The Effects of Home Computers on School Enrollment

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Abstract

Approximately 9 out of 10 high school students who have access to a home computer use that computer to complete school assignments. Do these home computers, however, improve educational outcomes? Using the Computer and Internet Use Supplement to the 2001 Current Population Survey, I explore whether access to home computers increases the likelihood of school enrollment among teenagers who have not graduated from high school. A comparison of school enrollment rates reveals that 95.2 percent of children who have home computers are enrolled in school, whereas only 85.4 percent of children who do not have home computers are enrolled in school. I find a difference of roughly 7.7 percentage points in school enrollment rates after estimating a bivariate probit model for the joint probability of school enrollment and owning a home computer. Use of computers and the Internet by the child's mother and father are used as instrumental variables. These variables should affect computer ownership, but not school enrollment (after controlling for family income, parental education, and parental occupation). The estimates are not sensitive to alternative combinations of instruments and different samples. I interpret the results as providing evidence that home computers increase the likelihood of staying in school.

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I. Introduction

The impact of computers in the workplace and schools has been hotly debated by policy makers, academics, and the media. The well-known evidence on the relationship between computer use and earnings ranges from a sizeable wage premium (Krueger 1993) to a potentially spurious correlation (DiNardo and Pischke 1997).[1] Meta-analyses and surveys of recent studies find widely varying estimates of the effects of computer use in schools on academic performance (see Noll, et, al. 2000 and Kirkpatrick and Cuban 1998 for example), and recent evidence from a quasi-experiment in Israel schools indicates no improvement in math test scores (Angrist and Lavy 1999). Interestingly, however, school principals and teachers overwhelmingly support the use of educational technology. In a recent national survey funded by the U.S. Department of Education, nearly all principals report that educational technology will be important for increasing student performance in the next few years, and a clear majority of teachers report that the use of technology is essential to their teaching practices (SRI 2002).

Policy makers also cannot agree on the importance of and solutions to disparities in access to information technology or the so-called "Digital Divide." The Department of Agriculture, Commerce, Education, Health and Human Services, Housing and Urban Development, Justice and Labor, each have programs addressing the digital inclusion of various groups, and spending on the E-rate program, which provides discounts to schools and libraries for the costs of telecommunications services and equipment, totaled $5.8 billion as of February 2001 (Puma, Chaplin, and Pape 2000). More recently, however, the current Chairman of the Federal Communications Commission, Michael Powell, referred to the digital divide as "a

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[1] See Freeman (2002) for a recent discussion of the impacts of information technology on the labor market.

Mercedes divide. I'd like to have one; I can't afford one," and the funding for several technology-related programs affecting disadvantaged groups is in jeopardy (Servon 2002).

The digital divide in access to computers at home poses a particularly controversial problem for policy makers. Should the digital divide be viewed simply as a disparity in utilization of goods and services arising from income differences just as we might view disparities in purchases of other electronic goods, such as cameras, stereos, or televisions? Or, should the digital divide be viewed as a disparity in a good that has important enough externalities, such as education, healthcare, or job training, that it warrants redistributive policies.[2] Although there is substantial disagreement over this issue, the consequences of access to home computers are relatively unknown. In particular, the literature on the educational impacts of home computers is especially sparse.[3]

To my knowledge, the only serious attempt to identify the effects of home computers on educational outcomes is provided by Attewell and Battle (1999). Using the 1988 National Educational Longitudinal Survey (NELS), they provide evidence that test scores and grades are positively related to home computer use even after controlling for differences in several demographic and individual characteristics. They find that students with home computers score 3 to 5 percent higher than students without home computers. Although Attewell and Battle (1999) control for several interesting and typically unobservable characteristics of the educational environment in the household, their estimates may be biased due to omitted

[2] See Noll, et al. (2000) and Crandall (2000) for an example of the academic debate.
[3] Recent studies have explored other effects of computers. See Morton, Zettelmeyer and Risso (2000), Bakos (2001), Borenstein and Saloner (2001), and Ratchford, Talukdar and Lee (2001) for consumer beneifts, Kuhn and Skuterud (2000 and 2001) for job search, Freeman (2002) for union membership, and Kawaguchi (2001) for employment and wages.

variables.[4] In particular, if the most educationally motivated families are the ones that are the most likely to purchase computers, then a positive relationship between academic performance and home computers may simply capture the effect of unmeasurable motivation on academic performance. Conversely, if the least educationally motivated families (after controlling for child and family characteristics) are the ones that are more likely to purchase computers then their estimates may understate the effects of home computers.

