Institutions and Job Polarization: evidence from Europe

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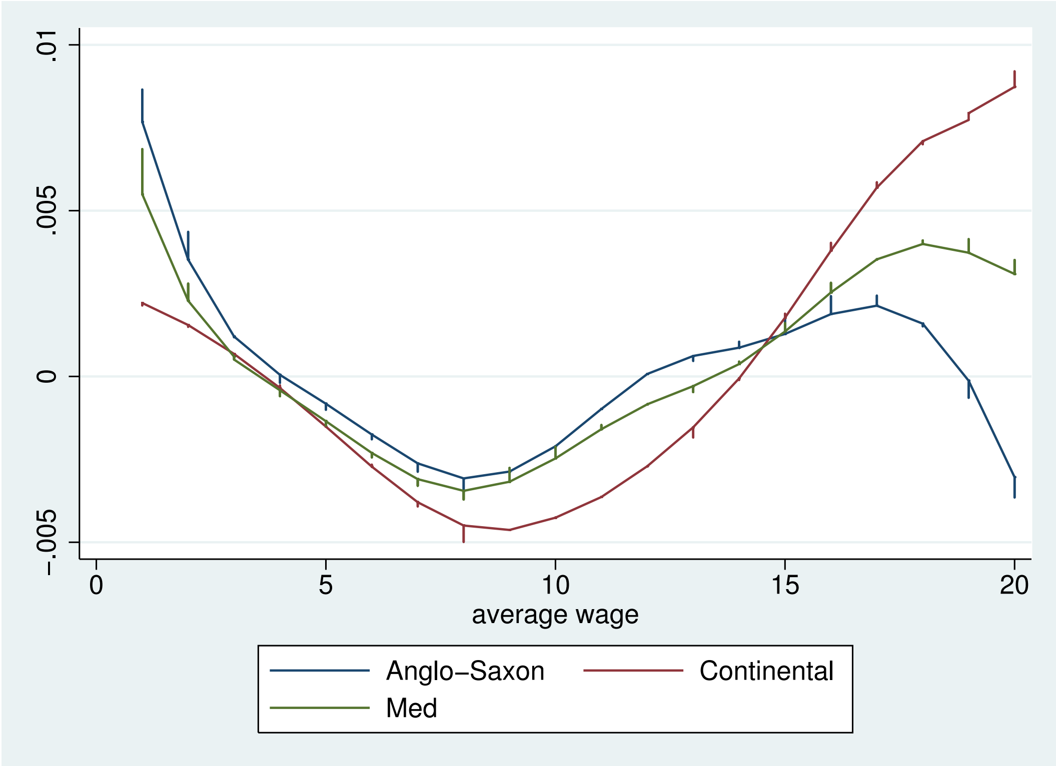
Abstract

This paper investigates the role played by institutions in shaping job polarization in Europe. We allow manufacturing and non-manual services sectors to use a three input CES production function while manual services use a Cobb-Douglas type of production. On this basis, we find first of all the relationships between elasticities of substitution across production inputs, labour share and price demand elasticity in order for job polarization to emerge following a drop in the price of computer-based technology, Next, using the same framework, we lay down a structural model of labour demand and wage setting that accounts for both product and labour market institutions on the equilibrium occupations by sector, country and time. The model is estimated using a panel of 16 European countries, from 1993 to 2010, which match ELFS data, OECD STAN sector data and OECD institutional data. Consistently, we adopt panel time series estimators that allow for heterogeneous slope coefficients across occupation-industry cells and control for cross-section dependence and common trends. Initial results suggest that the degree of imperfection in the product market, proxied by the extent of regulations, reduces the response of occupational changes; in particular, we find that this is the case for middling and low-skill occupations wheres high skill occupational changes are relatively unresponsive to regulations. Likewise, the role of employment protection legislations appears to hamper the extent of hallowing out of routine occupations, whereas the strictness in the use of temporary contracts mainly affects the responsiveness of low skill occupations.

Keywords: Job polarization, labour share, product market regulation
JEL Classification:

Figure 1: Job polarization across groups of countries: 1993-2010



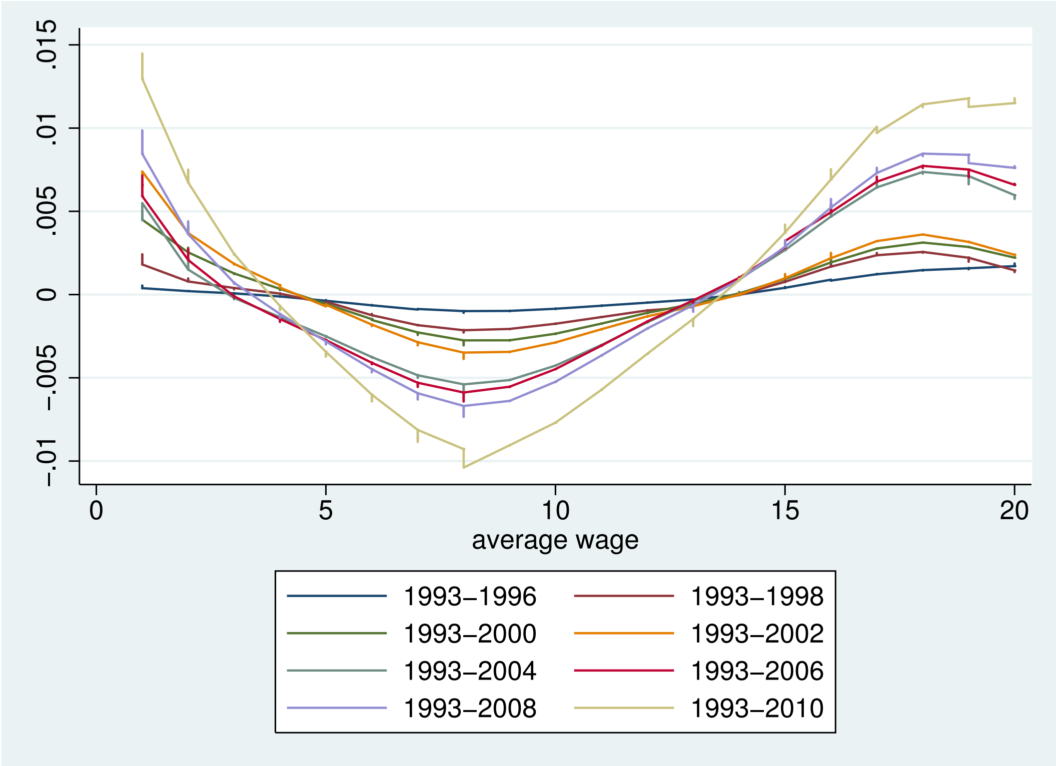
1 Introduction

The so-called job polarization is a phenomenon consisting in the wane of routine occupations accompanied by a quasi-simultaneous rise of non routine occupations, both high skilled conceptual ones and manual low skilled ones. Job polarization implies that the change in the shares of occupations in employment, measured along a skill intensity meter between two points in time, usually from the early eighties to mid 2000s, is typically U shaped. This reshuffling of occupations is well documented in Anglo-Saxon world, where it was first observed. Recent evidence extends job polarization to some European countries as well.

