NET Institute*

www.NETinst.org

Working Paper #05-25

October 2005

Rationalizing the E-Rate: The Effects of Subsidizing IT in Education

Michael R. Ward
University of Texas at Arlington

* The Networks, Electronic Commerce, and Telecommunications ("NET") Institute, http://www.NETinst.org, is a non-profit institution devoted to research on network industries, electronic commerce, telecommunications, the Internet, "virtual networks" comprised of computers that share the same technical standard or operating system, and on network issues in general.

“Rationalizing the E-Rate: The Effects of Subsidizing IT in Education”

Michael R. Ward

University of Texas at Arlington

mikeward@uta.edu

November, 2005

Abstract: Starting in 1998, the E-Rate program has provided $2.25 billion to subsidize Internet access in schools and libraries serving low income populations in the US. I analyze the effect of E-Rate subsidies on educational outcomes for Texas high schools over the 1994-2003 time period. Consistent with previous economic analyses, I find few, if any, improvements in student achievements. I do find evidence that experienced teachers are reallocated within districts toward schools receiving E-Rate grants. I also find evidence that the pool of college entrance exam takers is affected by E-Rate grants such that relying on average scores could lead to incorrect conclusions.

JEL Codes:J22, L86, I22, H20

Keywords: Education, Internet, Subsidy

I wish to thank the NET Institute for financial support for this project, Chuka Ikokwu and Arun Narayanasamy for valuable research assistance, and Cagatay Koc and David Reiffen for helpful comments.

I. Introduction

The US Telecommunications Act of 1996 primarily codified changes to US telecommunications competition policy. One aspect of the Act that was not related to competition policy, however, was the creation of a $2.25 billion per year fund from which school districts and libraries could hope to recover much of the costs of providing Internet and telecommunications services. This new federal subsidy, called the E-Rate program, was designed to provide larger subsidies to more economically disadvantaged schools where educational resources, including IT infrastructure, are thought to be lowest. In this way, the E-Rate program was meant to help bridge the so-called "digital divide" between the population that has access to and uses computers and the Internet and the population that does not.. Since this divide tends to separate based upon income and racial lines, this could be thought of as a form of a wealth transfer program.

From an economic perspective, such an intervention may be warranted if the current allocation is not welfare maximizing. There are a number of possible distortions that may make the current allocation sub-optimal. First, the distortions from public funding may be such that the marginal benefit from IT investment exceeds marginal costs, especially in low income areas. Second, since future employers may capture a fraction of any increased worker productivity from IT investment, current students under-invest in IT related training. Third, IT investment may generate positive externalities to society due to taxation of future increased income not captured by the current student and future worker. Fourth, better IT related skills in one worker may generate uncaptured "multiplier" effects on others' productivity. Fifth, a better informed populace may enhanced "citizenship" and a preferred future political outcomes. A necessary condition for most of these justifications is that the program enhances educational outcomes.

This study tries to measure the educational outcomes related to implementation of the E-Rate program by tracking performance measures in schools in Texas. From the Texas Educational Agency (TEA) we create a consistent set of data on school characteristics, performance measures, and staffing characteristics for the years 1994-2003. Since the E-Rate program began in 1998, this allows for establishment of a school or district level "baseline" before implementation of the program. Moreover, since not all districts, or schools within a district, received E-Rate subsidies, these data allow for standard difference-in-difference tests of E-Rate subsidies on performance.

Proper interpretation of results must take into account other consequent changes that may affect educational outcomes. First, I find evidence of a reallocation of more experienced teachers to E-Rate subsidy receiving schools from schools not receiving E-Rate subsidies. Second, I find evidence that E-Rate subsidies, perhaps through teacher reallocation, induce more, and more marginal, students into a school's pool of college entrance exam takers. Similarly, in districts receiving E-Rate subsidies, schools that do not receive the funds see a smaller fraction of students taking college entrance exams. Third, overall school average college entrance scores *fall* with E-Rate subsidies. However, inclusion or exclusion of marginal test takers due to E-Rate subsidies accounts for virtually all of any measured change in the average performance of a school's students on these exams.

