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Does Broadband Internet Affect Fertility?*

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Abstract

The spread of high-speed Internet epitomizes the digital revolution, affecting several aspects of our life. Using German panel data, we test whether the availability of broadband Internet influences fertility choices in a low-fertility setting, which is well-known for the difficulty to combine work and family life. We exploit a strategy devised by Falck et al. (2014) to obtain causal estimates of the impact of broadband on fertility. We find positive effects of high-speed Internet availability on the fertility of high-educated women aged 25 and above. Effects are not statistically significant both for men, low-educated women, and under 25. We also show that broadband access significantly increases the share of women reporting teleworking or part-time working. Furthermore, we find positive effects on time spent with children and overall life satisfaction. Our findings are consistent with the hypothesis that high-speed Internet allows high-educated women to conciliate career and motherhood, which may promote fertility with a "digital divide". At the same time, higher access to information on the risks and costs of early pregnancy and childbearing may explain the negative effects on younger adults.

JEL Codes: J11, J22

Keywords: Internet, Low Fertility, Work and Family, Teleworking.

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1 Introduction

The rapid diffusion of the Internet, and in particular of high-speed, broadband Internet, has characterized the digital revolution that has modified lives at the beginning of the Twenty-First Century. The profound social and economic implications of the spread of the Internet have been underlined since its inception by social science scholars (Di Maggio et al., 2001; Castells, 2002). More recently, researchers have also started to focus on the effect that the Internet has on family life, both in terms of daily schedules and of longer-term effects. Views and hypotheses have been diverse: for instance, the Internet has been portrayed as a disruptive technology that threatens more traditional family life (Conley, 2009); as the emerging and potentially universalistic new social intermediary in the search for partners (Rosenfeld and Thomas, 2012); as a technology that allows spill-overs from work to family life, but also vice-versa (Wajcman, 2014).

Scholars interested in family and fertility have long been focused on the importance of technological change. Ester Boserup's theory of the demographic transition emphasizes the crucial importance of (endogenous) technological shifts in population change (Boserup, 1976). Shifts in contraceptive technology have been seen as the precondition for the massive reproductive changes taking place in high-income societies during the last section of the Twentieth Century, i.e., the "Second Demographic Transition" (Lesthaeghe, 2010), and the massive increase in women's education and labor force participation (Goldin and Katz, 2002). Other sources of technological change affecting family life, and fertility decisions, as well as the labor force participation of women, have been household appliances (Greenwood et al., 2005; de V. Cavalcanti and Tavares, 2008), and medical advances (Albanesi and Olivetti, 2016). Household appliances, in particular, are seen as the "engines of liberation" that allow both partners to work for the market, and in principle to have fewer constraints in fertility choices.

In the era of very low and lowest-low fertility (Kohler et al., 2002; Billari and Kohler, 2004), the possibility to combine parenthood with work has become a central issue (Morgan and Taylor, 2006; Balbo et al., 2013). During the "first half" of the gender revolution, in particular, the opportunities for women to combine market work and family responsibilities are central in preventing the fall to lowest-low fertility (McDonald, 2000; Goldscheider et al., 2015). The discussion on low fertility, however, has not so far focused on the role of broader technological change and how it could shape the future of fertility, with the digital revolution epitomizing such technological change. An overarching research question is therefore the following: Can broadband Internet be seen as an "engine of liberation" that allows individuals to realize fertility desires and to combine work and family? If this is the case, and if we assume that desired fertility is higher than realized fertility in low fertility societies (Goldstein et al., 2003; Philipov, 2009), we expect broadband Internet to be linked to higher fertility levels in high-income, low fertility societies.

In this paper, we address this overarching question by analyzing the impact of the diffusion of high-speed Internet on fertility choices in a low-fertility setting, Germany. Our analyses are driven by theoretical considerations on the potential mechanisms linking the spread of broadband Internet to fertility. Related empirical studies have focused on the effect of the Internet on U.S. marriage rates (Bellou, 2015), teen fertility (Guldi and Herbst, 2017), and the labor force participation of married women (Dettling, 2017a). Our contribution to the literature is therefore threefold. First, to the best of our knowledge, this is the first paper to comprehensively assess the impact of broadband Internet on women and men of all ages. Examining the heterogeneity of the effects across age and education groups enables us to provide further insights on the mechanisms. Second, differently from previous studies (Guldi and Herbst, 2017; Billari et al., 2017), we use a novel instrumental variable (IV) strategy that allows us to investigate the causal effects of broadband technology on fertility. Third, we focus on a very different context. While other studies focus on the US, this paper analyzes a country such as Germany where the total fertility rate fell well below the replacement rate dipping as low as 1.2, and is now fairly stable at 1.35 (Haub, 2012).

In our analyses, we use data from the German Socio-Economic Panel (SOEP), a longitudinal panel dataset about the German population containing information on a rich set of individual socio-economic characteristics. These data are uniquely suited for the purpose of studying the effect of broadband diffusion on fertility. First, they contain retrospective life course information, including fertility histories. This information is used to construct our fertility outcomes, and for this reason the SOEP has been used in a number of studies on fertility in Germany (Hank, 2002; Hank and Kreyenfeld, 2003; Hofmann and Hohmeyer, 2013; Ziefle and Gangl, 2014; Bremhorst et al., 2016; Eibich and Siedler, 2016). Second, our data not only collect household information on whether Internet access is available, but also data on whether Internet access is based on a broadband (DSL) technology. This information is exploited to build our key explanatory variable. Lastly, the SOEP also contains rich information on individual life courses and conditions, including work from home, labor market behavior, time spent on childcare and life satisfaction, thereby enabling us to shed light on the potential mechanisms through which high-speed Internet access may affect fertility.

The identification of a causal effect of broadband Internet use is complicated by endogeneity concerns. Access to high-speed Internet is likely to be correlated with many unobservable determinants of fertility (e.g., unobserved socioeconomic determinants of fertility, regional characteristics, differences in time preferences), which may confound the main relationship of interest, i.e. whether the diffusion of high-speed Internet technology is affecting fertility. To address these concerns regarding endogeneity caused by omitted variables, we follow the strategy adopted by Falck et al. (2014), and employ an IV approach that exploits unique historical and technological peculiarities of the public telephone infrastructure across Germany. These peculiarities have produced large and plausibly exogenous variation in the diffusion of DSL technology throughout the country.

An additional source of concern is reverse causality. It is possible that parenthood leads individuals to seek DSL connection, rather than vice versa. This concern may arise if we look at the contemporaneous effect of DSL access on fertility. However, the fact that our instrument predates the observed fertility behavior and that we use the longitudinal dimension of our sample to analyze the impact of DSL access on subsequent fertility outcomes allows us to rule out reverse causality issues.

We find that DSL access increases fertility of 25-45 aged women. These results are largely driven by highly-educated women. Our findings suggest that the increase in fertility mostly reflects an increase in the probability of progressing to a second or higher-order child. Instead, we find negative effects of DSL access on fertility below age 25 and on low-educated individuals, though these effects are not precisely estimated. Reassuringly, our results are robust to several sensitivity checks. In the second part of our analysis, we exploit the breadth of our survey data to explore the potential mechanisms underlying these findings. In particular, we show that DSL availability increases the likelihood of teleworking, promotes part-time work and increases time spent on child-care of high-educated women. Consistent with our "engine of liberation" hypothesis, i.e., that these effects may relax the work-family trade-off, we also find positive impacts on life satisfaction for high-educated women.