To address these concerns, I use data from the Computer and Internet Use Supplement to the 2001 Current Population Survey (CPS) and instrumental variable techniques to estimate the causal relationship between home computers and an important educational outcome -- school enrollment. Access to home computers may directly improve academic performance, and thus enrollment through the use of educational software or by facilitating the completion of school assignments and learning.[5] It may also have an independent effect on school enrollment by "opening doors to learning" and doing well in school (Cuban 2001 and Peck, Cuban and Kirkpatrick 2002) or by altering the returns to completing high school. On the other hand, home computers may have negative effects on educational outcomes by providing a distraction for children through video games and the Internet or by displacing other more active forms of learning (Giacquinta, Bauer, and Levin 1993 and Stoll 1995).

The Computer and Internet Use Supplement to the 2001 CPS provides detailed information on locations of computer and Internet use, which allows for the creation of several

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[4] They include measures of the frequency of child-parent discussions of school-related matters, parent's familiarity with the parents of their child's friends, attendance in "cultural" classes outside of school, whether the child visits science or history museums with the parent, and an index of the educational atmosphere of the home (e.g. presence of books, encyclopedias, newspapers, and place to study). The composite measure of socioeconomic status included in their analysis, however, may not adequately capture the independent effects of family income, parental education, and parental occupation.

[5] Access to home computers may also be important for familiarizing the student with computers which in turn may increase the returns to classroom use of computers (Selwyn 1998 and Underwood, Billingham and Underwood 1994).

instrumental variables for computer ownership. Computer and Internet use at work by the child's parents should affect the probability of the family purchasing a home computer, but should not affect academic performance (after controlling for other factors).[6] There exists a strong correlation between using a computer at work by a household member and computer ownership by that household (U.S. Department of Commerce 2002). In addition, there is no obvious reason why we would expect parental use of computers or the Internet at work to have a strong effect on educational outcomes after controlling for family income, and the education levels and occupations of the child's parents. I provide evidence on these issues below.

II. Data

I use data from the Computer and Internet Usage Supplement to the September 2001 Current Population Survey (CPS). The survey, conducted by the U.S. Census Bureau and the Bureau of Labor Statistics, is representative of the entire U.S. population and interviews approximately 50,000 households. It contains a wealth of information on computer and Internet use, including detailed data on types and location of use.

The main sample used in the following analysis includes only children ages 16-18 who have not graduated from high school and live with at least one parent.[7] Parents living in the same household as the child are identified by using parent and spouse identification numbers provided by the CPS. Using this information, however, I cannot distinguish between biological parents and stepparents.

[6] Similar instruments -- the non-home use of the Internet by various household members -- have been used in Kuhn and Skuterod's (2001) study of the effects of on-line job search on unemployment spells.
[7] Of the total sample, 93.3 percent live with at least one parent.

III. Computer and Internet Use

The presence of computers and the Internet in the nation's schools is ubiquitous. The National Center for Education Statistics reported that 100 percent of all public secondary schools in the fall of 2001 were connected to the Internet (U.S. Department of Education, 2001b). In these schools, 88 percent of all instructional classrooms had Internet access, and there were 0.23 instructional computers per student on average.

For the sample of high school students ages 16-18 from the 2001 CPS, reported rates of computer and Internet use reflect these high levels of access. Ninety percent of enrolled high school students report using a computer at school and 62 percent report using the Internet at school.

Access to computers and the Internet at home is not universal, but fairly high. Slightly less than 77 percent of children ages 16 to 18 who have not graduated from high school and live with at least one parent have access to a computer at home (see Table 1). Levels of access, however, vary tremendously across income, educational and racial groups (see U.S. Department of Commerce 2002 and Fairlie 2002).

Patterns of home computer use are revealing. Teenagers appear to be using their home computers -- 94.6 percent of children who have access to a home computer use it. Interestingly, 95.0 percent of children who are enrolled in school use their home computer compared to 87.1 percent of children who are not enrolled in school suggesting that computers may be useful for completing homework assignments. Examining this issue directly, estimates from the CPS indicate that of those children who use a home computer and are currently enrolled in school, 92.8 percent use their computer to complete school assignments.

Teenagers also use home computers for many other purposes. The most common uses of home computers among teenagers are for the Internet (88.0 percent), games (81.5 percent), email (80.9 percent), and word processing (72.2 percent). Use of home computers for graphics and design (32.5 percent) and spreadsheets or databases (25.0 percent) are also fairly common. None of these uses among high school students, however, is as prevalent as using home computers to complete school assignments. Furthermore, the large percentage of high school students, especially relative to the percentage of dropouts, using home computers for word processing provides additional evidence that home computers are useful for completing homework assignments. Concerns that home computers are only used for non-educational purposes such as playing games, listening to music, and emailing friends, seem exaggerated (Giacquinta, Bauer and Levin 1993).

