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THE DISAPPEARING WAGE PREMIUM OF COMPUTER SKILLS*

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ABSTRACT: This paper attempts to shed further light on the effects of computer skills on individual wages using microdata for Finland. The estimation results suggest that the labour market does not reward any computer skills but rather knowledge in using particular computer-based machines. Also the employee's amount of computer knowledge turns out to be of considerable importance. Acquisition of multiple computer skills is found to have a notable impact especially on female wages. Otherwise, female and male employees tend, on average, to be more or less equally rewarded for their work-related computer skills. All in all, the estimation results for Finland seem to suggest that unobserved heterogeneity across employees cannot provide a full explanation of the estimated computer wage premia.

KEY WORDS: computer skills, education, gender, plant size, wages

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TIIVISTELMÄ: Tutkimuksessa tarkastellaan henkilökohtaisen atk-osaamisen vaikutusta palkkoihin Suomen työmarkkinoilla. Tutkimustulosten mukaan työnantajat eivät palkitse mitä tahansa työtehtävien suorittamiseen tarvittavaa atk-osaamista. Atk-laitteita työssään käyttävien ja ei-käyttävien välillä esiintyvä palkkaero näyttää päinvastoin syntyvän määrättyjen atk-laitteiden kuten atk-valvontalaitteiden hallinnasta. Palkkaeroja kasvattaa niinikään useamman atk-laitteen hallinta. Monipuoliset atk-tietotaidot antavat tulosten mukaan etenkin naispalkansaajille selvän palkkaedun. Ylipäänsä Suomea koskevien tulosten perusteella on vaikeaa yhtyä väitteeseen, että atk-laitteiden käyttöön liittyvä palkkaetu voidaan selittää yksinomaan palkansaajien välillä esiintyvillä ei-mitattavissa olevilla ominaisuuksilla.

AVAINSANAT: atk-osaaminen, koulutus, sukupuoli, palkka, toimipaikan koko

Yhteenveto

Tutkimuksessa tarkastellaan henkilökohtaisen atk-osaamisen vaikutusta palkanmuodostukseen Suomen työmarkkinoilla käyttäen Tilastokeskuksen työvoimatutkimusta neljältä vuodelta: 1987, 1989, 1991 sekä 1993. Työvoimatutkimus on toistaiseksi ainoa yksilötason tilastoaineisto, joka sisältää myös kansainvälisesti katsoen laajaa tietoa palkansaajien atk-laitteiden käytöstä työpaikallaan.

Atk-tietotaitojen palkkavaikutusten tutkiminen ei kerro pelkästään sitä, maksetaanko työssään atk-laitteita käyttäville palkansaajille korkeampaa palkkaa kuin muutoin samoja ominaisuuksia omaaville mutta ei atk-työtä suorittaville kollegoille. Yhtä tärkeää on se, että tiedot palkansaajien atk-laitteiden käytöstä avaavat mahdollisuuden tutkia palkkarakenteen suoraa yhteyttä teknologian kehitykseen. Useimmiten tätä yhteyttä on jouduttu selvittämään epäsuoria mittareita käyttäen, kuten esimerkiksi toimihenkilöiden ja työntekijöiden suhteellisten osuuksien ja palkkojen muutoksilla, jolloin toimihenkilöiden oletetaan edustavan osaavia palkansaajia.

Atk-teknologian leviäminen erityyppisiin ammatteihin ja työtehtäviin on Suomessa ollut hyvin nopeata etenkin 1990-luvun alun lamavuosina. Atk-työtä suorittavien osuus kaikista palkansaajista oli 1980-luvun lopussa alle 40 prosenttia, eli samaa suuruusluokkaa kuin Yhdysvalloissa ja Saksassa. Vuoteen 1991 mennessä osuus oli Suomessa noussut noin 51 prosenttiin ja vuoteen 1993 mennessä yli 56 prosenttiin. Ottaen huomioon, että työttömyysaste nousi hyvin voimakkaasti näinä vuosina, voidaan päätellä, että atk-tietotaitoja omaavilla oli selvästi pienempi todennäköisyys jäädä työttömiksi näinä nopeasti huonontuneen työllisyystilanteen vuosina. Sen sijaan atk-laitteita käyttävien jakautuminen eri palkansaajaryhmien keskuudessa on Suomessa, Saksassa ja Yhdysvalloissa hyvin samatyyppistä, suhteellisten osuuksien ollessa suurimmat muun muassa korkeammin koulutettujen, 25-44 vuotiaiden sekä ylempien toimihenkilöiden keskuudessa.

Tutkimustulokset osoittavat, että atk-laitteita käyttäneiden palkkataso oli 1980-lopussa keskimäärin 8–9 prosenttia korkeampi verrattuna muutoin samoja ominaisuuksia omaaviin palkansaajiin, jotka eivät työssään käyttäneet minkääntyyppisiä atk-laitteita. Atk-osaamisesta syntyvä palkkaetu on Suomessa pienempi kuin Saksassa ja Yhdysvalloissa. Koska palkkaerot Suomen työmarkkinoilla on yleisesti ottaen suhteellisen pienet useimpiin muihin teollisuusmaihin verrattuna, tämä on tuskin yllättävä tulos.

1990-luvun lamavuodet näyttävät kuitenkin syöneen atk-osaamiseen liittyvän palkkaedun. Tulokset osoittavat, että atk-laitteita käyttävien henkilöiden palkka-asema on peräti muuttunut ei atk-laitteita käyttävien kollegoiden palkka-asemaa heikommaksi. Tämä viittaisi siihen, että atk-laitteita vaativat työtehtävät ovat entisestään muuttuneet suhteellisen matalapalkkaisiksi rutiinitöiksi.

Tätä väitettä tukee myös se, että tutkimustulosten mukaan työmarkkinoilla ei palkita mitä tahansa atk-laitteen käyttöä työssä. Atk-osaamiseen liittyvä palkkaetu näyttää päinvastoin syntyvän vain määrättyjen atk-laitteiden, kuten esimerkiksi tietokonepäätteen tai atk-valvontalaitteen käyttämisen taidoista. Useampien atk-laitteiden hallintaa palkitaan niinikään selvästi paremmin kuin yhden tai muutaman atk-laitteen hallintaa. Etenkin naiset osoittautuvat hyötyvän palkallisesti monipuolisesta atk-osaamistaan. Muussa suhteessa naisten ja miesten atk-osaamisen palkitsemisessa Suomen työmarkkinoilla ei esiinny merkittäviä eroja.

