The Determinants of Computer Ability*

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Abstract

In the light of recent Italian government policies aiming at raising the computer literacy of young generations, this paper analyzes to what extent the probability of an individual to have computer abilities is affected by the computer skills of the other household members, i.e. if there are significant within household peer effects. We also investigate how peer effects are related to household computer ownership. We show how peer effects can be identified both under the assumption of exogeneity of computer ownership and in a simultaneous two-equation model in which computer ownership depends on the average skills in the family. Our first results indicate that peers' abilities inside a family increase significantly one's own probability, and that this amplifies the effect of owning a computer at home. We also calculate the variation in the probability of being a skilled individual, as the 2002 Italian Budget Law currently sets, if households with sixteen years old children receive a discount bonus on computer price. We compare the effect of the bonus policy as if it were applied to different age, income and occupation classes and find no clear evidence that a similar policy could be successful for that single target group, because it increases the relative literacy of high income households.

Keywords: Computer Use and Skills, Peer Effects

JEL classification: A13, C35, J24

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1 Introduction

Recently the Italian Government has been involved in the debate about raising the level of computer literacy among young generations. According to the Action Plan in favor of the Information Society of June 2000, the government committed to spread the diffusion of personal computers among students and dependent workers. According to that Plan, there would be a spontaneous trend in 2001 in the sales of about 2.5 millions PC, around 700,000 of which to households. Incentive plans in the 2000 Budget Law would allow a 20% increase in the number of computers allocated to students and workers: firms are permitted to donate old computers for free to schools or directly to their dependents' households in exchange of fiscal incentives. The same goes for Public Administration with respect to schools.[1,2] This way the scope of the measure is twofold: firms would be pushed to renovate their technological endowment, while spreading computer culture among workers and their families. Within the same program design funds are allocated to those schools which need to buy new technological instruments to improve teaching. With the 2002 Budget Law the government sets an additional measure addressed directly to young individuals to improve their personal abilities at computer use. The Law provides a special project to help individuals, whose sixteenth birthday falls in 2003, buying and using a personal computer. These young individuals are currently receiving a per capita bonus with a discount on computers of any price they find at stores participating the program. Why does all that stand for? No doubts new technologies are necessary for economic development, more opportunities for everyone, spurring social growth. Indeed, Information and Communication Technologies evolution, the Minister for

[1]Ministero per l'Innovazione e le Tecnologie, 2000.

[2]More precisely, income and payroll taxes due if computers transfer to workers and VAT if transfers go to schools, would be cancelled, provided that schools and families are their final destination. The 2000 Budget Law contains the following Article 7: *(Donazioni di opere librarie e di dotazioni informatiche) 1. I prodotti editoriali e le dotazioni informatiche non più commercializzati o non idonei alla commercializzazione, ceduti gratuitamente agli istituti di prevenzione e pena nonché alle istituzioni scolastiche sono considerati* ***distrutti agli effetti dell'imposta sul valore aggiunto*** *e non si considerano destinati a finalità estranee all'esercizio dell'impresa. Per il periodo d'imposta 2000, le disposizioni di cui al comma 1 si applicano anche alle cessioni gratuite ai propri dipendenti di dotazioni informatiche; il relativo* ***valore non costituisce compenso in natura****.*

Innovation and Technologies claims, is able to offer more and more labor opportunities (Stanca, 2002).

In the light of such policies spurring, the paper analyzes how important is household computer ownership to determine the probability of an individual to be a user and have computer abilities. We are interested in the evaluation of peer effects inside a family. If endogenous effects hold, then those types of policies may have different impacts. We discuss the personal and household characteristics which influence one's own ability to use a computer, as what Falk and Ichino (2003), following Manski (1993), called "confounding factors" to distinguish them from peer effects. Outcome data do not usually differentiate among these effects, because of the *reflection* problem (Manski, 2000). Data usually do not reveal whether individual behavior is influenced by group behavior, or groups are only the aggregation of individual behavior. This is true unless the model specifies for example a non-linear relationship between individual (expected) behavior and group variables (Brock and Durlauf, 2001), as in our paper. We explicitly show the identification conditions holding in our model. Individual computer aptness and the family technological endowment can be jointly modelled using a bivariate probit where individual actions depend on endogenous peer effects and an endogenous household characteristic (computer ownership), conditional to individual and family observed and unobserved characteristics.

We calculate the variation in the probability of being a skilled individual after a policy, like the directive in the 2000 Budget Law, is introduced - that is if computers are donated to families, or, as the 2002 Budget Law currently sets, if households with sixteen years old children receive a discount on computer price. One of the results is that having a computer at home does not imply having skilled individuals with certainty. Moreover, the effect of the bonus policy is mixed, according to age and income classes, as well as occupations. The policy seems to be more effective if families belong to the upper tail income distribution, if individuals are non manual workers or students and if in the family there are children under 13 years old (but it is almost as effective for individuals under 18 years old).

Section 2 describes the role of family background, education and age in modelling the probability of being a computer user, section 3 concerns the econometric framework to analyze that probability, the identification strategy of peer effects, and the way we evaluate the policy impact, section 4 concludes.

2 Is a computer all you need to be able to use it? The role of family background

2.1 The data

We exploit the information provided by the 2000 wave of the Bank of Italy Survey on Household Income and Wealth (SHIW) (see D'Alessio and Faiella, 2002). This is a representative sample of 8001 Italian households (22268 individuals), about half of which already interviewed at least once in the past. SHIW is one of the few micro data sets suitable to study the earnings distribution in Italy, and compared to other data sets, it has a finer description of workers and households characteristics. Furthermore, and crucial for our aim, the 2000 wave contains information on computer use and skills for all individuals more than 6 years old.

The SHIW questionnaire elicits information about computer use and abilities by asking if any household's member use a computer at home, at work or somewhere else. The individual degree of computer confidence/skill (on a 5 step ladder: none, modest, medium, good and very good) is then recorded for all members aged 6 or more, in those households with at least one user. All skilled workers are asked if they use a computer for their job. Households are finally asked if they use Internet, e-commerce or e-banking.

