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Offline effects of online connecting: the impact of broadband diffusion on teen fertility decisions

Melanie Guldi[1] · **Chris M. Herbst**[2]

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Abstract Broadband (high-speed) internet access expanded rapidly from 1999 to 2007 and is associated with higher economic growth and labor market activity. In this paper, we examine whether the rollout also affected the social connections that teens make. Specifically, we look at the relationship between increased broadband access and teen fertility. We hypothesize that increasing access to high-speed internet can influence fertility decisions by changing the size of the market as well as increasing the information available to participants in the market. We seek to understand both the overall effect of broadband internet on teen fertility and the mechanisms underlying this effect. Our results suggest that increased broadband access explains at least 7 % of the decline in the teen birth rate between 1999 and 2007. Although we focus on social markets, this work contributes more broadly to an understanding of how new technology interacts with existing markets.

Keywords Fertility · Birth rates · Broadband · New media

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✉ Melanie Guldi
mguldi@ucf.edu

✉ Chris M. Herbst
chris.herbst@asu.edu

[1] Department of Economics, University of Central Florida, 4000 Central Florida Blvd, Orlando, FL 32816-1400, USA

[2] School of Public Affairs and IZA, Arizona State University, 411 N. Central Ave., Ste. 450, Phoenix, AZ 85004-0687, USA

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1 Introduction

In 2010, the US teen birth rate was 34.3 births per 1000 women aged 15 to 19, 44 % lower than its recent peak in 1991 and 64 % lower than the historic high recorded in 1957. This reduction is showing no signs of slowing down: since 2007, the teen birth rate has fallen by nearly one fifth. In response, policymakers and scholars are now devoting significant attention to understand why these dramatic changes have occurred. Researchers have explored the role of technology (contraception), legal access (laws regulating minor access to abortion or contraception), and the tax and transfer system (cash assistance and Medicaid) as possible explanations for the observed decline in teen fertility. A recent paper by Kearney and Levine (2015a) tests a number of these factors and finds that, taken together, they account for only a small fraction of the reduction in teen birth rates between 1991 and 2010. This suggests that *the* principal cause (or causes) of the recent decline has not been identified by these first-order economic and policy explanations.

As a result, scholars have started pursuing alternative explanations. For example, two recent papers examine the role of media exposure via-a-vis MTV's popular show *16 and Pregnant* in accounting for the decline in teen fertility (Kearney and Levine 2015b; Trudeau 2015). Although these papers utilize somewhat different research designs, both conclude that the program, which first aired in June 2009, produced sizable declines in teen fertility. For example, estimates from Kearney and Levine (2015b) imply that the introduction of 16 and Pregnant along with its companion programs (*Teen Mom* and *Teen Mom 2*) explains approximately one quarter of the decline in teen births by the end of 2010.

In this paper, we examine a related though distinct explanation for the drop in teen births: the rapid diffusion of broadband internet providers. Currently, 98 % of US households reside in areas with broadband internet access, and 70 % of households have such a high-speed connection in the home, an increase from 3 % in 2000 (US Department of Commerce 2013; Zickuhr and Smith 2013). Conversely, the proportion of households using dial-up connections plummeted from 34 % in 2000 to 3 % today. Moreover, the rise in home broadband utilization has been ubiquitious, increasing even in rural areas, where access and adoption were initially slow. Over the last decade, there has been a 3.5-fold increase in the fraction of rural households with a high-speed internet connection (Horrigan 2009; Zickuhr and Smith 2013).

Teenagers have taken significant advantage of this reshaped internet landscape, becoming key consumers of "new media" (i.e., digital) content and using social media to create and expand friendship networks. Fully 95 % of teens regularly use the internet, a percentage that has remained virtually unchanged over the past decade and which exceeds internet use rates by all other age groups (Madden et al. 2013). In addition, 93 % of teens own or share a laptop or desktop computer at home, and nearly one quarter own a tablet computer.[1] Such widespread access to broadband internet has dramatically altered the intensity and manner in which teens interact, socialize, and exchange information. Teen computer users spend over 2 h per day on recreational (in-

[1] Rates of teen internet use exceed 90 % for nearly every demographic group—including non-Whites, those in rural areas, and those with low-education parents—while rates of computer ownership are consistently well above 60 % (Madden et al. 2013).

home) computer use, with visits to social media sites (e.g., MySpace and Facebook) and YouTube accounting for most of that time (Rideout et al. 2010). Indeed, at least three quarters of teens have an active MySpace or Facebook profile, and one quarter regularly use Twitter (Madden et al 2013; Lenhart 2012a; Rideout et al. 2010). The typical teen Facebook user has 300 friends, and one third are friends with individuals they have not met in person (Madden et al. 2013). Finally, 37 % of teens regularly participate in video chats using Skype, Googletalk, or iChat, and many create their own video content for others to consume (Lenhart 2012b).

Our simple conceptual framework posits that the diffusion of broadband internet may influence teenage fertility through several channels. The first mechanism operates through the information and social networking effects of broadband diffusion. Specifically, broadband access is an efficient means of reducing search frictions primarily by lowering the cost of seeking and sharing information. This may have implications for the regularity and nature of the interactions with potential intimate partners, the quantity and quality of information obtained on sexual practices and health, and an understanding of the costs and benefits of raising a child. Given the large amount of time that teens spend on internet-related activities, a second mechanism is through the displacement of other forms of social interaction. In other words, the time spent communicating with others via social media could supplant face-to-face interaction, thereby reducing the frequency of sex and, in turn, the birth rate. A final mechanism operates via changes in current or perceived future employment opportunities. Insofar as broadband diffusion increases local economic activity, the rise in income could have positive or negative effects on the teen birth rate that depend on whether the income or substitution effect dominates the childbearing decision. Overall, the relationship between broadband diffusion and teen fertility is theoretically ambiguous and thus warrants empirical analysis.

To examine the impact of broadband diffusion on teen fertility, we draw on zip-code-level data on broadband internet deployment from the Federal Communications Commission (FCC) Form 477. The FCC requires broadband providers to report whether there is at least one household or business subscriber (at least 200 kbit per s) in a given zip code. We use these data to construct a measure of the degree to which a given county has access to broadband internet providers. This information is then merged to county-level natality data from the National Center for Health Statistics (NCHS), resulting in a panel of counties over the period 1999 to 2007. This period is chosen because it represents the years during which broadband was aggressively rolled out across the USA. Thus, our identification strategy relies on the differential access to broadband internet across space (i.e., counties) and time (i.e., years). Although our primary outcome is the teen birth rate, we conduct auxiliary analyses to explore the abortion rate and rates of sexually transmitted infection. Therefore, a key goal of the paper is to understand not only the overall effect of broadband internet on teen birth rates, but also the mechanisms through which it influences the birth rate.

Our results suggest that increased broadband access is associated with a reduction in the teen birth rate. Specifically, our preferred estimate implies that the national broadband rollout between 1999 and 2007 can explain at least 7 % of the decline in teen births during this period. We also explore the relationship between increased broadband access and two proxies for teen risky behaviors: the abortion rate and the sexually transmitted infection (STI) rate. Our estimates are consistent with a decrease in STIs but provide little indication that the abortion rate changed, though none of these estimates are statistically significant. Taken together, our estimates indicate a decline in the birth rate and imply both an increase in the use of contraception and a decrease in sexual activity. Although we focus on social markets, this work also contributes more broadly to our understanding of how new technology interacts with existing markets.

The remainder of the paper proceeds as follows. Section 2 describes the conceptual framework for understanding the mechanisms through which broadband internet may influence teen fertility outcomes. Section 3 reviews the relevant literature on the economic and social impacts of broadband diffusion. Section 4 introduces the data, while Sect. 5 discusses the empirical model. We present the estimation results in Sect. 6 and provide concluding comments in Sect. 7.

