

Computers, Wages and Working Hours in Italy*

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Abstract

This paper provides an estimate of the relationships between wages, working hours and the use of computers at the workplace for the Italian labour market.

On the methodological side, we offer a contribution on the appropriate procedure for estimating the above effects: it is shown that the simultaneity between wages and hours must be taken into account when specifying the statistical model for the data and, furthermore, that the interactions between explanatory variables plays a significant role that cannot be neglected.

Our empirical findings are also of interest: by controlling for computer skill, workers' ability and many other covariates, we found that only for higher-level white collars the average wage premium associated with computer usage is in the same order of magnitude as the one estimated for the US, Germany and France, while the effect vanishes for lower qualifications. The use of computers at work increases the number of hours worked, although this effect is small and much lower than that estimated for the US. Moreover, since hourly wages have a negative impact on hours worked, computers seem to exert little, if any, impact on working time.

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1 Introduction

A rising body of empirical evidence, especially for the US and to a minor extent for European countries, has stressed that recent trends in a number of labour market variables have been strongly affected by the introduction

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of Information and Communication Technologies (ICT). In particular, it has been argued that the rapid diffusion of computers, e-mail and the Internet in the workplace has favoured skilled workers and increased wage differentials. As the evidence provided, among others, by Autor, Katz and Krueger (1998) suggests, ICT have shifted demand toward computer-literate, skilled and highly educated workers thereby giving rise to a wage premium, at least in the short-run.

According to Acemoglu (2002) the fact that capital and skills are complementary (or, put another way, that technical change is skill-biased) is not a novelty of the last decades. What recent years have witnessed is an acceleration of the above phenomenon which, on the one hand, has been induced by a marked increase in the supply of skilled workers and, on the other, has to do with the fact that new technologies influence wages not only directly but also by changing the way in which firms and the labour market are organised. For instance, ICT have affected not only wages, but also working time, job search and recruitment and even the way in which trade unions act (cf. Freeman, 2002).

Moreover, the idea that the increase in wage inequality is simply due to unusually rapid skill-biased technological change has been questioned by many scholars. Bresnahan (1999) and Bresnahan, Brynjolfsson and Hitt, (2002) have stressed that wage differentials and the skill composition of the labour force are affected by advances in Information Technology (IT) but only or particularly when they are coupled with organisational changes in workplaces. Similarly, Aghion and Howitt (2002) have developed a theoretical model in which the introduction of a general-purpose technology (such as ICT) does not explain by itself short-run wage differentials, but only in conjunction with the presence of different degrees of adaptability of workers to new jobs or tasks. Thus, the uneven diffusion of computers and ICT among workers alone cannot provide an exhaustive explanation for the large differentials observed in labour compensations.

None the less, starting from the late 1980s, cross-sectional estimates of a standard wage equation carried out for the United States showed that the inclusion of a dummy for 'working with a computer' is not only significant but the wage premium associated with computer use ranges from 15% to 17% and has not shown a substantial decline over time (that is from late 1980s to early the 2000s). Similar cross-sectional studies with individual data carried out in Germany and France give rise to an almost identical wage premium. With respect to working time, recent estimates for the US show that using a computer at work is associated with an increase of hours worked of about 5%. Although the causal interpretation of these results is open to question (the fact that only some workers use a computer can be simply a consequence of their greater unobserved ability or other individual characteristics), the regularity of the empirical evidence is noteworthy.

In this paper, we provide some estimates of the relationships between

computer use, wages and working hours for the Italian labour market. For this purpose, we use the survey carried out by the Bank of Italy on Italian household budgets which, in the 2000 edition, asked Italian households some questions on computer use at work and computer skills. Such information were not previously available at the individual level, so this is the first attempt to estimate the above relationships for Italy.

After analysing the Italian data by statistical procedures similar to those used in the literature, we found that both the wage premium (5%) and the increase in working time (0.8%) associated with computer use are much lower than those estimated for other countries. However, from a different specification of the wage equation — including control variables for workers' ability and the provision of different effects of computer usage across job types — it emerges that the impact on wages of using a computer at work becomes substantial for higher-level white collars, namely cadres and technicians (14%) and managers (16%). In the case of working time, an IV estimate (accounting for the simultaneity of hours and wages) indicates a 1.5% increase in working time associated with computer use, but the negative impact of wages on hours worked suggests that, for certain categories of employees, the net effect of computers on working time is negligible.

The paper is organised as follows. Section 2 provides a review of the empirical evidence concerned with the relationship between computer use and labour market outcomes. Section 3 analyses the extent of computer usage and skill among Italian employees according to the Bank of Italy survey. Section 4 is devoted to the estimates of the impact on hourly wages and weekly worked hours exerted by the use of computers at work and finally, some concluding remarks are contained in Section 5.

2 Computers and labour market outcomes. A review of the empirical evidence

Thanks to a very rich micro data base for the US, Alan Krueger was the first to address, within a comprehensive framework, "... the issue of whether employees who use computers at work earn more as a result of applying their computer skill, and whether the premium for using a computer can account for much of the change in the wage structure" (Krueger, 1993, p. 34).

With a set of about 13,300 individuals involved in the US Current Population Surveys (CPS) of 1984 and 1989, Krueger was able to estimate an equation for the log of hourly wage which, among a number of other regressors, also included a dummy for working with computers. Even in conjunction with a wide range of covariates (such as gender, marital status, race, experience, education, union membership, types of occupation), the computer dummy variable was extremely significant and the wage premium associated with computers increased from 15% in 1984 to 17.5% in 1989. For

the last year, the inclusion of a broader set of occupational dummies reduced the wage differential to 13.9% while the introduction of additional dummy variables for the use of computers at home and for some specific tasks associated with computer use (such as word processing, electronic mail and so on) did not change the results substantially.

