Secondary School Expansion through Televised Lessons: The Labor Market Returns of the Mexican Telesecundaria

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October 15, 2019

Job Market Paper

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Abstract

The lack of qualified teachers is an important constraint for expanding access to post-primary education, and using technology to deliver instructional content is a promising solution. This paper analyzes the impacts of a large-scale expansion of junior secondary education in Mexico through telesecundarias – schools using televised lessons serving 1.4 million students. I exploit the staggered construction of telesecundarias from its beginnings in 1968 to the present. I find that for every additional telesecundaria per 50 children, 8 students enroll in junior secondary education, and 2 pursue further education afterward. I show that individuals earn 14.5% higher wages as adults, partly due to participating more in the labor market and to shifting away from agriculture and job informality. Due to the sequential nature of schooling decisions, the estimated returns combine the direct effect of attending telesecundarias and the effects of further schooling. I decompose these two effects by interacting the telesecundaria construction with baseline access to upper secondary institutions. I find that almost 90% of the estimated returns come directly from attending junior secondary education, while the remaining 10% are returns to higher educational levels.

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I am extremely grateful to my advisors Matthew Notowidigdo, Christopher Udry, Jonathan Guryan and Seema Jayachandran for their continuous guidance and support. I also thank Sergio Armella, Bruno Barsanetti, Lori Beaman, Nicola Bianchi, Caterina Calsamiglia, Gaston Illanes, Kirabo Jackson, Vishal Kamat, Sam Norris, Pinchuan Ong and Gabriel Ziegler and participants in the Development Advising Group, Development lunch and Applied Micro seminar at Northwestern University for insightful discussions and suggestions. I would like to thank Aniket Panjwani for his early contributions to the paper.

1 Introduction

More than 200 million children of secondary school age worldwide are not in school (UNESCO, 2017) and, after 15 years of steady increase, the secondary school enrollment rate has stagnated around 66% since 2013[1]. An important constraint for providing post-primary education is that it requires teachers specialized in subjects at advanced levels, but they are in short supply in rural and isolated areas, especially in developing countries (Banerjee et al., 2013). Delivering instructional content through information and communication technologies (ICT) as a substitute to face-to-face instruction has the potential of lowering the barriers to expanding post-primary education in rural and marginalized areas worldwide.

This paper investigates the labor market returns of a large-scale expansion of secondary education in Mexico through schools using televised lessons, the telesecundarias. Telesecundaria is a type of junior secondary school that provides all lessons through television broadcasts in a classroom setting with a single support teacher per grade. The televised content follows the national curriculum and is complemented with learning guides and in-classroom work and discussions. It started in 1968 and, in 2016, 18,754 telesecundarias served 1.43 million students, representing 21.4% of all junior secondary students.

Telesecundarias were designed to provide secondary education in rural and marginalized locations. Given that telesecundaria students come from relatively disadvantaged backgrounds, a simple comparison between individuals with differential telesecundaria access would underestimate the effects of these type of schools. I solve this identification challenge by exploiting the staggered construction of telesecundarias across different geographical areas and over time. I find that a high density of telesecundarias significantly increases overall educational attainment above and beyond junior secondary education, long-run employment and average wages among individuals that could have attended them.

There is little well-identified evidence on the returns to secondary education in developing countries, and estimating the long-run returns of attending an educational level is challenging because schooling is cumulative. In particular, the estimate combines the returns of attending junior secondary education through telesecundarias with the returns of pursuing further education afterward. In this setting, I find that additional year of education *after* enrolling in telesecundarias increases average wages by 16.4%. I isolate the direct returns of attending junior secondary education by using as additional source of variation the differential access to upper secondary institutions, finding that they account for almost 90% of the total returns. Taken together, the results indicate that the telesecundarias successfully expanded access to secondary education using televised lessons as a substitute to face-to-face instruction. They

[1] Indicators retrieved from the World Bank indicators data webpage. The proportion of children out of school in Sub-Saharan Africa is 36% for lower secondary (ages 12 to 14) and 57% for higher secondary (ages 15 to 17). In Southern Asia, the percentages are respectively 19% and 49% (UNESCO, 2017).

provided large and persistent labor market benefits, mostly directly through attending the telesecundarias.

The telesecundaria expansion has three features that make it a particularly interesting setting. First, it is challenging to document the long-run effectiveness of using technologies in the classroom because most of these initiatives have a very short track record. The 50 years of program span allows to investigate very long run effects of providing access to secondary education in general, and of a program using remote lessons in particular. Second, this country-wide intervention contains heterogeneity in the presence of upper secondary institutions, allowing to study its impacts depending on the availability of further schooling. Third, many developing countries today face similar education challenges to the ones in Mexico during the 1960s[2]. As such, telesecundarias are a relevant example of a successful school expansion addressing current challenges in the developing world, and an early example of large-scale use of remote lessons in the classroom[3].