2 Conceptual framework

Standard economic models begin with the assumption that fertility decisions are made in a series of steps, beginning with the decision about whether to have sex (Levine 2004). Decisions are then made regarding the level of contraceptive intensity. If a pregnancy occurs, women must decide between aborting the pregnancy and giving birth. Two assumptions underlie the standard model. Women are assumed to act with perfect information and without search costs throughout this decision-making process, and they maintain perfect control over fertility outcomes. Based on these considerations, the model predicts that decreasing the costs associated with bearing and raising children increases the likelihood that a pregnancy will occur and increases the likelihood that a pregnancy will end with a birth (while reducing the probability of having an abortion). In the present paper, we assume that teens do not have perfect information and that search costs may exist. Relaxing these assumptions suggests that there are several mechanisms through which broadband diffusion might influence the birth rate. We consider each mechanism in turn.

The first mechanism operates through broadband's effect on information and media consumption. Broadband provides an efficient means of reducing search frictions primarily by reducing the cost of seeking information (e.g., on potential partners, affordable and effective contraception technologies, anecdotal evidence on parenting, and the costs and benefits of raising a child). Offline information markets tend to be highly decentralized, thereby increasing the time and psychic costs of finding reliable information on contraception and parenting. Online markets, on the other hand, are better organized and thus have the potential to mitigate these search frictions. Indeed, survey evidence suggests that teens are making increased use of online information. From 2004 to 2009, teen consumption of print media declined to 37 %. In its place, one half of teens report ever having read a blog, and 55 % report ever having investigated health information online (Rideout et al. 2010). In addition, the internet is now a key mode through which individuals consume media, and broadband diffusion has hastened this development. Indeed, activities related to media consumption—for example, watching YouTube videos, playing video games, or visiting web sites—account for nearly half the time that teens spend on the home computer (Rideout et al. 2010). To the extent that media consumption has an effect on individual behavior, broadband access could have a large influence on the birth rate.

Another mechanism focuses on the powerful role played by participation in social networking environments, including MySpace, Facebook, Twitter, and Snapchat.[2] Such services stimulate and centralize social interactions as well as serve as information-sharing venues in a variety of ways that may influence the teen birth rate.[3] An obvious effect of social media is to lower search frictions for potential partners by reducing the pecuniary and psychic costs relative to searches in traditional environments.[4] In fact, websites such as FunDateCity and MyLOL (which boasts a membership of over 300,000 worldwide) are designed specifically to promote teen dating. Moreover, anecdotal evidence suggests that teens increasingly use a variety of non-dating websites and services such as Instagram, Tumblr, and Xbox LIVE to seek out romantic relationships.[5] Another avenue for a social media effect is through a peer effect in which social norms, behaviors, and information are transmitted throughout one's network and are, in turn, adopted by others in that network. Still, another avenue is through the displacement of other forms of social interaction. In other words, the time spent engaging with others via social media could supplant—through a form of "incarceration"—face-to-face interaction, thereby reducing the frequency of sex and, in turn, the birth rate.[6] Such a possibility finds strong support in recent surveys of teens. Relative to a few years ago, teens are substantially less likely to socialize in person or over the phone (using a landline *or* cell) and are more likely to communicate via text messages (Lenhart 2012a).

On the other hand, it is possible that some alternative forms of virtual communication might increase the incidence of teen sexual activity. For example, a non-trivial fraction of teens—as high as 28 % in one study—engage in "sexting," defined as the electronic transmission of sexually explicit images or messages (The National Campaign to Prevent Teen Pregnancy and Unplanned Parenthood 2008; Temple et al. 2012). Several recent papers find that teens engaged in sexting are more likely to be sexually active (Temple and Choi 2014) and to report risky sexual behaviors including unprotected sex and multiple-partner sex (Benotsch et al. 2013). Finally, broadband access may influence sexual contact between teens in two other ways: an increase in the demand for prostitution via online markets (Cunningham and Kendall 2011) and an increase in the consumption of internet pornography (Regnerus et al. 2015). It is not clear to what extent teens are participating in the prostitution market, but it seems reasonable to assume that high-speed internet access may increase teens' use of pornography.

A third mechanism may operate through changes in current or perceived future employment opportunities. Previous research finds that local broadband diffusion is

[2] The services of MySpace (2003), Facebook (2004; 2006 for teens), Twitter (2006), Snapchat (2011), and others that we mention were not all available during our period of study; we include these as examples of "social media."

[3] Teens have been shown to be highly responsive to their peers' behaviors regarding teen childbearing and alcohol use (Fletcher 2012; Yakusheva and Fletcher 2015).

[4] Bellou (2015), which we discuss in more detail below, shows that friction in the marriage market is reduced as broadband internet access increases.

[5] For example, see http://www.huffingtonpost.com/2013/03/02/teens-discuss-online-relationships-and_n_2792601.html and http://dating.lovetoknow.com/Teen_Online_Dating.

[6] Incarceration effects are found to exist through the consumption of other forms of media. For example, Dahl and DellaVigna (2009) find that rates of violent crime are lower on the same day that popular violent movies are released in a given local area, which they attribute to an incarceration effect.

associated with increased employment growth (Atasoy 2013; Kolko 2012a, b). To the extent that broadband access increases local economic activity and living standards—primarily by way of increased earnings—a baseline prediction suggests that broadband may lead to an increase in the birth rate, assuming that children are normal goods. However, additional income from local broadband growth may reduce the birth rate (especially the teen birth rate) because of the increased opportunity costs associated with bearing and raising children. Income-driven reductions in the birth rate may also occur because individuals previously not using contraception may now be able to afford a basic level of protection, while those already using contraception may purchase a higher-quality (and presumably more effective) level of protection. Aside from these income-driven changes in fertility, it is plausible that the types of jobs created by broadband diffusion have implications for fertility decisions. For example, if broadband is associated with increased telecommuting or flextime work, such arrangements might lead to increased birth rates among working-age women, as the cost of bearing and raising children would likely decline. More importantly, new work arrangements might lead to lower teen birth rates if adults are more likely to supervise their teenage sons and daughters.[7]

Implicit in the preceding discussion is the notion that broadband diffusion can influence birth rates at two key points in the fertility decision-making process (Kane and Staiger 1996; Levine 2004). With broadband diffusion, teens gain additional information prior to pregnancy and between pregnancy and birth. Thus, the first point occurs when decisions are made about the level of sexual activity and contraceptive intensity. Teens might increase the level of contraceptive intensity or decrease the level of sexual activity in response to the increased opportunity cost of having a child. Additionally, increased information on contraception and where to obtain it may increase teens' use of various forms of birth control. The increased number of potential partners (via meeting others online and widening the size of the dating market) may increase the probability of sexual activity, while meeting virtually instead of face-to-face may decrease the probability of sexual activity. Predictions regarding sexual activity and use of contraception conditional on sexual activity are therefore ambiguous. The second point happens through changes in women's decision-making after a pregnancy occurs. Since broadband diffusion increases economic activity, additional income (assuming children are normal goods) could increase the number of pregnancies ending in birth. At the same time, the opportunity cost of giving birth rises (due to forgone wages), suggesting that economic activity could reduce the number of pregnancies ending in a birth.

3 Relevant literature

There is a small but growing body of work exploring the economic and social implications of broadband diffusion. Perhaps, the most widely studied outcomes are those dealing with labor market behavior and local economic development. For

[7] Dettling (2014) provides evidence that increased at-home broadband access leads to higher rates of married female labor force participation, suggesting that the ability to work from home is a key factor for this demographic.

example, using a panel of US counties between 1999 and 2007, Atasoy (2013) finds that the introduction of broadband increases the employment rate by 1.8 percentage points. Comparable results (qualitatively) are produced by Kolko (2012a, b), who relies on zip-code-level panel data over a similar time period and uses a different identification strategy as well as more detailed local controls. Interestingly, both studies find that broadband diffusion is particularly important to economic growth in areas with lower population densities.

