The Negative Effect of Residential Broadband Availability on Educational Attainment in the US

Polly Kang

Undergraduate Honors Thesis

Duke University

Durham, NC

December 2011

Professor Jacob Vigdor, Faculty Advisor

Acknowledgments

I am especially grateful to Professor Jacob Vigdor, Professor Judith Kelley, and Professor Michelle Connolly for their constant support, patience, and sound advice throughout the research and writing process. I also feel very lucky to have Gary Thompson for his invaluable computer help. Last but not least, I would like to thank my family and friends for energizing me with their enduring love and support.

Abstract

A student's decision to drop out of high school has repercussions for the individual and society. Broadband availability, which has become ubiquitous in the US since the late 1990s, can dramatically affect a student's willingness to attend school. This study attempts to understand how broadband availability affects a student's disengagement from school, which may lead to dropping out. I use data from two sources: the American Community Survey (ACS) regarding school enrollment and educational attainment on an individual level, and Federal Communication Commission (FCC) information on broadband availability. By using an application of difference-in-difference (DID) modeling and fixed effects, I compare trends in dropout behavior between areas that received full service by 2000 and those that acquired it in later years. The introduction of broadband correlates positively with an individual's dropout choice. However, there are threats to causal interpretation.

Introduction

High school dropout rates have been an enduring concern among policymakers and researchers. Even though many studies suggest dropping out has negative ramifications for both the individual and the society, dropout rates are still very high (Oreopoulos, 2007; The White House, 2010; Tyler & Lofstrom, 2009). This reconfirms the inability of adolescents to weigh the long-term benefits and short-term costs of attaining a high school diploma (Sowell, Thompson, Holmes, Jernigan, & Toga, 1999).

The government has provided funding to broaden the reach of computer and broadband availability based on the assumption that technology leads to positive impacts on student achievement. An example of this initiative is the federal E-Rate program, which allocated up to $2.25 billion annually to increase the access of computer and internet in public schools and libraries. However, there is presently no clear theoretical prediction regarding whether or not home computers are likely to have a negative or positive effect on student performance. Furthermore, there is very little scholarly attention on the effects of technology on educational attainment or high school dropout rates rather than student performance.

Broadband could have either positive or negative impacts on a student's level of disengagement from school. Broadband can provide ways to make assignments easier and encourage students to stay in school (Cuban, 2001; Peck, Cuban, & Kirkpatrick, 2002). However, it also gives adolescents new ways to waste time (Giacquinta, Bauer, & Levin, 1993; Stoll, 1995).

Based on previous literature, broadband most likely is harmful to educational attainment. Previous studies demonstrate varying results in terms of the effect of technology on student performance. However, the studies with the most convincing methodologies yield results that suggest that the impact of either computers or broadband tends to be harmful to student achievement (Vigdor & Ladd, 2010; Malamud & Pop-Eleches, 2008; Goolsbee & Guryan, 2006).

This study utilizes data from the American Community Survey (ACS), and data from the Federal Communication Commission (FCC). The ACS data regarding school enrollment and educational attainment allow the observation of eighteen and nineteen year olds' dropout choices in the US. The FCC data allow the comparison of regions that adopted full broadband availability in 2000 to those that did so in later years. In this study, the regions are defined at a regional level with each area including about 500,000 people.[1]

To estimate the impacts of residential broadband on dropout rates, this study uses an application of difference-in-difference (DID) design. The DID method utilizes the staggered timing and differing coverage amounts of broadband availability. This analysis allows us to compare trends of an individual's decision to drop out in two types of areas: those with full broadband availability from 2000 and those that gain complete coverage in later years. The DID uses a control group to subtract out other changes that occur simultaneously with the treatment. This is a valid analysis as long as other changes remain identical between the treatment and control groups.

Omitted variable bias can potentially create misleading associations between broadband availability and educational attainment. An omitted variable bias occurs to the

[1] These regions are called Public Use Microdata Areas, or pumas, another way to subdivide geographic regions, similar to a zip code. A little over 10,000 people populate a typical zip code.

extent that the dependent and independent variables in the regression are correlated to the omitted ones. Some examples of potentially problematic omitted variables are measures of wealth and parental educational attainment.