II. Previous Literature

Educators have largely embraced information technology in the classroom. In recent years, information technology has become an increasing part of general education curriculum. There are now at least two scholarly journals devoted to the study of IT and education, *The Journal of Technology, Learning and Assessment* and *Journal of Research on Technology in Education*. In these journals, education researchers report an overwhelming body of research that finds positive educational outcomes from IT adoption. For example, Goldberg, et al. (2002) reports meta-analysis of 26 studies between 1992 and 2002 of computers effect on student writing that finds both quality improvements and more engaged and motivated students.

Representative studies in this field tend to thoroughly examine a small number of students affected by the adoption of a particular IT program. For example, Gulek and Haken (2003) recently followed 259 middle school students who were given laptop computers for three years and found that positive educational outcomes resulted. O'Dwyer, et al. (2005) use test scores of 986 fourth grade students from 55 classrooms in nine school districts in Massachusetts to find that students who reported greater frequency of technology use at school to edit papers were likely to have higher total English/Language Arts test scores and higher writing scores. They also find out that student's recreational use of technology at home was negatively associated with the learning outcomes.

Economists, however, have not been as successful in finding educational outcome improvements from educational IT. For example, Fuchs and Woessman (2002) and Angrist and Lavy (2002) found no impact, or a negative impact, of computers on educational outcomes after controlling for household characteristics.[1] Puma et al., (2002) and Goolsbee and Guryan

[1]Fuchs and Woessman (2002)'s result that home computers have a negative effect on outcomes appears to confirm the O'Dwyer, et al. (2005) that recreational use lowers learning outcomes.

(forthcoming) find that the E-Rate program increased school district investment in Internet enabled classrooms. However, Goolsbee and Guryan's (forthcoming) examination of two years of E-Rate experience in California finds no evidence of improved educational outcomes from E-Rate subsidies.

There are at least three possible sources for the discrepancies between the findings of educational researchers and economists. First, educational researchers typically study the effects of small isolated IT experiments while economists examine data that implicitly aggregates many such experiments. These experiments could be susceptible to a number of biases including: selecting better performers into the treatment group, selecting students of better teachers into the treatment group, a temporary increased effort on the part of students or teachers in the treatment group, or a "Hawthorn Effect" in which teachers or students in the treatment group exert more effort due to the researchers' evaluation. While some studies are designed to avoid these biases, where they are present, they will tend to bias upward measures of educational success.

Second, the measurement methodologies used differ considerably. For example, economists tend to place great emphasis on methodologies that control for potential omitted variables and selection biases. A common characteristic of these efforts, and one shared by the present study, is to include standardized data from a large number of treatment and control observations. While education researchers' results may be biased, economists' methodologies that attempt to correct for these issues often result in tests of increased power, perhaps too much power to detect the actual effects.

Third, the two groups of researchers may be influenced by different publication and grant funding biases in which education researchers are rewarded for positive findings and economists are not.[2]

III. Background

On May 7, 1997, the Federal Communications Commission (FCC) adopted a Universal Service Order implementing the Telecommunications Act of 1996. The Order was designed to give all eligible schools and libraries affordable access to modern telecommunications and information services by providing up to $2.25 billion annually. The E-Rate program subsidized schools' purchases of computer and Internet technology at a progressively sliding rate that depends on poverty rate at the school and the school's urban/rural status. The subsidy rate ranges from 20 to 90 percent depending on the share of students that qualify for the national school lunch program, which itself depends on the fraction of students are from families with incomes below a specified level. The subsidy can be used for spending on "all commercially available telecommunications services, Internet access, and internal connections." Administrative functions of a library or school may be supported if they are "part of the network of shared services for learning" (Department of Education, 1997). The subsidies do not cover computers, software, or databases because they are not directly related to Internet connections (FCC, 2001). Schools may apply for the program individually or as a school district., however, the data available here is aggregated to the district level.

The E-Rate Program was designed to help schools and libraries gain access to the Internet and other digital technology. As one principal reported, "This program has allowed us to have more and better communications equipment and greater, faster access to the Internet. It has freed

[2]Cite to Friedman on research funding bias.

funds for other activities that would not have been available.” (Puma, et al. (2002)). Schools and libraries approved for the E-Rate Program receive discounts, thereby subsidizing market prices for telecommunication equipment and services. The E-Rate Program supports the acquisition of digital technology infrastructure, including telephone services (basic, long-distance, and wireless); Internet and web site services; and the acquisition and installation of network equipment and services, including wiring in school and library buildings. In the Texas sample used in this study, the breakdown was 67% of subsidy amounts were allocated for internal connections, 28% for telecommunication services and 5% for Internet Access. Other components of an educational technology system—including computer hardware and software, staff training, and electrical upgrades—are not covered under the E-Rate Program.

