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137. Jahrgang Dezember 2001
137e année Décembre 2001
137th Year December 2001

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Helbing & Lichtenhahn

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Schweizerische Zeitschrift für
Volkswirtschaft und Statistik

Revue suisse d'
économie et de statistique

Swiss Journal of
Economics and Statistics

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Swiss Journal of
Economics and Statistics

Redaktor/*Rédacteur*/Editor
Prof. Dr. Peter Kugler

Redaktionsadressen
Adresses des rédactions
Editorial Offices

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Publiziert mit Unterstützung der Schweizerischen Akademie der Geistes- und Sozialwissenschaften SAGW
Publiée avec le soutien de l'Académie suisse des Sciences humaines et sociales ASSH
Published with the financial support of the Swiss Academy of Humanities and Social Sciences SAHS

Herausgegeben von der
Schweiz. Gesellschaft für Volkswirtschaft und Statistik
Publiée par la
Société suisse d'économie et de statistique
Edited by the
Swiss Society of Economics and Statistics

Verlag/*Edition*/Publishing House
Helbing & Lichtenhahn Verlag
Elisabethenstr. 8
CH-4051 Basel
Tel. +41 61 228 90 70
Fax +41 61 228 90 71
E-Mail: zeitschriften@helbing.ch

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See last pages of the journal

Erscheint vierteljährlich/*Revue trimestrielle*/Quarterly
ISSN 0303-9692

Wages and the Use of New Technologies: An Empirical Analysis of the Swiss Labor Market

Axel Franzen*

1. INTRODUCTION

Wage inequality as well as the return to education have increased over the last several decades in almost all OECD countries. This has been shown for the USA (e.g., Autor, Katz and Krueger, 1998; Bound and Johnson, 1992; Johnson, 1997; Mincer, 1996) and for most European countries (Gottschalk, 1997; OECD, 1996).[1] A recent study by Leu, Burri and Priester (1997) suggests that Switzerland is no exception to this. As a matter of fact Switzerland's per capita GNP is above average compared to other OECD nations. It ranks among the top countries with respect to wage inequality (see also Korpi and Palme, 1998), and has also experienced an increase in wage inequality during the 80's.[2]

Most labor economists believe that the widening of the earnings gap is due to two related factors: First, OECD countries have experienced a rapid technological change. Many of these new technologies are skill-biased and have increased the demand for high-skilled labor (e.g., Mincer, 1991; Johnson, 1997; Bell, 1996). Thus, as long as the demand for skilled labor is higher than the supply, wages of the better-educated workers will increase. Second, globalization has led to an increase in outsourcing of low-skilled labor to low wage level countries thereby reducing the demand for low-skilled labor in OECD nations.

If the diffusion of skill-biased technologies is a prime reason for the increase in wage inequality then there should be two consistent empirical findings. First, new technologies should be adopted faster by the highly educated because it is more profitable for them (Bartel and Lichtenberg, 1987; Galor and Tsiddon, 1997) and second, on-the-job use of new technologies should increase productivity and, consequently earnings.

So far, there have been few studies investigating the earnings effect of new technologies for the US (e.g., Bartel and Lichtenberg, 1987; Bartel and Sicherman, 1999; Doms, Dunne and Troske, 1997; Krueger, 1993; Mincer 1991), Germany (DiNardo and

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Support from the research grant "Working conditions, work orientation and labor market participation" by the Swiss National Science Foundation is gratefully acknowledged.

1. The only exception is Germany (Gottschalk, 1997).
2. However, a recent study by Gugler and Blank (1999) suggests that there was only a very small further increase in wage inequality from 1992 to 1997.

PISCHKE, 1997; HAISKEN-DENEW and SCHMIDT, 1999), the United Kingdom (BELL, 1996), and France (ENTORF and KRAMARZ, 1997; ENTORF, GOLLAC and KRAMARZ, 1999). Two of these studies using cross sectional (KRUEGER, 1993) as well as longitudinal data (BELL, 1996) have reported a wage bonus for computer use, while all others report no or minor effects. Thus, the existing evidence is still sparse and controversial.

In this article the earnings effect of two new technologies, on-the-job use of personal computers and the Internet, is investigated for the Swiss labor market for the first time. The analysis uses micro-level cross sectional data of two different surveys recently conducted in Switzerland. The first data source is the Swiss Labor Market Survey (SAMS) that consists of a random sample of 3000 Swiss inhabitants. The second data set is the Internet Survey that contains data on 17'000 respondents from the German part of Switzerland. Two important results emerge from this study. First, no wage premium is found for the use of computers. Thus, the analysis replicates the compelling evidence presented by ENTORF and KRAMARZ (1997), ENTORF, GOLLAC and KRAMARZ (1999), and HAISKEN-DENEW and SCHMIDT (1999). Second, no consistent earnings effect is found for the use of the Internet at the work place either.

The remainder of the article proceeds as follows. In section II the existing evidence from studies conducted in the USA, the United Kingdom, and France is briefly summarized. Section III describes the data sets. In Section IV the effects of computer use and the Internet on earnings are estimated. The analysis proceeds in several steps by starting with MINCER's (1974) basic human capital function that is sequentially extended by proper control variables to eliminate individual heterogeneity. Section V concludes and discusses the results.