Kaiken kaikkiaan tutkimustulokset viittaavat siihen, että atk-osaaminen usein antaa selvän palkkaedun, samalla kun se näyttää selvästi nostavan henkilön todennäköisyyttä pysyä työllistettynä myös korkean työttömyyden aikoina. Samanaikaisesti atk-laitteiden käytön nopea leviäminen työympäristössä kuitenkin helposti muuttaa työnantajien asettamia atk-osaamisvaatimuksia, mikä myös heijastuu palkkarakenteeseen. Ylipäänsä Suomea koskevien tulosten perusteella on vaikeaa yhtyä väitteeseen, että atk-laitteiden käyttöön liittyvä palkkaetu on selitettävissä yksinomaan palkansaajien välillä esiintyvillä ei-mitattavissa olevilla ominaisuuksilla.

1. Introduction

In recent years, skill-biased technological change has increasingly been put forth as a major explanation of the changes in the wage structure that have occurred in a majority of industrialised countries. Few studies, however, have reported evidence on there possibly being a direct link between the observed changes in the wage structure and technical progress. A frequently cited exception is the study by Krueger (1993) stating that nearly 40 per cent of the increase in the rate of return to schooling in the US in the 1980s can be attributed to the expansion in computer use at work. His results also indicate that despite a substantial increase in computer utilisation rates in the US labour market, the computer-use wage differential has widened slightly. Moreover, the computer wage premium is found to be approximately the same for men and women.

Recently, however, DiNardo and Pischke (1996) have cast doubt on the Krueger results. Using German data they show that there are large wage differentials associated not only with computer use at work but also with on-the-job use of calculators, telephones, pens/pencils, and work performed while sitting down. They therefore conclude that the estimated returns to computer skills merely reflect unobserved heterogeneity across employees rather than true productivity gains from introducing computers in the workplace. Moreover, the same conclusion is drawn concerning the few studies in which the wage effects of computer use have been estimated from individual-level panel data (see the discussion in DiNardo and Pischke (1996)).

The present study provides further evidence on the effects of computer skills on individual wages based on four cross-sections from the Finnish Labour Force Survey. The Finnish results are of interest for several reasons. First, while the overall pattern of computer utilisation rates among various employee categories are very similar in Finland, Germany and the US, the proportion of employees using computers on the job turns out to be considerably higher in Finland. In the early 1990s, the share of workers who use computers at work amounted to less than 40 per cent in both Germany and the US, which corresponds to the situation in Finland in the late 1980s. By 1993, the share in the Finnish labour market had increased to over 56 per cent, obviously mostly due to the turbulence in the labour market that followed upon the deep recession that the Finnish economy suddenly plunged into in 1991. These differences in work-related computer use can be expected to also affect the estimated wage effects of computer skills and thus provide further insight on the link between technology diffusion and the wage structure.

Second, the data set used allows a fairly detailed investigation of potential wage premia arising from the employee's computer knowledge. More precisely, the labour force survey asks in detail about the respondents' use of computer-based machines on the job and the working time spent using computers. This information opens the possibility to explore not only the wage effects of any computer use on the job, but also of knowledge in using particular computer-based machines as well as of having acquired multiple computer skills.

The estimation results for the late 1980s point to a computer-use wage differential of 8–9 per cent. Despite a comparable proportion of employees using computers at work and similar basic patterns of computer use, the computer wage differential is, on average, clearly lower in Finland than in Germany and the US. This is, however, also to be expected in view of the more compressed wage structure in the Finnish labour market.

The deep recession in the early 1990s causing unemployment rates to rise from 3.5 per cent to some 18 per cent over a three-year period seems, though, not only to have swept away the computer wage differential but also to have put noncomputer users in a more favourable position than their computer-using colleagues. This dramatic change is no doubt, at least partly, to be explained by the explosion in computer use in practically all employee categories following upon rapidly worsening employment. Obviously computer skills and/or willingness to acquire computer skills lowered the probability of becoming unemployed.

But the estimation results also indicate that the labour market does not reward *any* computer skills. On the contrary, the computer wage differential is found to arise from the knowledge in using particular computer-based machines. Also the amount of computer knowledge turns out to be of considerable importance. Acquisition of multiple computer skills seems to have a notable impact especially on female wages. Otherwise, female and male employees tend, on average, to be more or less equally rewarded for their work-related computer skills. On the whole, the estimation results for Finland suggest that unobserved heterogeneity across employees cannot provide a full explanation of the estimated computer wage premia.

The rest of the paper is organised as follows. The next section presents the data and also gives a descriptive analysis of computer use in the Finnish labour market over the period 1987–1993. The methodology is discussed in Section 3, while Section 4 presents the empirical results. Section 5 and 6 relate the rewarding of computer skills to, respectively, the return to education and plant size. Section 7 gives concluding remarks.

2. The data

The analysis is based on four cross-sections from the Labour Force Survey conducted by Statistics Finland. The first two years, 1987 and 1989, represent the top of an economic boom which, at the turn of the decade, suddenly turned into the deepest recession in the Finnish economy since the 1930s. The bottom of the recession was reached in 1991, the third year studied. The analysis stops at 1993[1)], a year showing a weak tendency of recovery especially in the export sectors.[2)]

The biannual labour force survey is the only micro-level database for Finland containing fairly detailed information on people's use of computers at work. Specifically, the respondents are faced with a total of six questions (seven up to 1991) about their use of computers on the job. Based on these answers a summary variable is derived which classifies the respondents into two categories: those who answered at least one of the questions positively, and those who gave a negative answer to all questions, i.e. did not use any type of computers on their job. In addition to this, the workers are also asked about the approximate amount of time they spend using computers. The descriptive analysis of computer use in Finland over the period 1987 to 1993 presented in this section is entirely based on the derived summary variable, while the more specific information available on computer use at work is described and utilised in the subsequent empirical analysis.

