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ARE COMPUTERS AT HOME A FORM OF CONSUMPTION OR AN INVESTMENT? A LONGITUDINAL ANALYSIS FOR JAPAN*

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This study examines the effect on labour market outcomes, of computer possession at home using longitudinal data collected in Japan. There are positive correlations between computer possession and women's full-time employment and the salaries of both men and women. In a fixed effects analysis, however, no temporal, causal effects of computer possession on labour market outcomes were found. Overall, the results suggest that the positive correlation between computer possession and better labour market outcomes does not imply causality among workers strongly attached to the labour market.
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1. Introduction

Motivated by recent discussion on the "digital divide," this paper examines the effect of computer possession at home on labour market outcomes. The recent, rapid penetration of computers into people's daily lives has sparked public interest regarding the consequences of computer usage on people's economic success. Among those who view these consequences positively, IT is called the dynamo of the "New Economy"; according to a recent growth account study in the USA, 1/3 of the growth in national income during the 1990s is explained by IT-related investment (Jorgenson (2001)). At the same time, some social critics point to the positive correlation between computer possession at home and household income and claim that this is the dark side of IT penetration (see Figure 1). They view this finding as evidence of a digital divide and express concern that the progress of IT penetration might separate the population into two groups—"the haves" and "the have nots." Reflecting this concern, a recent piece of legislation in Japan, the so-called IT law, requires the government to ensure equal access to IT throughout its population (*Koudo Jōhō Tsushin Network Shakai Keisei Kihon Hō* (the IT law), Article 8). Here, lawmakers and social critics implicitly attribute a causal effect between computer possession at home and the subsequent labour market outcomes of workers who have mastered computer skills because they own computers. In this sense, lawmakers and social critics treat computers at home as investments that enhance human capital accumulation and, accordingly,

* The Japan Panel Survey of Consumers (*Shōhi Seikatsu ni Kansuru Paneru Chōsa*), published by the Institute for Research on Household Economics (*Kakei Keizai Kenkyūsho*), 1-3-13 Hirakawacho, Chiyoda-ku, Tokyo 102-0093, Japan, is used in this study. Due to a confidentiality agreement with the Institute, the data used cannot be released. The author would like to thank Tomomi Iwamoto and Akiko Nagai for their patient explanation of the dataset, Donna Maurer for editorial assistance, and Jeff Biddle, Linda Bailey, Ali Berker, Yoko Kijima, Kenji Moriyama and participants of the labour workshop at Michigan State University and the annual meeting of the Japanese Economic Association for useful comments. The author especially thanks David Neumark and Fumio Ohtake for their comments and encouragement. Thorough comments from an anonymous referee improved this paper significantly. The usual disclaimer applies.

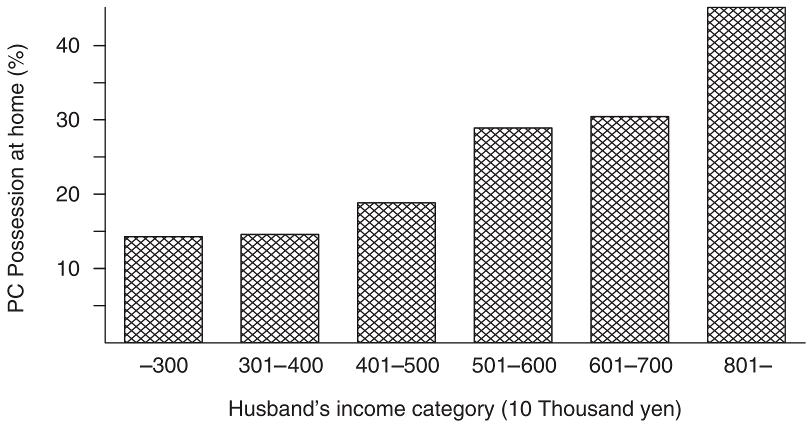

FIGURE 1. Ratio of PC Possession at Home by Husband's Income Category
Source: Author's Calculation from JPSC, 1996 Wave, $N = 924$.

future job market opportunities. In other words, they claim that having access to a computer or the Internet *causes* better future job market opportunities. However, economists and lawmakers should avoid making causal statements based on this observed correlation, since it is also probable that workers with unobserved characteristics that positively affect labour market outcomes tend to have computers. For example, those who accommodate changes well may work efficiently and, at the same time, own computers as consumption goods. In this case, there is no causal relationship between computer possession at home and current or subsequent labour market outcomes. If this is the case, there is little reason for the government to intervene in the market to ensure equal access to IT. Thus, determining the causal effect of computer possession on household income is crucial in order to derive policy recommendations, especially regarding governmental policy that seeks to assure equal access to IT.

To examine the causal effect of computer possession on various labour market outcomes, this study uses a recently published longitudinal data set of Japanese young women, the Japanese Panel Survey on Consumers (JPSC). In previous studies conducted in the USA, it has been generally difficult to identify such a causal effect in a credible manner because current population survey computer supplements, which are cross-sectional data, have been used to study the effect. To deal with the endogeneity of computer use or possession, the researcher must have an exogenous variation that affects computer use or possession but does not affect labour market outcomes; it is usually very difficult to find such an exogenous variation, however. The issue of endogeneity is more effectively addressed with panel data because such data make it possible to control the effect of unobserved, individual characteristics. With just a few exceptions of data sets that have been used for European studies (Bell (1996), Entorf, Gollac, and Kramarz (1999)), Haisken-DeNew and Schmidt (1999) and Anger and Schwarze (2003), individual-level, panel data with computer possession are rarely available, and this data constraint has made the credible study of the computer effect difficult. The JPSC is a rare panel data set that contains information on the possession of computers at home. However, despite the attractive panel feature of the data set, the JPSC has several drawbacks for studying the computer effect on labour market outcomes. First, we can only focus on the labour market outcomes for young women and their husbands, namely (i) young women's labour force participation, (ii) their earnings, and (iii) their husbands' earnings. However, how computers at home affect young women's labour market outcomes is crucial, since some argue that computers at home enable women to work while they stay home to take care of household responsibilities. Second, computer use at work is not available in this data set. Thus, the return to computer use at work cannot be estimated in this study. However, as discussed in the following literature review, most previous studies have interpreted the return to computer use at work as the return to computer skills or the skills to process information; thus what matters here is the return to these skills, rather than computer use itself.

Although many studies have examined the return to these skills, surprisingly few studies have examined how the skills are formed. Possessing a computer at home may be an important way to acquire computer skills, and therefore it is important to estimate the return to computer possession at home. In addition, by examining the causal relationship between home computer ownership and labour market outcomes, only the return to computer skills that is general across firms can be captured. If we examine the relationship between computer usage at work and earnings, we cannot disentangle the general and firm-specific aspects of computer skills. Even when computer ownership at home complements the firm-specific skills of computer usage among current workers, we can capture the effect of general computer skills on labour market outcomes by focusing on labour-force participation decisions among workers who are not currently employed. Disentangling the general and specific aspects of computer skills is important from both theoretical and policy perspectives, in particular, to determine who will pay for computer training and what public policy can do when workers experience liquidity constraints. Moreover, the discussion on the digital divide focuses on computer possession at home rather than computer use at work; consequently, the return to computer possession is important in its own right.

