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ARTICLE

E-learning and Labour Market: Wage-premium Analysis

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Abstract

The link between ICT and the demand for high-skilled labour is due to the fact that the introduction of digital technologies alters the skill requirements of occupations in three main ways (Spitz, 2003): 1) ICT capital substitutes repetitive manual and repetitive cognitive activities, 2) ICT capital is complementary to analytic and interactive activities, and 3) ICT capital increases the requirement for computing skills. Within this framework, we have analysed the determinants of labour productivity of individuals that have taken higher education programmes online to test how occupational skill requirements and the degree of ICT adoption by the industry matches skills of online students. In order to do this, we have assumed an implicit relationship between education and ability (Griliches and Mason, 1972), recognizing that online students may acquire specific skills, such as computing skills and abilities related to ICT use. For the empirical analysis we have used a database of degree students from the UOC (Universitat Oberta de Catalunya). The results from our model based on Mincerian equations show three important facts: 1) schooling is not a significant variable to explain wage differentials; 2) experience, understood as previous productivity and production losses avoided, is the most important variable explaining improvement of wages; and 3) ICT skills have a positive and significant effect on wage levels.

Keywords

e-learning, labour market, wages, labour productivity, ICT skills

JEL Classification: D61, I21, I22, I28

E-learning *y mercado de trabajo: Análisis de primas salariales*

Resumen

El vínculo entre las TCI y la demanda de personal altamente calificado se debe a que la introducción de las tecnologías digitales altera los requisitos de calificación de los puestos de trabajo de tres formas principales (Spitz, 2003): 1) el capital de las TIC sustituye actividades manuales y cognitivas repetitivas, 2) el capital de las TIC complementa las actividades analíticas e interactivas, y 3) el capital de las TIC aumenta los requisitos en cuanto a destrezas informáticas. En este marco, *hemos analizado los determinantes de la productividad laboral de personas que han seguido programas de educación superior por Internet para comprobar de qué forma los requisitos de capacidades ocupacionales y el grado de aplicación de las TIC por la industria se corresponden con las capacidades de las personas que han seguido cursos por Internet. Para llevar a cabo este análisis, hemos asumido que existe una relación implícita entre la educación y la capacidad (Griliches y Mason, 1972) reconociendo que las personas que han seguido cursos por Internet pueden adquirir habilidades específicas, como destrezas informáticas y habilidades relacionadas con el uso de las TIC. Para el análisis empírico, hemos usado una base de datos de estudiantes diplomados por la UOC. Los resultados de nuestro modelo basado en ecuaciones de tipo minceriano muestran tres hechos importantes: 1) la educación no es una variable significativa para explicar las diferencias salariales; 2) la experiencia, entendida como productividad previa y elusión de pérdidas de producción, es la variable más importante para explicar las mejoras salariales; y 3) las destrezas de uso de las TIC tienen un efecto positivo y significativo en los rangos salariales.*

Palabras clave

e-learning, *mercado de trabajo, salarios, productividad laboral, destrezas en el uso de las TIC*

1. Introduction

International literature provides clear empirical evidence that education leads to major benefits, both for individuals and for society as a whole. In economic terms, human capital accumulation as a result of the educational process must be considered a mixed good, i.e. a private good with positive public externalities. The nature of educational goods leads to the distinction between private and social educational benefits.

From the private benefits point of view, and following human capital theory approach, the increase in individuals' level of educational attainment is consistent with an increase in their productivity in the labour market, which explains higher wages for more educated workers. Since Mincer (1974), who estimated that individuals' schooling accounted for around 10% of wage increases in the USA, to today, a large amount of empirical evidence[1] demonstrates a high positive correlation between individuals' educational levels and wages. Therefore, taking into account age and experience, better-educated workers earn more than their less-educated peers (Cipollone, 1995). However, education is not the only explanatory variable of wage differentials. There are other variables, sometimes difficult to measure, that affect labour market outcomes: individuals' innate ability, social and economic status, family background and other social factors. But, as pointed out by Hinchliffe (1995), earnings functions and path analysis of the effects of individuals' background characteristics on occupational attainment and income have indicated that, while much of the variance remains unexplained, the most important single indicator is education. Indeed, it has also been proven that a virtuous circle arises within the complementary relations between education and income, so that education can explain higher earnings for workers while higher income causes increases in the demand for education (Sianesi and Van Reenen, 2002).

