Computers and young workers' wages in Europe

Dulce Contreras
University of Valencia

Rosario Sánchez
University of Valencia

Delfina Soria
University of Valencia

ABSTRACT

In this work evidence was found that wage differentials are in favour of those workers who have a home computer. In order to achieve these results the frontier stochastic method and the Kernel filter for analising errors was used. The research is based on the data provided by the survey of the European Community Household Panel (ECHP). Taking this survey as a starting point, a data panel is built containing those individuals that have remained in the sample for seven consecutives years. The results demonstrate that with the execption of Denmark, workers in each analised country, i.e. Germany, Italy, Spain and the United Kingdom have a wage premium measured by its closeness to the wage frontier and compared to workers with the same human capital but without the possession of a home computer.

Key words: Europe ,home computer, Kernel Filter ,panel data, stochastic frontier, and, wage differentials.

INTRODUCTION

In this paper, how computers have changed wage distribution is analysed. Authors analysing computing inequality have focused on the growth rate of the relative demand for more-skilled workers driven by a greater pace of skill-biased technological change (Bound and Johnson 1992). Krueger (1993) has found evidence consistent with the view that the measured wage differentials primary reflect a causal effect of on-the-job computer use. Here, the analysis is based on a complementary story of rising wage differentials of young workers who have a home computer. The introduction of computers in households has led to the development of skills wich are generally rewarded by the labour market granting higher paying jobs. The use of a computer increases the relative wage of any level of education. Evidence is obtained in favour of this hypothesis in four out of the five European countries analysed.

The stochastic frontier approach is used to analyse the effect of home computers on wage differentials among European young workers. This is an alternative method that add one-sided error to recognize the existence of inefficiency of an economic unit when trying to reach an economic objective[1]. This method is commonly used to the analysis of inefficiency regarding the production of companies. On adjusting this method to the exploration of earnings differences, the wage frontier will define the maximum possible salary related with a specified stock of human capital. If an individual gets less than the possible relative wage, this indicates inefficiency in the conversion of formal and vocational education into earnings. The variables included in the inefficiency model could explain these differences.

The following literature uses the stochastic frontier to estimate wage equations: Polachek and Yoon (1987, 1996); additionally, Polachek and Robst (1998) use this technique to analyse different aspects of the labour market and their effect on wages.

The estimations achieved in this paper about home computer wage premium indicate that young German, British, Italian and Spanish workers who have a computer at home are closer to the relative wage frontier representing the highest levels of relative wages of the sample. In the case of Denmark the results indicate that young Danish workers do not experience any difference in wages depending on their possession of a home computer.

The structure of the paper is: In section 2 the method of estimation is analysed, that is, the stochastic frontier. In section 3 data and variables are shown . Section 4 offers an analysis of the results. And, in Section 5 the main results are presented.

THE ECONOMETRIC METHOD

The stochastic frontier method is used to obtain the wage frontier, including an asymmetric error term to measure the earnings inefficiency to a standard earnings equation. Explicitly, the panel data of individuals is built, following Aigner et al. (1977, in which the salary inefficiency is estimated by the stochastic frontier method and explaining, at the same time, the inefficiency by the variables that could deviate from an efficient result[2]. This methodology eludes the inconsistency complications of a two-stage method when investigating inefficiency factors[3].

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[1] See Lovell (1993).

[2] **T**he Limdep statistical package is used to estimate the stochastic frontier and the inefficiency determinants (Greene, 2002).

[3] With the method of two-stage procedure, the stochastic frontier is obtained firstly and, secondly, the results of inefficiency are acquired under independently and identically distributed inefficiency effects. However, the second step inefficiency effects should be a function of some firm-specific determinants and this contradicts the assumption of identically distributed inefficiency effects.

A standard semi-logarithmic earnings equation (Mincer, 1974) is adopted but it is assumed that the possible or hypothetical remuneration could differ from the observed salary, that is, workers might be unable to convert the whole of their investment in education into earnings. This difference is called "wage inefficiency" and it is analysed with the addition of a one-sided error term into the ordinary wage equation, obtaining a frontier. Simultaneously the determinants of this wage inefficiency (the inefficiency model) are estimated. The estimated model is:

$$\ln W_{it} = \ln W^*_{it} - u_i = \alpha + \beta' X_{it} + v_{it} - u_i \qquad (1)$$

Equation 1 shows the wage frontier, which defines the highest possible wage related with a given human capital' investment. W^* is the maximum or theoretic wage, β are the parameters and X represents human capital variables. A composed error term is included: the first component, v_{it}, is a two-sided random error assumed to be *iid* $N(0, \sigma_v^2)$ and the second component, u_i, is a non-negative random variable describing inefficiency, that is distributed independently as $N(\mu_i, \sigma_u^2)$.