The Internet also appears to be useful for schoolwork. Nearly 90 percent of high school students who use the Internet use it to complete school assignments (see Table 2).[8] Perhaps this is not surprising given the proliferation of homework help sites on the web and high rates of access in schools (Lenhart, Simon, and Graziano 2001). The Internet is also frequently used, however, for non-educational purposes such as playing games (58.3 percent), chat rooms (37.0 percent), viewing TV or movies or listening to music (27.3 percent), and shopping (22.5 percent).

At a minimum, estimates from the 2001 CPS indicate that home computers and the Internet are useful for completing school assignments. Whether these students wrote better reports or could have completed their school assignments at a library, community center or school, however, is unknown. Furthermore, the prevalence of non-educational uses of

[8] The CPS does not distinguish between Internet use at home, school or other locations.

information technology, such as games, chat rooms and music, suggests that home computers may also provide a distraction that lessens or negates their educational impact.

IV. The Effects of Home Computers on School Enrollment

School enrollment among teenagers is positively associated with owning a home computer. Table 3 reports estimates of enrollment rates among children ages 16-18 who have not finished high school by access to home computers. Slightly more than 95 percent of children with home computers are enrolled in school. In comparison, only 85.4 percent of children without access to home computers are enrolled in school.[9] Although these estimates do not control for factors, such as the child's age or his/her family's income, they are suggestive of the direction and size of potential impacts.

To control for these factors and others, I first model the school enrollment decision. Assume that school enrollment is determined by an unobserved latent variable,

(4.1) $Y_i^* = X_i'\beta + C_i'\delta + u_i$,

for person i, $i=1,....,N$. Only Y_i is observed, which equals 1 if $Y_i^* \geq 0$, implying that person i chooses to enroll in school; Y_i^* equals zero otherwise. X_i is a vector of individual, family and geographical area characteristics, C_i is a dummy variable for the presence of a home computer, and u_i is the error term. Assuming that u_i is normally distributed, the data are described by the following probit model.

(4.2) $Prob(Y_i=1) = \Phi(X_i'\beta + C_i'\delta)$,

[9] Attewell and Battle (1999) also find large differences in academic performance based on access to home computers using the NELS. In particular, they find than eighth graders with home computers scored 6 points higher on reading and 5 points higher on math that eighth graders without home computers (average scores among NELS respondents on both tests were approximately 50).

where Φ is the cumulative normal distribution function. Although the normality assumption should only be taken as an approximation, the probit model provides a useful descriptive model for the binary event that a child enrolls in school.

Table 4 reports estimates from probit regressions for the probability of school enrollment among children ages 16 to 18 who have not graduated from high school. All specifications include the sex, race, and age of the child, number of children in the household, family income, mother's and father's presence in the household, education level, labor force status and occupation, region of the country, central city status, and the state-level unemployment rate, pupil-teacher ratio, average expenditures per pupil and dummy variables for the age requirements of compulsory schooling laws (means for most variables are reported in the Appendix).[10] As expected, family income and parental education have large positive effects on school attendance. Older children and boys have lower probabilities of attending school, all else equal.

Owning a home computer appears to increase the probability of high school enrollment. The coefficient estimate on the home computer variable is large, positive, and statistically significant. The marginal effect evaluated at the mean characteristics of the sample, which is reported below the coefficient estimate, implies that having a home computer is associated with a 0.0138 higher probability of being enrolled in school.[11] The effect of this variable on the probability of school enrollment is comparable in size to that implied by being a girl and is slightly smaller than that implied by having a high-school- or "some college-" educated mother (relative to a high school dropout). The effect, however, is much smaller than that implied by

[10] The state-level unemployment rate is from Bureau of Labor Statistics (2002), and the age requirements for compulsory schooling laws, pupil-teacher ratio and average expenditures per pupil are from U.S. Department of Education (2001a).

[11] The average treatment effect, which equals $1/n \, \Sigma \, \Phi(X_i'\beta + \delta) - \Phi(X_i'\beta)$, is larger (0.0195).

being 18 years old (relative to 16), having a college-educated mother, or moving from the bottom of the family income distribution to the top.

An immediate concern with these estimates is that some families may have purchased their computers after or near the time that the school enrollment decision was made, and thus may be caused directly by the school enrollment decision. Although the CPS does not provide information on the timing of when all computer purchases were made, it provides information on when the newest computer was obtained by the family. Therefore, as a check of these results I estimate a probit model that excludes all observations for which the newest computer was obtained in 2001. This exclusion is likely to be overrestrictive, however, because a computer purchased in 2001 may represent a replacement for an older model or may have been purchased several months prior to the survey date, which is in September. The results are reported in Specification 2 of Table 4. The coefficient estimate on home computer is slightly larger in this specification.

The findings from the probit model for school enrollment are consistent with the findings from previous research on the relationship between home computers and other educational outcomes using the 1988 National Educational Longitudinal Survey. Attewell and Battle (1999) provide evidence that test scores and grades are positively related to home computer use. As noted above, even after controlling for differences in several demographic and individual characteristics, students with home computers were found to score 3 to 5 percent higher than students without home computers.