Recent work also examines skill complementarities with respect to broadband diffusion. Akerman et al. (2013) combine broadband diffusion data with firm-level information in Norway and find that broadband adoption increases the productivity of skilled labor, while lowering the productivity of unskilled labor. Consistent with this, the authors find that broadband diffusion increases the wages of the former group and lowers the wages of the latter group. Taken together, findings from these studies suggest that broadband access increases the opportunity cost of having a child among high-skilled individuals. Dettling (2014), however, shows that increasing broadband connectivity at home leads to greater labor force participation rates among married women with children, suggesting that greater connectivity improves labor market outcomes for this demographic.

A small number of studies have explored how broadband influences an array of social outcomes. Bellou (2015) examines the impact of US broadband diffusion (measured at the state-level) on marriage decisions for non-Hispanic Whites aged 21 to 30 and finds that broadband availability is associated with large, positive increases in the marriage rate, ranging from a 13 to 30 % increase from the counterfactual marriage rate. The results are attributed to reduced search frictions in the marriage market made possible by increased access to high-speed internet. In a different vein, Bhuller et al. (2013) examine whether broadband diffusion has implications for sex crimes. Using Norwegian internet and sex crime data, the authors find that internet use substantially increases not only reports of but also charges and convictions for rape and other sex crimes.

This is the first paper that we are aware of that examines the fertility effects of broadband diffusion. It contributes to an established literature studying the implications of media access for a variety of social and familial outcomes.[8] For example, Olken (2009) finds that the introduction and proliferation of radio and television signals in Indonesian villages decreased social capital. La Ferrara et al. (2012) study the implications of soap operas in Brazil and find that the spread of these television shows reduced fertility rates. A related paper by Jensen and Oster (2009) shows that the diffusion of cable television in India reduced fertility rates and reshaped women's attitudes toward son preferences and female autonomy. In addition, this paper is tangentially related to a small set of studies exploring the health consequences of technology and mobile devices. A recent paper by Palsson (2014), for example, finds that the rapid adoption of smart phones (with 3G access) produced higher rates of child injuries as well as increases in risky parental behaviors. Similarly, a large number of studies investigate the impact of cell phone use on car accidents, with many finding a positive effect (e.g., Redelmeier and Tibshirani 1997; Bhargava and Pathania 2013).

[8] Dahl and Price (2012) provide a comprehensive review of the literature.

4 Data sources

4.1 Broadband data

We rely on the FCC's Form 477 to construct the measure of broadband availability.[9] These data, which have been used elsewhere to study the effect of broadband deployment (e.g., Atasoy 2013; Kolko 2012a, b), report the number of broadband providers that serve at least one customer in a given zip code. Broadband providers are defined as those offering services at 200 kbit per second or faster; these typically include telephone-based DSL lines, cable modems, and satellite services. Between 1999 and 2007, these data were recorded by the FCC biannually (in June and December) at the zip code level. However, the agency in 2008 began reporting these data at the county level, hampering our ability to construct a comparable measure of broadband access in the pre- and post-2008 period.[10] We do not view this as problematic since, as shown in Fig. 1, nearly all counties had at least one broadband provider by 2007. Therefore, we limit our analysis to the years 1999 to 2007. We utilize the December reports to construct the measure of broadband access.

These data are not without their limitations. First, the definition of high-speed broadband internet used in the original Form 477 is now outdated. The American Recovery and Reinvestment Act of 2009 stipulated that providers must sell products at speeds of at least 768 kbit per second to be deemed "high speed." A second limitation is that the Form 477 data measure the availability of broadband rather than adoption or utilization. However, given the time series evidence on household use of broadband reported in Zickuhr and Smith (2013), it is apparent that access and adoption closely track one another. Third, the data do not allow researchers to distinguish between consumer versus business access, advertised versus actual speeds, and whether the provider serves entities throughout the entire zip code as opposed to a portion of it. We are aware of the possibility that, at least in the early part of our study period, when household broadband take up was relatively low, local providers may have been predominately serving businesses and other large organizations. As a result, our measure of broadband access during this period may be measured with error, which would attenuate its effect on the birth rate. However, individuals often report accessing the internet somewhere other than their own home—such as at work, school, or a library—suggesting that a more comprehensive measure is preferable and that measuring only household access would result in an incomplete measure of broadband access. Despite these limitations, the FCC data represent the only publicly available archive documenting the US broadband rollout over a meaningful period of time. Furthermore, Kolko (2012a, b) argues that the number of providers in a local area

[9] Data were obtained from http://transition.fcc.gov/wcb/iatd/comp.html on June 20, 2012. As described within the documentation, these data are "lists of geographical zip codes where service providers have reported providing high-speed service to at least one customer as of December 31, [of the relevant year]. No service provider has reported providing high-speed service in those zip codes not included in this list. An asterisk (*) indicates that there are one to three holding companies reporting service to at least one customer in the zip code. Otherwise, the list contains the number of holding companies reporting high-speed service. The information is from data reported to the FCC in Form 477."

[10] Through correspondence with the FCC, we were informed that county-level counts are not available in the 1999 to 2007 period.

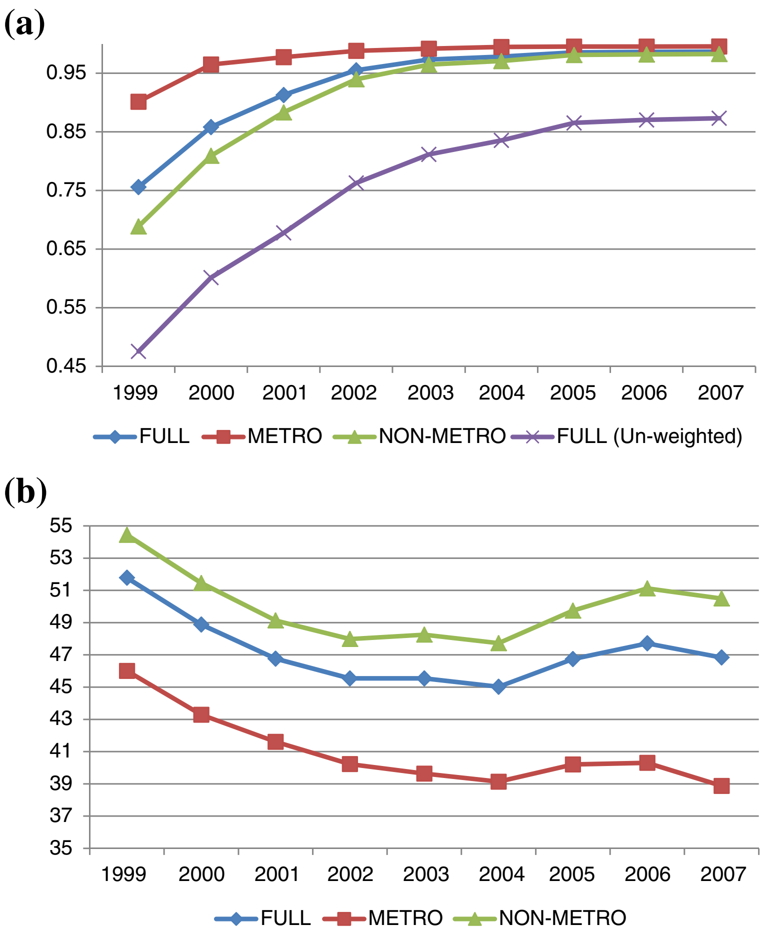


Fig. 1 County broadband provider presence and teen birth rates, 1999–2007. **a** Percentage of counties with one or more broadband providers. **b** Teen birth rate. Source of broadband access at county level (BBPCT): authors' computations using the FCC's Form 477 data. BBPCT is the percentage of zip codes within a county with at least one broadband provider, where the percentage is created by weighting each zip code's provider presence by the zip code population in 2000. The unweighted BBPCT measure is similar except that each zip code is equally weighted in the computation. This is described in more detail in the text. The zip codes that do not appear in the FCC data are assumed to have zero providers. The county is assumed to have a provider if at least one zip code in the county reports having a provider. Source of teen birth rates: National Vital Statistics Annual Reports and SEER population (see notes to Table 1, Summary statistics, for more information)

is a relevant proxy for internet access because the goal of broadband policy is to increase—through a variety of mechanisms—the supply of services in that area.

