Use IT or Lose IT?

The Impact of Computers on Earnings

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Since writing this paper Helen Robinson was tragically killed in a motorcycle accident. Peter Dolton and Gerry Makepeace would like to express their deepest sympathy to her son Sebastian.

1. Introduction

There are many reasons to be interested in the impact of computers on earnings. On a theoretical level, the introduction of information and computing technology (ICT) might help to explain the large increase in earnings inequality observed at the end of the last century. On a practical level, policy makers have been anxious to raise the level of computer skills in the general population and continue to seek guidance on the importance of doing so. A perception, for instance, that computers had little impact on earnings would suggest that the labour market was able to cope with the rapid changes in production technique that have taken place.

There is a widely held view that the large changes implied by ICT could not have had a lasting impact on earnings, because any earnings differentials would have quickly been eroded away in a competitive labour market. Given the nature and size of recent technology shocks, it seems inevitable, however, that workers would receive some of the recent productivity gains. Further, lagged adjustment processes ensure that these gains do not disappear in the short run. Several models explaining the increase in wage inequality allow for two types of workers (Acemoglu (2002) and Card and DiNardo (2002)). Krusell *et al* (2000) develop a theoretical approach with heterogeneous capital, in addition to low and high quality workers. In a model similar to Borghans and ter Weel (2004), they show how structural capital contributes to the marginal product of both types of workers, but equipment capital only augments the marginal product of high quality workers. The marginal product of labour depends on the amount and type of capital used by each type of worker. In what follows, we interpret computer use as an indicator of equipment capital, and we expect to see earnings premia associated with computer use. Specifically, given the complementary nature of specific tasks for which the computer is used by certain types of workers, we expect, *a priori*, these premia to vary both by individual worker type and by computer task.

The simple empirical question of whether working with computers raises earnings has generated a fierce debate since Krueger (1993) showed that computer use was associated with large increases in earnings. Many researchers have tried to explain the increased earnings by omitted variable bias. In the most famous case, DiNardo and Pishke (1997) argued that other unobserved job characteristics, such as using a pencil at work, gave similar increases in earnings.[1] A particularly telling criticism of the hypothesis is due to Entorf and Kramarz (1997) and, more recently, to Anger and Schwarz (2003). They obtain well-defined, cross-section estimates for the impact of computers that become insignificant when panel techniques are employed (although the former do use a particularly short panel). However, Dolton and Makepeace (2004) have presented panel estimates where the effect of using a computer differs across individuals according to exactly when they first used computers and by gender. They find that the first group of men to use computers received a large premium that persisted over time for just this group and that women always received a substantial premium.

The possibility of heterogeneity in the returns to computing implies that the provision of specific types of computer knowledge and skills might be more important than general training. The importance of different skills has been emphasised by Borghans and ter Weel (2004) and Dickerson and Green (2003) using, respectively, the 1997 and the 1997 and 2001 Skills Surveys of the Employed British Workforce. Following Krueger (1993) and Green (1998), we explore the possibility here that it is not the use of a computer at work that is important, but the tasks for which it is used. We use British data from an establishment survey, cohort studies and the European E-Living survey to investigate the extent to which the impact of computer skills depends on how computers are used. We are able to examine the importance of both activity and frequency of use in this variety of data sources. We can compare the experience in the year 2000 of samples of individuals who were born in 1958 and 1970 using the National Child Development Study (NCDS), and the British Cohort Study 1970 (BCS). This inter-cohort comparison focuses on the experiences of individuals born 12 years apart. We contrast the results from these cohort data with those of a general cross-section of the British population in the E-Living survey. The E-Living survey is of particular interest as it was designed to elicit the impact of new technologies on everyday life. We can exploit the strengths of the cohort data in terms of the detailed information available about individuals, their exposure to a common macroeconomic environment and large sample sizes. At the same time, we can contrast the specific experiences of these cohorts with those of a general cross-section of the population. Further, we develop a fixed-effect approach using

[1] However, the pencil effect wears off over time in contrast to the computer effect.

the Workplace Employee Relations Survey (WERS) to address the issue in order to control for unobserved heterogeneity across establishments.

We also emphasise differences by gender. Other things equal, the development and introduction of ICT might disadvantage women if they are over-represented amongst occupations which have not benefited from new technologies. Women perform the bulk of caring, cleaning and catering jobs that may not lend themselves to many forms of ICT. Such technology is only introduced when there is a clear benefit from doing so and any potential productivity gain is a function of effective implementation via organisational change (Brynjolfsson and Hitt (2000)). Where women carry out low-skill tasks there is no obvious advantage from incorporating sophisticated computer technology. The adoption of new technology may be biased in favour of more skilled workers. Krueger (1993) using US descriptive analysis showed in aggregate that women and highly educated workers were more likely to use computers at work than men and less-educated workers. Furthermore, Krueger *ibid* finds that the percentage gap between these groups grew between 1984 and 1989. Weinberg (2000) argues that the emergence of computerised production processes in hitherto 'physical' industries, such as pulp and paperboard, have been associated with the advent of female workers in those sectors. However, in the UK there are a low proportion of women in certain occupations that rely heavily on specific types of ICT. For example, in managerial positions 31 per cent are female (Robinson (2003)). Where there are female managers, these women are not located in the particularly high paying, sophisticated technology managerial subgroups. Amongst all managers, the highest hourly wages occur for corporate managers. Only 19 per cent of corporate managers are female compared with 81 per cent male (*ibid*). Women with caring responsibilities who work a truncated day may be further disadvantaged in their access to various forms of ICT and training in its use.