BIVARIATE PROBIT RESULTS

Although the findings presented in Attewell and Battle (1999) and those presented above are based on regression models that include numerous controls for individual, parental, and family characteristics, estimates of the effects of home computers on educational outcomes may be biased. For example, if children with higher levels of academic ability or children with more "educationally motivated" parents are more likely to have access to home computers, then the probit estimates may overstate the effect of home computers on school attendance. On the other hand, if parents of children with less academic ability or time to spend with their children are more likely to purchase computers, then the probit estimates may understate the effect. In either case, the effects of unobserved factors, such as academic ability and parental motivation, may invalidate the causal interpretation of the previous results.

A potential solution to this problem is to estimate a bivariate probit model in which equations for the probability of school enrollment and the probability of having a home computer are simultaneously estimated. This model is equivalent to an instrumental variables or two-stage least squares model and is preferred when both the dependent variable and endogenous variable are binary.

Similar to (4.1), assume that home computer ownership is determined by an unobserved latent variable,

(4.3) $C_i^* = X_i'\gamma + Z_i'\pi + \varepsilon_i$,

where only C_i equal to 0 or 1 is observed, Z_i is a vector of variables that are not included in (4.1), and ε_i is the error term. In this case, u_i and ε_i are distributed as bivariate normal with mean zero, unit variance, and $\rho=Corr(u_i, \varepsilon_i)$. The bivariate probit model is appropriate when $\rho\neq 0$.

The choice of Z_i is of paramount importance. I use information on whether the child's mother and father use a computer and the Internet at work. Computer and Internet use at work by the child's parents should satisfy the two necessary properties of a valid instrumental variable -- they affect the probability of purchasing a computer, but do not affect academic performance (after controlling for other factors). There exists a strong correlation between using a computer at work by a household member and computer ownership by that household (U.S. Department of Commerce 2002). In addition, we do not expect the use of a computer at work by the child's mother or father to have a strong effect on educational outcomes after controlling for family income, parental education, and parental occupations. Computer use at work may be associated with higher earnings, but this effect should be controlled for by the inclusion of family income.

Similar instruments have been used to examine the effects of on-line job search on unemployment durations (Kuhn and Skuterod 2001). Specifically, the non-home use of the Internet by various household members is used as an instrument for on-line job search. Kuhn and Skuterod argue that these instruments, especially the non-home use of the Internet by a household member outside one's nuclear family, should affect Internet use for job search by an unemployed respondent, but should not directly affect the length of the respondent's unemployment spell.

Estimates from the bivariate probit model for the probability of school attendance and having a home computer are reported in Specification 3 of Table 4. As expected, parental education is an important determinant of owning a home computer (reported in the first column). The probability of owning a home computer generally increases with both mother's and father's education. Education may be a proxy for wealth or permanent income and have an effect on the budget constraint or may have an effect on preferences for computers through pure tastes, exposure, perceived usefulness, or conspicuous consumption. Family income is also important in determining who owns a home computer. The relationship between the home computer probability and income is almost monotonically increasing across the listed categories. It is likely to be primarily due to its effect on the budget constraint, however, it may also be due its effect on preferences.

Race and ethnicity are also important determinants of computer ownership. Black, Latino, and Native American children have lower probabilities of having a home computer than do white children. In addition to these control variables, age, number of children, and region also have statistically significant effects on the home computer probability.

All four instrumental variables have positive coefficients in the home computer equation. Only mother's use of the Internet at work and father's use of the Internet at work, however, are statistically significant at conventional levels. The coefficients on these variables imply large effects on the probability of having a home computer. In particular, if the father uses the Internet at work then the probability of having a home computer is 0.0811 higher, all else equal. The stronger effects of Internet use compared to computer use at work may imply that communication and information retrieval uses of computers at work are associated with purchasing home computers and not other uses, such as appointment scheduling, database entry, and production.

The second column in Specification 3 reports the bivariate probit results for the school enrollment equation. Having a home computer has a large, positive and statistically significant effect on school enrollment. The coefficient estimate implies that the presence of a home computer increases the probability of school enrollment among children by 0.0767.[12] This effect is quite large as the sample average for the probability of school enrollment is 0.936.

[12] The average treatment effect is 0.1173.

Interestingly, this estimate lies between the probit estimate (0.0138) and the raw difference in school enrollment rates between children who have access to home computers and those who do not (0.098). Related to this issue the estimate of ρ indicates a negative correlation between the unobserved factors affecting home computers and school enrollment. Although it is unclear what causes this relationship, one possibility is that the least "educationally-motivated" families after controlling for observables are the ones that are most likely to purchase computers perhaps motivated by the many recreational uses of computers.