Our main analysis is performed at the county level. Armed with FCC data on the number of providers by zip code, our measure of broadband diffusion is defined as the population-weighted percentage of zip codes in a given county with at least one provider. To create this measure, we utilized SAS geographic information, Census ZCTAs, zip code-to-county crosswalks (available on the Missouri Census Data Center website), and a list of county FIPS codes available from the National Bureau of Economic Research (NBER) to create a county-by-year list of zip codes over the period 1999 to 2007.[11] We then merged the FCC data onto this master list and assumed that zip codes without matches did not have at least one broadband provider in December of that year.[12] Next, we weighted the broadband measure by the total population in a zip code in 2000 to create county- or state-level measures of the weighted percentage of the relevant area with at least one provider. Finally, we merged this file with the county- or state-level variables described below. The analysis sample is limited to 48 states and the District of Columbia.[13] Our main analysis dataset includes 22,887 county-year combinations.

Figure 1a shows the evolution of US broadband diffusion over the period 1999 to 2007. For the full sample, we display the population-weighted and population-unweighted versions of the broadband measure. We also show the evolution of the population-weighted measure (our key policy variable) for the metro and non-metro samples. Consistent with previous work, we find a dramatic rise in broadband coverage. In 1999, 75 % of all counties (access weighted by zip code population) had at least one broadband provider serving at least one customer. By 2007, this proportion rose to nearly 99 %. The unweighted measure of broadband provider presence follows a similar trend. It is also apparent from Fig. 1a that virtually all of the increase occurred between 1999 and 2003; for most counties, rates of broadband diffusion changed very little after 2003. It is useful to compare these rates of broadband diffusion to individual-level data on take-up of home broadband internet. Each year since 2000, Pew Research Center's Internet and American Life Project has asked a nationally representative sample of US adults whether they have a high-speed broadband internet connection. In 2000, 3 % had a home broadband connection, increasing to 47 % by 2007 (Zickuhr and Smith 2013).[14]

[11] We utilize information on the Missouri Census Data Center page to map postal zip codes into county geographic units: http://mcdc.missouri.edu/websas/geocorr12.html and information on county FIPS codes available on the National Bureau of Economic Research data page: http://www.nber.org/data/ssa-fips-state-county-crosswalk.html.

[12] Our measure of broadband diffusion is similar to, though distinct from, the measure used in previous studies. For example, our measure is most similar to Atasoy (2013) who creates a population-weighted binary indicator for the presence of any broadband provider in a given zip code (i.e., ZCTA). Kolko (2012a, 2012b)) creates a linear measure of access, assigning a value of 0 to zip codes with zero providers, a value of 2 to zip codes with one to three providers, and the actual number of providers to zip codes with more than three providers.

[13] We exclude Hawaii and Louisiana. We omit Louisiana counties due to changes in the infrastructure, including broadband, as a result of hurricane Katrina. Hawaii is omitted due to missing population information.

[14] The trend depicted by Pew Research Center's analyses accords with data collected by other entities. For example, the US Department of Commerce (2011) estimates that broadband internet use rose sevenfold, from 9 to 64 % between 2001 and 2009. Simultaneously, households with internet use at home (regardless of connection speed) rose from 18 % in 1997 to 62 % in 2007 (U.S. Census Bureau Current Population Survey, 1984-2009). Using these CPS data, we compute that households reporting a fast connection at home rose from approximately 5 % in 2000 to 56 % in 2007 (Flood et al. 2015). It may appear inconsistent that, on the one hand, we calculate a broadband penetration rate of 75 % in 1999, but on the other hand, the Pew survey shows that only 3 % of households reported a high-speed internet connection in 2000. The apparent disconnection is partially explained by the fact that our measure of broadband access includes take-up by households and firms (in addition to schools and universities, libraries, and public agencies). Given that take-up by households lagged that of non-households, the high broadband penetration rates in the early years suggest that the predominant customer was the former group. However, as we state in the text, individuals often report accessing the internet in places outside their own home, suggesting that a more comprehensive broadband measure is preferable because it captures the effect of internet use in these non-household environments.

5 Natality, gonorrhea, and abortion data

We examine a number of outcomes in this study, all drawn from different sources. First, we utilize the NCHS restricted-use geo-coded natality data to construct county-by-year counts of the number of births to individuals aged 15 to 19 as well as data from the Surveillance, Epidemiology, and End Result (SEER) Program to construct county-by-year counts of the population of women aged 15 to 19.[15] We calculate the county-by-year teen birth rate, the primary outcome in this study, over the period 1999 to 2007. Figure 1b shows the decline in teen births over this period for the full, metro, and non-metro samples. Second, county-level gonorrhea rates (number of cases for any age or gender divided by county population per 100,000) are available for the period 1999 to 2007 for a subset of 30 states. We obtained data for periods earlier than 2003 directly from the Centers for Disease Control (CDC). Third, abortion data were obtained from a third-party website containing county-level information for 33 states over the study period.[16] The abortion rate is calculated as the total number of abortions in a county (regardless of age) divided by county population per 1000.

6 County-level covariates

Our regression models control for a variety of observable county characteristics that may be correlated with local broadband penetration and teen fertility behavior. Specifically, we draw on economic models of fertility (e.g., Levine 2004) as well as recent empirical papers studying the impact of broadband diffusion on other economic and social outcomes (e.g., Atasoy 2013; Kolko 2012a; Dettling 2014) to inform the selection of our covariates. One set of controls, which includes population density, the unemployment rate, per capita personal income, the fraction White, the fraction Hispanic, and the share of the population with a bachelor's degree, is drawn from the Census Bureau and the Bureau of Labor Statistics. These variables capture differences across geographic areas in the strength of the local economy and their demographic composition. Indeed, recent works find that these variables are highly correlated with broadband availability. For example, Kolko (2012b) shows that local broadband availability is increasing in population density, household income, and the percent with a bachelor's degree. In addition, we draw on the Bureau of Economic Analysis' Regional Information System (REIS) to generate county-by-year expenditure data on such government programs as Medicaid, Supplemental Security Income (SSI), Temporary Assistance to Needy Families (TANF), and the Supplemental Nutritional Assistance Program (SNAP).[17] Access to and take-up of these social programs vary widely within and across geographic areas; in addition, previous work documents that some programs—particularly Medicaid and TANF—played a role in reducing teen birth rates over the past two decades (Kearney and Levine 2015a).

[15] SEER population data can be retrieved from the National Cancer Institute at http://seer.cancer.gov/popdata/.

[16] Abortion data source: http://www.johnstonsarchive.net/policy/abortion/#UC accessed April 15, 2014, to April 22, 2014.

[17] REIS data can be accessed via http://www.bea.gov/regional/.

Table 1 provides summary statistics for the broadband and outcome variables examined in the analysis. Over the period 1999 to 2007, approximately 93 % of counties contained at least one broadband internet provider serving at least one customer. The average county-level teen birth rate over this period is 47 births per 1000 women aged 15 to 19. However, as shown in Fig. 1b, this masks substantial heterogeneity throughout the study period: the teen birth rate declined from approximately 52 births in 1999 to 45 births in 2004 before rising slightly to 47 births in 2007. Additionally, teen birth rates in metro counties are lower than those in non-metro counties, suggesting that we should test whether broadband diffusion had different effects on teen fertility decisions in metro versus non-metro areas.