Table 1 gives a summary of the main characteristics of workers who report using some type of computer-based machines at work. The overall share of workers using a computer on the job turns out to have almost doubled over the investigated 7-year period, amounting to close to 60 per cent in 1993. It is noteworthy that a major part of the change seems to coincide with the economy reaching the bottom of the recession in 1991.

Women have traditionally been more likely to use computers at work; with the start of the economic recovery this situation was reversed, however. As is to be expected, the probability of using computers on the job increases with the completed educational level. Moreover, the percentage gap in computer use between more educated and less educated workers has widened markedly over the investigated time period. In 1987, workers with an upper secondary education were some 20 percentage points more likely to use computers on their job than workers having, at most, a basic education; by 1993 this gap

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1) The most recent labour force survey covering the year of 1995 is not yet available. Moreover, because of the influence of EU directives, the 1995 survey differs in some important respects from previously conducted labour force surveys, which partly affects the comparability of results across years.

2) For more detailed results concerning Finnish manufacturing, see e.g. Asplund & Vuori (1996).

Table 1. Share (%) of employees in selected categories who use a computer at work, 1987–1993

Employee category	1987	1989	1991	1993
Of all employees	33.0	39.6	50.6	56.4
Gender:				
Men	31.5	38.3	48.9	57.0
Women	34.5	41.0	52.2	55.7
Education:				
Primary education (9 years at most)	23.8	28.4	36.2	41.8
Lower secondary educ. (10–11 years)	24.8	31.1	38.3	42.0
Upper secondary educ. (12 years)	53.5	60.7	70.4	78.4
Short non-university educ. (14 years)	35.6	56.9	69.5	70.5
BA-level (15 years)	50.1	46.0	66.7	66.3
MA-level or more (16+ years)	55.8	62.7	76.9	86.1
Age group:				
Age 16–19	10.9	11.7	22.5	22.1
Age 20–24	30.0	38.0	41.7	40.6
Age 25–34	36.0	46.7	55.8	60.0
Age 35–44	38.3	40.9	54.6	61.6
Age 45–54	27.6	37.8	47.8	53.5
Age 55–64	21.3	27.4	37.8	48.0
Other selected characteristics:				
Tenure less than 1 year	24.6	31.0	38.0	40.8
Employer-financed training during past 12 months	47.7	55.6	67.7	72.6
Unemployment spells during past 12 months	12.4	22.9	34.8	41.4
Part-time job	15.1	25.9	27.5	34.4
Temporary job	21.9	31.5	36.4	45.2
Plant size:				
Less than 11 employees	n.a.	n.a.	38.3	58.2
11 to 19 employees	n.a.	n.a.	44.8	57.7
20 to 49 employees	n.a.	n.a.	50.8	54.6
50 to 99 employees	n.a.	n.a.	59.3	56.8
100 to 199 employees	n.a.	n.a.	59.0	61.8
200 to 499 employees	n.a.	n.a.	61.3	55.2
500 employees or more	n.a.	n.a.	70.9	67.3
Plant size unknown	n.a.	n.a.	24.7	54.8

Table 1. (cont.)

Employee category	1987	1989	1991	1993
Socio-economic status:				
Upper management	64.6	75.6	80.3	95.5
Engaged in research and planning	64.3	78.2	82.8	95.2
Engaged in education and training	31.2	39.7	63.5	75.2
Other senior officials and employees	41.8	52.9	65.6	67.4
Supervisors	46.9	54.9	65.4	75.8
Independent clerical and sales work	58.1	67.0	77.8	80.7
Routine clerical and sales work	69.3	82.8	88.1	99.1
Other lower-level employees	19.1	28.7	40.9	44.8
Workers in agriculture etc.	4.8	8.2	9.3	18.6
Manufacturing workers	17.9	22.9	26.9	34.9
Other production workers	15.3	18.7	25.2	30.6
Distribution and service workers	9.8	12.9	19.1	23.0
Industry sector:				
Agriculture, forestry and fishing	11.9	21.1	26.4	32.6
Mining and quarrying	16.5	-	50.6	49.3
Food manufacturing	27.4	42.5	43.1	50.1
Textile	11.8	25.3	29.1	30.9
Manuf. of wood products	23.9	19.0	40.2	33.8
Manuf. of paper products	46.9	53.7	68.3	65.6
Manuf. of chemicals	46.2	59.7	59.0	64.6
Manuf. of non-metallic products	34.4	27.8	51.1	40.1
Basic metal industries	66.1	46.0	60.2	78.9
Manuf. of metal products	39.7	43.5	56.2	64.2
Other manufacturing	50.3	-	46.5	78.7
Construction	11.5	13.5	21.7	24.3
Energy and water supply	41.8	51.8	56.4	61.8
Wholesale trade	55.4	58.7	67.3	69.7
Retail trade	43.2	51.4	57.2	65.4
Hotels and restaurants	29.0	32.4	33.3	52.2
Transport	25.1	36.2	43.8	49.3
Communication	36.9	44.0	51.2	62.6
Finance	88.5	91.2	91.7	95.2
Insurance	90.1	94.7	100.0	90.7
Real estate, cleaning and rental serv.	51.0	18.4	23.5	26.8
Technical and business services	-	72.3	80.4	84.7
Public administration and defense	41.6	52.8	69.2	82.6
Education and research	2.6	37.5	55.5	65.2
Health and social welfare services	18.9	20.3	31.6	35.6
Recreational and cultural services	24.3	32.4	57.7	69.2

had increased to 37 percentage points. The difference is even larger when comparing basic education with the MA-level: 32 points in 1987 and almost 45 points in 1993.

The probability of using computers at work has persistently been highest among workers aged 25–44. Computer use, however, turns out to be relatively common also among older workers; by 1993 far more common than in the youngest age groups. It is also noticeable that the increase in computer use between 1987 and 1993 correlates positively with age. Krueger (1993) reports similar results for the US, and finds them surprising. Possible explanations of the relatively low probability of young employees of using computers on the job are short tenure, little access to employer-financed training and part-time or temporary employment, as indicated by the figures given in the table.

The 1991 and 1993 labour force surveys also contain employee-reported categorised data on plant size. The figures for 1991 clearly point to rising computer use with the size of the plant in which the employee is working. Over 70 per cent of the workers in plants with more than 500 employees report using computer-based machines compared to a share of less than 40 per cent in plants with less than 11 employees, giving a differential of over 30 percentage points. The computer-intensity in different-sized plants is much more similar for 1993 which may, however, be partly explained by the considerable amount of missing information on plant size in the 1993 labour force survey.

