MODELING THE RELATIONSHIP BETWEEN INDUSTRIAL EMPLOYMENT AND INFORMATION AND COMMUNICATION TECHNOLOGIES

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ABSTRACT

In this paper, we develop a model to measure the effects of Information and Communication Technologies (ICT) on the labor market, aiming to settle down its net effect on employment creation. The main findings are:
1) Related with the sector services, where the regions with worse evolution of the industrial employment showed growth in the *information society* sector services, being it intensive in technology, and a certain negative incidence employment growth in the sector services in general and in the industrial one,
2) Related with the ICT, where two variables have a negative effect on the employment growth: the extranet and the own wireless net. This negative incidence has its base on the positive relationship between productivity and technology. This way, the ICT integration into the industry causes smaller new workers needs.
3) A second group of estimates highlights some of the factors that have influenced the recent industry evolution. The most prominent effect is the incidence of the ICT on the added value. The regions where there is more penetration of the ICT are the ones having bigger industry relevance in the Spanish economy.

4) In addition, the difficulties to find ICT skilled workers specialist is a factor that hinders the added value growth. These results reveal the need of a public policy favoring the skilled labor and the company's technological advances. The conjunction of both factors will improve the industry long-term benefits.

5) A last effects group reveals that regions with bigger industrial production growth have also a bigger growth of the employment in the services sector.

INTRODUCTION

Technological innovations and employment

The relationship between technology and work is an important, old and controversial field of discussion in the economic and social analysis. In the academic literature, two big tendencies coexist. The first one, the so-called compensation theory, states the positive and long-term influence of technological change on employment. The second, affirms that the technological change weakens, or even eliminates, the positive relationship between technology and number of jobs.
Several investigations -e.g. OECD, 1998- show clearly that the technological progress is associated to a high occupation growth, mainly of the skilled labor. Nevertheless, when tying to verify if the most innovative organizations are also the ones creating more employment, must be kept in mind the effects on their rival companies: maybe the innovative firms do create employment but at the cost of destroying it in less competitive rivals.

Overall, the effect of the technological change on employment is the combined result of innovations in productive sectors, of the labor markets (internal and external) existing conditions and of the economic activity institutional frame. When a knowledge intensive company introduces an innovation that increases its labor force, the effects spread to other sectors. The lost jobs due to the technological change tend to take place in the manufacturing sector and among the less skilled workers, while the new ones require more and different skills and concentrate on the services sector. The final effect will be positive if the necessary conditions are fulfilled: mainly macroeconomic stability and macroeconomic efficiency, besides others relative to the adjustment to the labor market changes and the adaptation of the institutions influencing it.

Besides, there are forces that, spontaneously, could compensate the short-term occupation reduction, resulting from the technical change. These

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compensatory mechanisms can be clustered (Vivarelli and Pianta, 2000) into six big types; compensation by means of: a) new jobs in other sectors, b) price reduction, c) new investments, d) fall of wages, d) rent increase and f) new products.

Summarizing, the real effect of the technology on the skills, organization and results at employment depends on the labor force characteristics, its learning abilities and experience, organizational structure, human resources management, company interaction with its environment, and on the pattern of economic and social competitiveness. So that, the effect of the technology can only be understood considering (Torrent, 2008) its interaction with the variables mentioned and in relation with the economic and social system in which is applied.

Employment and Information and Communication Technologies

When studying the influence of the ICT on employment creation and destruction is necessary considering, at least conceptually, to improve its understanding three types of effects: direct, indirect and on the markets structure.
a) **Direct effects**: creation of new employments intended for the new products and services that had not been possible without the new technology. b) I**ndirect Effects**: the ones derived from their use in any other sector of the economy. The incorporation of a new and more efficient technology generates a substitution of the less efficient technologies used so far. The question is how many employments do they preserve and create or wipe out the ICT, when making more competitive the sectors where they are applied? c) **Effects on market structure** of qualitative and quantitative nature, that influence the type of employment on demand, the skills required and even the labor market configuration.

The above-mentioned factors outline the complexity of the ICT influence in the labor market, and therefore of its evaluation. Being its effects of reinforcement as well as inhibitors, its net effect estimate on employment is not of easy determination. Besides, these effects are non homogeneous neither in all the societies nor in all the economic sectors; depending on the degree the economy of a country or region is able to take advantage of the potential possibilities of the new technologies, in relation with other competitor economies. In addition, it is to consider not only its effect on the number of employments but also on the type jobs, its quality, and wages.

