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Computer Use and the Wage Structure in Austria

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Abstract

In this paper we examine the relationship between computer premium and job position in Austria. We estimate cross-section wage equations and control for selectivity of computer use via a treatment effects model. We find that the size of the wage effect attributed to computer use varies significantly between job hierarchies. Persons in higher positions receive relatively lower rewards for computer use than workers at lower hierarchy levels. Overall we find that computerisation increased wage inequality in Austria. However, hierarchy-related differences in the relative computer premium in Austria might moderate the effects of computer use on the wage distribution.

Keywords

Technological change, computer wage premium, wage inequality

JEL Classification

C21, J30, O33

Comments

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Contents

I Introduction

The influence of technological change on the labour market chances of workers with different skill levels is hotly debated in the scientific literature (see e.g. Acemoglu 2002 for an overview). The skill-biased technological change hypothesis states that the recent rise in wage inequality in the US is caused by skill-biased technological change, associated in part with new computer technologies (see e.g. Autor et al. 1998, Autor and Katz 1999, Katz 1999, Card and DiNardo 2002 for overviews).

In his seminal paper Krueger (1993) reports a 15 - 20% wage premium attributed to computer use at the work place. Several studies also using cross sectional wage regressions confirmed this finding for different countries (see e.g. DiNardo and Pischke 1997, Haisken-DeNew and Schmidt 1999 for Germany; Entorf, Gollac and Kramarz 1999 for France, Bell 1996 for UK), even though studies using panel data techniques found a considerably smaller computer premium than Krueger did (Entorf, Gollac and Kramarz 1999, Haisken-DeNew and Schmidt 1999). Using panels of workers of the same age, Dolton and Makepeace (2002) try to disentangle the premium attached to the individual intrinsic ability to adapt and to learn and the premium for the skill to use a computer, which can be taught. They use computer use in 2000 as a proxy for ability in 1991, and find evidence that future computer use raises current earnings by 4% for men and insignificantly for women. Assuming that the effects of ability are constant over time, their estimates imply that returns on computer use net of ability amount to 8% for men and 2% (insignificant) for women. This result together with a series of technically different approaches convinces them of the existence of a considerable rate of return to computer use in the UK, which is not biased by unobserved ability.

Most empirical research shows that more well educated than less educated workers are users of new technologies, and technical change is likely to be skill-biased. It is therefore straightforward to link an analysis of returns to education with the question of a wage premium for computer users. Using data of a British cohort, Bell (1996) finds that the introduction of a computer dummy dramatically reduces the rise in the estimated returns to education over the 1980s. He interprets these results as indicative of large skill-biased technical change effects on the education premium. Chennels and Van Reenen (1999) conclude from their literature survey that there is considerable evidence of a positive correlation of various measures of technology with the skill structure suggesting that technology is, on average, biased towards skilled labour. Furthermore, they find strong evidence of a positive correlation between wages and innovation. Also Krueger (1993) finds a higher computer premium for better-educated workers, which rose between 1984 and 1989. Entorf, Gollac and Kramarz (1999) analyse the interaction between computer use and education using cross-section estimates. In contrast to Krueger and other literature mentioned above, they find higher computer premia for less educated workers, and using individual fixed effects they find computer premia to be highest for workers with a medium education level.

But still, as Bresnahan (1999) points out, the empirical investigations lack a theory of how technology affects labour demand in the firm. Bresnahan focuses his theoretical considerations on computer use in white-collar bureaucracies. He states that the heart of skill-biased technical change embodied in information and communication technology is a limited substitution. The substitution of machine decision making for human decision making is limited to low- and medium-skilled white-collar work, but not applicable to high levels of human cognitive skills or for ‘people skill’. This makes the complementarity between technology and highly skilled workers more apparent on the level of firms than of workers. Lindbeck and Snower (2000) analyse the shift from Tayloristic to holistic work organisations within firms and their consequences for wage differentials. They argue that advances in production technologies promoting technological task complementarities are one driving force behind this structural process.[1]

Using pooled cross-section, industry-level time-series data, Wolff (2002) finds no econometric evidence that computer use is linked to total factor productivity growth, over and above the inclusion in the TFP measure. However, he finds computerisation to be positively associated with occupational restructuring and changes in the composition of intermediate inputs and the capital coefficient. There is evidence that the growth of worker skills is positively related to industry productivity growth, but the effects are very modest. Bresnahan et al. (2002) find evidence for the hypothesis that the combination of the information technology (IT), complementary workplace reorganisation and product innovations constitutes a significant skill-biased technical change affecting labour demand in the United States. For the UK Haskel and Heden (1999) report a robust positive relation between computerisation and skill upgrading.