This sequel of questions provides a consistent set of information on computer use and skills at individual and household level. In particular, it allows to check if, all other things being equal, there is any effect of any household members' computer skills on individual skills, and to distinguish the effect of computer use and ability in the estimation of their wage return.

The information in the survey on the diffusion and use of computers among Italian households can be compared to that available from ISTAT Multipurpose Survey (ISTAT 2002). The two surveys share a similar sampling design, but they have different scope and sample size (20000 households in the Multipurpose Survey). A systematic comparison between the two goes beyond the scope of our paper, nevertheless few characteristics can help assessing the quality of the data collected in SHIW. Table 1 in Appendix shows that the fraction of households owning a computer is remarkably different between the two samples as far as the South of Italy is concerned. The reason might reside in the fact that SHIW tends to over-sample older and smaller families and sampling weights provided by the Bank of Italy are not sufficient to correct for this phenomenon.[3] According to both surveys the gap between the North and South of Italy is striking: the fraction of households owning a computer in the North East is almost twice as much the fraction of owners in the Islands. 18.8% of the households living in the North East already held a computer in 1997: using Schmitt and Wadsworth (2002) terminology Sicily and Sardinia were "three years behind" the North East region in 2000. The difference between North and South is somewhat reduced when we consider the "number" of users. We define an individual to be a computer user, according to SHIW information, if she has at least some computer skills (we are not interested in the frequency of use). Therefore information on computer use is available only for those individuals aged 6 or more. In the 2000 Multipurpose Survey computer use is directly recorded for all individuals aged at least 3. By accounting for these differences the two surveys give an overall estimate of the fraction of users that is very close to each other (see Table 2 in Appendix: 31% in SHIW and 29.6% in Multipurpose).[4] SHIW tends to underestimate the proportion of users among the young and to overestimate among people over 45 years old. In both surveys the fraction of users peaks at the secondary school age 15-19, across the areas and (almost) independently from the gender. As

[3]Battistin, Miniaci and Weber (2003) find a similar feature when comparing SHIW and ISTAT Survey on Family Budget.

[4]Kids between 3 and 5 years old are included in SHIW total computation as non-users. Individual sampling weights are not available in SHIW, hence we simply report sample averages.

far as gender differences are concerned, both surveys confirm that males are more likely computer users, and that gender gap starts widening at the age of 35.

At last, Table 3 in Appendix reports the percentage of users who use a computer at work. ISTAT survey distinguishes when the computer is used at home or away from home: 25.1% of Italian computer users work with a computer at home, and 45.5% work with a computer away from home. We can compare these figures with SHIW one: 39.5% of users work with a computer, either at home or away. This means that according to ISTAT at least 13.5% of the population uses a computer to work, while according to the Bank of Italy this percentage amounts to 12.2%. Once again, the two surveys give overall the same picture about the diffusion of PC use in Italy. Things do change when we look at the corresponding figures conditional on age and gender: the proportion of skilled individuals who use a computer to work seems considerably lower for people younger than 20 and older than 60 in the Bank of Italy's survey. This is partially due to the fact that the question on computer use at work in SHIW questionnaire applies to employed individuals (maybe there is also some misreporting for these age classes). Anyway we are mainly interested in the sub-sample of employed males in the labor force, and SHIW works reasonably well for these individuals according to Table 3.

2.2 The importance of the family background

According to both ISTAT Multipurpose and SHIW surveys the probability of using a computer is strongly correlated with personal characteristics like age, gender, schooling, and so forth, but it is also with each individual's family background. One of the advantages of using SHIW data is that the description of the family background is very fine, as it includes a measure of household income and wealth, and the school attainment of the parents of the head of the household and its partner. Table 4 shows how relevant the family background is. Overall, the probability of using a computer is 45.6% for individuals whose father has a junior high school degree. This probability rises to 71.2% for those individuals whose father has a university degree. Father's educational attainment is clearly a determinant of the wealth of the household, but the percentage gap described here is not fully due to a wealth effect: even conditioning on per capita wealth (and age) father's education plays a prominent role. The third panel in Table 4 shows that computer skills are strongly correlated with schooling, and that even conditioning on individuals' education, the level of fathers' education matters. Other two features deserve noting, being crucial to describe the family background: household's computer ownership and the number of family members with some computer skill. It is much more likely to be a computer user if the household owns a personal computer and other members of the family are with some degree able to use a computer, as shown in Table 5. Without further assumptions it is impossible to say whether there is any causality effect and in which directions, between individual computer skills and family involvement in computer technology. In fact, the other way round could be true, that the more a computer is used by household members (at work, at school, at friends', etc.) the more likely is that the household purchases a PC. Unfortunately, we do not know from the data when the individuals started using a computer, or when the household bought its current PC.

2.3 Computer skills and computer use at work

Not all of the workers with some computer confidence use a computer to work. If we consider the sub-sample of male labor force aged 20 to 60, 43% of the sample has some computer skills but only 38.4% of employed men use a computer to work (Table 6). The fraction of skilled individuals goes from about 22% among unemployed and blue collar to over 75% among managers and teachers. The users are a mere 9.7% among blue collars, 54.8% among white collars and over 60% among teachers and managers. The difference between blue and white collars is large in terms of percentage of skilled workers who use a computer at work: only 44% of the blue collars able to use a computer do indeed use it at work, while the percentage goes up to 83% among white collars.

It is interesting to compare these figures with similar figures for male workers in the same age range in the US, Germany and the Great Britain in 1997 (Borghans and ter Weel, 2002): the fraction of work-users was 43.6% in the US (source: Current Population Survey), 58.3% in the Lander of the former West Germany (source: GSOEP) and 69.2% in the UK (source: Skills Survey of the Employed British Workforce). These numbers confirm that Italy is "many years behind" its main competitors with respect to the diffusion of ICT, even if the rates of investment of Italian business sector in IT and communication equipment and software in the period 1995-2000 are of comparable magnitude (Colecchia and Schreyer, 2001).
Table 7 shows the fraction of PC users at work by type of occupation. Public sector workers are less likely to be computer users: 61% of private sector white collars use a PC at work, while only 44.5% of public white collars do. Computer use rates are higher in the public sector only for those workers with a lower level of education.