2. EXISTING EVIDENCE

Existing evidence draws on different types of data sources, on micro-level data (KRUEGER 1993; BELL, 1996; DINARDO and PISCHKE, 1997; ENTORF and KRAMARZ, 1997; HAISKEN-DENEW and SCHMIDT, 1999; ENTORF, GOLLAC and Kramarz, 1999), industry level data (DOMS, DUNNE, and TROSKE, 1997; BARTEL and LICHTENBERG, 1987; BARTEL and SICHERMAN, 1999) and on nationally aggregated data (MINCER, 1991). Also, the types of technologies investigated differ. KRUEGER (1993) reports that employees on the US labor market receive a wage premium of about 10 % to 15 % if they use computers on-the-job. However, KRUEGER' s (1993) conclusion that on-the-job computer use increases earnings was debated by DINARDO and PISCHKE (1997). These authors also analyzed micro-data and found that higher wages are not only found for workers that use computers, but also for the use of other office tools such as pencils or calculators. Their interpretation of this finding is that new technologies go to the highly skilled workers and that the cause of the wage premium is unobserved ability rather than on-the-job use of new technologies. However, KRUEGER's (1993) analysis receives further support from BELL (1996), who uses information on individuals' technical skills and other ability measures in order

to control for individual heterogeneity. BELL (1996) estimates the wage premium for computer use at around 5 % to 10 % for the British labor market. He also tries to support his findings with an analysis of longitudinal data, a wage difference model comparing 1981 with 1991 earnings. However, his 1981 survey contained no information on computer use. This information was gathered retrospectively in the 1991 survey.

More compelling evidence stems from ENTORF and KRAMERZ (1997), ENTORT, GOLLAC and KRAMARZ (1999), as well as from HAISKEN-DENEW and SCHMIDT (1999). The first two studies analyze the wage premium of computer use for the French job market and the second for the German labor market. All three studies use fixed-effects models of large scale panel surveys for France and Germany. The estimated wage premium is 1 % for Germany and 2 % for France, and therefore almost nil.

Other studies use industry level data for the USA. BARTEL and LICHTENBERG (1987) find evidence that industries with high investments in new technologies have a greater demand for highly educated workers. Furthermore, BARTEL and SICHERMAN (1999) report a positive correlation between technological change and wages. However, they also suggest that this correlation is due to unobserved worker characteristics rather than to on-the-job use of new technology. DOMS, DUNNE and TROSKE (1997) find that new technologies are introduced in industries that already have a highly skilled labor force before the adoption of new technology. The authors interpret the findings as evidence that the correlation between technological change and wage inequality cannot be interpreted causally.

MINCER (1991) analyzed aggregated time series data for the USA and found that the increased wage differential between college and high school graduates is best explained by aggregated expenditures in research and development. He interprets the latter as a proxy for the demand for educated workers that is driven by the adoption of new technologies.

In sum, standard economic reasoning suggests that new technologies should enhance productivity and that workers should profit from enhanced productivity through higher wages. However, the empirical evidence and its interpretation on the association of skill-biased technology and earnings are controversial.

3. THE WAGE PREMIUM FOR COMPUTER USE IN SWITZERLAND

In the following analyses the wage premium for computer use will be estimated with two different cross sectional surveys conducted in Switzerland in 1998. In addition to the search for a possible productivity-enhancing effect of personal computers, on-the-job use of the Internet is also investigated. The first survey that will be analyzed is the Swiss Labor Market Survey (SAMS).[3] This survey is a random sample of the Swiss population.

3. The survey was conducted via telephone and written questionnaires and had a response rate of 63 %. For detailed information about the survey see DIEKMANN et al. (1998). The Swiss Labor Market Survey should not be confused with the Swiss Labor Force Survey (SAKE). The latter contains information on socio-demographic variables of about 16'000 respondents, but no information about on-the-job use of new technologies.

It contains 3028 cases and detailed information needed for an analysis of the effects of skill-biased technologies on earnings. In particular, the survey contains information about on-the-job computer and Internet use. Let us first turn to a few descriptive results. 51 % of the 3028 individuals surveyed reported that they were employed full-time. 54 % of them use a personal computer at the work place and 17 % use the Internet. Thus, both technologies, and particularly PCs, have strongly penetrated the Swiss labor market. HAISKEN-DENEW and SCHMIDT (1999) report that 52 % of all full time employed use a PC for work in Germany (in 1997). Hence, the German and Swiss labor market are rather similar with regard to the diffusion of personal computers at the work place. Table 1 displays the percentage of work places that use computers in different sectors. Not surprisingly, new technologies are mostly found in the financial service sector (banking and insurance, 75 % and 82 % respectively) and are least common in gastronomy (32 %), agriculture or energy and mining (22 %).

Table 1: Percentage of employees that use personal computers on the job in different sectors (percentage and N employed in given sector).