My findings indicate that broadband availability is positively correlated to an individual's decision to drop out. The perceived benefits of broadband were mostly contributed by year and region level changes. The failure to control for fixed effects can lead to misleading results. Although this study demonstrates strong correlations, there are threats to causal interpretation.

This paper is divided into eight sections. Section II gives a background of the long-term consequences of a student's decision to drop out of high school and the potential impacts of broadband on educational attainment. Section III discusses the theoretical model and how this study furthers previous research. The next section briefly summarizes the previous literature. Section V describes the data. Section VI is the methodology section, which includes a detailed explanation of the empirical strategy. Section VII presents the results of the study and broadband availability's impact on an individual's decision to drop out. The final section concludes the paper with a discussion on future directions.

Background

The Individual and Societal Impacts of a High School Student's Decision to Dropout

High school dropouts have become a large problem in the United States. In 2009, President Obama summarized the scope of the problem in the following statement,

> Every school day, about 7,000 students decide to drop out of school—a total of 1.2 million students each year—and only about 70% of entering high school freshman graduate every year. Without a high school diploma, young people are less likely to succeed in the workforce. Each year, our nation loses $319 billion in potential earnings associated with the dropout crisis. (The White House, 2010)

A student's decision to drop out of high school has both individual and social costs, and yet, many students make the detrimental decision. Tyler and Lofstrom (2009) give a very detailed account of some consequences caused by dropping out. Some of the "individual costs include lower earnings, higher likelihood of unemployment, and greater likelihood of health problems" (Tyler & Lofstrom, 2009, p. 86). To give an example of individual monetary impacts, in 2006, the difference between average annual earnings of a woman with and without a high school diploma was $8896 (Tyler & Lofstrom, 2009). They also outline some of the societal costs, which "include loss of tax revenue, higher spending on public assistance, and higher crime rates" (Tyler & Lofstrom, 2009, p. 87).[2] However, a

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[2] An important question to address before moving forward is: which individuals are considered to be high school graduates? Some count General Educational Development (GED) attainment as a proxy for high school graduation. For example, data from the National Center for Education Statistics (NCES) include individuals who earn GED credentials as "completers" (Tyler & Lofstrom, 2009). The focus of this study is not on graduation rates or years of educational attainment for two main reasons. First, the implications of attaining a high school diploma are very different from that of acquiring a GED. Furthermore, the economic impacts associated with GEDs are not immediate and only help those "who leave school with very low skills" (Tyler, 2003, pg. 379). Secondly, GED holders do not tend to pursue postsecondary education or on-the-job training (Tyler, 2003). Moreover, determining a universal definition of "graduate" is very difficult because there is no universal cutoff age. At what age can we say that people are

cross-sectional comparison is an unreliable way to assess the causal costs of dropping out. Although dropping out may have a positive correlation with individual and societal costs, it is difficult to measure causation accurately because the students likely to drop out are predisposed to bad outcomes. Oreopoulos (2007) reliably demonstrates the importance and economic returns of a high school education by including students who are both likely and unlikely to drop out in his sample. He implements the change to compulsory schooling laws to identify the marginal benefit of staying in school longer. He finds that "one year of compulsory schooling increases average lifetime spending by 15%" (Oreopoulos, 2007, pg. 2214).

General Trends in Broadband Availability

Although disparities in school computer access have become largely eliminated, the problem still persists in homes. Since the late 1990s, broadband availability has become ubiquitous in the US. The mean percentage of broadband availability in each region increased from 95.8% in 2000, to 99.89% in 2007. An average subdivided area without complete availability in 2000 still has a high level of coverage, 89.9%. The residential areas that have complete availability maintained it, while others with limited availability acquired it in the following years. Because the timing of broadband availability is staggered and incremental across different regions, this study can compare trends of dropout decisions in areas with full broadband acquisition by 2000 to the areas that acquired it in later years.