Borghans and ter Weel (2002) develop a model to explain the time-varying impact of diffusion of computer use on the within-group and between-group wage inequality. In their model computer use increases individual productivity, but also the supply of goods. Therefore workers producing similar goods without computers are negatively affected. They show that inequality between skilled and unskilled workers initially falls when the first skilled workers adopt computers. When unskilled workers also start to use computers, inequality increases strongly because of the increased supply of labour in terms of efficiency units. In the long run, when all workers have adopted computers, the level of inequality depends on differences in productivity gains due to computer use and is lower (higher) than before the onset of computer diffusion if unskilled (skilled) workers benefit more.

[1] See also Acemoglu (1998) for a model explaining a positive relationship between technology and human capital.

As schooling levels are known to display only limited information on individual productivity, more recent literature tries to utilize additional data sources on skills or abilities. Autor, Levy and Murnane (2001) investigate the way in which computer technology complements skilled labour or substitutes for unskilled labour by looking into the tasks each job performs. They hypothesize that computer capital (1) substitutes for a limited and well-defined set of human activities, those involving routine (repetitive) cognitive and manual tasks; and (2) complements a second set of activities, those involving non-routine problem solving and interaction tasks. As routine and non-routine tasks are imperfect substitutes, the task framework implies measurable changes in the task content of employment. They find that computerisation is associated with declining relative industry demand for routine manual and cognitive skills and increased relative demand for non-routine cognitive skills. Translating these task shifts into educational demand, they find that within-industry and within-occupation task shifts together can explain approximately thirty percent of the observed relative demand shift favouring college versus non-college labour between 1970 and 1998. Changes in task content within normally unchanging occupations explain more than half of the overall demand shift induced by computerisation.

A different line of reasoning for the relation between higher wage levels and more frequent computer use is followed by Borghans and ter Weel (2001), who observe that opportunity costs of computer use are higher for workers with higher wages. Therefore, Borghans and ter Weel hypothesize a reversed causality compared to the hypothesis of productivity enhancing computer use. More workers with higher wages than low-wage workers are computer users, because the relative costs for high-wage workers to carry out a certain task are much higher than for low-wage workers performing a similar task. Hence, firms gain more by letting high-wage workers complete such tasks using computerised equipment. Using British survey data containing information on the sophistication of computer use and on computer skills, they find that wages are an important determinant of computer use. On the other hand, both computer skills and complementary skills do not seem to be able to explain the higher wages of computer users.

To summarize, there is theoretical and empirical evidence that technical change associated with computerisation implies stronger labour demand for high-skilled workers and is therefore responsible for an increase in wage inequality. In this paper we try to examine the distributional consequences of computer wage premia for Austria. We are interested in the question if the effect of computer use is uniform across the wage distribution. A higher computer wage premium for workers in the lower segment of the wage distribution would - at least partly – counter'act the distributional consequences of skill-biased technological change. Up to now, no evidence for Austria on this topic has been available.

In this paper, we empirically investigate the distributional consequences of computer premia. Following the Krueger-approach we use a sample of micro data to run cross-sectional wage regressions for 1997. In accordance with international evidence we find a significant computer premium for Austria, which is around 15 %. Quantile regressions show almost constant returns to computer use across the wage distribution. However, the size of the wage effect attributed to computer use varies significantly between job hierarchies. Persons in higher positions receive less reward for computer use than workers at lower hierarchy levels. Overall we find that computerisation increased wage inequality in Austria. However, hierarchy-related differences in the relative computer premium in Austria moderate the effects of computer use on the wage distribution.

The paper is organized as follows. The next chapter discusses data issues. Section III presents the frequency of computer use in Austria in front of an international background. Section IV compares evidence on the effect of computer use on pay for Austria to US and German figures. Section V provides estimations of computer premia by hierarchy levels. Section VI concludes.

II The Dataset

The data used in this paper are drawn from the 1997 September Microcensus of the Austrian Central Statistical Office. The Microcensus is a quarterly household survey, which is representative for the Austrian economy. It contains detailed information on individual characteristics like sex, age, nationality, human capital, labour market status, working hours, occupation and industry affiliation.