IV. Methodology and Data

Schools, rather than libraries, receive about 85% or $1.9 billion of the $2.25 billion E-Rate funds dispersed annually. By way of comparison, all federal, state, local and other funding for elementary and secondary education came to $536 billion for 2004-2005. Since this program represents less than half a percentage point increase in school funding, it may be difficult to detect any consequent increase in educational achievement. However, three factors suggest that the actual impact may be detectable. First, these funds are targeted for classroom information and communications technologies which usually represent much less than 5% of a school district’s costs. Second, not all schools receive E-Rate funds and, those that do, may not receive the funds every year. In fact, the average E-Rate grant receiving district in 2003 was awarded about $100 per student in the district, or about 2% of the average expenditure per student in

Texas that year. Third, the E-Rate program is targeted toward economically disadvantaged schools within districts. This subset of all schools will receive a relatively large portion of the funds. Moreover, these schools tend to have lower levels of expenditure per pupil, especially levels of IT expenditures. These factors suggest that receipt of an E-Rate grant could substantially increase a schools IT budget, and even its total education budget.

With these data, it is natural to employ a difference-in-difference estimator to measure the effects of the E-Rate subsidy on educational outcomes. Table 1 suggests how the panel nature of these data lend themselves to a difference-in-difference estimation. Outcome data are available both before and after the implementation of the E-Rate program. Thus, we have a pre-treatment period with which to generate a "baseline," or, more precisely, a school fixed effect. Moreover, not all schools have received the E-Rate subsidy. This cross-sectional variation allows us to compare the change from the baseline between districts and schools that received grants and those that did not.

The estimator also must take into account the likely time series nature of IT on educational attainment and of these grants. IT investment represents a durable good providing a flow of services over a number of years. An educational outcome in any given year could have been affected by grant receipts over the past few years. IT infrastructure may depreciate faster than most durable goods and the effects of these investments are likely to diminish over time. The specification below allows for four years worth of lagged E-Rate subsidies affecting current educational outcomes. Grant receiving districts may receive grants in subsequent years, but also may not. In the data, once grants were available, about half of all grant receiving districts had also received grants the previous year. Even when a district receives a grant in subsequent years, the funds may flow to different schools within the district. Almost 30% of districts never received a grant over the five year period in which they were available. Thus, even among the "treatment group," there is substantial variation in the timing of the treatment. Finally, there could be secular trends in the sample, suggesting year dummy variables.

E-Rate subsidies to one school in a district could lead to a resource shift between schools within that district. If so, we can expect different effects of an E-Rate subsidy to a district on performance at the schools within the district depending on the fraction of low income students. A direct affect of an E-Rate subsidy to a school, all else equal, is hypothesized to increase student performance. An indirect affect might be that a district tends to reallocate other resources across schools because of the subsidy. For example, if there are teacher quality-IT complementarities in an education production function (Bartel and Lichtenberg, 1987; Chun, 2003), a district may optimally reassign better teachers who may have had IT experience in other schools to the lower quality school that now has IT infrastructure. In this case, improvements in performance at a subsidy receiving school will be the sum of the effects from additional IT and from better teachers. Performance in schools not receiving a subsidy would only be affected by the change in teacher quality.

Ideally, one would like to measure the effect of E-Rate dollars per pupil on educational performance. However, E-Rate subsidy data are available at the district level but grants are for specific schools. Districts vary in both the number of schools and in the number of schools included in a grant proposal. Moreover, subsidies are more likely and are larger in schools with a larger fraction of economically disadvantaged schools. Thus, a simple district dollar per pupil suffers both because it will undervalue the treatment to subsidy receiving schools in larger districts and because it assumes equal treatment across all schools in a district. The solution I adopt is to use two E-Rate variables. First, I create a dummy variable equal to one if a district receives an E-Rate subsidy. This is intended to measure any district-wide affects. Second, I interact this dummy variable with the fraction of students at a school who are classified as "economically disadvantaged."[3] Since the size and likelihood of an E-Rate subsidy is roughly proportional to this fraction, this is intended to measure school-specific effects of an E-Rate subsidy.