3 Probability model of computer use

So far we have shown that the probability of being a computer user depends on individual and household characteristics as well as on household computer ownership. We now assume that individuals belonging to the same household affects each other's behavior in terms of computer abilities. The reference groups in the model are families of two to nine components. We first estimate the effect of computer ownership and other members' capacities (peer effects) on increasing the probability that an individual is skilled, after controlling for individual and family observed and unobserved characteristics, which could be considered as "confounding factors" (Manski, 1993). Second, we reasonably assume that household computer ownership is (endogenously) determined by the computer skills of all family members, on average, and thus estimate a system of equations. In this section we show how to identify separately computer ownership and peer effects in the first case, while it is obvious how to extend identification strategy to the system of equations. The equation of interest is the following:

$$k_{ih}^{*}=\beta_{1}^{\prime}x_{ih}+\beta_{2}^{\prime}\overline{x}_{h}+\beta_{3}c_{h}^{*}+\beta_{4}\overline{k}_{h(-i)}^{*}+\alpha_{h}+\varepsilon_{ih} \tag{1}$$

where k_{ih}^{*} is a measure of the computer ability of individual i living in the household sized n_h, x_{ih} refers to her individual characteristics, $\overline{x}_h$ is a the vector of household level means, c_h^* is a measure of computerization of the household, $\overline{k}_{h(-i)}^{*}=\sum_{j\neq i}k_{ih}^{*}/\left(n_h-1\right)$, and α_h is an unobservable household specific random effect. Computer ability k_{ih}^{*} and computerization c_h^* are continuous variables unobservable to us, though we observe two discrete outcomes k_{ih} and c_h related to them: we assume that the individual i is skilled if $k_{ih}^{*}>0\,(k_{ih}\geq 1\,(k_{ih}^{*}>0))$, and her family owns a computer if $c_h^*>0$ $(c_h=1\,(c_h^*>0))$.[5] Following Manski (1993), we refer to β_4 as the parameter of the endogenous peer effect, $\beta_2^{\prime}$ expresses exogenous effects, $\beta_1^{\prime}$ direct effects and α_h accounts for the correlated effects (i.e. household members behave similarly because they have similar unobserved characteristics). We assume that all the observable variables are uncorrelated with the stochastic terms (i.e. we assume there is no sorting on the unobservables). We first follow the standard literature on peer effects and consider the characteristic c_h^* of the reference group as an exogenous variable. In the next sub-section we let c_h^* be endogenous.

Note that the average skills of "other" family members can be derived as:

$$\overline{k}_{h}^{*} = \frac{n_h-1}{n_h}\overline{k}_{h(-i)}^{*}+\frac{1}{n_h}k_{ih}^{*}$$

$$\overline{k}_{h(-i)}^{*} = \frac{n_h}{n_h-1}\overline{k}_{h}^{*}-\frac{1}{n_h-1}k_{ih}^{*}$$

which we substitute in (1) and rearrange terms to obtain:

$$k_{ih}^{*}=\frac{n_h-1}{n_h-1+\beta_4}\left[\beta_{1}^{\prime}x_{ih}+\beta_{2}^{\prime}\overline{x}_{h}+\beta_{3}c_{h}^{*}+\beta_{4}\frac{n_h}{n_h-1}\overline{k}_{h}^{*}+\alpha_{h}+\varepsilon_{ih}\right] \tag{2}$$

[5]We are aware that the social equilibrium solution (3) below depends on the choice of support, where the support is discrete (Soetevent and Kooreman, 2004). In our case, identification strategy is obtained on our (unobserved) dependents, which have a continuous support. In any case, it seems plausible that only positive skills have a multiplier effect, so even a discrete choice $\{0,1\}$ support would make sense. In our estimates we use the degrees of skillness of households members as the dependent, requiring an ordered probit.

taking the average across family members from (2) and rearranging, it is easy to derive the average computer skills in the household (provided that $\beta_4 \neq 1$) also known as *social equilibrium equation*:

$$\overline{k}_h^* = \frac{\beta_1' + \beta_2'}{1-\beta_4}\overline{x}_h + \frac{\beta_3}{1-\beta_4}c_h^* + \frac{\alpha_h + \overline{\varepsilon}_h}{1-\beta_4} \tag{3}$$

Substituting (3) in (2) we get the reduced form equation (4):

$$k_{ih}^* = \frac{n_h - 1}{n_h - 1 + \beta_4}\left[\beta_1' x_{ih} + \beta_2'\overline{x}_h + \beta_3 c_h^* + \beta_4 \frac{n_h}{n_h - 1}\left(\frac{\beta_1' + \beta_2'}{1-\beta_4}\overline{x}_h + \frac{\beta_3}{1-\beta_4}c_h^* + \frac{\alpha_h + \overline{\varepsilon}_h}{1-\beta_4}\right) + \alpha_h + \varepsilon_{ih}\right]$$

$$\begin{aligned} k_{ih}^* \quad = \quad & \tfrac{n_h-1}{n_h-1+\beta_4}\beta_1' x_{ih} + \left(\tfrac{1}{1-\beta_4}\beta_2' + \tfrac{n_h}{n_h-1+\beta_4}\tfrac{\beta_4}{1-\beta_4}\beta_1'\right)\overline{x}_h + \\ & + \tfrac{\beta_3}{1-\beta_4}c_h^* + \tfrac{\beta_4}{1-\beta_4}\tfrac{n_h}{n_h-1+\beta_4}\left(\alpha_h + \overline{\varepsilon}_h\right) + \tfrac{n_h-1}{n_h-1+\beta_4}\left(\alpha_h + \varepsilon_{ih}\right) \end{aligned} \tag{4}$$