Thus, the idea that rapid skill-biased technological change during the 1980s was an important cause of the raising differentials in productivity and wages among different types of workers received a strong support from Krueger's contribution, chiefly because previous empirical studies, supporting the same hypothesis, had been carried out exclusively at the industry level or using time-series of aggregate data.

However, with the approach followed by Krueger, the problem of unobserved heterogeneity among workers arises (cf. DiNardo and Pischke, 1997). Suppose that the observed wage differentials are primarily due to the unobserved ability (i.e. productivity) of different workers and that employers or senior managers do not assign computers at random but only to the most productive workers. If this is the case, Krueger's results simply suggest that the 'best' workers are those equipped with computers and therefore no causal relationship between computer use and wages can be identified.

To address the issue of unobserved heterogeneity, Krueger carried out further cross-sectional regressions of the wage equation but for a smaller sample of individuals (4,684) which attained only the high school (the data base was The High School and Beyond Survey); controlling for individual characteristics that could be taken as proxies of inherent ability such as parents' education, the grade point and the achievement test¹ score obtained in high school, the estimated wage premium associated with computer use was 10%, and thus remained substantial. Such a variety of estimates allowed Krueger to conclude that employees using computers in the workplace earn a 10 to 15% higher wage rate and, since the large majority are highly educated workers, computer use could be viewed as a factor enhancing the returns to education which, in the US, were already substantial.

According to DiNardo and Pischke (1997), Krueger's attempt to account for the problem of unobserved ability was not satisfactory since with a cross-section analysis one cannot fully control for individual fixed effects. Moreover, and most importantly, they estimate a wage equation similar to Krueger's with a large sample of German workers and found that, in 1991-92, there was a substantial wage premium for using a computer at work (equal to 19%) but a comparable premium also emerged for using a calculator, a telephone and even a pen or a pencil. Their results thus suggest that the decision by the employer to give a wide set of office tools to a worker is strongly ability-driven; all these tools are more likely to be assigned to

¹A cognitive test of vocabulary, reading and mathematics.

‘better’, higher paid workers². Thus, again, one cannot say that the use of computers is the cause of higher wages or, put another way, that when a worker changes her status from non-user to user her wage immediately increases.

A similar conclusion was reached by Entorf and Kramarz (1997) who used large samples of French workers (available for the period 1985-87 also in the longitudinal dimension) in order to estimate an equation for monthly wage. A cross-sectional estimate similar to Krueger’s gave rise to a 17% wage premium for computer users but when the years of experience with computers were included in the regression such a premium decreased to 6% and 10% could be ascribed to experience. Moreover, exploiting the longitudinal dimension of their sample, Entorf and Kramarz carried out a panel regression with individual-fixed effects and found that only experience with computers exerted a significant impact on wages. With a subsequent analysis concerned with the period 1991-93, Entorf, Gollac and Kramarz (1999) obtained similar results (apart from the fact that the years of computer experience were less significant); a 15-20% wage premium for computer use emerged from the cross-section regression but decreased to about 2% when the longitudinal estimate was performed. It is worth mentioning that, in both studies, the authors were able to match individual data with firm-level data and, thus, estimate the wage equation also including firm-fixed effects; however, the above mentioned findings did not change, suggesting that the impact of computer variables on wages was not significantly influenced by firm-specific variables such as performance or compensation schemes.

It must be pointed out that a direct comparison between Krueger’s results and those on European workers is not possible, since the latter do not take into consideration all the controls for individual characteristics that Krueger used and employ different measures of wages³. Nonetheless, the issue of unobserved heterogeneity cannot be ignored and, even in cross-sectional studies, further and better proxies of individual ability should be taken into account.

The empirical studies examined so far refer to the late 1980s and early 1990s. Since the diffusion of computers among workers has continued and also the introduction of other ICT in the workplaces (such as e-mail and

²Recently, by using micro data for Britain, Borghans and ter Weel (2002) have found that the decision to introduce computers in the workplace depends on workers’ wages rather than skills (proxied by age and level of education).

³DiNardo and Pischke (1997) do not use continuous data but the mid points of different wage classes; this implies an artificial reduction of wage differentials among workers who have an identical qualification, sector of employment, size of firm, and so on (i.e. workers who are likely to belong to the same wage class) and can explain, for instance, why a worker using a pencil gets a wage premium similar to that of another working with a computer. Entorf and Kramarz (1997) and Entorf, Gollac and Kramarz (1999) used, as the dependent variable, the log of monthly rather than hourly wages but did not adequately control for worked hours; moreover, in the former study continuous data for wages were not available.

the Internet) experienced a very rapid increase in the second half of the 1990s (cf. Lucchetti and Sterlacchini, 2003), it is interesting to see whether the wage premium associated with computer use is still substantial or has declined in recent years⁴.

Recent estimates for the US are provided by Freeman (2002) who uses, as Krueger did, the data taken from the CPS. The wage equation, in which the dependent variable is the log of hourly wage (computed as the ratio of usual earnings per week to usual hours worked), includes the dummy for working with computers and, in line with previous studies, many covariates⁵. Starting from 1997, the CPS provides information also on the use of the Internet at work and Freeman has included in his regressions also this dummy variable, separately and together with the one concerned with computer use. The upper part of table 1 shows the estimated coefficients (and related standard errors) of ICT dummies. For 1997, the wage premium for computers is 16.8% ($e^{0.155} - 1$) and decreases only to 13.8% when the Internet dummy is inserted in the same regression (the latter determines an additional premium of 10%); for 2001 the wage increase remains substantial (15.6%) when the computer dummy is used separately from the Internet dummy but decreases sharply in the other case (6.2%); at the same time, the wage premium for using the Internet in the workplace becomes greater (14.7%) than that related to computer use.