Classifying all sample workers according to their socio-economic status reveals widespread computer use especially at the upper management level and among employees engaged in research and planning and in routine clerical and sales work. The probability of using computers at work was very high in these three socio-economic categories already in 1987 and had, by 1993, increased to close to 100 per cent. Manual workers, on the other hand, were still in 1993 much less likely to use computers on their job; the largest share (some 35 per cent) is noted for manufacturing workers.

Grouping the employees according to their industry affiliation, finally, displays substantial differences in computer use across industries.[3)] Computer use is extremely widespread in the finance and insurance sectors, whereas the share of employees using computers at work was still in 1993 relatively low in the agriculture, textile, wood products, construction and cleaning and rental services industries. In most of the other industries over 60 per cent of the employees use some type of computers on their job.

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3) Some of the 2-digit industry sectors are not fully comparable between 1987 and 1989 because of a change in the classification of industries in 1988.

3. Methodology

The previous analysis has clearly revealed that the computer utilisation rate varies markedly across employee categories. Also the growth in computer use within the different employee categories shows notable variation with, still in 1993, a relatively limited share of employees using computer-based machines in some categories compared to a coverage approaching 100 per cent in certain educational, age, socio-economic, industry and plant-size categories.[4] Simultaneously we know from previous empirical studies of individual wage determination in the Finnish labour market that much the same employee and employer characteristics are estimated to give rise to significant wage premiums also after having controlled for a broad set of potential wage-related background variables.[5]

In view of this, two interrelated questions may be raised: Do employees who use computers on their job earn more than observationally identical employees who report no computer use at work, i.e. do computer skills have an independent effect on the wage level? If yes, does the wage premium for using computers affect – and in which direction – the estimated wage gap between differently educated employees? Following Krueger (1993), answering these types of questions can, in effect, be argued to provide direct evidence on the impact of technological change on relative wages; the rapid expansion in computer technology has no doubt contributed substantially to recent technological progress. The dynamic perspective allowed for by the used data set and, moreover, over an extremely turbulent economic period definitely underscores the relevance of the above questions.

To answer these questions a conventional cross-sectional wage function supplemented with variables containing information about the individuals' use of computer-based machines on the job is estimated for each of the four years investigated. Specifically, log (before-tax) hourly wages are regressed on a broad set of personal and job-related characteristics: formal education, (actual) work experience, tenure, participation in employer-financed training, gender, family responsibilities, socio-economic status, location of residence, industry affiliation, plant size, previous unemployment spells, pay scheme, working time, employment status (part-timer, temporary worker), and union membership.

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[4] Nonetheless it may be argued that neither the computer-intensity across employee categories nor the growth in computer use within employee categories seem to display such a clear-cut pattern or systematic trend to question the assumption of a nonrandom selection of the employees who use computers at work.

[5] See e.g. Albæk et al. (1996), Asplund (1993,1997) and Wadensjö (1996).

Initially only the summary variable derived from the more specific information available on computer use, is added to the wage equation. The analysis is thereafter extended to allow for individual differences in the type and amount of computer use on the job. These variables are presented in more detail when discussing their estimated wage effects.

All reported estimation results are obtained using ordinary least squares techniques (OLS). Attempts were also made to correct for potential sample selection bias in the estimates by implementing the full-information maximum likelihood estimator (FIML). And for some of the years investigated the estimation results did point to non-negligible sample selection problems. The OLS estimates are, nevertheless, preferred for two main reasons. First, the Heckman correction for sample selection has, in recent years, been subject to serious critique, not least due to the usually high correlation between the exogenous variables in the selection equation and the main equation making even the FIML estimator very unrobust. Implementing the methods suggested by Puhani (1997) revealed, indeed, collinearity problems in the data.[6] Second, the OLS and the FIML estimators produced highly similar parameter estimates; the coefficients estimated for the computer variables were almost identical.

4. Empirical results

Table 2 gives the wage premia estimated for employees using some type of computers at work. The wage advantage of male employees over their non-using colleagues amounted to between 6½ and 8½ per cent in the years 1987 to 1991.[7] Moreover, only in 1987 were women in computer work rewarded significantly less than their male counterparts. By 1993, however, the wage premium of computer skills had disappeared among both genders.

The estimation results obtained for 1993 further indicate that if also controlling for the working time that the employee spend using a computer, then computer usage at work turns into a demerit of close to 10 per cent, irrespective of gender. Simultaneously the coefficients estimated for the dummies capturing differences in computer usage time reveal a pattern that is specific to 1993; for previous years the coefficients estimated for

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[6] Puhani (1997) suggests two methods for investigating the potential presence of collinearity problems in the data: calculating either R^2 of the regression of the inverse Mills' ratio on the regressors of the main equation, or the corresponding condition number.

[7] Tossavainen (1994) reports for Finland a computer wage premium ranging from 7.2 per cent to 8.5 per cent depending on the specification of the wage model, estimated from the 1987 Labour Force Survey.

Table 2. Estimated wage premia for employees using a computer at work, 1987–1993. The dependent variable is the log hourly wage.

Variable	1987	1989	1991	1993	
Computer use (dummy = 1)	0.084* (.015)	0.081* (.014)	0.064* (.014)	0.006 (.018)	-0.091** (.038)
Computer use * Woman (dummy = 1)	-0.048* (.021)	-0.033 (.019)	-0.005 (.018)	0.041 (.024)	0.098 (.064)
Controls for working time spent using a computer	no	no	no	no	yes
R^2 adj.	0.455	0.469	0.503	0.441	0.441
SEE	0.276	0.279	0.270	0.286	0.287
F-statistic	51.29*	58.31*	63.98*	31.61*	27.14*
No of obs.	3797	4217	4101	2524	2524

Notes: Standard errors are given in parentheses below the estimates and are adjusted for heteroskedasticity according to White (1980). Other control variables included in the estimations are: completed educational degree (6 levels), gender, married, small or school-aged children, work experience (6 splines), tenure (dummy for tenure < 1 year, tenure, tenure squared), participation in employer-financed training, socio-economic status (12 categories), 2-digit industry sectors (28 categories), residence in capital area, part-time work, temporary work, regular day-time work, piece-rate pay scheme, previous unemployment spells, union membership. Definitions and full estimation results are available from the author upon request.