In the first part of the paper, I estimate the causal effects of telesecundaria construction on long-run education and labor market outcomes. The empirical strategy exploits quasi-exogenous variation in telesecundaria availability generated by the gradual construction of telesecundarias across all Mexico during almost 50 years with a difference-in-differences approach. Intuitively, it compares the labor market outcomes of individuals with access to different densities of telesecundarias, net of cohort and locality averages. First, I show that, for every additional telesecundaria per 50 school aged children, 8 students enroll in lower secondary education, and 2 students continue to pursue upper secondary education. This results in an average increase of 0.75 years of education. Second, I document a significant increase in labor force participation and on hourly wages. The results suggest that two channels for these effects are the shift away from the agricultural sector towards services and working in the formal sector.

In the second part of the paper, I estimate the combined returns of enrolling in junior secondary education through telesecundarias on earnings. I implement an instrumented difference-in-differences approach, using the intensity of telesecundaria construction as instrument. I estimate that an additional year of education after enrolling in telesecundarias increases income by 16.4% on average 20 years after attending secondary education[4].

[2]In 1965, the number of primary school graduates unable to enter secondary school in Mexico was about 37% of the previous year's 6^{th} graders (Mayo, 1975), and there was a shortage of trained teachers willing to work in remote rural areas (Calderoni, 1998).

[3]Many countries implemented educational television between 1970 and 1990. Two examples are the National Open School of India in 1989, and Brazil's telecurso in the late 1970s. Educational television, mostly using interactive TV, is currently used in rural and isolated areas in developing countries like Brazil, Ethiopia or Ghana. For example, the *Centro de Mídias de Educação do Amazonas* (Center for Media Education in Amazonas) offers TV- broadcasted daily live classes through an interactive TV, taught remotely by teachers and supported by a tutor in their classes.

[4]The private rate of secondary education worlwide is around 7.2%, and the the rate of return to tertiary

However, as recently lighted in (Heckman et al., 2016) and (Heckman et al., 2018), when individuals enroll in additional educational levels after the intervention, the estimated impact is a combination of the direct effects of the program and of all subsequent schooling. In this context, it is unclear which of the two channels accounts for the majority of the rerturns of the intervention.

On the one hand, telesecundarias may provide large payoffs in the labor market through increasing workers' productivity after the acquisition of human capital, consistent with the seminal work of Becker (1964) and Mincer (1970). This may be because telesecundarias solve two prevalent problems in developing countries, the supply constraint of trained secondary education teachers, and high teacher absenteeism rates (Banerjee and Duflo (2006); Duflo et al. (2012)). With the appropriate infrastructure, telesecundarias offer timely lessons conducted by remote lecturers selected for their professional competence (Martinez Rizo, 2005). The returns can be particularly large given that the content is delivered by "superstar teachers" (Acemoglu et al., 2014). On the other hand, even if telesecundarias are not rewarded in the labor market, students may still use them as a door to accessing further educational levels. Upper secondary education, vocational or technical training, or college degrees can provide large returns in the labor market, especially in developing countries[5].

The last part of the paper isolates the direct returns of attending junior secondary education through telesecundarias. This decomposition is relevant to researchers and policymakers interested on implementing successful programs in contexts where there may be different availability of further schooling, or where it may not be feasible to simultaneosuly invest in additional education levels. First, I lay out a simple theoretical framework of sequential schooling choices under the presence of different alternatives. In the model, individuals choose their schooling level and the type of junior secondary education that maximizes their utility, taking into account the distance to each school modality and an idiosyncratic opportunity cost of education. The purpose of the model is establish a microfoundation supporting the methodology that separates the returns.

Second, I isolate the returns to junior secondary education from the combined returns by constructing an additional instrument interacting the telesecundaria construction with a baseline covariate, the presence of nearby upper secondary institutions. The differential proportion of individuals pursuing further education in localities with and without upper secondary schools nearby generates the additional source of variation needed to separately identify the two sequential effects. I find that attending a telesecundaria accounts for almost 90% of the total returns, while the remaining 10% are returns of higher educational

education is around 15.2% (Montenegro and Patrinos, 2014).

[5]The evidence on effectiveness of vocational training programs in developing countries is mixed. While many programs have at best modest impacts (see McKenzie (2017) for a recent review), vocational training may yield positive returns in certain circumstances (Alfonsi et al., 2019).

levels. While the estimated returns of attending further education are significantly *larger* than for attending junior secondary education, the proportion of individuals pursuing upper secondary education after a telesecundaria construction is small, so the returns to higher education have a limited contribution to the overall wage premium. Taken together, the findings of the paper indicate that attending junior secondary education through telesecundarias has large returns, even when no further education is pursued afterward.

This paper relates to several strands of the economics literature. First, it contributes to a large body of research investigating the labor market returns to secondary education. There is a large literature documenting the returns to secondary education in developed countries[6]. Previous research has also documented the impacts of expanding access to primary education in the developing world on education and labor market outcomes, many using big school construction projects as sources of variation (Duflo (2001); Duflo (2004); Kazianga et al. (2013); Akresh et al. (2018); Karachiwalla and Palloni (2019); Delesalle (2019)). Yet, very few papers rigorously document the long-run labor market returns to secondary education in developing countries (Spohr (2003); Ozier (2016)). Duflo et al. (2017) is the first evidence on the returns of free access to secondary education, using a randomized experiment providing scholarships in Ghana. To the best of my knowledge, this is the first paper computing the returns to education of a country-wide secondary education expansion, as opposed to using an experimental sample or investigating programs with smaller scale. I also contribute to this literature by explicitly isolating the long-run direct returns of secondary education, separating them from the returns to further schooling.