Figure 1 shows the U shape for three usual groups of countries: Anglo-Saxons, Continental European and Mediterranean. The polarization is indeed clear in all groups though the extent of the changes differ, mainly at the tails[1]

[1] As far as the Anglo-Saxon countries are concerned, the twist at the far right of the distribution is due the classification change from SOC90 to SOC2000

Figure 2: the cumulation of job polarization: 1993-2010



The polarization appears also to be a sort of gradual phenomenon, as it is revealed by Figure 2 that draws the cumulative change in the occupational shares from the base year onwards. There are, however some accelerations: from 2003 to 2004 and from 2008 to 2010 which may be due to recession-induced changes (Jaimovich, 2013).

The most accredited view relates job polarization to the diffusion of computer-based technology that allows machines to perform well-sequenced and repetitive tasks, thus replacing workers in so called routine jobs.

Once the declining price of computer-based technology is initiated, the emergence of job polarization rests essentially on the features of the production function, as far as the right tail of the U-shaped distribution is concerned, while the production function properties are necessary but not sufficient to explain the left tail of the U-shaped occupational share distribution.

The increase of high-skill conceptual occupations is related to the complementarity between high skilled labour and computer technology, a fact which is supported by the evidence of the positive role that the introduction of ICT has had on the marginal productivity of cognitive jobs. If labour is paid according to its marginal productivity, this also implies the wage of high skilled labour increases. In contrast, routine work, which is assumed to be a substitute for computers, will experience a wage drop as the price of computers is declining.

The account of the rising share of occupations at the lower end of the intensity skill meter calls for additional ingredients, as computer-based technology cannot complement non routine low-skill tasks.

Autor and Dorn (2013) show that a sufficient condition for the non routine low-skill employment share to increase relative to the routine one, is that the elasticity of substitution between computer and routine labour in production is greater than the elasticity of substitution in consumption between goods and services. A sufficiently high elasticity between the two factors implies that as the price of computer declines the demand for routine workers also declines; meanwhile the complementarity between goods and services implies that consumers demand (personal) services, the production of which calls for non routine manual occupations.

On a similar vein Weiss (2008) emphasizes that if the price of manual services rises in response to a rise of demand, then the ratio between manual and routine wages may rise even if the ratio of the corresponding marginal productivities (MRTS) does not.

Hence while high skill labour is attracted by a wage premium which reflects an increase in its marginal productivity, the wage premium of low skill manual jobs is instead ultimately determined by the aggregate demand characteristics (e.g. the price elasticity of goods/services ratio, as in AD (2013) or the demand for personal services induced by a rise of high skilled occupation as in Weiss (2008) (see also Moretti (2010)).

Since wage determination in most European countries is largely based on union bargaining at the national, sector and/or company level and both labour and product market undergo various types of regulations which impact on their degrees of competition, we expect occupational trends to be affected by institutions. The extent this is the case, the role of specific institutions is a relevant issue as job polarization has far reaching implication on growth as well as on inequality.

The paper is organized as follows: in the next section we introduce the role of institutions by stating the conditions that need to hold between the labour share, the elasticity of demand and the elasticities of substitution among production inputs in order for job polarization to emerge. In section 3 we lay down a structural model of labour demand and wage bargaining in order to gain more insight into the role of specific product and labour market institutions. This approach allows us to account for the institutional heterogeneity across European economies and quantify its contribution to the degree of job polarization. The data used for the empirical estimation, described in section 4, allow to adopt a relatively novel strategy that relies on panel time series estimators which allow for heterogeneous slope coefficients across occupation-sector-country cells and control for cross-section dependence and common trends (Eberhardt et al, 2012). This class of model is based on the notion of "common factor framework", as the primary interest is to estimate at the macro-level the relevance of institutional determinants of job polarization while accounting for any unobserved heterogeneity and possible common trends. This ensures that the results are not merely driven by ad hoc assumptions on the structure of the data. Concretely, we are able to compare the estimates across alternative empirical specifications with inherently different assumptions about error term independence and heterogeneity in institutional determinants across occupation, industry and country. Results are reported and commented in section 56.The final section concludes.

2 A simple comparative static analysis

In the following we make use of the well known relationship between elasticities of substitution in production and the price elasticity of demand in order to obtain the necessary conditions for the emergence of job polarization.

Following Autor and Dorn (2013) and Goos Manning and Salomons (2014) it is useful to distinguish the total production of an economy into two different outputs, which are produced with different technologies and face different demands. The latter are defined in standard fashion: $Y^d = (P_Y)^{-\varepsilon}$ and $S^d = (P_S)^{-\gamma}$, while production functions are both assumed to be CES with CRS.

The first technology produces manufactured goods, financial intermediation services and some public services (Y)using three inputs: computer capital K, routine labour R and conceptual labour H. The remaining services S are produced using the second type of technology, whose inputs are routine labour R and manual labour M.

A three input production function allows factor complementarity (Hicks, 1970), which is a useful property to exploit as computer based technology K and conceptual labour H have indeed been found to be complementary. Recalling the formula of the cross elasticities of derived demands in the three inputs case (Hicks, 1970), for factor H we have:

$$E_H/E_{Pk} = -(1 - \kappa_H - \kappa_R) \cdot \varepsilon + (1 - \kappa_H - \kappa_R) \cdot \sigma_{KH} \quad (1)$$

where κ_H and κ_R are the labour shares. Under the assumption of p-complementarity between H and K (i.e. σ_{KH} is negative), E_H/E_{Pk} is negative, which implies that an exogenous drop in the price of K will always increase the derived demand for H.