Chemical Industry	32 %	28
Watch Industry	43 %	21
Machinery	42 %	97
Other Production Industry	46 %	145
Construction	39 %	128
Gastronomy	32 %	37
Trade	47 %	120
Transport Industries	58 %	48
Banking	75 %	61
Insurance, counseling, other services	82 %	84
Service (teaching, research etc.)	62 %	294
Public Administration	62 %	133
Agriculture	38 %	24
Energy, Mining	22 %	9
Average/N	54 %	1226

To begin with, let us take a look at estimates of the standard earnings function derived from human capital theory (BECKER, 1975; MINCER, 1974) using the Swiss Labor Market Survey. The earnings function is usually specified as

$$\text{Ln } Y = \beta_0 + \beta_1 s + \beta_2 x + \beta_3 x^2 + u \qquad (1)$$

with Ln Y = the natural logarithm of earnings (per working hour)
s = years of schooling
x = years of on-the-job-training
u = stochastic error term

Descriptive information on the variables is contained in Table B in the appendix. Results of the estimation of model (1) for the sub-sample of full-time employed individuals of the Swiss Labor Market Survey is given in Table 2, column 1.

Thus, the rate of return for an additional year of education results in a 7 % increase in hourly earnings. The first year of on-the-job training increases hourly wages by 3 % and diminishes thereafter as indicated by the negative sign of the quadratic term of on-the-job training. The analysis replicates recent estimates of the return to schooling for Switzerland and Germany. DIEKMANN and ENGELHARDT (1995) report a rate of return to schooling of 7.5 % for men and 8 % for women, and their estimate for the starting year of on-the-job-training results in 5.4 % for men and 3.9 % for women. Also, analysis of the Swiss Labor Force Survey 1998 (SAKE) results in identical findings. Furthermore, the estimated returns to schooling and on-the-job training are very similar to the ones reported for the USA. Thus, WILLIS (1986) estimated the rates of return for college education to be around 8 % to 9 % for the period of 1967 to 1981.

The standard human capital earnings function has been extended by many succeeding studies to investigate the effects of gender, labor market sector or marriage status on the earnings distribution (e.g., CAIN 1986). The results of such an extended model are shown in column 2 of Table 2. Thus, as in other studies, we find a negative earnings effect for women even if schooling and work experience is controlled for. First, if the gender effect is introduced into model 1 the estimate suggests that women earn 14 % less than men (column 1 of Table 2). Other studies on earnings inequality for Switzerland estimate a gender gap of 10 % to 15 % (HENNEBERGER and SOUSA-POZA, 1999). Hence, the result from the Swiss Labor Market Survey is rather similar to former findings. However, the gender wage difference drops to 6 % if other variables are introduced (column 2, Table 2).[4] Moreover, the extended model shows a marriage premium of 7 % for married respondents. Married women, on the other hand, earn 23 % less than married men. These effects are similar to results usually found for the USA. Thus, DANIEL (1995) reports that estimates of the male marriage premium range from 10 to 35 percent and KRUEGER (1993) estimates the marriage malus for women at −14 %.[5]

Next, the model also includes dummy variables that indicate whether respondents live in the French or Italian speaking part of the country. The wage level in both parts is a little lower than in the German part. However, both estimates are not significant. This finding suggests that there are no regional differences in Switzerland. Another dummy variable that is included indicates whether respondents have experienced unemployment. As expected, periods of unemployment are associated with lower present earn-

4. A detailed analysis of gender earnings inequality would require further refinements such as the control for the possible presence of children or corrections for sample selection of female labor force participation. However, the gender wage inequality is not our concern here.
5. Separate earnings regressions for full-time employed women and men were also run. The results are basically the same. According to the results of those separate regressions, married men earn 7 % more than unmarried men. Married women on the other hand earn 14 % less than unmarried women.

ings. This effect is quite strong. Respondents who had experienced unemployment earn on average 10 % less compared to respondents that never lost their jobs. Furthermore, the results reveal that foreigners earn 10 % less than Swiss citizens.

Finally, column 2 in Table 2 contains the two variables that measure the use of new technologies at the work place. Respondents were asked whether they use a computer at work, and whether they use the Internet at work. The results indicate that individuals who do use a computer earn 8 % more than others. So far these results are similar to KRUEGER's (1993) or BELL's (1996) findings. Results also show that on-the-job use of the Internet is even associated with a 13 % wage bonus.

These results are of course only preliminary. The crucial question is whether the effects found for the use of new technologies can be interpreted causally. Standard economic reasoning suggests that the introduction of new technologies into the work place should enhance productivity otherwise these investments would hardly be made by employers. If the technologies are skill-biased, the demand for skilled labor should rise resulting in higher earnings for skilled labor, at least as long as demand is greater than supply.

However, there are other possibilities that could explain the wage premium for new technologies. For instance, highly skilled workers might be equipped with new technologies and it is their pre-adoption skill level that produces the earnings differential prior to actual technology adoption. Therefore, it could be skill that produces higher wages rather than on-the-job use of computers. KRUEGER (1993) tried to rule out this possibility by including measures for intellectual skill in the earnings function. However, it is arguable whether general skill measures adequately control for relevant on-the-job skills. DINARDO and PISCHKE (1997) included other office tools (e.g. pencils and calculators) and found that they also increase earnings. They interpret this finding as evidence that computers and other office tools are simply indicators of a priori work skills that cannot be causally linked to the technologies themselves. Hence, the regression model specified so far leaves much room for the possibility of mis-specification. Particularly if the model lacks variables that are correlated with earnings and computer use, basic assumptions of the OLS-regression are violated, which would result in biased estimates.