Second, it also contributes to the large literature on the impacts of technology in education, surveyed in Bulman and Fairlie (2016) and Escueta et al. (2017)[7]. Most of the research on remote lessons evaluates them as complements to formal schooling and face-to-face instruction in developed countries, focusing on Massive Open Online Courses (MOOCs) and college online classes (Figlio et al. (2013); Banerjee and Duflo (2014); Alpert et al. (2016); Bettinger et al. (2017); Goodman et al. (2019)) or early childhood educational TV programs (Kearney and Levine, 2015a). In developing countries, Johnston and Ksoll (2017) finds significant numeracy and literacy gains of a program broadcasting instruction via satellite to rural primary school students. Beg et al. (2019) reports large effects of a randomized experiment of short math and science videos in Pakistan on student achievement. Bianchi et al. (2019) investigates the effect of providing computer-assisted learning and recorded lectures

[6] See, for example, the literature surveyed in Card (1999), Gunderson and Oreopoulos (2010)

[7] In a broad sense, the paper relates to the studies investigating the effectiveness of mass entertainment media programs on educational attainment and labor market outcomes (Gentzkow and Shapiro (2008); (Kearney and Levine, 2015b)) and on changing perceptions of social norms and shaping behaviors (Chong and La Ferrara (2009); La Ferrara et al. (2012); Berg and Zia (2013); Kearney and Levine (2015b); (Banerjee et al., 2019)). It contributes to the entertainment education literature by investigating the long-run impacts of televised content designed to cover a formal education curriculum.

to rural students in China, finding improvements in academic achievement, labor market performance and mental health. I contribute to this literature by examining the long-run impacts of a type of school exclusively using televised lessons to deliver the formal curriculum content as substitute to face-to-face instruction. In contrast with common results in the literature, I find large positive returns from a program delivering educational content through technology with no degree of personalization and targeting to individual student needs.

Third, it relates to papers estimating dynamic treatment effects in schooling decisions. Leveraging on the dynamic treatment effects framework in Heckman et al. (2016) and Heckman et al. (2018), I show how the variation of an instrument interacted with a baseline covariate can be used to decompose the combined effects into the direct and continuation effects of the program. These identification arguments exploit previous ones from Kirkeboen et al. (2016), Kline and Walters (2016) and Hull (2018), who develop these for multiple simultaneous alternatives but not for dynamic choices. My results show that these results can be appropriately modified to account for dynamic treatment effects[8].

The rest of the paper is organized as follows. Section 2 describes the institutional background of junior secondary education in Mexico, and provides details on the telesecundarias and its rollout. Section 3 describes the data sources. Section 4 lays out the empirical strategy. Section 5 presents the reduced-form effects of telesecundaria on educational attainment and labor market outcomes. Section 7 develops the theoretical framework and empirically investigates the proportion of the returns attributed to telesecundarias and to further education. Section 8 discusses alternative explanations, and Section 9 concludes.

2 Background

In this section, I provide background on the education system in Mexico and on the particular characteristics and rollout process of the telesecundarias.

Secondary education in Mexico. Compulsory basic education encompasses preschool education (ages 3 to 5), primary education (grades 1 through 6, ages 6 to 11) and lower secondary education (grades 7 to 9, with ages 12 to 14). There are three main modalities of lower secondary education: General schools *(secundaria general)*, technical schools, which besides general subjects also offer a wide variety of technical subjects, and telesecundarias,

[8]Research on dynamic complementarities (e.g., Malamud et al. (2016); Johnson and Jackson (2018)) examine the returns of combining two sequential interventions in addition to the separate returns of each one. In contrast, in this context individuals need to complete junior secondary education before completing higher secondary, so the individual effect of higher schooling levels cannot be estimated.

which provide lower secondary education through specialized television programs complemented with in-class guidance.[9] In 2016-2017 there were 6.71M lower secondary students: 50.6% and 27.1% attended general and technical schools respectively, and 1.43M attended telesecundarias, representing 21.4% of the total. Out of the 39,265 lower secondary schools, 47.8% were telesecundarias (INEE, 2017). I define brick-and-mortar schools as all lower secondary schools with conventional teaching lessons, which includes both general secondary education and lower technical education. Classes in lower secondary education are taught by teachers specialized in specific subjects. All lower secondary school students receive an official certificate of completion after finishing lower secondary education, which is required to enroll in higher secondary education. The administration and operation of the educational services are descentralized and the statal authorities are responsible of providing them.[10]