We investigate here the tasks for which a personal computer is used, and persistently find that the impact of using a machine for electronic mail and internet access is significant. This suggests that the adoption of some types of ICT is associated with a wage premium, and certain types of use are linked with a finely disaggregated job type that is not reflected in the crude occupational classifications often used in economic research. For example, corporate managers who use electronic mail combine ICT with their unobserved ability. Entorf and Kramarz (1997) reveal that highly able French workers harnessing computers (for 'intelligent use') experience obvious complementary increases in productivity. Our use of four British datasets enables us to investigate the type of tasks to which the computer is put and to analyse the size of these differences by gender whilst controlling for the various types of ICT. Hence the strategy of the paper is to bring all the available evidence to bear on the question of whether certain types of computer use have an impact on earnings. Most specifically our basic questions are: Who uses a computer and for what purpose? How often are computers used at work? How much does the wage premium differ across cohorts of people born 12 years apart? Does it differ for men and women? Does the type of use matter in earnings determination? Does frequency of use matter in earnings determination? Data relating to these questions is relatively rare and we are fortunate to be able to use the cohort studies of NCDS and BCS, WERS and the E-Living data alongside each other.

2. Data

Overview

Two of our datasets, NCDS and BCS come from British longitudinal cohort surveys. The NCDS began in 1958, with follow up surveys of the whole cohort carried out at ages 7, 11, 16, 23, 33 and most recently at age 42. The BCS70 began in 1970 and full sample surveys took place at ages 5, 10, 16, 26 and most recently at age 30. Both cohorts were simultaneously interviewed in 1999/2000 using a common survey for the first time. These data are particularly useful for our purposes as they contain information on computer use over a period when the growth in the use of computers accelerated rapidly.

The timing of the revolution in computing gives a new source of cohort variation since almost all of the NCDS cohort would have left school by the end of 1976. A relatively small number would have studied computer science as a subject at university, but no one would have had access to a computer in school. Members of this cohort would have been introduced to computers at a later stage in life when their labour force positions were already well established. In contrast, the younger BCS cohort grew up in the 'Information Age' when the facility to use a computer was available to all young people.[2] This BCS cohort could have left school in 1986 at the earliest. By 1984 all schools in the UK would have had a computer housed in the school with the result that all pupils could have had some access to basic IT literacy. Indeed, 52% of the respondents to this part of the survey had received instruction in the use of computers at school and a further 21% had received some instruction somewhere else (primarily at home). The actual use of computers could have been even higher given that the question referred to instruction rather than use. Arabsheibani and Marin (2003) have reported that the use of computers raises wages in the previous sweep of the NCDS. We are able with the latest data to examine specifically how computers are used and to compare the experiences of individuals in NCDS and BCS.

Both sets of data are cohort data in which all individuals are the same age. Most other studies use data for all age groups leading to difficulties with compositional effects. Whatever the effects of aggregate conditions, including the impact of the ICT revolution, have been, they will have been the same for all individuals in our cohort data. The basic underlying factors driving the process of computer skill acquisition may differ across cohorts, which may change the composition of the IT user group. There has been an important upward trend in the use of computers, and in particular the ability distribution within the computer use group is likely to have widened, with lower categories beginning to use them. This may mean that the average return to computer use may have fallen. Therefore, the characterisation of the distribution of computer literacy between cohorts and within cohorts is particularly important.

The E-Living data forms part of a larger research project entitled "E-Living: Life in a Digital Europe". As such, the study was designed to ensure consistency across the six countries taking part in the survey (Bulgaria, Germany, Israel, Italy, Norway and the UK). In contrast with the cohort studies where the data was collected in personal interviews, the data for all countries was collected over the telephone, apart from in Bulgaria. As most people who use the internet at home do so through a telephone link in the UK, this method of data collection should be borne in mind. We use the information from the 1,760 interviews in the UK that were conducted from September to mid-November in the year 2001. This represents (subject to the choice of definition) a response rate of around 25 per cent.

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[2] The UK government had a programme of introducing at least one BBC microcomputer into every school over the 1982-84 period. By 1986 there was one computer per 75 pupils in all schools. (Personal Computer World, March 1986).

The WERS 2004 study provided matched employer-employee data which contains detailed information on nearly 21,000 individual employees in 1700 establishments employing 10 or more persons. It is a nationally representative data set that includes responses on all the variables contained in the other datasets, but, in addition, it allows the derivation of estimates that adjust for occupation, industry and establishment fixed effects. Face-to-face interviews take place at each establishment with the senior person who deals with industrial relations or personnel matters. Where appropriate, interviews also take place with worker representatives. The specifications are estimated on the WERS earnings sample after removing the outliers that lie in the top and bottom 1% of the wage distribution.

Basic information on the spread of computer use at work in the different datasets is provided in Tables 1 and 2. Table 1a shows how computer use varies across our samples. Computers are an important feature of working life in the cohort studies with the percentage of the cohort using a computer rising from 65% in NCDS to 69% in BCS. The proportion has fallen slightly over the cohorts for men, but has increased dramatically for women from 63% to 72%. The E-Living data provides our more recent information on computer use and reveals an absence of any real difference in usage by gender. The propensity to use a computer at work is lower in the E-Living data probably reflecting the fact that the E-Living data is a cross section of people of all ages containing older people who are less likely to use a computer (Table 1b). The E-Living survey also contains information on how long a person has been using a computer at work. What is interesting in Table 2 is that UK women have been using computers at work for a shorter duration of time: just over one-quarter of E-Living female users have been using a computer at work for between 1 and 3 years. This is in contrast to around one-fifth of male users.

Computer information in NCDS/BCS/E-Living

The cohort data can be used to measure computer competence and computer intensity in several different ways. Each person who uses a computer at work was asked how they used computers and how frequently they used them. More specifically, we know whether members of our sample used a computer for: word processing, internet, email, data analysis, databases, design packages, games, sending faxes, accessing CD–ROMs, composing or listening to music, photography, programming or some other use. We also know whether individuals used computers daily; 2-4 times a week; once a week; or less than once a week in the NCDS/BCS and how many hours a day they use the computer at work in the E-Living data.

The categories of computer software used are recorded for each individual in the E-Living data together with the duration of usage (in terms of hours a day) and self-assessed levels of competence. For example, individuals are asked if they know how to construct a web page, send a file via email, cut and paste in a document, copy or download a file or reboot a computer. In addition, the E-Living survey contains a vast array of information relating to other technical skills. Specifically, individuals are asked to best describe how they mostly use a computer at work from the following categories: word processing, web design, spreadsheet management, emailing/internet, desktop publishing, or programming.