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unlikely to pursue education or a GED? Given the difficulties of defining "graduate," the variable of interest in this study is "dropout," an individual's dropout choice.

Theoretical Model

Assuming that high school students are rational actors, technology can potentially increase these individuals' future living standards, such as increased lifetime spending. A rational student should take advantage of activities, such as research, made relatively less costly by the introduction of broadband and stay in school longer or perform better. As discussed above, high school graduation is attributed to higher standards of living, so technology should have a positive impact on a student's life. However, broadband availability can also introduce non-productive activities that students prefer, such as playing games and participating in chat rooms and social networking sites. The following describes how a teenager may make his time allocation decision.

Dropping out: The Decision Calculus of an Adolescent

A high school student's maximization problem is one of allocating time and money in a bundle of activities A, which provides the highest utility U. Whether or not it provides positive or negative utility for a high school student, engaging in an activity has both temporal costs T and monetary costs P. Each activity may or may not have a direct impact on a student's future living standards S. For example, the discussion above demonstrates how a high school diploma may add to a student's future living standard. A rational actor considers future living standards as a value that generates utility. Therefore, a student's utility can be written as:

(1) $U= U(A, S(A))$

These costs are restrained by both time and budget constraints, where they can be written as:

(2) $PA \leq Y$

(3) $TA \leq M$

where Y is income and M is available time. Given this framework, the introduction of home broadband availability affects the temporal and monetary costs associated with activities.

Adolescents most likely ignore the future consequences of dropping out because they are "predisposed to myopic behavior" and likely underestimate expected returns from educational attainment (Oreopoulos, 2007, pg. 2214). A teenager is not a rational actor and is prone to making irrational decisions. Given this assumption, adolescents are basing their decisions on immediate benefits of dropping out, such as working to make money, rather than dealing with the burdens of graduating high school, such as time spent attending classes and completing assignments. Furthermore, present value is always greater than future value. The utility gained immediately from activities such as online gaming can outweigh the utility to be gained in the future from education. This raises yet another question—what are these immediate costs that make educational attainment so unattractive to high school students? Are they related to the rise of broadband? In order to address these questions, we must examine how broadband may affect the immediate factors in an adolescent's decision calculus.

Theoretically, broadband can either increase or decrease school disengagement. Students who tend to dropout feel disengaged from school (Oreopoulos, 2007; Lilliard & DeCicca, 2001). Broadband availability makes completing homework assignments much easier, which decreases the monetary and temporal costs of completion (Lenhart, Simon, & Graziano, 2001; Cuban, 2001; Peck, et al., 2002). Students can now easily explore a wide variety of subjects in depth if they so desire. Because the marginal cost of creating a more interesting curriculum is also lower for teachers, they can potentially better engage students by effectively using technology in classrooms or requiring student use of technology in interactive ways. Broadband can even lead to more parental engagement to prevent a student's decision to substitute productive activity with non-productive ones. Teenagers with concerned parents can outsource their decision making because they are unable to make rational choices.

However, broadband can also be an underlying factor of school disengagement by providing distractions, such as games, chatting, email, and social networking (Giacquinta et al., 1993; Stoll, 1995). Family characteristics like parental involvement, family stability, parental education, and socioeconomic status (SES) are important contributions to an individual's educational attainment. With the introduction of broadband, parental monitoring becomes even more important. Furthermore, teachers may now have higher standards for their students precisely because of the benefits of broadband (Lillard & DeCicca, 2001). As discussed above, schoolwork becomes relatively less costly in terms of money and time. Higher standards can negatively impact students who already perform poorly. This is because students who tend to drop out are poor performers, exhibiting low scores, failed classes, and grade retention—or have early adult responsibilities that require leaving school—such as teen pregnancies (Tyler & Lofstrom, 2009). An examination of the empirical evidence is necessary because this theoretical model does not help to make a prediction regarding the sign or magnitude of the impact broadband availability may have on the decision to drop out.