7 Empirical model

To study the impact of broadband internet diffusion on teen birth rates, we estimate regressions of the following form:

$$Y_{ct+1} = \beta_0 + \beta_1 BBpct_{ct} + \beta_2 X_{ct} + \gamma_c + \tau_t + \delta_{ct} + \varepsilon_{ct}$$

where Y_{ct+1} is the teen birth rate in county c in year $t+1$ and is calculated as the number of children born to women aged 15 to 19 divided by the number of women aged 15 to 19 in each county-year cell. We estimate these regressions on the full sample and on the metro and non-metro sub-samples. Counties are classified as metro or not based on the US Department of Agriculture's Economic Research Services (1993) rural-urban continuum code classification.[18] Auxiliary regressions examine the natural log of the teen birth rate (in year $t+1$), as well as the county gonorrhea rate (in year t) and the county abortion rate (in year t). As described above, the measure of broadband access, $BBpct_{ct}$, is defined as the population-weighted percentage of zip codes in a given county with at least one broadband provider, the year before we observe the birth. The coefficient of interest, β_1, is interpreted as the change in the teen birth (or gonorrhea or abortion) rate, as broadband diffusion within a county increases from zero geographic coverage to full geographic coverage. Identification comes from the differential timing in the introduction and subsequent expansion of broadband internet across counties.

The model also includes a rich set of observable county covariates, X_{ct}, as listed in Sect. 4 above. In addition, the model includes county fixed effects, γ_c, to absorb permanent unobserved county heterogeneity, year fixed effects, τ_t, to absorb unobserved time-varying shocks, and county-specific linear time trends, δ_{ct}, to control for unobservables that are differentially trending across counties. All regressions are weighted by the county population, and the standard errors are robust to heteroskedasticity and are clustered by county to account for possible serial correlation within each county.[19]

Although we are not studying a randomly assigned experimental treatment, to interpret the regression estimates as causal, we must assume that the common trend

[18] Codes obtained from http://www.ers.usda.gov/data-products/rural-urban-continuum-codes on April 10, 2014.

[19] Estimates from unweighted regressions produce similar coefficient estimates, though the unweighted estimates are less precisely estimated.

Table 1 Summary statistics

	Full sample (1)	Low BBPCT (2)	Middle BBPCT (3)	High BBPCT (4)
Panel A: outcome variables				
Teen birth rate	47.20	49.68	47.61	44.32
Standard Deviation	21.48	22.51	21.23	20.31
Gonorrhea rate	90.13	87.22	88.95	93.28
Standard Deviation	107.29	101.99	106.32	111.78
Abortion rate	8.52	6.45	7.78	11.02
Standard Deviation	8.43	7.10	6.52	10.29
Panel B: broadband measure				
BBPCT	0.93	0.86	0.95	0.99
Standard deviation	0.15	0.22	0.09	0.03
Panel C: county-level covariates				
Percent metro	0.31	0.10	0.28	0.56
Population density	290	43	102	725
Percent with BA degree	17.84	13.88	17.28	22.34
Unemployment rate	5.32	5.66	5.38	4.91
Per capita personal income	26,940	24,233	26,394	30,288
Percent White	0.87	0.88	0.89	0.86
Percent Hispanic	0.07	0.05	0.07	0.08
Medicaid payments	103,883	27,290	62,522	225,403
SSI payments	13,824	3671	8726	29,534
TANF payments	53,678	13,758	34,567	114,491
SNAP payments	8515	2613	5758	17,442
Other income maintenance payments	17,780	3563	10,627	39,794
Number of observations	22,887	7623	7632	7632

The table contains mean values of each variable by sample sub-group. Column (1) includes the entire sample. Columns (2) through (4) are broken into areas with low (lowest third), middle (middle third), and high (highest third) broadband provider presence in 1999. Sources: BBPCT is the population-weighted percentage of zip codes within a county with a broadband provider (see notes to Fig. 1). Teen birth rate is computed as the number of births to women aged 15 to 19 in each county (obtained from the Vital Statistics Natality Detail data from 2000 to 2008), divided by the population of women aged 15 to 19 in those years (SEER). Gonorrhea rate is the county-level rate obtained from the Center for Disease Control. The abortion rate is the number of abortions in each county in each year (http://www.johnstonsarchive.net/policy/abortion/#UC), divided by the number of women aged 15 to 44 (SEER). Metro designation indicates whether the county is classified as metropolitan according to the USDA's 1993 rural-urban continuum. High school enrollment, population density, and the percent with a BA degree are from the US Census Bureau. The variable above-median HS enrollment indicates whether the county high school enrollment rate is above the median enrollment rate in 1999. Population density is computed as county population divided by land area in 2000. County unemployment rate is from the Bureau of Labor Statistics. From the Bureau of Economic Analysis, we have obtained per capita personal income, public assistance medical care payments (Medicaid), income maintenance payments (TANF), Supplemental Security Income (SSI) payments, Supplemental Nutrition Assistance Program (SNAP) payments, and other income maintenance payments (other income maintenance). The percent White and percent Hispanic are computed using SEER data assumption holds, that is, counties with and without broadband, would have had similar trends in the teen birth rate if the diffusion of broadband had not occurred. For the full sample, it is difficult to examine pre-treatment trends directly, since some counties enter the study period with a provider presence that is already nontrivial.[20] We can, however, examine birth rate trends for a group of counties with very low penetration in 1999 ($BBpct_{1999} < 0.10$). We break this group of counties into those that subsequently have full provider presence by 2002 ($BBpct_{2002} > 0.98$) and those that do not. These trends are presented in Fig. 2. We find that prior to 1999, trends in the teen birth rate are fairly similar until the fully treated counties begin to have a provider presence (after 1999), at which point, the birth rate in these counties falls substantially below the birth rate in the untreated counties.[21] A few years later (after 2005)—when most counties are fully or nearly fully treated—the birth rate trends become comparable again.[22] Although we cannot reproduce this graph for all counties in the estimation sample, these figures provide support for the idea that teen birth trends were evolving similarly prior to the proliferation of broadband. Since this may have occurred for some counties prior to 1999, we adjust for county-specific time trends in the main analysis.

8 Results

8.1 Teen births

Tables 2 and 3 report the main fertility results. The former table reports the teen birth rate results, while the latter reports results from the natural log of the teen birth rate. Columns (1) and (2) in each table show the full sample estimates. Columns (3) and (4) estimate the model separately on the subset of non-metropolitan counties, while columns (5) and (6) estimate the model separately on the subset of metropolitan counties. Columns (2), (4), and (6) are our preferred models, respectively, given that they include the full set of controls.

The estimates reported in columns (1) and (2) of Table 2 show that the level of the teen birth rate is negatively associated with the proportion of the county with at least one broadband provider; as the proportion of a county with broadband access rises from zero to 100 %, we expect the teen birth rate to decline between 2.2 and 2.3 births per 1000 teens aged 15 to 19. Using our preferred estimates (Table 2, column 2), we find that BBPCT led to a 0.67 % decline in teen births from 1999 to 2007.[23] This explains 7 % of the total decline in teen birth over the period.[24] Our estimate is smaller than the 4.3 % drop in teen births

[20] The FCC data that we use is only available starting in 1999, so we are unable to observe the exact time when every county gets their first provider.

[21] The figure looks very similar if we examine the natural log of the birth rate rather than the birth rate.

[22] We experiment with several alternative cutoff points. Specifically, we examine penetration cutoffs of 5, 10, 15, and 20 % as well as an upper-limit cutoff of 90 or 95 % (instead of 98 %). In all cases, the patterns of results discussed in the text are quite comparable to when these alternative cutoffs are used.

[23] We compute the percentage change in teen births due to BBPCT, $\hat{\beta} * \frac{\Delta BBPCT}{BBPCT_{1999}} = -2.185 * 0.231 / 0.7557 = -0.6679$ %, indicating that teen births fall by 0.6679 % with a 30.5 % increase in broadband over the period.

[24] We compute the percentage change in teen births over the period as follows: % change in teen births over the period: $(46.83483 - 51.78337) / 51.78337 = -9.556$ %. We find that $(0.6679) / 9.556 = 6.9893$ % or about 7 % of the drop in teen births over the period can be explained by broadband expansion.