The remainder of this paper is organized as follows. Section 2 provides the theoretical and empirical background and the main hypotheses of this study. Section 3 presents a description of the context and the data we use. Section 4 discusses the identification strategy and empirical model. The main results of the paper are reported in Section 5, which also includes a set of robustness checks. The potential mechanisms linking broadband Internet access and fertility are discussed in Section 6. In section 7 we conclude and discuss the implications of our findings.

2 Does Internet Matter for Fertility? Background and Main Mechanisms

An extensive social science literature has analyzed the determinants of fertility decisions in low fertility settings (Morgan and Taylor, 2006; Balbo et al., 2013). As a pervasive innovation that affects all realms of society, the Internet is likely to affect several behaviors. How could the Internet in general, and broadband Internet more specifically, possibly affect fertility? Taking into account the relevant literature, we now discuss three potential mechanisms through which this effect could take place, and the implications for testing empirically the relationship, once a plausible causal link has been established.

First, the Internet provides access to unprecedented information about contraceptive behaviors and about the possible life course consequences of the choice to become (or not to become) a parent. Differently from traditional one-directional media, the Internet may enforce social interaction processes that have been seen as important channels in shaping fertility decisions through social learning and/or social influence (Bongaarts and Watkins, 1996; Kohler, 2001; Kohler et al., 2001; Bernardi et al., 2007; Balbo and Barban, 2014). In addition to research on higher fertility settings (La Ferrara et al., 2012), there have been contributions highlighting the role of traditional media in shaping teen fertility in lower fertility settings. Kearney and Levine (2015) study the MTV franchise *16 and Pregnant*, a series of reality TV shows also including the *Teen Mom* sequel, which follows the lives of pregnant teenagers during the end of their pregnancy and early days of motherhood. They investigate whether the show influenced teens interest in contraceptive use or abortion, and whether it ultimately altered teen childbearing outcomes. They find that 16 and Pregnant led to more Google searches and Twitter tweets regarding birth control and abortion, and ultimately led to a 5.7 percent reduction in teen births in the 18 months following its introduction. This accounts for around one-third of the overall decline in teen births in the United States during that period. While these results are in accordance with the findings of Trudeau (2016), they have been challenged in a replication study by Jaeger et al. (2016). Directly relevant for our study are the findings of Guldi and Herbst (2017), who study the effects of broadband Internet roll-out on U.S. teen fertility decisions and focus on understanding how broadband diffusion, by changing the size of the market and increasing the information available to participants, contributed to the observed decline in teen birth rates. Furthermore, Internet may increase the quality and quantity of information on child-care costs and benefits as well as on health and sexual practices. For what concerns the social learning mechanism, it is important to take into account the existence of a "digital divide" in the ability to extract information from the Internet by educational levels (Hargittai, 2010).

Through this first mechanism, we can therefore hypothesize, in line with Guldi and Herbst (2017), that the Internet has a fertility-decreasing impact at lower ages. As a caveat, we might take into account that the setting we study, Germany, has one of the lowest teenage pregnancy rates in the world (Sedgh et al., 2015). This decreasing effect might be reversed at higher ages, if information seeking and social learning are tied to the proactive achievement of higher desired fertility at later ages. One of the features of the hypothesis linked to information seeking is that Internet access *per se* is more relevant than the access to broadband, high-speed Internet.

Second, the Internet may affect the transition to marriage, and more generally the likelihood of finding a partner who is going to become the parent of a joint child (Rosenfeld and Thomas, 2012). As noted by Bellou (2015), the Internet may decrease search costs and increase the offer arrival rate. The arrival of the Internet has partly displaced traditional pathways in partnership formation, such as family and school, but also other pathways such as neighborhoods, the workplace, and the friendship network (Rosenfeld and Thomas, 2012). However, the net impact on marriages, and the total indirect impact on fertility, may be ambiguous as the larger pool may at the same time increase the likelihood of match as well as increase the desired reservation quality of the searcher with respect to potential partners. The Internet may also crowd out time spent with a partner (or searching for a partner) and thus have negative effects on fertility.

In accordance with this second mechanism, we hypothesize that the effect of the Internet on fertility can be mediated via marriage.

Third, high-speed Internet may affect labor force participation and work-family balance (Dettling, 2017b; Wajcman, 2014), allowing individuals to therefore better reconcile work and parenthood. Some recent research has highlighted the role of home production technology and medical progress (Goldin and Katz, 2002; Greenwood et al., 2005; Albanesi and Olivetti, 2016) in facilitating the balance between female labor force participation and fertility choices. Similarly, access to high-speed Internet can relax time-constraints helping individuals to conciliate work and parenthood. By allowing individuals to work remotely, access to high-speed Internet can reduce commuting times, reduce absenteeism and increase productivity, and more importantly for our purposes, it can reduce child-care costs and allow individuals to spend more time with their families reducing the non-pecuniary costs of working (Dettling, 2017b). This can be seen as particularly relevant for high-educated individuals, who can potentially work in occupations for which telework is possible. It also relies on broadband Internet, rather than any Internet access, as it presupposes reliable and stable connections. Moreover, it might be more relevant for women in their 30s, as they are under more pressure in terms of work-family balance than men, being in their "rush hour of life" (Bittman and Wajcman, 2000; Buber-Ennser et al., 2013). With regard to this latter mechanism, Germany represents an interesting case study, since compared to other European countries, the proportion of individuals working from home has remained low (Brenke, 2016).

For this third mechanism, we expect broadband Internet to be positively related to fertility. We expect this effect to be present in particular for high-educated individuals, for women, and for higher reproductive ages. Furthermore, we expect that if the mechanism underlying the positive relationship between broadband Internet and fertility is the facilitation of the work-family balance, broadband may have limited effects on the decision of whether having children or not (extensive margin), but larger effects on the probability of having a second or higher-order child (intensive margin).

3 Data

We draw our data from the SOEP, which is a household panel survey containing information on approximately 12,000 households and more than 20,000 individuals starting from 1984 in West Germany, and from 1990, after German reunification, in East Germany. Each household member above the age of 16 is asked questions annually. The SOEP consists of several subsamples and is constructed to ensure the representativeness of the entire population in Germany. A unique feature of this data source lies in its wide range of information at the individual and household level, including, for instance, socio-economic characteristics, labor market outcomes, and health-related measures. For a detailed description of the survey, see Wagner et al. (2007).

The SOEP data contain a number of features that make them particularly attractive for the present analysis. First, they collect retrospective information on many dimensions of the life histories of respondents, including fertility histories. We use this information to create our main outcome of interest: the probability of a child being born in a given year.