For given prices of K and R it is also the case that:

$$E_{Ph}/E_K = -\frac{(1-\kappa_H-\kappa_R)}{\varepsilon} + \frac{(1-\kappa_H-\kappa_R)}{s_{KH}} \tag{2}$$

which implies that the price of H rises relative to those of K and R, if K and H are q-complements (i.e. $s_{KH} > 0$, which we assume) and $s_{KH} < \varepsilon$.[2]

Likewise, the cross elasticity of the derived demand for factor R is:

$$E_R/E_{Pk} = -(1-\kappa_H-\kappa_R)\cdot\varepsilon + (1-\kappa_H-\kappa_R)\cdot\sigma_{KR} \tag{3}$$

Since K and R are p-substitutes,[3] σ_{KR} is positive and E_R/E_{Pk} is positive (implying that a drop in the price of computer brings about a reduction in the derived demand of routine labour, as actually observed) as long as $\sigma_{KR} > \varepsilon$.

If the elasticity of substitution between K and R is high and the product market for Y is sufficiently imperfectly competitive so that the above inequality holds, then the more intense the drop of P_k the larger the number of routine workers that become redundant in the production of Y. For the production of output S, this can be regarded as an exogenous increase in the supply of input R, the price of which will therefore fall. In order to assess the implication on the derived demand of M, let us use again the corresponding cross elasticity of derived demand:

$$E_M/E_{Pr} = -(1-\kappa_M)\cdot\gamma + (1-\kappa_M)\cdot\sigma_{RM} \tag{4}$$

The drop in the price of routine labour will determine an increase in the demand for M as long as the $\sigma_{RM} < \gamma$. Notice also that if σ_{RM} is positive, as it is reasonable to assume, the same inequality condition implies that an exogenous increase in R will also rise the price of manual labour relative to routine labour, thus making it attractive for

[2] Notice that the cross elasticity of price of R: $E_{Pr}/E_K < 0$ as long as $s_{KR} < 0$, i.e. K and R are q-substitutes.

[3] In the case of three factors if a pair of inputs are p-complements, then the other two pairs must be p-substitutes. Moreover, if a pair is p-complements then it must be q-complement (Hicks, 1970). These imply that the pairs K,R and R,H are both p-substitute and that the pair K,H is q-complement.

routine workers to move into manual jobs.

$$E_{Pm}/E_R = -\frac{(1-\kappa_M)}{\gamma} + \frac{(1-\kappa_M)}{\sigma_{RM}} \tag{5}$$

On the whole, on the assumptions of p-complementarity between H and K and of substitutability between R and M, an exogenous drop of the price of K produces job polarization, if the following two inequalities hold:

$$s_{KH} < \varepsilon < \sigma_{KR} \tag{6}$$

$$\sigma_{RM} < \gamma \tag{7}$$

Provided these conditions are satisfied, the extent of the phenomenon may differ across time, sectors and countries, depending on the magnitudes of variables and parameters involved.
The relative rise of high-skill conceptual occupations will be larger the larger are ε and $|\sigma_{KH}|$ and the lower are the factor shares of H and R.[4]
The hollowing out of routine occupations is expected to be greater the higher σ_{KR} and the smaller ε and the labour shares.
The relative rise of the manual occupations is likely higher the lower the share of M and the larger is γ relative to σ_{RM}.

Job polarization is therefore more likely to emerge, ceteris paribus, in countries/sectors with more competitive product markets. Moreover, the partial elasticities of substitution between computer-based technology and high-skilled labour $|\sigma_{KH}|$ and between computer-based technology and middle-skilled routine labour σ_{KR} will depend on the education level of the labour force, on their training schemes, and on the extent of organizational changes that allow complementarity or substitutability to take place. Differences across sectors and countries may reveal different forces behind observationally similar phenomena.

[4] Chirinko and Mallick (2011) have shown that in Hicks' formula for the own price elasticity of derived demand of factor a, say, E_a/E_{Pa}, the factor share κ_a is constant to a change in the factor price only in the Cobb-Douglas case of $\sigma = 1$. More generally, they show that in a two-factor CES the factor share κ_a is a function of the CES elasticity parameter, σ, of the relative price of the factor Pa/Px, where Px is the output price, and of the CES distribution parameter.

3 A structural model

The structural model accounts for both product and labour market institutions, which are an essential features of European countries we are investigating.
The model is set out at the country-sector level where the wage bargaining is also assumed to take place. Along the lines sketched above, in each sector output is obtained using one of two possible production functions, depending on the outcome being either manual services (for example.) or manufacturing goods and non.manual services (for example).

3.1 Labour demand

Sectors, which are identified by subscript j, are distinguished according to their production being either manufacturing goods and non-manual services, Y_j^g or manual services Y_j^s . In the first case the production function inputs are conceptual labour (H), routine labour (R^g) and computer-based technology (K), where the latter and routine labour are substitutes, with elasticity $1/(1-\mu) > 1$, while H and K have a unitary elasticity of substitutions (Autor and Dorn, 2013).[5] Accordingly, the production function can be written as follows where, for convenience, we omit the time subscript:

$$Y_j^g = H_j^{1-\alpha}[(a_{R^g} R_j^g)^\mu + (a_K K_j)^\mu]^{\alpha/\mu} \tag{8}$$

The production of manual services uses manual and routine labour (R^s), combined according to a Cobb-Douglas production function:

$$Y_j^s = M_j^{1-\theta} R_j^{s\theta} \tag{9}$$

Goods and service markets are both imperfectly competitive, firms are profit maximizers and face firing costs. Firms' objectives can then be written as follows (Angrist and Kugler, 2003):

$$\Pi_j^g = (1-\phi)^{-1}(P_j^g Y_j^g - W_{Hj}(1+\tau_P)H_j - W_{R^g j}(1+\tau_P)R_j^g - P_{Kt}K_j - \phi(\lambda_{Hj}C_{Hj}H_j - \lambda_{R^g j}C_{R^g j}R_j^g)) \tag{10}$$

[5]The latter assumption is taken for analytical reasons. With respect to the framework discussed in section 2, for the cross elasticity E_H/E_{Pk} (equation 1) to be negative ε should then be greater than 1.

$$\Pi_j^s = (1-\phi)^{-1}(P_j^s Y_j^s - W_{Mj}(1+\tau_P)M_j + W_{R^s j}(1+\tau_P)R_j^s - \phi(\lambda_{Mj}C_{Mj}M_j - \lambda_{R^s j}C_{R^s j}R_j^s)) \tag{11}$$

where P_j^g and P_j^s are sector output prices, $W_{ij}(1+\tau_P)$, λ_{ij}, C_{ij}, $i = H, R^g, R^s, M$, are, respectively, nominal labour costs, fractions of the workforce that get dismissed and relative firing costs; τ_P is the employer tax rate, p_K is the computer based technology price and ϕ is the discount factor.