The rest of this paper is organized as follows. The next section reviews the literature on the effect of computers or new technology on labour market outcomes. The third and fourth sections describe the empirical strategy and data, respectively. The fifth section presents the results of the estimation, and the last section offers concluding remarks.

2. Literature review

Widely observed earnings dispersials during the 1980s and 1990s in the USA and Western Europe stimulated an investigation into their cause. Among several possible explanations, skill-biased technological progress, represented by computerization, has been identified as a major cause of earnings dispersion (Katz, 2002). There are two strategies for identifying the effect of computerization on earnings inequality: (i) estimate how computerization changes the relative demand for skilled workers compared with unskilled workers, and (ii) estimate the return to computer skills by estimating wage regression, using individual data.

The first strategy regresses the relative demand for skilled workers in an industry or establishment on their computerization. In this analysis, the relative demand is typically represented by the wage-bill share of skilled workers in the total wage bill or the share of skilled workers in the total number of workers. An industry-level study by Autor, Katz, and Krueger (1998) showed that computerization had increased the relative demand for skilled workers in the USA over a 20-year period. Haskel and Heden (1999) found similar results for the UK through establishment- and industry-level analyses. However, an establishment-level study of the USA by Doms, Dunne, and Troske (1997) doubted its causality; although the researchers found that computerization had a positive effect on the relative demand for skilled workers in cross-sectional estimates, the effect disappeared in the first-difference estimation. Consequently, they suggested that establishments with highly skilled workers adopt high technology, rather than a causal relationship that moved from computerization to skill upgrading. This study, however, focused only on the manufacturing industry, and thus the conclusion is only suggestive. Panel data that cover a wide range of industries are needed to derive a definitive conclusion regarding the causal effect of computerization on the demand for skills.

The second strategy consists of the direct estimation of the wage regression with a computer-use dummy. The first study by Krueger (1993), which used US cross-sectional data, found a 15–20% computer premium in a wage regression with standard covariates, which the researcher interpreted as the return to computer skills. Reilly (1995) also found a 13% computer premium using Canadian cross-sectional data. These cross-sectional studies were criticized by DiNardo and Pischke (1997), however. The latter insisted that cross-sectional estimates of the computer premium do not necessarily reflect the return to computer skills because they also found a premium for pencil use in Germany. Since writing is not a scarce skill in Germany, they speculated that the unobserved skill that is correlated with both computer use and pencil use had rendered a spurious premium in each case. Borghans and ter Weel (2003) implemented a similar study using 1997 UK cross-sectional data and obtained similar results. Thus, again, the main question is whether computer use causes skill acquisition or the possession of skills causes computer use.

Chennells and Reenen (1997) attacked this endogeneity issue, using UK establishment-level, cross-sectional data and the IV Method,[1] where computer use was instrumented with industry-level technology availability proxied by the ratio of R&D expenditures per sales or the number of patents. Although they found the computer premium in an OLS estimation, the premium was not found in the IV estimation, and thus they concluded that the computer premium found in the OLS estimation was spurious. Panel data, another source typically used to work around the endogeneity problem, were used in several European studies. Bell (1996) analyzed British panel data (1981 and 1991) and found a computer premium in the OLS estimation. This computer premium was found even after controlling for individual heterogeneity through a first-difference estimation. However, Entorf, Gollac, and Kramarz (1999) found a 7% computer premium in an OLS estimation that disappeared in the first-difference estimation using French panel data (1991 and 1993). Using the German Socio-economic Panel, Anger and Schwarze (2003) and Haisken-DeNew and Schmidt (1999) also found that the computer premium in the cross-sectional estimates virtually disappeared in the fixed-effects estimates. Although the difference in the results between Bell (1996) and the other studies may seem striking at first glance, the difference in the length of the panel period, in addition to the differences between the counties analyzed, may explain the dissimilarity of their findings. Considering skill acquisition over a 10-year period, the assumption of time-constant, unobserved skills employed by Bell (1996) might be too strong, and the violation of this assumption might make the first-difference estimator upwardly biased. In sum, wage regressions using US and Western

[1] The model used in this method is more than simple IV estimation due to the non-linearity of the computer use equation; however, the issue of identification does not depend on the non-linearity of the functional form.

European data have found a computer premium in cross-sectional estimates; however, many studies have found that this computer premium is due to unobserved skills that increase both computer use and earnings.

Several notable studies have estimated the return to PC possession at home using Japanese cross-sectional data. Shimizu and Matsuura (1999) found a 20% premium on computer possession at home, using cross-sectional data from 1994. To deal with the endogeneity issue, they estimated a structural model in which income and computer possession were simultaneously determined. The consistency of the system estimator, however, depends on the validity of the exclusion condition; in their study the variables excluded from the wage equation were children's ages, school attendance and other variables. Since women were included in the sample, having small children, which is negatively correlated with computer possession, might also be negatively correlated with the error term in the wage equation. Furthermore, children's high school or college attendance, which was positively correlated with computer possession, might be positively correlated with error in the wage equation because the wage equation did not include educational attainment due to the data restriction; also, the educational attainments of parents and children tend to have a positive correlation. Based on the potential positive correlation of the error term in the wage equation and the variable excluded from the wage equation, it is reasonable to suspect an upward bias in the system estimator found in Shimizu and Matsuura (1999). Shimizu and Matsuura (2000) again found a 20% wage premium on computer possession using other cross-sectional data from 1999, as well as a similar structural estimation. In this study, the excluded variables from the wage equation were computer use at work, which was positively correlated with computer possession at home, and other variables. Since the positive effect of computer use at work on wages is rather obvious based on evidence from the USA and Western Europe, it is fair to say that the estimate was upwardly biased. Given those tenuous, excluded variable assumptions in the system estimations, the OLS estimate of a 7.4% premium, which appeared in Shimizu (1999) based on the same data used by Shimizu and Matsuura (2000), should be understood as the upper bound estimate of the premium.

Kohara and Ohtake (2001) examined the effect of computer use at work on workers' wages, using the panel data of workers who had experienced job change in the Osaka prefecture. They found around a 6% (with a standard error of about 3%) computer premium in the OLS estimation; however, the estimated coefficient was as small as 4.7%, with standard error of 2.6% in the fixed-effects estimation. They concluded that part of the computer premium in the OLS estimation was due to unobserved heterogeneity, such as the ability to adopt new technology.