Second, our dataset provides information on Internet access. Of particular importance for our study is the fact that the 2008 SOEP wave for the first time provides not only household information on whether Internet access is available, but also data on whether Internet access is based on a DSL technology. The availability of such information is essential because it allows for the analysis of the effects of high-speed Internet. Therefore, our key explanatory variable is a dummy variable that indicates whether a household has a DSL connection. As noted by Falck et al. (2014), in 2008 the DSL technology was still in its initial phase of development across Germany. As a result, our analysis identifies the effects of the introduction of broadband Internet.

Third, our dataset contains information on individual labor market behavior; whether individuals are working from home; how many hours they spend on childcare during a normal weekday/Saturday/Sunday; life satisfaction; and marital histories. Since we hypothesize that the diffusion of DSL technology improves work-family balance, these variables enable us to shed some light on the potential mechanisms through which broadband Internet use affects fertility. In particular, our indicator of working from home is a dummy variable taking value one if the employee reported any work from home, and zero otherwise. We analyze employment status by constructing three binary variables that indicate whether *(i)* the individual works full-time, *(ii)* the individual works part-time, *(iii)* he/she is not working at the time of the interview. We also examine the relationship between broadband and hours worked. To test the marriage channel hypothesized by Bellou (2015), we exploit information on the year of marriage, and build a dummy taking value one (and zero otherwise) if the individual got married in a given year. Finally, we construct an indicator variable taking value one (and zero otherwise) if the respondent has a life satisfaction higher than the median (8 out of 10 points) as an indicator of high life satisfaction.

Our working sample is constructed as follows. We consider the survey years 2008-2012, and restrict attention to individuals aged 17-45 during the years in which outcomes were measured. Moreover, we constrain the analysis to observations with non-missing data on fertility, DSL access and our main covariates. After these restrictions, we obtain a final longitudinal sample that contains 34,495 person-year observations resulting from 17,467 individuals. Table 1 reports descriptive statistics on the main variables used in the analysis. About 7% of individuals in the sample report a birth in a given year. Approximately 21% of individuals are working from home, and the majority of them are working full-time, although about 26% are not working at all. On average, individuals spend about 3.3 hours on childcare per weekday and 5.4 hours at weekends. They are 34 years old on average, about 82% have a DSL subscription at home, approximately 33% have received an academic secondary school track (*Abitur*) and close to 34% have obtained at most an intermediate track education (*Realschulabschluss*). Throughout the paper, we define as high-educated those individuals with intermediate secondary education and academic secondary school tracks.[1] It is worth mentioning that the German secondary school system is traditionally structured as a tracked system. A detailed description of the German school system can be found in Jonen and Eckardt (2006).

[Table 1 - around here]

In Figures 1 and 2, we analyze age differences in the fertility behavior among high-educated and low-educated individuals, respectively. Overall, the pattern that emerges is that broadband

[1] We define as low-educated those individuals in the residual category, which includes individuals with lower-secondary education (*Hauptschulabschluss*), as well as individuals who left school without the certificate or are still in school. However, the results remain intact if only the individuals with lower-secondary education are included.

Internet access at home is positively correlated with the probability of a child birth, but only among high-educated individuals older than 25. However, it is not clear whether this correlation is driven by selection on unobservables or whether it is capturing a causal effect. In what follows, we employ an IV identification strategy to investigate whether DSL availability has causally increased fertility.

[Figures 1 and 2 - around here]

4 Empirical Methodology

4.1 Model Specification

Our main working model is an annual linear probability model for child birth:

$$Y_{ist} = \alpha + \beta DSL_{ist} + \gamma X_{ist} + \mu_t + \eta_s + \lambda_s^1 t + \varepsilon_{ist} \tag{1}$$

where the index ist denotes an individual i residing in state s at the year of interview t. The outcome variable Y_{ist} represents the probability of a child birth of individual i.

Our variable of interest is DSL_{ist}, defined as a dummy variable taking value one if the individual has a DSL subscription, and zero otherwise. Thus, the treatment effect β denotes whether fertility increases for individuals with a DSL subscription. Model (1) contains survey year fixed effects (μ_t) to account for possible trends in fertility behavior. We also include a full set of federal state fixed-effects (η_s) to control for unobservable, time-invariant differences across states that may influence fertility,as well as a set of linear state-specific time trends $(\lambda_s^1 t)$, to control for unobserved cross-state differences in fertility over time. X_{ist} is a vector of individual covariates that may affect fertility. Specifically, we include gender, age and age squared, a set of secondary school track effects (basic, intermediate or academic track), indicators for marital status, occupational status, migration background, a dummy indicating the ownership of a house or flat, and the logarithm of net household income. Finally, ε_{ist} represents a disturbance term.

The need for an identification strategy arises from the potential correlation of high-speed Internet with various unobservable determinants of fertility (including, for instance, unobserved socioeconomic factors, regional characteristics, heterogeneity in time preferences). Such correlation may confound our relationship of interest. For example, one obvious concern might be that richer and better educated households may be more willing to pay for DSL subscription at home, and this may induce telecommunication carriers to strategically deploy DSL infrastructure in areas with higher average income. Moreover, richer individuals may be systematically different from the rest of the population in terms of their fertility behavior. While we are able to control for a large set of observed background characteristics to address this concern, there may still be unobserved confounders, which would bias our estimates of β. To circumvent this endogeneity concern caused by omitted variables, we employ an Instrumental Variable (IV) identification strategy based on the geography and history of the layout of the preexisting telephone infrastructure across Germany, detailed in the next subsection.

One additional source of concern may be reverse causality. Families with young children may seek DSL access to conciliate parenthood and work. However, this concern is mitigated by the fact that we rely on an instrument that pre-dates the fertility behavior under study and that we exploit the longitudinal dimension of the data to analyze the impact of DSL availability on subsequent fertility outcomes over the period 2008-2012.

4.2 Identification Strategy

To address the concern regarding endogeneity of broadband Internet use, we follow the identification strategy adopted by Falck et al. (2014) to study the effects of DSL access on voting behavior. Their main idea is to exploit historical variation in pre-existing telephone infrastructure which significantly affected the cost of broadband adoption across Germany. In particular, Falck et al. (2014) exploit three unique historical and technological peculiarities of the traditional public telephone network, which influenced the deployment of DSL in German municipalities.[2] A crucial cost factor to enable DSL connection is the distance between a household and the main distribution frame (MDF). For technical reasons, when the distance is larger than approximately

[2] See Falck et al. (2014) for a full and detailed description of the variation in the diffusion of DSL technology across municipalities throughout the country. Importantly, the authors argue that high-speed Internet subscriptions in Germany are almost exclusively based on DSL technology.

4,200 meters, DSL technology becomes substantially more costly unless households can be connected to an alternative MDF situated in the close vicinity.