Furthermore, the survey contains information about job-position, characterised by the skill intensities and/or training requirements. We use this information to construct a variable representing six job hierarchy levels. Following Winter-Ebmer and Zweimüller (1997), we differentiate between the following hierarchy levels: (I) unskilled (no schooling and training requirements) (II) low skilled (apprenticeship or equivalent qualification), (III) medium skilled (middle school level or equivalent), (IV) high skilled (high school degree or equivalent), (V) leading (university degree or equivalent), and (VI) leading manager in large firms/institutions.

Information about net monthly earnings of the dependent working population is available every second year. Only in the September 1997 survey the question of regular computer use on the job was asked.

III Computer Use by Personal Characteristics

This section provides descriptive evidence about the personal characteristics of computer users in Austria and allows a comparison with Germany and the US. In 1997 35.5 percent of all workers in Austria report that they regularly use a computer in their work. Compared to data for Germany and the US as in DiNardo and Pischke 1997 this seems to be a considerably lower percentage of computer users, given that our data refer to a more recent period and that computer use increased significantly during the last decade. A comparable level of computer use had been reached in Germany in 1991/92 and in the US in the late 1980s. On the other hand, the reported lower level of computer use in Austria could originate from a differently asked question. The Austrian census asked for *regular* computer use, which imposes frequent computer use, while German and US data seem to refer to *any* computer use in course of one's work.

Table I: Percent of Workers in Various Categories Who Are Computer Users

	AUT 1997	US 1993	GER 91-92
All workers	35.5	46.6	35.3
Men	32.8	41.1	36.4
Women	39.3	53.2	33.5
Less than high school (*Pflichtschule* only)	10.3	10.4	9.9
Apprenticeship (*Lehre*)	24.5		
High school (*BMS*)	57.7	34.6	32.7
Some college (*AHS*)	67.9	53.1	48.4
Some commercial or technical college (*BHS*)	64.9		
College (*Universität*)	57.4	70.2	61.6
Age 18-24	31.4	34.3	27.8
Age 25-39	39.1	49.8	39.9
Age 40-54	32.9	50.0	35.9
Age 55-64	28.3	37.3	23.7
Blue collar	7.6	17.1	10.7
White collar	59.2	67.6	50.2
Civil servants	43.8		
Part time	29.8	29.3	26.5
Full time	36.4	51.0	37.0

Columns 2 and 3 are from Table I in DiNardo and Pischke (1996). Data for column 1 are from the Microcensus September, data for column 2 are from October Current Population Survey, data for column 3 are from Qualification and Career Survey.

As in other countries, Austrian workers aged between 25 and 39 are more likely to be computer users than other age groups. Computer use in Austria seems to lag rather far behind: In the US even the age group 55-64, which is not very prone to computer use, has on average more computer users than the Austrian average of all age groups. More white-collar workers and civil servants than blue-collar workers use computers in their jobs. Only 7.6 of 100 blue-collar workers have access to a computer at their workplace in Austria 1997, which roughly corresponds to a level that US blue-collar workers had reached already in 1984. There seems to be more international divergence concerning computer use of full-time workers than of part-time workers: Less than 30% part-time workers use a computer in all three countries, while between 51% (US) and 37% (Austria, Germany) full-time workers use a computer in their jobs.

Usually one expects a higher share of computer users in better-educated sub samples. This does not hold true for all educational levels in Austria: As in other countries, only a very low percentage of workers with vocational training only (24%) or without any education beyond mandatory schooling (10%) uses computers in their jobs. University graduates on the other hand are less likely to be computer users than graduates of roughly high school equivalent institutions (AHS, BHS), which does not correspond to results for Germany and the US. Comparing computer use by educational level, striking differences between the three countries become apparent. In Austria, the share of computer users in all BMS-graduates is about the same size as the share of computer users in university graduates. In Germany and the US, however, the share of computer users in university graduates is about twice as high, compared to BMS or high school graduates. This might reflect weaknesses in defining comparable educational groups for the three countries, but this might as well reflect differences in work organization.

IV Wage Premium for Computer Use

In his seminal study Krueger (1993) finds that workers who use computers on the job earn 15 to 20 percent more than nonusers after controlling for standard worker attributes. In this section we follow the Krueger-approach and run cross sectional wage regressions to estimate computer premia for Austria. We compare the Austrian results to evidence for Germany and the US.