This paper contributes to the evaluation of the ICT effects on the work market, aiming to settle down if its net effects, direct and indirect, on the employment creation are positive or negative. In the next sections, we present the data and method, later a model of structural equations (graph 2) is developed whose parameters are estimated by the method of maximum likelihood with full information (FIML). The paper finishes with some conclusions and recommendations.

Data and Model

The main statistical source to analyze the industrial employment evolution in Spain is the Industrial Survey, carried out yearly by the National Institute of Statistic (INE). It will also be used the survey of ICT use and electronic trade in the companies, that contains information on the use of the new technologies and their regional diffusion degree. Lastly, the regional accounting and the central directory of companies (DIRCE) complete the information, with data generated by industry, market size and number of companies in each region. All these surveys are representative at regional level.
With regard to time, we consider two types of variables. On one hand, the ones describing time variations (for example, variation of the employment) and, on the other, the ones referred to a year period, having a structural character (for example, number of companies). In the first case, the temporary period is 1996-2006, both included, in the second the year 2006.

The variables considered in modeling the industrial employment behavior are in the chart 1, following.

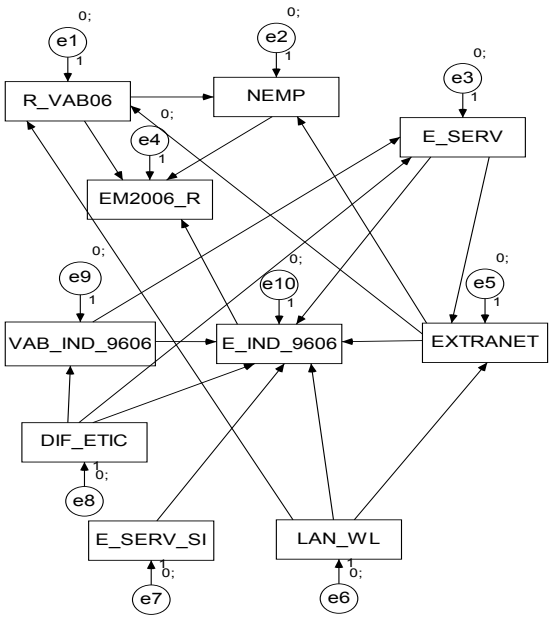
Table 1. Industrial employment variables

Name	Label
EM2006	Industry employment (number of workers year 2006)
HT2006	Number of worked hours
NEMP	Number of industry firms
HrelESP	Ratio worked hours in region and nation total (percent)
EMPrel	Ratio number of regional firms to the total nation total (percent)
R_HT_EMP	Worked hours per firm
EMP_DIRC_SC	Ratio variables hrelesp/emprel
E_TIC	Percentage of firms employing, in January 2007, skilled ICT workers
ESP_TIC	Total skilled ICT workers (%)
FC_TIC	Total number of firms with ICT training programs for employees (%)
G_TIC	ICT training expenses (thousands Euros)

LAN	Firms with local area network (%)
LAN_WL	Firms with wireless local area network (%)
INTERNET	Firms with Internet connection (%)
EXTRANET	Firms with extranet connection (%)
GTIC_R	Ratio ICT regional expenses/ total ICT nation expenses (%)
E_EMP	Ratio (Region industrial employment)/(Nation industrial employment)
E_IND_9606	Industrial employment variation (1996-2006)
E_SERV	Services employment variation (1996-2006)
E_SERV_SI	Information services society employment variation (1996-2006)
EM2006_R	Ratio industry employment/ total nation employment
DIF_ETIC	Firms with difficulties on enrollment of skilled, user level, ICT (%)
VAB_IND_9606	Gross added value industry variation (96-06)
R_VAB06	Ratio Gross added value region/ Nation gross added value

To estimate the effects on industrial employment of the ICT diffusion, a model of structural equations was applied whose representation is in graph 2.

Graph 2. Structural equations model



To alleviate the problem of the reduced sample size, 17 regions, and confirm the FIML results, these were checked applying bootstrap and Bayesian methods (results not included here) finding no significant differences.