Other individual benefits from higher levels of education, directly related and complementary to wages, are 1) the higher likelihood of participating in the labour market and 2) the lower of being unemployed. Participation in the labour market and unemployment rates are closely related to education (OECD, 1997 and 1998; de la Fuente, 2003) and help to explain the economic benefits for individuals.

An important concern is that benefits of educational investments for individuals extend beyond increases in earnings and employment conditions to other factors that have an indirect effect on economic benefits. In this sense, education has a positive impact, among other factors, on health (Taubman and Rosen, 1982; Desai, 1987), on intergenerational cognitive development (Angrist and Lavy, 1996; Lam and Dureya, 1999), on developing more rational organizational and financial competence, and better analytical skills (Lassibille and Navarro Gómez, 2004), on increasing the likelihood of participating in politics and social decision mechanisms (Campbell *et al.*, 1976), on adopting a better

1. Some recent contributions to this field are: DE LA FUENTE (2003), HARMON, WALKER and WESTERGAARD (2001) CARD (2001), ASHENFELTER, HARMON and OOSTERBECK (1999), LASSIBILLE and NAVARRO GÓMEZ (1998), OECD (1998) or PSACHAROPOULOS (1994).

consumption technology and a greater efficiency in making consumption choices (Rizzo and Zeckhauser, 1992) and on higher saving rates (Solomon, 1975). All these additional advantages are real benefits from education but they are difficult to measure in monetary terms.

From a social point of view, education plays an important role in determining the level and the distribution of income, in productivity and in economic growth of firms (and institutions in general).

Firms and institutions benefit from having more educated employees at their disposal through two main channels: 1) through the positive effect of education and training on the improvement of productivity levels and rates of growth (Dearden *et al.*, 2000; Bresnahan, Brynjolfsson and Hitt, 2002), and 2) through the spill-over effects from better-educated workers. Therefore, the incidence of higher levels of educational attainment is shown not only in the higher productivity of educated workers, but also in the increase in productivity of other workers as a result of learning by imitation and improving their skills from working with them (London Economics, 2005).

For the society as a whole, the empirical evidence suggests that there is a positive relationship between education (through human capital formation mechanisms) and economic growth (Lucas, 1988; Romer, 1990; de la Fuente and Ciccone, 2002; Jorgenson, Ho and Stiroh, 2005), particularly when technological change is considered (Psacharopoulos and Patrinos, 2004). These economic benefit estimations are usually based on gross wages across the economy and on the fiscal incomes derived from economic growth of the industry.

There are also other social benefits that indirectly affect performance of economies through different channels. Education produces external effects that have a positive impact on agents other than those benefiting from it. These externalities, such as social cohesion, political stability, or citizen participation on public policy issues, are difficult to identify and, especially, to measure. Nevertheless, some authors have tried to identify and quantify educational externalities (Weisbrod, 1964; Havenam and Wolfe, 1984; Heckman and Klenow, 1997; McMahon, 2000; Acemoglu and Angrist, 2000; or Davies, 2002) by three major methods: 1) consumer surplus or welfare improvements, 2) expenditure on related private goods, and 3) hedonic pricing models. The results of these studies show that the measure of social spill-overs explains the existence of significant higher returns to investment in education for societies. In fact, the most plausible sources of these externalities are the link between human capital and the rate of technological change, and the indirect effect of education on productivity and employment through the quality of institutions that may be considered a component of social capital (de la Fuente and Ciccone, 2002).

In addition, the increase of individual and social human capital acquired through e-learning provision and e-learning contribution to develop workers' e-skills may help to reduce skill-biased technological change effects on wages distribution in labour markets.

2. Costs and benefits from education

Costs and benefits can be combined in several ways for a cost-benefit analysis. The most common methods are rates of return, cost-benefit (and benefit-cost) ratios and net present values. The estimation of internal rates of return on investment, i.e. the interest rate that equates the present values of benefits and costs (Psacharopoulos and Woodhall, 1985), captures the complete picture of the costs and benefits of education and, therefore, it demonstrates which forms of investment produce the best value for money.

The rate of return to investment in education is a measure of the future net economic payoff to an individual or society of increasing the amount of education offered (Carnoy, 1995). It is calculated by setting the discounted value of costs (C_i) and benefits (B_i) over time equal to zero and solving for the implicit discount rate r:

$$\sum \frac{B_t}{(1+r)^t} = \sum \frac{C_t}{(1+r)^t} \qquad (1)$$

Private rates of return for individuals and rates of return for society are estimated, in which private benefits are added to those accruing to firms and society, and private costs are also added to costs incurred by firms and society (table 3).