Following Falck et al. (2014), we construct two household-level binary instruments: the first instrument is equal to one for households with distances to their MDF above the threshold of 4,200 meters, and zero otherwise; the second instrument is equal to one for households above the threshold which could not be connected to another MDF at a distance below 4,200 meters. Finally, a third binary instrument identifies areas in East Germany that adopted the optical access line (OPAL) technology. After reunification, many regions in East Germany lacked a proper telephone network and adopted OPAL, which at the time was the best telephone technology on the market. Yet, a decade later this technology proved to be not compatible with DSL technologies, thereby implying substantially higher costs for DSL connection in these areas. These three instruments provide us with plausibly exogenous variation in DSL availability, which we exploit to identify the causal effects of broadband Internet access on fertility decisions.[3]

Model (1) is estimated using two stage least squares (2SLS), and the first stage regression is given by:

$$DSL_{ist} = \eta + \delta Threshold_{ist} + \theta(No\ closer\ MDF)_{ist} + \sigma OPAL_{ist} + \rho X_{ist} + \mu_t + \eta_s + \lambda_s^1 t + \nu_{ist} \quad (2)$$

where DSL_{ist} is instrumented with $Threshold_{ist}$, an indicator for whether the respondent resides more than 4,200 meters away from their MDF. Similarly, $(No\ closer\ MDF)_{ist}$ is a binary variable identifying those respondents who were more than 4,200 meters away from their MDF, but could be connected to a closer MDF. Our third instrument is given by $OPAL_{ist}$, which indicates whether the respondent resided in an area initially supplied with OPAL technology. X_{ist}, μ_t, η_s, $\lambda_s^1 t$ are defined in the same way as in equation (1). Throughout the analysis, we cluster standard errors by household, the level of variation of our instruments.[4]

[3]As in Falck et al. (2014), to construct these three household-level binary instruments, we used data on the geo-coordinates of the SOEP households, which for confidentiality reasons are available only on-site at the DIW in Berlin.

[4]Our coefficient of interest remains significant when clustering at the municipality or county level.

5 Results

5.1 Main Results

Table 2 reports the estimates of the effects of DSL access on fertility based on the identification strategy previously described. Columns 1 to 3 display the results for the sample of individuals aged 17-45 by gender, whereas columns 4 to 6 and 7 to 9 report the estimates obtained by dividing the sample into two groups: individuals aged 17-24 and those aged 25-45, respectively. In addition, the lower part of Table 2 presents the corresponding results from the first stage regression. As described in the previous section, in each regression we include a set of individual controls, survey year, and state fixed effects, as well as state-specific time trends.

The first stage results show that our instruments are negatively related to DSL availability, and that considering the sample of individuals aged 17 or 25 and above, the F-statistic of excluded instruments varies between 13.66 and 24.03. This confirms that in these two age groups our instruments are good predictors of access to broadband Internet. Moreover, the overidentification test statistics for each of the models reported in Table 2 are far from critical values at conventional significance levels, thereby providing support that the three instruments are jointly valid instruments.

We now move to the examination of the IV results. IV estimates are larger than the OLS estimates (see Table A.1 in the Appendix), suggesting a negative correlation between unobservable determinants of fertility and access to DSL. Another plausible explanation for the fact that the OLS is downward biased is that measurement error in self-reported DSL access may drive our OLS estimate towards zero. A further explanation is that because our instruments do not affect the entire population across local areas, our identification strategy allows us to recover a Local Average Treatment Effect (LATE) instead of averages across the population (ATE). When examining the sample as a whole (see column 1), we find that the coefficient on DSL access is positive but non-significantly different from zero. Interestingly, these average effects mask heterogeneous effects by gender and age. Effects are marginally significant among women (see column 2), while the point estimate is positive but closer to zero among men (see column 3).[5]

[5] The result on men may reflect the fact that we restrict the sample to individuals aged up to 45. This restriction is dictated by our focus on female fertility behavior, yet notably men tend to become parents at an older age than women do. Furthermore, men are less likely to respond to the survey questions on biological children which we used to construct our main fertility outcome. This also reduces the sample size and may explain the loss of precision in the

Furthermore, columns 4 to 6 show no evidence of significant impacts among individuals aged 17-24. If anything, the coefficient on young women is negative, consistent with the findings of Guldi and Herbst (2017). Therefore, this result supports the hypothesis that information and prevention may be the dominant mechanisms for relatively young women.

When considering the individuals aged 25 and above, the treatment dummy on DSL availability becomes positive, with a statistically significant effect (at the 10% percent level) for women (see column 8). For the latter group, access to high-speed Internet implies an increase in the probability of a child birth by 9.3 percentage points, which corresponds to an increase of approximately 0.36 standard deviations. These effects are consistent with the idea that relatively older women may be more responsive to the increase in work-flexibility that may be associated with the possibility of working from home and/or working part-time. Again, there is no evidence of significant effects for men (see column 9). Overall, Table 2 suggests the presence of heterogeneous effects by age group and gender, with the fertility behavior of women aged 25-45 being significantly affected by DSL access at home. We would expect these effects to be larger among high-educated women.

[Table 2 - around here]

To further investigate these differential effects, Table 3 provides the 2SLS estimation results by education group for the individuals aged 25 and above. Consistent with our prior, we find a positive effect of DSL on fertility among the high-educated women (see column 3). On the contrary, the coefficient is not statistically significant and negative among the low-educated. The magnitude of the effect of DSL access for the high-educated women is 12 percentage points, which corresponds to approximately 0.46 standard deviations. The treatment effect remains positive, albeit non-significant (5.4 percentage points), among highly educated men. Thus, the remaining part of the paper will focus only on high-educated women aged 25-45, which is the group mostly affected by the high-speed Internet availability at home.

Our main results are driven by the choice of having a second or higher-order child (see Table A.2 in the Appendix) suggesting that while Internet does not affect fertility choice on the

estimates. However, it is worth noting that in most instances the point-estimate of the effect on men's fertility is not statistically different from the one estimated for women.

extensive margin, it has significant effects on the intensive margin.

[Table 3 - around here]

5.2 Robustness

To assess the robustness of our main results, in Table A.3 in the Appendix we report the sensitivity of our main estimates to the use of different samples or specifications. We focus on our baseline sample: 25-45 years old high-educated women.

First, a possible threat to the validity of our identification strategy arises from the possible endogenous sorting of families across Germany in response to better DSL connections available in a given area. In particular, if families systematically move away, and fertility outcomes are correlated with the household decision to move, this can lead to biased estimates of high-speed Internet. To check that our results are not driven by potential violations of this no-sorting condition, in column 1 we show that the effect of DSL access remains substantially unchanged when we estimate equation (1) excluding from the sample individuals who changed the county of residence during the sample period.[6]

Second, as a placebo test in column 2 we demonstrate that there is no correlation between low-speed Internet and fertility using our instrumental variable approach for the period 2000-2004, which predates the deployment of DSL technology in Germany (see also Bauernschuster et al. (2014)). We also find no significant correlation between our instrumental variables and an index of fertility predictors built estimating the fitted values of a regression of fertility on the observable covariates (results are available upon request).

Third, we show that the main result still holds when we control for the previous number of children, which is a potentially endogenous variable, but is clearly related to subsequent fertility (see column 3).

Fourth, the main result is not affected by the inclusion of regional policy regions (ROR) fixed effects and ROR-specific time trends (instead of federal state fixed effects and state-specific

[6] Results are not affected if we exclude from the sample individuals who changed the zip code or the residential address during the sample period.

time trends), which are meant to control for unobservable, time-invariant differences across 96 regional policy regions throughout Germany (see column 4).