Our data sources provide us with definitions of computer use that have considerable congruence, although the form of the questions asked means that we cannot make an exact comparison of the estimated coefficients. Respondents to the E-Living survey were asked which tasks they mostly used a computer for, while respondents to the cohort surveys were simply asked what they used a computer for at work. That is, they could give more than one use and their answers were not ranked. Table 3 summarises how we used the use of computer information in the different datasets. We constructed six dummy variables to capture whether an individual used a computer in the way specified in the table. The omitted category for the analysis is "no use of a computer at work". For example, the dummy "email" takes the value 1 if an individual uses email or the internet. An individual can reply positively to more than one question.

Table 4 provides summary statistics relating to the type of computer use exhibited in the four datasets broken down by gender. Subject to the caveats of the different ways in which these data were collected we can compare these figures across time. It should also be borne in mind in doing this that the E-Living data and the WERS data are both age cross sections surveyed two years apart in 2002 and 2004 respectively, whereas the NCDS and the BCS are cohorts of 42 year olds and 30 year olds surveyed in 2000. In the interpretation of this table, it should be remembered that in the E-Living it is the 'mostly use' categories that are recorded, whereas in the cohort datasets any use is recorded. The basic summary information tells us, not surprisingly, that the most popular uses of computers are for word processing, spreadsheets and email (usually that in that rank ordering for women). From the descriptive statistics it would appear that there is not a huge difference in the overall proportion of NCDS and BCS people using computers at work. That is, not learning to use them in school does not seem to have disadvantaged the NCDS cohort. Table 4 shows us that men seem to use computers more than women for most functions except for 'Other' uses. It is clear that men's use of computers at work is more diverse than women's. Another interesting fact which emerge is that spreadsheets are used more by women in the WERS 2004 data than by men. This was not true in data relating to earlier periods. Overall there has been a marked rise in the use of word processing use by both men and women over time. Perhaps the most interesting finding in this table is that the highest rise in the use of the computer has been for email and the internet. For the first time women now use this IT capability more than men with over 60% of women using this facility compared to 58% by men. This is in contrast to the NCDS figure for men in 2000 which was 37% whilst it was only 23% for women. These findings are also evident from the E-Living survey.

Tables 5a and 5b present summary information relating to the frequency and intensity of use of computers at work. It will be remembered that the frequency question is also different in the various datasets. In the cohort data respondents were simply asked whether they used a computer at work daily; 2-4 times a week; once a week; or on a less than weekly basis. In the E-Living respondents were actually asked to record how many hours a day they used a computer at work. It would appear that whilst men use computers slightly more frequently, the E-Living data reveals to us that women are more likely to be using the computer all day than men. These differences in how often a computer is used at work, and for what fraction of the day, are an interesting reflection of the kind of gender occupational segregation that is taking place in the labour market.

Specifications

The dependent variable in our analysis is the logarithm of hourly earnings. Our main analysis uses the four datasets to quantify the impact of the use of a computer using the different dimensions available and to examine differences by gender. As educational explanatory variables, we use the five standard NVQ levels, alongside total years of schooling. We include the amount of potential, rather than actual, work experience (and its square) for the E-Living estimation, since this is the only possible experience measure available. In the cohort datasets, we have used actual work experience. Other controls common to each of our datasets include marital status, and occupation and industry dummies. Following Reilly (1995), we regard the inclusion of the number of workers at a workplace as important, because firm size may represent unobserved differences in human capital between establishments. We also include a dummy for part-time work (defined as working less than 30 hours a week).

3. Estimation Results

Table 6 displays our regression results. We estimate three nested specifications for men and women separately for each dataset. The simplest model is a basic human capital specification augmented by a simple dummy for computer use at work. The second contains the dummies for type of computer use and the other controls, such as educational attainment, documented in the data section above. The third includes occupation and industry dummies to control for type of work and industrial backdrop. The first three columns of Tables 6a-6c show the results for women and the last three for men. The top panel of Table 6d presents the WERS results for women, whilst the bottom panel reports the results for men. Table 6d reports fixed-effects estimates. Specifically, column 4 reports the computer use premium, whilst attempting to control for unobserved heterogeneity across establishments. Similarly, column 5 provides evidence of our fixed-effects specification whilst controlling for the type of use to which the computer is put. The computer-use dummies in E-Living differ from those in the cohort studies as detailed above, but the remaining regressors have the same definitions across the datasets.

The simple use of a computer at work raises earnings by around 27% for women in all four datasets.[3] There is a remarkable consistency in the values of the estimates that is not reflected in the men's results where the estimates give mark-ups of around 29% (BCS), 38% (E-Living) and 40% (NCDS) (columns 4). These estimates may appear large, and they show

[3] The normal assumption that $\exp(x)\approx 1+x$ significantly under-estimates the value of $1+x$ for these values of x.

that there is a significant effect for computer use that requires further investigation. Part of the explanation lies in the effects of omitted variables and our remaining specifications address that argument by including a wide range of controls for other worker attributes. In the original Krueger (1993) paper, it is argued that the size of the estimated computer-task coefficients on, say, electronic mail reflect "the fact that high-ranking executives often use E-mail" (*ibid* p. 41). Krueger goes on to argue in the same paragraph that if the positive premium were merely reflecting the employers' ability to pay higher wages, then even workers who use a computer for so-called non-productive computer tasks would command relatively higher wages, and this is not so. Here, the premium from computer use appears to depend on the type of job a woman does (columns 3). The results for men show a large change over time. Perhaps the most relevant result with respect to the overall premium on earnings is in column (4) of Table 6d and 6e relating to the WERS data. In these estimations fixed effects are included for the 1700 different firms and Dolton and Pelkonen (2006) have shown that including such fixed effects for establishments passes the relevant exogeneity tests on the computer use variable. Here we find that the premium is around 8% for women and 12% for men. These lower premiums should be borne in mind when judging the size of the effects by type of use which is the focus of this paper.[4]

The one consistent result that appears across the different data sets is the importance of email and internet use. This is always strongly significant regardless of gender. The magnitude of its impact depends on the data set and gender reflecting the different snapshots through time of the population. Nonetheless the estimated premium is at least 10% (for women in the BCS) or 11% (fixed effects for women in WERS and for women in NCDS).[5] There is evidence of a larger mark-up for men with corresponding premia for men of 15% in BCS, 14% in WERS and 20% in NCDS. We would favour the most serious consideration for the results with the lowest premia in our estimations as these are those relating to the WERS data with the firm fixed effects which makes it less likely that the possible endogeneity of the variables in question are at issue. WERS also offers an interesting contrast to the remaining results regarding the value of specific computing skills. It appears from E-Living, BCS and NCDS that more sophisticated use of computers for design and programming does not benefit workers. However, programmers in WERS do obtain a wage premium.