Thus, it appears that, during the second half of the 1990s, the wage increase associated with computers did not decline substantially in the US; however, in recent years, wages seem more affected by the use in the workplace of other ICT which, starting from 1994 (in conjunction with the ‘connectivity boom’ due to the Internet) have witnessed a very rapid diffusion (cf. Lucchetti and Sterlacchini, 2003).

As stressed by Freeman (2002, p. 291) “Since the demand shifts favourable to persons who work with computers should affect the quantity as well as price of their labour, working with a computer ought to be associated with greater hours worked as well as higher hourly pay.” If one considers the distinctive features of the most recently diffused ICT, such as e-mail and the Internet, the hypothesis of a computers’ impact on working time seems plausible. To test it, Freeman ran a set of regressions in which the dependent variable is the log of hours worked per week and the independent variables

⁴If the supply of workers able to operate with computers increases more than the demand of computer-literate workers one should expect a reduction in the wage premium. The same is likely to occur as the share of computer users becomes larger.

⁵Apart from the experience and its square, most of these covariates are expressed as dummy variables: marital status, gender and the interaction between them, race, veteran status, part-time worker, self-employed worker, union membership, metropolitan and regional residence, seven levels of education and eleven types of occupation. In 1997 and 2001 the samples used by Freeman included, respectively, 12,440 and 14,630 individuals who were at work in the week preceding the interview, were aged 18-65 inclusive and earned more than \$1.5 and less than \$250 per hour.

Table 1: Impact of computer use on log hourly wage and log hours worked per week in the US

	1997		2001	
<i>Wage</i>				
Computer	.155 (.006)	.129 (.010)	.145 (.006)	.060 (.012)
Internet		.097 (.012)		.137 (.012)
<i>Hours worked</i>				
Computer	.073 (.006)	.070 (.007)	.059 (.006)	.035 (.007)
Internet		.013 (.008)		.037 (.007)

Source: Freeman (2002). Standard errors are in brackets. The estimated coefficients reported in the table arise from OLS regressions which include also the variables described in footnote 5.

are the same used for explaining wages: the estimated coefficients of the computer and Internet dummies are reported in the bottom part of table 1. In 1997 the impact of computer use on working time is relevant (7.6%) and does not change significantly when both dummies are used, while in 2001 the same impact decreases, especially when computers and the Internet are jointly taken into account (both are associated with a similar increase – 3.6 and 3.8% – of hours worked). Thus, ICT exert a significant influence on working time but lower than that on wages; this result, according to Freeman, might be due to the fact that, in the CPS, individuals are asked to report only the hours spent at work; if, thanks to the use of e-mail and the Internet, the hours worked at home are not negligible (as seems to be the case, at least for certain medium- and high-level white-collar occupations), the impact of ICT on total working time should be greater.

Apart from the latter observation, Freeman’s estimates, as well as those previously discussed, must be taken with caution for many reasons. First, the problem of the unobserved ability of workers is neglected and this means that a causal relationship running from computers and ICT to wages and hours worked cannot be taken for granted. Second, the sample also includes self-employed and part-time workers; the latter, by definition, work less than other employees, while the earnings and working time of the former are not as constrained as those of dependent workers (who must bargain with their employers for both wages and hours worked). Third, when employees decide the amount of working hours, they take into account how much they will earn per hour, so that the working time equation should be estimated simultaneously with the wage equation. In the empirical analysis on Italian employees presented in section 4, we will attempt to address the above issues.

Table 2: Share of workers using computers at work

	1997	2000	2001	Source
US	55.1	55.9		Freeman (2002)
EU15		41.4*	48.9	Eurobarometre (2000, 2001)
Italy		38.5*	51.5	Eurobarometre (2000, 2001)
Italy		33.7		Banca d'Italia (2002)

*: Original percentages for 2000 were concerned with ‘computer use for working reasons’ which, according to the 2001 survey, are bigger than those referring to ‘computer use in the workplace’; in order to follow a common definition, 2000 figures have been adjusted by applying the ratio, available in 2001, between the percentages corresponding to the two definitions.

3 Computer use and skill in Italy: a descriptive analysis

In March 2000, with the European Council of Lisbon, European policy makers have fixed the main strategic goal of Europe as that of becoming the most dynamic and competitive knowledge-based economy in the world, capable of generating growth and qualified jobs. Within this broad framework, great emphasis has been put on the systematic collection of data on the diffusion of ICT and its impact on the labour market, with particular reference to job quality. In this connection, a specific survey on the use of ICT at work has been carried out by the Eurobarometre in all European countries (see Commission of European Communities, 2002; Eurobarometre, 2000 and 2001). In order to make some international comparisons and insert the Italian position in a broader context we begin this section by presenting some results from the above survey.

Table 2 reports the percentages of workers who use computers at work for the US (using the figures presented in Freeman (2002)), the European Union (15 countries) and Italy. In Europe, the share of computer users is much lower than that in the US; although it significantly increased from 2000 to 2001, it remains fairly below the figure for the US in 2000. According to Eurobarometre, in only one year the Italian share of computer users witnessed a staggering increase and, in 2001, overtook that recorded by Europe as a whole. However, considering that the Eurobarometre survey is based on national samples composed of about 1,000 individuals only, the above percentages must be taken with extreme caution, especially when one looks at a single country (the confidence limits, indicated by the Eurobarometre, are in fact $\pm 3\%$).

In the Italian case, we believe that the European survey overestimates

Table 3: Computer use by gender and type of occupation (2000)

	EU15 ¹	Italy ²
Men	44.4	32.6
Women	45.9	35.6
Self-employed	41.5	33.2
Managers	79.8	75.3
Other white collars	66.8	57.7
Blue collars	21.8	8.9

1= Source: Eurobarometre (2000 and 2001).