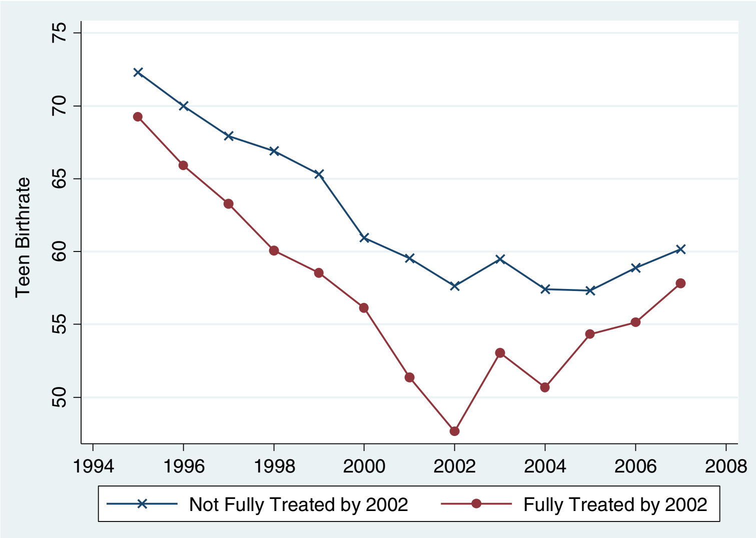


Fig. 2 Teen birth rate trends in counties with low percentage of providers in 1999 (source: see notes to Table 1, Summary statistics). Counties represented have less than 10 % broadband penetration in 1999. Plotted values represent annual mean teen birth rates in counties with greater than 98 % broadband penetration in 2002 (fully treated) or otherwise (not fully treated)

(explaining 24.3 % of the decline) due to MTV's Teen Mom television program in the late 2000s (Kearney and Levine 2015b). Our estimate is also smaller than the 5.6 % drop in teen births (explaining 12.6 % of the decline) due to public family planning and welfare programs over the period 1991–2010 (Kearney and Levine 2015a).

The results reported in columns (3) through (6) examine the impact of broadband availability for metropolitan and non-metropolitan counties. Examining each area separately, we see suggestive evidence of drops in the teen birth rate for both types of counties and that these drops appear larger in magnitude for the metropolitan counties. We find, however, that our estimates are not statistically different for these counties.[25] [26] In Table 3, we examine whether the results are robust to specifying the outcome variable as a logarithmic function. The estimates suggest that the drop in the teen birth rate is similar, although some statistical significance is lost.

In results not presented in the tables, we replace the measure of the overall teen birth rate with birth rates by race and ethnicity (White or Black and Hispanic origin).[27] Consistent with our main results, we estimate declines in the teen birth rate across all groups and coefficient estimates that are larger in magnitude for metro areas; they are also larger for Black teens

[25] For the full sample, we estimate a specification similar to that used to produce the estimates in Table 2, but where we include an interaction of BBpct and the metro indicator. No coefficient estimates for these interactions are statistically significant, suggesting that the effects are not different for metro versus non-metro counties.

[26] In an additional set of analyses not presented in the tables, we re-estimated the birth rate regressions omitting the county-specific linear time trends. The coefficient estimates within metro or non-metro areas are similar in magnitude to those in the baseline specification. However, for the estimates that are statistically significant, the standard errors are smaller when the county- specific trends are omitted, suggesting that including trends is the more conservative approach and the approach that we have chosen to take throughout the paper.

[27] Results are available upon request.

Table 2 Estimates of the impact of broadband diffusion on the teen birth rate

BBPCT	(1)	(2)	(3)	(4)	(5)	(6)
	−2.267**	−2.185**	−1.226	−1.213	−3.829	−3.956
	(1.058)	(1.075)	(1.158)	(1.171)	(2.469)	(2.548)
Estimation sample	Full	Full	Non-metro	Non-metro	Metro	Metro
County fixed effects	x	x	x	x	x	x
Year fixed effects	x	x	x	x	x	x
County linear trends	x	x	x	x	x	x
County covariates		x		x		x
Observations	22,887	22,496	15,678	15,512	7209	6984

Robust standard errors (in parentheses) are clustered by county to account for possible serial correlation. All regressions are weighted by the total county population. The dependent variable is the teen birth rate, which is the number of births to teens aged 15 to 19 divided by the population of female teens aged 15 to 19 per thousand in the county of interest. BBPCT is the percentage of county zip codes that has a provider. The metro sample contains counties classified as metropolitan counties according to the USDA's 1993 rural-urban continuum. The county covariates include the population density, the unemployment rate, the county personal income per capita, the percentage White, the percentage Hispanic, the percentage of the population with a BA degree, county-by-year expenditure on Medicaid, Supplemental Security Income (SSI), Temporary Assistance to Needy Families (TANF), Supplemental Nutritional Assistance Program (SNAP), and a summary measure of county expenditure on other income maintenance benefits. Louisiana and Hawaii are omitted from the analysis

**Indicates statistical significance at the 0.05 level

Table 3 Estimates of the impact of broadband diffusion on the natural log of the teen birth rate

BBPCT	(1)	(2)	(3)	(4)	(5)	(6)
	−0.026	−0.028	−0.013	−0.015	−0.031	−0.030
	(0.023)	(0.023)	(0.025)	(0.025)	(0.064)	(0.066)
Estimation sample	Full	Full	Non-metro	Non-metro	Metro	Metro
County fixed effects	x	x	x	x	x	x
Year fixed effects	x	x	x	x	x	x
County linear trends	x	x	x	x	x	x
County covariates		x		x		x
Observations	22,887	22,496	15,678	15,512	7209	6984

Robust standard errors (in parentheses) are clustered by county to account for possible serial correlation. All regressions are weighted by the total county population. The dependent variable is the teen birth rate, which is the number of births to teens aged 15 to 19 divided by the population of female teens aged 15 to 19 per thousand in the county of interest. BBPCT is the percentage of county zip codes that has a provider. The metro sample contains counties classified as metropolitan counties according to the USDA's 1993 rural-urban continuum. The county covariates include the population density, the unemployment rate, the county personal income per capita, the percentage White, the percentage Hispanic, the percentage of the population with a BA degree, county-by-year expenditure on Medicaid, Supplemental Security Income (SSI), Temporary Assistance to Needy Families (TANF), Supplemental Nutritional Assistance Program (SNAP), and a summary measure of county expenditure on other income maintenance benefits. Louisiana and Hawaii are omitted from the analysis

**Indicates statistical significance at the 0.05 level (irrespective of Hispanic ethnicity). However, none of the estimates are statistically significant. This is perhaps due to the decrease in sample size as we are restricted to counties that report births for teens in these demographic sub-groups.

One concern is that even with a rich set of observable covariates included in the baseline regression (as well as county and year effects), we may still be estimating a spurious relationship between teen births and broadband. If so, then, we should find similar estimates when examining teen births from a slightly earlier period, since teen births have been declining at a fairly steady rate since the early 1990s. To explore this possibility, we conduct a type of falsification test in which we examine the relationship between teen birth rates lagged 3 ($i=4$) and 4 years ($i=5$) along with the current-year *BBpct* using a model similar to our main specification:

$$Y_{c(t-i+1)} = \beta_0 + \beta_1 BBpct_{ct} + \gamma_c + \tau_{(t-i)} + \delta_{c(t-i)} + \varepsilon_{ct}$$

Results from the falsification exercise are presented in Table 4. Column (1) presents the full sample estimates, while those in columns (2) and (3) show the non-metro and metro results, respectively. Current-year *BBpct* has no statistically significant impact on a 3- or 4-year lag of the teen birth rate in any of the specifications. In addition, the magnitude of the coefficients on *BBpct* is comparatively small. Together, this exercise suggests that our results are not simply picking up a spurious correlation between broadband and teen births but, instead, indicate that teen birth rates actually decline as counties adopt broadband.[28] Next, we explore possible mechanisms for the observed drop in births.