On the assumption of no aggregate uncertainty and linear adjustment costs of labour we find the following FOCs:

$$\frac{\partial Y_j^g}{\partial H_j} = \frac{W_{Hj}}{P_j^g}(1+\tau_P)(1+\phi\lambda_{Hj}c_{Hj})(1+\mu_j^g) \tag{12}$$

$$\frac{\partial Y_j^g}{\partial R_j^g} = \frac{W_{R^g j}}{P_j^g}(1+\tau_P)(1+\phi\lambda_{R^g j}c_{R^g j})(1+\mu_j^g) \tag{13}$$

$$\frac{\partial Y_j^g}{\partial K_t} = \frac{P_{Kj}}{P_j^g}(1+\mu_j^g) \tag{14}$$

$$\frac{\partial Y_j^s}{\partial R_j^s} = \frac{W_{R^s j}}{P_j^s}(1+\tau_P)(1+\phi\lambda_{R^s j}c_{R^s j})(1+\mu_j^s) \tag{15}$$

$$\frac{\partial Y_j^s}{\partial M_j} = \frac{W_{Mj}}{P_j^s}(1+\tau_P)(1+\phi\lambda_{Mj}c_{Mj})(1+\mu_j^s) \tag{16}$$

where $\mu^g = \frac{1}{\varepsilon^g - 1}$ and $\mu^s = \frac{1}{\varepsilon^s - 1}$ are sector mark ups, where ε^g, ε^s are the (absolute values) of demand elasticities, and firing costs are assumed to be proportional to wages. We use equations 12 and 8 to obtain the labour demand function for conceptual labour and 16 and 9 to obtain the labour demand function for manual labour:

$$H_j = (1-\alpha)Y_j^g \Big[\frac{W_{Hj}}{P_j^g}(1+\tau_P)(1+\phi\lambda_{Hj}c_{Hj})(1+\mu_j^g)\Big]^{-1} \tag{17}$$

$$M_j = (1-\theta)Y_j^s \Big[\frac{W_{Mj}}{P_j^s}(1+\tau_P)(1+\phi\lambda_{Mj}c_{Mj})(1+\mu_j^s))^{-1} \tag{18}$$

With regard to routine labour, we are interested in its demand relative to computer-based capital, in the goods and non manual market, and relative to manual labour in the market for manual services:

$$\frac{R_j^g}{K_j} = \Big[\frac{W_{R^g j}(1+\tau_P)(1+\phi\lambda_{R^g j}c_{R^g j})}{P_{Kt}}\Big]^{-\frac{1}{1-\mu}}\Big(\frac{a_K}{a_R^g}\Big)^{-\frac{\mu}{1-\mu}} \tag{19}$$

$$\frac{R_j^s}{M_j} = \Big[\frac{W_{R^s j}(1+\phi\lambda_{R^s j}c_{R^s j})}{W_{Mj}(1+\phi\lambda_{Mj}c_{Mj})}\Big]^{-1}\Big(\frac{1-\theta}{\theta}\Big)^{-1} \tag{20}$$

3.2 Wage setting

We assume that wages are the result of a right to manage bargaining between unions and firms, at the industry level; this model is well suited to the European context[6] and delivers the equilibrium solution along the labour demand curve.
Again, for convenience, we omit time and country indices. In each country, at time t, the bargained wage in sector j is obtained by solving the following Nash problem:

$$\max_{\tilde{W}_j} \quad \Omega_j = (V_j - \bar{V}_j)^{\beta}\tilde{\Pi}_j$$
$$\text{s.t.} \quad N_j = N_j^d$$

where Ω is the Nash maximand, N^d is labour demand, β is the relative union bargaining power, where the firm's bargaining power is normalized to 1. Firms' real profits $\tilde{\Pi}$ and union members' utility V and fall back utility $\bar{V}$ are defined as follows:

$$\tilde{\Pi}_j = Y_j - \frac{W_j}{P_j}(1+\tau_P)(1+\phi\lambda_j c_j)N_j \tag{21}$$

$$V_j = \frac{W_j}{P_C}(1-\tau_L)\frac{N_j}{L} + \frac{WA}{P_C}(1-\tau_L)\frac{(L-N_j)}{L} \tag{22}$$

$$\bar{V} = \frac{WA}{P_C}(1-\tau_L) \tag{23}$$

where τ_L is the employee social security contribution rate, P_C are consumption prices and the alternative wage WA is a weighted average of expected earnings:

$$\frac{WA}{P_C}(1-\tau_L) = \frac{N}{L}\frac{W}{P_C}(1-\tau_L) + \frac{N_G}{L}\frac{W_G}{P_C}(1-\tau_L) + \frac{U}{L}\frac{B}{P_C} \tag{24}$$

where L is the labour force, $N = \sum N_j$ is total private employment, N_G is public employment, $W = \sum \frac{N_j}{L} W_j$ is the (weighted) average wage in the private sector, W_G is

[6] Since the industry level may not be the proper level in some countries, we will take care of this assumption in the empirical section using centralization indices.

the average wage in the public sector and U is unemployment. The relationship between P_C, which is relevant for union members' consumption wage and P_j, which is relevant for firms' profits is the following:

$$P_C = P_j^{1-s} P_M^s (1+t) = P_j \zeta^{-s}(1+t) \tag{25}$$

where s is the share of imports in GDP, P_M is the average import price, t is the tax rate on goods (value added and import taxes) and $\zeta = \frac{P_j}{P_M}$ is a competitiveness index (real exchange rate)

Taking into account the above definitions, the Nash maximand then becomes:

$$\max_{\frac{W_j}{P_j}} \quad \Omega_j = \Big[\frac{W_j - WA}{P_j}\Big(\frac{1-\tau_L}{1+t}\zeta^s\Big)\frac{N_j}{L}\Big]^\beta \Big[Y_j - \frac{W_j}{P_j}(1+\tau_P)(1+\phi\lambda_j c_j)N_j\Big]$$

$$\text{s.t.} \quad N_j = N_j^d$$

The bargained real wage is then given by:

$$\frac{W_j}{P_j} = \frac{WA}{P_j}\Big(1 - \frac{\beta}{S_{\Pi_j}}\Big)^{-1} \tag{26}$$

where $S_{\Pi_j} = \frac{W_j N_j^d (1+\tau_P)(1+\phi\lambda_j c_j)}{\Pi(N^d)_j}$ is the share of labour costs on maximized profits $\Pi(N^d)$.