Finally, when aggregating the analysis at the municipality-year level and analyzing the effect of DSL access on fertility rates, the point estimate is smaller but not statistically different from the one obtained in the main analysis (see column 5).

6 Potential Mechanisms

What could be the mechanism underlying the relationship between broadband Internet use and fertility? As discussed in Section 2, the Internet may affect fertility through three main mechamisms: information, marriage, and work-family balance.

To test for the relative role of information, we analyze the OLS relationship between low-speed Internet and fertility.[7] In fact, while working from home may require high-speed Internet, one could still obtain information having access to a low-speed Internet connection. The OLS estimates displayed in Table A.4 in the Appendix suggest that information plays a limited role in explaining the positive effects of broadband on fertility. There is no significant relationship between access to low-speed Internet and fertility and, if anything, the coefficient on high-educated women aged 25-45 is negative (coef.: -0.001; std. err.: 0.006).

Broadband Internet access may affect fertility also through its potential effects on marriage (Bellou, 2015). We find a positive but non-significant relationship between access to high-speed Internet and the likelihood of getting married for the high-educated women aged 25-45 (see column 1 of Table 4). Furthermore, the fact that as previously mentioned, the results on fertility are driven by the second or higher-order child (see Table A.2 in the Appendix), suggests that while broadband may have an impact on marriage, this effect does not fully account for our main results on fertility.

DSL technology provides employees with more opportunities to carry out at least part of their work from home, thereby relaxing time constraints, especially among more educated women, and favoring the work-family balance. Work flexibility and the possibility of reducing the costs

[7] As shown in the previous section, our instruments are not correlated with access to low-speed Internet since they affected the costs of switching to DSL technology. Thus, we cannot rely on the same IV approach to analyze the impacts of low-speed Internet on fertility.

of commuting may enable women, and in particular high-educated women, to conciliate motherhood and labor force participation.

To test this hypothesis, we first analyze the effects of DSL access on the likelihood of reporting any work from home, part-time vs. full-time work, employment status for the high-educated women aged 25 and above. We report the results of this analysis in columns 2 to 6 of Table 4. In our sample period, information on work from home is available only for the year 2009. To minimize measurement error in teleworking, we add information from the associated study "Families in Germany" (FiD) for the years 2010 and 2012 instead of just relying on the 2009 survey answers.[8]

While sizable standard errors warrant caution in interpreting the results, in column 2 we find evidence that high-speed Internet increases the likelihood of working from home by 29.6 percentage points (+.67 standard deviations). Columns 3 and 4 suggest that access to DSL encourages part-time vs. full-time work. Consistently, in column 5 we find that the overall number of hours worked diminishes (approximately 15 hours less per week, reflecting the observed shift towards part-time). While the point-estimate suggests a positive effect on female employment (extensive margin), there is no evidence of significant effects (see column 6). This result is in line with previous literature suggesting limited evidence of causal effects of high-speed Internet on employment (see Falck (2017) for a comprehensive review). Thus, taken together, our evidence suggests that broadband facilitates part-time vs. full-time, with little effects on female employment and labor force participation.

We also investigate the effects of DSL access on time spent on childcare activities per weekday and life satisfaction (see columns 7 and 8).[9] These outcomes are clearly endogenous, but they provide corroborating evidence to the hypothesis that DSL availability facilitates the balance between career and family. Access to DSL significantly increases time spent on childcare by approximately 3.4 hours on an average weekday (+.55 standard deviations). Consistent with

[8]The FiD panel survey is an extension study of the SOEP, with the focus on low income families, single parents, and large families. For further information, see Schröder et al. (2013). Note that the point estimate is practically unchanged if we do not include individuals in the FiD sample, but given that in our sample period information on teleworking is available only in one wave, our identification power is substantially reduced when using only the regular SOEP data-base. It is also worth noting that all the results for fertility and the mechanisms are not sensitive to the inclusion of the FiD sample in our analysis.

[9]We choose to focus on hours spent on childcare on a typical weekday, given the potential conflict between working time and family time.

the reasoning that the Internet may enable high-educated women to be more flexible and better organized their time-use, we find evidence of a significant effect of DSL on the likelihood of reporting a high life satisfaction. We also find no evidence of significant effects on teleworking, labor market outcomes, childcare and life sastifaction of low-educated women (see Table A.5 in the Appendix).

[Table 4 - around here]

7 Conclusion

In this paper, we studied the effects of access to broadband Internet on fertility in a low-fertility, high-income context: Germany. We found a robust and positive impact of broadband Internet on the fertility of high-educated women aged 25-45. In particular, broadband increased significantly the likelihood of progressing to a second or higher-order child. On the contrary, we found no evidence of effects, and, if anything, negative effects on individuals under the age of 25. We showed that broadband access significantly increased the share of women reporting work from home and working part-time.

Building on the extisting literature, we cast three main mechanism through which Internet may affect fertility: information, marriage, and work-family balance. The findings of our analyses are consistent with the hypothesis that broadband Internet access allows high-educated women to better concile work and motherhood, which in turn may promote fertility. At the same time, higher access to information on the risks and costs of pregnancy and childbearing may explain the negative effects on younger adults, consistently with previous findings from the literature.

The lack of yearly information on teleworking limits our ability to fully disentangle the mechanisms at play, and in particular to document how access to broadband Internet might have changed the daily life of working and reproductive age individauls. This is an important limitation of our study. Given the increasing number of firms that adopt smart working policies, flexible hours and telecommuting programs, exploring the effects of these work practices on fertility and other life course choices is a promising and important avenue of research.

Overall, our findings suggest that increasing access to broadband may promote fertility among high-educated women by easing the burden of balancing work and family duties. This may be particularly important in countries like Germany that have been lagging behind in terms of the share of telecommuters compared to other advanced economies (Brenke, 2016). The downside of our findings is that broadband might introduce a "fertility digital divide", allowing high-educated individuals to realize their fertility goals, while not improving the chances of low-educated individuals who tend to be employed in less flexible occupations. Further research is also needed on this avenue.