These consideration lead to a specification,

$$Outcome_{st} = \beta X_{st} + \sum_{\tau=1}^{4} \gamma_{\tau} dSubs_{dt-\tau} + \sum_{\tau=1}^{4} \phi_{\tau} dSubs_{dt-\tau} \frac{LoIncStu_{s}}{Students_{s}} + \varepsilon_{st}$$

where X includes school dummies, year dummies, the fraction of low income students at the school that year, and the square of this fraction. More low income students at a school tends to be negatively associated with student educational performance. Inclusion of these measures would capture any time varying effect above and beyond school fixed effects. To avoid spurious correlation through the time varying fraction of students who are low income, the interaction term with the subsidy dummy variable uses the average fraction of low income students over the sample years. With four lags of variables of interest, the E-Rate dummy variables and their interaction with the fraction of a school's low income students, the full affect of a change occurs over four years and is measured as the sum of the four coefficients.

Outcome measures reflecting student behavior improvements for lower achieving

[3]For the TEA, an "economically disadvantaged student" is defined as one eligible for free or reduced-price lunch or eligible for other public assistance. Thus, this is almost identical to the measure used for calculating E-Rate subsidies.

students include the school's dropout rate and its attendance rate. For higher achieving students, the outcome variables available include average standardized college admissions scores from the ACT and the SAT and a measure of the percentage of test takers scoring above a critical level associated with moderate college admissions standards.[4] To test for resource reallocation within a district, I also examine teacher experience levels both as the percent with more than 10 years experience and the average number of years experience at a school. Teachers with more experience are meant to be a proxy for teacher quality. Finally, we measure the affect of E-Rate subsidies on the fraction taking either the ACT and SAT.

E-Rate data come from the Schools and Libraries reports of the Universal Service Administrative Company (USAC) available on the Internet.[5] Again, Table 1 indicates the frequency at which Texas public school districts received E-Rate subsidies. Educational outcome data come from the Texas Education Agency (TEA) Academic Excellence Indicator System (AEIS) also available on the Internet.[6] The analysis includes only high schools because 1) most of the outcome measures pertain to high school students, 2) IT is disproportionately used in high schools relative to junior high and elementary schools, and 3) students exposed to a subsidy because they attended an "economically disadvantaged" lower level school are likely to attend an "economically disadvantaged" high school and thus be captured by the estimation strategy. By 2004, the TEA had data on 1,667 public high schools of all types in 1,227 Texas

[4]For the ACT, the critical value is 24. For the SAT, the critical value is 1110. Thus, the measure is the percentage of students taking either exam takers who scored above these values on either exam.

[5]See <http://www.sl.universalservice.org/>.

[6]See <http://www.tea.state.tx.us/perfreport/aeis/>.

public school districts.[7] The match rate between the TEA and E-Rate data was above 98%. Not all high schools reported valid values for all variables of interest. Table 2 provides some summary statistics for the outcome variables used in the analyses.

The fraction of students who are low income factors prominently into the analysis. Table 3 demonstrates how the outcome measures differ across schools with this measure of student income. There is a nearly monotonic decline in a school's student outcomes and teacher experience as the fraction of low income students rises. The college entrance exam scores, in particular, show a dramatic decline with the percent of low income students. These differences in outcomes suggest differences in educational opportunities and thus are, no doubt, an impetus to an income based subsidy program, such as the E-Rate program. However, the education of one's children is very likely a normal good. Some differences in outcomes would emerge even educational opportunities were identical across all schools.

V. Results

Estimation results for dropout and attendance rates, two student behavior measures associated with low performing students, are presented in Table 4. While training with IT is generally considered to be associated with higher skilled careers associated with higher performing students, it may be that additional IT in a school could enhance performance of lower performing students. Unfortunately, a consistent time series of standardized test scores does not

[7]In 2004, there were 153 districts with no high schools, 815 with one high school, 171 with two high schools, 31 with three high schools and fewer than 70 with more than three high schools.

exist.[8] These two measures are indicators associated with low performers staying in school which is related to improved performance. The F-Statistic for the E-Rate dummies in Table 3 indicates no overall change in high school dropout rates in districts receiving E-Rate subsidies, though one of the individual coefficients is positive and significant at the 10% level. The F-Statistic for the interaction terms suggests that E-Rate subsidies may lower dropout rates in schools receiving E-Rate subsidies by 07-0.8 percentage points for schools where all students are catagorized as "economically disadvantaged." In contrast, E-Rate subsidies appear to have no effect on attendance rates.