From the standpoint of the individual, to estimate the private rates of return, private costs and benefits must be computed. The benefits of additional education are the additional income the individual earns as a result, the non-economic consumption benefits that educational investment provides over a person's life, and the direct consumption benefits derived from the educational process. However, in measuring private rates of return, economists have limited themselves to the earnings benefits of education (Carnoy, 1995).

From the standpoint of society, social costs and benefits must be estimated. Social benefits are usually estimated by using the same average earnings streams as in the private rates of return calculation, corrected for income taxes.

Therefore, in order to analyse the economic return effects from education investment, two different types of discount rates must be estimated:

1) The private rate of return to education (r_p) through the discounted value of private costs (PC) and benefits (PB):

$$\sum \frac{PB_t}{(1+r_p)^t} = \sum \frac{PC_t}{(1+r_p)^t} \qquad (2)$$

2) The social rate of return to education (rs), defined as the relation between social costs (SC) and benefits (SB):

$$\sum \frac{SB_t}{(1+r_s)^t} = \sum \frac{SC_t}{(1+r_s)^t} \qquad (3)$$

Where:

$SB = PB + UB$ UB = Benefits accruied by firms and society.

$SC = PC + UC$; UC = Costs incurred by firms and society.

Table 1. Rates of return to education

Rates of return to education				
Private benefits	+	Benefits to firms and society	=	Social benefits
–				-
Private costs	+	Costs by firms and society	=	Social costs
=				=
Private rate of return				Social rate of return

Source: London Economics (2005)

3. Estimating the returns to education. Theoretical models

There are two principal methods used in estimating rates of return to education: the "traditional method" and the "Mincer method".

The traditional method takes into account calculated annual costs and earnings by education level. To estimate private returns to education direct and indirect costs carried by individuals are added to opportunity costs (earnings foregone). And these are added to public costs to estimate annual social costs for the social rate of return. Annual private and social benefits are calculated from the difference in average earnings of those who have different levels of education. For the private rate income differences are estimated using net values, but for the social rate gross income figures are used. These annual costs and benefits are inserted into equation (1) to estimate the discount rate that makes costs and benefits equal.

The Mincer method uses regression analysis to fit a Mincerian human capital earnings function. The classical specification used to estimate the effect of individual schooling on wages has been the following (Mincer, 1974):

$$\ln W_i = \alpha + \theta S_i + \gamma E_i + \mu E_i^2 + \varphi X_i + u_i \qquad (4)$$

Where W is the wage (earnings), S the years of schooling, E the experience, X a set of individual characteristics, and u the variation in log-wages not captured by the computed variables. The parameter θ measures the percentage increase in wages associated with an additional year of schooling. Under certain conditions (which include the assumption that there are no direct costs of education) θ can be interpreted as the private rate of return to schooling. This is why θ is known as the *Mincerian return to schooling* and also as the schooling wage-premium or as the *gross* return to schooling (de la Fuente and Ciccone, 2002).

The reasoning behind this calculation is that partial differentiation of lnW with respect to S gives a method of the calculation of rates of return (Carnoy, 1995), in a continuous form:

$$\theta = \frac{\delta \ln W}{\delta S} \qquad (5)$$

And also in discrete form:

$$\theta = \frac{\ln W_s - \ln W_0}{\Delta S} \qquad (6)$$

Where W_s and W_o refer to the earnings of those individuals with s and o years of schooling, respectively.

Therefore, marginal rates of return to particular levels of education can be estimated from Mincerian regressions by substituting a string of dummy variables for each level of schooling.

Rates of return have been estimated for a large number of countries, by types and levels of education, by gender, and, for some countries, over time (Psacharopoulos and Patrinos, 2004).