Ideally, the data set should contain variables that allow for the separation of a priori adoption skill level from on-the-job use of new technologies. Additionally, variables that separate the mere availability of new technologies at the work place from their actual use are helpful. The Swiss Labor Market Survey contains some information that can be used as proxies for the intended separation. In particular, the data set contains the question of whether respondents also use a PC at home. PC use at home can be seen as a proxy for computer skills and its inclusion separates the effect of skills from actual on-the-job use. However, the results indicate that computer use at home is not associated with earnings (model 3 in Table 2). Second, the survey also contains the question whether respondents have access to electronic mail at the work place. Such access indicates that a personal computer linked to the Internet is available at the work place. Here the results indicate that such work places are indeed associated with higher paid jobs. The estimated effect is 6 % (model 3 Table 2).

Table 2: Estimates of human capital earnings function with the Swiss Labor Market Survey (SAMS)

Models	(1)	(2)	(3)
Constant	2.09	2.27	2.57
	(34.56)	(38.76)	(35.26)
Schooling (years)	0.07	0.05	0.04
	(17.42)	(13.52)	(8.45)
On-the-job training (years)	0.03	0.03	0.03
	(8.84)	(8.41)	(10.74)
On-the-job training squared	−0.0004	−0.0004	−0.0004
	(−5.65)	(−5.40)	(−5.92)
Gender (0 = male/1 = female)	−0.14	−0.06	−0.06
	(−6.92)	(−2.42)	(−2.36)
Marital status (0 = unmarried/1 = married)		0.07	0.07
		(3.07)	(3.50)
Marital status * gender		−0.23	−0.23
		(−5.40)	(5.88)
French part of CH (0 = no/1 = yes)		−0.03	−0.02
		(−1.62)	(−0.79)
Italian part of CH (0 = no/1 = yes)		−0.05	−0.06
		(−1.00)	(−1.34)
Experienced unemployment (0 = no/1 = yes)		−0.10	−0.09
		(−3.41)	(3.18)
Non-Swiss citizen (0 = no/1 = yes)		−0.10	−0.07
		−4.10)	(−2.84)
Computer use (0 = no/1 = yes)		0.08	0.01
		(4.38)	(0.67)
Internet use (0 = no/1 = yes)		0.13	0.05
		(5.47)	(2.06)
E-mail availability at work (0 = no/1 = yes)			0.06
			(2.57)
Supervision (0 = no/1 = yes)			0.07
			(3.99)
Work motivation			0.001
			(0.12)
PC at home (0 = no/1 = yes)			−0.01
			(−0.47)
Occupational dummies	no	no	yes
Sector of employment dummies	no	no	yes
N	1172	1172	1170
Adjusted R^2	0.32	0.39	0.48

Notes: Dependent variable is the logarithm of hourly earnings. The data set is restricted to individuals working full-time. Values in brackets denote the T-values. Analysis of the Swiss Labor Force Survey 1998 (SAKE) of model 1 results in almost identical findings: Estimates for education, work experience and sex difference are 7 %, 3 % and −15 % respectively.

Model 2 is further extended by other variables that might be linked to the earnings differential. Such variables are people's work motivation and whether respondents supervise others at their work place. Work motivation was measured by the question of whether respondents try to work harder than is expected. 40 % answered that this is very much the case. Moreover, 56 % said that part of their work consists of supervising others. Both (dummy) variables explain part of the wage differential. Supervision increases the average wage by 7 %, but the self-reported work motivation is not related to earnings.

Finally, model 3 in Table 2 contains 9 occupational categories of the International Standard Classification of Occupations (ISCO-88)[6] and 13 dummies for the sector of the workplace (see Table 1). Including these dummies decreases the size of the effect of computer use on wages to 1 % and more importantly, the effect is no longer significant. Notice also that the estimate for on-the-job use of the Internet drops to 5 % and is barely significant.[7] Thus, standard OLS regression analysis of the Swiss Labor Market Survey reveals that on-the-job use of personal computers is not significantly linked to wages. If information on the availability of new technologies as well as occupation and sector dummies are introduced into the model, the effect for on-the-job use of PCs drops to 1 % and on-the-job use of the Internet to 5 %.

Results of the extended model 3 (Table 2) confirm that there are no regional wage differences between the French, Italian and German parts of Switzerland. However, models 2 and 3 consistently suggest that respondents who experienced unemployment earn 9 % less. Also, non Swiss citizens earn on average 7 % less than respondents with a Swiss passport.