2= Source: Banca d'Italia (2002).

the percentage of workers using a computer at work and our belief is based mainly on the results of the survey on “Italian household budgets” carried out by the Bank of Italy (cf. Banca d'Italia, 2002). In the 2000 edition, this survey included some questions on computer use and skills for individuals, and on the use of other ICT (such as Internet, e-commerce and e-banking) but only at a family level. The survey covers 8,000 households, composed of 22,268 individuals, including 8,012 workers (6,202 employees and 1,819 self-employed). Thus, we believe that the most reliable figure for Italy is the one reported in the last row of table 2, being based on a sample of workers eight time larger than that employed by the Eurobarometre, indicating that 33.7% of Italian workers used a computer in their workplace in the year 2000. Such a share is significantly lower than that for the whole EU.

As table 3 shows, from the European survey it emerges that there are not significant differences by gender in the usage of computers at work; in fact, the share of women is even slightly higher than that of men, and this result is confirmed by the Bank of Italy survey. With respect to the types of occupation, both in the EU and Italy 3 managers out of 4 are computer users (although the share for the EU is slightly larger), while in other occupations the percentage of users is significantly lower in Italy; this is particularly the case for blue-collar workers, but for other white-collar workers the gap is also substantial (67% versus 58%). However, in both cases, there is a strong association between the use of computers at work and the type of qualification, as expected.

In the remainder of this section, we present other descriptive statistics *on employees only* (i.e. excluding self-employed workers) and based on the Bank of Italy survey of 2000. This survey, along with that on computer use, included a question on the level of each individual’s computer skills; respondents could choose between five possibilities: none, some, average, good and very good computer skill. Although subjective (but, to our knowledge, all the measures of computer skills have a similar shortcoming), the range

Table 4: Computer use by computer skill: Italian employees (2000)

<i>Use</i>	Yes	No	Total	Total
	Row %		(abs. value)	Column
<i>Skill</i>				
None	0.0	100.0	3257	53.8
Some	46.6	53.4	667	11.0
Average	71.5	28.5	703	11.6
Good	84.6	15.4	917	15.2
Very good	92.0	8.0	505	8.4
Total	34.0	66.0	6049	100.0

Source: Banca d'Italia (2002).

of this qualitative indicator is sufficiently large, and it is interesting to see which kind of interaction arises with the use of computers at work.

First of all, as illustrated by table 4 (last column), about 54% of Italian employees do not have any computer knowledge, but the share of those who do not use a computer at the workplace is significantly larger (66%). Interestingly enough, the percentage of employees with very good computer skills is only 8.4%, but those with good skills are more than those who declared to have only some or 'average' computer skills. Second, apart from the perfect overlap between the complete absence of computer knowledge and computer use, it emerges that the share of computer users becomes very high (larger than 70%) for workers with average computer skills, and continues to increase with skill. It could be said that these findings are obvious, but the presence of about 13% of Italian employees with a good or very good skill who, in spite of this, do not work with computers suggests that the relationship between computer use and skill is more complex than may appear at a first sight. Probably, as the advocates of the skill-shortage hypothesis will contend, for many Italian employers it is difficult to find people with very good computer skills (and for some ICT jobs they cannot be substituted by less skilled individuals). At the same time, however, there is also an under-utilisation of good and average computer skills that workers have attained via education, self-learning or previous working experience.

Table 5 shows the distributions of computer use and skill across different groups of employees. As already said, most white-collar workers are computer users but the percentages are particularly high (greater than 70%) for managers, followed by cadres and technicians; however, the latter record the highest share of individuals with very good computer skills. The sectors with the greatest percentages of computer use and skill are Credit & Insurance and Business services, with the latter prevailing in terms of workers with very good computer skills. Transport & Communication is behind the Pub-

Table 5: Computer use and skill - percentages of employees in each group (2000)

	Use of computer at work	Average or good computer skill	Very good computer skill
Blue collars	9.1	10.5	1.8
Office workers	55.5	41.3	12.9
School teachers	35.7	31.7	6.4
Cadres and technicians	70.1	45.4	24.7
Managers	75.9	50.0	22.2
Agriculture	6.5	8.0	0.6
Industry & Mining	28.4	21.8	8.0
Building & Construction	18.2	15.8	6.8
Wholesale & Retail Trade	32.6	27.4	7.5
Transport & Communication	29.4	20.8	11.9
Credit & Insurance	74.1	45.9	14.9
Business services	70.4	45.5	24.9
Domestic services	15.7	13.4	2.6
Public administration	40.9	33.5	8.1
None or elementary school	1.6	2.7	0.1
Middle school	12.7	11.2	1.7
Professional school	27.9	28.3	6.7
High school	52.6	40.1	12.6
University degree or more	63.5	45.0	20.4
Total	34.0	26.7	8.4

Source: Banca d'Italia (2002).

lic administration and Trade sectors in terms of computer use, but is ahead in terms of very good computer skills; this result is obviously affected by the fact that the former sector is composed by two industries with very different level of ICT intensity, very high in Communication and considerably lower in Transport.

Finally, as expected, computer variables are strongly associated with educational levels. More than half of the employees with high school diplomas and more than 63% of those with a university degree use a computer at work. In the same fashion, the highest levels of computer skill are attained by the most educated workers.

4 Computer, wages and hours worked: estimation results

In this section we will analyse the data on computer usage, wages and working hours by means of regression techniques. In order to proceed in a statistically correct way, however, our sample had to be restricted to ensure that individuals whose characteristics were structurally too far apart from the rest were excluded.

Therefore, the original Bank of Italy sample (composed of 6,049 employees; cf. table 4 in the previous section) was restricted to respondents who:

1. were not part-time workers, school teachers or employed for less than three months during 2000;
2. worked between 25 and 48 hours per week;
3. earned a net hourly wage greater or equal to 5000 Italian liras (2.58 €)⁶;
4. were employed in firms with more than 4 employees.