Table 2. Returns to investment in education by level, full method, regional averages (%), 2003

Region	Social			Private		
	Primary	Secondary	Higher	Primary	Secondary	Higher
Asia*	16.2	11.1	11.0	20.0	15.8	18.2
Europe/Middle East/North Africa*	15.6	9.7	9.9	13.8	13.6	18.8
Latin America/Caribbean	17.4	12.9	12.3	26.6	17.0	19.5
OECD	8.5	9.4	8.5	13.4	11.3	11.6
Sub-Saharan Africa	25.4	18.4	11.3	37.6	24.6	27.8
World	18.9	13.1	10.8	26.6	17.0	19.0

* Non-OECD
Source: Psacharopoulos and Patrinos (2004)

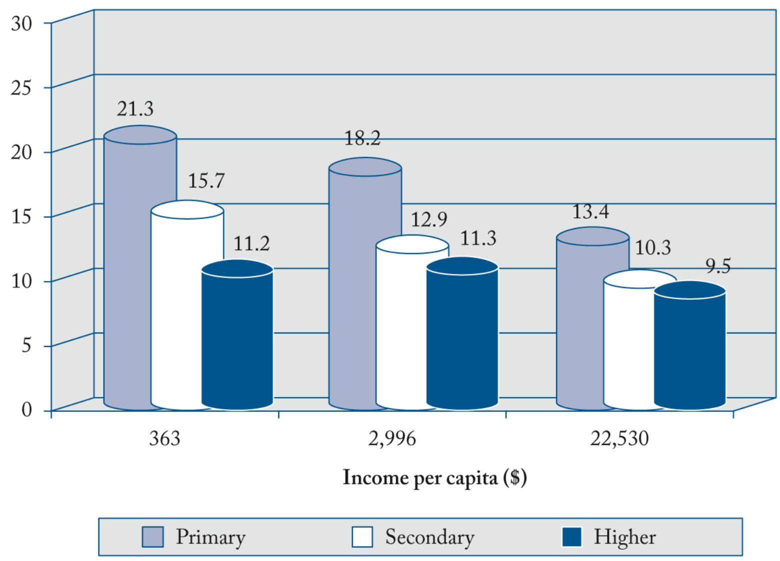

Figure 1. Social returns to investment in education by income level
Source: Psacharopoulos and Patrinos (2004)

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The return to education is negatively related with the level of economic development of the country. This relation can be seen at all education levels (primary, secondary and higher education) but is most observable in the primary and secondary levels of education. Nevertheless, the major return to education of the primary and secondary education is a common pattern over time and across the countries. Indeed the classical pattern of falling returns to education by level of economic development and level of education are maintained (Psacharopoulos and Patrinos, 2004).

4. Education and wages: the role of ICT in the relationship between e-learning and labour productivity

From a labour economics point of view, published theories and empirical findings demonstrate that technological change has a significant impact on the labour market. This topic has been an important concern of economic research, and the discussion has intensified in the two last decades due to generalized adoption of ICT in the economic sphere (Spitz, 2003). A key observation in this field is that highly skilled workers, and especially those with higher levels of educational attainment, are more likely to use computers in their jobs (Krueger, 1993). These facts have led to the important consensus in the labour economics literature that a burst of new technology causes a rise in the demand for highly skilled workers, which in turn implies an increase in the wages of skilled workers relative to unskilled workers. This hypothesis is known as the Skill-Biased Technological Change (Acemoglu, 2002; Acemoglu, 1998).

In this sense, some research (Berndt *et al.***,** 1992; Berman *et al.***,** 1994; Kaiser, 2000) shows that, over the last few decades, this has been during a structural shift towards the increase in deployment of white-collar work in most sectors of developed economies and a rise in employment of workers with high levels of formal education. Moreover, other studies (Wolff, 2000; Autor *et al.***, 2001)** have found that the changing in employment patterns resulted in an upgrading of cognitive and interactive skills and a decreasing demand for manual skills. This evidence is simultaneous with the increase of ICT investment and extent to which firms adopt ICT. The link between ICT and the demand for high-skilled labour is due to the fact that the introduction of digital technologies alters the skill requirements of occupations in three main ways (Spitz, 2003): 1) ICT capital substitutes repetitive manual and repetitive cognitive activities, 2) ICT capital is complementary to analytic and interactive activities, and 3) ICT capital increases the requirement for computing skills. This relationship underlies the evidence that, compared to previous technological revolutions (that aimed to routinize manual tasks), digital technologies are also capable of taking over simple human cognition tasks such as perceiving, choosing and manipulating processes, and searching and managing information; and in addition computer technologies are complementary to analytical and interactive activities. There is also evidence that ICT capital does not substitute whole occupations, but that it is limited to some tasks. This limited substitution relationship, pointed out by Bresnahan (1999) shifts the demand for labour towards workers with higher levels of education who are considered to have a comparative advantage in performing analytical and interactive tasks. Thus, computer technologies shift the relative skills requirements of occupations towards analytical and interactive activities.