* Denotes significant estimate at a 1 per cent level.
** Denotes significant estimate at a 5 per cent level.

the time dummies are throughout insignificant.[8)] Employees using, at most, half of their working time at a computer are found to have earned, in 1993, some 10 to 12 per cent more than their colleagues in more computer-intensive jobs and in noncomputer jobs, suggesting that routine computer work has been degraded to the same ranking level as noncomputer jobs. The results point to no significant differences between men and women in this respect.

The dramatic change in the rewarding of computer skills that seems to have occurred between the deep recession year of 1991 and the weak recovery year of 1993 may, at least to some part, origin in a revaluation of different computer skills due to the explosion in computer use in a wide variety of working tasks. The wage equations were

8) The data classify the employees using a computer at work into five groups: those who use a computer all the time, those who use a computer during, respectively, around 75 per cent, 50 per cent and 25 per cent of their working time, and those whose computer use covers less than 25 per cent of their working time.

Table 3. Estimated wage premia by kind of computer use, 1987–1993

Variable	1987	1989	1991	1993	
ADB1: Computer cash register or cash reg. terminal	-0.077 (.043)	0.013 (.060)	-0.047 (.036)	-0.033 (.036)	-0.022 (.038)
ADB2: Computer terminal	0.087* (.018)	0.045* (.016)	0.028 (.015)	0.034 (.020)	0.052** (.023)
ADB3: Micro-computer	0.042 (.022)	0.036 (.019)	0.035** (.017)	-0.009 (.022)	0.010 (.024)
ADB4: Programmable machine tool	-0.005 (.033)	0.009 (.027)	0.014 (.042)	-0.070 (.041)	-0.055 (.042)
ADB5: Computer monitoring equipment	0.078* (.025)	0.087* (.021)	0.090* (.023)	0.024 (.027)	0.034 (.028)
ADB6: Some other computer	0.014 (.025)	0.039** (.019)	0.027 (.018)	0.042 (.022)	0.054** (.024)
ADB1 * Woman	0.080 (.048)	-0.014 (.062)	0.064 (.040)	0.013 (.044)	-0.007 (.045)
ADB2 * Woman	-0.056** (.022)	-0.006 (.021)	0.018 (.019)	-0.018 (.026)	-0.066** (.032)
ADB3 * Woman	-0.003 (.031)	0.042 (.026)	-0.012 (.021)	0.041 (.027)	0.004 (.030)
ADB4 * Woman	-0.001 (.063)	-0.054 (.052)	0.004 (.071)	0.095 (.089)	0.067 (.091)
ADB5 * Woman	-0.071 (.085)	-0.039 (.052)	-0.127** (.052)	0.051 (.058)	0.032 (.059)
ADB6 * Woman	0.029 (.053)	-0.004 (.036)	0.070 (.042)	-0.011 (.035)	-0.024 (.038)
Controls for working time spent using a computer	no	no	no	no	yes
R^2 adj.	0.457	0.470	0.505	0.441	0.442
SEE	0.276	0.278	0.270	0.286	0.286
F-statistic	44.69*	50.78*	56.10*	27.20*	24.20*
No of obs.	3797	4217	4101	2524	2524

Notes: See Table 2 above.

* Denotes significant estimate at a 1 per cent level.

** Denotes significant estimate at a 5 per cent level.

therefore re-estimated augmented with dummies for the six types of computer use asked in the questionnaire: computer cash register or cash register terminal, computer terminal, micro-computer, programmable machine tool, computer monitoring equipment, or some other computer.

The estimation results displayed in *Table 3* point to significant variation in wage premia conditional on the type of computer-based machines used on the job. Employees using computer monitoring equipment seem to have gained the most from their computer skills. Their wage advantage amounted to close to 10 per cent still in the deep recession year of 1991 but had, by 1993, turned negligible. Their female colleagues were significantly less rewarded only in 1991.

An almost equally dramatic change is observable among employees using a computer terminal. Their wage advantage was halfed during the boom years in the late 1980s, and fell further during the deep recession. If again controlling for computer usage time for 1993, their relative wage position seems, however, to be recovering. But simultaneously also the different rewarding of computer terminal skills across genders is reappearing.

The other four categories of computer skills mostly reveal no significant wage premia compared to noncomputer users. This holds for both genders. A cautious generalization of the results would thus be that the rewarding in the labour market of computer use is clearly concentrated to particular computer skills, albeit the wage advantage shows a declining trend over the investigated time period. And in most cases women gain as much as their male colleagues from their computer knowledge.

It is also noticeable that in contrast to what would perhaps be expected, the estimated wage premia of the six computer usage categories do not correlate with the relative share of employees using different computer-based machines; significant wage premia show up both for small and large computer usage categories (cf. Table A1 in the Appendix). The vary stable shares of the six computer usage categories among employees using a computer on the job, in turn, suggest that the declining trend in the wage premia of computer skills might, at least in part, be explained by a larger increase in the supply than the demand for computer skills.

Relative to all employees, however, the shares of the six computer use categories rose rapidly during the deep recession years in the early 1990s consequent on the enormous loss of jobs (almost half a million jobs within three years) and especially among older,

Table 4. Estimated wage premia by amount of computer skills, 1987–1993

Variable	1987	1989	1991	1993	
ADBSUM1: One type of computer use	0.073* (.017)	0.065* (.017)	0.064* (.016)	-0.024 (.021)	-0.124* (.044)
ADBSUM2: Two types of computer use	0.138* (.024)	0.094* (.020)	0.073* (.019)	0.033 (.025)	-0.062 (.044)
ADBSUM3: Three types of computer use	0.094* (.037)	0.119* (.030)	0.072* (.027)	0.053 (.029)	-0.046 (.050)
ADBSUM4: At least four types of computer use	0.133* (.039)	0.160* (.037)	0.160* (.051)	0.029 (.047)	-0.057 (.063)
ADBSUM1 * Woman	-0.040 (.023)	-0.022 (.022)	-0.017 (.021)	0.073* (.028)	0.133** (.068)
ADBSUM2 * Woman	-0.078** (.034)	-0.025 (.028)	0.005 (.024)	0.010 (.032)	0.067 (.068)
ADBSUM3 * Woman	-0.104** (.050)	-0.052 (.046)	0.008 (.047)	-0.024 (.044)	0.037 (.078)
ADBSUM4 * Woman	-[1)]	-0.079 (.080)	0.025 (.072)	0.183 (.098)	0.246** (.121)
Controls for working time spent using a computer	no	no	no	no	yes
R^2 adj.	0.458	0.470	0.505	0.442	0.442
SEE	0.276	0.278	0.270	0.286	0.286
F-statistic	47.49*	53.56*	59.02*	28.76*	25.35*
No of obs.	3797	4217	4101	2524	2524

Notes: See Table 2 above.

