Educational Attainment and Household Internet;
An econometric study of 50 states over 4 years in the 2000s

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Educational Attainment and Household Internet

Education is one of the cornerstones to the economic welfare and longevity in a society. Increasingly, the more-educated person is better off than the less-educated person. The computer and Internet are two of the greatest educational tools the world has ever seen, and yet many households in the United States do not have a home computer or access to the Internet. This is putting people without access, usually rural and poor people who need them the most, at a distinct disadvantage

Computers and the Internet can assist in the education of the youth and expand the breadth of educational topics students are exposed to inside and outside of school. When a child has household access to the Internet they can supplement their classroom learning with better home learning, increasing their interest and the effectiveness of their education. When a household does not have access to a computer or the Internet, then the students are restricted to what is in their book and the knowledge of the teacher in the classroom. If a student is curious about something and it is not in the book or the teacher does not know the answer, then without the Internet the student may never get an answer to the question. The answer could be found eventually in a library, but it may only reach one student instead of the entire class. This puts students with a computer and Internet access with a distinct advantage in school performance and success in the future. I will attempt to show the educational advantage that is acquired by access to a household computer and Internet by explaining the factors that contribute to state average SAT scores.

Background

The Internet is one of the most important tools for our country to continue to be at the forefront of a global economy. It can enhance education, communication, and the growth of our economy. President Obama has recongnized that computers and the Internet are important to the success of our country and had taken certain initiatives to support that stance. Programs like the American Recovery and Reinvestment Act of 2009 (Recovery Act) have begun to pave the way for the advancement of computer and Internet access across the nation. Under the Recovery Act, the National Telecommunication and Information Administration (NTIA) provides $4 billion to fund 229 projects across the nation through the Broadband Technology Opportunities Program (BTOP) (Blank & Strickling, 2011: i). This $4 billion and the investments from the Department of Agriculture's Broadband Initiative Program equal $7 billion focused on the advancement of Internet and computer access across the nation (Blank & Strickling, 2011: i). These investments are the governments attempt to keep the nation on an even playing field with the rest of the world.

Since the implementation of the Recovery Act much advancement has been made across the nation and results have started to be noticed. The BTOP has installed or upgraded over 18,000 miles of new broadband networks to give people who have not previously had access to high speed Internet the access they need to be successful (Blank & Strickling, 2011: i). The BTOP has also installed or upgraded over 16,000 computer workstations across the nation giving people the tools they need to use the new access they now have because of new broadband networks (Blank & Strickling, 2011: i). The NTIA has also launched DigitalLiteracy.gov to give people the knowledge they need to become familiar with their strange new Internet. These improvements have shown some stimulation to Internet use and are expected to continue to simulate growth in the future.

The Current Population Survey (CPS) was expanded in 2010 to more accurately gauge the state of Internet usage in the United States. According to the October 2010 CPS, 68% of the current population had broadband Internet access (Blank & Strickling, 2011: v). This was a 4 percentage point improvement from the same survey the year before. Dial-up home use has declined to 3% of the preferred form of residential Internet access after being the primary source of access in the mid-90's and early 2000's (Blank & Strickling, 2011: vi). This shows the importance of upgrading and installing broadband networks since dial-up has become obsolete. The CPS also showed that 77% of the population had a computer in the household, up from 62% in 2003 (Blank & Strickling, 2011: iv). Low computer use has been highly correlated with low broadband adoption rates in households (Blank & Strickling, 2011: vi). These results show that almost a third of our nation does not have access to technologically relevant Internet and almost a quarter of our nations population does not even have a computer. This puts these people at a distinct disadvantage in comparison with the rest of the nation. More specifically the children who grow up in these disadvantaged areas are not gaining access to skills and tools that can enhance education and will be needed throughout their lives.