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Figures and Tables

Figure 1: Annual probability of child birth by DSL access - High-educated individuals

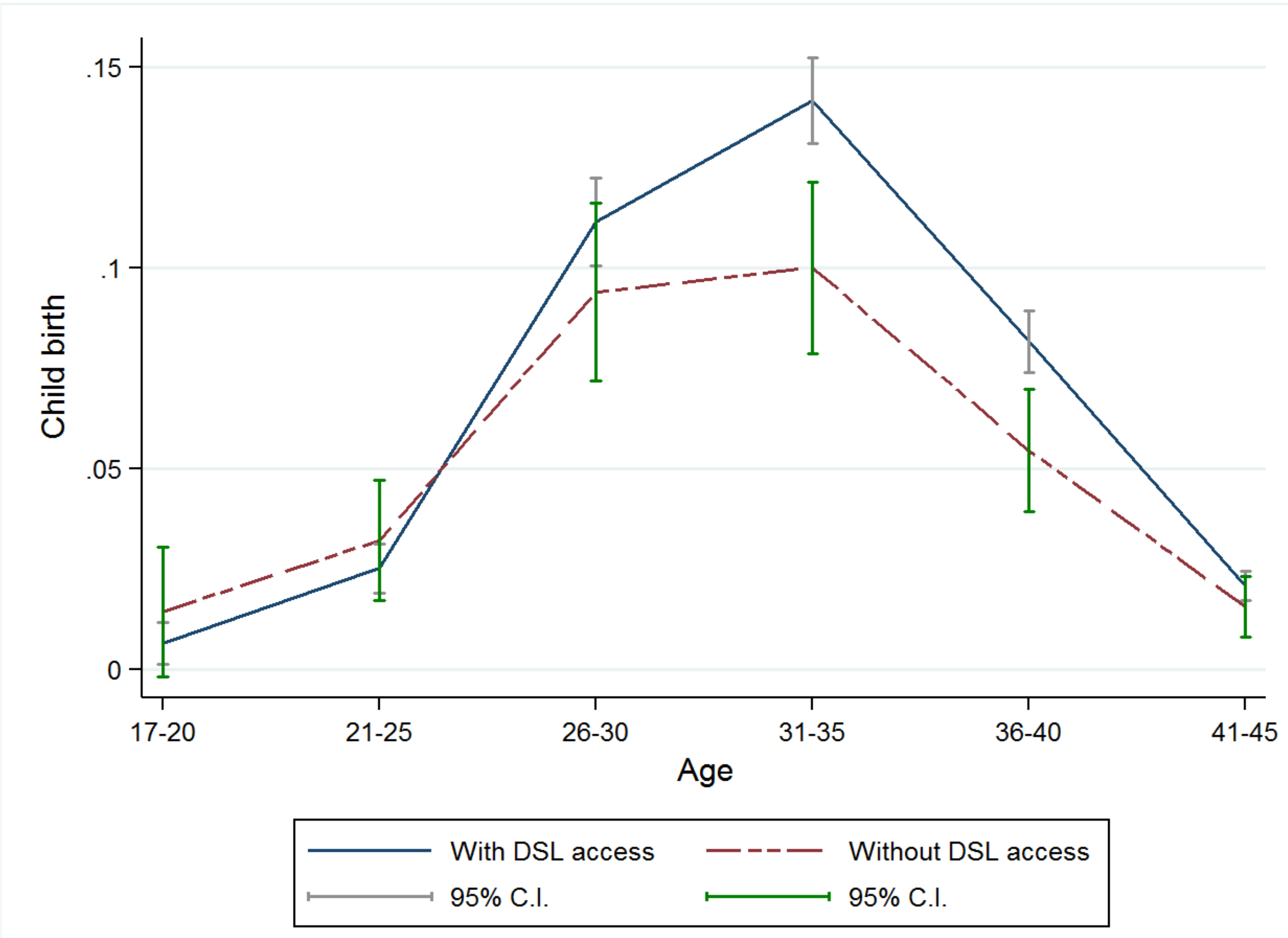

Figure 2: Annual probability of child birth by DSL access - Low-educated individuals