Estimates for college admission scores are reported in Table 5. The results are fairly consistent across all three measures. District wide, E-Rate subsidies have a small positive effect on test scores but these are only statistically significant for one measure and that one is at the ten percent level. However, at the campus level, E-Rate subsidies have a clear negative effect on average test-taker performance. A school where all students are low income would see ACT test scores fall by 0.6 points (-0.769+0.165), SAT scores fall by 31 points (-38.088+7.230) and the fraction meeting minimum college admission standards fall by 5.3 percentage points (-7.367+2.046). This would appear to indicate that E-Rate subsidies to a school not only do not improve student performance, but instead worsen student performance.

Before we conclude negative marginal productivity from the E-Rate subsidy program, it is worthwhile investigating alternative hypotheses. First, as alluded to above, non-IT educational

[8] Texas changed standardized test instruments at precisely the time that E-Rate subsidies became available prior to 1999 each student in third, fifth, eighth and twelfth grade were required to take the Texas Assessment of Academic Skills (TAAS) and afterward the Texas Assessment of Knowledge and Skills) (TAKS). Education officials caution against making comparisons between the results from the two.

resources may be reallocated within the district. It may be that E-Rate subsidies to a school cause administrators to assign lower quality teachers to this school. In this case, the lower test scores may be related to the lower quality teachers and not necessarily to the subsidy program. On the other hand, these results are not consistent with higher quality teachers being reassigned from schools not receiving a subsidy to those that do. Second, the average quality of a test taker may have fallen. If implementation of the E-Rate resulted in more students considering college, then more students from subsidy receiving schools are likely to be taking the college entrance exams. These additional test takers are likely to by marginal performers relative to the group that would have taken the test without the E-Rate subsidy. If so, average test performance may fall simply because more students are trying to succeed.

Estimates for teacher experience are reported in Table 6. More experienced teachers are used as a proxy for higher quality teachers. The pattern for both the fraction with more than ten years experience and for the average number of years of experience are similar. District-wide, E-Rate subsidies are associated with less experienced teachers while at the school level, E-Rate subsidies are associated with more experienced teachers. A school with no low income students would see 3% fewer teachers with more than 10 years experience and average experience levels fall by about half a year. A school with all low income students would see 3.5% (6.55%-3.01%) more teachers with more than 10 years experience and average experience levels rise by about three-fifths of a year (1.11-0.52). This is consistent with a reallocation of high quality teachers toward E-Rate receiving schools.

Estimates for the percent of students taking the ACT or SAT are also reported in Table 6. These results indicate negative but insignificant district-wide affect on the percent taking these tests but a positive school-level affect on the fraction taking the test. A school where all students are low income would increase its percentage of students taking these tests by 2.5% (3.61%-1.10%). This finding is consistent with either Internet connections or teacher quality generating more test takers. In schools not receiving E-Rate subsidies, fewer students take these exams and the average rises. In like manner, at schools with more low income students, E-Rate subsidies induce more of the marginal students to take the exams and have generated a lower quality pool that performed worse on average.

Controlling for the propensity to take college entrance exams, these estimates indicate virtually no change in the percentage of students in a high school whose college entrance exam scores meet a minimum standard due to the E-Rate subsidy. This percentage is the product of the percentage taking the exams and the percentage of exam takers who scored at a critical value. From Table 3, for an average school with no low income students, these percentages are approximately 25.8% and 58.9% resulting in 15.2% of students in the school passing. With the district-wide E-Rate effects from Tables 5 and 6 these become 26.3% and 57.8% resulting in the same 15.2% students in the school passing post E-Rate subsidy. For an average school with all low income students, these percentages are approximately 5.2% exam takers passing and 40.4% of students taking for 2.1% of students in the school passing without the E-Rate subsidy. With an E-Rate subsidy, these values become approximately 4.9% exam takers passing and 42.9% of students taking resulting in the same 2.1% of students passing without the E-Rate subsidy. Thus, the more than sevenfold difference across these groups remains virtually unchanged. These results suggest that it is likely that there was little if any change in average ACT and SAT scores for a comparable group of test takers pre- and post-E-Rate subsidy.