The raw log wage differential for computer use in Austria is 0.213 in 1997.[2] Haisken-DeNew and Schmidt (1999) found a similar raw differential of 0.218 for Germany in 1997. This is somewhat lower than the 0.325 differential for the United State in 1989 reported by Krueger (1993). The inclusion of controls such as education, experience, gender, and others lowers the computer wage differential. In Table 2 we report estimates from OLS wage regressions

[2] The raw log wage differential is achieved by regressing log wages on a constant and the computer use dummy.

that include a computer dummy and other covariates. The second two columns are reproduced from DiNardo and Pischke (1997). Our estimates from the Austrian data, reported in the first column of Table 2, are 0.162. The estimated computer wage differentials for Germany and Austria are very similar,[3] the U.S. estimates are slightly higher. Note, though, that also wage increases with higher levels of schooling or experience are lower in Austria, compared to Germany or the US.

Table 2: OLS Regressions for the Effect of Computer Use on Pay

Dependent variable: Log Hourly Wage (Standard Errors in Parenthesis)

	AUT 1997	**US 1993**	**GER 91-92**
Computer	0.162 (0.005)	0.204 (0.008)	0.171 (0.006)
Years of Schooling	0.054 (0.001)	0.081 (0.002)	0.072 (0.001)
Experience	0.017 (0.001)	0.026 (0.001)	0.030 (0.001)
Experience^2/100	-0.020 (0.002)	-0.041 (0.003)	-0.046 (0.002)
R^2	0.343	0.424	0.336
Number of obs.	13,024	13,305	20,042

Columns 2 and 3 are from Table II in DiNardo and Pischke (1996). Data for column 1 are from the Microcensus September, data for column 2 are from October Current Population Survey, data for column 3 are from Qualification and Career Survey. All models include an intercept, a dummy for part time, large city/SMSA status, female, married, female*married. Regressions for the US also include dummies for black, other race, veteran status, union membership and three regions. Regressions for Austria and Germany also include a dummy for civil servants (Beamte).

One could argue that computer use depends on the occupation or industry of the worker. Therefore we include dummies for industry and occupation. The results are reported in Table 3. The inclusion of the additional control variables lowers the return to computer use. However, even after including industry and occupation dummies we still find a significant computer differential of 0.102. While the inclusion of industry dummies results only in minor changes of the size of the computer dummy, the inclusion of occupational dummies seems to be of major importance. This is in line with the literature pointing at the importance of job tasks when investigating the effect of computer use on wages (Autor, Levy, Murnane 2001, Borghans and ter Weel 2001), and is also in line with results on the positive relationship between changes in occupational structure and total factor productivity growth (Wolff 2002).

[3] Note, however, that Haisken-DeNew and Schmidt (1999) report a considerably smaller computer use premium of 0.072. They include controls for industry and firm size.

Table 3: OLS Regressions for the Effect of Industry and Occupation on Pay

Dependent Variable: Log Hourly Wage (Standard errors in Parenthesis)

Computer	0.161 (0.005)	0.149 (0.006)	0.114 (0.006)	0.102 (0.006)
Occupational dummies	NO	NO	8	8
Industry dummies	NO	8	NO	8

Data are from the Microcensus September 1997. All regressions include an intercept, years of schooling, experience, experience squared, dummies for part-time, city of Vienna, female, married, married * female, and for civil servants (Beamte).

V Job Hierarchy and Returns to Computer Use

In this section we analyse the relationship between the computer premium and the wage structure. In a first attempt we estimate quantile regressions to analyse the effect of computer use on wages at different positions in the wage distribution. We run regressions with the variables used in the previous section (including industry and occupational dummies) and include also job hierarchy dummies. Our estimations yield a computer premium of 0.087 at the 50 %-quantile, the results for the 25 %-quantile (0.090) and the 75 % quantile (0.085) are relative similar. There is only weak evidence for different effects of computer use across the wage distribution as we find a coefficient of .088 for the 10 % quantile and 0.075 for the 90 % quantile. As next step we examine the relationship between job position and computer premium. We proceed by interacting the dummy variables for the 6 hierarchy levels, described in section 2, with the dummy for computer use.