The telesecundarias. Telesecundaria is a lower secondary school modality that provides all lessons through television broadcasts in a classroom setting. The telesecundarias are small schools, usually with only one class per grade and between 15 and 30 students per class. There is typically only one teacher per grade or even per school, the *maestro monitor* (supervisor teacher)[11], in contrast with brick-and-mortar schools, where there are on average 11 or 12 teachers specialized in different subjects. The supervisor teachers are specially trained for this education modality and their main functions are to supervise the classroom, answer students' questions and grade homework and exams with the support of teaching guides that extend all topics covered in the televised lessons. Daily classes consist of a combination of distance and in-person instruction: Students in each grade watch a 15 minutes lesson in the television, followed by 35 minutes of class work guided by the *maestro monitor*, and basic concept books and learning guides (INEE, 2005). The televised lessons follow the national curriculum, designed by pedagogical experts and recorded in a television studio in Ciudad de Mexico by teachers selected for their communication skills, the *telemaestros*. Lessons are simultaneously broadcasted to all telesecundarias in the country, first through microwaves and TV antennas and later using satellite technology. This broadcasting method has been later supplemented with videotapes and recordings. The telesecundarias' average administrative cost per student is half the cost of brick-and-mortar schools: In 2002, telesecundarias cost 6,811 pesos per student, compared to 12,460 pesos for general lower secondary schools and 14,572 for lower secondary technical schools (Martinez Rizo, 2005). In telesecundarias, there is a wide range of quality in the adequacy of infraestructure and

[9] There are residual lower secondary school modalities, the community secondary schools and the secondary education for workers (0.6% and 0.3% of enrollment respectively (INEE, 2017)).

[10] 84% of basic education students are responsability of the state educational authorities, 9% are in private schools, and less than 7% are direct responsability of the federal government (SEP, 2014).

[11] In 2008-2009, 20% of telesecundarias had only one or two teachers managing the three grades (SEP, 2014).

delivery of education services[12]. They were initially designed to provide education in small localities, rural areas or areas with difficult access, but they were later also used in urban areas, specially in marginalized locations with teacher supply constraints. As such, students tend to come on average from families with lower socioeconomic status than those attending brick-and-mortar schools[13].

Telesecundaria introduction and rollout. Telesecundaria was first introduced in 1968 as an alternative educational modality aimed to address the challenges concerning the expansion of secondary education. At the end of the 1950s, Mexico had very low literacy and school attendance rates. Forty-two percent of children between 6 and 14 years-old were not attending basic education. Among those enrolled, only one third finished 6^{th} grade in urban areas and only 2% in rural areas. A plan expanding access to primary education raised the number of primary schoolers from 4.1 million to 6.6. million in 10 years (DGME, 2010). This led to an accelerated increase in primary school completion and a sudden increase in the demand for secondary education, exceeding by far the existent capacity, especially in rural and isolated areas. Telesecundarias were created to solve the inadequate supply of secondary education and two specific challenges associated to constructing additional brick-and-mortar secondary schools. First, with a shortage of trained teachers to willing to work in remote rural areas, the telesecundarias were an attractive alternative due to the lower teaching body requirements (Martinez Rizo, 2005). Additionally, the telesecundarias' reduced class and school size made it easier to supply secondary education in areas with only few primary graduate students (INEE, 2005). In 1968, the lesson transmission started in 300 teleaulas in Distrito Federal and seven states, and in 1970 transmissions were extended to seven more states[14]. During these 50 years of existence, telesecundarias have been gradually constructed all over Mexico, and the concentration of this school modality differs by region[15]. Figure 2 shows the temporal and spatial distribution of telesecundaria construction. There were two major waves of telesecundaria expansion: In the academic year of 1981-1982, there was an

[12]In 2001, out of all surveyed telesecundarias, 10,3% didn't have electricity, 35% didn't have TV and 17% had one in bad shape, 25% had low reception signal, and 22% didn't have the basic concept books (Martinez Rizo, 2005),

[13]For example, only 36.8% of students that attended telesecundarias in 2016 had mothers with secondary education or higher, compared to the students that attended general secondary schools and technical schools, with 64.6% and 62.5% respectively (INEE, 2017). In 2015, almost 60% of telesecundaria students benefited from th Prospera/Oportunidades conditional cash transfer (CCT) program, against around 23% of brick-and-mortar lower secondary students (INEE, 2016).

[14]The 8 states that had telesecundarias in 1968 were Hidalgo, México, Morelos, Oaxaca, Puebla, Tlaxcala and Vercruz. In 1970, they started in Sonora, Jalisco, Nuevo León, Coahuila, Tamaulipas, Chiapas and Baja California (Martinez Rizo, 2005)

[15]Many northern states have less than 10% of telesecundaria enrollment, whereas Zacatecas, Veracruz, Hidalgo and Puebla have the highest concentrations of this education modality among their lower secondary education students, with between 39% and 44.7% (INEE, 2005).

increase of 372% in the number of telesecundarias (from 694 to 3,279) due to the expansion of the modality to new states (Martinez Rizo, 2005). Additionally, in 1993 lower secondary education became compulsory, and telesecundarias were an attractive option in places that didn't have access to lower secondary education, since they were cheaper and required less teachers to operate than brick-and-mortar schools. I exploit this country-wide variation in the timing and location of telesecundaria construction to identify the causal effects of the program. Mayo (1975), Calderoni (1998) and Santos (2001) are some of the papers investigating the impacts of telesecundaria on educational attainment using descriptive techniques. In this paper, I investigate the causal effects of the program on educational attainment and long-run labor market outcomes.