All parameters of interest can be identified from the ratios of the estimated coefficients, through household dimension specification. For instance, if $n_h = 2, 3$ equation (4) becomes:

$$\begin{aligned} k_{ih}^* \quad = \quad & \tfrac{1}{1+\beta_4}\beta_1' d_{i2} x_{ih} + \left(\tfrac{1}{1-\beta_4}\beta_2' + \tfrac{2}{1+\beta_4}\tfrac{\beta_4}{1-\beta_4}\beta_1'\right) d_{i2}\overline{x}_h + \\ & + \tfrac{2}{2+\beta_4}\beta_1' d_{i3} x_{ih} + \left(\tfrac{1}{1-\beta_4}\beta_2' + \tfrac{3}{2+\beta_4}\tfrac{\beta_4}{1-\beta_4}\beta_1'\right) d_{i3}\overline{x}_h + \\ & + \tfrac{\beta_3}{1-\beta_4}c_h^* + \tilde{\varepsilon}_{ih} \end{aligned}$$

where d_{i2} and d_{i3} are dummy variables equal one for households with two and three members respectively. The estimate of peer effects $\hat{\beta}_4$ is calculated by taking the ratio of the estimated coefficients of $d_{i2}x_{ih}$ and $d_{i3}x_{ih}$. Once we know $\hat{\beta}_4$ we can calculate the direct effect $\hat{\beta}_3$ from the estimated coefficient of c_h^*, and also disentangle β_1 and β_2.

The observed dependent variable k_{ih} is ordered by the degree of skillness of individuals. The degrees vary from 0 (no skill at all) to 4 (very good skill) at using the computer. We estimate model (4) with an ordered probit with heteroskedasticity (the variance of the residuals depends on family size).

3.1 Two-equations system with endogenous computer ownership

Individual computer confidence and the family technological endowment can be jointly modelled using the following 2-equation system, where the notation follows from above:

$$\begin{cases} k^*_{ih} = \beta_1' x_{ih} + \beta_2' \overline{x}_h + \beta_3 c^*_h + \beta_4 \overline{k}^*_{h(-i)} + \alpha_h + \varepsilon_{ih} \\ c^*_h = \gamma_1' \overline{x}_h + \gamma_2' z_h + \gamma_3 \overline{k}^*_h + v_h \end{cases} \tag{5}$$

With respect to the standard literature on peer effects we allow one of the characteristic of the reference group (c^*_h) to be endogenous. In particular we assume that the degree of computerization of the household depends on the skills of all family members. The structural parameters β and γ can be drawn from the estimated coefficients as explained before. We use system (5) to find a consistent specification for a SURE reduced form model that allows us to evaluate how computer ownership, individual and household characteristics affect computer skills.

By combining equation (3) with the computerization equation and using equation (4) we obtain a system at the individual and household level that we write in matrix form:

$$\begin{bmatrix} k^*_{ih} \\ c^*_h \end{bmatrix} = \begin{bmatrix} \pi_{11}' & \pi_{12}' & \pi_{13}' \\ \pi_{21}' & \pi_{22}' & \pi_{23}' \end{bmatrix} \begin{bmatrix} x_{ih} \\ \overline{x}_h \\ z_h \end{bmatrix} + \begin{bmatrix} u_{k,ih} \\ u_{c,h} \end{bmatrix}$$

$$\Pi' = \begin{bmatrix} \frac{n_h-1}{n_h-1+\beta_4}\beta_1' & \frac{1}{1-\beta_4-\beta_3\gamma_3}\beta_2' + \frac{1}{1-\beta_4}\left[\frac{n_h}{n_h-1+\beta_4}\beta_4 + \frac{\beta_3\gamma_3}{1-\beta_4-\beta_3\gamma_3}\right]\beta_1' + \frac{\beta_3}{1-\beta_4-\beta_3\gamma_3}\gamma_1' & \frac{\beta_3}{1-\beta_4-\beta_3\gamma_3}\gamma_2' \\ 0 & \frac{\gamma_3}{1-\beta_4-\beta_3\gamma_3}\beta_2' + \frac{\gamma_3}{1-\beta_4-\beta_3\gamma_3}\beta_1' + \frac{1-\beta_4}{1-\beta_4-\beta_3\gamma_3}\gamma_1' & \frac{(1-\beta_4)}{1-\beta_4-\beta_3\gamma_3}\gamma_2' \end{bmatrix}$$

$$\begin{bmatrix} u_{k,ih} \\ u_{c,h} \end{bmatrix} = \begin{bmatrix} \frac{1}{1-\beta_4-\beta_3\gamma_3}\left(\alpha_h + \beta_3 v_h + \frac{n_h\beta_4+\beta_3\gamma_3(n_h-1)}{n_h-1+\beta_4}\overline{\varepsilon}_h\right) + \frac{n_h-1}{n_h-1+\beta_4}\varepsilon_{ih} \\ \frac{\gamma_3(\alpha_h+\overline{\varepsilon}_h)+(1-\beta_4)v_h}{1-\beta_4-\beta_3\gamma_3} \end{bmatrix}$$

from which we derive the variance/covariance matrix. If $\beta_4 = 0$ there is no peer effect. If $\beta_4 > 0$ ($\beta_4 \neq 1$), we will observe a skilled individual and a household owning a computer according to[6]

$$\begin{cases} k_{ih} = \mathbf{1}\left(\pi_{11}' x_{ih} + \pi_{12}' \overline{x}_h + \pi_{13}' z_h + u_{k,ih} > 0\right) \\ c_h = \mathbf{1}\left(\pi_{22}' \overline{x}_h + \pi_{23}' z_h + u_{c,h} > 0\right) \end{cases} \tag{6}$$

where

$$Var\left(u_{k,ih}\right) = \frac{1}{(1-\beta_4-\beta_3\gamma_3)^2}\left(\sigma_\alpha^2 + \beta_3^2\sigma_v^2 + 2\beta_3\sigma_{\alpha v} + \frac{1}{n_h}\right) + \frac{(n_h-1)^3}{n_h(n_h-1+\beta_4)^2}$$

$$Var\left(u_{c,h}\right) = \frac{1}{(1-\beta_4-\beta_3\gamma_3)^2}\left[\gamma_3^2\sigma_\alpha^2 + (1-\beta_4)^2\sigma_v^2 + 2\gamma_3(1-\beta_4)\sigma_{\alpha v} + \frac{\gamma_3^2}{n_h}\right]$$

$$Cov\left(u_{k,ih}, u_{ch}\right) = \frac{1}{(1-\beta_4-\beta_3\gamma_3)^2}\left[\gamma_3\sigma_\alpha^2 + \beta_3(1-\beta_4)\sigma_v^2 + (1-\beta_4+\beta_3\gamma_3)\sigma_{\alpha v} + \frac{\gamma_3}{n_h}\right]$$

$$Cov\left(u_{k,ih}, u_{k,jh}\right) \neq 0,\ Cov\left(u_{k,ih}, u_{k,jh}|\alpha_h\right) \neq 0$$

that is the covariance matrix of the residuals is not constant across households because it depends on household size n_h. System (6) above can be estimated with MLE or PMLE accounting for heteroskedasticity.