The Swiss Labor Market Survey is certainly a rich data basis which provides the possibility of including many control variables. However, the survey has the disadvantage that the results are only based on 1200 full time employed respondents. Hence, it is worthwhile repeating the analysis with a second data set, the Internet Survey. This data set was collected under supervision of the author among the customers of Switzerland's largest Internet provider during March and April of 1998. At that time, the provider had 76'806 customers in the German speaking part of the country.[8] All of them received an electronic mail introducing the survey and asking for participation. The mail gave a link leading to the questionnaire which contained approximately 70 questions on aspects of computer and Internet use and various socio-demographic variables (e.g., sex, age, income, and occupation). Pre-tests showed that it took between 20 and 30 minutes to complete the questionnaire. After completion, the questionnaire could be returned via the Internet and the data was stored in a data base. To increase the response rate, a lottery was announced through which participants could win three cellular phones and a number of credit slips worth the equivalent of 20 to 80 US$. For that purpose subjects had to give their e-mail address, which ensured that only customers of this specific provider were included in the study. In contrast to most other surveys done over the Internet, this procedure also ensured that the participants could only respond once. Furthermore, these controls enable the calculation of the exact response rate. Two weeks after the first e-mail a reminder to participate was published on the homepage of the provider and remained there throughout the data collection period. The questionnaire was returned by 15'852 customers, which constitutes a response rate of about 20 %. This is a rather low response rate compared to surveys done via written or telephone interviews. The data differs in important socio-demographic aspects from known distributions (see Table A in appendix). Respondents of the Internet sample are predominately male, younger and have a higher education than the average Swiss population.

6. The ISCO-Classification is developed by the International Labor Organization (ILO, 1990) and adopted as standard by ZUMA, the central research agency of German sociology as well as by the National Opinion Research Center (NORC).
7. These results remain stable if education is not, as here, measured in years but rather by dummy variables that indicate respondents educational degree.
8. The provider's market share in Switzerland exeeds 30 %.

As a control group we randomly drew 2500 households from the German part of Switzerland who received an almost identical written questionnaire.[9] Of these, 1196 were completed and returned, which constitutes a response rate of 50 %.[10] Comparison between sample distributions of age, education, respondents' sex and size of households with the official statistical information available show no important deviations (see Table A in the appendix). Both data sets, the random sample with 1196 respondents and the Internet sample with 15'852 cases, were combined to make up a data basis of 16'915 cases. The data set clearly has the advantage of its large number of cases and the disadvantage that only a small part of it is a random sample of the Swiss German-speaking population. But, as will be shown, this disadvantage has only a minor effect on the correlational analyses.

Let us first start with estimating the standard human capital earnings function with the Internet sample. Most of the estimates are similar to the results from the Swiss Labor Market Survey (see column 1 in Table 3). Thus, every additional year of education increases earnings by 5 % and the first year of work experience increases earnings by 3 %. Women earn, according to the Internet sample, 6 % less, and the earnings of married women are 13 % lower than that of married men. Moreover, column 1 in table 3 contains dummy variables that measure whether respondents work in the service sector or not and whether they belong to the Internet group versus the written control sample. Earnings in the service sector are on average 5 % higher than in the industrial or agricultural sector. Also, respondents that were interviewed via the Internet report 5 % higher wages. This result can of course not be interpreted causally. The difference probably reflects the fact that the Internet sample is generally made up of more educated and skilled individuals.

9. The written questionnaire was a little shorter than the e-mail version since we did not ask questions on aspects of Internet use.
10. 138 of the addresses drawn were invalid due to address changes. Thus, they were deducted from the valid random sample. Random selection within the household was used via the 'birthday method'.

Table 3: Estimates of human capital earnings function with the Internet Survey

Models	(1)	(2)	(3)
Constant	2.30	2.03	2.24
	(90.30)	(64.92)	(52.50)
Schooling (years)	0.05	0.05	0.04
	(38.26)	(36.77)	(21.06)
On-the-job training (years)	0.03	0.03	0.03
	(20.70)	(20.44)	(19.45)
On-the-job training squared	−0.0004	−0.0004	−0.0004
	(−13.09)	(−12.79)	(−12.59)
Gender (0 = male/1 = female)	−0.06	−0.05	−0.06
	(−4.00)	(−3.75)	(−3.54)
Marital status (0 = unmarried/1 = married)	0.11	0.10	0.08
	(13.12)	(12.09)	(9.70)
Marital status * gender	−0.13	−0.13	0.12
	(-4.62)	(-4.72)	(-3.92)
Sibship size	−0.01	−0.01	−0.01
	(−4.27)	(−3.00)	(−2.63)
Service sector (0 = no/1 = yes)	0.05	0.06	0.04
	(7.83)	(7.92)	(5.71)
Internet sample (0 = no/1 = yes)	0.05	0.04	0.02
	(3.30)	(2.77)	(0.15)
Achievement orientation		0.06	0.06
		(13.77)	(11.35)
Computer on-the-job (0 = no/1 = yes)		0.08	0.03
		(9.25)	(2.68)
Internet on-the-job (0 = no/1 = yes)		−0.02	−0.02
		(−3.22)	(−2.78)
PC at home (0 = no/1 = yes)			0.07
			(4.41)
PC available at workplace (0 = no/1 = yes)			0.06
			(4.63)
Occupational dummies	no	no	yes
Occupational ranking dummies	no	no	yes
N	9873	9656	7766
Adjusted R^2	0.30	0.32	0.37

Notes: Dependent variable is the logarithm of hourly earnings. The data set is restricted to individuals working full-time. Values in brackets denote the T-values.