* Denotes significant estimate at a 1 per cent level.
** Denotes significant estimate at a 5 per cent level.
[1)] The estimate is based on two observations only and is therefore not reported.

less educated employees.[9)] An equally plausible explanation therefore is that the wage differentials arising from work-related computer use have simply been driven down by the large relative increase in the number of employees using computers on the job.

[9)] For more details on the winners and losers in the turbulent Finnish labour market in the late 1990s, see e.g. Asplund & Vuori (1996).

In view of the results presented so far the question arises whether the explosion in computer skills and the turbulence in the Finnish labour market in the early 1990s possibly shifted the attention from particular computer skills *per se* to the rewarding of the employees' amount and combination of computer skills. The wage equations were therefore re-estimated with the dummies for type of computer usage replaced with dummies reflecting the amount of various computers used on the job. In particular, the employees using computers were classified into four categories according to their number of affirmative answers to the specific computer usage questions analysed separately above. The first category is made up of those having answered only one of the questions positively, a category the share of which declined from 63 per cent in 1987 to 51 per cent in 1993 (see Table A1 in the Appendix). The second and third categories comprise employees having answered, respectively, two or three questions positively, while the forth category covers those with an extremely wide use of computers (four or more questions were given affirmative answers).

The estimates reported in *Table 4* point to a clear increase in the wage premium with the amount of computer skills, a tendency that strengthened further up to 1991. Hence, the steadily growing share of employees being able to handle more than one type of computers does not seem to have lowered the rewarding of multiple computer skills. The disadvantageous situation observed for women in 1987 had disappeared already by 1989.

Again, however, 1993 stands out as a trend breaker. Adding controls for computer usage time displays a pattern indicating that female employees specialised in merely one type of computer use gain from their skills while their male counterparts face a demerit from such a specialisation. The wage premium of work-related computer use turns out to be even larger if the female employee has very broad computer knowledge. Thus in contrast to their male colleagues women seem to gain either from specialising in a particular type of computers or acquiring multiple computer skills.

5. Computer skills and returns to schooling

It could be expected that the individuals' computer skills reflect, at least in part, their acquired human capital in general and educational achievement in particular. Krueger (1993), for instance, reports for the US that nearly 40 per cent of the increase in the return to schooling between 1984 and 1989 can be attributed to the expansion in computer use.

Table 5. Estimated impact of computer use on the average return to education with schooling defined both in years and by degree level, 1987–1993

Variable	1987		1989		1991		1993	
	No computer control	Computer control	No computer control	Computer control	No computer control	Computer control	No computer control	Computer control
Years of schooling	0.081* (.003)	0.077* (.003)	0.082* (.003)	0.078* (.003)	0.086* (.003)	0.082* (.003)	0.080* (.004)	0.077* (.004)
R^2 adj.	0.384	0.392	0.396	0.406	0.437	0.445	0.383	0.388
SEE	0.294	0.292	0.297	0.295	0.288	0.285	0.301	0.300
F-statistic	52.35	53.04	58.5	59.69	66.00	66.82	33.01	32.97
No of obs.	3797	3797	4217	4217	4101	4101	2524	2524
Educational level:								
Primary	0	0	0	0	0	0	0	0
Lower secondary	0.060* (.012)	0.057* (.012)	0.053* (.011)	0.050* (.011)	0.049* (.012)	0.046* (.011)	0.050* (.015)	0.049* (.015)
Upper secondary	0.204* (.017)	0.184* (.017)	0.196* (.015)	0.175* (.015)	0.199* (.014)	0.179* (.015)	0.162* (.019)	0.146* (.019)
Short non-university	0.397* (.023)	0.385* (.023)	0.381* (.022)	0.359* (.022)	0.421* (.021)	0.399* (.022)	0.351* (.030)	0.334* (.030)
BA-level	0.496* (.030)	0.475* (.029)	0.478* (.034)	0.468* (.035)	0.495* (.026)	0.478* (.026)	0.441* (.040)	0.429* (.040)
MA-level or more	0.609* (.026)	0.583* (.026)	0.635* (.026)	0.610* (.026)	0.625* (.023)	0.602* (.023)	0.599* (.029)	0.580* (.029)
R^2 adj.	0.398	0.406	0.412	0.421	0.455	0.463	0.397	0.402
SEE	0.290	0.289	0.293	0.291	0.283	0.281	0.297	0.296
F-statistic	51.26	51.82	57.83	58.95	65.69	66.42	32.40	32.35
No of obs.	3797	3797	4217	4217	4101	4101	2524	2524

Notes: For notes, see Table 2. The reported educational returns are estimated from wage equations excluding controls for the individuals' socio-economic status. The effects of computer use on educational returns are, however, of the same magnitude when also controlling for differences in socio-economic status.

* Denotes significant estimate at a 1 per cent level.

The estimation results for Finland, in contrast, reveal no such trend. The average return to additional years in schooling displayed in *Table 5* varies over time in the same way irrespective of whether computer skills are controlled for or not. The change in the return to schooling years when also controlling for computer use is, in fact, insignificant for all four years according to a simple t-test. Adding controls for the individuals' socio-economic status produces the same outcome.