Table 4: Computer Users by Job Hierarchy, Percent (Number)

Hierarchy	**All**	**Male**	**Female**
Unskilled	12.6% (2095)	12.0% (815)	13.0% (1280)
Low skilled	21.2% (3544)	16.6% (1850)	26.3% (1694)
Medium skilled	33.4% (4556)	23.5% (3201)	56.7% (1355)
High skilled	64.8% (1837)	70.8% (989)	57.8% (848)
Leading	64.6% (833)	69.0% (555)	55.8% (278)
Leading, large firm	73.6% (159)	72.8% (147)	83.3% (12)
Total	33.6% (13024)	31.1% (7557)	37.2% (5467)

Data are from the Microcensus September 1997.

Frequencies for computer use by job hierarchy duplicate our results for computer use by educational level (see Table 4). While only one out of 8 workers of the lowest hierarchy level frequently uses a computer at the workplace, two out of three workers do so in the upper half of our hierarchy ladder. In our highest hierarchy level, managers of large firms, almost three out of four employees are frequent computer users.

Computers are assumed to fulfil two functions, substitute for routine cognitive and manual tasks, and complement activities involving non-routine problem solving and interaction tasks (Autor, Levy, Murnane 2001). If computers are used mainly to substitute for routine work, the observed computer premium will be relatively high in jobs where the extent of such routine work is rather high; we may assume such jobs are found mainly in the lower part of job hierarchies, but will be concentrated in a fraction of low-skill jobs only, as not all jobs contain routine tasks which can be computerised. If, on the other hand, the main function of computers is to support non-routine problem solving and like tasks, computer premia in higher hierarchy positions might be high, as such tasks are of more importance there. Returning to table 1, we realize that computer use by Austrian college graduates is lower, but computer use by Austrian graduates from AHS, BHS, and BMS is higher than that of (more or less) comparable workers in the USA or, to a lesser extent, in Germany. This might point at computer use in Austria fulfilling the function of substituting routine tasks more thoroughly than the function of complementing non-routine tasks in higher job hierarchies.

We regress wages on our usual control variables, the hierarchy dummies and interact computer use with the hierarchy dummies to test for differences in the computer premium across job positions. However, one could argue that we have a sample selectivity problem. If computer use is not evenly distributed among the workers, OLS produces inconsistent estimates. To account for potential selectivity, we estimate the following treatment effects model by full maximum-likelihood (see e.g. Greene 1997, 974ff). Computer use is modelled as an outcome of an unobserved latent variable (z^*). It is assumed that z^*_i is a linear function of the exogenous covariates w_i and a random component u_i.

(1) $y_i = x_i\beta + \delta z_i + \zeta v_i z_i + \varepsilon_i$, where $z_i = 1$ if $w_i\gamma + u_i > 0$, and 0 otherwise

(2) $z_i^* = w_i\gamma + u_i$,

where y is log wages, x is the vector of independent variables, z is the computer dummy variable, v represents the hierarchy levels, and $\varepsilon_i \sim N(0, \sigma)$, $u_i \sim N(0, 1)$ and $corr(\varepsilon, u) = \rho$. ζ is the coefficient vector of the interaction of job hierarchy and computer use.

In the selection equation we use schooling, 3 age dummies, 8 occupational dummies, 5 hierarchy variables and 8 industry dummies as exogenous covariates.[4] The estimates of the selectivity equation are in line with our expectations.[5] Younger and better-educated workers use computers more often. Our occupation variables indicate that managers, professionals,

[4] We identify the wage equation by the assumption that occupation has only an indirect influence on wages via computer use.

[5] The Appendix contains the full set of results.

technicians, clerks and service workers use computers more often than all other workers. The percentage of computer users increases with the hierarchy level of the job. The probability of using a computer for work is above average in the industries of financial intermediation, energy/mining and manufacturing and below average in tourism, farming, construction and also in the transport industry (reference group is the service industry).

Table 5 shows the main results of the wage equation. As a likelihood ratio test of independent equations rejects the null hypothesis of no correlation we discuss only results with selectivity correction.[6] In low hierarchy levels computer use is less frequent than in higher hierarchical positions, but the computer premium is higher and amounts to about 25%. For higher hierarchy levels, the computer premium drops again to levels of about 15%. Note that in contrast to our estimates without selectivity correction all workers receive a significant computer premium.