These disadvantaged people are the ones who most need access to the Internet and computers. According to the CPS, in October of 2010 lower-income families, blacks, Hispanics, those with less education, and rural residents lagged behind the national averages in both broadband adoption and computer usage (Blank & Strickling, 2011: vi). In the CPS 47% of household stated lack of interest as the reason for not adopting broadband or dial-up, 24% said affordability, and 15% said that they had an inadequate computer (Blank & Strickling, 2011: vi). Of those 24% who reported affordability, both initial cost and recurring monthly cost were both cited as factors (Blank & Strickling, 2011: vi). Over a third of the population has reported some

sort of financial issue as being involved with their reason for not having a computer. The children of these households with no access to Internet have less opportunity for upward mobility because they lack the tools to facilitate this upward movement. If these children had access to computers and the Internet at home then they could increase their education and performance in school. Arguably success in school increases your chances of success in life and that is why it is so important for our children to have Internet access.

Literary Review

The literature on the impact of computers in the household on education is widely varying. Authors such as Korupp, Beltran, Das, Fairlie, Attwell, Suazo-Garcia, and Battle maintain that computer have a positive effect on educational outcomes in children. We also have the works done by Warschauer, Knobel, Stone, Fuchs, and Woessmann who have found evidence that computers may or may not have an effect on education, which could be due to the different uses by high- and low-income families. Then we have the opposite viewpoint on computers and education that computers hurt the performance of children in school, held by Clotfelter, Ladd, Vigor, Peslak, and Robinson. The results of these studies gives a variety of conflicting views suggesting that more research must be completed to indentify the advantage of home computer use and education.

Daniel Beltran, Kuntal Das, and Robert Fairlie (2011) conducted a study on the effect of home computers on high school graduation. They used two national surveys to obtain their information and found a positive effect of computers on graduation in both surveys. They found that 81.6% of teenagers not enrolled in high school used computers at home as opposed to 95.2% of teenagers enrolled in high school (Beltran,Das,Fairlie, 2011: 11). Additionally 93.4% of the

enrolled students reported using their home computers to complete some sort of school assignment (Beltran,Das,Fairlie, 2011: 11). This high percentage shows that when children do have the access to a computer at home almost all of them used it for some sort of educational activity related to school giving them an advantage over the students who do not have this option.

These authors also found a difference in usage between enrolled students with home computers and those not enrolled. Of those enrolled in high school with a computer at home, 71.1% of them use their computer for word processing as opposed to only 38.8% of those not enrolled with a home computer (Beltran,Das,Fairlie, 2011: 11,12). This suggests that the school students are using the computer more productively and gain more of an educational advantage from the computer. Those not enrolled in school may simply be using their computers for gaming and social networking.

Further analysis of one survey found that 73.3% of teenagers who have a home computer graduated on time and only 56.7% of teenagers who do not have home computers (Beltran,Das,Fairlie, 2011: 13). A second survey showed similar results, with nearly 95% of children who had a home computer between the ages of 15-17 graduating on time as compared to only 70.7% of children who did not have a computer (Beltran,Das,Fairlie, 2011: 13). Both of these surveys show exactly how important home computer use is to the educational success of children showing large gaps between the two graduation rates. The second study also showed that home computers have a positive effect on grade point average of .216, which is the difference between a C+ and a B (Beltran,Das,Fairlie, 2011: 23). So not only are these children graduating at a higher rate but the higher grade point average suggests that they are performing at a higher level on a day-to-day basis.

Another national study done by Paul Attewell, Belkis Suazo-Garcia, and Juan Battle (2003) showed positive effects from home computer use. However these positive effects were only observed with moderate computer use on a weekly basis. They observed a slightly younger age group then the Beltran, Das, and Fairlie (2011) study and still found a positive relationship. The participants were broken down into three categories: not computer users, moderate computer users which was less then 8 hours a week, and heavy users, which was over 8 hours per week. The results showed that children who engaged in moderate computer use scored higher on measures of letter recognition, reading comprehension, mathematics calculation problems, and self-esteem tests (Attewell, Suazo-Garcia, Battle, 2003: 291). This all supports the notion of computers having a positive effect on education and is essential to households with school-aged children. The interesting result from this study was that children who were recorded as heavy users spent 4 hours less outside per week, had a higher body mass index roughly 12 pounds heavier, and their scores were not statistically different from the not and moderate computer users (Attewell, Suazo-Garcia, Battle, 2003: 291). However, this may be because of reverse-causation with heavy users. Children who are overweight and unathletic are more likely to spend more time inside anyway and the presence of a computer is just an activity to do inside without physical activity which appeals to this type of child. Regardless of the reason this study raises an interesting question of whether or not the computer can hurt the educational and social well being of school aged children.