Previous Literature

Although the specific association between broadband availability and an individual's dropout decision has not been examined in past research, numerous studies have been conducted on either computer or internet use in both home and school settings with varying conclusions. Believing in the positive impacts of computers and broadband on student achievement, policymakers are concerned about leaving the lower SES students behind—widening the digital gap. For example, the FCC conducted a Federal E-Rate program, demonstrating significant commitment to using public funds to increase access to computers and internet, despite the fact that there is no scholarly consensus for their assumptions.[3]

Several studies on the impact of computer and broadband use in school settings demonstrate mixed results (Wenglinsky, 1998; Peck, Cuban, & Kirkpatrick, 2002; Valadez & Duran, 2007; Goolsbee & Guryan, 2006; Vigdor & Ladd, 2010). Goolsbee and Guryan (2006) and Valadez and Duran (2007) demonstrate that computer use in schools does not always result in a positive instructional or learning outcome. Wenglinsky (1998) and Peck et. al (2002) demonstrate positive correlations between computer use in school settings and student achievement. However, many of these studies have confounding variables because of the instructional context of technology use (Wenglinsky 1998; Becker and Center 1999; Peck, Cuban et al. 2002; Valadez and Duran 2007). Furthermore, only two studies examine broadband (Valadez & Duran, 2007;

[3] Annually, the Federal E-Rate program allocated up to $2.25 billion to improve internet access in public schools and libraries. This program was authorized as part of the Telecommunications Act of 1996.

Vigdor & Ladd, 2010).[4] Goolsbee and Guryan (2006) employ a reliable research design, DID analysis, and demonstrate that school computer use has very little to negative impact on student performance. They focus on high school students in California, using data from the Current Population Survey (CPS) of October 2003 and the Stanford Achievement Test. Student achievement—measured as the increase in test scores—demonstrates no significant difference between schools that received varying amounts of subsidies.

Literature on the impact of home computer and internet access also demonstrates mixed results (Attewell & Battle, 1999; Fairlie, Beltran, & Das, 2010; Jackson, von Eye, Biocca, Barbatsis, Zhao, & Fitzgerald, 2006; Fiorini 2009; Becker and Center 1999. Malamud & Pop-Eleches, 2008; Fairlie & London, 2009; Wenglinsky, 1998; Valadez & Duran, 2007; Vigdor & Ladd, 2010).[5] Although only three of these studies examine the effect of broadband on education, the results remain inconsistent (Vigdor & Ladd, 2010; Valadez & Duran, 2007; Jackson et al., 2006).[6] Malamud and Pop-Eleches (2008) implement a noteworthy regression discontinuity design, an effective methodology to address omitted variable bias. It allows for the comparison between pre- and post-treatment, which in this case was access to computers, and holds constant the unobservable variables correlated to the error term. They demonstrate the negative

[4] Only Valadez and Duran (2007) study both broadband and computer use in both home and school settings. Vigdor and Ladd (2010) examines both broadband and computer use in the home.

[5] Malamud and Pop-Eleches (2008), Valadez and Duran (2007), Beltran et al. (2006), Attewell and Battle (1999), and Fairlie and London (2006) study the impact of computers in home settings. Only Malamud and Pop-Eleches (2008) and Valadez and Duran (2007) do not find a positive correlation between home computer use and student performance.

[6] Jackson et al. (2006), Valadez and Duran (2007) and Vigdor and Ladd (2010) study the impact of home broadband on student achievement and find conflicting results. Jackson et. al (2007) finds positive correlations.

impact of home computer access on student achievement. However, Malamud and Pop-Eleches (2008) study computers, not broadband, and may have limited insights for the US because they took advantage of a very specific educational reform in Romania that granted computers to low-income families.