Apart from the fact that self-employed workers are deemed to be structurally different from employees (as discussed at the end of section 2), and thus not included in the sample from the outset, the restrictions of point 1 are applied in order to exclude employees who, by definition or contractual arrangements (this is the case of Italian school teachers), have a weekly or annual working time lower than that of the other workers (cf. OECD, 2000). The same restrictions are extended to all the employees by applying the lower bound of weekly working time of point 2, while with the upper bound of 48 hours worked per week we avoid the inclusion of outliers in

⁶Hourly wages are computed as the annual labour income net of taxes, divided by the weeks worked and then by the hours worked per week.

the regressions⁷. With the same rationale we exclude employees below the minimum hourly wage of point 3⁸. Finally, Italian workers employed in very small firms (less than 5 employees) are not included in the sample as they are usually less paid, their weekly working time is extremely flexible and, often, not all the hours worked are regularly paid. Moreover, it is rather common that in very small firms some of the workers reported as employees are actually firm partners, and therefore self-employed. By applying all the above restrictions and with the further exclusions of individuals with missing values in some of the variables, we end up with a sample of 3,931 observations.

4.1 Comparison with other studies

The first step in our empirical analysis is a comparison with the findings of the other studies reviewed in section 2: therefore, we ran some OLS regressions for the separate (reduced form) equations of wages and hours worked, mimicking as closely as possible the methods used in the literature.

Starting from the equation for the log of hourly wage, the first block of columns in table 6 shows that the use of computers in the workplace has a positive and significant influence on wages. The computer dummy coefficient indicates a wage premium of 5.1%. All the other variables inserted as controls are very significant and get the expected sign; nonetheless, the RESET test for the wage equation indicates some misspecification (most likely, omitted variables).

Moving to the log of hours worked per week (second block of columns, table 6), our estimates show that the impact on working time exerted by the use of computers at work is quite low (less than 1%) and barely significant. In comparison with the wage estimate, some controls are less significant. Although the specification passes the RESET test, the R^2 of the regressions is rather low.

If the above results are compared with those arising for the US, Germany and France (cf. section 2), it can be surmised that there is also a wage premium for workers using computers in the workplace in the Italian labour market. Such a premium, though, is much lower than the 15-17% wage increase estimated for other countries. Similarly, the increase in hours

⁷The upper limit of 48 hours per week is certainly adequate for the Italian labour market. The European Council Directive 93/104, article 6, states that “Member States shall take the measures necessary to ensure that, in keeping with the need to protect the safety and health of workers: ... the average working time for each seven-day period, including overtime, does not exceed 48 hours”. Italian legislation (Law 196/97) and collective bargaining have enforced the above Directive. For instance, the national agreement for the metal working and mechanical engineering workers sets 48 hours as the working week upper bound. In the textile industry, the same limit is 44 hours.

⁸Assuming 40 hours worked per week and 4 weeks per month, with an hourly wage lower than € 2.58 a full-time employee would only earn € 413 per month.

Table 6: Impact of computer use on log hourly wages and hours worked OLS regressions)

	Log of hourly wage			Log of hours worked		
	Coef.	Std. Err.		Coef.	Std. Err.	
Constant	2.324	0.036	**	3.628	0.011	**
Use of computer	0.050	0.013	**	0.008	0.004	*
Experience	0.010	0.002	**	0.003	0.001	**
Experience squared /100	-0.017	0.005	**	-0.007	0.002	**
Tenure	0.010	0.002	**	-0.002	0.001	**
Tenure squared /100	-0.014	0.005	**	0.005	0.002	**
Female	-0.094	0.019	**	-0.004	0.006	
Married	0.098	0.016	**	0.008	0.005	
Female*Married	-0.054	0.022	**	-0.029	0.008	**
Middle school	0.051	0.022	**	-0.013	0.008	*
Professional school	0.084	0.025	**	-0.021	0.010	**
High school	0.122	0.025	**	-0.012	0.009	
University degree or more	0.254	0.034	**	-0.008	0.011	
Blue collar	-0.108	0.015	**	0.010	0.005	**
Cadre and technician	0.103	0.023	**	0.024	0.008	**
Manager	0.377	0.046	**	0.036	0.010	**
Agriculture	-0.113	0.041	**	0.056	0.014	**
Industry & Mining	0.023	0.017		0.057	0.006	**
Building & Construction	0.028	0.025		0.059	0.011	**
Trade	0.006	0.023		0.059	0.007	**
Transport & Communication	0.087	0.026	**	0.046	0.009	**
Credit & Insurance	0.176	0.023	**	0.028	0.008	**
Business services	0.021	0.036		0.038	0.012	**
Domestic services	-0.130	0.031	**	0.036	0.011	**
Firm size (5-19 empl.)	-0.150	0.017	**	0.019	0.006	**
Firm size (20-49 empl.)	-0.078	0.017	**	0.009	0.005	
Firm size (50-99 empl.)	-0.042	0.019	**	0.005	0.006	
Firm size (100-499 emp.)	-0.040	0.016	**	0.010	0.006	
Central Italy	-0.036	0.012	**	-0.015	0.005	**
Southern Italy	-0.090	0.015	**	-0.014	0.005	**
Sample size	3931			3931		
R-squared	0.484			0.186		
RESET test	6.27	**		1.08		

*=significant at 0.05; **=significant at 0.10; heteroskedasticity-robust standard errors.

Default values: 'None or elementary school', 'Office worker', 'Public administration', 'Firm size > 499 employees' and 'Northern Italy'.

worked associated with the use of computers is just 0.8% versus a value of 5% estimated by Freeman for the US.