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[4] The reader should note that there are no equivalent tests for endogeneity when there are multiple types of computer use variable which we focus on here. But the result from the Dolton and Pelkonen (2006) paper is indicative that including fixed effects for firms will 'rid' computer variables of the possible endogeneity.

Gender differences are clearly important in assessing the impact of computer use. Once we control for industry and occupation, we find that word-processing is associated with lower earnings, but that use of email or the internet is associated with an earnings boost. Word-processing is clearly associated with particular jobs for women since its negligible effect only appears when we have controlled for type of job. In contrast, the type of use of computers has widespread effects for men. Even after we have controlled for industry and occupation, all men earn about 17% from email or internet use and around a further 6% from word-processing (averaging across columns). The small effect of word-processing disappears for women in the younger BCS cohort although they still receive a large premium of around 9% from email or internet use (controlling for industry and occupation). The additional premiums for word-processing and use of email or the internet are slightly smaller for the 30-year-old men, but they are still substantial and significant. When we consider the E-Living results presented in Table 6c, the only consistent premium we observe for women is for email and internet use. It is, however, much larger at around 17% in the E-Living data although the differences in definitions outlined above may account for this.

Table 7 summarises the results for frequency of computer use. Men and women both receive higher earnings if they use a computer at age 42 in the NCDS. They receive a further increase if they use the computer daily. In both cases, men receive a much bigger premium than women. Women also have higher earnings if they use a computer weekly. The BCS results are considerably different. Men no longer receive an automatic premium for computer use, although women do. The earnings of both men and women are boosted if they use a computer daily. It appears that the returns to computer use have turned around in favour of women. Indeed, even women who use a computer daily have a larger increment to earnings than the corresponding men in BCS, once the constant term is taken into account.

[5] We are setting the computer use dummy effect equal to zero.

4. Conclusion

We have a rather interesting set of results for the impact of computer use on earnings. This is not perhaps surprising given the enormous yet disparate effect that ICT has had in the last 25 years or more. We find that the impact depends on which group of workers is examined. There are large differences by gender and differences over time, exemplified by the contrasting cohort results. The impact also depends on whether cohort or general cross-section datasets are analysed.

The main finding is that the use of computers for the internet and for email is positively significant. This variable may be a proxy for the size of a person's communication network and position in an organisational hierarchy. It may merely reflect that a person's marginal product is directly higher, the more they use the internet. For example, the variable may be capturing the size of the customer base or turnover of the firm in the fields of selling and marketing. It may well be an indicator of job type. We would interpret the positive effect of word-processing for men in NCDS as confirming this hypothesis. Fewer men work in administrative roles compared to women, but many men may use computers for some word-processing, even as managers.

There are clear differences between men and women. Men in the NCDS and E-Living surveys receive higher earnings regardless of how they use a computer. The increase for women depends on how the computer is used. As the implementation of ICT requires bundles of characteristics that do not rely on attributes such as physical strength, it might be argued that the technology lends itself to female workers. It would seem that expanding the different types of computer use for women (for example, through training) would do much to facilitate access to higher earnings.

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Table 1a Percent of workers who use a computer at work (numbers in parentheses)

Sample	*Men*	*Women*	*All*
NCDS	68 (3951)	63 (4000)	65 (7951)
BCS	67 (4187)	72 (3903)	69 (8090)
E-Living	57 (377)	57 (393)	57 (770)

Table 1b Percent of workers who use a computer at work (numbers in parentheses) – E-Living only

Age	*Men*	*Women*	*All*
16-24	54	57	55
	(33)	(30)	(63)
25-33	67	69	68
	(58)	(81)	(139)
34-42	64	53	59
	(68)	(49)	(117)
43-51	48	51	49
	(32)	(42)	(74)
52-60	41	47	44
	(18)	(16)	(34)
Total	57	57	57
16-60	(209)	(218)	(427)

Note. Percentages defined over non-missing real hourly wage earners

Table 2 Percent of workers in various time categories who use a computer at work by gender (E-Living)

	Men	*Women*	*All*
less than one year	5.1	10.2	7.7
1-3 years	20.9	26.6	23.8
4-6 years	24.5	19.9	22.1
7-10 years	24.5	21.6	23.0
more than 10 years	23.9	18.7	21.3
Do not know	1.2	2.9	2.1

Note. E-Living data only.

Table 3 Type of computer use

	E-Living use of computers	*NCDS/BCS use of computers*	*WERS 2004use of computers*
Word processing	Word processing	Word processing	Word processing
Spreadsheet	Spreadsheets, databases	Data analysis, databases	Record keeping, Data Entry, Data Analysis.
Email/Internet	Email/Internet	Internet, Email	Email
Design	Web Design/Management, Desk Top Publishing, Analysis	Design packages	Desk Top Publishing, Computer Aided Design.
Programming	Programming, Network Systems Management, PC Support	Programming	Programming or compiling syntax.
Other	Don't know	Other	Checking stock movements, availability or pricing, Ordering , Purchasing, Any other task

Table 4: Type of computer use at work

	WERS *Cross section of ages in 2004*		*BCS* *30 year olds in 2000*		*NCDS* *42 years olds in 2000*		*E-Living* *Cross section of ages in 2002*	
	Women	Men	Women	Men	Women	Men	Women	Men
Word processing	59.1	53.0	38.2	39.6	32.4	40.0	60.2	49.9
Spreadsheet	59.3	56.6	36.6	45.6	32.6	45.8	49.1	55.3
Email/internet	60.6	58.3	30.9	37.5	23.1	37.2	49.7	56.8
Design	11.4	13.4	7.3	14.8	5.9	11.9	14.0	19.9
Programming	1.3	5.9	3.9	12.7	3.3	10.2	7.0	19.0
Other	47.7	48.9	51.6	45.9	56.4	45.3	13.5	10.9
Any Use	78.2	72.1	72.0	67.0	68.0	63.0	57.0	57.0

Note. E-Living question is "Of the following computer tasks, which best describes the way you mostly use your computer at work." (Respondents able to tick more than one category.)
The WERS 2004 question is "Do you use computer for any of the following tasks as part of your work?". Twelve options are presented and respondents are asked to tick all that apply.
In NCDS and BCS, respondents were asked 'Do you use a computer at work?' If the answer was 'Yes' then they were asked to indicate in which ways the computer was used at work, as summarised in Table 3.

