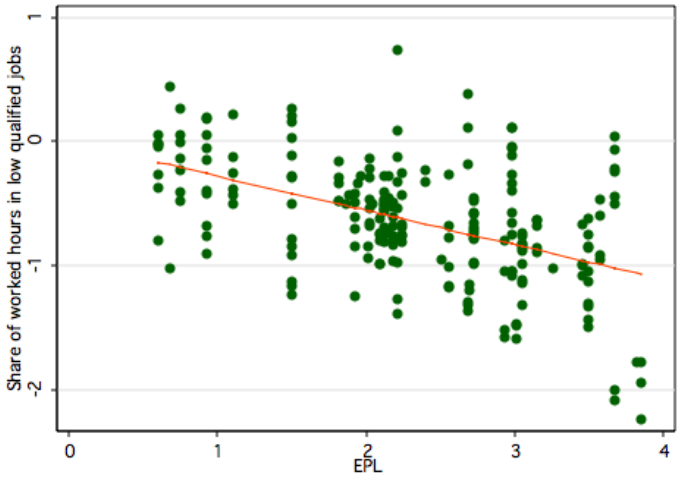

Figure 3: Source: Eurostat and OECD, 1993-2008. We use yearly data on every European country. We control for year and country fixed effects.

Figure 3 shows that EPL and the difference in the low-skilled and the middling-skilled employment shares are negatively correlated. In a regression of EPL on this difference, which controls for year and country fixed effects, we observe a significant at 1% coefficient. Thus, the degree of employment polarization is higher when labor market institutions have a less strict policy, as predicted by our model.

As the different weights of the labor market institutions can affect the polarization process , we look for a possible correlation between the pattern of the low-paid employment and the unemployment rate.
Figure 4 shows that the national unemployment rate in European countries

[19]The EPL is strictly related to the union since the most part of the employment protection measures derives from the collective bargaining led by unions

and the share of hours worked in lowest skilled occupations (crafts and related trade workers, plant and machine operators and assemblers) are negatively correlated (the slope of the curve is different from zero at 1%). Thus, countries where job opportunities in low-qualified tasks have increased the most have experienced less unemployment. This means that where we observe a more clear employment polarization pattern, associated with a higher employment growth among the low paid jobs, the unemployment is lower. Such evidence is compatible with the Prediction 2: in labor markets characterized by $\phi > 0$, the activity of institutions implies that the manual employment growth that occurs after a positive demand shock is lower than the supply increase. Therefore, we observe a statistical correlation between the unemployment and a measure of polarization (the share of hours in low qualified jobs). Moreover, the negative relatioship between the two variables is coherent with our expectation in case of a strong technological shock, as the one experienced by European countries. Indeed, the result of Figure 4 is compatible with the specific case in which the *wage effect* prevails on the *employment effect*. That is, with the situation in which higher ϕ, implying lower polarization, induces higher unemployment.

Unemployment rate and the share of low-quality jobs

Figure 4: Source: Eurostat, 1993-2008. We use yearly data on every European country. We control for year and country fixed effects.

The empirical evidence highlighted in Figures 3 and 4 supports the theoretical findings. Indeed, it emerges that when the role of the institutions is higher the low skilled employment grows relatively less and, moreover, that

the low skilled employment is negatively correlated to the unemployment rate.

5 Conclusions

Autor et al. (2006) explain polarization trends in US wages and employment with the sharp decrease of computing power price and the related diffusion of computers. Since technological diffusion and the following routinization process are global phenomena, that has also been affecting continental Europe, we may expect that the labor markets in continental Europe and in the US have reacted in a similar way to this shock. However, wages and employment in many European countries are determined through bargaining between the confederations of trade unions and the association of entrepreneurs and thus they may not directly reflect changes in labor demand and supply as it happens in a market without these frictions.

The comparison between wage and employment patterns in the US and UK and in some continental European countries (e.g., Italy, France, Belgium, Germany and Spain) shows a clear discrepancy: during the period 1988-2004, the US labor market was characterized by a clear job polarization trend, conversely in continental Europe the employment share of low-paid jobs did not increase at all. The lack of job polarization has been correlated with: (i) the unemployment; (ii) the strength of EPL; (iii) a huge polarization in wages (at least in Italy).

In order to explain these patterns, we propose a theoretical framework that studies the effect of the technological diffusion in the labor market and that captures national peculiarities in the institutional environment. In particular, we give voice to the role played by unions in the process of wage setting. In our model, the union can choose to adopt different policies depending on its employment target. As a result, labor market institutions regulate the trade-off between low-skilled wage growth and low-skilled employment growth. Indeed, in our framework, the emergence of involuntary unemployment can be seen as the alternative outcome to the employment polarization that rises in countries where institutions play a weaker role. The model is consistent with our findings relative to the different patterns between Europe and US and with the previous literature on labor market polarization (i.e. Dustmann et al, 2007; Fortin, Lemieux, 1997 and especially the work of Oesch and Rodriguez Menes, 2010).

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