Furthermore, model 1 in Table 3 depicts a negative effect for sibship size. For every additional sibling respondents earn on average 1 % less. This effect is in line with other studies that found negative correlations between sibship size and intellectual ability. The standard interpretation of this effect is that children's intellectual development depends on familial resources. The larger the family size, the more parental resources are diluted.

However, new results by GUO and VANWEY (1999a) suggest that the relation between family size and intellectual development is spurious. The authors argue that intellectual ability is affected by other family background variables (values, intellectual climate or heritage). Once these factors are controlled for, the negative correlation between sibship size and ability disappears (see also the discussion by PHILLIPS 1999; DOWNEY et al., 1999, and GUO and VANWEY, 1999b). Hence, a careful interpretation treats the sibship size variable as a proxy for other familial background variables. By and large, the results of the human capital earning function depicted in column 1 of Table 3 replicate the results from the Swiss Labor Market Survey, as well as of other studies.

Next, model 2 in Table 3 contains a measure on respondents' work motivation as well as two dummies that measure whether respondents use personal computers and the Internet at the work place.[11] As can be seen from model 2 in Table 3, the achievement variable has a sizable impact on earnings. The achievement measure ranges between five categories from 'not at all important' to 'very important'. Respondents have a 6 % increase in earnings for every unit change on the achievement item. Next, it can be observed that on-the-job computer users have 8 % higher earnings than non-users and that this result is highly significant (t-value=9.25). However, a negative earnings effect can be observed for on-the-job use of the Internet.

So far, the initial estimate of the on-the-job use of computers is rather similar to the findings reported by KRUEGER (1993). However, the results are only preliminary until further control variables are corroborated into the model. This is accomplished in model 3 of Table 3. First of all, model 3 in Table 3 controls for accessibility of a PC at home and for PC availability at the workplace. As can be seen, both variables are significantly related to earnings and thus sketch out some individual heterogeneity that is related to skills and the general status of the workplace. Furthermore, model 3 in Table 3 contains the dummy variables of the International Standard Classification of Occupations (ISCO88). Including all of these controls, the estimate for on-the-job use of computers decreases from a wage bonus of 8 % to 3 %. The estimated t-value is 2.7 and thus, the estimated wage bonus from computer use is still significant to a significance level of $p < 0.01$. However, this is still a rather low significance level considering that the analysis contains almost 8000 full-time employed individuals. Moreover, the Internet Survey provides less information to control for individual heterogeneity than the Swiss Labor Market Survey. In particular, there is only improper control for the sector of employment. Also, the Internet survey does not provide any information as to whether respon-

11. The measure of achievement orientations differs somewhat from the Swiss Labor Market Survey. The Internet survey contained a few questions on what respondents think is most important to them at work. Answer categories included good promotion possibilities, social relations to colleagues, the opportunity to earn a high income etc. These question were taken from the ISSP in 1998 on work orientation. I ran different analyses with various items and scales. In the end it turned out that the single item 'opportunity to earn a high income' is as good as any item combination. Roughly 5 % of respondents said that a high income is very or somewhat important to them. I assume that income orientation is a good proxy for achievement orientation.

dents are supervising others at the workplace. Including this information would most likely further downsize the estimate for on-the-job computer use.[12] Furthermore, estimation of the earnings effect for on-the-job use of the Internet in model 3 (Table 3) reveals that the Internet reduces earnings by 2 %.

4. CONCLUSIONS

In this study two cross-sectional micro-level data surveys recently conducted in Switzerland are analyzed, the Internet Survey with almost 8000 cases and the Swiss Labor Market Survey with 1200 full time employed individuals. Ordinary-least-square estimation of the Swiss Labor Market Survey suggests that on-the-job computer use is not associated with a wage bonus. Estimates with the Internet survey reveal a wage differential of 3 %. These estimates are much smaller than the 10 % to 15 % reported by KRUEGER (1993) or the results reported by BELL (1996). Moreover, the estimate is only significant using the Internet Survey with roughly 8000 full time employed individuals, but the result is insignificant using the Swiss Labor Market Survey. Thus, given that the wage bonus is small, was not consistently found in both surveys and might be due to uncontrolled individual heterogeneity in the Internet Survey, I am led to the conclusion that there is no sizable wage bonus for PC use in Switzerland. This conclusion is in line with ENTORF and KRAMARZ (1997), ENTORF, GOLLAC and KRAMARZ (1999) and HAISKEN-DENEW and SCHMIDT (1999). These authors report wage bonuses of 2 % for the French labor market and 1 % for Germany.

The results are not as conclusive with regard to on-the-job use of the Internet. Estimation using the Swiss Labor Market Survey suggests that Internet usage increases wages by 5 %. However, analysis of the Internet survey suggests that there is no wage bonus for Internet use whatsoever.