9 Mechanisms

The forthcoming discussion focuses on a number of potential mechanisms through which broadband diffusion might influence teen birth rates. First, we examine other teen outcomes related to sexual activity. We begin by examining whether teen abortion rates changed in response to broadband diffusion. Such an outcome is important to study in light of the fertility decision tree discussed earlier, in which an increase in the abortion rate may provide one explanation for why the teen birth rate has fallen. Table 5 provides results from regressions of the county abortion rate on *BBpct*. The coefficient estimates are quite mixed in terms of sign, are never statistically significant, and are fairly small in magnitude. While we cannot rule out positive or negative effects, a tentative conclusion is that broadband diffusion did not influence teen abortion behavior, which implies that the reduction in the teen birth rate occurred through other channels. One drawback of the county abortion rates is that they are not specifically teen abortion rates. This measurement error may attenuate estimates of the true relationship between broadband access and teen abortions.[29]

[28] For these regressions, the analysis sample is somewhat smaller relative to our main analysis sample (see Table 2) since some counties in our original sample do not have teen birth information for the mid-1990s. In results not reported in the paper, we show that the reduction in the sample size does not appear to be driving the results.

[29] We would prefer to create an age-specific abortion rate at the county level. Unfortunately, to our knowledge, only the total number of abortions is collected at the county level (and not the number of abortions by age). However, we use two different county population denominators when creating the measure: females aged 15 to 19 and females aged 15 to 44. While our coefficients change from one denominator to another, our qualitative findings are robust to choice of denominator. In the main analysis tables, we use the county female population aged 15 to 44 as the denominator, as this reflects the population likely representing the total number of abortions in a county in a given year.

Table 4 Current broadband provider influence on past teen births, 1999–2007

	(1)	(2)	(3)
3-year lag of teen birth rate			
BBPCT	−1.083(2.562)	−0.881 (1.016)	−0.614 (1.047)
4-year lag of teen birth rate			
BBPCT	−0.033 (2.821)	0.708 (1.068)	1.226 (1.115)
Estimation sample	Metro	Non-metro	Full
Observations	7277	15,791	23,068

Each column represents a separate regression. The dependent variable is the county's teen birth rate lagged by the respective year. All regressions contain county and lag-year fixed effects and county-specific lag-time trends. Louisiana and Hawaii are omitted from the analysis

Next, Table 6 reports estimates of the relationship between the county gonorrhea rate (number of cases per 100,000 individuals in the county) and broadband access. The coefficients in columns (1) and (2) are both negative, which is consistent with declining gonorrhea rates due to the roll-out of broadband. The estimates for non-metro [columns (3) and (4)] versus metro [columns (5) and (6)] suggest that this might be driven by drops in non-metro counties. Overall, these estimates are consistent with a decline in the incidence of STIs over the period 1999 to 2007, although we are cautious about this interpretation, given the lack of statistical significance of the estimates. Assuming that there is a drop in STIs, it could be due to a drop in sexual activity or an increase in the use of methods of contraception that also deter STIs or both, which we attempted to address in a state-level analysis.[30]

In results not reported in the paper, we explore a number of teen risky behaviors using data available at the state level.[31] Specifically, we use the Youth Risk Behavior Survey to examine whether a teen is currently sexually active, has ever had sex, and, if sexually active, whether contraception was used at last sex.[32] We also use CDC reports of state teen gonorrhea rates to examine state-level teen STI.[33] Our state estimates, while generally statistically insignificant, are signed in ways that suggest that increasing broadband access decreases the percentage of teens considered sexually active or who have ever had sex and using a method at last sex. In addition, we find that estimates for state teen gonorrhea rates are negatively signed, consistent with the county gonorrhea estimates.

Finally, we consider the roles of education and labor market conditions as potential moderators of broadband effects. If broadband access augments the dampening effects of education on teen fertility, then we would expect greater reductions in teen fertility in counties with higher educational engagement within the teen population. Additionally,

[30] It should also be noted that Sabia and Rees (2012) show that educational attainment drops as the number of sex partners increases. If broadband access is contributing to a drop in sexual activity and, hence, a drop in sexual partners, then it may also be leading to higher educational attainment for the affected teens.

[31] Results are available upon request.

[32] Only nine states report information on the variables of interest throughout our study period. The states are as follows: Delaware, Massachusetts, Michigan, Missouri, Montana, Nevada, South Dakota, Wisconsin, and Wyoming.

[33] We obtain state-level teen gonorrhea rates from the CDC's ATLAS tool for the period 2000 to2007. http://gis.cdc.gov/GRASP/NCHHSTPAtlas/main.html accessed February 19, 2015.

Table 5 Estimates of the impact of broadband diffusion on the abortion rate

	(1)	(2)	(3)	(4)	(5)	(6)
BBPCT	0.002	−0.070	−0.021	−0.086	0.083	0.226
	(0.302)	(0.293)	(0.319)	(0.327)	(0.920)	(0.900)
Estimation sample	Full	Full	Non-metro	Non-metro	Metro	Metro
County fixed effects	x	x	x	x	x	x
Year fixed effects	x	x	x	x	x	x
County linear trends	x	x	x	x	x	x
County covariates		x		x		x
Observations	16,821	16,453	11,205	11,053	5616	5400

Robust standard errors (in parentheses) are clustered by county to account for possible serial correlation. All regressions are weighted by the total county population (SEER). The dependent variable is the county abortion rate (number of abortions per 1000 women aged 15 to 44) for the 33 states with county information over the period 1999 to 2007. BBPCT is the population-weighted percentage of county zip codes that has a provider. The metro sample contains counties classified as metropolitan counties according to the USDA's 1993 rural-urban continuum. The county covariates include the population density, the unemployment rate, the county personal income per capita, the percentage White, the percentage Hispanic, the percentage of the population with a BA degree, county-by-year expenditure Medicaid, Supplemental Security Income (SSI), Temporary Assistance to Needy Families (TANF), Supplemental Nutritional Assistance Program (SNAP), and a summary measure of county expenditure on other income maintenance benefits

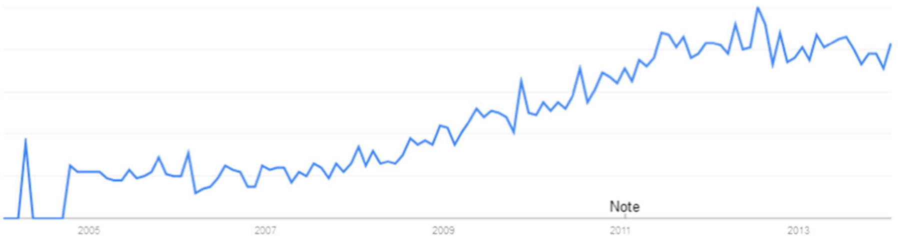
improved labor market opportunities present with the expansion of broadband may interact with teen fertility decisions. In results not reported, we do not find statistically

Table 6 Estimates of the impact of broadband diffusion on the gonorrhea rate, 1999–2007

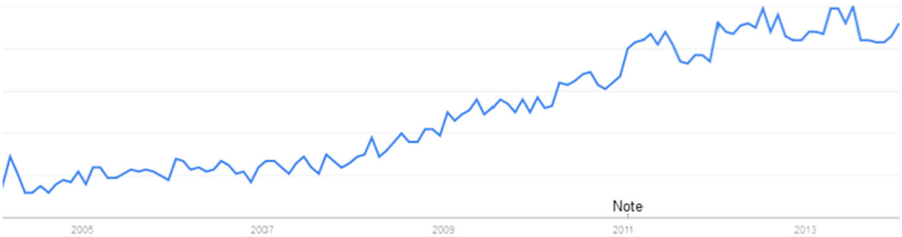
	(1)	(2)	(3)	(4)	(5)	(6)
BBPCT	−10.980	−9.703	−9.531	−8.506	1.387	0.483
	(9.906)	(10.097)	(10.485)	(10.655)	(35.831)	(38.775)
Estimation sample	Full	Full	Non-metro	Non-metro	Metro	Metro
County fixed effects	x	x	x	x	x	x
Year fixed effects	x	x	x	x	x	x
County linear trends	x	x	x	x	x	x
County covariates		x		x		x
Observations	8894	8561	5130	5004	3764	3557