We estimate the one-equation model and the system for all households and for those households with at least one child 15 to 17 years old. We consider the direct effects of individual characteristics x_{ih} such as age, age squared, gender, years of

[6]Manski (1993) discussed the coherency of binary response models with social effects, as well as the number of social equilibria. Identification of the underlying structural parameters could rest on the combination of the estimates of individual and household level models (Glaeser, Sacerdote and Scheinkman, 2002). In our case, identification should also take into account that we have small size groups (Soetevent and Kooreman, 2004), and that the nature of our problem is such that $\Pr\left(\overline{k}_h^* > 0 | c_h^* > 0\right) = 1$. See also previous note 5.

education, student status, occupation, marital status and the interaction between marital status and gender. Average family characteristics plus area of residence, family size, home ownership and family income as exogenous effects. Computer ownership is considered exogenous in model (4). However, home ownership and household income are used as instruments (z_h) for computer ownership in system (6). Table 8 (one-equation model) shows that for all households the hypothesis that there is no direct effect is rejected. For many of the characteristics in x both the direct effects β_1 and the average effect β_2 are significantly different from zero, that is, the characteristics of the family members significantly affects the probability of the individual to be skilled. Peer effects are certainly present and significant, given that $\hat{\beta}_4 = 0.214$ significant at 1% level. Even direct computer ownership has a large effect on individual's ability. Estimating the same equation with parental background reduces estimates of individual characteristics to non-significant, while only region of residence, β_3 and β_4 remains statistically significant, $\hat{\beta}_4$ being even more than double. Estimates of the bivariate system are being currently worked out and will be on a table in the near future.

3.2 Policy implication

We now reflect on the objective of a policy aimed at improving the computer skills of individuals. It is interesting to calculate the variation in the probability of becoming a skilled individual after a policy, like the directive in the 2000 Budget Law, is introduced, that is if computers are donated to families, or, as 2002 Budget Law currently sets, if households with sixteen years old children receive a discount on computer price. Let's decompose the marginal probability of being computer skilled:

$$\begin{aligned}\Pr(k^*_{ih}|x_{ih}, \overline{x}_h, z_h) = [&\Pr(k^*_{ih} > 0|c_h = 1, x_{ih}, \overline{x}_h, z_h) - \Pr(k^*_{ih} > 0|c_h = 0, x_{ih}, \overline{x}_h, z_h)] * \\ &* \Pr(c_h|\overline{x}_h, z_h) + \Pr(k^*_{ih} > 0 \mid c_h = 0, x_{ih}, \overline{x}_h, z_h)\end{aligned}$$

The predicted difference $\Pr(k^*_{ih} > 0|c_h = 1, x_{ih}, \overline{x}_h, z_h) - \Pr(k^*_{ih} > 0|c_h = 0, x_{ih}, \overline{x}_h, z_h)$ indicates the change in the probability when a computer arrives at home. $\Pr(c_h)$ is the probability of possessing a computer by a household, and it is the channel used by the policymaker to increase the level of computer literacy in the population. The two policies act alternatively on the price of computers or on companies donation. We are not able to observe employers behavior, so it is not possible to conjecture how $\Pr(c_h)$ has been affected by firms donation. The bonus policy influences the price (through the discount). What we observe is that decreasing the price has an indirect effect by raising real income:

$$\begin{aligned}\Pr\left(c_h^* > 0\right) &= \Phi\left(\pi_{2x}\overline{x}_h + \pi_{2p}\ln p + \pi_{2y}\ln\frac{y}{p}\right) \\ \frac{\partial \Pr(c^* > 0)}{\partial p} &= \left(\frac{\pi_{2p} - \pi_{2y}}{p}\right)\phi(\cdot)\end{aligned}$$

We are not able to identify π_{2p}. As far as $\pi_{2p} < 0$, this means underestimating the probability change of computer ownership. The most important point is that low income families might have binding constraints and the policy may not be effective for them. For example, average PC expenditure (€1000) in 2002 was 4% of total expenditure: that means in our sample that for lowest 5% income class (≤€8500) the expenditure would amount 11.8% of annual income, for 10% income class (€12100) it would amount to 8.3% and those on 25% income class (€19000) the expenditure would be 5.3%. This is even worse for target households, which have children 15-17 years old and no computer at home: households in the 10% income bracket (€8080) should spend 12.4% of their annual income and households in the 25% income class (€13500) should spend 7.4%. These constraints might be binding even with a discount bonus. Given that we cannot observe computer prices, we calculate predicted probabilities to increase one's own skill if individuals receive a computer for free. Thus these estimates can be regarded as upper bounds of the effect of the discount policy. Table 9 considers the unskilled and low skilled individuals only. It reports the probabilities of becoming a skilled individual (or increasing one's own skill by one degree) *ex ante* (before the policy comes up), *ex post* when her household receives a computer, and for those who have already a computer at home. Probabilities are calculated by age classes, occupation and income classes. Columns (1)-(3) regard the unskilled. Column (1) is the initial probability before any policy is set. Column (2) is the resulting probability due to the bonus policy (which we assume is a "gift" policy). Column (3) is the conditional probability of becoming a computer user when the family has already a computer at home. Columns (4)-(6) are equivalent probabilities for low skilled individuals who increase their skill by one degree. One of the conclusions is that having a computer at home does not imply having skilled individuals with certainty. Indeed, this probability is equal to 59.2% on average for the unskilled who receive a gift and 48.2% for those who have already a computer at home, and 19.4% on average for the low skilled both whether they receive a gift or they possess already a PC. When we look at the decomposition by class, the probability decreases with age (especially after 35 years old), increases with income and it is higher (more than 70%) for non manual workers and students. And yet, this is not true for those individuals with some skill: the probability of increasing skill is about the same for all age classes (apart from the over 56 for whom it drops dramatically), for all occupation (apart from those out of the labor force) and slightly increasing by income class with no big differences. The effect of the bonus policy is higher for children between 14 and 18 years old (81.6%), and increases with income. The difference between non-manual and manual workers is 14.7% *ex ante*, and the gap increases to 31% *ex post*.[7] The lowest panel in this table show the predicted probabilities for target households only, by income class. It is evident that probabilities *ex ante* are higher than average except for very low income families, whose values after the policy is lower than the probability for those who already possess a PC. It is still clear that probabilities of becoming skilled are increasing with income brackets. For individuals with some skill in the target population, probabilities *ex post* are lower than average population and do not change much with income brackets.