3. Empirical model

This section discusses the empirical strategy used to identify the effect of possessing computers at home on labour market outcomes. Although various outcomes are considered, the same econometric strategy is used consistently. As outcomes, young women's full- and part-time labour force participation, their salary and hourly rates of pay, and their husbands' salaries are considered. In the model, possessing a computer is assumed to help computer skill accumulation and, accordingly, enhance positive labour market outcomes. The labour market outcomes are assumed to be a function of skills:

$$y_{it} = f(h_{it}^{pc}, h_{it}^{other}), \tag{1}$$

where y_{it} is the labour market outcome of individual i at time t, h_{it}^{pc} is computer skills, and h_{it}^{other} is other human capital. The computer skills are accumulated through computer possession at home and other opportunities to use computers:

$$h_{it}^{pc} = g(pc_{it}, pc_{it-1}, pc_{it-2}, \ldots, train_{it}, train_{it-1}, \ldots), \tag{2}$$

where pc_{it} is the dummy variable for PC possession at home and $train_{it}$ is other opportunities to acquire computer skills. Assuming only the current possession of a PC at home affects current computer skills (i.e. $h_{it}^{pc} = g(pc_{it}, train_{it}, train_{it-1}, \ldots))$ and applying a first-order linear approximation, the labour market outcomes are specified as:

$$y_{it} = \alpha pc_{it} + x_{it}\beta + c_i + e_{it}, \tag{3}$$

where i and t index the individual and time respectively, y is labour market outcomes, pc is the dummy variable that takes one if the individual possesses a computer at home, x is the vector of variables that affects labour market outcomes, c is individual, unobserved heterogeneity, and e is the idiosyncratic error term. If two conditions, $E(c_i \mid pc_i, x_i) = 0$, and $E(e_{it} \mid pc_i, x_i, c_i) = 0$, where $x_i = [x_{i95}, x_{i96}]$, are satisfied, then the pooled OLS estimator and the OLS estimator for each cross-section are unbiased estimators.

There are two issues related to this estimation. First, although the outcome is a binary variable in the case of the employment equation, the linear probability model is employed here because of its simplicity in dealing with unobserved heterogeneity. Using the linear probability model is not restrictive because the purpose of this estimation is to recover the marginal effect of x on y evaluated at the sample mean of x, rather than recovering the conditional expectation of y on x over the whole region of x. In addition, the marginal effect of x on y evaluated at the sample mean based on non-linear models often coincides with the coefficient estimated through the linear probability model; that is the case for the data used in this study. Second, a sample selection issue arises when estimating the women's wage equation if we attempt to interpret the equation as the equation for wage-offer determination. Two conditions $E(c_i \mid pc_i, x_i, emp_{it} = 1) = 0$ and $E(e_{it} \mid pc_i, x_i, c_i, emp_{it} = 1) = 0$, where emp_{it} is the dummy variable that takes one if the individual i is employed, are sufficient conditions for identifying the wage-offer equation. These are strong assumptions considering women's endogenous labour-force participation decisions, but correcting for this possible sample selection bias requires an instrumental variable that affects women's labour force participation but not women's wage. It is very difficult to find such a variable in our data set, and thus I do not attempt to correct for possible sample selection bias. Thus, the results that follow should be interpreted with some caution.

Since opportunities to accumulate computer skills other than PC possession at home are included in e, pc and e are likely to be positively correlated, since those who possess a computer at home are more likely to have other opportunities to learn computer skills. However, if computer possession at home encourages those opportunities, the estimated coefficient α estimates the *total or reduced* effect of computer possession at home on labour market outcomes. If unobserved, individual characteristics, such as "high motivation" or the "skill to process information effectively," have a positive impact on labour market outcomes and are positively correlated with computer possession at home, then the first assumption $E(c_i \mid pc_i, x_i) = 0$ is violated, and the pooled OLS estimator is an upwardly biased estimator. This possible upward bias can be avoided by estimating the first-difference model:

$$\Delta y_{it} = \alpha \Delta pc_{it} + \Delta x_{it} \beta + \Delta e_{it}. \tag{4}$$

The first-difference estimator is an unbiased estimator if $E(e_{it} \mid pc_i, x_i, c_i) = 0$. Again, if PC possession at home and other opportunities to accumulate computer skills are positively correlated, this assumption is violated; however, if PC possession induces those other opportunities, the estimated α is an unbiased estimator of the total effect. If the current idiosyncratic shock to labour market outcomes is positively correlated with the current possession of computers, then the OLS estimator of α is still upwardly biased, since Δpc_{it} and Δe_{it} are positively correlated. This estimator, however, is useful for "tightening" the upper bound of α.

The measurement error in *pc*, however, causes serious bias in the first-difference estimator; the latter is more tenuous than the OLS estimator when there is measurement error in the independent variable.[2] Interviewees may miscount the number of computers at home, and the tendency to miscount may not be consistent over time. In this situation, Δpc is measured with error and the first-difference estimator of α is seriously biased, since the variation in Δpc may mainly consist of the variation in reporting error. The direction of bias cannot be determined *a priori*, since the measurement error cannot be classical in this situation. Suppose the recoded Δpc consists of true variation and measurement error, such as:

$$\Delta pc_{it} = \Delta pc_{it}^{*} + v_{it}, \tag{5}$$

where Δpc_{it}^{*} is true variation in PC possession and v_{it} is the measurement error. Since Δpc_{it} can take values, $-1, 0, 1$, $v_{it} = 0, -1$ or -2 if $\Delta pc_{it}^{*} = 1$. Similarly $v_{it} = 1, 0$ or -1 if $\Delta pc_{it}^{*} = 0$ and $v_{it} = 2, 1$ or 0 if $\Delta pc_{it}^{*} = -1$. Obviously, the measurement error and the true variation are negatively correlated, and the usual discussion for classical measurement error does not hold. Since Δpc and Δpc^{*} can have opposite signs, the measurement error is not a usual "regression to their mean" style. Therefore, we cannot determine the direction of the bias *a priori*.

Fortunately, the survey also recorded the number of PCs purchased during the previous year. The difference between the stock variable, Δpc, and the dummy variable that indicates whether an individual had purchased more than one computer are positively correlated, although those two variables do not exactly match, due to the scrapping or transfer of computers or simply because of measurement error. Using this property, the inconsistency caused by measurement error in *pc* can be corrected by estimating the model, which is obtained by substituting (5) for (4):

$$\Delta y_{it} = \alpha \Delta pc_{it} + \Delta x_{it} \beta + (\Delta e_{it} - \alpha v_{it}), \tag{6}$$

where Δpc_{it} is instrumented with the dummy variable that takes one if the individual has bought one or more PCs in the previous year, which is denoted as *ippc*. As mentioned in Black, Berger, and Scott (2000), when the true variation of computer possession, Δpc^{*}, is negatively correlated with the measurement error, v, the probability limit of the IV estimator of α is the upper bound of the true parameter α because the instrument *ippc* is positively correlated with the error term $(\Delta e_{it} - \alpha v_{it})$ through the negative correlation between *ippc* and v_{it}.[3] Thus, if the IV estimate of α is virtually zero, then it implies

[2] See Griliches and Hausman (1986) for a general discussion and Freeman (1984) for the specific case in which the independent variable is dichotomous.

[3] Notice that *ippc* and Δpc^{*} are positively correlated.

that computer possession does not change labour market outcomes in a causal sense.