3 Data

School construction data. I examine the effects of having access to telesecundarias by using information on secondary schools from the *Secretaría de Educación Pública* (Ministry of Education). I use two different sources of lower secondary school data: a school directory of all lower secondary schools in Mexico for the 2015-2016 academic year, and yearly school records of all lower secondary schools for the 1990-2014 period. Among other information, each dataset includes the school's unique identifier, address, geographical coordinates and school modality. The school directory contains information on the foundation date, date it was registered into the system and closing and reopening dates, and the yearly records on the total number of enrolled students. The data on upper secondary schools comes from the 2016-2017 school directory, with the same features as the lower secondary school directory.

The identification strategy relies on comparing cohorts with telesecundaria access with slightly older cohorts without telesecundaria access from the same locality, which requires knowing the exact year the telesecundaria was constructed. I combine three different sources of information to impute the school construction date[16]. Mexico Distrito Federal (DF) is completely excluded from the analysis given its particular status as a federal district during part of the period of interest. The telesecundarias' primary purpose was to provide secondary education in rural and isolated areas where it was unfeasible to construct brick-and-mortar secondary schools, although they were later also constructed in urban localities, specially in marginalized neighborhoods. Given that, the analysis in this paper focuses on the effects of telesecundarias in localities with less than 100,000 habitants. Out of the 6,235 localities in the sample, 14% are low urbanization localities (between 2,500 and 14,999 habitants), and 82% are rural localities (less than 2,500 habitants).

[16] The technical details of the imputation procedure of the school construction date are in Appendix B.2. The main results are robust to alternative imputation procedures.

Figure 3 reports the average number of schools opened by year in all localities in Mexico with less than 100,000 habitants (Panel (a)) and restricted for only the localities used in the analysis (Panel (b)). Consistent with the rollout history, both figures display rapid increases in the number of telesecundarias constructed after 1982 and after 1993. The relatively smooth increase of brick-and-mortar schools along the same years suggests that the observed increases in telesecundarias are due to constructions rather than being artifacts of the definition of school creation date variable. Panel (a) in Table 1 reports relevant descriptive statistics on schooling access for individuals in localities with less than 100,000 habitants. For comparison purposes, I also report the same statistics for all individuals in the sample. 66% of the individuals in the sample had access to some type of secondary education in their locality after they finished primary school (as opposed to over 80% in the full sample): 57% had access to brick-and-mortar schools[17] and 172,078 individuals had access to telesecundarias (representing a 20% of the sample)[18]. Among those with access, the average number of telesecundarias per locality was 1.65, whereas the average number of brick-and-mortar schools was 6, with a very large variance.

Education and labor market outcomes. All education and labor market individual outcomes are constructed using data from the *Encuesta Nacional de Ocupación y Empleo* (ENOE, Employment and Occupation National Survey), administered by the *Instituto Nacional de Estadística y Geografía* (INEGI, Statistics and Geography National Institute). It is a quarterly household survey on the labor market characteristics of the population and administered as a five-quarter rotating panel. The survey is not representative at the locality and cohort level, only at the national and state levels, and for the locality size group I use for the analysis. Even though it is a limitation for the validity of the results, the distribution of individuals in the ENOE sample by year of the first school construction in their locality is roughly similar to the distribution of construction dates for all schools in Mexico, mitigating the concerns that the non-representativeness of the ENOE sample (Figure 4, Panel (a) and Panel (b)).

One dataset limitation is the lack of individual-level information about the modality of secondary school attended. Given this, I follow an intent-to-treat (ITT) approach, defining the treatment as a function of telesecundaria accessibility. However, the ENOE dataset only contains information on the individual's state of birth and locality of residence at the time of the survey. I use the telesecundaria access measure in their locality of residence as treatment, under the assumption that individuals did not move from the locality since their

[17] I denote brick-and-mortar all lower secondary schools with conventional teaching methods, offering either general secondary education or lower technical education.

[18] 40% of individuals in the sample with telesecundaria access live in rural localities (less than 2,500 habitants), and 43% in urban localities (between 15,000 and 100,000 habitants).

school-age years. This is a strong assumption, since migration in Mexico is a common phenomenon[19]. If migration decisions were uncorrelated with the secondary education access, this method would just introduce measurement error in the estimates, attenuating the effects towards zero. However, migration is influenced by education opportunities and human capital investment decisions in the location of origin, which could bias the estimates in either direction. To mitigate this concern, I restrict the sample to individuals born in the same state they were living during the survey year, excluding from the analysis interstate and international migrants. I further discuss the extent of the migration concerns and provide some robustness checks in Section 8.

I use all ENOE waves from the 2005-2016 period, keeping only the first observation for each unique individual to avoid non-random attrition in subsequent survey waves. The sample includes only individuals older than 15 years-old at the time of the interview, since it is the minimum legal age to work in Mexico. Since telesecundarias were first constructed in 1968, I also restrict the analysis to individuals born later than 1948 in an attempt to keep the comparison groups relevant. As explained above, the analysis only includes individuals living in the same state they were born in, and living in localities with less than 100,000 habitants. The final sample consists of 871,241 individuals in 6,235 localities. In this sample, I exploit the construction of 2,738 telesecundarias in 1,694 different localities.