Thomas Fuchs and Ludger Woessmann (2004) did an international study on educational achievement and the availability and use of computers at home. When they initially did a simple regression on the data they found a positive relationship between the presence of computers and educational achievement which would support the hypothesis that computers are advantageous.

Fuchs and Woessmann then adjusted their data and included family background and financial status and found a negative relationship between computer use and educational achievement, which would attribute the higher scores to family background and status (Fuchs, Woessmann, 2004: 12). They also found that small doses of Internet showed positive results, and children who used Internet and email frequently performed better (Fuchs, Woessmann, 2004: 16). This suggests that relationship between computers and education may be U-shaped. At small levels of computer use for productive activities like Internet are advantageous, but after a certain level of use computers are harmful to the education of children. This shows that maybe the problem is not only the presence of computers but also the use of computers and the presence of the Internet to supplement the computer.

Similar results were found in a study done in North Carolina public schools by Charles T. Clotfelter, Helen F. Ladd, and Jacob L. Vigor (2008). They found that students with home access to a computer attained scores between 1.7% and 1.9% of a standard deviation higher on math and reading tests then those without home computer access (Clotfelter, Ladd, and Vigor, 2008: 25). When they looked further into the data they found that students who used a computer 1 or 2 times a month performed 4 to 5% of a standard deviation higher then other students. Students that claimed they used the computer everyday for schoolwork performed worse on math and reading tests. This suggests the same thing as Fuchs and Woessmann that the advantage obtained by computer use may follow a U-shaped curve. Moderate use of the computer will enhance the learning environment but too much use can become a distraction and lead to less educational success.

This idea that it is the actual activities performed on the computer that improves education is somewhat reinforced by Mark Warschauer, Michele Knobel, and Leeann Stone

(2004) when they observed 5 public schools in California. Three of these schools were low income schools and the other two were in high-income districts. They did not notice higher performance in the classroom in the higher-income areas but they did notice a difference in the use of the computer. In the high-income school when children were given computer assignments, the assignments were geared toward the mastery of software or computer related activity. One assignment given was to make a Power Point presentation and use as many different effects on each slide as the children possibly could. This promotes the use of the program and make the kids familiar with a tool that will be needed further in education and in the workplace. The low-income schools simply gave the students an assignment that involved looking up information in which most of the students went to Google and used the first match returned for their search. They would then copy and paste the information and be done with the assignment not knowing if they had a reliable source and not engaging in any kind of critical thinking involving the computer. This suggests that the problem is not only the access to computers but the way the children are taught to use the computer. It seems that low-income children do not have the tools around them to teach them how to use computers in a productive manner for future advancement.

There are also studies that show no relationship between computers and education also. Alan R. Peslak (2004) conducted a study in California of 1090 school and 6 million students and found no relationship between computers and reading and math scores in grades 2-11. Robert Fairlie and Johnathan Robinson (2012) also did a study of 1,123 school children in grades 6-10 from 15 schools and also could find no effects on grades or standardized test scores. Despite their failure to find a relationship there is enough literature out there to suggest that there is a relationship between educational achievement and home-computer use, whether it is positive,

negative, or a U-shaped curve. The relationship warrants further exploration in order to make the proper decisions regarding computer-and Internet access so as to enhance the education of our youth.