Why might we expect that access to home computers will have a positive effect on school enrollment among teenagers? There are several reasons. First, computers may improve academic performance directly through the use of educational software. Second, home computers may facilitate the completion of school assignments and learning -- either by making it easier and more rewarding to complete homework assignments or by familiarizing the student with computers increasing the returns to computer use in the classroom (Underwood, Billingham and Underwood 1994). Estimates reported above indicate that approximately 9 out of 10 high school students who have access to a home computer use that computer to complete school assignments, and 46 percent of teachers report that student access to technology/Internet is a barrier to effective use of technology in the classroom (SRI 2002). Third, the use of computers may "open doors to learning" and doing well in school (Cuban 2001 and Peck, Cuban and Kirkpatrick 2002), and thus may encourage some teenagers to stay in school.[13] Finally, home computers and the skills acquired using them may alter the economic returns to completing high school. For example, computer skills may be improve employment opportunities, but only after meeting the minimum threshold of graduating from high school.

[13] The use of computers at home may also translate into more positive attitudes towards information technology potentially leading to long-term use (Selwyn 1998). Many teachers report that educational technology increases outside class time initiative among students (SRI 2002).

INSTRUMENTAL VARIABLE ISSUES

The evidence from the bivariate probit model suggests that access to home computers increase the likelihood of staying in school. As noted above, this interpretation depends on whether work computer and Internet use by parents satisfy the two necessary properties of valid instrumental variables -- they are partially correlated with the home computer probability (after netting out X_i), but are not correlated with the school enrollment probability (i.e. uncorrelated with u_i). Internet use at work by the child's mother and father, at least, appear to be consistent with the first requirement. The coefficient estimates in the home computer equation are positive and statistically significant. The coefficient estimates, however, on the mother's and father's computer use at work variables are not statistically significant in the bivariate probit model.[14]

Because of concerns about the effects of weekly correlated instruments (e.g. Bound, Jaeger, and Baker 1995 and Staiger and Stock 1997), I estimate a bivariate model that only includes mother's and father's use of the Internet at work as instrumental variables. I am also concerned about the interdependence of the instruments. Of those mothers and fathers who use a computer at work, 65.5 and 77.3 percent also use the Internet at work, respectively. Estimates are reported in Specification 1 of Table 5. The coefficient estimate on having a home computer is slightly larger and remains statistically significant. As expected, the implied effects of mother's and father's use of the Internet at work on having a home computer are now larger and more significant.

I also estimate a model that only includes a dummy variable for whether either parent uses the Internet at work (Specification 2). Approximately, 40 percent of children who have one

[14] The coefficient estimates and statistical significance for the instruments are very similar in a probit model for the probability of having a home computer.

parent who uses the Internet at work also have another parent who uses the Internet at work. The coefficient estimate on home computer is slightly larger than the estimate in the main specification. Another test of the sensitivity of results is to estimate the probit model only including the computer at work instruments. The results are reported in Specifications 3 and 4. In both cases, the coefficient estimates are similar to the original estimates. The coefficients on mother's and father's use of computers at work are now statistically significant. The estimates reported in Table 5 indicate that the estimated effect of home computers on school enrollment is quite robust to alternative specifications of instruments, such as the exclusion of "weaker" instruments or correlated instruments.

Are computer and Internet use at work by the child's parents uncorrelated with u_i? One method of exploring this issue is to estimate a probit model for school enrollment that includes the four instrumental variables. Although not reported, I find that none of the instruments is statistically significant. Mother's and father's use of computers at work have negative coefficients, and mother's and father's use of the Internet at work have positive coefficients. I also estimate probit models for school enrollment that include all four combinations of instruments listed in Table 5. In each of the specifications, none of the instruments has a statistically significant coefficient estimate. Although this is not a formal test of the validity of the instruments, it suggests that computer and Internet use at work by the child's parents do not have a large effect on the probability of being enrolled in school after controlling for family income, parental education, parental occupation, and other factors.

ADDITIONAL ESTIMATES

I investigate the sensitivity of the results to several alternative samples. First, similar to above, I estimate a specification that excludes all children living in households in which the newest computer was obtained in 2001. The exclusion of these children rules out the possibility that some families may have purchased their computers after or near the time that the school enrollment decision was made. Specification 1 of Table 6 reports results. The coefficient estimate implies a slightly larger effect and remains statistically significant.

Another concern regarding the robustness of estimates is the exclusion of children who do not live with their parents. The main justification for removing these children is that they do not have parents who are "at risk" of using a computer and/or the Internet at work for use as instrumental variables. One method of addressing this concern is to add these children back to the sample and set mother's and father's use of computers and the Internet at work to zero. Estimates are reported in Specification 2. The coefficient estimate for home computer is not sensitive to the inclusion of these children.