VI. Conclusion

At $2.25 billion per year, the E-Rate subsidy program is a large intervention into primary education. As such, it merits asking the question whether there are identifiable returns to this investment. Since it is directed at specific IT investments, it merits asking whether this is the best allocation for these educational expenditures. Finally, since the program is directed toward improving student attainment in low income areas, it merits asking whether any improvements come at a cost to performance in higher income areas. This study attempts to answer some of these questions using ten years worth of outcome data from Texas public schools that spans the inception of the program. In general, I find modest, if any, improvements in educational attainment due to the E-Rate program. Only the dropout rate unambiguously fell. A school's average college entrance exam scores actually fall due to the E-Rate program. After controlling for effects on teacher experience and selection into who takes college entrance exams, I find evidence of that student performance on these exams is unaffected..

Two findings suggest a reconciliation between the overall differences in findings between economists and educational researchers. First, there appears to be a resource reallocation of more experienced teachers from relatively higher income schools not receiving an E-Rate subsidy toward relatively lower income schools receiving an E-Rate subsidy. Second, E-Rate subsidies, perhaps through the more experienced teachers, appears to induce more students to take college entrance exams. The additional students appear to be of lower ability than otherwise, causing average scores of *examinees* to fall even though the fraction *students* meeting a minimum standard remains unchanged. Educational researchers examining the introduction of IT into a classroom, may be measuring improvements properly associated with increased teacher quality.

Economists examining average exam statistics may not have always controlled for selection in to the pool of test takers.

These results suggests directions for future work. First, the distinct findings of this study regard the reallocation of experienced teachers and the selection of test takers. These results will need confirmation before they are accepted unambiguously. Second, other measures of educational success may yield hidden benefits. The existing measures are usually associated with "college-bound" students from wealthier families who are likely to have IT access at home. Measures associated with lower or average ability students or students from households without IT access are more likely to reveal benefits. Third, measures associated with post-secondary education may reveal enhanced success in the labor market or in college careers despite lack of improvements in secondary school achievements. Finally, this study confirms economists' prior findings of a lack of benefits from IT in primary education. While one might hypothesize that the benefits are small relative to the costs, the absence of any benefits, especially in light of the education researchers' findings, remains a puzzle.

REFERENCES

Angrist, Joshua and Victor Levy (2002). "New Evidence on Classroom Computers and Pupil Learning." *The Economic Journal*, 112, p735-65.

Bartel, Ann P. and Frank R. Lichtenberg (1987), "The Comparative Advantage of Educated Workers in Implementing New Technology," *The Review of Economics and Statistics*, 69(1)., 1-11.

Chun, Hyunbae (2003) "Information technology and the demand for educated workers: Disentangling the impacts of adoption versus use" *The Review of Economics and Statistics*, 85 (1): 1-8.

O'Dwyer, Laura M., Michael Russel, Damien Bebell, & Kevon R. Tucker-Seeley (2005) "Examining the Relationship Between Home and School Computer Use and Students' English/Language Arts Test Scores," *The Journal of Technology, Learning, and Assessment*, 3(3)

Funding Commitment Data. 6 Dec. 2004. The Universal Service Administrative Company. 6 Dec. 2004 <http://www.sl.universalservice.org/funding/previous.asp>.

Goldberg, A., Russell, M., & Cook, A (2003). "The Effect of Computers on Student Writing: A Meta-analysis of studies from 1992 to 2002." *Journal of Technology, Learning, and Assessment*, 2(1).

Goolsbee, Austan and Jonathan Guryan (forthcoming) "The Impact of Internet Subsidies in Public Schools," *Review of Economics and Statistics*.

Gulek, James Cengiz and Hakan Demirtas (2004), "Learning With Technology: The Impact of Laptop Use on Student Achievement,"*Journal of Technology, Learning, and Assessment*, 3(2).