The difficulties of some individuals of converting human capital endowments in earnings are computed by the ratio of actual wage related to the maximum or potential wage available by a worker (in absence of inefficiency); the efficiency (EF) of a worker is[4]:

$$EF = \frac{f(X_{it};\beta)\exp(v_{it} - u_i)}{f(X_{it};\beta)\exp(v_{it})} = \exp(-u_i) \qquad (2)$$

The marks achieved from Equation (2) are equal to 1 when the worker' skills are entirely converted into wages, and less than 1 otherwise.

The mean of the inefficiency term (μ) is a function of variables that could explain the difficulties of transforming human capital into market earnings.

$$\mu_i = \delta_0 + \delta' Z_i \qquad (3)$$

Here, Z_i is a (Mx1) vector of variables that explains the amount of inefficiency in the conversion of education investment into salaries, and δ' is a (1xM) vector of parameters to be estimated.

Then the wage equation is estimated for the entire sample, including the inefficiency whose mean depends on a number of inefficiency factors.

The coefficients (β) and the parameters (δ) were estimated using a panel data technique to control unobserved heterogeneity. From the estimation, the variance parameters is also obtained: $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = \sigma_u/\sigma_v$, and then $\gamma = \lambda^2/(1+\lambda^2) = \sigma^2_u/\sigma^2$, can be calculated, and the relative relevance of the inefficiency with respect to the random noise on explaining differences between the potential and the obtained wage can be measured.

DESCRIPTION DATA

The European Community Household Panel (ECHP) is a harmonised cross-national longitudinal survey focusing on household income and living conditions. The ECHP is a standardised questionnaire that is filled in through the annual interviewing of a representative panel of households and individuals in each country. The corresponding balanced panel of individuals currently working 15 or more hours per week between 1995 and 2001 is analysed. The number of observation adds up to 10,248 with 1,464 indivuals remaining in the sample for 7 consecutive years. These samples were of young employed people aged 18-40 who have

[4] Individual efficiency scores u_i, which are unobservable, can be predicted either by the mean or the mode of the conditional distribution of u_i given the value of $(v_i - u_i)$ using the technique suggested by Jondrow et al. (1982).

been working for at least seven consecutive years. The dependent variable is the monthly avarage wage of the individual divided by the avarage monthly wage of his/her country. As usual, the individuals that report an extremly high or low record for wages, working hours etc are deleted.

COMPUTERS AND WAGES.

The maximum-likelihood results of the earnings frontier parameters refer to equation (1) together with the measurement of inefficiency determinants described in equation (3), are shown in Table 1. Also in table 1 the average level of wage efficiency and the variance model components estimated by the statistical package is presented. The significance of the inefficiency component using the generalised likelihood ratio (LR) test[5] is verified. All tables and figures are in the appendix.

The lambda parameter shows that inefficiency is stochastic. This indicates that the frontier model should not be reduced to a mean-response wage equation (OLS estimation). The part of the distance to the frontier that can be explained by inefficiency as: $\gamma = \sigma_u^2/\sigma^2$, where $\sigma^2 = \sigma_v^2+\sigma_u^2$ is also calculated. In the estimation, this variance parameter takes the value of 0.2189. This means that the variance of the inefficiency term is an important component of the total error term variance. This implys that divergences from the maximum possible salary are not simply a result of random factors. Also, the distribution of "u" with non-parametric techniques, such as the Kernel filter is estimaed, and a one-sided error and the inefficiency indicators are obtained.

The first generalised likelihood ratio test stated in table 1 supports the significance of the inefficiency components in the model. The outcomes reject the null hypothesis according to the idea that inefficiency components are not in the model. The second test indicates the joint consequence of the elements involved in the inefficiency model. The null hypothesis that states that these elements are not significant to explaining inefficiency is rejected.

During the analysed period, the estimated degree of wage inefficiency is around 12%, this means that on average these European young workers obtained a salary that was 12% lower than the salary they could have achieved given their investment in education and training and their socioeconomic characteristics.

The young workers' wage equation

Human capital variables were significant and had the expected indicators for Germany, United Kingdom and Spain. Here, the dummies that showed the impact of age and education to the potential salary of workers are included.