The other concern is the lagged effect of PC possession on labour market outcomes. Acquiring computer skills may take time, and the effect of computer possession at home may affect labour market outcomes with a time lag. The lagged effect is specified as

$$y_{it} = \alpha pc_{it} + \gamma pc_{it-1} + x_{it}\beta + c_i + e_{it}. \tag{7}$$

The following first-difference model is estimated to deal with unobserved heterogeneity:

$$\Delta y_{it} = \alpha \Delta pc_{it} + \gamma \Delta pc_{it-1} + \Delta x_{it}\beta + \Delta e_{it}. \tag{8}$$

Since Δpc_{it-1} is not available because the number of computers at home is not available for the 1994 survey, $ippc_{it-1}$, available from the 1995 survey, is used in place of Δpc_{it-1}. To check the robustness of the result, the other specification in which Δpc_{it} is also replaced with $ippc_{it}$ is estimated.

4. Data

The empirical analysis employs the third (1995) and fourth (1996) waves of the Japanese Panel Survey on Consumers (JPSC). *Kakei Keizai Kenkyū-sho* (The Research Institute of Household Economy) has conducted the survey since 1993 for women between the ages of 24 and 34 at the time of the survey. These individuals are national representatives of this demographic group due to the two-step, clustering, random sampling method that is designed to achieve equal probability sampling. The original sample consisted of 1500 individuals, and those individuals are interviewed annually. The sample size was reduced to 1342 in 1995 and 1298 in 1996 due to attrition. The number of computers possessed by individuals (for single women) or married couples (for married women), which is available for the third and fourth wave, is used as the main independent variable in the following analysis. As labour market outcomes, whether the respondent was employed or not, full-time employed or part-time, monthly salary and the hourly rate of pay were extracted. The distinction between full- and part-time employment is based on the information supplied by respondent's. The monthly salary is recorded for monthly and weekly paid workers, and the hourly rate of pay is recorded for hourly paid workers. The survey asks married women their husband's monthly earnings, and this variable is also used as a labour market outcome in the present study. To control for workers' backgrounds, variables usually included in the wage equation were extracted. The descriptive statistics for the sample appear in Table 1. From the table, we can see that married, educated, full-time employed women with higher salaries were more likely to have computers. As we can see from Table 2, 8.91% of the sample did not have a computer in 1995 but had one in 1996. At the same time, 2.03% of the sample did not have a computer in 1996 although they had one in 1995. These observations, consisting of 10.94% of the sample, identify the computer premium, α, in the first-difference estimation. Table 3 is the cross-tabulation of the change of the stock of PCs and the indicator of whether the respondent had purchased one or more PCs in the previous year. We can confirm a strong correlation between these two variables, and this assures that to correct for measurement error in PC possession the IV strategy is warranted.

Table 1
Descriptive Statistics (Sample: Women ages 25–35 in 1993)

	1995 Panel			1996 Panel		
	Total	Without computer at home	With computer at home	Total	Without computer at home	With computer at home
N	1342	1146	196	1298	1021	277
Demographic						
Age	30.911	30.812	31.485	31.913	31.783	32.401
	(3.226)	(3.238)	(3.101)	(3.230)	(3.214)	(3.248)
Married	0.745	0.729	0.837	0.771	0.746	0.863
(=1 if married)						
Number of children	1.307	1.303	1.332	1.404	1.393	1.448
	(1.090)	(1.091)	(1.085)	(1.092)	(1.105)	(1.043)
Education						
(Dummy variables)						
High school	0.448	0.463	0.357	0.448	0.474	0.354
Technical college	0.206	0.209	0.194	0.204	0.210	0.184
Junior college	0.195	0.191	0.219	0.197	0.181	0.256
4 yr college	0.122	0.107	0.209	0.123	0.106	0.188
Graduate school	0.003	0.002	0.010	0.003	0.002	0.007
School miscellaneous	0.004	0.004	0.005	0.005	0.005	0.004
Labour Market						
Employed	0.580	0.589	0.526	0.567	0.574	0.540
(=1 if Employed)	[1342]	[1146]	[196]	[1292]	[1016]	[276]
Full-time worker	0.602	0.588	0.702	0.567	0.548	0.652
(=1 if Working full time)	[679]	[595]	[84]	[633]	[518]	[115]
Experience	7.792	7.744	8.074	8.277	8.344	8.031
	(3.843)	(3.823)	(3.955)	(4.024)	(4.051)	(3.922)
	[1337]	[1141]	[196]	[1294]	[1017]	[277]
Tenure	2.205	2.179	2.357	2.186	2.248	1.957
	(3.799)	(3.719)	(4.244)	(4.010)	(3.997)	(4.056)
	[1342]	[1146]	[196]	[1298]	[1021]	[277]
Salary	208.636	203.969	235.951	217.878	215.106	228.429
(Thousand yen)	(70.561)	(68.310)	(77.643)	(74.737)	(75.268)	(72.186)
	[418]	[357]	[61]	[370]	[293]	[77]
Hourly rate of pay	875.059	859.376	1054.952	879.363	866.127	955.099
(Yen)	(351.260)	(326.538)	(544.879)	(360.216)	(355.711)	(475.832)
	[212]	[195]	[17]	[242]	[206]	[36]
Industry (dummy variables)						
Not specified	0.150	0.139	0.215	0.156	0.133	0.243
Agriculture	0.003	0.003	0.000	0.004	0.003	0.007
Fishery	0.005	0.006	0.000	0.004	0.005	0.059
Mining	0.004	0.004	0.000	0.001	0.002	0.000
Construction	0.146	0.043	0.037	0.041	0.037	0.000
Manufacturing	0.184	0.148	0.131	0.154	0.168	0.099
Wholesale and retail	0.080	0.192	0.131	0.189	0.195	0.165
Finance, insurance, real estate	0.027	0.078	0.094	0.076	0.080	0.059
Transportation and communication	0.003	0.031	0.000	0.028	0.032	0.013
Energy	0.000	0.003	0.234	0.003	0.003	0.000
Service	0.248	0.251	0.140	0.239	0.245	0.217
Government	0.105	0.100	0.019	0.105	0.097	0.138
Miscellaneous	0.005	0.003	0.000	0.000	0.000	0.000
	[789]	[682]	[107]	[753]	[600]	[152]
Occupation (dummy variables)						
Agriculture & fishery	0.015	0.012	0.037	0.020	0.018	0.026
Self-employed	0.016	0.016	0.019	0.015	0.013	0.020
Family worker at family business	0.058	0.055	0.075	0.069	0.062	0.099
Self-employed (specialists)	0.014	0.013	0.019	0.016	0.002	0.020