Puma, Michael E., Duncan Chaplin, Kristin Olson, Amy Pandjiris, “The Integrated Studies of Educational Technology: A Formative Evaluation of the E-Rate Program.” *Washington (D.C.) Urban Journal*, 10 Oct. 2002. <http://www.urban.org/UploadedPDF/410579_ERateFinalReport.pdf>

Puma, Michael E., Duncan Chaplin, Andreas D. Pape, *E-Rate Program and the Digital Divide: A Preliminary Analysis from the Integrated Studies of Educational Technology*. The Urban Institute, Washington, D.C. Sept., 2000. <http://www.urban.org/UploadedPDF/410385_Standards.pdf>

Table 1
E-Rate Summary Statistics

Year	Number of Districts: Non-Grant Recipients	Number of Districts: Grant Recipients	Award Amount per Student: All Districts	Award Amount per Student: Grant Receiving Districts
1995	1,045	0		
1996	1,059	0		
1997	1,059	0		
1998	1,061	0		
1999	604	499	\$30.27	\$66.93
2000	467	716	\$33.49	\$55.32
2001	465	735	\$53.86	\$87.99
2002	432	789	\$70.29	\$108.83
2003	435	789	\$67.42	\$104.59

Table 2
Summary Statistics

Variable	Valid Observations	Mean	Standard Deviation	Minimum	Maximum
Dropout Rate	13,913	2.22%	4.07%	0.0%	78.9%
Attendance Rate	15,019	92.82%	5.78%	10.9%	100.0%
Average ACT Score	8,603	19.77	1.83	12.2	26.7
Average SAT Score	7,518	939.17	97.62	548	1,296
SAT/ACT Min. Std.	9,530	19.28%	13.27%	0.0%	100.0%
Pct. Students Taking ACT or SAT	9,298	54.95%	26.10%	0.0%	100.0%
Pct. Teachers with > 10 years Exp.	14,683	49.82%	16.98%	0.0%	100.0%
Avg. Teacher Exp.	14,656	12.43	3.44	0.0	44
Fraction of Students "Econ. Disadvant."	15,221	0.397	0.239	0.0	1.0

Table 3
Descriptive Statistics by
Fraction of Students Who are Low Income

	Percent of Students "Economically Disadvantaged"			
	0-25%	25-50%	50-75%	75-100%
Pct. of High Schools	30.48%	39.01%	20.13%	10.38%
Dropout Rate	2.19%	1.85%	2.34%	3.53%
Attendance Rate	93.35%	93.52%	91.93%	90.29%
Average ACT Score	20.90	19.77	18.53	17.05
Average SAT Score	981.35	942.07	867.83	830.75
SAT/ACT Min. Std.	25.75%	18.47%	11.94%	5.20%
Pct. Students Taking ACT or SAT	58.93%	57.38%	49.12%	40.36%
Pct. Teachers with > 10 years Exp.	51.59%	51.00%	47.82%	43.71%
Avg. Teacher Exp.	12.64	12.66	12.15	11.44

Table 4
Affect of E-Rate Subsidy on Student Behaviors

	Dropout Rate		Attendance Rate	
	Coef.	s.e.	Coef.	s.e.
E-Rate Dummy for t-1	-0.259	(0.159)	-0.026	(0.132)
E-Rate Dummy for t-2	0.322+	(0.191)	0.061	(0.153)
E-Rate Dummy for t-3	0.011	(0.212)	-0.260	(0.161)
E-Rate Dummy for t-4	0.018	(0.220)	0.190	(0.158)
Low Income Fraction x E-Rate Dummy for t-1	0.491	(0.340)	-0.111	(0.285)
Low Income Fraction x E-Rate Dummy for t-2	-1.075*	(0.410)	-0.198	(0.335)
Low Income Fraction x E-Rate Dummy for t-3	-0.160	(0.449)	0.553	(0.349)
Low Income Fraction x E-Rate Dummy for t-4	-0.086	(0.454)	-0.297	(0.332)
Low Income Fraction	0.013	(0.008)	-0.029*	(0.007)
Low Income Fraction Squared x 100	-0.030*	(0.008)	0.040*	(0.007)
		F-Stat		F-Stat
Sum E-Rate Dummies	0.092	0.15	-0.035	0.04
Sum Interactions	-0.829+	4.20	-0.053	0.03
Observations	13,913		15,019	
High Schools	2,030		2,050	
Within R^2	0.070		0.043	
Between R^2	0.002		0.014	
Overall R^2	0.005		0.004	

This table reports results from a fixed effects panel estimator. Coefficient estimates of year dummy variables are not reported. Statistical significance is indicated by an asterisk for one percent level and by a plus sign for the ten percent level.