The only study that examines the impact of home broadband access on performance demonstrates negative effects (Vigdor & Ladd, 2010).[7] Vigdor and Ladd (2010) find that broadband is differentially harmful and widens the achievement gap. They use metrics of student achievement in terms of math and reading test scores as dependent variables. Their subjects are students in grades five through eight in North Carolina between April 2000 and April 2005. Compared to a sample of older adolescents, this age group may demonstrate a more rational decision calculus by outsourcing some of their decision-making to parents. Their dataset comes from both the FCC and North Carolina. North Carolina middle schools provide information on end-of-grade test scores. These data come from the end-of-year questionnaire results required by all North Carolina middle schools. The data include self-reported information such as time spent on homework and frequency of home computer and internet use for studying. They utilize FCC data to determine whether a zip code has no service, between one and three service providers, or greater than four providers on a yearly basis. They use broadband service availability, rather than access, to mitigate self- selection bias in models and effectively compare students in areas that transition from no broadband to having it. This is primarily because address-level matching is infeasible. This methodology requires the assumption that the unobserved, confounding factors do not vary enough to affect the

[7] Within this study, Vigdor and Ladd (2010) also conduct a longitudinal, within student analysis for home computer use.

dependent variable, relative to the treatment variable—home broadband availability. However, this assumption also implies that computer purchases do not correlate with broader changes to the household. For example, the model cannot capture the impacts of a low SES family that acquires broadband due to a positive income shock. This implies an understatement of the impacts of computer access.

While there are many general studies on technology and student achievement, the insights on home broadband availability, educational attainment, or high school students are quite limited. Although no studies address the specific question of broadband availability on high school dropout rates, previous literature suggests that broadband most likely has a negative effect on student performance and therefore educational attainment. A sound research design mainly concerns controlling for nonrandom selection biases of broadband availability and other unobservable variables affecting both availability and educational attainment.

Data

This study relies on a principal dataset that combines two datasets provided by the ACS and the FCC[8]. For each respondent, the ACS collects individual level data on basic socioeconomic characteristics such as age, sex, race, family and relationships, disabilities, income and benefits, health insurance, education, and veteran status in order to determine how to allocate state and federal funds each year. The ACS also collects information that is crucial for this study pertaining to educational attainment and current school enrollment. The sample only includes data from years 2000, 2006, and 2007 because of limitations in the ACS dataset. This analysis is limited to students who are either eighteen or nineteen years old, based on the assumption that individuals have made their dropout decision by this age. Table 1 presents summary statistics including the racial composition of the sample.

Because the ACS alone does not provide any information on broadband access, the FCC data are crucial to this study. The FCC regulates telecommunication industries throughout the United States. The FCC provides information on the number of broadband service providers, ISPs, with at least one subscriber in the zip code at the end of each year. Since the end of 1999, the FCC requires broadband service providers to submit data regarding the number of subscribers. About 67.74% of the subdivided regions have complete broadband availability since 2000. The mean availability in those areas with limited coverage is 89.9%. However, if there are less than or equal to 3

[8] The FCC provides zip code level data while the ACS provides puma level data. Therefore, Geocorr is necessary to facilitate orienting all of the data into puma level data. Geocorr, a geographical correspondence engine, provides information on which zip codes correspond to each puma.

service providers in the area, the FCC does not present the actual number of providers available in order to protect confidentiality. Therefore, this study assumes that an area has complete availability with at least one service provider, which greatly overestimates usage.

Using a metric of availability rather than access includes both households that are and are not subscribed to broadband, which helps to mitigate self-selection biases. Broadband availability is the outcome of the provider's choice, not the subscriber or household. The decision of a household to subscribe to broadband may have direct or indirect impacts on educational attainment. Household decisions are much more likely to correlate with unobserved determinants of dropout than the decisions of broadband service providers. The validity of this argument is contingent upon broadband availability having no correlation with factors that influence educational attainment, while broadband access does.

Methodology

The main methodological challenge of this study is omitted variable bias. Coefficients of the independent variables absorb the effects of the omitted ones to the extent that the omitted variables are correlated with the dependent and independent variables. Some examples of omitted variable bias are measures of wealth and parental education. These variables may decrease the decision of dropping out directly or indirectly. Fixed effects are often used to help control for omitted variable bias that is consistent over time. Hypothetically, if the addition of region fixed effects causes a previously large, negative broadband availability coefficient to decrease in magnitude or change signs, then this suggests that areas with higher broadband availability had higher educational attainment levels mostly because of characteristics attributed to the area of residence—not broadband itself. If adding region fixed effects do not change existing coefficients predicting the impact of broadband availability, the implication would be that these effects on intensity occur within regions, not between.