[7]We calculate the probabilities for the target households, who have at least one child in the age class 15-17 and find no significant variation in the results.

4 Conclusions

The paper analyzes the probabilities of being a computer skilled individual by first modelling individual computer skills keeping family computer ownership exogenous, second by jointly modelling the individual computer confidence and the family technological endowment using a bivariate probit. The two equations are estimated at different level of aggregation (individual and household level) and we follow the literature on the social multiplier to regard individual actions as depending on endogenous peer effects but also on an endogenous household characteristic (computer ownership). Our PMLE results indicate that there are both significant direct effects and peer effects of using a computer in a family. We decompose the marginal probability of being skilled, and show that possessing a computer does not imply being a skilled individual with certainty. For the target population of the policy designed by the 2002 Italian Budget Law the probability of being skilled increases by 56.1 points on average, but this difference decreases with age (especially after 35 years old), increases with income and it is higher (more than 70%) for non manual workers and students. We simulate the introduction of a policy, which normally changes the price of computers and affect the purchasing power of the family. We assume that families without computers receive one for free, such that we calculate upper bounds values for the probability of being skilled when a PC arrives at home. The effect of the policy is higher for children 14-18 years of age (55 points) and increases with income. The difference between non-manual and manual workers is 14.7% *ex ante*, and the gap increases to 31% *ex post*. For low income households, the probability increase is 40% on average, for the highest income class it increases by more than 50%.

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Table 1: **Percentage of households owning a computer**

	Bank of Italy SHIW 2000	ISTAT Multipurpose 2000
North West	32.9	32.8
North East	33.7	34.6
Centre	29.5	30.7
South	17.1	24.9
Islands	16.6	18.7
Italy	24.9	29.4

Table 2: **Percentage of people able to use a computer by gender, age, area of residence**

					ISTAT Multipurpose Survey 2000							
Area-gender	3-5	6-10	11-14	15-19	20-24	25-34	35-44	45-54	55-59	60-64	65+	Total
North West												
Males	14.3	47.6	65.5	74.3	60.4	51.4	54.0	40.2	25.3	13.8	5.9	39.6
Females	15.0	43.6	66.9	76.2	67.2	51.2	44.4	6.1	6.7	1.9	0.9	30.5
Total	14.6	45.6	66.2	75.3	63.8	51.3	49.3	33.1	15.8	7.7	2.9	34.9
North East												
Males	10.7	51.8	74.1	77.7	62.2	56.6	52.9	37.4	16.7	11.5	4.5	39.5
Females	21.4	45.1	74.9	73.8	62.8	51.9	43.9	23.4	11.8	5.9	0.6	30.7
Total	15.9	48.7	74.5	75.7	62.5	54.4	48.5	30.5	14.3	8.5	2.2	35.0
Centre												
Males	19.6	38.1	63.9	67.7	56.3	48.8	49.8	37.8	27.0	15.2	3.3	36.5
Females	16.8	38.4	63.5	51.7	58.6	46.2	34.7	20.8	6.8	3.9	0.5	26.0
Total	18.2	38.2	63.7	60.3	57.4	47.6	42.1	28.7	17.7	9.4	1.7	31.1
South												
Males	5.1	25.6	48.5	50.4	41.4	34.1	36.2	28.0	12.5	9.6	2.1	27.9
Females	4.9	24.6	39.1	44.9	35.1	25.1	20.2	12.1	4.6	1.2	0.1	18.0
Total	5.0	25.1	43.9	47.6	38.3	29.7	27.9	20.0	8.4	5.3	0.9	22.8
Islands												
Males	3.8	17.8	40.6	44.5	36.2	29.8	29.8	27.9	14.8	9.1	1.8	24.1
Females	2.2	19.9	35.6	41.2	35.1	25.5	18.2	15.3	3.0	2.5	0.2	17.2
Total	3.0	18.8	38.2	42.8	35.6	27.6	24.1	21.4	8.6	5.8	0.8	20.5
Italy												
Males	10.4	35.8	57.2	61.9	51.4	45.6	45.9	35.0	20.3	12.3	3.8	34.3
Females	11.9	33.8	54.0	56.6	51.9	41.2	33.4	20.1	6.8	3.1	0.5	25.1
Total	11.1	34.8	55.7	59.3	51.6	43.4	39.6	27.4	13.5	7.6	1.9	29.6
					Bank of Italy SHIW 2000							
Area-gender	3-5	6-10	11-14	15-19	20-24	25-34	35-44	45-54	55-59	60-64	65+	Total
North West												
Males		37.0	65.9	59.7	61.1	54.9	54.5	47.6	36.8	24.9	7.8	41.0
Females		31.3	66.7	66.0	61.2	54.5	50.1	35.4	12.4	8.6	1.0	32.2
Total		34.4	66.3	62.2	61.1	54.7	52.3	41.4	24.2	16.7	4.1	36.6
North East												
Males		43.3	68.9	77.9	75.0	62.5	64.4	49.7	38.5	25.8	7.1	47.0
Females		44.0	68.4	71.7	72.3	64.7	49.9	34.5	16.8	12.1	1.2	37.0
Total		43.6	68.6	74.9	73.8	63.5	56.5	42.1	28.3	18.8	3.8	42.0
Centre												
Males		42.5	60.0	70.1	58.3	46.6	52.8	48.0	26.8	18.5	3.0	38.6
Females		39.5	77.8	63.7	62.2	47.5	38.9	27.4	8.4	4.5	1.9	29.2
Total		41.1	69.1	67.1	60.1	47.1	45.5	37.4	17.4	11.4	2.4	33.7
South												
Males		21.2	36.5	37.5	33.9	30.2	28.2	25.5	23.4	13.9	2.4	23.7