These results are puzzling. Either new technologies do not enhance productivity, or if they do, higher productivity is not returned to employees in the form of wages. Since I cannot believe that new technologies do not enhance productivity, the absence of a wage premium must be attributed to other reasons. One possibility is that employees might receive other non-monetary benefits in return for higher work productivity, such as greater autonomy or a lower workload. Another explanation might be the rigidity of the labor market. Germany and France, but also Switzerland, are known to have less flexible labor markets than the US or Great Britain. In the former countries, employment contracts are much more likely to be determined collectively under the supervision of trade unions. Thus, higher wages go collectively to all employees of a given position in a given sector, which might equalize individual productivity differences. This may partly

12. In principle, mis-specification can be tested via the Hausmann Specification Test (GUJARATI, 1995). However, such a test would require at least one variable that predicts on-the-job computer use and is uncorrelated with wages. Unfortunately, such a predictor is not available in the Internet Survey.

explain the different findings for Germany, France and Switzerland on the one hand and the US and the UK on the other.

However, there might also be a third aspect. Global trade and competition has increased among the economies of the OECD. This development is thought to be responsible for low inflation rates, even in phases of economic growth. Thus, firms cannot increase prices for products and services due to competition and by the same token, wages cannot rise even if work productivity increases. Thus, the ability to use new technologies on the job might ease the entrance into the job market or protect individuals from unemployment, but it does not increase wages due to higher competition. In addition, it could also be the case that all workplaces in which PCs can be used are already equipped with PCs. Thus, the use of PCs could be a prerequisite to enter certain jobs. The 46 % of employees that reported not to use a PC must then perform types of activities such as manual work or management activities for which PCs are not helpful.

APPENDIX

Table A: Comparison of Internet Survey with official sources of the Swiss Statistical Bureau

	Internet Survey (1998)		Statistical bureau[13]	
	Internet-sample N = 15624	Random-sample N = 1196	Total population	Population above 18 years
Sex[14]				
male	87.3 %	52.3 %	48.8 %	48.15 %
female	12.7 %	47.7 %	51.2 %	51.85 %
Age				
20–39 years	57.4 %	39.7 %	39.6 %	
40–64 years	40.6 %	42.2 %	40.9 %	
65 and older	1.9 %	17.5 %	19.5 %	
Marital status[2]				
single	41.0 %	26.8 %	41.9 %	26.4 %
married	53.1 %	58.7 %	47.1 %	59.6 %
divorced	5.4 %	8.6 %	5.1 %	6.5 %
widowed	0.4 %	5.9 %	5.9 %	7.5 %
Household size				
1 person	17.1 %	22.2 %	32.4 %	
2 persons	32.5 %	37.7 %	31.7 %	
3 persons	16.9 %	15.9 %	14.9 %	
4 persons	23.0 %	16.1 %	14.5 %	
5 and more persons	10.5 %	8.1 %	6.5 %	
Schooling			SAKE Data 1996*	
Primary school	4.4 %	13.4 %	19.8 %	
Secondary I	38.6 %	59.6 %	51.9 %	
Secondary II (technical schools, higher occupational education)	38.0 %	20.5 %	18.8 %	
University	19.0 %	6.5 %	9.5 %	

* The Swiss Labor Force Survey (SAKE) is a panel study with 16'000 interviews.

13. Data from the Swiss Statistical Bureau refers to the 31st of December 1996.
14. All data refer to the population from the age of 18 onward living permanently in Switzerland.

Table B: Means or proportions of variables used from the Swiss Labor Market Survey and the Internet Survey

	Swiss Labor Market Survey	Internet Survey	
Earnings per working hour (log)	3.30		3.37
Schooling (years)	11.75		13.14
On-the-job training (years)	21.39		19.02
Gender (proportion female)	0.29		0.08
Marital status (unmarried/married)	0.48		0.55
Sibship size	–		2.25
French part of CH (no/yes)	0.25		–
Italian part of CH (no/yes)	0.04		–
Non-Swiss citizen (no/yes)	0.16		–
Experienced unemployment (no/yes)	0.09		–
On-the-job computer use (no/yes)	0.54		0.85
On-the-job Internet use (no/yes)	0.17		0.32
E-mail availability at work (no/yes)	0.34		–
Internet availability at work (no/yes)	0.26		–
Computer availability at work (no/yes)	–		0.88
PC at home (no/yes)	0.22		0.94
Internet sample (no/yes)	–		0.94
Achievement orientation (no/yes)	0.42		3.71
Supervision at workplace (no/yes)	0.65		–
Service sector (no/yes)	–		0.63
Legislators, Senior Officials and Managers	0.08		0.14
Scientists	0.18		0.36
Technicians and Associate Professions	0.24		0.23
Clerks	0.11		0.08
Service & Sales Workers	0.10		0.03
Skilled Agricultural & Fishers Workers	0.03		0.01
Craft and Trade Workers	0.18		0.12
Plant and Machinery Operators	0.05		0.02
Elementary occupations	0.03		0.01
Chemical Industry	0.02	employment rank	
Watch industry	0.02	very low	0.01
Machinery	0.08	low	0.05
Other Industry	0.12	middle	0.23
Construction	0.10	high	0.35
Gastronomy	0.03	very high	0.18
Trade	0.10	self employed	0.13
Transportation	0.04	self employed in agriculture	0.02
Banking	0.05		
Insurance and other services	0.07		
Service (School, Science etc.)	0.24		
Public Administration	0.11		
Agriculture	0.02		
Energy	0.01		
N	1226		8155

Table C: Question wording or variable definition in the Swiss Labor Market Survey