Based on the discrete education level variable, I define four indicator variables for whether the individual enrolled in lower secondary education, graduated from lower secondary education, enrolled in upper secondary education, and enrolled in tertiary education (college or graduate education)[20]. Individuals in localities with less than 100,000 habitants have on average lower educational outcomes than individuals in the full sample (Table 1, Panel (a)). On average, they have 8.6 years of education, as opposed to 9.6 in the full sample, 65% completed some lower secondary and 33% some upper secondary education grades. Regarding tertiary education, 12% completed some years of college or technical degrees.

For long-term labor market outcomes, I use information on the individual's labor market participation, unemployment status, weekly hours worked and hourly income. The labor market participation identifies economically active individuals, either working[21] or actively looking for a job. Among individuals in the analysis sample, there is a 63% of labor force participation rate, similar to the average participation rate in the ENOE, and there is a low unemployment rate of 4%. The number of hours worked in a week is 41, and the average

[19] Just in the 2005-2010 period, 1.1% of the Mexican population were international migrants, 3.1% intrastate migrants, and 3.5% interstate migrants (CONAPO, 2014).

[20] Appendix B.1 includes a detailed description of the construction of outcomes.

[21] In the ENOE, workers are defined as individuals engaged in an economic activity in the week prior to the interview, (either working in a formal job, earning some income informally, helping in land work or family business), and individuals temporarily not working (e.g., for a strike) or absent but with a secured job after the temporality finishes).

wage earned per hour worked among workers is 11.7 Mexican pesos (MXN), significantly lower than the 23.21 MXN in the full sample. I also investigate the labor market sector and the informality of the individual's occupation. 20% of individuals in the sample work in agriculture, over 30% in manufacturing and commerce, and 36% in the services sector. Almost 40% of individuals in the sample work in an informal occupation, and 30% do not have health care benefits through their jobs. Regarding the type of employers in the sample, 47% work in formal companies or institutions, 20% in subsistence agriculture, 29% in the informal sector, and 4% are paid domestic workers[22].

4 Empirical strategy

Treatment. The main source of identifying variation is the staggered construction of telesecundarias across Mexico over almost 50 years. The gradual process of school construction naturally leads to variation in the availability of telesecundarias across regions and across cohorts. I construct a binary measure of telesecundaria exposure, $AboveTS_{lc}$, that captures the treatment intensity in locality l when cohort c finished primary school. I define the continuous density of telesecundarias at the locality-cohort level as:

$$TS_{lc} = \frac{\text{Number of telesecundarias}_{lc}}{\text{Population ages 12 to 14}_{l}} \times 50 \tag{1}$$

TS_{lc} is the number of telesecundarias opened in locality l when individuals from cohort c were 12 years-old, scaled by the total population of individuals targeted by the program[23]. I construct the binary treatment measure that identifies individuals with high telesecundaria exposure, $AboveTS_{lc} = 1[TS_{lc} \text{ above median}]$, which is equal to 1 if the telesecundaria density is above the sample median of localities exposed to telesecundarias. The preferred measure of telesecundaria exposure is the binary measure of telesecundaria exposure for tractability purposes in the decomposition in Section 7.2. However, I report the estimates using the continuous measure of telesecundaria exposure as alternative specification in Appendix **??**[24].

[22] See the Data Appendix B.1 for details on the definitions of labor market informality.

[23] Population sizes widely vary across the localities in sample, and the same number of available telesecundarias represents different treatment intensities depending on the total number of children that can potentially enroll in them. Normalizing the number of schools with the targeted population size mitigates the imprecision in the measurement of exposure to treatment.

[24] For the subsamples with similar locality sizes, the estimated reduced-form results using both measures are very similar.

Reduced-form effects. Since the construction of telesecundarias is not random[25], a comparison of mean outcomes for individuals in the same cohort living in regions with different telesecundaria density may lead to biased estimates of the program effects with unknown direction. For example, if the government constructs more telesecundarias in underdeveloped regions in need of public investments, the results would likely underestimate the true impacts of the program. On the other hand, if telesecundarias are built in areas where they are more likely to be successful, the effects would be overestimated. A comparison of mean outcomes between older and younger cohorts with different telesecundaria exposure living in the same region would likely upward-bias the estimates since, within the same population, education attainment tends to increase over time.

A difference-in-differences strategy addresses the potential biases outlined above by comparing the mean outcomes of individuals with different telesecundaria exposure net of locality and cohort averages. Intuitively, it uses the introduction of a telesecundaria in locality l to compute the difference in outcomes of individuals too old to attend the telesecundaria with those young enough to benefit from it, and compares it with the difference in outcomes from the same cohorts in a locality that did not construct a telesecundaria that year. The main specification is a two-way fixed-effects difference-in-differences regression, an OLS regression of the outcome on the average telesecundaria density in the lindividual's ocality and cohort, and on locality and cohort fixed effects. Formally, for individual i from cohort c living in locality l:

$$Y_{ilc} = \alpha + \beta AboveTS_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc} \tag{2}$$

where Y_{ilc} is the outcome of interest (educational attainment, labor market participation, income, ...), $AboveTS_{lc}$ is defined as in (1), γ_l and λ_c are locality and cohort fixed effects, $\mathbf{X}_{ilc}$ is a vector of individual characteristics, and ε_{ilc} is the error term. To account for the presence of heteroskedasticity and serial correlation, standard errors are clustered at the locality level. The estimates of equation (2) measure the reduced-form difference in outcome Y_{ilc} related to the construction of an additional telesecundaria per 50 children of the targeted ages. In a framework with 2 localities and 2 periods, β would capture the average treatment effect on the treated (ATT). In this setting with multiple localities and cohorts, the treatment effect β is a weighted average of ATTs obtained from all possible two-by-two DiD estimators across all localities and cohorts, where the weights on the two-by-two DiD's are porportional to the group sizes and the treatment variance within each pair[26] (de Chaisemartin and