Table 1
Continued

	1995 Panel			1996 Panel		
	Total	Without computer at home	With computer at home	Total	Without computer at home	With computer at home
N	1342	1146	196	1298	1021	277
Management	0.003	0.004	0.019	0.013	0.013	0.000
Engineer and technician	0.107	0.100	0.019	0.003	0.093	0.145
Teacher	0.068	0.062	0.150	0.104	0.062	0.112
Clerical worker	0.343	0.346	0.103	0.072	0.331	0.263
Technician and artisan	0.127	0.136	0.318	0.317	0.165	0.066
Sales	0.200	0.213	0.065	0.145	0.211	0.171
Side job at home	0.036	0.032	0.112	0.203	0.025	0.079
Miscellaneous	0.009	0.010	0.065	0.036	0.000	0.000
	[797]	[690]	[107]	[753]	[601]	[152]
Firm Size (dummy variables)						
1–4	0.107	0.096	0.181	0.094	0.093	0.097
5–9	0.084	0.089	0.048	0.078	0.070	0.114
10–29	0.132	0.142	0.060	0.159	0.173	0.097
30–99	0.152	0.149	0.169	0.144	0.145	0.140
100–499	0.182	0.189	0.133	0.189	0.188	0.193
500–999	0.048	0.048	0.048	0.046	0.045	0.053
1000–	0.171	0.170	0.181	0.165	0.174	0.123
Government	0.125	0.117	0.181	0.125	0.112	0.187
	[666]	[583]	[83]	[630]	[516]	[114]
Husband's annual income	528.501	520.277	569.458	537.178	510.154	618.717
(Ten thousand yen)	(364.101)	(385.092)	(229.495)	(272.044)	(268.090)	(268.149)
	[927]	[772]	[155]	[927]	[206]	[230]

Notes:
Sample means are reported and standard deviations are in parentheses. The number of observations used to calculate statistics are in the square brackets under the statistics. Education variables are dummy variables that take one if the respondent's highest level of education completed falls into the category. Completion of junior high school is the omitted category. School miscellaneous takes one if the respondent graduated from a school that is not listed in the table, but not from junior high school. Employment statuses and actual labour market experiences are available for all observations, except for the cases of no response or invalid response. Actual labour market experience is constructed based on the question that asks respondent's job experience (measured in years and months) in the first survey in 1994 and for consecutive surveys, months in the labour market since the last survey is added. Full-time working statuses are available for all employed observations. Salaries are available for all observations that are employed and monthly or weekly paid workers, except for the cases of no response or invalid response. Hourly rate of pay is available for all observations that are employed and paid daily or hourly. Hours worked per day are not available for the 1995 and 1996 observations; thus average hours worked per day in 1993 are used to impute the hourly rate of pay for 1995 and 1996. US$1 = JP101.50YEN (the average of the inter-bank spot rate at Tokyo between January 1995 and December 1996).

Table 2
Transition of PC holdings ($N = 1033$)

			1996		
			Computer possession at home		
			No	Yes	
1995	Computer possession at home	No	76.96%	8.91%	85.87%
		Yes	2.03%	12.10%	14.13%
			78.99%	21.01%	100.00%

Table 3
Measurement error in the change of PC possession status ($N = 1033$)

		Change in PC possession (Δpc)			
		−1	0	1	Total
Purchased more than one computer in the last year (*ippc*)	No	100.00%	97.50%	44.57%	92.84%
	Yes	0.00%	2.50%	55.43%	7.16%
	Total	100%	100%	100%	100%

Note:
χ^2 statistics under the null of independence of row and column = 354.0474 (p-value less than 0.000).

Table 4
Determination of Full-time Employment (Linear Probability Models)
Dependent Variable: Employed Full Time
Sample: All Observations (Women)

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	FD	FDIV	OLS	FD	FD
PC holding	0.073	−0.003	−0.007	0.012	−0.001	—
	(0.025)	(0.032)	(0.055)	(0.040)	(0.033)	
PC holding (Lagged)	—	—	—	0.099	—	—
				(0.047)		
PC purchase	—	—	—	—	—	−0.008
						(0.036)
PC purchase (Lagged)	—	—	—	—	0.043	0.044
					(0.034)	(0.033)
Married	0.412	−0.201	−0.200	0.698	−0.197	−0.197
	(0.156)	(0.132)	(0.134)	(0.244)	(0.132)	(0.133)
# of children	−0.064	−0.081	−0.080	−0.069	−0.080	−0.080
	(0.012)	(0.032)	(0.032)	(0.017)	(0.032)	(0.032)
Log annual husband income	−0.140	−0.003	−0.003	−0.180	−0.004	−0.004
	(0.025)	(0.019)	(0.019)	(0.038)	(0.019)	(0.019)
High school	0.050	—	—	0.033	—	—
	(0.079)			(0.108)		
Technical college	0.084	—	—	0.077	—	—
	(0.082)			(0.111)		
Junior college	0.068	—	—	0.056	—	—
	(0.081)			(0.110)		
College	0.201	—	—	0.211	—	—
	(0.083)			(0.114)		
Grad. school	0.238	—	—	0.108	—	—
	(0.195)			(0.258)		
Miscellaneous	0.174	—	—	0.128	—	—
	(0.119)			(0.140)		
Age, Age^2, Age^3, Age^4	Yes	Yes	Yes	Yes	Yes	Yes
Regional size and year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−101.388	−0.001	−0.001	−63.824	−0.001	−0.001
	(100.545)	(0.008)	(0.008)	(211.616)	(0.008)	(0.008)
First-stage F-statistics	—	—	148.92	—	—	—
			(<0.000)			
Wu-Hausman test (F-statistics)	—	—	0.01	—	—	—
			(0.938)			
Observations	2066	1033	1033	1033	1033	1033
R-squared	0.31	0.06	0.06	0.29	0.06	0.06

Note:
Heteroscedasticity-robust standard errors are in parentheses. For the FDIV estimation, PC purchase in the last year is used as an instrumental variable. First-stage F-statistics are calculated under the null that regression coefficients for the instrument are zero in the first stage regression. Wu-Hausman statistics are calculated under the null that Δpc is exogenous in the second-stage regression. The dummy that indicates computer purchase in a year is not differenced in the first-difference estimation, since the variable is already a flow variable. For non-married observations, 10 thousand yen (approximately US$80) was assigned as the husband's annual income. For the IV estimation, p-values are in parentheses for the first-stage F-statistics and the Wu-Hausman statistics.