Table 5a Percentage Frequency of Computer use in BCS and NCDS

	BCS		*NCDS*	
	Women	Men	Women	Men
Less than weekly	2.02	2.49	2.55	2.06
Weekly	3.97	4.08	2.59	3.93
Daily	43.33	48.44	36.86	49.02

Table 5b Percentage Intensity of Daily Computer use for E-Living

	Women	*Men*
Up to 2 Hours	25.00	26.74
3-4 Hours	18.15	19.44
5-6 Hours	21.58	20.83
7-8 Hours	28.77	22.92
9 Hours or More	6.51	10.07

Note. E-Living question is "How many hours a day do you usually use a computer as part of your job?"

Table 6a Earnings for the BCS Data with Type of Computer Use

	Women			*Men*		
	(1)	(2)	(3)	(4)	(5)	(6)
Computer Use	0.274			0.291		
	(0.017)**			(0.015)**		
Word processing		0.112	0.037		0.098	0.058
		(0.019)**	(0.018)*		(0.020)**	(0.020)**
Spreadsheet		0.042	0.016		0.053	0.043
		(0.015)**	(0.015)		(0.017)**	(0.017)*
Email		0.119	0.091		0.185	0.148
		(0.018)**	(0.018)**		(0.020)**	(0.020)**
Design		0.031	0.026		0.031	0.014
		(0.020)	(0.018)		(0.021)	(0.021)
Programming		0.023	0.017		0.037	0.036
		(0.030)	(0.029)		(0.021)	(0.021)
Other		0.011	0.012		-0.014	-0.003
		(0.015)	(0.014)		(0.016)	(0.016)
Experience	0.025	0.009	0.010	0.066	0.029	0.029
	(0.009)**	(0.008)	(0.008)	(0.014)**	(0.014)*	(0.013)*
Exp Sq /100	0.017	0.058	0.031	-0.112	0.059	0.023
	(0.058)	(0.054)	(0.052)	(0.075)	(0.073)	(0.070)
Years Education.	0.077	0.037	0.025	0.082	0.046	0.037
	(0.004)**	(0.005)**	(0.005)**	(0.004)**	(0.005)*	(0.005)**
London	0.216	0.189	0.186	0.273	0.265	0.249
	(0.022)**	(0.021)**	(0.020)**	(0.025)**	(0.024)**	(0.023)**
nvq1 Basic		0.018	0.014		-0.024	-0.011
		(0.039)	(0.038)		(0.028)	(0.028)
nvq2 GCSE		0.071	0.043		0.041	0.034
		(0.029)*	(0.028)		(0.023)	(0.023)
nvq3 Intermediate		0.141	0.114		0.134	0.103
		(0.034)**	(0.032)**		(0.027)**	(0.026)**
nvq4 Degree		0.311	0.255		0.212	0.162
		(0.033)**	(0.032)**		(0.028)**	(0.028)**
nvq5 Masters		0.341	0.223		0.223	0.192
		(0.043)**	(0.042)**		(0.042)**	(0.041)**
Small firm		0.065	0.061		0.057	0.071
		(0.025)*	(0.025)*		(0.026)*	(0.025)**
Medium firm		0.091	0.092		0.089	0.110
		(0.023)**	(0.023)**		(0.025)**	(0.025)**
Med/Large firm		0.129	0.145		0.097	0.139
		(0.023)**	(0.023)**		(0.025)**	(0.025)**
Large firm		0.204	0.213		0.180	0.222
		(0.024)**	(0.024)**		(0.027)**	(0.027)**
Married		0.022	0.007		0.086	0.074
		(0.015)	(0.015)		(0.014)**	(0.013)**
Part Time		-0.031	-0.009		-0.045	0.027
		(0.020)	(0.020)*		(0.091)	(0.088)
Observations	3903	3903	3903	4187	4187	4187
R-squared	0.29	0.36	0.41	0.24	0.33	0.38
Soc/Sic			Yes			Yes

Note. 1. Standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%.
2. Columns 1 and 4 represent the basic human capital specification augmented by a simple dummy for computer use at work. Columns 2 and 5 incorporate dummies for type of computer use and the other controls. Columns 3 and 6 add occupation and industry dummies alongside the standard controls.