The returns estimated to various educational degrees are not affected by the inclusion of a computer use dummy, either *(Table 5 lower panel)*. In other words, the computer wage differential does not seem to be larger for more highly educated workers. Interacting the computer dummy with the years of schooling variable points in the same direction; the coefficient estimated for the interaction term is throughout insignificant. Also in this respect the Finnish results differ clearly from those reported by Krueger (1993); in the US the wage premium of computer use tends to increase with education. The Finnish outcome can, at least in part, be explained by fairly small wage differentials between differently educated individuals (see Wadensjö, 1996), and by wage growth having been on average equally fast in low-tech, slowly growing industries as in high-tech, fast growing industries (Asplund and Vuori, 1996)

6. Computer skills and plant size

The CPS data used by Krueger (1993) do not include information on employer size. He refutes the objection that the computer wage premium merely reflects the impact of omitted employer size by refering to the findings by Hirschorn (1988) and Reilly (1995). Both studies point to a relatively weak relationship between computer skills and plant size, leaving the computer wage premium almost unchanged when introducing plant size as a regressor in the wage equation. Indeed, it is rather the plant size than the computer skills effect on wages that disappears when controlling for differences both in computer access and in plant size.[10)]

The data used in the present study allow the potential interrelationship between employer size and computer wage differentials to be tested for the early 1990s. Both the 1991 and the 1993 Labour Force Survey contains self-reported information on the size of the individual's working place categorised into seven plant-size classes (see Table 2 above).

[10)] A strong relationship between measures of the use of computer-based machines and plant size with the size-wage premia being reduced when controlling for advanced technology is also reported by Dunne and Schmitz (1995).

Table 6. Estimated wage premia for employees using a computer at work with and without controls for plant size, 1991 and 1993

Variable	1991		1993			
	No plant size controls	With plant size controls	No plant size controls	With plant size controls	No plant size controls	With plant size controls
Computer use	0.064*	0.054*	0.006	0.007	-0.091**	-0.098**
	(.014)	(.014)	(.018)	(.018)	(.038)	(.038)
Computer use * Woman	-0.005	-0.010	0.041	0.040	0.098	0.105
	(.018)	(.018)	(.024)	(.024)	(.064)	(.065)
Controls for working time spent using a computer	no	no	no	no	yes	yes
R^2 adj.	0.503	0.512	0.441	0.440	0.441	0.440
SEE	0.270	0.268	0.286	0.287	0.287	0.287
F-statistic	63.98*	59.84*	31.61*	28.18*	27.14*	24.86*
No of obs.	4101	4101	2524	2524	2524	2524

Notes: See Table 2.

* Denotes significant estimate at a 1 per cent level.
** Denotes significant estimate at a 5 per cent level.

In assessing the results to be reported below due allowance should, however, be made for two facts: first, 1991 represents the bottom of an extremely deep economic recession and second, for 1993 the share of missing plant-size information amounts to as much as 52 per cent in the estimation sample.

The parameter estimates obtained for the computer use dummy and its interaction with gender when adding plant-size dummies to the wage equation are given in *Table 6*. For convenience, the table also reproduces the corresponding estimates reported in Table 2 above when not controlling for differences in plant size.

The table clearly shows that the estimated computer wage premia do not simply capture omitted employer size-wage effects. On the contrary, the computer estimates change only marginally when adding controls for plant size. The outcome is exactly the same when replacing the single computer use dummy with the dummies reflecting kind of computer use or amount of computer skills. These results are given in Tables A2 and A3 of the Appendix.

7. Concluding remarks

The results reported in this paper indicate that the rapid spread of computer-based technologies within practically all employee categories in combination with the turbulence that the Finnish economy experienced in the early 1990s has swept away the computer wage premia that characterised the Finnish labour market still in the deep recession year of 1991. Indeed, in 1993, noncomputer users seem even to have been in a more favourable wage position than their computer-using colleagues. Moreover, no significant differences can be found between men and women in this respect.

Attempts were also made to explore whether the use of a summary variable reflecting any use of computers on the job is likely to hide potential shifts in the demand towards specific computer skills. The estimation results do point to significant variation in wage premia conditional on the type of computer-based machines used on the job but, again, only up to 1991. For 1993, the only noticeable finding is a weak recovering of the wage premium linked to computer terminal usage, but only among male employees.

The estimation results do support the hypothesis that the employers' attention have to some extent shifted from the employees' knowledge in using a particular type of computer-based machines to their total amount of computer knowledge. But this increase in the computer wage premium with the amount of computer skills is discernible up to 1991 only. Again 1993 stands out as a trend breaker, sweeping away the rewarding also of multiple computer skills but, interestingly, among men only; female employees with broad knowledge of computer-based machines seems to have been able to retain their favourable position in the labour market.

The results further indicate that accounting for the employees' computer skills does not affect the estimated returns to education. There is also no tendency of the computer wage differential of being larger for more highly educated workers. These results for Finland contrast sharply with results reported by Krueger (1993) for the US. In accordance with previous international evidence, however, also the Finnish results imply that the estimated computer wage differentials do not merely reflect the impact of omitted employer size. In fact, adding controls for plant size affects the computer premia only marginally.

To conclude, the estimation results suggest that the labour market does not reward *any* computer skills. Instead most of the estimated computer wage premia seem to originate in the knowledge of using particular computer-based machines, preferrably in

combination with some other strategic computer knowledge. The computer wage differential also seems to be very sensitive to changes in the computer intensity in the working environment, as indicated by the dramatic drop in the wage effects of computer skills that occurred in the early 1990s. A rapid spread of computers both vertically and horisontally in the job hierarchy turns out to exert an almost immediate influence on the rewarding of work-related computer use, pointing to a strong impact of supply and demand factors.

But simultaneously the Finnish results display a clear tendency of a renewed differentiation in wages linked to computer skills with the "normalisation" of the labour market situation. When contrasting all these findings to the discussion in DiNardo and Pischke (1996) of the role of unobserved heterogeneity across employees, it seems unlikely that the computer wage premia estimated for the Finnish labour market merely capture the wage effect of unobserved skills of computer users not possessed by their colleagues using no computers whatsoever at work.