RESULTS

The industrial employment survey data show that the Madrid region reduced the employment in this sector in almost 14.000 people in the 1996-2006 period. This tendency is similar to the one of Catalonia region, where the industrial employment decreased, according to National Statistical Institute (INE) data, in roughly 17.000 people. However, the rest of regions registered net increases on the number of employees in industry. This way, the tendency experienced in the group for Spain was, on the whole, more positive being created slightly more than 200.000 jobs in the along the period. In absolute terms Madrid and Catalonia are, according to 2006 data, the two regions with more industrial employment. Together both regions added 862.625 jobs in this sector, 32,8 % of the industrial employment in Spain. In addition, both regions generated a strong growth of the employment in the services sector in this period that compensated the fall of the industrial employment. Is there any relationship between this increment and the employment increase in the services sector observed in the last years? To answer this question, the table 2 shows the model coefficients.

In what concerns to the first part of the effects (chart 2.A) -those that influencing the industrial employment- it is necessary to highlight three types of effects: 1) those related with the sector services, 2) the relatives to the ICT, 3) the incidence of the growth of the industrial VAB. In what follows, the main results are analyzed,

being indicated, among parenthesis, the standardized values and their p-value.

In what concerns to the first one, the services, the results indicate that there is a negative effect of the growth of the employment in the services of society of the information (variable E_SERV_SI) that is statistically very significant (E_SERV_SI=-0,137; p=0,005). This means that those regions, like as Madrid that registered worse industrial employment evolution also registered growths in the ICT sector. It is also established that there is certain negative incidence (variable E_SERV) of the employment growth in the sector services in the industrial employment (E_SERV=-0,214; p=0,31), nevertheless, less significant (69% confidence level).

Table 2. Model estimated parameters

Explained variable	Indicator	Standardized Not	Stand	S.E	C.R.	p-value
A. Industry employment variation effects						
E_IND_9606	E_SERV	-0,214	-0,167	0,165	-1,02	0,31
E_IND_9606	E_SERV_SI	-0,317	-0,233	0,082	-2,84	0,005
E_IND_9606	EXTRANET	-0,284	-1,415	0,889	-1,59	0,111
E_IND_9606	DIF_ETIC	0,194	0,39	0,371	1,05	0,293
E_IND_9606	LAN_WL	-0,414	-1,902	0,628	-3,03	0,002
E_IND_9606	VAB_IND_9606	0,717	0,78	0,222	3,52	***
B,Industry effects						
EM2006_R	E_IND_9606	0,070	0,029	0,016	1,79	0,073
EM2006_R	R_VAB06	0,760	0,676	0,084	8,00	***
EM2006_R	NEMP	0,273	0	0	3,04	0,002
VAB_IND_9606	DIF_ETIC	-0,543	-1,003	0,387	-2,59	0,01
R_VAB06	LAN_WL	0,363	0,778	0,46	1,69	0,091
R_VAB06	EXTRANET	0,389	0,904	0,499	1,81	0,07
A. Other effects						
E_SERV	VAB_IND_9606	0,875	1,218	0,261	4,66	***
E_SERV	DIF_ETIC	0,725	1,863	0,483	3,86	***
EXTRANET	E_SERV	-0,644	-0,101	0,025	-4,12	***
EXTRANET	LAN_WL	0,443	0,408	0,144	2,84	0,005
NEMP	R_VAB06	1,084	6042,1	506,9	11,92	***
NEMP	EXTRANET	-0,301	-3896,6	1178,1	-3,31	***

The second group of variables with incidence on the industry employment growth is the ICT use. Here it is necessary to highlight, in the first place, the negative effect on the of the employment growth of the extranet use (EXTRANET =0,284; p=0,111) and the use of own wireless net (LAN_WL=0,414; p=0,002). This negative incidence has its base in the positive relationship that exists between the productivity and the technology. A technological improvement is translated into productivity growth and, as consequence, in a smaller employment need to generate the same production before this advancement. The industrial activity is a typically an intensive technology sector where the margins of the companies depend more and more of the capacity to adapt technological advances to its production chain. This way, the incorporation of the ICT to the industry is reflected in terms of smaller employment need. The difficulty of hiring skilled ICT workers doesn't have significant effects although, with a 70,7%, confidence level has a positive correlation on regions with bigger employment growth. A third relative aspect to the growth of the industrial employment incorporated in the model is the growth of the industrial VAB (VAB_IND_9606). As expected, earnings in the gross added value are reflected in more need of industrial employment (VAB_IND_9606=0,717; p <0,001).