One of the most concerning omitted variables, a metric of wealth, is not a key component of this study for three main reasons. First, the changes in community wealth over time are not a significant driver of changes in broadband availability over time. According to Vigdor and Ladd (2010)'s study, the variation in the introduction of broadband seems to be idiosyncratic. They found that "ZIP codes receiving initial service in 2000 had an average median household income of $45,924, versus $44,200 for ZIP codes receiving initial service in 2004" (Vigdor & Ladd, 2010, pg. 16). Next, the data limit analysis to two time periods: 2000, when full broadband rollout had been incomplete, and 2006 through 2007, when most areas gained availability in the entire region. Therefore, there are no observations of variation in the rate of introduction in my dataset. Finally, measuring wealth is very difficult, given that the data available only provides income variables, an imperfect proxy.

The regression method in this study is the DID estimator using the incremental introduction of broadband availability as the treatment. This identification strategy is based on a number of assumptions and therefore has its own advantages and shortcomings. The DID method allows the comparison of an individual's decision to drop out between places with full broadband coverage since 2000 and areas with limited availability that gain it in later years. In any given cross-section, the areas with broadband may be different from those without it along a number of dimensions. If these differences are consistent over time, the DID specification eliminates the problem. The assumption made—that the time trend is the same across all regions—allows us to discount any unobserved year and region specific effects.

Although this assumption is imperfect, it allows us to discount any unobserved time and region specific effects and helps avoid making a worse alternative assumption—that places with broadband at one point in time are otherwise identical to the places that do not. The areas with initial limited access started out with a mean household income of $54552.89, which is significantly smaller than that of areas that already gained complete coverage in 2000, $65485.87.[9] However, even in 2000, two thirds of all regions had

[9] This is because broadband providers most likely provided service to areas with more potential subscribers—large, densely populated areas that can afford subscription. Increasingly, the decision to roll out broadband seems to be driven by economies of scale rather than differences in wealth or income since only about 5% of all regions still have limited availability by 2007. As broadband availability became more ubiquitous, the marginal cost of offering service to nearby areas also decreased for the providers, which

complete broadband coverage.[10] By 2007, most areas had a very high level of coverage.[11] In 2007, the smallest amount of coverage in any given area was 40.1%; and 95.27% of all areas had full broadband coverage. The areas with "limited" coverage had a mean availability of 97.7%.[12] The ideal experiment would require randomizing the timing of broadband service introduction, but this is not possible.

Empirical Strategy

I estimate the binary outcome variable, dropout, by using the probit model. Probit regressions are nonlinear models designed for binary dependent variables. This model uses cumulative distribution functions (CDFs) to force the predicted estimates to be between 0 and 1. This model assumes that error is distributed normally, where Φ is the cumulative standard normal distribution function.

The regressions using the continuous treatment variable is as follows:

$$(4)\quad \Pr(DROPOUT_{ipt}=1 \mid AVAILABILITY_{pt}, AGE_i, RACE_i, MALE_i) = \Phi\,(\beta_0+\beta_1 AVAILABILITY_{pt} + \beta_2\, AGE_i + \beta_3\, RACE_i + \beta_4\, MALE_i + a_t + \mu_p)$$

allowed them to offer service to nearby, less wealthy areas. Therefore, the few areas left with limited availability by 2007 are most likely both isolated and poor.

[10] In 2000, 197260 out of 336676 pumas had full coverage.

[11] Areas with less than 50% availability in 2007 were all located in one puma in Georgia, while areas with availability between 50% and 80% were located in two areas in Georgia and one in Connecticut.