Notice that the state balance budget expression:

$$\sum_j \frac{N_j}{L}\frac{W_j}{P_C}\tau_L + \frac{N_g}{L}\frac{W_G}{P_C}\tau_L + \sum_j \frac{N_j}{L}\frac{W_j}{P_C}\tau_P = \frac{U}{L}\frac{B}{P_C} + \frac{N_G}{L}\frac{W_G}{P_C} \tag{27}$$

together with equations 24 and 25, allows to express WA in the alternative convenient way (Fiori et al, 2007):

$$\frac{WA}{P_j} = \sum_j \frac{N_j}{L}\frac{W_j}{P_j}\Big(\frac{1+\tau_P}{1-\tau_L}\Big) = l\frac{W}{P}(1+\tau) \tag{28}$$

where $l = N/L$ is the private sector employment rate, W/P is the average real wage in the private sector and $1+\tau = 1+\tau_P+\tau_L \simeq \frac{1+\tau_P}{1-\tau_L}$ is the wedge.

Then, the bargained real wage, equation 26, can be expressed as follows:

$$\frac{W_j}{P_j} = l\frac{W}{P}(1+\tau)\Big(1-\frac{\beta}{S_{\Pi_j}}\Big)^{-1} \tag{29}$$

3.3 The equilibrium

The bargained sector wage (equation 29) form the basis for the sector-occupation wage present in the labour demand. In particular, we assume that for each occupational group $s = H, R^g, R^s, M$ the wage is the wage bargained in the relevant sector j, adjusted by the average education level of the occupational group:

$$W_{sj} = W_j^{\alpha_j + \alpha_{sj}\ \mathrm{edu}_{sj}} \tag{30}$$

Hence, occupation-sector wages, as they appear in the above labour demands, can be expressed as follows:

$$\frac{W_{Hj}}{P^g} = \Big(\frac{P_j}{P^g}\Big)^{-1}\Big[l\frac{W}{P}(1+\tau)\Big(1-\frac{\beta}{S_{\Pi_j}}\Big)^{-1}\Big]^{\alpha_j+\alpha_{Hj}\ \mathrm{edu}_{Hj}} \tag{31}$$

$$\frac{W_{Mj}}{P^s} = \Big(\frac{P_j}{P^s}\Big)^{-1}\Big[l\frac{W}{P}(1+\tau)\Big(1-\frac{\beta}{S_{\Pi_j}}\Big)^{-1}\Big]^{\alpha_j+\alpha_{Mj}\ \mathrm{edu}_{Mj}} \tag{32}$$

$$\frac{W_{R^gj}}{P_k} = \Big(\frac{P_j}{P_k}\Big)^{-1}\Big[l\frac{W}{P}(1+\tau)\Big(1-\frac{\beta}{S_{\Pi_j}}\Big)^{-1}\Big]^{\alpha_j+\alpha_{R^gj}\ \mathrm{edu}_{R^gj}} \tag{33}$$

$$\frac{W_{R^sj}}{W_{Mj}} = \frac{\Big[l\frac{W}{P}(1+\tau)\Big(1-\frac{\beta}{S_{\Pi_j}}\Big)^{-1}\Big]^{\alpha_j+\alpha_{R^sj}\ \mathrm{edu}_{R^sj}}}{\Big[l\frac{W}{P}(1+\tau)\Big(1-\frac{\beta}{S_{\Pi_j}}\Big)^{-1}\Big]^{\alpha_j+\alpha_{Mj}\ \mathrm{edu}_{Mj}}} \tag{34}$$

Employment at country-sector-occupation level is finally obtained by substituting equations 31-34 in equations 17-20.

4 Data

The main data source is the 1993-2010 waves of the individual level European Labour Force Survey (ELFS) which contains information on employment status, 2-digit occupation (ISCO88) and 1-digit industry codes (NACE 1.1 revision). ELFS is a collection of harmonized labour force surveys conducted at national levels in the European countries. Given limitations in the sample size and data availability, we limit our sample to 16 European countries as in Goos et al. (2014): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom. Throughout this paper, we use number of person employed aged between 15 and 64 as the measure of employment, using the ILO definition and eliminating the so-called unpaid family workers. Another choice concerns the set of occupations and industries we include in our analysis. We follow Goos et al. (2014) and exclude several occupations and industries because the data are unreliable or have classification problems.[7] Our analysis requires a time consistent definition of occupational labour market and the employment data is build up by summing the number of person employed in each country, industry, occupation and year cell.

Additional crucial inputs in our analysis are measures of product market regulation and labour market institutions. Concretely, we exploit OECD product market regulation (PMR) statistics that provide time series data on policies that prevent market liberalisation. The basic idea of PMR is to disentangle the impact of regulations that are potentially anti-competitive. The general index PMR can be decomposed in three components, respectively "state control", "barriers to entrepreneurship" and "barriers to trade and investment". At the same way, to gauge the effects of labour market institutions on job polarization, we focus on OECD employment protection indicators that covers regulation affecting workers on both permanent and temporary contracts. The OECD index summarizes EPL along 21 items quantifying the monetary and procedural costs involved in firing workers under open-ended contracts and in hiring workers under temporary contracts. These indices are classified in three main components: protection of regular workers against individual dismissal (EPLR), regulation of temporary forms of employment (EPLT) which includes both the regulations for temporary work agency employment and fixed-term contracts and lastly, specific requirements for collective dismissals (EPLC). To capture unions' power in the wage bargaining process we adopt two measure: the union density from OECD and the coverage of collective bargaining provided by ICTWSS.