From the private benefits point of view, and following human capital theory approach, the increase of individuals' level of educational attainment is consistent with an increase of their productivity in the labour market, which explains higher wages for more educated workers.

Moreover, there is a relation between the labour market experience, major education attainment and higher earnings. As we can see in the table below, 10 years of experience in the labour market increase real earnings by approximately 16% for employees with less than upper secondary education, 30% for employees with upper secondary education and 40% for employees with tertiary education. These data make it evident that earnings grow with experience significantly faster for the more educates employees than for the less educated.

To determine differences in wages between individuals that have followed higher education programmes through online methodology it is useful to test how occupational skill requirements and the degree of ICT adoption by industry matches online students' skills.

In order to do this, it is necessary to assume an implicit relationship between education and ability (Griliches and Mason, 1972), recognizing the fact that online students may acquire specific skills. In particular, it is assumed that online students should attain higher computing skills and more abilities related to ICT use, such **as** knowledge transmission by digital devices, information management, self-programming and continuous learning abilities (Levin *et al.*, 1987).

Data from Spitz's work *IT Capital, Job Content and Educational Attainment* (2003) allow us to see some changes, and new trends in the skills requirement along the period from 1979 to 1999. The data describe an increase in the average proportion of interactive skills in the work of all occupational categories (all the occupational groups increase the interactive tasks more than 50 %). Furthermore, professional, technical and clerical workers realize less analytic tasks than in 1979 in contrast to production operatives and craft workers who carry out more analytic tasks in their occupations. This trend may be partially due to the increase in education for the production operatives and craft workers.

TABLE 3. Trends in aggregate skills requirements (workers between 15-65 years old in West Germany and of German nationality)

	Analytic skills	Interactive skills	Repetitive cognitive	Repetitive manual	Non-repetitive manual skills	Computer skills
1979	12.8	11.5	15.2	10.9	49.2	0.3
1985/86	10.0	23.8	16.7	18.8	27.9	2.8
1991/92	8.3	23.6	15.3	11.4	36.1	5.3
1998/99	15.2	63.7	3.0	2.1	11.0	5.0

Source: Spitz (2003)

The repetitive and the non-repetitive manual skills requirements decreased significantly over the two decades in all the occupational groups, even among the operatives and craft workers. There was a progressive increase in pc-skills requirement in all the occupational groups during this the period. Clerical workers are the occupational group that use their pc-skills more intensively..

TABLE 4. Distribution of task intensities by educational groups (workers between 15-65 years old in West Germany and of German Nationality)

	Analytic skills	Interactive skills	Repetitive cognitive	Repetitive manual	Non-repetitive manual skills	Computer skills
High level of education	19.1	53.6	12.1	2.0	8.3	5.0
Medium level of education	11.4	28.4	13.3	10.9	32.5	3.4
Low level of education	8.0	23.2	10.0	15.9	41.4	1.5

Source: Spitz (2003)

5. E-learning skills and productivity: the case of UOC's degree students

Within the Skill-Biased Technological Change framework, we aim to verify two interesting points:

- Experience, understood as production losses avoided, is a critical factor in explaining wage improvement for online graduates.
- ICT skills have a positive and significant effect on labour productivity (wages) as firms value the interactive and analytical abilities beyond ICT uses at the place of work.

According to the theoretical framework, it is feasible to identify some critical sets of variables in the explanation of online degree students' wages. We have divided these variables into three categories:

1. The usual variables in wage analysis, based on individual's traits (sex, age, parenthood and economic position at home) and on schooling.

2. An additional set of variables based on the individual's position at work: the kind of job and the existence of flexitime at work.