Following the reasoning of Borghans and ter Weel (2001) and Autor, Levy and Murnane (2001), this result might reflect different degrees of routine work in different job hierarchy levels. If computers are used in order to facilitate routine work, incentives to supply workplaces with computer equipment are bigger for high wage workers. In the uppermost levels of hierarchy, on the other hand, we expect rather high wages but a lower degree of routine work compared to medium hierarchy levels. Widespread computer use in higher hierarchy jobs is more likely to be explained by computers complementing complex tasks. Thus, widespread computer use but a low computer premium in those top jobs could be explained.

If we run separate regressions for male and female workers, the emerging picture changes somewhat. The computer premium for our baseline category, lowest hierarchy, sticks at about 25% for male as well as for female workers. But while this 'general' computer premium is considerably reduced in case of male computer users in higher hierarchical positions, our regressions with the female sample show hardly any significant reductions of the computer premium, regardless of hierarchical levels. In the female sample, only computer users in hierarchy level 'high skilled' experience a significantly lower computer premium than workers in other hierarchy levels. The medium skill level consists mainly of job positions, where the capability to work with a computer is more or less inevitable for relevant workers.

At the medium level of job hierarchy, computers may be employed to fulfil both functions, substitute for a limited set of routine tasks as well as complement activities involving non-routine problem solving. If the computer premium in higher hierarchies is lower in the male compared to the female sample, this may be related to different tasks being fulfilled in both segments of the labour market. Possibly higher computer premia in all but the top hierarchy of the female sample hint at a higher share of routine work involved in female workers' jobs.

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[6] According to OLS we find a significant computer premium only for low hierarchy jobs.

Table 5: Job Hierarchy and Returns to Computer Use by Gender
Dependent Variable: Log Hourly Wage

	Total Sample		Male		Female	
	Coef.	Std.Err.	Coef.	Std.Err.	Coef.	Std.Err.
Computer use	.255	(.022)	.264	(.033)	.247	(.029)
Hierarchy interaction:						
Comp*Low skilled	.010	(.020)	.001	(.031)	.024	(.027)
Comp*Medium skilled	-.009	(.019)	-.023	(.029)	.013	(.027)
Comp*High skilled	-.107	(.021)	-.126	(.032)	-.078	(.029)
Comp*Leading	-.078	(.025)	-.135	(.036)	-.005	(.039)
Comp*Leading, large firm	-.106	(.049)	-.129	(.054)		
Log likelihood	-6673.8		-3518.8		-2933.3	
Number of observations	13.024		7.557		5.467	

Data are from the Microcensus September 1997. All regressions include an intercept, years of schooling, experience, experience squared, dummies for part-time, city of Vienna, female, married, married * female, and for civil servants (Beamter), 5 hierarchy levels, hierarchy level times computer use, 8 industry dummies. To control for selectivity of computer use we estimated a sample selection model by full-maximum likelihood using 3 age dummies, years of schooling and 8 occupation dummies in the selection equation.

VI Conclusion

The influence of technological change on the labour market chances of workers with different skill levels is hotly debated in the scientific literature. In this paper, we investigate the relationship between the computer premium and the wage structure. Quantile regressions provide only weak evidence for different computer premia across the wage distribution. However, the size of the wage effect attributed to computer use varies significantly between job hierarchies. Persons in higher positions receive relatively less reward for computer use than workers at lower hierarchy levels. These differences by job hierarchy are more pronounced in the male subsample.

One possible explanation for the computer premium is that more workers with higher wages than low wage workers are computer users, because the relative costs for high-wage workers to carry out a computerisable routine task are much higher than for low-wage workers performing a similar task (see Borghans and ter Weel 2001). Hence, firms gain more by letting high-wage workers complete tasks using computerised equipment. If such tasks predominantly consist of routine work, this might explain our result that relative computer premia in lower hierarchy levels exceed computer premia in higher hierarchies, where computer equipment is rather used for complementing complex tasks than for routine work. We can apply the same line of interpretation to the different patterns of computer premia for male and female workers in the upper half of the hierarchy ladder. We then arrive at the hypothesis of women in same hierarchical positions like men fulfilling tasks with a higher routine component, and thus in many cases tasks requiring lower skill levels. This interpretation is compatible with suboptimal employment of skilled female labour. An alternative explanation is that employers have to offer a wage premium in order to attract competent workers. As computer knowledge is less common for people working at lower hierarchy levels competent low-wage computer users would command a higher computer premium.