Table 6b Earnings for the NCDS Data with Type of Computer Use

	Women			*Men*		
	(1)	(2)	(3)	(4)	(5)	(6)
Computer Use	0.250			0.399		
	(0.016)**			(0.016)**		
Word processing		0.060	0.010		0.119	0.057
		(0.019)**	(0.019)		(0.027)**	(0.025)*
Spreadsheet		0.092	0.059		0.088	0.055
		(0.016)**	(0.016)**		(0.019)**	(0.018)**
Email		0.125	0.108		0.281	0.198
		(0.019)**	(0.018)**		(0.025)**	(0.023)**
Design		-0.004	-0.026		0.017	0.003
		(0.026)	(0.024)		(0.027)	(0.026)
Programming		0.012	-0.021		-0.008	-0.012
		(0.031)	(0.030)		(0.025)	(0.024)
Other		0.014	0.006		-0.029	-0.014
		(0.015)	(0.014)		(0.019)	(0.017)
Experience	0.007	0.006	0.005	0.006	-0.004	-0.009
	(0.004)+	(0.004)	(0.004)	(0.016)	(0.016)	(0.015)
Exp Sq/100	0.046	0.034	0.026	0.037	0.045	0.050
	(0.015)**	(0.014)*	(0.013)+	(0.042)	(0.041)	(0.040)
Years Education.	0.103	0.063	0.045	0.082	0.042	0.038
	(0.004)**	(0.005)**	(0.005)**	(0.005)**	(0.006)**	(0.006)**
London	0.184	0.180	0.169	0.198	0.177	0.169
	(0.027)**	(0.026)**	(0.024)**	(0.031)**	(0.029)**	(0.027)**
nvq1 Basic		-0.035	-0.033		0.019	0.025
		(0.029)	(0.029)		(0.032)	(0.031)
nvq2 GCSE		0.049	0.032		0.095	0.064
		(0.029)+	(0.029)		(0.029)**	(0.028)*
nvq3 Intermediate		0.041	0.002		0.158	0.103
		(0.033)	(0.032)		(0.031)**	(0.029)**
nvq4 Degree		0.282	0.133		0.210	0.126
		(0.032)**	(0.033)**		(0.033)**	(0.032)**
nvq5 Masters		0.362	0.164		0.286	0.227
		(0.051)**	(0.050)**		(0.057)**	(0.054)**
Small firm		0.076	0.084		0.119	0.120
		(0.022)**	(0.021)**		(0.029)**	(0.028)**
Medium firm		0.068	0.077		0.133	0.144
		(0.021)**	(0.020)**		(0.026)**	(0.026)**
Med/Large firm		0.111	0.122		0.145	0.164
		(0.021)**	(0.021)**		(0.027)**	(0.027)**
Large firm		0.182	0.171		0.210	0.235
		(0.023)**	(0.022)**		(0.028)**	(0.028)**
Married		0.044	0.026		0.114	0.069
		(0.016)**	(0.016)+		(0.018)**	(0.017)**
Part Time		-0.034	0.012		-0.294	-0.230
		(0.016)*	(0.016)		(0.055)**	(0.054)**
Observations	4000	4000	4000	3951	3951	3951
R-squared	0.37	0.42	0.49	0.26	0.36	0.44
Soc/Sic			Yes			Yes

Note. 1. Standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%.
2. Columns 1 and 4 represent the basic human capital specification augmented by a simple dummy for computer use at work. Columns 2 and 5 incorporate dummies for type of computer use and the other controls. Columns 3 and 6 add occupation and industry dummies alongside the standard controls.

Table 6c Earnings for the E-Living Data with Type of Computer Use

	Women			Men		
	(1)	(2)	(3)	(4)	(5)	(6)
Computer Use	0.314			0.384		
	(0.050)**			(0.061)**		
Word processing		0.106	0.034		0.084	0.059
		(0.054)+	(0.055)		(0.077)	(0.078)
Spreadsheet		0.078	0.043		0.017	-0.005
		(0.058)	(0.059)		(0.104)	(0.091)
Email		0.200	0.168		0.286	0.253
		(0.054)**	(0.051)**		(0.075)**	(0.082)**
Design		0.071	0.069		0.105	0.125
		(0.078)	(0.078)		(0.081)	(0.082)
Programming		0.174	0.125		-0.060	-0.065
		(0.094)+	(0.085)		(0.098)	(0.102)
Other		0.156	0.108		-0.001	0.020
		(0.063)*	(0.061)+		(0.155)*	(0.152)
Experience	0.038	0.026	0.021	0.043	0.038	0.030
	(0.006)**	(0.006)**	(0.006)**	(0.009)**	(0.009)**	(0.008)**
Exp Sq /100	-0.074	-0.049	-0.039	-0.079	-0.072	-0.055
	(0.013)**	(0.014)**	(0.013)**	(0.017)**	(0.017)**	(0.015)**
Years Education.	0.053	0.032	0.024	0.032	0.017	0.012
	(0.009)**	(0.008)**	(0.007)**	(0.008)**	(0.009)+	(0.009)
London	0.274	0.314	0.307	0.066	0.091	0.040
	(0.079)**	(0.081)**	(0.079)**	(0.083)	(0.085)	(0.081)
nvq1 Basic		-0.305	-0.285		0.254	0.252
		(0.113)**	(0.109)**		(0.152)+	(0.145)+
nvq2 GCSE		0.036	0.053		0.078	0.129
		(0.063)	(0.059)		(0.087)	(0.095)
nvq3 Intermediate		-0.057	-0.057		-0.010	-0.006
		(0.065)	(0.067)		(0.105)	(0.104)
nvq4 Degree		0.292	0.227		0.309	0.252
		(0.060)**	(0.054)**		(0.087)**	(0.092)**
nvq5 Masters		0.373	0.304		0.184	0.115
		(0.117)**	(0.111)**		(0.155)	(0.150)
Small firm		-0.086	-0.095		0.150	0.175
		(0.071)	(0.067)		(0.087)+	(0.089)+
Medium firm		-0.041	-0.040		0.074	0.073
		(0.071)	(0.069)		(0.102)	(0.107)
Med/Large firm		0.074	0.055		0.153	0.180
		(0.078)	(0.077)		(0.078)+	(0.074)*
Large firm		0.099	0.060		0.303	0.329
		(0.074)	(0.069)		(0.072)**	(0.076)**
Married		0.035	0.037		0.132	0.113
		(0.047)	(0.045)		(0.057)*	(0.051)*
Part Time		-0.055	0.027		0.306	0.313
		(0.050)	(0.051)		(0.186)	(0.176)+
Observations	376	376	376	364	364	364
R-squared	0.32	0.45	0.52	0.20	0.29	0.36
Soc/Sic			Yes			Yes

Note. 1. Standard errors in parentheses. + significant at 10%; * significant at 5%; ** significant at 1%.
2. Columns 1 and 4 represent the basic human capital specification augmented by a simple dummy for computer use at work. Columns 2 and 5 incorporate dummies for type of computer use and the other controls. Columns 3 and 6 add occupation and industry dummies alongside the standard controls.