[12] In 2000, the smallest amount of coverage in a given area was 39.22% 41.41% of all areas had full broadband coverage; and the average broadband availability of those that did not are 89.77%.

where *i* is the index for individual, *p* is the index for region, and *t* is the index for time; β_0 is a constant; $DROPOUT_{ipt}$ is the binary dependent variable, which represents the likelihood of an individual *i* dropping out in region *p* at time *t*. A dropout is defined as an individual who is not enrolled in school and has less than twelve years of educational attainment. However, this definition most likely understates the true dropout rate because some individuals who are still enrolled in school when the data was collected will drop out before they graduate. Although each individual is only sampled once, this is not a problem because the dependent variable is a time-invariant factor, which means longitudinal data is not necessary. The $AVAILABILITY_{pt}$ term is the treatment variable indicating the percentage of broadband availability in region *p* at time *t*; AGE_i is a continuous variable measuring the age of each individual *i*, where the sample population includes eighteen and nineteen year olds; $RACE_i$ represents a vector of variables indicating the race of the individual *i*; $MALE_i$ is a binary variable, which is zero when individual *i* is female. The a_t term is a set of year-fixed effects, which includes the components of error that are consistent for all regions at one point in time *t*. The μ_p term is a set of region-level fixed effects, which includes all unobserved variables constant over time for each region *p*. Once the fixed effect terms are in the equation, the intercept term is redundant and can be removed. To verify the nature of selection biases, we also estimate versions of equation (4) that omit region specific fixed effects and both region and year fixed effects.

To summarize, the empirical strategy is as follows. The years selected for study were limited to 2000, 2006, and 2007 because of data limitations. Using an application of the DID analysis, I am able to compare the differential trends across areas depending on whether they transitioned into broadband over time, or had it since 2000. Including fixed effects in the model helps to address the omitted variable bias by controlling for unobserved time invariant year and region specific effects.

Results

To sum, dropout rates worsened in areas that acquired universal broadband service after 2000 relative to those that had it in place by then. All coefficients demonstrate statistical significance at a 1% significance level and have small standard deviations. The regression results suggest that the perceived benefits of broadband on educational attainment come from time and region specific characteristics.[13] Table 1 presents a noteworthy detail regarding the significant difference in the percentage of students who drop out in the two time periods. The differential trend is measured against the backdrop of an already declining dropout rate.

We cannot rely on the results from the regressions without the appropriate fixed effects. By using z-scores and the coefficient on Table 2, I find that the implied change in probability associated with a one-standard deviation increase in broadband access is an increase of 1.19 %. This means that broadband availability leads to a significant decrease in the dropout rate, and therefore has a positive impact on a student's educational attainment.

[13] Similar regression analyses were conducted on a continuous variable representing years of educational attainment. Because a student can continue pursuing more education beyond the 18-19 years of age, these sets of results are not included as primary findings. However, these regressions have coefficients that are much easier to interpret and demonstrate similar trends. With no fixed effects, the coefficient estimate of broadband availability is .7650743, implying that a student with broadband availability in 2000 attains about 9 more months of schooling. Including only year fixed effects demonstrates a much lower coefficient of .2827331, indicating a little over 3 months of extra school. Moreover, including both year and puma-level fixed effects also lead to a change in sign of the coefficient on availability on attainment to -.2590623, indicating about 3 months less of school. However, these results are overestimating the implied change because the actual range of variation observed of broadband access is not from 0% to 100%, but rather from .39% to 100%.

The results vary significantly when including the year fixed effects. With the inclusion of year fixed effects, I rely even more exclusively on cross-sectional variation. Table 3 shows the more accurate estimates of the magnitude of broadband availability's impact on dropout rates. Compared to the first regression with no fixed effects, this regression implies a smaller change in the dropout choice. With one-standard deviation increase in broadband access, the implied negative change in probability becomes .21%. This is much smaller than that of the first regression, 1.19%. This result implies that broadband availability has a positive impact on educational attainment, but by a much lesser degree.

Interestingly, the results from Table 4 of the primary regression with both fixed effects indicate that the impact of increased broadband availability on dropping out is in fact positive and therefore has a negative impact on educational attainment. In this regression, I find that the implied change in probability associated with a one-standard deviation increase in broadband access is an increase of .14%. Although a small change, this reveals that broadband availability in a region leads to a greater likelihood of an individual's decision to drop out. There are significant racial differences in dropout behavior.