Robust standard errors (in parentheses) are clustered by county to account for possible serial correlation. All regressions are weighted by the total county population (SEER). The dependent variable is the county gonorrhea rate (cases per 100,000 of county population) as computed by the Center for Disease Control (CDC) for the counties in the 30 states reporting county information to the CDC from 1999 to 2007. BBPCT is the population-weighted percentage of county zip codes that has a provider. The metro sample contains counties classified as metropolitan counties according to the USDA's 1993 rural-urban continuum. The county covariates include the population density, the unemployment rate, the county personal income per capita, the percentage White, the percentage Hispanic, the percentage of the population with a BA degree, and county-by-year expenditure of Medicaid, Supplemental Security Income (SSI), Temporary Assistance to Needy Families (TANF), Supplemental Nutritional Assistance Program (SNAP), and a summary measure of county expenditure on other income maintenance benefits

(a) U.S. Google Searches for “should i have sex…”, 2004-2014



(b) U.S. Google Searches for “does the pill…”, 2004-2014



(c) U.S. Google Searches for “best condoms”, 2004-2014

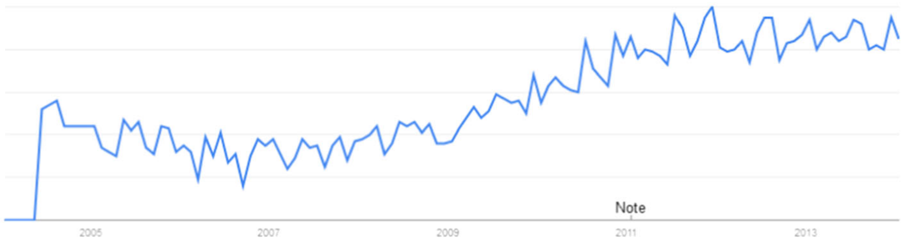


Fig. 3 **a** US Google searches for “should i have sex…,” 2004–2014. **b** US Google searches for “does the pill…,” 2004–2014. **c** US Google searches for “best condoms,” 2004–2014. **d** US Google searches for “does sex cause…,” 2004–2014. **e** US Google searches for “will I get pregnant…,” 2004–2014. **f** US Google searches for “boyfriend cheating,” 2004–2014. The *top line* in each figure represents a search volume score of 100, while the *bottom line* indicates a search volume score of 0. Note that in each figure, the Google Trends hits 100 at some point, which denotes the point in time at which the search volume for a given phrase reached its peak within the 2004–2014 period. Thus, all other numbers indicate the search volume at a particular point in time relative to its peak volume

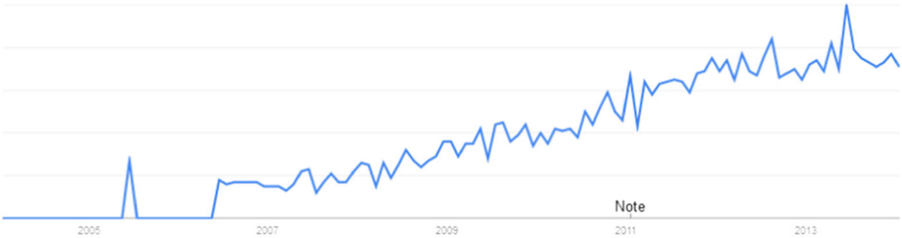
different effects for counties with above- and below-median high school enrollment rates or for counties with above- and below-median unemployment rates.[34]

10 Discussion and conclusion

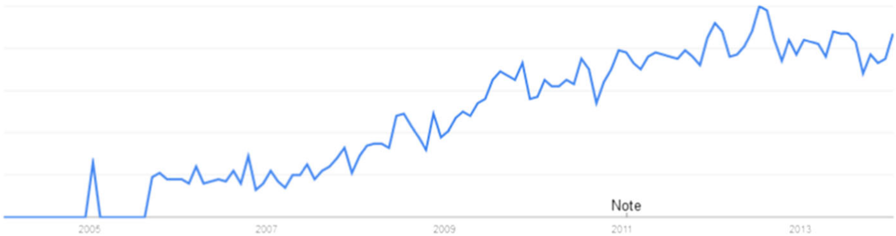
The decline in the US teen birth rate has continued virtually unabated since the early 1990s. As a result, investigations such as that conducted by Kearney and Levine (2015a, 2015b) attempt to understand the factors underlying this dramatic decline. Although Kearney and Levine (2015a) note that the reduction is explained by a decline

[34] Results available upon request.

(d) U.S. Google Searches for “does sex cause…”, 2004-2014



(e) U.S. Google Searches for “will i get pregnant…”, 2004-2014



(f) U.S. Google Searches for “boyfriend cheating”, 2004-2014

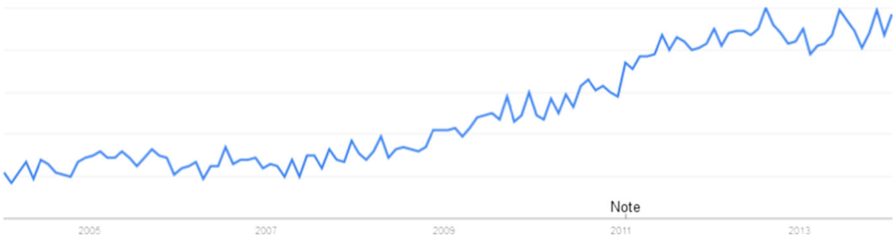


Fig. 3 (continued)

in teen sexual activity and the increased use of contraception, it remains unclear as to what is driving these emerging teen behaviors. This paper proposes and tests a novel explanation for the reduction in the teen birth rate: the rapid diffusion of high-speed broadband internet.

At the start of the twenty-first century, broadband internet was used by a very small number of US households. Today, however, such an internet connection is the norm within most homes. Broadband internet has the potential to shape in powerful ways the nature and intensity of individuals’ social connections as well as the quantity and quality of information received on relationships and sexual health. Indeed, as shown in Fig. 3a–f, Americans are increasingly turning to the internet for a wide range of advice on romantic relationships, sex, and contraceptive methods. These figures show the volume of US Google searches between (January) 2004 and (January) 2014 that contain various phrases. Americans—including teens—are asking for guidance on everything from whether they should have sex with a certain individual and the most effective forms of contraception to how to deal with a cheating boyfriend. Teens, who now spend more time engaging with various forms of media—much of it online—than any other activity (aside from sleep) (Rideout et al. 2010), are particularly well positioned to take advantage of new information and relationship landscape created by explosion in broadband internet.

The purpose of this study is to examine whether increases in the number of broadband providers influence teen fertility. We posit that the increased availability of information influenced the teen birth rate, but in a potentially ambiguous direction. Our empirical analysis suggests that teen birth rates declined with the greater access to information due to broadband access, and our estimates suggest that at least 7 % of the total decline in the teen birth rate between 1999 and 2007 can be explained by increases in high-speed internet access. We hypothesize that a decline in births could be due to changes in sexual activity, contraception use, abortion, or some combination. Although our evidence on risky behavior is too weak to draw definitive conclusions regarding mechanisms, our estimates of a decrease in STIs at the county level are consistent with decreases in sexual activity as well as increases in contraceptive use. We do not find statistically significant evidence that broadband access leads to changes in abortion, though we caution that the count of abortions includes all individuals, including non-teens, which makes it a noisy measure of teen activity.

Our estimates revealing declines in the teen birth rate due to broadband are congruent with other recent studies on the teen fertility effects of new media. Kearney and Levine (2015b), for example, find that the MTV show 16 and Pregnant led to a 4.3 % decline in teen births in the 18 months after the show's debut. Our results suggest a smaller effect—approximately 0.67 % over 8 years—but show that the effects of new media are present during an intermediate period of the growth in access to digital media in the US. Additionally, although not tested in this paper, we suggest that access to the internet through even slow-speed connections during the 1990s may have had a dampening effect on teen fertility.

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