[25]In telesecundaria's beginnings, government agencies nationally planned school allocations based on geographical and urbanistic conditions, economic, cultural, social and higienic factors (SEP, 1967). More recently, the Ministry of Education decides school allocations based, among other things, on an algorithm that determines the unmet demand for each education level in every locality (SEP, 2012).

[26]Note that, for some comparison pairs, one locality-cohort group will be treated and the other locality-

D Haultfoeuille (2018); Goodman-Bacon (2018)).

The main assumption needed to be able to interpret the estimated β as the reduced form effect of telesecundaria construction is a common trends assumption, which requires that the potential growth path of the outcomes is independent from the actual treatment assigment[27]. In other words, had the telesecundaria not been constructed, treatment and control localities would have experienced the same trends on mean outcomes. Since the regression relies on group sizes and treatment variances to weight up the simple two-by-two DiD estimates, the appropriate identifying assumption is a variance-weighted version of common trends between all groups (Goodman-Bacon, 2018). Section 5.1 provides descriptive evidence in favor of the parallel trends assumption, and Figures 6 and 7 provide additional evidence by reporting the estimated effect by age at telesecundaria construction, and are discussed in Sections 5.2 and 5.3.

Because the specification has multiple localities and periods, the DID setting also requires a treatment monotonicity assumption and a stable treatment effect over time assumption (de Chaisemartin and D Haultfoeuille, 2018). The first automatically holds if the treatment is constant within each locality $\times$ period cell. Hence, it holds for the reduced-form effects of telesecundaria construction, where the treatment is defined at the locality-cohort level, but not for the returns to education estimates, since the secondary education varies within locality and cohort. The second allows treatment effect heterogeneity across localities but restricts it over time. An additional concern in two-way fixed-effects settings is the potential existence of negative weights on the weighted average, which are only a concern when treatment varies within locality and cohort (de Chaisemartin and D Haultfoeuille, 2018). (Goodman-Bacon, 2018) shows that these only occur when treatment effects vary over time, and that they tend to bias the DiD estimates away from the sign of the true effect.

Returns to lower secondary education. An ordinary least squares (OLS) estimation of the effect of attending lower secondary education on labor market income is subject to two potential types of bias. First, a bias related to unobserved differences correlated with the access to education, explained above. Second, a selection bias if individuals decide to enroll into school based on some unobserved characteristics correlated with their labor market outcomes, such as their academic ability. I use an instrumented difference-in-differences

cohort group untreated. For other comparison pairs, one locality-cohort group already treated will act as control for another locality-cohort group receiving treatment in a given period.

[27]Following de Chaisemartin and D Haultfoeuille (2018), it can be formalized as follows. Let $L \in \{0, 1, \ldots, \bar{L}\}$ denote the locality and let $C \in \{0, 1, \ldots, \bar{C}\}$ denote the cohort the individual belongs to. Let $Y(0)_{ilc}$ denote the potential outcome of individual i without any telesecundaria constructed. The observed outcome is $Y(TS_{lc})_{ilc}$. The common trends assumption requires that the mean of $Y(0)$ follows the same evolution over time in every group: $E[Y(0)|L, C = c] - E[Y(0)|L, C = c-1]$ does not depend on L, for all $c \in \{1, \ldots, \bar{C}\}$. An analogous assumption can be written for the IV-DiD case, using $Y(D(Z))$ and $D(Z)$.

(IV-DID) approach to overcome these two potential sources of bias. Let Y_{ilc} be the long-run labor market income, and $D^S_{ilc} \in \{0,1\}$ be a binary variable indicating whether the individual enrolled in lower secondary education. The equation of interest is:

$$Y_{ilc} = \alpha + \beta D^S_{ilc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc} \tag{3}$$

with all parameters defined as in equation (2). I use as instrumental variable the binary measure of the telesecundaria exposure variable, $Z^T_{lc} = AboveTS_{lc}$. Then, the first-stage and the reduced-form equations are:

$$D^S_{ilc} = \pi_0 + \pi_1 Z^T_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \nu_{ilc} \tag{4}$$

$$Y_{ilc} = \phi_0 + \phi_1 Z^T_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\varphi + \upsilon_{ilc} \tag{5}$$

with all parameters defined as in equation (2).