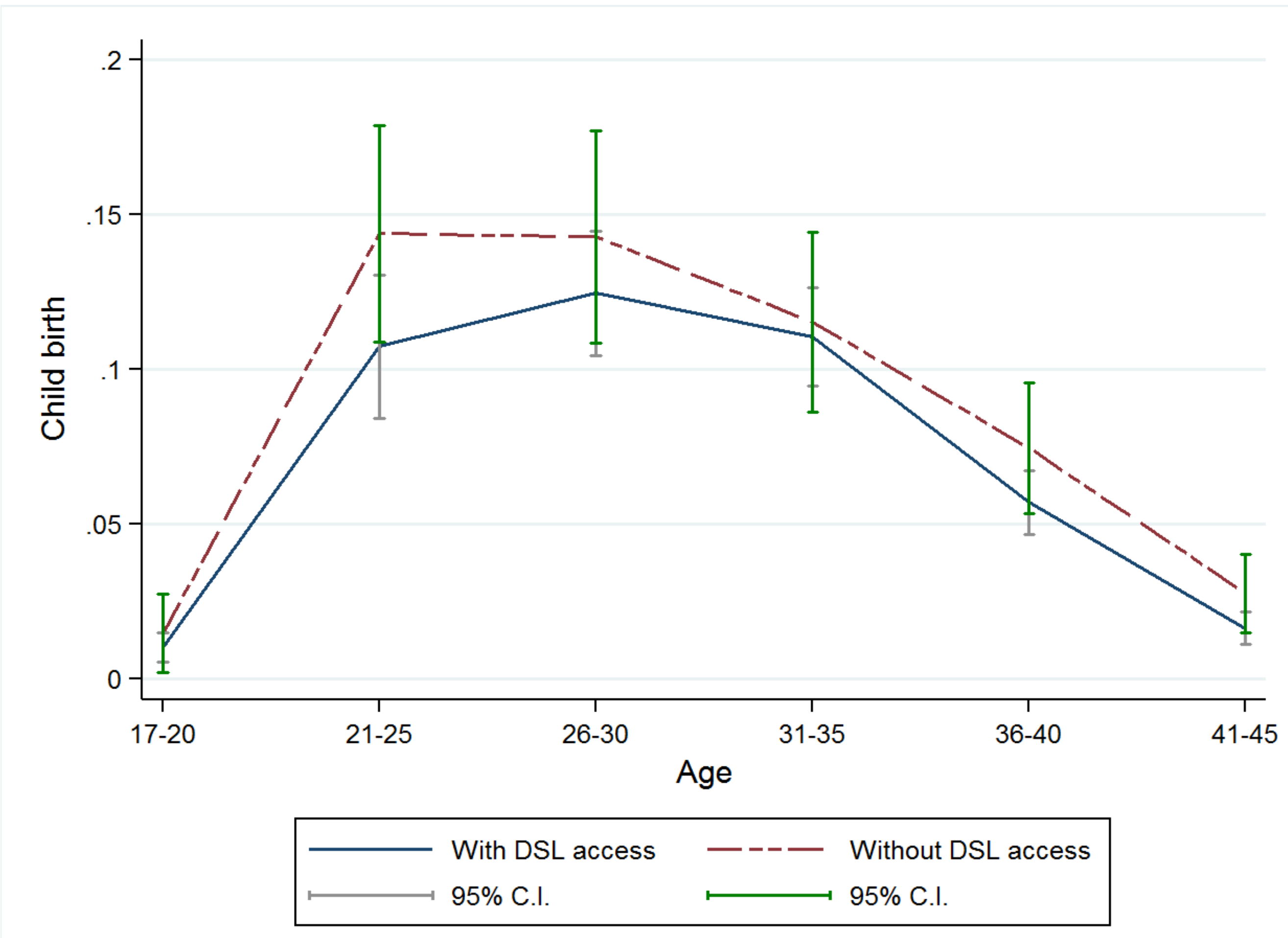

Table 1: Descriptive statistics - Observations: 34,495

	(1) Mean	(2) Std. Dev.	(3) Min.	(4) Max.
Outcome Variables				
Child birth in current year	0.065	0.247	0	1
Work from home	0.208	0.406	0	1
Part-time work	0.313	0.464	0	1
Full-time work	0.431	0.495	0	1
Working hours (weekly)	32.064	14.804	0	60
Not working	0.256	0.437	0	1
Hours spent on childcare (weekdays)	3.276	4.994	0	24
Hours spent on childcare (weekends)	5.358	6.134	0	24
Life satisfaction	7.303	1.646	0	10
High life satisfaction	0.207	0.405	0	1
Got married in current year	0.024	0.154	0	1
Broadband Internet				
DSL subscription in household	0.815	0.388	0	1
Threshold dummy	0.111	0.314	0	1
"No closer MDF" dummy	0.942	0.233	0	1
OPAL dummy	0.010	0.101	0	1
Control Variables				
Female	0.553	0.497	0	1
Age	33.763	8.031	17	45
Married	0.538	0.499	0	1
Single	0.398	0.490	0	1
Divorced	0.060	0.237	0	1
Number of children	1.234	1.166	0	11
West Germany	0.820	0.384	0	1
Lower secondary education	0.199	0.399	0	1
Medium secondary education	0.344	0.475	0	1
Higher secondary education	0.325	0.469	0	1
Apprentice	0.127	0.333	0	1
Unemployed	0.073	0.260	0	1
Blue-collar worker	0.222	0.416	0	1
White-collar worker	0.400	0.490	0	1
Entrepreneur	0.058	0.234	0	1
First-generation immigrants	0.130	0.336	0	1
Second-generation immigrants	0.109	0.312	0	1
Homeowner	0.463	0.499	0	1
Household income (log)	7.861	0.546	0	11.408

Notes - Data are drawn from the SOEP (v32) for individuals aged 17-45 years (2008-2012). All the samples contain individuals for whom information on child birth in current year, all observables and the respective outcome variable are not missing. The sample sizes for work from home, working hours, childcare (weekdays), childcare (weekends) and life satisfaction are, respectively, as follows: 11,590; 24,559; 33,273; 10,802; 34,169.

Table 2: Effects of broadband Internet on fertility by age group

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Age group:		17-45			17-24			25-45	
	All	Women	Men	All	Women	Men	All	Women	Men
Dep. var.: Child birth									
DSL subscription	0.047	0.080*	0.021	0.013	-0.012	0.045	0.057	0.093*	0.020
	(0.046)	(0.048)	(0.051)	(0.052)	(0.086)	(0.039)	(0.055)	(0.054)	(0.065)
Mean of dep. var.	0.065	0.065	0.066	0.028	0.041	0.015	0.073	0.069	0.078
Std. dev. of dep. var.	0.247	0.246	0.248	0.165	0.198	0.121	0.260	0.254	0.268
First stage									
Threshold	-0.132***	-0.124***	-0.141***	-0.161***	-0.137***	-0.186***	-0.126***	-0.122***	-0.128***
	(0.018)	(0.020)	(0.023)	(0.040)	(0.049)	(0.054)	(0.019)	(0.020)	(0.024)
"No closer MDF"	-0.062**	-0.052**	-0.073**	-0.096*	-0.084	-0.100	-0.056**	-0.045*	-0.066**
	(0.024)	(0.026)	(0.030)	(0.050)	(0.060)	(0.070)	(0.025)	(0.026)	(0.031)
OPAL	-0.089**	-0.067	-0.114*	-0.076	-0.102	-0.050	-0.089**	-0.058	-0.123**
	(0.043)	(0.047)	(0.060)	(0.085)	(0.097)	(0.135)	(0.044)	(0.049)	(0.059)
F-test of excluded instruments	24.03	19.04	17.04	6.91	3.64	4.81	21.28	19.10	13.66
Overidentification test	0.773	0.764	0.498	1.244	1.535	0.633	1.173	1	0.724
$\chi 2$ p-value	0.680	0.682	0.780	0.537	0.464	0.729	0.556	0.607	0.696
Observations	34,495	19,069	15,426	5,988	3,036	2,952	28,507	16,033	12,474

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, gender, marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. All regressions further include state and survey years fixed effects, as well as state-specific time trends. The *F*-test for excluded instruments refers to the Kleibergen-Paap *F*-statistic. The overidentification test is based on the Huber-White robust variance-covariance matrix without clustering. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 3: Effects of broadband Internet on fertility by education - Individuals aged 25-45

	(1)	(2)	(3)	(4)	(5)	(6)
Education group:	All high-educated	All low-educated	Women high-educated	Women low-educated	Men high-educated	Men low-educated
Dep. var.: Child birth						
DSL subscription	0.096*	-0.068	0.120**	-0.100	0.054	0.016
	(0.057)	(0.117)	(0.061)	(0.126)	(0.064)	(0.155)
Mean of dep. var.	0.075	0.070	0.072	0.063	0.079	0.076
Std. dev. of dep. var.	0.263	0.255	0.258	0.244	0.269	0.265
First stage						
Threshold	-0.134***	-0.106***	-0.125***	-0.119**	-0.148***	-0.089**
	(0.021)	(0.033)	(0.022)	(0.047)	(0.030)	(0.037)
"No closer MDF"	-0.062**	-0.042	-0.045	-0.051	-0.089**	-0.022
	(0.028)	(0.045)	(0.029)	(0.057)	(0.037)	(0.055)
OPAL	-0.092**	-0.105	-0.037	-0.330**	-0.157**	0.033
	(0.046)	(0.104)	(0.051)	(0.156)	(0.065)	(0.138)
F-test of excluded instruments	18.97	4.933	15.61	4.809	12.17	2.663
Observations	19,818	8,689	11,710	4,323	8,108	4,366

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, gender, marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. All regressions further include state and survey years fixed effects, as well as state-specific time trends. The *F*-test for excluded instruments refers to the Kleibergen-Paap *F*-statistic. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table 4: Potential mechanisms - High-educated women aged 25-45

Dep. Var.:	(1) Got married	(2) Work from home	(3) Part-time work	(4) Full-time work	(5) Working hours	(6) Not working	(7) Childcare (weekday)	(8) High life satisfaction
DSL subscription	0.031	0.296*	0.371**	-0.318*	-14.687**	-0.053	3.377*	0.282**
	(0.040)	(0.179)	(0.173)	(0.168)	(5.842)	(0.141)	(1.918)	(0.133)
Mean of dep. var.	0.026	0.072	0.474	0.320	28.207	0.207	5.353	0.219
Std. dev. of dep. var.	0.16	0.258	0.499	0.466	(14.097)	0.405	5.982	0.414
First stage								
Threshold	-0.121***	-0.126***	-0.125***	-0.125***	-0.115***	-0.125***	-0.124***	-0.127***
	(0.022)	(0.029)	(0.022)	(0.022)	(0.024)	(0.022)	(0.021)	(0.022)
”No closer MDF”	-0.044	-0.022	-0.046	-0.046	-0.028	-0.046	-0.048	-0.046
	(0.030)	(0.040)	(0.029)	(0.029)	(0.033)	(0.029)	(0.029)	(0.029)
OPAL	-0.037	0.013	-0.035	-0.035	-0.010	-0.035	-0.035	-0.027
	(0.051)	(0.063)	(0.051)	(0.051)	(0.052)	(0.051)	(0.051)	(0.051)
F-test of excluded instruments	14.48	10.06	15.33	15.33	11.90	15.33	15.32	15.80
Observations	11,710	4,067	11,710	11,710	9,164	11,710	11,393	11,615

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, gender, marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. All regressions further include state and survey years fixed effects, as well as state-specific time trends. The *F*-test for excluded instruments refers to the Kleibergen-Paap *F*-statistic.* Significant at 10%; ** significant at 5%; *** significant at 1%.