For each country-industry-year cell in our data set, we construct a number of variables. First, from OECD STAN, we recover information on net operating surplus, import penetration, labour share and R&D intensity at country-industry-year level. Second, we use EUKLEMS data to obtain information on ICT capital at industry level for the countries in our sample. Third, to capture the impact of task-biased technological change

[7] More precisely, concerning occupations, we exclude legislators and senior officials (ISCO11), teaching professionals and associate professionals (ISCO 23 AND 33), skilled agricultural workers (ISCO 61) and agricultural, fishery and related laborers (ISCO 92). About industries, we drop agricultural, fishery and hunting (NACE A), fishing (NACE B), mining and quarrying (NACE C), public administration and defense (NACE L), education (NACE M) and extra territorial organizations and bodies (NACE Q).

(TBTC), we exploit the Routine Task Intensity (RTI) index used by Autor and Dorn (2013) and Goos et al. (2014) and defined as the difference between the log of Routine tasks and the sum of the log of Abstract and the log of Manual tasks.

For European countries, individual level data on wages and labour market characteristics comes from two alternative sources, European Community Household Panel (ECHP) and European Union Statistics on Income and Living Conditions (EU-SILC), both provided by Eurostat. The ECHP is a panel survey of 15 European countries from 1994 to 2001, while EU-SILC provides cross-sectional and longitudinal data on income and living conditions defining individual-level changes over time since 2003. In sum, there is no single data source to investigate the evolution of the wage structure in Europe. Nonetheless the differences between ECHP and EU-SILC, we can recover a measure of average wages for each country-industry-occupation-year cell in our sample for the period 1994-2010.

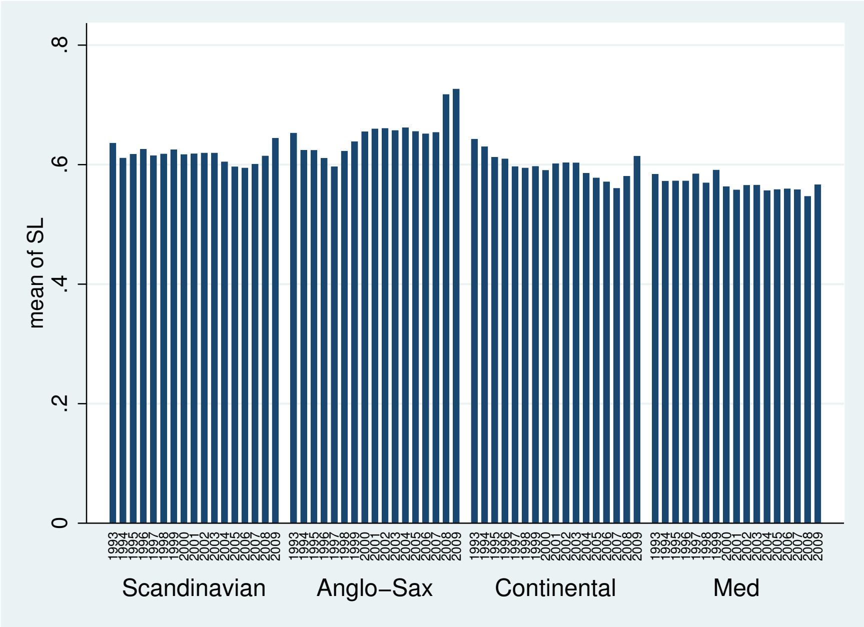
5 The empirical link between labour share, elasticity of substitution and elasticity of demand

In the following section we use the framework of section 2 to gain a first insight of the link between job polarization and institutions in some European countries. The main data sets are the OECD STAN and the European labour force survey. Figure 3 shows the evolution of the employment share [8] over time and over four groups of countries: Scandinavian (Denmark, Finland, Norway and Sweden), Anglo-Saxson (Ireland and UK), Continental (Austria, Belgium, Germany, Netherlands) and Mediterrenean (France, Greece, Italy, Portugal and Spain). The average labour share is lowest in Mediterrenean countries and exhibits a significant decline in Continental Europe. On average, it is highest in the Anglo-Saxon countries where it has been trending upwards since 1998.
Figure 4 distinguishes sectors into two groups, depending on the role of manual work.[9]

[8] Employment shares are computed at 2 digit sector level using OECD STAN ISIC Rev3 data and are defined as ratio between compensation of employees and value added at factor costs.

[9] Although tentatively, we define as intense in manual work the following tertiary sectors: Public admin. and defence - compulsory social security Education Health and social work Sewage and refuse disposal, sanitation and similar activities Activities of membership organizations n.e.c. Recreational, cultural and sporting activities Other service activities Private households with employed persons Sale, maintenance and repair of motor vehicles and motorcycles - retail sale of automotive fuel Wholesale, trade and commission excl. motor vehicles Retail trade excl. motor vehicles - repair of household goods Hotels and restaurants Land transport - transport via pipelines Water transport Air transport Supporting and auxiliary transport activities Post and telecommunications.

Figure 3: Labour share over time and countries



The labour share of these sector is higher than that of the remaining ones, mainly manufacturing; indeed, across countries, the main difference in the average labour shares is due to the labour share of manual intensive sectors.
The higher the share, other things equal, the lower the expected polarization.[10]

The evolution of the price of the computer-based technology Pk is taken from BLS[11] and is depicted in Figure 5. The sharp decline comes to end around 2003 and the price dynamics flattens since then.

5.1 The cross price elasticity

From equations 1 and 3 we can derive an estimable regression of the following type:

$$\log N_{jsct} = \log Pk_t \cdot (1 - \kappa_L)_{jsct} \cdot \sum_{\iota=1}^{3} (\beta_\iota \cdot I_\iota) + \nu_{jsct} \tag{35}$$

[10]Notice that as the labour share is computed using VA at factor cost, the indirect taxation which impact on VA at market prices, is excluded.

[11]BLS Industry price index, Monthly data. The series - General purpose digital computers- is from the Electronic computers (SIC) sector, from 1992 to 2004 (base Dec. 1998==100) and from the Electronic computer manufacturing (NAICS) sector, from 2003 to 2014 (base Dec. 2003==100) . Series are rebase to Dec 1993==100. The annual average is then used.