3. Some variables reflecting individual's ICT skills and professional-ICT based skills.

Table 5. Dependent, independent and control variables in Mincerian regressions

Dependent variable	Measures	Characteristics
	Individual earnings	
Wages	Gross annual earnings in current euros	Numerical
Explanatory variables	**Measures**	**Characteristics**
	Individual characteristics, Schooling, Experience, Labour relations, Labour category, Professional skills, ICT skills	
Sex	1= Male 2 = Female	Binary
Age	Age at time of graduation	Numerical
Children	Having children Number of children	Binary Numerical
Economic position at home	Main income provider = 1 Not main income provider = 0	Binary
Schooling	Number of years studying before starting at UOC	Numerical
Experience	Number of years holding a job	Numerical
Kind of work	Entrepreneur = 1 Worker = 0	Binary
Flexitime at work	Full time worker = 1 Part time worker = 0	Binary
Professional ICT-based skills	Technical knowledge, continuous learning, self-programming, time management, decision making, adaptability, communication, networking	Numerical (1,10)
ICT skills	Computers, software, Internet, data bases, Virtual communication channels	Numerical (1,10)
Control variables	**Measures**	**Characteristics**
	Place living, Economic sector, Undergraduate programme, Motivation of education, ICT in industries	
Place living	Barcelona = 1 Others = 0	Dummy
Economic sector	Private sector = 1 Public sector = 0	Dummy
Job categories	Managers = 1 Others = 0	Dummy
Type of labour contract	Fix = 1 Temporary = 0	Dummy
Kind of undergraduate programme	Economics, Computer Engineering, Laws = 1 Others = 0	Dummy
Motivation of education decision	Improve at work = 1 Others = 0	Dummy
ICT in industries	ICT users = 1 Not users = 0	Dummy

Source: authors

We also used a database of degree students from the UOC which has information on individuals' wages and skills, obtained through a survey conducted in 2005.

TABLE 6. Sample of UOC's degree students

Undergraduate programme	Number of students
Business	544
Psychopedagogy	535
Laws	110
Computer Management Engineering	99
Computer Systems Engineering	135
Business Administration	424
Librarian Studies	294
Philosophy	83
Total sample	**2,224**

Source: authors

We have used Mincerian wage functions to analyse the relationship between wages and the abovementioned set of explanatory variables The results from the analysis show that all the variables used in our model have a positive and significant relation with degree students' wages, except schooling and professional ICT-based skills. Moreover, we can also confirm that the explanatory variables we have computed are useful to explain more than 60% of the differences in wages of degree students.

Our results show some interesting features:

- First of all, it is very important to comment that schooling, in which studies at UOC are included, is not a significant variable to explain the level of wages for degree students after their investment in education.
- A second result that should be hightlighted is that experience, understood as previous productivity and production losses avoid, is the most important variable explaining wages improvement for online degree students.
- A third notable result is that we have been able to demonstrate that the more ICT skills are developed in individuals, the more likelihood there is of increasing labour productivity, measured through wages. We have also found that soft skills related to ICT uses (technical knowledge, continuous learning, self-programming, time management, decision making, adaptability, communication, networking) do not have a significant effect on wages improvement, showing a gap between workers skills and labour needs in Catalan industries.
- In addition, we can affirm that there are some individual characteristics that have a positive and significant impact in the explanation of wage differentials: married men who are the main income providers are more likely to have higher wages than the rest of the sample.
- Finally, from the labour market point of view, entrepreneurs have higher returns than workers, and within this last category full-time workers in the private sector receive higher wages than workers in the public sector or part-time workers.

Table 7. Results. Wage analysis

Dependent variable: Wages after graduation
Method: Least squares
Included observations: 543

Variable	Coefficient	Std. error	T-statistic	Prob.
C	9.135596	0.110561	82.62944	0.0000
Sex	0.655371	0.027767	2.354242	0.0189
Civil status	0.094512	0.027396	3.449860	0.0006
Flexibility at work	0.312414	0.059494	5.251183	0.0000
Economic sector	0.087368	0.027110	3.222749	0.0013
Economic position home	0.125698	0.027681	4.541004	0.0000
Wages before graduation	2.05E-05	1.08E-06	19.00719	0.0000
Experience	0.019895	0.007084	2.808414	0.0052
Kind of work	0.88011	0.042752	2.058619	0.0400
Schooling	0.025385	0.070988	0.357592	0.7208
ICT skills	0.004042	0.001849	-2.186302	0.0292
Professional ICT skills 1	-0.017371	0.009939	-1.747742	0.0811
Professional ICT skills 2	0.005144	0.003835	1.341185	0.1804
Professional ICT skills 3	-0.005353	0.006578	-0.813769	0.4161
Motivation	0.099511	0.026550	3.748021	0.0002
R-squared	0.609250	Mean dependent var.		10.21674
Adjusted R-squared	0.598889	S.D. dependent var.		0.431083
S.E. of regression	0.273019	Akaike info criterion		0.268685
Sum squared resid	39.35681	Schwarz criterion		0.387390
Log likelihood	-57.94810	F-statistic		58.80333
Durbin-Watson stat	2.061097	Prob. (F-statistic)		0.000000

Source: authors

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