5. Results

The first labour market outcome considered is women's full-time employment. The results of the estimations appear in Table 4. First, the result of a pooled OLS estimation, which appears in Column 1 of Table 4, tells us that computer possession at home increases the probability of full-time employment by 7.3 percentage points ($t = 2.92$). Thus, the cross-sectional estimate weakly exhibits the positive effect of computer possession on women's full-time employment. The estimates for the other independent variables are standard and there is no need for discussion. The positive effect of computer possession, however, disappears after controlling for correlated, unobserved heterogeneity through the first-difference estimation. (The result is reported in Column 2 of Table 4.) This is evidence that the unobserved heterogeneity that encourages women's full-time employment is positively correlated with computer possession. We can speculate that a positive correlation between computer possession and full-time employment is observed in the cross-sectional estimates because of reverse causality: women's full-time employment due to unobserved heterogeneity causes computer possession at home through income effects. As Column 3 in Table 4 indicates, the result of the first-difference IV estimation essentially does not change after instrumenting computer possession (Δpc) with the dummy variable of computer purchase in the previous year (*ippc*). The coefficient for computer purchase is still not statistically different from zero, and this provides evidence that the first-difference results are not due to measurement error in *pc*. The OLS estimates with lagged effects appear in Column 4 of Table 4. These results indicate that PC possession in the previous year increases the probability of full-time employment by about 10 percentage points. However, the first-difference estimation results reported in Columns 5 and 6 show that the lagged effects are not statistically different from zero. To summarize the findings for full-time employment, a correlation between full-time employment and PC possession was found in the cross-sectional estimates; however, the findings from the first-difference estimates indicate that the correlation was not due to a causality that moved from PC possession to full-time employment. Although the contemporaneous, causal effect of computer possession on full-time employment was not found, a lagged causal effect of computer possession on full-time employment was indicated; the effects were not statistically significant, however.

Second, the effect of computer possession on part-time employment is examined using individuals who were full-time workers in neither 1995 nor 1996. The sample is restricted in this way because the effect of computer possession on the choice between part-time employment and staying home is the main interest. The assumptions (1) $E(c_i \mid pc_i, x_i, full_i = 0) = 0$ and $E(e_{it} \mid pc_i, x_i, c_i, full_i = 0) = 0$ or (2) $E(e_{it} \mid pc_i, x_i, c_i, full_i = 0) = 0$, where $full_i$ is the dummy variable that takes one if individual i is a full-time worker, assure the lack of bias of the pooled OLS and the first-difference estimator respectively. The results of the estimations appear in Table 5. The results of the pooled OLS, which appear in Column 1, indicate that possessing a computer *negatively* affects part-time employment. This somewhat surprising result is not sustained in the first-difference estimation, whose results appear in Column 2. These results imply that the unobserved factor that makes women work part-time is negatively correlated with computer possession. For example, a household's mortgage loan payment may increase the wife's part-time work to supplement household income, while reducing the probability of computer possession. The results that appear in Column 3 are not essentially different from the results in Column 2. Thus, the measurement error in *pc* does not drive the results for the first-difference estimation. The specifications with lagged effects reported in Columns 4 to 6 indicate that

TABLE 5
Determination of Part-time Employment (Linear Probability Models)
Dependent variable: Employed as a Part-time Worker
Sample: Not a Full-time Worker in either 1995 or 1996 (Women)

	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	FD	FDIV	OLS	FD	FD
PC hold	−0.126	−0.082	−0.046	−0.099	−0.078	—
	(0.031)	(0.063)	(0.095)	(0.056)	(0.063)	
PC hold (Lagged)	—	—	—	−0.028	—	—
				(0.063)		
PC purchase	—	—	—	—	—	−0.035
						(0.062)
PC purchase (Lagged)	—	—	—	—	0.065	0.082
					(0.092)	(0.094)
Married	0.702	−0.120	−0.128	0.964	−0.112	−0.124
	(0.221)	(0.395)	(0.399)	(0.302)	(0.395)	(0.400)
Number of children	−0.086	−0.130	−0.130	−0.086	−0.130	−0.132
	(0.016)	(0.051)	(0.051)	(0.023)	(0.051)	(0.052)
Log annual husband income	−0.156	0.014	0.016	−0.199	0.013	0.016
	(0.035)	(0.064)	(0.064)	(0.047)	(0.064)	(0.064)
High school	0.070	—	—	0.151	—	—
	(0.081)			(0.095)		
Technical college	0.018	—	—	0.090	—	—
	(0.084)			(0.100)		
Junior college	0.049	—	—	0.130	—	—
	(0.084)			(0.101)		
College	−0.003	—	—	0.065	—	—
	(0.088)			(0.107)		
Grad. school	−0.251	—	—	−0.163	—	—
	(0.096)			(0.119)		
Miscellaneous	−0.031	—	—	−0.101	—	—
	(0.155)			(0.102)		
Age, Age^2, Age^3, Age^4	Yes	Yes	Yes	Yes	Yes	Yes
Regional size and year	Yes	Yes	Yes	Yes	Yes	Yes
Constant	−150.505	0.001	0.000	−8.488	0.001	0.000
	(140.789)	(0.018)	(0.018)	(297.478)	(0.018)	(0.018)
First-stage F-statistics	—	—	88.44	—	—	—
			(<0.000)			
Wu-Hausman test	—	—	0.19	—	—	—
(F-statistics)			(0.660)			
Observations	1296	648	648	648	648	648
R-squared	0.13	0.02	0.02	0.15	0.03	0.02

Note:
The same note applies as in Table 4.

the lagged PC possession increases the probability of current, part-time employment by six to eight percentage points, but these positive coefficients are not statistically significant.

Third, the effect of computer possession on monthly salary is examined. The results in this analysis can be compared with the previous cross-sectional studies on the computer premium in Japan. The results of the estimations appear in Table 6. As Column 1 indicates, the home-computer premium on salary is about 13.4% ($t = 3.72$), using the pooled OLS result. This number is larger than the 7.4% in Shimizu (1999) obtained from cross-sectional OLS. The difference in estimates still may be in the range of sampling error, considering the relatively small sample size. The other interpretation for the difference would be a declining home-computer premium during the period. The sample period used in this study is 1995−96 and Shimizu (1999) used the data from 1999. However,