Figure 4: Labour share over countries and sectors

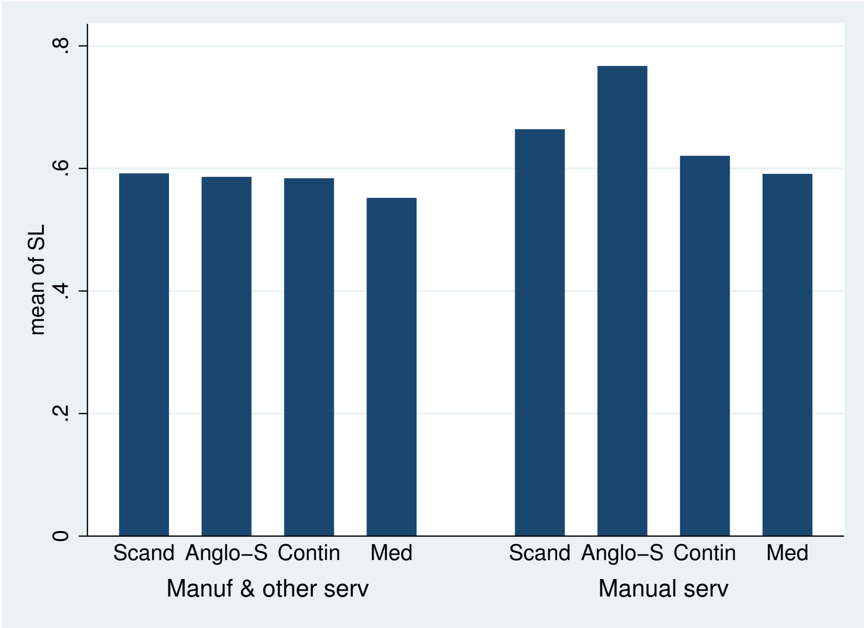


Figure 5: Log price of computer-based technology

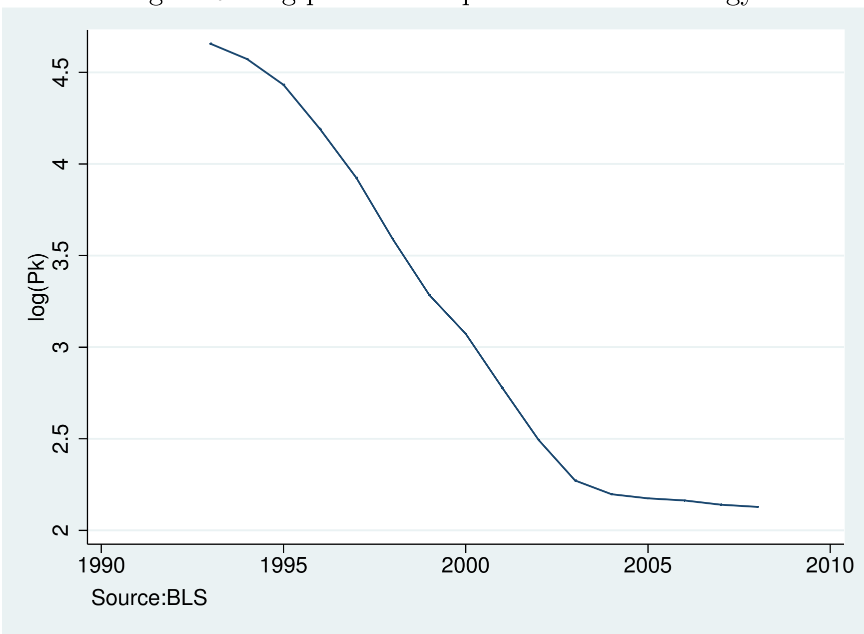


Table 1: Occupations response to the price of computer-based technology

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$(1-\kappa_L)\cdot \log Pk \cdot I_H$	–0.210***	–0.170***	–0.168***	–0.259***	–0.115***	–0.161***	–0.046***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
$(1-\kappa_L)\cdot \log Pk \cdot I_M$	–0.044***	–0.046**	0.013	–0.090***	0.064***	0.018	0.154***
	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)	(0.02)
$(1-\kappa_L)\cdot \log Pk \cdot I_L$	0.052**	–0.208***	0.123***	0.006	–0.234***	–0.322***	–0.189***
	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)
constant	3.466***	4.258***	4.661***	3.517***	5.555***	5.685***	5.392***
	(0.02)	(0.05)	(0.03)	(0.04)	(0.05)	(0.05)	(0.07)
occupation fixed effects	No	Yes	No	No	Yes	Yes	Yes
industry fixed effects	No	No	Yes	No	Yes	Yes	Yes
country fixed effects	No	No	No	Yes	No	Yes	Yes
year fixed effects	No	No	No	No	No	No	Yes
RMSE	2.02	1.85	1.88	1.96	1.65	1.54	1.50
N	38228	38228	38228	38228	38228	38228	38228

Notes: Dependent variable: log Employment. Data are for 16 countries, from 1993 to 2010. OLS regressions. Standard errors in brackets. *** (**) [*] corresponds to 1 (5) [10]% level of significance.

where N is employment Pk is the general-purpose digital computer production price, κ_L is the share of labour and subscripts j, s, c, t refer to occupation, sector, country and year. I is an indicator variable that allows β to vary across three occupational groups: low (L), middle (M) and high (H)[12]. The error terms is assumed to comprise country, sector, occupation and year fixed effects in addition to a random effect term: $\nu_{jct} = d_c + d_s + d_j + d_t + \psi_{jct}$.

On account of the considerations of section 2, we expect β to be negative for high skilled occupations and positive, but smaller for middling occupations, since the effects of the elasticity of substitution and of the elasticity of demand may tend to cancel out. As far as the manual low-skilled occupations are concerned, the above regression is only an approximation of equation 4 , to the extent that change in the price of Pk captures the change in the wage of routinely occupations. In this case, we expect β to be negative.

Results, reported in Table 1, confirm the expected signs, once fixed effects for occupations and sectors are both included (column 5). Additional controls for country and year fixed effects do not change the qualitative results though they affect the magnitude of the estimated coefficients. The estimated coefficients are negative for high skilled and manual labour and positive for routine labour, which accord with the polarization of occupations in response to a decline of the price of computer-based technology.