Table 5
Affect of E-Rate Subsidy on Student Performance

	Average ACT Score		Average SAT Score		Percent Scoring > Col. Admit. Std.	
	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
E-Rate Dummy for t-1	0.101	(0.073)	4.248	(3.082)	1.072+	(0.536)
E-Rate Dummy for t-2	-0.005	(0.094)	4.132	(3.965)	0.897	(0.694)
E-Rate Dummy for t-3	0.029	(0.124)	4.820	(5.268)	0.426	(0.918)
E-Rate Dummy for t-4	0.039	(0.141)	-5.969	(6.026)	-0.349	(1.046)
Low Income Fraction x E-Rate Dummy for t-1	-0.177	(0.158)	-10.171	(6.887)	-3.226*	(1.165)
Low Income Fraction x E-Rate Dummy for t-2	-0.148	(0.204)	-16.639+	(8.826)	-2.451	(1.503)
Low Income Fraction x E-Rate Dummy for t-3	-0.087	(0.250)	-7.937	(10.839)	-1.442	(1.846)
Low Income Fraction x E-Rate Dummy for t-4	-0.358	(0.275)	-3.341	(11.973)	-0.248	(2.033)
Low Income Fraction	-0.015*	(0.006)	-0.561+	(0.237)	-0.057+	(0.039)
Low Income Fraction Squared x 100	0.008	(0.006)	0.244	(0.250)	0.000	(0.041)
		F-Stat		F-Stat		F-Stat
Sum E-Rate Dummies	0.165	1.73	7.230	1.79	2.046+	4.95
Sum Interactions	-0.769*	10.98	-38.088*	14.19	-7.367*	18.69
Observations	8,603		7,518		9,530	
High Schools	1,220		1,144		1,374	
Within R^2	0.008		0.574		0.138	
Between R^2	0.473		0.202		0.470	
Overall R^2	0.357		0.302		0.218	

This table reports results from a fixed effects panel estimator. Coefficient estimates of year dummy variables are not reported. Statistical significance is indicated by an asterisk for one percent level and by a plus sign for the ten percent level.

Table 6
Affect of E-Rate Subsidy on Teacher Experience and
the Students Taking College Entrance Exams

	Percent Teachers with > 10 Years Exp.		Average Years of Teacher Exp.		Percent Taking SAT/ACT Exams	
	Coef.	s.e.	Coef.	s.e.	Coef.	s.e.
E-Rate Dummy for t-1	-0.250	(0.554)	-0.098	(0.104)	-0.163	(0.707)
E-Rate Dummy for t-2	-1.796*	(0.641)	-0.360*	(0.121)	1.843+	(0.888)
E-Rate Dummy for t-3	-1.131+	(0.672)	-0.036	(0.127)	-1.206	(1.175)
E-Rate Dummy for t-4	0.172	(0.659)	-0.028	(0.124)	-1.583	(1.325)
Low Income Fraction x E-Rate Dummy for t-1	0.541	(1.199)	0.323	(0.226)	0.117	(1.500)
Low Income Fraction x E-Rate Dummy for t-2	4.234*	(1.404)	0.825*	(0.265)	-2.932	(1.868)
Low Income Fraction x E-Rate Dummy for t-3	2.543+	(1.461)	0.089	(0.275)	4.438+	(2.322)
Low Income Fraction x E-Rate Dummy for t-4	-0.770	(1.390)	-0.127	(0.262)	1.989	(2.546)
Low Income Fraction	-0.135*	(0.029)	-0.006	(0.006)	0.025	(0.045)
Low Income Fraction Squared x 100	0.084*	(0.030)	0.002	(0.006)	-0.001	(0.046)
		F-Stat		F-Stat		F-Stat
Sum E-Rate Dummies	-3.01*	17.17	-0.52*	14.72	-1.10	0.82
Sum Interactions	6.55*	27.86	1.11*	22.60	3.61+	2.71
Observations	14,683		14,656		9,298	
High Schools	1,959		1,955		1,606	
Within R^2	0.009		0.044		0.015	
Between R^2	0.001		0.047		0.000	
Overall R^2	0.002		0.001		0.000	

This table reports results from a fixed effects panel estimator. Coefficient estimates of year dummy variables are not reported. Statistical significance is indicated by an asterisk for one percent level and by a plus sign for the ten percent level.