Table 6
Determination of Monthly Salary (Linear Models)
Dependent Variable: Log (Monthly Salary); Sample: Weekly and Monthly Paid Workers (Women)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	FD	OLS	FD	FDIV	OLS	FD	FD
PC hold	0.134	0.021	0.122	−0.001	−0.129	−0.001	0.021	—
	(0.036)	(0.049)	(0.036)	(0.041)	(0.072)	(0.052)	(0.049)	
PC hold (Lagged)	—	—	—	—	—	0.138	—	—
						(0.051)		
PC purchase	—	—	—	—	—	—	—	−0.083
								(0.044)
PC purchase (Lagged)	—	—	—	—	—	—	−0.041	−0.025
							(0.036)	(0.035)
Actual experience	0.071	0.121	0.077	0.026	0.053	0.071	0.123	0.115
	(0.028)	(0.447)	(0.029)	(0.232)	(0.491)	(0.035)	(0.448)	(0.462)
Actual experience squared	−0.002	−0.000	−0.003	−0.002	−0.000	−0.002	−0.000	−0.000
	(0.001)	(0.004)	(0.001)	(0.003)	(0.005)	(0.001)	(0.004)	(0.004)
Age	−0.240	0.000	−0.261	0.000	0.000	−0.213	0.000	0.000
	(0.128)	(0.000)	(0.131)	(0.000)	(0.000)	(0.152)	(0.000)	(0.000)
Age squared	0.004	−0.002	0.004	0.001	−0.002	0.003	−0.002	−0.002
	(0.002)	(0.004)	(0.002)	(0.002)	(0.004)	(0.002)	(0.004)	(0.004)
Tenure	0.032	−0.017	0.032	−0.022	−0.009	0.022	−0.018	−0.015
	(0.015)	(0.062)	(0.015)	(0.032)	(0.068)	(0.016)	(0.062)	(0.064)
Tenure squared	−0.001	0.001	−0.001	0.001	0.000	−0.000	0.001	0.001
	(0.001)	(0.003)	(0.001)	(0.002)	(0.003)	(0.001)	(0.003)	(0.003)
Married	−0.116	−0.002	−0.138	0.016	0.014	−0.108	−0.002	−0.002
	(0.049)	(0.033)	(0.053)	(0.035)	(0.034)	(0.050)	(0.033)	(0.032)
# of children	−0.046	0.004	−0.048	−0.013	0.070	−0.039	0.003	0.008
	(0.027)	(0.034)	(0.026)	(0.037)	(0.065)	(0.030)	(0.034)	(0.033)
High school	−0.020	—	−0.031	—	—	0.120	—	—
	(0.159)		(0.107)			(0.107)		
Technical college	0.156	—	0.061	—	—	0.294	—	—
	(0.164)		(0.118)			(0.115)		
Junior college	0.070	—	−0.008	—	—	0.229	—	—
	(0.170)		(0.126)			(0.128)		
College	0.314	—	0.213	—	—	0.493	—	—
	(0.183)		(0.136)			(0.146)		
Grad. school	0.373	—	0.222	—	—	0.611	—	—
	(0.200)		(0.168)			(0.175)		
Miscellaneous	0.188	—	0.106	—	—	0.266	—	—
	(0.159)		(0.114)			(0.107)		
Ind. occ. Firm-size Dummies	No	No	Yes	Yes	No	No	No	No
Constant	8.423	0.033	9.083	0.008	0.103	7.989	0.034	0.047
	(1.938)	(0.502)	(1.885)	(0.270)	(0.549)	(2.317)	(0.503)	(0.518)
First-stage F-statistics	—	—	—	—	32.05	—	—	—
					(<0.00)			
Wu-Hausman test	—	—	—	—	6.26	—	—	—
(F-statistics)					(0.01)			
Observations	564	282	562	280	282	282	282	282
R-squared	0.31	0.02	0.42	0.18	—	0.31	0.02	0.03

Note:
The same note applies as in Table 4. All specifications include region size and year dummies.

the results are not sustained in the first-difference estimation, as shown in Column 2; the coefficient for computer possession is essentially zero. The findings of the pooled, OLS estimation and the first-difference estimation are hardly different when industry, occupation, and firm-size dummies are included in the regression (Columns 3 and 4). When Δpc is instrumented with *ippc* to caliber the effect of the measurement error in

TABLE 7
Determination of Hourly Wage (Linear Models)
Dependent Variable: Log (Hourly Rate of Pay); Sample: Hourly Paid Workers (Women)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	FD	OLS	FD	FDIV	OLS	FD	FD
PC hold	−0.005	0.026	−0.013	0.022	0.135	−0.020	0.040	—
	(0.104)	(0.040)	(0.079)	(0.044)	(0.125)	(0.117)	(0.044)	
PC hold (Lagged)	—	—	—	—	—	−0.015	—	—
						(0.173)		
PC purchase	—	—	—	—	—	—	—	0.118
								(0.093)
PC purchase (Lagged)	—	—	—	—	—	—	0.112	0.103
							(0.045)	(0.041)
Actual experience	0.037	0.036	0.037	0.095	0.044	0.083	0.030	0.029
	(0.027)	(0.215)	(0.027)	(0.159)	(0.213)	(0.048)	(0.216)	(0.216)
Actual experience squared	−0.002	0.004	−0.002	0.004	0.005	−0.003	0.004	0.004
	(0.001)	(0.005)	(0.001)	(0.005)	(0.005)	(0.002)	(0.005)	(0.005)
Age	−0.123	0.000	−0.200	0.000	0.000	−0.178	0.000	0.000
	(0.140)	(0.000)	(0.138)	(0.000)	(0.000)	(0.175)	(0.000)	(0.000)
Age squared	0.002	−0.004	0.003	−0.003	−0.004	0.002	−0.004	−0.004
	(0.002)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Married	−0.085	−0.314	−0.106	−0.406	−0.316	−0.072	−0.317	−0.322
	(0.075)	(0.048)	(0.060)	(0.080)	(0.046)	(0.083)	(0.047)	(0.045)
# of children	−0.032	0.088	−0.018	0.119	0.090	−0.032	0.089	0.090
	(0.031)	(0.024)	(0.023)	(0.037)	(0.023)	(0.034)	(0.024)	(0.023)
High school	0.195	—	0.078	—	—	0.267	—	—
	(0.061)		(0.096)			(0.079)		
Technical college	0.214	—	0.084	—	—	0.264	—	—
	(0.091)		(0.101)			(0.108)		
Junior college	0.269	—	0.108	—	—	0.312	—	—
	(0.064)		(0.114)			(0.077)		
College	0.770	—	0.668	—	—	0.912	—	—
	(0.143)		(0.175)			(0.186)		
Grad. school	0.000	—	0.000	—	—	0.000	—	—
	(0.000)		(0.000)			(0.000)		
Miscellaneous	0.000	—	0.000	—	—	0.000	—	—
	(0.000)		(0.000)			(0.000)		
Ind. occ. Firm-size Dummies	No	No	Yes	Yes	No	No	No	No
Constant	8.685	0.174	10.191	0.005	0.164	9.526	0.175	0.160
	(2.268)	(0.299)	(2.274)	(0.242)	(0.299)	(2.805)	(0.300)	(0.301)
First-stage *F*-statistics	—	—	—	—	49.33	—	—	—
					(<0.00)			
Wu-Hausman test	—	—	—	—	1.62	—	—	—
(*F*-statistics)					(0.21)			
Observations	276	138	276	138	138	138	138	138
R-squared	0.36	0.05	0.52	0.29	—	0.41	0.05	0.06

Note:
The same note applies as in Table 6. Tenure and its squared are not included in the specification due to a large number of observations with missing values.

pc on the first-difference result, a *negative* coefficient of −0.129 ($t = -1.79$) is found (Column 5).[4] This somewhat surprising result shows that the possible measurement error in *pc* cannot explain the result obtained in the first-difference estimation. Neither of the lagged effects of computer possession on salary are found (Columns 6 and 7). To summarize

[4] The IVFD estimator may be negatively biased because of the violation of the assumption $E(\Delta e_{it} \mid \Delta pc_{it}, \Delta x_{it}, ippc_{it}) = 0$. If a positive earnings shock in the previous year causes a computer purchase in the current year, then e_{it-1} and $ippc_{it}$ are positively correlated, even after conditioning on Δpc_{it} and Δx_{it}, then $\mathrm{Cov}(\Delta e_{it}, ippc_{it} \mid \Delta pc_{it}, \Delta x_{it}) < 0$.