As workers in higher job positions receive a lower premium, we find evidence for a small but significant effect, reducing c.p. wage inequality due to computerisation. However, the overall effect of computer use on wage inequality depends on the relative wage premium and the distribution of computer use. We perform a back-of-the-envelope calculation to infer the effects of computer use on wage inequality in our sample. We use the Gini coefficient to compare wage inequality with and without the computer premium. Starting with the wages in our sample as the wage distribution including computer premia we find a Gini coefficient of 0.19347. We construct two counterfactual wage distributions without computer premia in the following way. First, we subtract the relative computer premium by hierarchy level as shown in Table 5 from the (log) wages of each computer user. Second, we subtract a uniform computer premium of 0.149 from the (log) wage of each computer user. This exercise yields wage distributions with Gini coefficients of 0.18789 and 0.18474, respectively. These results are in line with our expectations. According to our calculations a uniform computer premium would imply an increase in inequality by 0.873 percentage points. The job hierarchy dependent computer premium, however, implies an increase of 0.558 percentage points. Therefore, computerisation has increased wage inequality in Austria. However, hierarchy-related differences in the relative computer premia seem to moderate the effects of computer use on wage inequality.

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Appendix

Table A1: Description of sample

Variable	Mean	Std. Dev.
(log) wage (lwage)	9.680851	.3396155
years of schooling (school1)	10.84498	2.115857
years of experience (pexp)	21.09721	10.62723
experience squared (pexp2)	558.0213	474.38
Parttime (part)	.1541001	.3610586
Region Vienna (dvienna)	.1332924	.3399035
Male (dmale)	.5802365	.4935391
Married (dmaried)	.6127918	.4871306
Civil servant (cs1)	.1469595	.3540791
Male*Married (dmafe)	.2367936	.4251309
Computer use (computer)	.3365326	.4725416
Industry dummies		
dind1	.0117475	.1077517
dind2	.0161241	.1259576
dind3	.2333385	.4229721
dind4	.0984337	.2979115
dind5	.1541769	.3611321
dind6	.0410012	.1983006
dind7	.0744011	.2624326
dind8	.0423833	.2014698
Job position dummies		
dhier2	.272113	.4450649
dhier3	.3498157	.4769299
dhier4	.1410473	.3480837
dhier5	.0639588	.244689
dhier6	.0122082	.1098186
Computer use * job position		
cdhier2	.0577396	.2332593
cdhier3	.1167844	.3211755
cdhier4	.0913698	.2881453
cdhier5	.0413084	.1990101
cdhier6	.0089834	.0943578
Age dummies		
dage2	.4419533	.4966382
dage3	.3790694	.4851741
dage4	.0601198	.2377178
Occupation dummies		
disco1	.0374693	.1899161
disco2	.0980498	.2973933
disco3	.1339066	.340565
disco4	.1621622	.3686137
disco5	.1309889	.3374012
disco6	.0060657	.0776492
disco7	.2035473	.4026515
disco8	.1135596	.3172878
No of obs	13024	

Table A2:
Wage premium and computer use – (Treatment effects model – MLE)

Wage Equation	Full sample		Male sample		Female sample	
-	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
school1	.0224678	.0016559	.0241795	.0021469	.0186615	.0026113
pexp	.0159454	.0009456	.0170674	.0012659	.0142766	.0014521
pexp2	-.000183	.0000203	-.0002053	.0000264	-.0001452	.0000326
part	.0922253	.0074544	.1142591	.0200457	.0910619	.0084878
dvienna	.0427863	.0068086	.0244535	.0090526	.0621225	.0103325
dmale	.132547	.007851				
dmaried	.0453028	.0069689	.0426354	.007363	-.054786	.0082473
cs1	.0260378	.0077846	.0067186	.0097753	.0726394	.0131998
dmafe	-.1016471	.0097652				
computer	.2546955	.0215792	.2640201	.0332403	.2472385	.0285682
computer						
* hier2	.0100987	.0201373	.0006559	.0312717	.0241644	.0267812
* hier3	-.0093067	.0190606	-.0232778	.0291314	.0130465	.0268367
* hier4	-.1067576	.0213349	-.1258743	.0322498	-.0778888	.0293307
* hier5	-.0774569	.0253609	-.1353496	.0355529	-.0036459	.0386528
* hier6	-.1061336	.0493283	-.128502	.0536524		
dhier2	.0327149	.0081638	.050864	.0117672	.0164724	.0115087
dhier3	.112493	.0086118	.1247507	.011229	.0953824	.0153198
dhier4	.2589247	.014397	.2733371	.0204764	.2423328	.0206184
dhier5	.3259476	.0195907	.3811186	.0255763	.2904136	.0301971
dhier6	.5056097	.0418415	.5231279	.0428132		
dind1	-.089228	.0222166	-.0657156	.0275599	-.0932549	.0372172
dind2	.1250735	.0192092	.1588565	.0206079	.0801	.0515181
dind3	.0457088	.0073373	.0903406	.0096757	-.0139457	.0119391
dind4	.074749	.009916	.1034731	.0117615	.0586092	.0315806
dind5	-.0015976	.007879	.0309693	.0119335	-.018282	.0106382
dind6	-.0459978	.012824	-.0443663	.0214657	-.0476158	.0163637
dind7	-.0168208	.0099452	.0332469	.0115996	-.0946729	.0212315
dind8	.0475176	.0134604	.0868248	.0186689	.0197936	.0192476
cons	8.89783	.0215222	8.964419	.0283396	8.971259	.0323889
No. obs.	13.024		7557		5467	
Log likelihood	-6673.8444		-3518.7505		-2933.3459	