Conclusion

The results are consistent with previous literature, confirming my hypothesis that dropout rates worsened due to the introduction of broadband. High school graduation rates declined in areas that attained complete broadband availability after 2000 compared to those that obtained it previously. This result also suggests that more affluent areas receive access first because most of the perceived benefits of broadband were from baseline differences between areas that gain access earlier and those that acquire it later. Once I implement the fixed effects to isolate the effect of broadband, the sign of the treatment variable's coefficient becomes negative, revealing its detrimental nature. The results imply that region and year specific factors strongly affect broadband access and the individual's decision to drop out.

While this study demonstrates high positive correlations between broadband availability and an individual's decision to drop out, there are threats to the validity of the results. Furthermore, the strong correlation is not an indication that broadband should be taken away from homes. There are many different purposes and benefits to broadband, regardless of its potential causal impacts on educational attainment (Krueger, 1993). Policy attention in the US must shift from promoting access—which is now close to universal—to finding ways to make the impact of broadband a positive one.

Future directions of this topic should include a focus on subpopulations divided by demographic factors, such as race, gender, and SES, as well as other variables, including the introduction of social networking websites. This is because broadband availability may differentially influence subpopulations. After isolating specific subpopulations, scholars can conduct qualitative studies in depth to find ways to make broadband an even more useful tool.

Table 1 *Sample Descriptive Statistics*	2000, 2006-07 Average	2000	2006-2007 Average
Student characteristics			
Percentage of students who are			
White	71.57	70.89459438	72.76165678
Black	12.96	13.16571446	12.28643883
American Indian	1.24	1.262260533	1.077292331
Asian	3.87	3.791276294	4.415911349
Other	10.35	10.88615434	9.458700709
Percentage of students who are			
Dropouts	10.23758	11.5521185	6.989443029
Percentage of students who are			
18	50.89477286	50.39278651	52.13514898
19	-49.89477286	-49.39278651	47.86485102
Number of Observations	562545	400472	162073

Table 2

Determinants of Whether a High School Student will Drop Out

Age	0.0856252
	(0.0046042)
Race	
White	(omitted)
Black	0.2515293
	(0.006574)
American Indian	0.429599
	(0.0181075)
Asian	-0.4232692
	(0.0161889)
Other	0.5440792
	(0.0065691)
Male	0.1909222
	(0.0046353)
Availability	-0.5828483
	0.031705
Observations	562545
Pseudo R-squared	0.0301

Note. Robust standard errors in parentheses.

All reported observations are significant at 1% significance level: $p < .01$.

Table 3

Determinants of Whether a High School Student will Drop Out--
Controlling for Year Fixed Effects

Age	0.0825134
	(0.0046207)
Race	
White	(omitted)
Black	0.2460558
	(0.0065933)
American Indian	0.449684
	(0.0181586)
Asian	-0.4301903
	(0.016271)
Other	0.5309344
	(0.0065989)
Male	0.1934816
	(0.0046603)
Availability	-0.1907516
	(0.0330269)
Observations	562545
Pseudo R-squared	0.0362

Note. Robust standard errors in parentheses. Year effects included but not reported. All reported observations are significant at 1% significance level: $p < .01$.

Table 4
Determinants of Whether a High School Student will Drop Out--
Controlling for Year Fixed Effects and Region Fixed Effects

Age	0.0945606
	(0.0047654)
Race	
White	(omitted)
Black	0.1329393
	(0.0078871)
American Indian	0.4282707
	(0.0199615)
Asian	-0.3478981
	(0.0175486)
Other	0.4453102
	(0.0074396)
Male	0.1937555
	(0.0047965)
Availability	0.1747054
	(0.0716128)
Observations	562195
Pseudo R-squared	0.0804

Note. Robust standard errors in parentheses. Year and region effects included
but not reported.
All reported observations are significant at 1% significance level: $p < .01$.

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