As expected, the higher the age of the individuals is, the higher their potential wage becomes. Being older than 30 years increased the potential wage by around 15% compared to the wage of those younger than 30. This variable also acts as a proxy for experience in the labour market. Also, as expected, having primary or secondary education reduced the potential wage that the individual could obtain. Particularly, in Germany (a reduction of around 10% for primary and 8% for secondary education) and in the United Kingdom (a reduction of 16% for primay and 11% for secondary education) compared with having higher education, which is the reference category. The exception were Denmark and Italy, where neither coefficients were significant, wich means that do not show differences with respect higher education level. In the case of Spain it has been found that the differences are

[5] LR=-2{ln[$L(H_0)$]-ln[$L(H_1)$]}, where $L(H_0)$ and $L(H_1)$ are the results about the likelihood function of the null and alternative hypotheses. LR is distributed as an approximately chi-square.

significant for the case of primary education (around reduction of 9% in potential wages) while there are not significant differences when considering secondary education with respect to higher education.

With the occupational variables, wage differentials generated by different types of jobs are controlled. The reference category was elementary occupations. The expected result was achieved: the potential wage was higher as the occupational skills increased.

As expected, when the individual move from another place within the same locality or another area inside the same country the potential wage increased by about 7%.

Different types of contracts as additional cause of wage disparities are included. Two groups are established: stable contract and other types of contracts. Under this category, temporary contracts, which take into account the higher number of individuals, were considered the reference category. Having a permanent contract increased potential earnings by nearly 9%.

Home computer and young workers' wage: The inefficiency model

The estimated frontier defines the highest wage that an individual could obtain according to his or her human capital endowment (potential wage). The wage inefficiency measures the distance to the frontier for each individual, that is, the difference between the potential and the observed wage. It is assumed that this wage inefficiency is a function of having a computer at home. This variable has been included by country. The estimated parameters of the inefficiency model indicate only the direction of the effect of variables on inefficiency. The value of these parameters is presented, toghether with the estimates of the stochastic frontier in Table 1.

Denmark is the country with the highest number of people with a home computer adding up to 59.3% followed by the United Kingdom with a percentage of 42.8, Germany with 34.2%, Spain 27.4% and finally Italy with 26.6%. Considering the participation of each country in the whole sample, the distribution of this percentage is as follows: Germany accounts for 12.4%, the United Kingdom for 11.1%, Denmark for 7.1%, Italy for 3.9% and Spain for 3.1%. Summarizing, it can be said that 37.6% of young Europeans analised have a home computer. Additionally, 16.1% of them have a universitary degree, 16.3% have secondary education and 5.2% exhibit primary education.

A negative and significant coefficient is obtaiend in four out of the five countries analised. The inefficiency of transforming socioeconomic variables and skills into wages in the labour market is showed when the estimated coefficent has a negative sign. The highest impact is for Spain followed by Germany, Italy and the United Kingdom. This result reflects that given the level of education, the occupation, age etc. of these young European workers, the possession of a computer does increase their relative wages compared with the same young workers that do not possess it.

There has been a great amount of analysis remarking the wage differentials generated by the introduction of new technologies and, as a consequence of that there is an increasing demand for more educated workers. In fact, it can be easily verified that there is a positive wage differential for workers in those sectors that can be considered higly technological. The generalized use of computers which started in the eighties has increased the efficiency level of many jobs due to higher productivity which naturally leads to higher salaries. Wages act as an incentive which determines which skills to develop in order to achieve a better salary. No wonder, that having a home computer helps those who own it to be more efficient in their utilization and to convey these capacities to their usual jobs. At certain occasions this may work just the other way round, meaning that the markets already recognize it by mean of higher salaries.

CONCLUDING REMARKS

In this work, evidence that wage differentials are in favour of those workers who have a home computer has been found. In order to achieve these results the frontier stochastic method and the Kernel filter for analising errors were applied. A panel of individuals that remain in the sample for seven consecutive years was used, hence, it is assumed that they are fully consolidated in the job market. As a matter of fact, 94.2% of these workers have a permanent position in the firm they work for.

In particular, for Germany and the United Kingdom significant differences according the educational level of the workers are found, that is to say comparing universitary level to secondary and primary education. With regard to Spanish workers, the differences arise between universitary level and primary education, and there are no significant differences between primary and secondary education. Surprisingly enough, for Italy and Denmark, there is not significant difference between any educational level.

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APPENDIX

Description of variables and results of the Stochastic frontier model

The net monthly wage of the individual divided by the average wage of its country in logs (Pi211M) that is the dependent variable

The wage equation variables are:

Age: This is a set of two dummy variables:
Age1: equal to 1 if individual is younger than 30, zero otherwise. This is the category of reference.
Age2: equal to 1 if individual is older than 30 and 0 otherwise.

Education Classification:

This is a set of three dummy variables:
Primary : Lower than upper secondary education: equal to 1 if the individual has lower than second stage of secondary education (ISCED 0-2).
Secondary: Upper secondary education: equal to 1 if individual has finished the upper secondary level of education (ISCED 3) and 0 otherwise (reference category).
Higher Education: Tertiary education: equal to 1 if individual has finished tertiary education (ISCED 5-7) and 0 otherwise. This is the reference category.