In principle, different reasons could be adduced to explain these findings: a lower share of Italian workers using computers, a lower wage dispersion due to a strictly regulated labour market and a lower propensity of Italian firms to introduce, along with computers, significant changes in work organisation. However, before reaching a definitive conclusion, it is necessary to see if the above results are robust to different specifications of the basic equations and if they change when a simultaneous estimate of wages and hours worked is performed.

4.2 Further estimates

According to the literature survey presented in section 2, the most important shortcoming of the empirical analyses concerned with computer and labour market outcomes derives from unobserved heterogeneity of workers in terms of ability or productivity. The data available for Italy, described in section 3, allow us to carry out only a cross-sectional analysis for the year 2000 and therefore, unfortunately, the lack of a time dimension prevents us from properly addressing the issue of unobserved ability. However, we have tried to take this problem into consideration by inserting into our regressions three specific controls for ability that were not used, at least all together, in previous empirical studies:

- ability with computers, which is a portion of working ability, is controlled by means of three skill dummies for employees with computer skills equal to: “none or some”, “average or good” and “very good”;
- a portion of the unobserved ability of individuals is controlled through the educational level of their parents; it is therefore assumed that individuals with more educated parents have a greater aptitude for taking on difficult tasks and responsibilities in the workplace;
- another portion of innate ability is taken into account by inserting in the regressions a dummy variable for the educational proficiency of workers, equal to 1 if the individual attained a grade greater or equal to 90% of the maximum grade⁹ at high school or university.

Considering that, in line with previous studies, the working ability acquired via learning by doing is controlled through the years of experience and tenure (see table 6), it is possible to say that our cross-sectional analysis contains the widest set of explanatory variables so far used to control for the unobserved ability of workers.

⁹It follows from this definition that individuals with an educational level lower than high school are included in the group of ‘less able’ workers.

Another feature that is absent in previous work on the subject is accounting for the possibility that the wage premium could be different across the job spectrum. The productivity of a given worker must be measured in the context of her typical activities: these clearly differ widely across industries, qualifications and even, conceivably, firm size. Assuming that all these activities, for every worker, receive an equal boost from computer usage seems to us an unduly restrictive hypothesis.

Finally, the possibility that hourly wage and hours worked could be simultaneously determined must also be taken into account, especially as the working time choice cannot be considered independent from hourly wages. As a consequence, instead of estimating two separate, reduced form equations as done by Freeman (2002), we modelled the impact of computer usage on wages and working hours by a simultaneous system. A fairly general model of the relationships between working time (h) and the hourly wage (w) could be described by the following system of equations (both dependent variables are in logs):

$$w = \alpha_0 + \alpha_1 h + \alpha_2 X + \alpha_3 Z + u_w \quad (1)$$

$$h = \beta_0 + \beta_1 w + \beta_2 X + \beta_3 Y + u_h \quad (2)$$

where $W = \{X, Y, Z\}$ is a set of conditioning variables, which are assumed to be exogenous and include information on computer usage and skill.

Since the variables “computer usage” and “computer skill” are included in the conditioning set, the issue of endogeneity obviously arises. This problem is completely analogous to a widely studied one, that is the estimation of returns to education (see for instance Blundell et al., 2000). In this context, it is safe to say that any endogeneity that could be present between wage and computer-related variables is mainly due to unobservable heterogeneity among individuals in terms of overall ability and/or motivation. Therefore, once one conditions on variables which capture these effects (at least partially), this problem is likely to be much less severe, if not resolved altogether.

In formal terms, if we wrote equation (1) as

$$w = CU\gamma_0 + CS\gamma_1 + CV\gamma_2 + u_w,$$

(with CU = computer usage, CS = computer skills, CV = control variables), we assume that $E[u_w|CU, CS, CV] = E[u_w|CV]$. This assumption can be expressed verbally as “all other characteristics being equal, computer-related variables are weakly exogenous”. Obviously, the conditioning variables CV should include an appropriate set of proxies for unobserved heterogeneity, and especially ability. We believe that the set of regressors discussed above as ability proxies is sufficient for the purpose.

As is customary in the estimation of simultaneous systems, the identification of parameters depends on the definition of Y and Z . Unfortunately,

while it is relatively straightforward to identify *a priori* a set of instruments Z for equation (2) (namely, exogenous variables that could affect the hourly wage but not the working time), the same does not hold for the set of variables Y ¹⁰. However, estimation is possible if the parameter α_1 in equation (1) is equal to zero: this hypothesis is not unreasonable in our case, since

- in most empirical work on hourly wages, working time is not usually taken into account; to our knowledge, no previous studies on the particular subject we are dealing with here (see section 2) have included hours worked in the wage equation specification;
- our sample only considers employees who reported a number of hours worked per week between 25 and 48: if we confine ourselves to workers whose working time is neither unusually low or high, it is not clear whether the hourly wage should increase or not when an employee works more hours (normally, overtime hours are paid more than contractual ones but, with a progressive income tax, net hourly wages could remain nearly constant).

Hence, we estimate the following equations:

$$w = \alpha_0 + \alpha_2 X + \alpha_3 Z + u_w \quad (3)$$

$$h = \beta_0 + \beta_1 w + \beta_2 X + u_h \quad (4)$$

The system (3–4) is a triangular system and therefore equation (3) can be estimated by OLS regression; the parameters in equation (4), however, can be consistently estimated by OLS only if the correlation between the two disturbances terms u_w and u_h is null. Since there are no plausible arguments to assume it is so (in fact, one may think of a number of reasons why it should *not* be so), we used the instrumental variables (IV) technique for the second equation, performing a Hausman test to make a final decision. As customary in IV estimation, a Sargan-Hansen test for the over-identifying restrictions was also computed.