Data

The equation I will use to show the relationship between computers and education is all on a national level and has been obtained through government surveys. More specifically we will be focusing on the effect computers and Internet have on standardized testing. We will be using Average Total SAT scores by state as our dependent variable. This information was obtained from collegeboard and is directly from the yearly report of the organization administering the tests. Our independent variables will include the SAT participation rate by each state, as the states with a higher participation rate have more observations that will include less successful high-school students that should lower their state averages. This information was also obtained from the yearly report released by collegeboard. The next independent variable to be used will be the percentage of state gdp spent on education. These numbers were obtained from usgovernmentspending.com which is a website devoted to the comparison of government spending. This will adjust for the disparity in the quality of education across states. The next two independent variables relate to household income. They are poverty and, household disposable income and were taken from the United States Census Bureau. Families with less money are obviously less likely to have a computer and to have good standardized testing scores. The final variable, household Internet access, also Census data, is included to see the advantage that is obtained by such access and gauge the effect web resources have on testing. This is one

of our innovative variables, along with our last, the cost of a computer as measured by the CPI for Information Technology, hardware and services. The high price of computers is often cited as a barrier to the purchase of a computer and should have a negative effect on SAT scores since children who can not afford them should perform worse in school and be at a disadvantage for the SAT.

All of the data was recorded from the years 2000, 2001, 2003, and 2007, since the information on internet was only available for these years. With data from each of the 50 states and not including DC we have 200 observations to perform our analysis.

The full equation to be estimated is:

TotalSat = $\beta 0 + \beta 1$ SAT participation rate + $\beta 2$ Cost of Computers + $\beta 3$ Poverty + $\beta 4$ Total Spending on Education + $\beta 5$ Household Internet Usage + $\beta 6$ Real Household Disposable Income.

The expected signs of the variables are as follows: $\beta 1 < 0$, $\beta 2 < 0$, $\beta 3 < 0$, $\beta 4 > 0$, $\beta 5 > 0$, $\beta 6 > 0$

Econometric Analysis

First an ordinary least squares regression was run to see the initial relationship between the variables and check for any problems such as heteroskedasity and autocorrelation. I found evidence of heteroskedasity, not surprising since most of the observations represented variation across the states, and needed to rerun the regression. I now identified the year of the data so as to treat this as time-series panel data. Instead of running an OLS regression I am ran a robust regression that adjusted for heteroskedasity with time-series panel data.

When this robust regression was run, some results confirmed expectations, and some were a surprise. As expected, SAT participation rate, Cost of Computer, and Poverty all show negative coefficients in this equation and were all statistically significant. Although Total Spending as a percentage of GDP on Education and Real disposable household income show the positive coefficients expected, they are not statistically significant, and Household Internet Access shows a negative coefficient which is not what we expected, but it is statistically insignificant as well (See Table 2).

This initial regression supports the notion that the cost of computer has a direct effect on SAT performance. The higher the cost of computer the less people can afford them and student performance goes down on these tests. The effect of -.05 means that for ever $50 increase in prices the average SAT score goes down 2.5 points. This relationship is significant but an effect that small is not going to have a large social impact. The poverty level also has a negative effect on average SAT score. This shows that for every 1% point increase in poverty level, average SAT scores decrease by 1.6 points. This is a minimal effect on the total SAT scores that wouldn't make or break SAT scores that are around 1000. These are the households that are most likely to be unable to afford computers; this offers additional support for the hypothesis that the lack of computer presence may be one of the causes of lower SAT performance.

Also, as expected, SAT participation rate had a significant effect on SAT scores. States with low participation rates more than likely have test-takers mostly comprised of students who are very prepared for the test and pursuing 4 year colleges. In states with high participation rates there are more students, including those who have not done as well in school, will perform less well on the test and bring the average down.

I then ran a correlations matrix to see the correlations between each of my explanatory variables, as seen in Table 3. This did not tell me much about the explanatory variables as the only highly correlated variables were real personal disposable income and household internet use. Aware that there may be collinearity which masks the contributions of the other three variables, I began to omit certain variables to see the change on the equations.