Table 6d Female Earnings for the WERS Data with Type of Computer Use – Fixed effect estimates (adjustment for establishment and occupation fixed effects)

Women	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*
Use any	0.236	0.214		0.080	
	(0.009)**	(0.010)**		(0.012)**	
Word			0.114		0.054
			(0.010)**		(0.010)**
Spreadsheet			0.005		-0.018
			(0.009)		(0.009)*
Email			0.188		0.106
			(0.011)**		(0.011)**
Design			-0.010		-0.004
			(0.012)		(0.011)
Program			0.144		0.089
			(0.031)**		(0.033)**
Other			-0.021		-0.004
			(0.008)**		(0.007)
Experience	0.023	0.022	0.021	0.015	0.015
	(0.001)**	(0.001)**	(0.001)**	(0.001)**	(0.001)**
Exp Sq/100	-0.040	-0.037	-0.035	-0.024	-0.023
	(0.002)**	(0.003)**	(0.002)**	(0.002)**	(0.002)**
Years Education.	0.073	0.053	0.045	0.030	0.028
	(0.001)**	(0.003)**	(0.003)**	(0.003)**	(0.003)**
nvq1 Basic		-0.015	-0.003	-0.017	-0.013
		(0.021)	(0.021)	(0.019)	(0.019)
nvq2 GCSE		0.075	0.065	0.032	0.031
		(0.015)**	(0.014)**	(0.014)*	(0.014)*
nvq3 Intermediate		0.040	0.028	0.004	0.003
		(0.015)**	(0.014)	(0.014)	(0.014)
nvq4 Degree		0.173	0.178	0.060	0.062
		(0.021)**	(0.020)**	(0.020)**	(0.020)**
nvq5 Masters		0.156	0.156	0.051	0.050
		(0.031)**	(0.030)**	(0.029)	(0.029)
Small firm		0.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
Medium firm		-0.038	-0.025	-0.025	-0.022
		(0.009)**	(0.009)**	(0.009)**	(0.009)*
Med/Large firm		0.074	0.057	0.047	0.045
		(0.011)**	(0.010)**	(0.011)**	(0.011)**
Large firm		0.097	0.086	0.065	0.064
		(0.012)**	(0.012)**	(0.012)**	(0.012)**
Married		0.020	0.015	0.001	-0.001
		(0.010)*	(0.010)	(0.009)	(0.009)
Part Time		-0.034	0.008	0.056	0.067
		(0.008)**	(0.008)	(0.008)**	(0.008)**
Observations	11249	11249	11249	11249	11249
R-squared	0.30	0.32	0.35	0.54	0.54
Soc/Sic			Yes		

Note. 1. Standard errors in parentheses. * significant at 5%; ** significant at 1%. 2. Column 1 represents the basic human capital specification augmented by a simple dummy for computer use at work. Column 2 incorporates dummies for type of computer use and the other controls. Column 3 adds occupation and industry dummies alongside the standard controls. Columns 4 and 5 report the results from incorporating the firm and occupation fixed effects approach.

Table 6e Male Earnings for the WERS Data with Type of Computer Use – Fixed effect estimates (adjustment for establishment and occupation fixed effects)

Men	(1)	(2)	(3)	(4)	(5)
Use any	0.287	0.268		0.123	
	(0.009)**	(0.009)**		(0.011)**	
Word			0.135		0.061
			(0.012)**		(0.012)**
Spreadsheet			0.005		0.001
			(0.010)		(0.010)
Email			0.224		0.136
			(0.013)**		(0.013)**
Design			-0.021		-0.011
			(0.011)		(0.011)
Program			0.117		0.059
			(0.016)**		(0.017)**
Other			0.003		0.005
			(0.008)		(0.008)
Experience	0.036	0.029	0.028	0.023	0.023
	(0.001)**	(0.001)**	(0.001)**	(0.001)**	(0.001)**
Exp Sq/100	-0.058	-0.048	-0.048	-0.040	-0.039
	(0.002)**	(0.003)**	(0.003)**	(0.002)**	(0.002)**
Years Education.	0.063	0.051	0.040	0.033	0.031
	(0.001)**	(0.003)**	(0.003)**	(0.003)**	(0.003)**
nvq1 Basic		0.014	0.021	-0.001	0.002
		(0.018)	(0.018)	(0.017)	(0.016)
nvq2 GCSE		0.085	0.068	0.036	0.037
		(0.015)**	(0.015)**	(0.014)**	(0.014)**
nvq3 Intermediate		0.066	0.051	0.015	0.017
		(0.015)**	(0.015)**	(0.014)	(0.014)
nvq4 Degree		0.128	0.092	0.029	0.025
		(0.022)**	(0.021)**	(0.021)	(0.020)
nvq5 Masters		0.106	0.072	0.026	0.021
		(0.031)**	(0.030)*	(0.029)	(0.029)
Small firm		0.000	0.000	0.000	0.000
		(0.000)	(0.000)	(0.000)	(0.000)
Medium firm		-0.039	-0.039	-0.041	-0.037
		(0.009)**	(0.009)**	(0.009)**	(0.009)**
Med/Large firm		0.082	0.077	0.079	0.076
		(0.012)**	(0.012)**	(0.012)**	(0.012)**
Large firm		0.096	0.092	0.093	0.089
		(0.014)**	(0.013)**	(0.014)**	(0.014)**
Married		0.135	0.129	0.086	0.085
		(0.010)**	(0.010)**	(0.009)**	(0.009)**
Part Time		0.020	0.055	0.173	0.182
		(0.014)	(0.013)**	(0.014)**	(0.014)**
Observations	9843	9843	9843	9843	9843
R-squared	0.36	0.38	0.42	0.61	0.62
Soc/Sic			Yes		

Note. 1. Standard errors in parentheses. * significant at 5%; ** significant at 1%. 2. Column 1 represents the basic human capital specification augmented by a simple dummy for computer use at work. Column 2 incorporates dummies for type of computer use and the other controls. Column 3 adds occupation and industry dummies alongside the standard controls. Columns 4 and 5 report the results from incorporating the occupation and firm fixed effects approach.