Results of our estimates are presented in tables 7 and 8 for the hourly wage and working hours, respectively. Standard diagnostic checking detected no particular problem in our specifications: both equations pass the RESET test for correct specification; there is some evidence against homoskedasticity (Breusch-Pagan test, excess kurtosis), but this is customary

¹⁰The Bank of Italy survey does in fact provide some variables which, in theory, could be used for instrumenting worked hours: in a preliminary attempt, we constructed some indicators of an individual's time-consuming, unpaid activities like child care, commuting time and others. Unfortunately, these variables turned out to be extremely weak instruments, while the number of missing cases would considerably reduce the sample size. In no case, however, did we obtain an estimate of α_1 which was significantly different from zero.

Table 7: OLS regression; log hourly wage

Variable	Coefficient	std. Err.	<i>z</i> -stat.	<i>p</i> -val
Constant	2.293	0.037	62.670	0.000
Use of computer	0.017	0.021	0.820	0.410
Average/good computer skill	0.028	0.017	1.620	0.106
Very good computer skill	-0.045	0.024	-1.860	0.063
Use of computer*Blue collar	0.012	0.031	0.410	0.685
Use of computer*Cadre	0.134	0.044	3.010	0.003
Use of computer*Manager	0.150	0.076	1.980	0.048
Joint test: F (6, 3621) = 5.52, p = 0				
Female	-0.092	0.018	-5.190	0.000
Married	0.093	0.016	5.990	0.000
Female*Married	-0.061	0.022	-2.790	0.005
Joint test: F (3, 3621) = 57.07, p = 0				
Middle school	0.060	0.022	2.700	0.007
Professional school	0.102	0.026	3.880	0.000
High school	0.123	0.027	4.630	0.000
University degree or more	0.220	0.039	5.680	0.000
Joint test: F (4, 3621) = 9.60, p = 0				
Blue collar	-0.112	0.017	-6.770	0.000
Cadre and technician	0.015	0.035	0.420	0.675
Manager	0.257	0.058	4.400	0.000
Joint test: F (3, 3621) = 24.47, p = 0				
Agriculture	-0.116	0.042	-2.740	0.006
Industry & Mining	0.019	0.017	1.110	0.266
Building & Construction	0.017	0.026	0.650	0.519
Trade	-0.001	0.024	-0.030	0.977
Transport & Communication	0.058	0.025	2.330	0.020
Credit & Insurance	0.151	0.024	6.410	0.000
Business services	0.027	0.038	0.720	0.471
Domestic services	-0.129	0.032	-4.060	0.000
Joint test: F (8, 3621) = 10.16, p = 0				
Central Italy	-0.040	0.012	-3.240	0.001
Southern Italy	-0.086	0.015	-5.760	0.000
Joint test: F (2, 3621) = 17.70, p = 0				
High educational grade	0.023	0.021	1.090	0.275
Parents' educ.=middle school	0.022	0.013	1.600	0.110
Parents' educ.=profess school	0.035	0.020	1.780	0.075
Parents' educ=high school	0.075	0.022	3.380	0.001
Parents' educ.=university	0.171	0.033	5.150	0.000
Joint test: F (5, 3621) = 6.64, p = 0				
Experience	0.010	0.002	4.550	0.000
Experience squared /100	-0.016	0.005	-3.250	0.001
Tenure	0.011	0.002	5.240	0.000
Tenure squared /100	-0.016	0.005	-3.260	0.001
Joint test: F (4, 3621) = 51.53, p = 0				
Firm size (5-19 empl.)	-0.150	0.017	-8.680	0.000
Firm size (20-49 empl.)	-0.080	0.018	-4.450	0.000
Firm size (50-99 empl.)	-0.040	0.019	-2.050	0.040
Firm size (100-499 emp.)	-0.037	0.017	-2.230	0.026
Joint test: F (4, 3621) = 20.40, p = 0				
Sample size				3661
R^2				0.502
Residual skewness				0.627
Residual kurtosis				6.505
Breusch-Pagan heteroskedasticity test			20.68	0
RESET test (up to 4th powers)			2.06	0.104
Jarque-Bera Normality Test			2113.9	0

Default values: 'None or some computer skills', 'None or elementary school', 'Office worker', 'Public administration', 'Firm size > 499 employees' and 'Northern Italy'.

Table 8: Instrumental Variables regression; log weekly hours worked

Variable	Coefficient	std. Err.	z-stat.	p-val
Constant	3.911	0.058	67.520	0.000
Log hourly wage	-0.123	0.025	-4.960	0.000
Use of computer	0.015	0.004	3.340	0.001
Female	-0.017	0.007	-2.470	0.014
Married	0.018	0.006	3.040	0.002
Female*Married	-0.033	0.008	-4.180	0.000
	Joint test: 2(3) = 66.57, p = 0			
Middle school	-0.008	0.008	-0.920	0.358
Professional diploma	-0.011	0.010	-1.060	0.290
High school	0.004	0.010	0.400	0.693
University degree or more	0.022	0.014	1.590	0.112
	Joint test: 2(4) = 11.82, p = 0.019			
Blue collar	-0.001	0.006	-0.230	0.816
Cadre and technician	0.038	0.008	4.580	0.000
Manager	0.088	0.015	5.780	0.000
	Joint test: 2(3) = 43.52, p = 0			
Agriculture	0.045	0.013	3.340	0.001
Industry & Mining	0.062	0.005	12.140	0.000
Building & Construction	0.063	0.010	6.190	0.000
Trade	0.061	0.007	8.290	0.000
Transport & Communication	0.057	0.009	6.630	0.000
Credit & Insurance	0.049	0.010	5.190	0.000
Business services	0.048	0.011	4.310	0.000
Domestic services	0.019	0.012	1.620	0.104
	Joint test: 2(8) = 181.94, p = 0			
Central Italy	-0.020	0.005	-4.290	0.000
Southern Italy	-0.025	0.005	-4.850	0.000
	Joint test: 2(2) = 30.77, p = 0			
Experience	0.004	0.001	4.860	0.000
Experience squared /100	-0.007	0.002	-4.940	0.000
	Joint test: 2(2) = 24.91, p = 0			
Sample size				3661
R^2				0.203
Residual skewness				-0.41
Residual kurtosis				6.58
Breusch-Pagan heteroskedasticity test			37.37	0
RESET test (up to 4th powers)			1.05	0.37
Jarque-Bera Normality Test			2057.414	0
F test for excluded instruments			38.09	0
Hausman test vs. OLS			49.62	0
Sargan-Hansen overidentification test			21.149	0.132