TABLE 8
Determination of Monthly Salary (Linear Models)
Dependent Variable: Log (Monthly Salary); Sample: Weekly and Monthly Paid Workers (Men)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	OLS	FD	OLS	FD	FDIV	OLS	FD	FD
PC hold	0.081	−0.005	0.068	−0.010	0.038	0.034	−0.008	—
	(0.021)	(0.022)	(0.020)	(0.023)	(0.042)	(0.032)	(0.023)	
PC hold (Lagged)	—	—	—	—	—	0.053	—	—
						(0.035)		
PC purchase	—	—	—	—	—	—	—	0.026
								(0.025)
PC purchase (Lagged)	—	—	—	—	—	—	−0.026	−0.028
							(0.040)	(0.038)
Actual experience	0.025	0.096	0.028	0.081	0.082	0.023	0.101	0.092
	(0.013)	(0.124)	(0.013)	(0.134)	(0.128)	(0.014)	(0.124)	(0.125)
Actual experience squared	−0.001	0.001	−0.001	0.001	0.001	−0.001	0.001	0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Age	−0.048	0.106	−0.052	0.108	0.119	−0.045	0.103	0.114
	(0.036)	(0.104)	(0.037)	(0.107)	(0.104)	(0.043)	(0.104)	(0.104)
Age squared	0.001	−0.001	0.001	−0.001	−0.001	0.001	−0.001	−0.001
	(0.000)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Tenure	0.004	−0.004	0.003	−0.004	−0.005	0.005	−0.004	−0.004
	(0.005)	(0.018)	(0.005)	(0.018)	(0.018)	(0.006)	(0.018)	(0.018)
Tenure squared	0.000	−0.000	0.000	−0.000	−0.000	0.000	−0.000	−0.000
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)	(0.001)	(0.001)
Married	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
# of children	0.004	0.019	0.008	0.019	0.019	0.004	0.017	0.019
	(0.013)	(0.024)	(0.011)	(0.024)	(0.024)	(0.014)	(0.024)	(0.024)
High school	0.129	—	0.104	—	—	0.113	—	—
	(0.075)		(0.074)			(0.093)		
Technical college	0.178	—	0.137	—	—	0.162	—	—
	(0.082)		(0.080)			(0.100)		
Junior college	0.095	—	0.044	—	—	0.055	—	—
	(0.100)		(0.097)			(0.121)		
College	0.301	—	0.209	—	—	0.275	—	—
	(0.082)		(0.082)			(0.099)		
Grad. school	0.460	—	0.397	—	—	0.420	—	—
	(0.104)		(0.106)			(0.121)		
Miscellaneous	0.649	—	0.661	—	—	0.595	—	—
	(0.089)		(0.104)			(0.107)		
Ind. occ. Firm-size Dummies	No	No	Yes	Yes	No	No	No	No
Constant	6.236	−0.096	6.261	−0.085	−0.088	6.272	−0.096	−0.094
	(0.585)	(0.118)	(0.611)	(0.127)	(0.122)	(0.710)	(0.118)	(0.118)
First-stage F-statistics	—	—	—	—	78.18	—	—	—
					(<0.00)			
Wu-Hausman test	—	—	—	—	1.35	—	—	—
(F-statistics)					(0.25)			
Observations	1134	567	1134	567	567	567	567	567
R-squared	0.27	0.01	0.35	0.04	—	0.25	0.01	0.01

Note:
The same note applies as in Table 6.

the results, the pooled OLS estimation finds a cross-sectional correlation of computer possession and high salary; however, the correlation does not imply the causal effect of computer possession on salary. The results from the first-difference estimation instead may imply a reverse causality. A natural interpretation of this result would be that workers with a high salary due to unobserved heterogeneity tend to have a PC at home because a PC is a normal good.

Fourth, the effect of computer possession on hourly rate of pay is examined using hourly or daily paid workers as a sample. The results of the estimations appear in Table 7. In this specification, years of job tenure and its squared term are excluded because there are many observations for which years of tenure is missing. The difference of the results between the OLS and the first-difference estimates suggests a negative correlation between PC possession and unobserved heterogeneity. This negative correlation may seem odd at first glance, but not once we realize that the sample is hourly and daily paid workers; most of them are presumably supplementary earners in their households. Those women who have husbands with high incomes are more likely to have a PC at home and to work in a job with less intensity due to the income effect. No coefficients for computer possession or computer purchase are statistically significant, except for the lagged effects in the first-difference estimations reported in Columns 7 and 8. These results imply that lagged PC possession at home increases the hourly rate of pay by about 10% among hourly and daily paid workers once unobserved heterogeneity is controlled for. We cannot reject the null hypothesis that PC possession at home positively affects the wages of workers who are marginally attached to the labour market, such as hourly and daily paid workers.

Finally, the effect of computer possession on a husband's salary is examined. The analysis of a husband's labour force participation and hourly rate of pay are not conducted, since men without jobs or who work hourly/daily paid jobs are rare in this sample. The estimated effects of PC possession on husband's salary appear in Table 8. The estimated results are similar to the results for women's salary: the estimated computer premium is 8.1% ($t = 3.86$) in the pooled OLS results, but essentially zero in the first-difference results. The possible measurement error in *pc* does not explain the first-difference results; in addition, the lagged effect was not found in the first-difference estimation. These results reinforce the previous conclusion that the positive correlation between PC possession and salary is due to the effect of having a higher salary on computer possession through the positive income effect.

6. Conclusion

This paper analyzed the effect of computer possession at home on several labour market outcomes, including women's full-time/part-time employment, women's salary/hourly rate of pay, and husbands' salary. Cross-sectional analyses indicated that computer possession has a positive effect on women's full-time employment and the salaries of both sexes; however, those positive effects disappear after controlling for the individual heterogeneity that is allowed to be correlated with computer possession. This evidence implies that individuals with unobservable characteristics that result in positive labour market outcomes tend to possess computers at home. The positive correlation between income and computer possession may be observed because higher income *causes* computer possession, but not the other way around. This conclusion is consistent with many studies from European countries that have relied on panel data.

The conclusion of this study warrants skepticism about the causal effect of *current* computer possession at home on *current* labour market outcomes. However, some results do suggest the lagged effect of PC possession on women's full- and part-time employment and hourly and daily wage. No effects were found on women's salary and husbands' salary, even when lagged effects were allowed. If computer possession has any causal effects on labour market outcomes, they exist among the workers who are currently not attached or only marginally attached to the labour market. This is probably because having a PC at home is a good opportunity to acquire computer skills for those marginal workers. In contrast, the lagged, causal effects were not found among salaried workers, who presumably have a strong attachment to the labour market, probably because those workers were able to acquire computer skills in other ways, including through the training provided by their employers, if computer skills were needed.

The results from this study do not offer strong grounds for government policies that attempt to enhance people's access to computers as a labour market policy. However, policies directed toward people who are currently not employed or only marginally attached to labour market would be effective.

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