I began by omitting Real Personal Disposable Income from the equation to observe the changes. This resulted in a higher level of significance for SAT participation rate, Cost of Computer, and Poverty (Table 2). The only significant coefficient whose coefficient increased was Cost of Computer, but the other two coefficients decreased in their effect. As you can see in Table 2, excluding other variables resulted in much the same estimations, as the only three variables to show significance are always SAT participation rate, Cost of Computer, and Poverty. The regression for the equation with the highest levels of significance and highest corrected R-squared is shown in Table 2. This regression includes the three previously significant variables of the equation, and Total Spending on Education. In this equation Total Spending on Education returns the expected positive sign, but it is not significant at even the 15% level. The Three previously significant factors, SAT participation rate, Cost of Computer, and Poverty are all significant at the 1% level.

Conclusion

The results have shown that, as predicted, the cost of a computer, SAT participation rate, and the poverty rate all returned a significant relationship with the average SAT scores for each state. These three variables also show a negative sign in the regression equation.

This supports the idea that the presence of a computer in the household is essential to education. However the other three variables household internet usage, disposable household income, and percent of GDP spent on education by state, all were insignificant even after adjusting for heteroskedasity. Since one of the main variables unique to this study, cost of computer was significant and the other main variable household internet usage was insignificant it is difficult to say that a computer has an observable effect on SAT performance. Without the Internet, the advantage gained from the computer would be more observable in school grades rather then the SAT's. The main advantage gained would be in writing papers and mathematical calculations made easier by the computer. It is even more difficult to support the positive effect of computers when the effect of every dollar increase in the cost of a computer is a negative .05 of a point on the SAT. This along with the insignificance of household Internet usage, seem to challenge the suggestion that computers enhance educational attainment.

Even though the data does not return the expected results they do seem to suggest that there might be some relationship that the data retrieved in this study could not capture. In a study like this, it is hard to control for all factors that affect education in order to isolate the effect of computers. In future studies it would be more beneficial to conduct research on a more microeconomic local level instead of a macroeconomic national level. This along with the disparities in participation rates in the SAT among states may have hidden most of the effect the Internet would have had since many of the states with low participation rate probably also had low internet-usage percentages. The results may not have been what we expected but it is clear that more research needs to be done on the impact of computers on

education so that we can fully understand this amazing tool and use it to ensure the education and future of our children and nation.

Bibliography

Attewell, P., Suazo-Garcia, B., & Battle, J. (2003). Computer and Young Children: Social Benefit or Social Problem?. *Social Forces*, *82*(1), 277-296. Retrieved March 20, 2012, from Stable URL: http://www.jstor.org/stable/3598146

Beltran, D., Das, K., & Fairlie, R. (2011, November 29). Board of Governors of the Federal Reserve System International Finance Discussion Papers. *Home Computers and Educational Outcomes: Evidence from the NLSY97 and CPS*. Retrieved May 14, 2012, from www.federalreserve.gov/pubs/ifdp/2008/958/ifdp958.pdfhttp://

Blank, R., & Strickling, L. (2011, November 30). Exploring the Digital Nation. *computer and internet use at home*. Retrieved May 30, 2012, from 1. http://www.esa.doc.gov/sites/default/files/reports/documents/exploringthedigitalnation-computerandinternetuseathome.pdf

Choemprayong, S. (2006). Closing Digital Divides: The United States' Policies. *Libri*, *56*, 201-212. Retrieved March 26, 2012, from http://www.librijournal.org/pdf/2006-4pp201-212.pdf

Clotfelter, C., Ladd, H., & Vigdor, J. (2008, July 29). Scaling the Digital Divide. *Home Computer Technology and Student Achievement*. Retrieved May 21, 2012, from www.hks.harvard.edu/pepg/PDF/events/colloquia/Vigdor_ScalingtheDigitalDivide.pdf

Fairlie, R., & Robinson, J. (2012, April 30). Experimental Evidence on the Effects of Home Computers on Academic Achievement among Schoolchildren. *sole-jole.org*. Retrieved May 16, 2012, from http://www.sole-jole.org/12192.pdf