Monthly earnings	What is your personal monthly income before tax but after social security deductions?
Schooling	What is your highest schooling grade (recoded into years)
On-the-job training	Age-Education in years-6
Work hours per week	How many hours do you usually work a week?
Gender	What is your sex?
Marital status	What is your marital status?
French part of CH	Respondent lives in the French speaking part of CH
Italian part of CH	Respondent lives in the Italian speaking part of CH
None Swiss Citizen	What is your nationality?
Experienced unemployment	Computed variable from information on employment biography
On-the-job computer use	Do you use a computer at work?
On-the-job Internet use	How many hours a week do you spend on the Internet for work?
E-mail availability at work	Do you have access to e-mail at work?
Internet availability at work	Do you have access to the Internet at work?
PC at home	Do you have a PC at home, which you can use for work?
Achievement orientation	Do you try to work harder than expected at work?
Supervision at workplace	Is supervising others part of your job?
Occupation	International Standard Classification of Occupations (ISCO88)
Sector of employment	In which sector is the company you are employed mostly active?

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SUMMARY

Wage inequality as well as the return to education have increased in recent decades in most OECD countries. Most labor economists agree that the increase in wage inequality is due to increased demand for skilled labor. However, there is disagreement as to whether this increased demand is due to skill-biased technological innovation. Some authors (e.g., KRUEGER, 1993) argue that on-the-job use of new technologies increases productivity, and thus earnings. Others (e.g., DINARDO and PISCHKE, 1997) argue that the adoption of new technologies is simply an indication of higher a priori ability. The present study investigates the effects of on-the-job use of personal computers and the Internet using two different micro-level cross-sectional data sets recently conducted in Switzerland. The results suggest that neither on-the-job use of computers nor on-the-job use of the Internet are rewarded by a wage premium. Thus, the study presented replicates findings by ENTORF, GOLLAC and KRAMARZ (1999) and HAISKEN-DENEW and SCHMIDT (1999) who also found no sizable wage bonus for computer use on the French and German labor market.

ZUSAMMENFASSUNG

Sowohl Einkommensunterschiede als auch Bildungsrenditen haben in den letzten zwei Jahrzehnten in den meisten OECD Staaten zugenommen. Die meisten Arbeitsmarktökonomen stimmen darin überein, dass die gestiegene Einkommensungleichheit auf die gestiegene Nachfrage nach qualifizierten Arbeitskräften zurückgeführt werden kann. Uneinigkeit besteht aber in bezug auf die Frage, ob die gestiegene Nachfrage nach qualifizierten Arbeitskräften mit der technologischen Innovation zusammenhängt. Einige Autoren (z. B. KRUEGER, 1993) glauben, dass die Nutzung neuer Technologien am Arbeitsplatz die Arbeitsproduktivität und damit auch das Einkommen erhöht. Andere Studien (z. B. DINARDO und PISCHKE, 1997) argumentieren, dass die Übernahme neuer Technologien an Arbeitsplätzen stattfindet, die sich sowieso schon durch eine hohe Arbeitsproduktivität auszeichnen. Die vorliegende Studie untersucht die Auswirkungen des Einsatzes von PCs und dem Internet. Die Analyse basiert auf zwei Querschnittserhebungen, die vor kurzem in der Schweiz durchgeführt wurden. Die Ergebnisse der Studie zeigen, dass weder die Nutzung von PCs noch des Internets auf dem Schweizer Arbeitsmarkt mit einem Einkommensbonus prämiert wird. Die präsentierten Befunde bestätigen damit die Untersuchungen von ENTORF, GOLLAC und KRAMARZ (1999) sowie von HAISKEN-DENEW und SCHMIDT (1999), in denen auch keine Einkommensverbesserung aufgrund der Nutzung von PCs für den französischen und deutschen Arbeitsmarkt festgestellt werden konnte.

RESUME

Dans la plupart des pays de l'OCDE, les différences de revenu et le rendement de la formation se sont accrus au cours des deux dernières décennies. La plupart des économistes concordent sur le fait que les différences de revenu plus prononcées sont dues à une demande plus élevée de personnel qualifié. Par contre, la discorde règne sur la question s'il existe un lien entre la demande de personnel qualifié et l'innovation technologique. Certains auteurs (p. ex. KRUEGER, 1993) pensent que l'utilisation de nouvelles technologies augmente la productivité du travail et ainsi le revenu. D'autres études (p. ex. DINARDO et PISCHKE, 1997) soutiennent que les nouvelles technologies sont introduites à des places de travail déjà caractérisées par une productivité du travail élevée. L'article suivant examine les conséquences de l'utilisation des PC et de l'internet. L'analyse se base sur deux enquêtes effectuées récemment en Suisse. Les résultats de cette étude démontrent que ni l'utilisation du PC, ni celle de l'internet n'est rémunérée par un bonus sur le marché du travail suisse. Les résultats présentés ici confirment ceux de ENTORF, GOLLAC et KRAMARZ (1999) ainsi que de HAISKEN-DENEW et SCHMIDT (1999), qui n'ont pas non plus réussi à détecter une amélioration du revenu due aux PC sur les marchés du travail français et allemand.