The age requirements for compulsory schooling laws differ across states ranging from 16 to 18 (U.S. Department of Education 2001a). I currently include dummy variables for whether the age requirements are 17 or 18 years of age (with age 16 being the left out category). However, I am concerned that the process determining school enrollment may differ between children under the age cutoff and children above the age cutoff.[15] To address this issue, I estimate a bivariate probit model that excludes all children under the age requirement of the compulsory schooling law in their state. Estimates are reported in Specification 3. The coefficient estimate implies a similar size effect although it is no longer statistically significant.

[15] School enrollment rates are not 100 percent for children who are younger than the age requirement for compulsory schooling in their state. For example, less than 97 percent of 17-year olds living in states with age 18 compulsory schooling laws are enrolled in school.

In all previous specifications I include a dummy variable for missing family income, which represents 14.0 percent of the sample. Specification 4 reports estimates for a sample that excludes these missing values. The coefficient estimate is not sensitive to this change. Finally, I experimented with specifications that alternately removed the controls for parental occupation, parental education, and state-level variables. The coefficient on the home computer variable was not sensitive to any of these changes. Overall, the coefficient estimate on home computer in the bivariate probit is quite robust to alternative specifications and samples.

V. Conclusions

Estimates from the Computer and Internet Use Supplement to the 2001 Current Population Survey, provide evidence on whether access to home computers increases the likelihood of school enrollment among teenagers who have not graduated from high school. A comparison of school enrollment rates reveals that 95.2 percent of children who have home computers are enrolled in school, whereas only 85.4 percent of children who do not have home computers are enrolled in school. I find a smaller, but large positive difference in school enrollment rates after estimating a bivariate probit model for the joint probability of school enrollment and owning a home computer. Use of computers and the Internet at work by the child's mother and father are used as instrumental variables. The coefficient estimates imply that the probability of school enrollment is 0.0767 higher in the presence of a home computer. I interpret the results as providing evidence that home computers increase the likelihood of being enrolled in school.

Although the results are exceptionally robust to alternative specifications and samples, there is always the possibility that the large positive estimates of the effect of home computers on school enrollment are due to a correlation between the instruments and the error term in the enrollment equation. One potential problem is that parents with Internet access at work may be more able to communicate via email with teachers regarding their child's academic, attendance or behavior problems in school resulting in better educational outcomes. Only 28 percent of parents, however, report using email to communicate with their children's teachers (Lenhart, Simon, and Graziano 2001). Furthermore, the majority of email communication between parents and teachers may occur at home instead of work.

Unfortunately, the CPS does not include information on other aspects of work (e.g. the use of pencils) that would allow for a "reality check" of the results using computer or Internet use at work as instruments for home computers. In the end, however, there is no obvious reason to suspect that parental use of computers or the Internet at work is strongly correlated with educational outcomes after controlling for family income, and the education levels and occupations of the child's parents. Although more research is needed, the estimates presented above suggest that the household consumption of computers may provide positive externalities to families through better educational outcomes among children.

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Table 1
Home Computer Use among Children Ages 16-18
Current Population Survey, 2001

	All Children	Enrolled in School	Not Enrolled
Percent of children with access to a home computer	76.6%	78.5%	52.1%
Sample size	4281	4008	273
Percent of children with access to a home computer who use that computer	94.6%	95.0%	87.1%
Sample size	3370	3217	153
Percent of home computer users who:			
use computer for school assignments		92.8%	
use computer for the Internet	88.0%	88.5%	78.5%
use computer for games	81.5%	81.5%	82.8%
use computer for electronic mail	80.9%	81.5%	67.4%
use computer for word processing	72.2%	73.6%	43.5%
use computer for graphics and design	32.5%	32.8%	24.2%
use computer for spreadsheets or databases	25.0%	25.0%	25.4%
Sample size	3189	3056	133

Notes: (1) The sample consists of children ages 16-18 who have not graduated from high school and live with at least one parent. (2) All estimates are calculated using sample weights provided by the CPS.

Table 2
Internet Use among Children Ages 16-18
Current Population Survey, 2001

	All Children	Enrolled in School	Not Enrolled
Percent of children who use the Internet anywhere	77.9%	80.1%	49.2%
Sample size	4281	4008	273
Percent of Internet users who:			
use the Internet to complete school assignments		89.2%	
use the Internet for electronic mail	83.7%	84.0%	78.0%
use the Internet for playing games	58.3%	58.0%	65.6%
use the Internet to search for information about products and services	54.0%	54.2%	50.3%
use the Internet to get news, weather or sports	53.3%	53.3%	52.6%
use the Internet for chat rooms or LISTSERVs	37.0%	36.5%	46.8%
use the Internet for viewing TV or movies, or listening to music	27.3%	27.2%	28.8%
use the Internet to purchase products or services	22.5%	22.5%	22.8%
Sample size	3433	3298	135

Notes: (1) The sample consists of children ages 16-18 who have not graduated from high school and live with at least one parent. (2) All estimates are calculated using sample weights provided by the CPS.