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... table 2 continued

Bank of Italy SHIW 2000												
Area-gender	3-5	6-10	11-14	15-19	20-24	25-34	35-44	45-54	55-59	60-64	65+	Total
Females		16.2	38.6	40.7	30.6	23.3	19.7	13.9	6.9	3.0	0.6	16.6
Total		18.8	37.5	39.0	32.2	27.0	23.7	19.3	15.4	8.3	1.4	20.1
Islands												
Males		28.7	44.8	37.1	37.4	28.2	36.3	27.2	18.8	13.2	3.6	25.8
Females		26.2	36.1	45.2	34.8	29.4	28.8	17.2	8.8	4.9	0.4	20.5
Total		27.5	40.6	40.6	36.1	28.8	32.3	22.1	14.2	8.9	1.8	23.1
Italy												
Males		33.4	53.1	53.6	52.2	44.4	47.5	40.5	29.9	19.8	4.9	35.2
Females		29.5	57.2	55.3	49.2	43.4	37.6	26.0	10.7	6.6	1.1	26.9
Total		31.5	55.2	54.4	50.8	43.9	42.3	33.1	20.4	13.1	2.7	31.0

Table 3: **Percentage of people using a computer to work among individuals with some computer confidence**

	ISTAT Multipurpose 2000		Bank of Italy SHIW 2000
	At home	Away from home	
Area			
North West	26.8	50.5	44.1
North East	25.7	50.0	46.4
Centre	24.4	43.3	38.0
South	23.5	36.3	30.1
Islands	22.5	41.2	28.0
Italy	**25.1**	**45.5**	**39.5**
Males			
15-17	13.0	15.1	0.4
18-19	17.5	15.7	1.2
20-24	25.3	31.5	20.2
25-34	34.1	60.8	56.6
35-44	38.0	69.9	72.8
45-54	39.1	69.2	73.2
55-59	34.9	55.9	50.2
60-64	42.2	37.7	19.3
Females			
15-17	8.6	12.5	0.0
18-19	11.6	16.9	5.0
20-24	19.1	38.1	22.4
25-34	25.4	64.4	49.4
35-44	30.0	67.0	56.1
45-54	35.4	62.6	52.2
55-59	35.5	43.6	31.2
60-64	21.1	27.4	12.8
Males and Females			
15-17	11.0	13.9	0.02
18-19	14.5	16.3	3.0
20-24	22.2	34.8	21.3
25-34	30.1	62.5	53.4
35-44	34.6	68.7	65.0
45-54	37.7	66.8	64.7
55-59	35.1	52.8	45.3
60-64	37.8	35.6	17.6

Table 4: **Computer skills and family background, SHIW**

	Father's school attainment					
Age class	None	Elementary	Junior high	High school	University	Total
6-10	0.0	15.4	25.6	40.3	45.5	32.2
11-14	7.7	29.5	45.6	70.8	77.4	55.4
15-19	0.0	28.3	48.3	73.6	81.7	55.4
20-24	12.1	32.2	48.0	72.1	84.7	52.5
25-34	10.1	34.9	50.2	73.1	76.6	46.2
35-44	18.6	42.2	58.8	69.5	76.3	44.7
45-54	14.9	35.3	56.0	62.0	80.3	35.2
55-59	7.6	22.0	36.0	50.0	68.0	20.8
60-64	4.2	15.4	28.6	47.5	42.1	14.1
65+	0.4	4.4	13.4	10.7	34.9	3.6
Per Capita Wealth Quartile						
1st (<10000)	4.5	17.5	33.1	49.5	58.3	21.8
2nd (10000-33000)	6.3	27.3	39.1	55.7	69.8	30.1
3rd (33000-68000)	9.2	33.2	55.3	68.4	68.0	40.4
4th (>68000)	11.9	34.4	59.6	70.4	76.4	45.0
Total	7.6	28.5	45.6	63.1	71.2	34.7
Education (no full time students. N=13936)						
Elementary	1.0	3.2	8.6	6.3	-	2.1
Junior High	11.7	19.7	23.3	22.7	-	18.7
Vocational school	22.9	35.6	45.9	48.3	-	37.0
High school	36.6	54.6	55.3	63.1	67.4	55.5
University	52.6	68.5	71.8	78.0	77.0	72.9
Total	7.5	27.9	46.5	60.6	71.6	29.6

Sample: individuals at least 6 years old, heads of household, their partner and their children. N = 17464

Table 5: **Computer skills and ownership, SHIW**

	PC at home		Other users		
	No	Yes	No	Yes	Total
6-10	6.5	69.2	0.04	63.4	31.5
11-14	11.5	95.5	2.9	92.6	55.2
15-19	15.1	96.9	6.1	95.5	54.4
20-24	16.2	95.7	9.7	93.5	50.8
25-34	18.5	91.6	14.5	88.3	43.9
35-44	16.6	79.4	11.5	75.4	42.3
45-54	8.8	63.4	5.5	59.3	33.1
55-59	5.9	49.1	3.4	44.7	20.4
60-64	3.4	47.7	3.9	38.7	13.1
65+	0.3	24.2	1.4	12.6	2.7
Total	9.3	75.0	6.2	70.4	31.8