Instruments for the hourly wage: High educational grade, Parent's education, Tenure, Tenure squared, Firm size, Computer skill, Computer skill * Use of computer. Default values: 'None or elementary school', 'Office worker', 'Public administration' and 'Northern Italy'.

with cross-sectional data and is easily accommodated by a White correction in estimated standard errors. For equation (4) in table 8, the Hausman test indicates that OLS and GIVE estimates are in fact significantly different from each other, so the IV method was preferred. The Hansen-Sargan over-identification test allows us to accept the null of instrument validity quite confidently. Finally, as suggested by Staiger and Stock (1997), the partial F test for excluded instruments in the first stage regression is also reported, which shows no sign of instrument weakness.

As far as the wage equation is concerned (table 7), it is worth pointing out that computer usage is not significant by itself but only in its interactions with the dummies for the workers' qualifications; moreover, its interactions with medium- and high-level white collars are not only significant but both estimated coefficients are rather high, indicating a wage premium for cadres and technicians of 14% and one for managers equal to 16%. The result for cadres is specially interesting, since the non-significant coefficient of their qualification dummy indicates that only cadres who use a computer at work have a wage greater than that of the reference group (i.e. office workers). We also explored the possibility of differentiating the effect of computer usage not only between qualifications, but also across other job characteristics, such as industry and firm size. These were not significant, and therefore excluded from the final specification. The same happened when the interaction between computer use and computer skill was considered.

The workers' ability (or their social and cultural capital endowment) proxied by the levels of parents' education is very significant, while high education grades or very good computer skills are not rewarded at all; in fact, although the coefficient is significant only at 10%, the employees most skilled in computer usage experience a wage *decrease* of 4.6%. Assuming that the majority of employees with a very good computer skill is occupied in specific IT jobs (such as those of programmer, data base administrator, and so on), this result is not surprising; it simply suggests that a wage premium for computer use arises especially when a cadre or a manager is *not* an IT expert.

Table 8 shows the results on working time. The hourly wage exerts a negative impact on the number of hours worked per week, with an elasticity of 12%; on the contrary, the use of computers generates an increase in working time equal to 1.5%. Therefore, the impact on computer usage on working time seems to be rather small. Moreover, for some categories of workers the computer effect on hourly wage must also be taken into account: since for cadres and managers there is a wage premium for computer use ranging from 14 to 16%, the net effect on hours of using a computer at work is, at least for the above types of workers, not positive but slightly negative¹¹.

¹¹As a cautionary note, however, it should be said that these workers are those most likely to spend time working at home. As argued in section 2, the impact of ICT on this

5 Concluding remarks

In this paper, a body of fairly recent data was used to analyse and evaluate the impact of computer usage on hourly wage and working time for Italian employees in the year 2000. Applied literature on the subject has shown that, for other major industrialised countries, the introduction of computers in the workplace has determined a sizeable impact on hourly wages, in that computer-using employees seem to earn 10-15% more than others, *ceteris paribus*. The effect of computers on working time has been less studied, but all the same appears to be non-negligible.

For Italy, these results seem much less evident: estimates obtained by using the same methods as in previous literature point to a “computer effect” in wages whose order of magnitude is around 5%; working hours seem to be very little affected. However, in our opinion, the estimation methods used so far have to be revised in order to obtain soundly interpretable evidence. Some of the points that we explicitly considered when setting up our empirical models were: possible simultaneity between wages and hours; better modelling of unobserved heterogeneity between workers in order to avoid spurious effects; possibly different impact on computer usage across industries, firm size and qualifications; different levels of computers skills between individuals; and finally, overall attention to the statistical properties of the model via systematic diagnostic checking.

Our findings confirm that these precautions are worth taking: in fact, while wage differentials due to computer usage across different industries and firm sizes appear to be statistically insignificant, it thus emerges very clearly that the type of qualification plays an important role: the wage gain due to computer usage is in the order of magnitude of 15%, but only for higher-level white collars, while there seems to be none for blue collars and office workers. The fact that computer skills are also significant in determining wage differentials reflects a picture in which the outcome of computer usage on wages is less clear-cut than previously thought. Moreover, there is ample evidence that individual characteristics, such as unobserved ability, are a fundamental factor in explaining wage differentials: failure to take this into account leads to serious mismeasurement of the impact of computer-related variables on wages.

As far as working time is concerned, the finding we consider most important on the empirical side is the limited impact of computer usage. On the methodological side, our main result is that the negative effect of hourly wage on hours worked induces a form of simultaneity between equations. As a consequence, modelling the effect of computer-related variables on working hours by estimating reduced forms entails an inevitable loss of efficiency; beside this, a structural equation as we employ has the additional advantage

behaviour could be substantial, but impossible to ascertain quantitatively with our data.

of exposing the causal links between variables.

The main policy message that can be drawn from our findings is that the adoption of computers in the workplace is no magical recipe which improves job quality and compensation under any circumstances. Some workers benefit more than others from computers introduction; some do not benefit at all. Generalised gains from ICT adoption are foreseeable only if coupled with appropriate improvements in work organisation, especially those aimed at upgrading the tasks and competencies and increasing the decisional autonomy of the employees with lower qualifications.

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