[12] These groups are defined according to Table E1 in GMS, AER 2014

If we multiply the estimated coefficients by the complement to 1 of the average labour share[13] we find a proxy of the cross elasticity of labour to the price of computer-based capital; the cross elasticity, thus computed, is -1.82% for high skills, 6.23% for middling skills and -7.41% for manual skills.

If we consider that between 1993 and 2003 the price of computer based technology dropped by 90%, the corresponding changes in employment have been of 1.64% and 6.67% in high skill and manual occupations respectively, and of -5.61% in routine occupations.

5.2 The role of product and labour market regulations

Recall that the β, in regression 35 is a compound coefficient, being the difference between the elasticity of substitution and the elasticity of demand. In order to capture the role of different degrees of competition in the product market, we consider the following specification: $\beta = \beta_0 + \beta_1 \cdot PMR_{ct}$, where PMR is the OECD measure of product market regulation which varies between 0 and 6 and is increasing in the strictness of regulations. Results are reported in Table 2, column 1.

Notice that since PMR varies across time and countries but not across sectors or occupations, it essentially captures country-level effects. In particular, results suggest that the lower PMR , the higher the cross elasticities of middling and low occupation groups, in absolute value. Hence, an increase in product market regulations reduces the responsiveness of employment in middling and low occupational groups while high skill groups do not appear to be affected: In fact, the coefficient significance drops and changes in high skill groups remain associated to fixed effects only.
In Table 2, columns 2 and 3 distinguish PMR into the so-called State control component (STC) and the Barriers to entrepreneurship component (BTE). The former appears to affects elasticities in the same way as PMR, whereas barriers to entrepreneurship effectively reduces the responsiveness of low skill employment.

The final two columns investigate the role of labour market institutions as captured by two standard OECD indicators: employment protection for regular workers (EPR) and flexibility in the use of temporary contracts (EPT). Both indicators vary between 0 and 6 and are increasing in protection and strictness. Results indicate that restrictions on

[13]The average labour share, over the period and the countries considered is: 0.603 0.595 0.608 for high, middling and low occupations.

Table 2: The role of institutions

	Product Market			Labour Market	
	(1)	(2)	(3)	(4)	(5)
$(1-\kappa)logPk\_H$	0.065	0.071	–0.011	0.050	–0.021
	(0.06)	(0.06)	(0.07)	(0.05)	(0.03)
$(1-\kappa)logPk\_M$	0.321***	0.336***	0.289***	0.457***	0.170***
	(0.07)	(0.06)	(0.07)	(0.05)	(0.03)
$(1-\kappa)logPk\_L$	–0.363***	–0.400***	–0.329***	–0.020	–0.160***
	(0.09)	(0.08)	(0.09)	(0.07)	(0.04)
$(1-\kappa)logPk\_H \cdot PMR$	–0.035				
	(0.03)				
$(1-\kappa)logPk\_M \cdot PMR$	–0.057*				
	(0.03)				
$(1-\kappa)logPk\_L \cdot PMR$	0.121***				
	(0.04)				
$(1-\kappa)logPk\_H \cdot STC$		–0.027			
		(0.02)			
$(1-\kappa)logPk\_M \cdot STC$		–0.045**			
		(0.02)			
$(1-\kappa)logPk\_L \cdot STC$		0.087***			
		(0.02)			
$(1-\kappa)logPk\_H \cdot BTE$			0.003		
			(0.03)		
$(1-\kappa)logPk\_M \cdot BTE$			–0.030		
			(0.03)		
$(1-\kappa)logPk\_L \cdot BTE$			0.091***		
			(0.03)		
$(1-\kappa)logPk\_H \cdot EPR$				–0.018	
				(0.02)	
$(1-\kappa)logPk\_M \cdot EPR$				–0.095***	
				(0.02)	
$(1-\kappa)logPk\_L \cdot EPR$				–0.026	
				(0.03)	
$(1-\kappa)logPk\_H \cdot EPT$					0.008
					(0.01)
$(1-\kappa)logPk\_M \cdot EPT$					0.018*
					(0.01)
$(1-\kappa)logPk\_L \cdot EPT$					0.029**
					(0.01)
PMR	0.116***				
	(0.04)				
STC		0.115***			
		(0.02)			
BTE			–0.092**		
			(0.04)		
EPR				0.023	
				(0.02)	
EPT					–0.045***
					(0.01)
constant	5.410***	5.290***	5.919***	5.564***	5.755***
	(0.11)	(0.10)	(0.12)	(0.09)	(0.08)
occupation fixed effects	Yes	Yes	Yes	Yes	Yes
industry fixed effects	Yes	Yes	Yes	Yes	Yes
year fixed effects	Yes	Yes	Yes	Yes	Yes
RMSE	1.59	1.59	1.59	1.59	1.59
N	35877	35877	35877	36040	36040

Notes: Dependent variable: Log employment. Data are for 16 countries, from 1993 to 2010. OLS regressions. Standard errors in brackets. *** (**) [*] corresponds to 1 (5) [10]% level of significance.

regular contracts strongly reduce the response of middling occupations while restrictions on temporary contracts reduce the response of low occupations.

6 Results from the estimated structural model

to be added

7 Conclusion

Using a comparative static approach in a two CES framework, where one of the production function is allowed to comprise three inputs, the paper states the static conditions that link price demand elasticity, elasticity of substitution in production and labour share, in order for job polarization to emerge, following a drop in the price of computer-based technology. The conditions are empirically assessed using panel of 16 European countries, from 1993 to 2010, which match ELFS data, OECD STAN sector data and OECD institutional data.

In the period under consideration, and for the average of 16 European countries, we find that the estimated cross elasticity of employment to the price of computer-based technology is -1.82% for high skill occupations, 6.23% for middling skills and -7.41% for manual skills, thus corroborating the role of computer-based technology on job polarization.

In addition, we find that the degree of imperfection in the product market, proxied by the extent of regulations, reduces the response of occupational changes; in particular, we find that this is the case for middling and low-skill occupations wheres high skill occupational changes are relatively unresponsive to regulations. Likewise, the role of employment protection legislations appears to hamper the extent of hallowing out of routine occupations, whereas the strictness in the use of temporary contracts mainly affects the responsiveness of low skill occupations.

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