Table 6: **Computer skills and computer use at work, SHIW**

	Fraction of men able to use a computer					
	20-24	25-34	35-44	45-54	55-59	Total
Blue collar (1824)	0.338	0.243	0.237	0.155	0.054	0.22
White collar (1125)	0.69	0.69	0.675	0.641	0.548	0.662
Teacher (124)		0.778	0.886	0.782	0.76	0.806
Manager (415)		0.672	0.816	0.736	0.821	0.761
Self-employed (1168)	0.568	0.54	0.542	0.438	0.399	0.492
Unemployed (630)	0.276	0.25	0.135	0.089	0.152	0.216
Total (5286)	0.382	0.411	0.479	0.427	0.385	0.43
	Fraction of men using a computer at work					
	20-24	25-34	35-44	45-54	55-59	Total
Blue collar (1824)	0.162	0.121	0.094	0.06	0.022	0.097
White collar (1125)	0.521	0.612	0.553	0.519	0.435	0.548
Teacher (124)		0.778	0.714	0.6	0.44	0.613
Manager (415)		0.621	0.735	0.643	0.692	0.675
Self-employed (1168)	0.351	0.444	0.419	0.349	0.288	0.384
Total (4656)	0.266	0.343	0.373	0.343	0.298	0.384

Table 7: **Computer use at work - private vs. public sector, SHIW**

	Private	Public	Total
Occupation			
Blue collar (1824)	0.102	0.043	0.098
White collar (1125)	0.611	0.445	0.549
Manager (415)	0.708	0.613	0.677
Education			
Elementary	0.044	0.00	0.041
Junior high	0.136	0.215	0.147
Vocational school	0.23	0.314	0.24
High school	0.543	0.464	0.526
University	0.765	0.721	0.75
Total	0.322	0.429	0.341

Table 8: **Ordered Probit of Computer Skills: single equation**

	Coeff (Robust St.Err.)	P-value
β_1		
Age	-.018 (.007)	.012
Age^2	-.000 (.0001)	.001
Gender	.287 (.037)	.000
Marital	-.295 (.071)	.000
G*Marital	.359 (.053)	.000
Schooling	.099 (.007)	.000
Student Middle	.155 (.078)	.046
Student High School	.373 (.063)	.000
Student University	.322 (.064)	.000
Manual	-.133 (.056)	.018
Employee	.723 (.064)	.000
Manager	.429 (.067)	.000
Autonomous	.067 (.070)	.344
Entrepreneur	.600 (.082)	.000
Unemployed	.046 (.067)	.494
β_2		
Gender(h)	-.159 (.085)	.063
Student University(h)	-.239 (.133)	.072
Manual(h)	-.185 (.095)	.051
Unemployed	-.277 (.140)	.048
North West	.090 (.047)	.057
North East	.180 (.050)	.000
Center	.108 (.048)	.025
South	-.109 (.047)	.021
$\ln(Y_h)$	.166 (.032)	.000
β_3		
Computer ownership	1.310 (.078)	.000
β_4		
Peer Effect	.214 (.069)	.002
$\beta_4 * \phi(\cdot)$	.0395 (.0127)	
$\beta_4 * \phi(\cdot \mid c_h = 0)$	.0469 (.0151)	
$\beta_4 * \phi(\cdot \mid c_h = 1)$	.049 (.0157)	
α_0		
	1.580 (.254)	0.000
α_1		
	2.015 (.264)	0.000
α_2		
	2.474 (.277)	0.000
α_3		
	3.263 (.305)	0.000

Sample: individuals at least 10 years old. N = 18698. α's are cut-off points.

Table 9: **Probability of increasing skill, SHIW**

	Unskilled				Low Skilled			
	Freq.	(1)	(2)	(3)	Freq.	(4)	(5)	(6)
Age classes								
≤ 13	422	0.161	0.696	0.716	29	0.057	0.209	0.205
14-18	528	0.241	0.788	0.856	24	0.103	0.205	0.200
19-25	1020	0.227	0.744	0.785	37	0.104	0.200	0.181
26-35	1495	0.182	0.655	0.615	83	0.091	0.182	0.185
36-45	1472	0.109	0.504	0.513	79	0.088	0.175	0.180
46-55	1604	0.053	0.352	0.407	57	0.051	0.189	0.178
56+	4193	0.012	0.154	0.249	46	0.021	0.155	0.157
Occupation								
Manual	2428	0.085	0.485	0.426	94	0.045	0.184	0.176
Non manual	995	0.314	0.805	0.731	125	0.112	0.182	0.194
Student	1087	0.250	0.790	0.803	69	0.087	0.204	0.197
Unemployed	880	0.117	0.573	0.528	12	0.065	0.202	0.190
Out of LF	5344	0.018	0.198	0.283	55	0.024	0.158	0.148
Income classes								
0-5%	966	0.052	0.367	0.330	2	0.025	0.163	0.135
5-10%	1006	0.082	0.436	0.344	13	0.039	0.175	0.168
10-25%	2272	0.089	0.426	0.351	50	0.052	0.192	0.185
25-50%	2887	0.090	0.383	0.396	98	0.068	0.193	0.181
50-75%	2348	0.099	0.396	0.403	93	0.080	0.181	0.182
>75%	1255	0.132	0.481	0.445	99	0.092	0.176	0.178
Income classes (target hh)								
0-5%	257	0.069	0.431	0.481	1	0.004	0.109	0.130
5-10%	239	0.112	0.532	0.323	4	0.039	0.162	0.174
10-25%	414	0.137	0.577	0.388	13	0.044	0.188	0.184
25-50%	253	0.166	0.603	0.455	17	0.078	0.192	0.188
50-75%	136	0.228	0.684	0.529	6	0.072	0.197	0.189
>75%	32	0.281	0.772	0.629	6	0.102	0.168	0.188

Frequencies refer to individuals without computer. Columns 1-3 refer to unskilled individuals, columns 4-6 refer to individuals with some skill. Target households are those who potentially benefit from the 2002 bonus policy.

(1) 1-P($k^* < \alpha_0 | c_h = 0$) for those without computer (*ex ante*)

(2) you give a computer to (1) (*ex post*)

(3) subsample with already a computer at home, $c_h = 1$

(4) P($\alpha_1 < k^* < \alpha_2 | c_h = 0$) for those individuals without computer

(5) same as (2)

(6) same as (3).