Appendix A: Supplemental Tables

Table A.1: Effects of broadband Internet on fertility - High-educated individuals aged 25-45, OLS

	(1)	(2)	(3)	(4)	(5)	(6)
	All	All	Women	Women	Men	Men
Dep. var.: Child birth						
DSL subscription	0.014**	0.003	0.015**	0.005	0.013*	0.000
	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)
Covariates	No	Yes	No	Yes	No	Yes
Mean of dep. var.	0.075	0.075	0.072	0.072	0.079	0.079
Std. dev. of dep. var.	0.263	0.263	0.258	0.258	0.269	0.269
Observations	19,818	19,818	11,710	11,710	8,108	8,108

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, state and year fixed effects, as well as state-specific time trends. Columns (2), (4) and (6) further include marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A.2: First child vs. second or higher-order child by education

	(1)	(2)	(3)	(4)
	First-child		Second or Higher-order Child	
Education group:	Women high-educated	Women low-educated	Women high-educated	Women low-educated
DSL subscription	0.043	0.071	0.192**	-0.207
	(0.094)	(0.129)	(0.082)	(0.181)
Mean of dep. var.	0.0412	0.030	0.083	0.070
Std. dev. of dep. var.	0.199	0.170	0.276	0.256
First stage				
Threshold	-0.138***	-0.111	-0.124***	-0.120**
	(0.043)	(0.118)	(0.025)	(0.050)
”No closer MDF”	-0.004	0.082	-0.068**	-0.081
	(0.060)	(0.139)	(0.032)	(0.060)
OPAL	0.109	-0.410	-0.091*	-0.328*
	(0.107)	(0.362)	(0.055)	(0.168)
F-test of excluded instruments	6.199	2.765	11.28	3.492
Observations	3,275	738	8,435	3,585

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, gender, marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. All regressions further include state and survey years fixed effects, as well as state-specific time trends. The *F*-test for excluded instruments refers to the Kleibergen-Paap *F*-statistic. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A.3: Robustness checks - High-educated women aged 25-45

	(1) Exclude county movers	(2) Placebo analysis	(3) Incl. number of children	(4) ROR F.E.	(5) Child birth at municipality
DSL subscription	0.129**		0.125**	0.127**	0.061
	(0.061)		(0.061)	(0.062)	(0.061)
Low-speed Internet		-0.292			
		(0.487)			
Mean of dep. var.	0.049	0.054	0.072	0.072	0.049
Std. dev. of dep. var.	0.216	0.227	0.258	0.258	0.183
First stage					
Threshold	-0.120***	-0.027	-0.125***	-0.125***	-0.125***
	(0.025)	(0.028)	(0.022)	(0.022)	(0.021)
"No closer MDF"	-0.040	-0.021	-0.045	-0.047	-0.016
	(0.034)	(0.037)	(0.029)	(0.029)	(0.030)
OPAL	-0.007	0.009	-0.037	-0.064	-0.054
	(0.055)	(0.055)	(0.051)	(0.051)	(0.046)
F-test of excluded instruments	10.75	0.333	15.60	15.64	19.19
Observations	8,940	7,290	11,710	11,710	5,398

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, gender, marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. All regressions further include state and survey years fixed effects, as well as state-specific time trends (except for column (4) which includes ROR fixed effects and ROR-specific time trends) . The *F*-test for excluded instruments refers to the Kleibergen-Paap *F*-statistic. * Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A.4: Effects of low-speed Internet on fertility by age group, OLS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Age group:		17-45			17-24			25-45	
	All	Females	Males	All	Females	Males	All	Females	Males
Low-speed Internet	-0.003	-0.003	-0.003	-0.002	-0.001	-0.004	-0.002	-0.002	-0.002
	(0.005)	(0.005)	(0.005)	(0.006)	(0.008)	(0.006)	(0.006)	(0.006)	(0.006)
Observations	34,495	19,069	15,426	5,988	3,036	2,952	28,507	16,033	12,474
Mean of dep. var.	0.0653	0.0648	0.0658	0.0281	0.0408	0.0149	0.0731	0.0694	0.0778
Std. dev. of dep. var.	0.247	0.246	0.248	0.165	0.198	0.121	0.260	0.254	0.268

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, gender, marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. All regressions further include state and survey years fixed effects, as well as state-specific time trends. Significant at 10%; ** significant at 5%; *** significant at 1%.

Table A.5: Potential mechanisms - Low-educated women aged 25-45

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. Var.:	Got married	Work from home	Part-time work	Full-time work	Working hours	Not working	Childcare (weekday)	High life satisfaction
DSL subscription	-0.001	-0.182	0.338	0.149	-1.867	-0.487	-4.411	-1.653
	(0.083)	(0.191)	(0.281)	(0.197)	(10.194)	(0.312)	(3.516)	(1.056)
Mean of dep. var.	0.0243	0.0989	0.455	0.156	22.862	0.389	6.121	0.193
Std. dev. of dep. var.	0.154	0.299	0.498	0.363	13.675	0.487	6.100	0.395
First stage								
Threshold	-0.118**	-0.223***	-0.122***	-0.122***	-0.126**	-0.122***	-0.122***	-0.122***
	(0.047)	(0.072)	(0.047)	(0.047)	(0.058)	(0.047)	(0.046)	(0.047)
”No closer MDF”	-0.053	-0.195**	-0.050	-0.050	-0.059	-0.050	-0.051	-0.053
	(0.057)	(0.085)	(0.057)	(0.057)	(0.070)	(0.057)	(0.057)	(0.057)
OPAL	-0.334**		-0.336**	-0.336**	-0.236	-0.336**	-0.326**	-0.327**
	(0.157)		(0.152)	(0.152)	(0.182)	(0.152)	(0.157)	(0.156)
F-test of excluded instruments	4.613	4.909	5.142	5.142	2.96	5.142	4.937	4.868
Observations	4,323	1,163	4,323	4,323	2,672	4,323	4,228	4,281

Notes - Standard errors are reported in parentheses and are clustered at the household level. All models include controls for education, age and its quadratic term, gender, marital status, occupational status, migration background, a dummy indicating house/flat ownership, and log of net household income. All regressions further include state and survey years fixed effects, as well as state-specific time trends. The *F*-test for excluded instruments refers to the Kleibergen-Paap *F*-statistic. * Significant at 10%; ** significant at 5%; *** significant at 1%.