Selectivity equation	Full sample		Male sample		Female sample	
-	Coef.	Std. Err.	Coef.	Std. Err.	Coef.	Std. Err.
dage2	.0672663	.043889	.1738914	.0641236	-.0605435	.0632594
dage3	-.095691	.045435	.0408573	.0660748	-.2729624	.065935
dage4	-.1888362	.0683584	-.0552178	.087695	-.4598818	.1310535
school1	.0323418	.0089415	.0343652	.0121668	.0216658	.0135688
disco1	1.432511	.0920332	1.144813	.1179072	1.842874	.1559834
disco2	1.159582	.0809398	.9543176	.1081195	1.523779	.1278483
disco3	1.238847	.0685058	1.150353	.0913073	1.400638	.1095836
disco4	1.779787	.0663248	1.184763	.0930635	2.254047	.105769
disco5	.7785493	.0693625	.8905733	.0961494	.8515147	.108477
disco6	-.0164785	.2784091	.0091246	.3086428		
disco7	-.1100955	.0728251	-.1932753	.090968	-.0405387	.1509615
disco8	.0157369	.0778961	-.085231	.0959315	-.0769707	.1668193
dhier2	.3791384	.0495282	.3229371	.0756222	.3794181	.0682239
dhier3	.7136003	.0483488	.6061428	.0720608	.6881515	.0696964
dhier4	.9072095	.0586744	1.050707	.0855707	.6336665	.0845277
dhier5	.8878091	.0750534	.9496836	.1043143	.61575	.1156144
dhier6	.9537117	.1267289	.9404957	.1442791	.6797406	.4287725
dind1	-.360026	.189555	-.4387312	.2303	-.5341456	.3331939
dind2	.7440533	.105733	.6802471	.1158311	.7937541	.314491
dind3	.410064	.0435224	.3530234	.0563784	.4271235	.0803701
dind4	-.3605704	.0708416	-.556579	.0861887	.2893865	.1741307
dind5	.0606451	.0441571	.1288215	.0646945	-.0387541	.063171
dind6	-.5263655	.0893854	-.8090917	.141495	-.3651285	.1172006
dind7	-.1343977	.0573069	-.1165977	.0723359	-.0016045	.1119271
dind8	.8379918	.0813874	1.011192	.1167607	.756567	.1198657
_cons	-2.266445	.1171495	-2.147054	.1639885	-2.236264	.1764596
/athrho	-.3211761	.0330308	-.3064336	.0462991	-.3467475	.0471724
/lnsigma	-1.326869	.0072786	-1.358615	.0096351	-1.29651	.0110439
rho	-.31057	.0298449	-.2971891	.0422099	-.3334879	.0419262
sigma	.2653067	.001931	.2570165	.0024764	.2734847	.0030203
lambda	-.0823963	.0082495	-.0763825	.0112612	-.0912038	.0120042
LR test of indep. eqns. (rho = 0):						
	chi2(1) = 93.04		chi2(1) = 42.09		chi2(1) = 53.29	
	Prob > chi2 = 0.0000		Prob > chi2 = 0.0000		Prob > chi2 = 0.0000	

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