On the other hand, a second group of estimates highlights some of the factors that have affected the recent industry evolution (chart 2.B). Essentially, being the biggest the ICT effect on the added value. The regions where there is more penetration of the ICT, are in fact in those where industry has bigger relevance (LAN_WL=0,363;p=0,091;EXTRANET=0,389;p=0,07) . In addition, the difficulties to find skilled ICT workers are shown as a factor that impedes the biggest growth in the added value (DIF_ETIC=-0,543; p=0, 01). These results reveal the necessity on the part of the authorities of promoting the ICT skills on workers and the installation of technological advances in the companies. The conjunction of both factors will improve industry long term the results.

A last group of effects reveals aspects of importance that corroborate the previously described (chart 2.C). Regions with bigger growth of the industrial production have also registered bigger employment growth of the sector services (VAB_IND_9606=0,875; p <0,001). This way, since the growth of the industrial VAB takes place, mainly, based on productivity growths, it is the sector services the one capturing that work force. This fact confirms the results of chart 2A.

It is necessary to highlight, additionally, the positive correlation among the difficulties to find skilled ICT workers in the industry and the employment growth in the services sector (DIF_ETIC = 0,725; p <0,001). This is, as much as is the difficulty to find specialist skilled ICT workers is bigger the growth of the employment on the services sector. This is logical if, also, one keeps in mind the negative relationship, already noted, between the employment growth in the information society segment and the industrial one.

CONCLUSIONS

1. It is necessary to measure the real dimensions of this phenomenon -the creation of net employment in the economic sectors as consequence of the application of the ICT- so that, the employment policies have a reliable bases where to stand on. After several years of analysis, the economic and social effects of Internet continue surprising even the experts.

2. It is needed to better understand the possibilities of the use of the technology and their implications in the regulation.

3. The education policy should be directed toward the use of the digital technologies. For societies obtain the advantages of the ICT requires that the great majority of

the citizens has the necessary knowledge to participate in the digital economy.

4. It would be necessary the regular use of the computers in all the educational levels as well as in management courses.

5. The widespread use, in the formative centers, of the software necessary for the respective profession would confer an advantage to them, and would be a factor for the attraction, to hire its students, of the companies creating employment.

6. Considering the effects affecting the variation of the industrial employment - it is necessary to highlight:

1) Those related with the services sector, where the regions that shown a worse evolution of the industrial employment shown growth in the information society sector services, this being technology intensive, and a slight negative incidence on the employment growth in the sector services in general and in the industrial one.

2) Those related to the ICT. Where two variables have a negative effect on the employment growth: the extranet use and the use of their own wireless net. This negative incidence has its base in the positive relationship that exists between productivity and technology. This way, the incorporation of the ICT to the industry is being reflected in terms of smaller employment need.

7. A second group of estimates reveals some of the factors that have influenced the industry recent evolution. The most prominent outcome is the effect of the ICT in the added value. The regions with more ICT diffusion are those with bigger industry relevance on the Spanish economy. In addition, a difficulty to find skilled ICT workers is a factor that impedes a biggest added value growth. These results reveal the necessity on the part of the competent authorities to expand a qualified work force and the installation of technological advances in the companies. The conjunction of both factors will improve the industry long-term results.

8. A last group of effects reveals that regions with bigger growth of the industrial production have also bigger growth on the sector services employment.

9. An important aspect, not approached in this work, it is determining how many employments have been kept due to the ICT effect on competitiveness.

REFERENCES

Efron, Bradley and R. Tibshirani. 1993. *An Introduction to Bootstrap*. Chapman and Hall.

Díaz-Chao, Ángel (Coord.). 2008. *Nuevas tecnologías, nuevos mercados de trabajo*. Ediciones Mundi-Prensa. Fundación SEPI. Madrid.

Gelman, Andrew, J.B. Carlin, H.S: Stern and J. B. Rubin. 2004. *Bayesian Data Analysis*. Chapman and Hall.

OCDE. (1998). *Technology, productivity, and job creation. Best policy Practices.* OCDE.

Torrent, Joan. (2008). "Cambio tecnológico digital sesgador de habilidades (e-SBTC), ocupación y salarios: un estado de la cuestión". UOC Papers (on-line dossier).Núm. 6. UOC.

Vivarelli, M and Pianta M. (2000. *The Emplyment Impact of Innovation. Evidence and Policy. Routledge*.

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