Table 3
School Enrollment among Children Ages 16-18
Current Population Survey, 2001

	Enrollment Rate	Sample Size
School enrollment among children without access to home computer	85.4%	911
School enrollment among children with access to home computer	95.2%	3370

Notes: (1) The sample consists of children ages 16-18 who have not graduated from high school and live with at least one parent. (2) All estimates are calculated using sample weights provided by the CPS.

Table 4
Probit and Bivariate Probit Regressions for School Enrollment and Home Computer
Current Population Survey, 2001

	Specification			
Explanatory Variables	(1)	(2)	(3)	
Dependent variable	Enrollment	Enrollment	Computer	Enrollment
Model type	Probit	Probit	Bivariate	Bivariate
Female	0.1975	0.1797	0.0941	0.1819
	(0.0709)	(0.0750)	(0.0541)	(0.0780)
Black	0.2062	0.1945	-0.6869	0.3501
	(0.1179)	(0.1232)	(0.0842)	(0.1399)
Latino	0.0364	0.0006	-0.4218	0.1320
	(0.1233)	(0.1291)	(0.0882)	(0.1429)
Native American	0.1593	0.3016	-0.6420	0.2941
	(0.2397)	(0.2664)	(0.1830)	(0.2944)
Asian	0.3489	0.4850	0.1748	0.3130
	(0.2443)	(0.2890)	(0.1474)	(0.2808)
Age 17	-0.3067	-0.3107	-0.0493	-0.2963
	(0.0873)	(0.0930)	(0.0589)	(0.1016)
Age 18	-1.3409	-1.3088	-0.2435	-1.2604
	(0.0904)	(0.0958)	(0.0780)	(0.1113)
Family income: missing	0.2490	0.2891	0.3419	0.1376
	(0.1643)	(0.1711)	(0.1261)	(0.1826)
Family income: $10,000 to $15,000	0.0171	0.0052	0.1218	-0.0070
	(0.1825)	(0.1887)	(0.1469)	(0.1933)
Family income: $15,000 to $20,000	0.0841	0.1519	0.3185	-0.0030
	(0.2036)	(0.2149)	(0.1541)	(0.2082)
Family income: $20,000 to $25,000	0.1071	0.2128	0.1514	0.0565
	(0.1811)	(0.1904)	(0.1406)	(0.1921)
Family income: $25,000 to $30,000	0.0891	0.0413	0.3772	-0.0127
	(0.1921)	(0.1982)	(0.1453)	(0.2063)
Family income: $30,000 to $35,000	0.0401	0.1586	0.4234	-0.0721
	(0.1947)	(0.2078)	(0.1549)	(0.2173)
Family income: $35,000 to $40,000	0.1737	0.1649	0.6257	0.0168
	(0.2115)	(0.2214)	(0.1631)	(0.2334)
Family income: $40,000 to $50,000	0.3246	0.3282	0.6831	0.1327
	(0.1818)	(0.1896)	(0.1402)	(0.2258)
Family income: $50,000 to $60,000	0.1380	0.2582	0.7657	-0.0357
	(0.1904)	(0.2038)	(0.1528)	(0.2151)

(continued)

Table 4 (continued)

Probit and Bivariate Probit Regressions for School Enrollment and Home Computer

Explanatory Variables	Specification (1)	(2)	(3)	
Family income: $60,000 to $75,000	0.4841 (0.2042)	0.5443 (0.2187)	0.8480 (0.1542)	0.2890 (0.2334)
Family income more than $75,000	0.3810 (0.1845)	0.3364 (0.1943)	0.9684 (0.1505)	0.1960 (0.2117)
Mother-high school graduate	0.2413 (0.1103)	0.2855 (0.1148)	0.2681 (0.0848)	0.1584 (0.1230)
Mother-some college	0.2529 (0.1224)	0.2891 (0.1283)	0.5511 (0.0949)	0.1268 (0.1480)
Mother-college graduate	0.4199 (0.1602)	0.4342 (0.1701)	0.5436 (0.1266)	0.2984 (0.1780)
Father-high school graduate	-0.0134 (0.1278)	-0.0940 (0.1361)	0.0565 (0.0922)	-0.0294 (0.1352)
Father-some college	0.0150 (0.1406)	-0.0186 (0.1509)	0.1989 (0.1047)	-0.0318 (0.1489)
Father-college graduate	0.2428 (0.1775)	0.2538 (0.1953)	0.5248 (0.1453)	0.1991 (0.1879)
Home computer	0.1878 (0.0864)	0.2115 (0.0904)		0.8562 (0.3152)
Marginal effect	0.0138	0.0166		0.0767
Mother uses computer at work			0.0924 (0.0885)	
Father uses computer at work			0.1433 (0.1117)	
Mother uses the Internet at work			0.2251 (0.0982)	
Father uses the Internet at work			0.4034 (0.1335)	
Mother's occupation controls	Yes	Yes	Yes	Yes
Father's occupation controls	Yes	Yes	Yes	Yes
ρ			-0.3958 (0.1790)	
Mean of dependent variable	0.9358	0.9321	0.7860	0.9358
Sample size	4,239	3,607	4,239	