Table 7 Frequency of Use Coefficients for BCS/NCDS

	BCS		*NCDS*	
	Women	Men	Women	Men
Computer Use	0.149	0.039	0.104	0.135
	(0.045)**	(0.050)	(0.041)*	(0.049)**
Less than Weekly	0.014	0.027	0.061	-0.002
	(0.059)	(0.062)	(0.054)	(0.069)
Weekly	0.011	0.046	0.148	0.043
	(0.052)	(0.057)	(0.047)**	(0.059)
Daily	0.073	0.197	0.127	0.238
	(0.044)+	(0.049)**	(0.041)**	(0.048)**
Observations	3903	4187	4000	3951
R-squared	0.35	0.30	0.41	0.32

Note. Standard errors in parentheses. + significant at 10%; * significant at 5%;
** significant at 1%.
In NCDS and BCS, respondents were asked 'Do you use a computer at work?' If the answer was 'Yes' then they were asked to indicate in which ways the computer was used at work, as summarised in Table 3. The frequency of this use are reported above.

APPENDIX

The Use of Lagged Information on Computer Use

Dolton and Makepeace (2004) use panel methods to investigate the effects of using a computer without specifying the type of use. Unfortunately, standard panel methods cannot be applied in this context, because the lagged values for type of computer use are not available in NCDS, and BCS collected its first information on computer use in 2000. NCDS does show whether computers were used at work in 1991. However, we can relate our approach above to an underlying fixed effects model. Consider the structural equation for individual *i* over time *t*:

$$\ln E_{it} = \alpha + \gamma U_{it} + f_i + \nu_{it} \qquad \text{(A.1)}$$

where *E* is earnings and, for simplicity, *U* is a dummy for one type of computer use and *f* is an unobserved fixed effect (as described in Baltagi (1995)). Here, there are only two values of *t* corresponding to the two NCDS surveys in 1991 and 2000. The estimation problems arise because *f* is correlated with *U* in each period. Define the linear projection of *f* as:

$$f_i = \mu U_{it} + \lambda U_{i,t-1} + \upsilon_i \qquad \text{(A.2)}$$

Substituting into equation A.1 yields the reduced form equation,

$$\ln E_{it} = \alpha + (\gamma + \mu) U_{it} + \lambda U_{i,t-1} + \varepsilon_{it} \qquad \text{(A.3)}$$

The main text reports results based on the structural equation. If the omitted variable bias is not serious, then the estimated coefficients of U_{it} should be similar in the structural and reduced form equations (A.1 and A.3). The reduced form requires lagged values for type of computer use. Here, we replace U_{t-1} by a dummy for any computer use in the previous period (C_{t-1}) and its interaction with type of computer use. Our model is:

Structural form: $\ln E_{it} = \alpha + \gamma U_{it} + f_i + \nu_{it}$ (A.4

Linear projection: $f_i = \mu U_{it} + \lambda C_{i,t-1} + \kappa (C_{i,t-1} * U_{it}) + \upsilon_i$ (A.5)

Reduced form: $\ln E_{it} = \alpha + (\gamma + \mu) U_{it} + \lambda C_{i,t-1} + \kappa (C_{i,t-1} * U_{it}) + \varepsilon_{it}$ (A.6)

We examine informally whether the estimated coefficient of U_t is sensitive to the addition of the lagged values. It is similar in each specification, we will conclude that the bias in the estimates in the main text is likely to be small.

We first repeat the estimation of the full specification of our original model for the sub-sample that has lagged values for computer use. The columns of Table A1 labelled 'main text' and 'sub-sample' display the estimates using the full and sub-samples. The significance of the different variables is not affected by restricting the sample and the significant coefficients only change by a small amount. We then created interaction terms for all the types of computer use in 2000 with computer use in 1991. The interaction variables and computer use in 1991 were added to the full specification of the model that included occupation and industry dummies. We accept the null hypothesis that the joint significance of the interaction terms is zero.[6] We therefore omit the interaction terms and re-estimate the model retaining only the lagged value for any computer use. The results for this specification are shown in the column labelled 'Reduced from'.

Comparing the results in the main text with the reduced form estimates, our conclusions appear well founded. In particular, the important result for the use of email remain while signing, programming and other uses have no effect. The use of spreadsheets raises earnings for both men and women but the estimate for men falls from 0.055 to 0.035 and is no longer significant at the 1% level. Word-processing is associated with higher earnings for men, but not for women.

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[6] The F statistics have *p*-values of 0.52 for men and 0.30 for women.

Table A1 Estimates for the NCDS using lagged computer use

	Women			*Men*		
Sample	Main text	Sub-sample		Main text	Sub-sample	
Specification	Structural form		Reduced	Structural form		Reduced
	(1)	(2)	(3)	(4)	(5)	(60
Lagged			0.043*			0.105**
Computer use			(0.017)*			(0.018)**
Word processing	0.010	0.011	0.007	0.057*	0.072**	0.056*
	(0.019)	(0.020)	(0.020)	(0.025)*	(0.026)**	(0.026)*
Spreadsheet	0.059**	0.062**	0.057**	0.055**	0.050**	0.035+
	(0.016)**	(0.017)**	(0.017)**	(0.018)**	(0.019)**	(0.020)+
Email	0.108**	0.106**	0.102**	0.198**	0.198**	0.187**
	(0.018)**	(0.019)**	(0.019)**	(0.023)**	(0.024)**	(0.024)**
Design	-0.026	-0.031	-0.033	0.003	0.003	-0.008
	(0.024)	(0.026)	(0.026)	(0.026)	(0.027)	(0.027)
Programming	-0.021	-0.017	-0.016	-0.012	-0.012	-0.006
	(0.030)	(0.032)	(0.032)	(0.024)	(0.025)	(0.025)
Other	0.006	0.003	0.001	-0.014	-0.013	-0.020
	(0.014)	(0.015)	(0.015)	(0.017)	(0.018)	(0.018)
Observations	4000	3580	3580	3951	3407	3407

Note. Each estimation includes the full set of control variables shown in the main text. + denotes significance at 10%; * significance at 5% and ** significance at 1%.