Fuchs, T., & Woessmann, L. (2004, November 30). COMPUTERS AND STUDENT LEARNING:. *cesifo-group.de*. Retrieved May 17, 2012, from http://www.cesifo-group.de/portal/pls/portal/docs/1/1188938.PDF

Korupp, S. (2006). No Man is an Island: The Influence of Knowledge, Household Settings, and Social Context on Private Computer Use. *Internation Journal of Internet Science*, *1*(1), 45-57. Retrieved March 13, 2012, from http://www.ijis.net/ijis1_1/ijis1_1_korupp.pdf

Peslak, A. (2004). "An empirical study of the effect of information technology expenditures on student achievement " *Information Research*, **9**(4) paper 185 [Available at http://InformationR.net/ir/9-4/paper185.html]

Warshauer, M., Knobel, M., & Stone, L. (2004). No Man is an Island: The Influence of Knowledge, Household Settings, and Social Context on Private Computer Use. *Educational Policy*, *18*(4), 562-588. Retrieved March 13, 2012, from http://www.gse.uci.edu/person/warschauer_m/docs/tes.pdf

Tables

Table 1.)

Variable Means and Standard Deviations

	Variable Means	Standard Deviations				
		Equation 1	2	3	4	5
SAT PART RATE	37.56	0.1576	0.1539	0.1649	0.1539	0.1552
Cost of Computer	177.96	0.0189	0.0196	0.0147	0.0196	0.0134
Poverty	12.62	0.8155	0.7279	0.7960	0.7279	0.7304
Total Spending on Education % GDP	6.02	3.0464	2.9321	3.0233	2.9321	3.0227
Household Internet Usage	59.29	0.3200		0.2133		
Real Personal Income	30,049.77	0.0008	0.0005		0.0005	

Table 2.)

Econometric Results for Combined SAT Scores, 50 States, 2000, 2001, 2003, 2007

	Equation 1	**Equation 2**	**Equation 3**	**Equation 4**	**Equation 5**
totalsat	Coef. (t-value)				
satpartrate	-2.185163 (-13.86)*	-2.201477 (-14.3)*	-2.17196 (-13.17)*	-2.201477 (-14.3)*	-2.19883 (-14.17)*
costofcomp~r	-0.056780 (-3)*	-0.055048 (-2.81)*	-0.06422 (-4.36)*	-0.055048 (-2.81)*	-0.05062 (-3.77)*
poverty	-1.65791 (-2.03)*	-2.111964 (-2.9)^	-1.46712 (-1.84)*	-2.111964 (-2.9)^	-1.99054 (-2.73)*
totalspend~d	3.780503 (1.24)	3.208915 (1.09)	3.671237 (1.21)	3.208915 (1.09)	3.371796 (1.12)
householdi~t	-0.304778 (-0.95)		-0.26824 (-1.26)		
realperson~e	0.0003247 (0.43)	-0.000077 (-0.15)		-0.000077 (-.15)	
_cons	1172.033 (44.16)	1175.536 (45.70)	1178.702 (55.51)	1175.536 (45.70)	1169.798 (53.01)
[R-squared]	[.794]	[.802]	[.784]	[.802]	[.801]
{Adjusted R-squared}	{.788}	{.797}	{.778}	{.797}	{.797}
<F-stat>	<123.98>	<157.16>	<140.82>	<157.15>	<196.22>

Significant at 1% level *

Significant at 5% level ^

Table 3.)

Correlation Coefficients

	sat part rate	*Cost Of Computer*	*real personal disp income*	*Poverty %*	*Household Internet*	*Total spending on Ed*	*total sat*
sat part rate	1						
Cost Of Computer	-0.00869988	1					
real personal disp income	0.363224594	-0.680962463	1				
Poverty %	-0.35063537	-0.337250407	-0.2026767	1			
Household Internet	0.271629984	-0.724142397	0.83166265	-0.137581	1		
Total spending on Ed	-0.27653803	-0.096309333	-0.2694768	0.373139	-0.11061733	1	
total sat	-0.87825749	-0.035909093	-0.1290593	0.0869744	-0.10962163	0.153307334	1