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Table A1. Sample means for those having reported some use of computers on the job, 1987–1993

	1987	1989	1991	1993
Number of respondents reporting use of computer-based machines on the job	1254	1671	2073	1423
Share in the total number of obs.	33.0	39.6	50.6	56.4
Computer use * Woman	17.6	20.4	26.7	29.8
Kind of computer use:				
ADB1: Computer cash register or cash register terminal	13.3	13.9	11.1	12.0
ADB2: Computer terminal	67.3	66.1	67.7	69.7
ADB3: Micro-computer	31.6	39.6	49.7	55.7
ADB4: Programmable machine tool	5.7	6.6	4.1	4.4
ADB5: Computer monitoring equipment	8.0	9.2	7.8	7.7
ADB6: Some other computer	12.9	15.4	13.2	15.3
ADB1 * Woman	10.6	11.2	8.5	8.9
ADB2 * Woman	38.0	35.7	37.2	38.4
ADB3 * Woman	13.4	18.1	25.1	27.9
ADB4 * Woman	1.8	1.8	0.7	1.0
ADB5 * Woman	1.1	1.5	1.0	1.3
ADB6 * Woman	3.3	3.8	3.2	3.6
Amount of computer skills:				
ADBSUM1: One type of computer use	62.8	59.3	56.0	50.8
ADBSUM2: Two types of computer use	25.0	28.2	32.7	36.8
ADBSUM3: Three types of computer use	5.8	7.2	6.9	9.6
ADBSUM4: Four or more types of computer use	2.0	3.2	2.8	2.8
ADBSUM1 * Woman	35.0	32.5	31.6	29.2
ADBSUM2 * Woman	12.9	14.3	17.1	19.7
ADBSUM3 * Woman	2.3	2.5	2.6	3.4
ADBSUM4 * Woman	0.2	0.8	0.6	0.6
Total number of observations	3797	4217	4101	2524
Share of women	51.0	49.9	51.1	52.3

Table A2. Estimated wage premia by kind of computer with and without controls for plant size, 1991 and 1993

Variable	1991		1993			
	No plant size controls	With plant size controls	No plant size controls	With plant size controls	No plant size controls	With plant size controls
ADB1: Computer cash register ...	-0.047	-0.043	-0.033	-0.032	-0.022	-0.022
	(.036)	(.035)	(.036)	(.037)	(.038)	(.038)
ADB2: Computer terminal	0.028	0.016	0.034	0.035	0.052**	0.051**
	(.015)	(.014)	(.020)	(.020)	(.023)	(.024)
ADB3: Micro-computer	0.035**	0.032**	-0.009	-0.010	0.010	0.008
	(.017)	(.016)	(.022)	(.022)	(.024)	(.024)
ADB4: Programmable machine tool	0.014	0.009	-0.070	-0.071	-0.055	-0.056
	(.042)	(.041)	(.041)	(.041)	(.042)	(.042)
ADB5: Computer monitoring equipment	0.090*	0.093**	0.024	0.026	0.034	0.035
	(.023)	(.023)	(.027)	(.027)	(.028)	(.028)
ADB6: Some other computer	0.027	0.028	0.042	0.041	0.054**	0.053**
	(.018)	(.019)	(.022)	(.022)	(.024)	(.023)
ADB1 * Woman	0.064	0.064	0.013	0.010	-0.007	-0.009
	(.040)	(.039)	(.044)	(.044)	(.045)	(.046)
ADB2 * Woman	0.018	0.018	-0.018	-0.019	-0.066**	-0.066**
	(.019)	(.019)	(.026)	(.026)	(.032)	(.032)
ADB3 * Woman	-0.012	-0.017	0.041	0.043	0.004	0.007
	(.021)	(.021)	(.027)	(.027)	(.030)	(.031)
ADB4 * Woman	0.004	-0.001	0.095	0.087	0.067	0.061
	(.071)	(.071)	(.089)	(.089)	(.091)	(.091)
ADB5 * Woman	-0.127**	-0.127**	0.051	0.052	0.032	0.034
	(.052)	(.052)	(.058)	(.058)	(.059)	(.059)
ADB6 * Woman	0.070	0.067	-0.011	-0.009	-0.024	-0.021
	(.042)	(.041)	(.035)	(.035)	(.038)	(.038)
Working time spent using a computer	no	no	no	no	yes	yes
R^2 adj.	0.505	0.514	0.441	0.440	0.442	0.441
SEE	0.270	0.267	0.286	0.287	0.286	0.286
F-statistic	56.10*	53.14*	27.20*	24.92*	24.20*	22.38*
No of obs.	4101	4101	2524	2524	2524	2524

Notes: See Table 2 in the text.

Table A3. Estimated wage premia by amount of computer skills with and without controls for plant size, 1991 and 1993

Variable	1991		1993			
	No plant size controls	With plant size controls	No plant size controls	With plant size controls	No plant size controls	With plant size controls
ADBSUM1: One type of computer use	0.064*	0.056*	-0.024	-0.022	-0.124*	-0.129*
	(.016)	(.016)	(.021)	(.021)	(.044)	(.044)
ADBSUM2: Two types of computer use	0.073*	0.059*	0.033	0.033	-0.062	-0.069
	(.019)	(.019)	(.025)	(.025)	(.044)	(.045)
ADBSUM3: Three types of computer use	0.072*	0.062*	0.053	0.052	-0.046	-0.053
	(.027)	(.027)	(.029)	(.029)	(.050)	(.050)
ADBSUM4: Four+ types of computer use	0.160*	0.154*	0.029	0.029	-0.057	-0.063
	(.051)	(.051)	(.047)	(.047)	(.063)	(.063)
ADBSUM1 * Woman	-0.017	-0.023	0.073*	0.072*	0.133**	0.138**
	(.021)	(.021)	(.028)	(.028)	(.068)	(.069)
ADBSUM2 * Woman	0.005	0.002	0.010	0.009	0.067	0.074
	(.024)	(.024)	(.032)	(.032)	(.068)	(.069)
ADBSUM3 * Woman	0.008	-0.002	-0.024	-0.025	0.037	0.044
	(.047)	(.047)	(.044)	(.044)	(.078)	(.079)
ADBSUM4 * Woman	0.025	0.027	0.183	0.178	0.246**	0.248**
	(.072)	(.071)	(.098)	(.098)	(.121)	(.122)
Working time spent using a computer	no	no	no	no	yes	yes
R^2 adj.	0.505	0.513	0.442	0.441	0.442	0.441
SEE	0.270	0.268	0.286	0.286	0.286	0.286
F-statistic	59.02*	55.61*	28.76*	26.21*	25.35*	23.35*
No of obs.	4101	4101	2524	2524	2524	2524

Notes: See Table 2 in the text.

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