Occupation in current job:

This is a set of eight dummy variables:
Legislators, senior officials and managers
Professionals
Technicians and associate professionals
Clerks
Service workers and shop and market sales workers
Craft and related trade workers
Plant and machine operators and assemblers
Elementary occupations (reference category)

Type of contract:

Dummy variable equal to 1 if the worker has a permanent contract and 0 otherwise (fixed-term contract or a non-standard contract).

Mobility:

Dummy variable equal to 1 if the individual has moved to another place, area or country and 0 otherwise.

Firm size:

Large firms, equal to 1 if the firm has more than 500 workers and 0 otherwise.

The inefficiency model: Possession of a home computer by countries. Category of reference: No possession of computer.

Germany: Dummy variable equal to 1 if the German worker has a computer and zero otherwise.
Denmark: Dummy variable equal to 1 if the Danish worker has a computer and zero otherwise.
United Kingdom: Dummy variable equal to 1 if the English worker has a computer and zero otherwise.
Italy: Dummy variable equal to 1 if the Italian worker has a computer and zero otherwise.
Spain: Dummy variable equal to 1 if the Spanish worker has a computer and zero otherwise.

Table 1: Wage frontier estimates for young workers of Germany , Denmark, Italy, Spain and the UK.			
Variable		**β- Coefficient**	**t-value**
Constant		1.0925	0.001
Age. Category of reference: Less or equal than 30.			
Older than 30		0.1534	31.631
Level of education by countries. Category of reference: Higher Education			
Germany	Secondary	-0.0812	-6.051
	Primary	-0.1033	-5.114
Denmark	Secondary	0.0091	0.532
	Primary	-0.0260	-0.728
United Kingdom	Secondary	-0.1052	-9.871
	Primary	-0.1593	-12.381
Italy	Secondary	0.0296	0.886
	Primary	0.0054	0.166
Spain	Secondary	-0.0276	-1.357
	Primary	-0.0866	-4.357
Occupation in current job. Category of reference: Elementary occupations.			
Legislators, seniors officials and managers		0.1742	13.698
Professionals		0.1275	10.133
Technicians and associate professionals		0.0808	7.068
Clerks		0.0130	1.129
Service workers and shop and market sales workers		-0.0065	-0.528
Skilled agricultural and fishery workers		0.0030	0.218
Craft and related trade workers		0.0554	5.267
Plant and machine operators and assemblers		0.0473	3.751
Move from another place within this locality or another area of this country. Category of reference: Hasn't move.			
Mobility		0.0663	14.441
Type of contract. Category of reference: Other type of contract, different from permanent contract.			
Permanent		0.0784	13.378
Activity in the private sector. Category of reference: Public sector.			
Private sector		0.0537	8.116
Number of regular paid employees in the local unit in current job. Category of			

reference: Fewer than 500 workers.		
More than 500 workers.	0.0504	9.904
Inefficiency Model		
Variable	**δ- Coefficient**	**t-value**
Constant	5.645	0.001
Possession of a home computer by countries. Category of reference: No possession of computer.		
Germany	-0.3371	-4.486
Denmark	-0.1077	-0.803
United Kingdom	-0.2190	-2.424
Italy	-0.3259	-2.267
Spain	-0.4269	-3.802
Avarage Inefficiency	0.1188	
Variance Parameter		
Lambda	1.5076	43.210
Sigma (u)	0.2626	56.030
Gamma ($\gamma = \lambda^2/(1+\lambda^2) = \sigma^2_u/\sigma^2$) (Own calculation)	0.2189	
Generalised likelihood-ratio (LR) tests of null hypothes		
Null hypothesis, H_0	LR test of one-sided error	
Testing the absence of inefficiency effects. H_0: δ_0=......= δ_5=0; critical value at 1% (16.8)	7196.234	
Testing if the joint effect of the explanatory variables on the wage inefficiency is significant. H_0: δ_1=......= δ_5=0; critical value at 1% (15.1)	5155.81	

APPENDIX 2

Results of the Kernel Filter.
Table 2: Kernel Density Estimator for U

Observations	**=**	**10248**
Points plotted	**=**	**100**
Bandwidth	**=**	**.003138**
Statistics for abscissa values		
Mean	**=**	**.118884**
Standard Deviation	**=**	**.022108**
Minimum	**=**	**.063644**
Maximum	**=**	**.245761**
Kernel Function	**=**	**Logistic**
Cross val. M.S.E.	**=**	**.000000**
Results matrix	**=**	**KERNEL**