Notes: (1) The sample consists of youth ages 16-18 who have not graduated from high school and live with at least one parent. (2) The sample in Specification 2 excludes children in families obtaining their newest home computer in 2001. (3) All equations also include a constant, number of children in the household, dummy variables for region, central city status, mother's and father's presence in the household and labor force status, and the state-level unemployment rate, pupil-teacher ratio, average expenditures per pupil, and dummy variables for the age requirements of compulsory schooling laws.

Table 5
Additional Bivariate Probit Regressions Using Different Instruments
Current Population Survey, 2001

	Specification			
	(1)	(2)	(3)	(4)
Home computer	0.9014	0.9509	0.8029	0.8655
	(0.3051)	(0.2966)	(0.3380)	(0.3224)
Marginal effect	0.0820	0.0881	0.0710	0.0783
Instrumental variables				
Mother uses the Internet at work	0.2783			
	(0.0846)			
Father uses the Internet at work	0.5103			
	(0.1005)			
Either parent uses the Internet at work		0.4879		
		(0.0730)		
Mother uses computer at work			0.2132	
			(0.0757)	
Father uses computer at work			0.3794	
			(0.0838)	
Either parent uses computer at work				0.3311
				(0.0674)
ρ	-0.4212	-0.4506	-0.3638	-0.3994
	(0.1713)	(0.1666)	(0.1952)	(0.1849)
Mean of dependent variable	0.9358	0.9358	0.9358	0.9358
Sample size	4,239	4,239	4,239	4,239

Note: See notes to Table 4.

Table 6
Additional Bivariate Probit Regressions Using Various Samples
Current Population Survey, 2001

	Specification			
	(1)	(2)	(3)	(4)
Sample restrictions	Removes computers purchased in 2001	Adds children living alone	Compulsory schooling sample	Removes missing income observations
Home computer	1.1198 (0.2630)	0.9958 (0.2637)	0.7088 (0.4291)	0.8868 (0.3467)
Marginal effect	0.1214	0.1060	0.0740	0.0774
ρ	-0.5341 (0.1451)	-0.4484 (0.1526)	-0.2677 (0.2539)	-0.3991 (0.1947)
Mean of dependent variable	0.9321	0.9213	0.9147	0.9363
Sample size	3,607	4,548	2,720	3,644

Notes: (1) See notes to Table 4. (2) See text for a more detailed description of the sample restrictions used in each specification.

Appendix
Sample Means of Selected Variables
Current Population Survey, 2001

Variable	Mean	Standard Deviation
School enrollment	0.9358	0.2451
Home computer	0.7860	0.4102
Female	0.4735	0.4994
Black	0.1151	0.3192
Latino	0.0979	0.2972
Native American	0.0198	0.1394
Asian	0.0373	0.1895
Age 17	0.4084	0.4916
Age 18	0.1314	0.3379
Number of children in household	2.1515	1.2240
Family income: missing	0.1404	0.3474
Family income: $10,000 to $15,000	0.0422	0.2011
Family income: $15,000 to $20,000	0.0342	0.1818
Family income: $20,000 to $25,000	0.0533	0.2247
Family income: $25,000 to $30,000	0.0465	0.2105
Family income: $30,000 to $35,000	0.0495	0.2170
Family income: $35,000 to $40,000	0.0429	0.2027
Family income: $40,000 to $50,000	0.0937	0.2914
Family income: $50,000 to $60,000	0.0896	0.2857
Family income: $60,000 to $75,000	0.1064	0.3084
Family income more than $75,000	0.2574	0.4372
Lives only with father	0.0559	0.2298
Mother-not in the labor force	0.1925	0.3943
Lives only with mother	0.2404	0.4274
Mother-high school graduate	0.3218	0.4672
Mother-some college	0.2880	0.4529
Mother-college graduate	0.2232	0.4164
Father-high school graduate	0.2406	0.4275
Father-some college	0.1984	0.3988
Father-college graduate	0.2241	0.4170
Father-not in the labor force	0.0446	0.2064
Mother uses computer at work	0.4343	0.4957
Father uses computer at work	0.3711	0.4832
Mother uses the Internet at work	0.2843	0.4511
Father uses the Internet at work	0.2869	0.4523
Sample size	4,239	

Note: The sample is the same as that used in Specification 3 of Table 4.