Four assumptions are needed to interpret the estimated coefficients as local average treatment effects (LATE): The exclusion restriction and the monotonicity assumption, standard in the IV literature and the common trends assumption[28], which has to be satisfied for both the treatment and the outcome[29]. The plausibility of the assumptions in this setting are discussed in Section 6.1. If they hold, β^{LATE} identifies weighted sums of the LATEs of the switchers in each group and period, where switchers are the units that experience a change in their treatment status between two consecutive periods[30]. In other words, β^{LATE} estimates the effect of attending lower secondary education through the telesecundarias on long-run outcomes for the complier subpopulation, i.e., those individuals induced to enroll in secondary education because they had better access to telesecundarias ($Z^T_{lc} = 1$) that would have not enrolled otherwise ($Z^T_{lc} = 0$). The estimated coefficient can be expressed as a Wald estimator, writing it as the ratio of the reduced form and the first stage coefficients, $\beta^{LATE} = \phi_1/\pi_1$. For simpification, consider the case where there are only two periods, 0 and 1. Then,

$$\beta^{LATE} = \frac{E[Y_{il1} - Y_{il0}|Z^T_{lc} = 1] - E[Y_{il1} - Y_{il0}|Z^T_{lc} = 0]}{E[D^S_{il1} - D^S_{il0}|Z^S_{lc} = 1] - E[D^S_{il1} - D^S_{il0}|Z^T_{lc} = 0]} \tag{6}$$

[28] Instead of the IV independence assumption, the exogeneity of the instrument in the IV-DiD relies on the common trends assumption.

[29] As above, the two-way fixed-effects regression also requires a stable treatment assumption and a monotonicity of treatment assumption (de Chaisemartin and D Haultfoeuille, 2018)

[30] For simplification purposes, consider the case of an IV-DiD with only 2 groups and periods. Formally, let $D^S(Z^T)_{ilc}$ denote the potential secondary education enrollment status of individual i depending on her telesecundaria access, Z^T_{lc}. Let $Y(d,z)_{ilc}$ identify the potential outcome of individual i given D^S_{ilc} and Z^T_{lc}. Then, $\beta^{LATE} = E[Y(d,1)_{ilc} - Y(d,0)_{ilc}|D^S(0)_{ilc} < D^S(1)_{ilc}]$.

Intuitively, this empirical strategy scales the DiD effect of telesecundaria exposure on the labor market outcome by the DiD effect on the share of individuals enrolled in secondary education.

A common metric to measure the effectiveness of educational interventions is the estimation of labor market returns as the average monetary returns of an extra year of schooling. A limitation of the measure is that it assumes that the returns to an additional year of schooling are constant, regardless of the educational level completed. Given the empirical evidence that worldwide returns to schooling differ by educational level (e.g., see Montenegro and Patrinos (2014)), and that one of the goals of this paper is to separately estimate the returns of different educational levels, the main treatment of interest is enrolling in lower secondary education, rather than an additional year of schooling. I also report the estimates of the returns of an additional year of schooling to facilitate the comparison with the returns to other interventions.

5 Effects of telesecundaria construction

In this section, I examine the reduced-form effects of constructing telesecundarias on long-run education and labor market outcomes. Tables 2, 10 and 4 show the results of the estimation of the difference-in-differences equation (2) using as dependent variable the density of telesecundarias TS_{lc}. The regressions include individual-level controls (gender, age, age^2 and interactions between them). All standard errors are clustered at the locality level. I also investigate the heterogeneity of the difference-in-differences effects by age at the first telesecundaria construction in the locality, and provide evidence that the common trends assumption is likely to hold for the education outcomes (Figures 6 and 7)[31]. I find that the construction of telesecundarias significantly increases enrollment in education levels above and beyond lower secondary education level, raising by 0.75 the average years of education. The results also show that there is an increase in the extensive margin of labor supply, and that it significantly raises the average hourly wage.

5.1 Descriptive evidence

Figure 5 provides evidence in favor of the parallel trends assumption. It presents descriptive trends using raw averages of the lower secondary enrollment rate, years of education and hourly income in localities with and without telesecundarias. The averages are computed

[31]Tables X and and Figure X in Appendix X report the reduced-form estimates using the binary treatment $AboveTS_{lc}$. The interpretation of the figures is more straightforward but the estimates are less precise, since the measure does not account for the fact that the the intensity of treatment varies with differences in number of schools and population sizes.

with respect to the age of individuals the year the first telesecundaria was constructed in their locality[32]. The cohort averages follow the same trends in localities with and without telesecundaria construction for all cohorts too old to benefit from a telesecundaria once it was constructed. The outcome averages start to diverge for the cohorts that had access to telesecundarias in their locality, while the averages for the same cohorts without access remain in the same trend.

One common concern in a DiD setting is the simultaneous introduction of other policies or programs that could confound the estimates. Contrary to other DiD designs that exploit a one-time policy change as main source of identification, the variation used in this paper comes from the construction of more than 2,700 telesecundarias across Mexico over 50 years. It is unlikely that another policy introduced at the federal, state or local level systematically coincides with the introduction of a large number of telesecundarias and only affects the treated cohorts within a locality[33]. A related concern is that the construction of telesecundarias in a locality may be correlated with investment in other infraestructure, and that the estimated effects are due to the infraestructure improvements. For example, building roads or providing electricity or a TV antenna may be needed to construct telesecundarias, but these infraestructures will equally affect cohorts of roughly the same age, either too old or young enough to attend telesecundarias. Hence, the DiD strategy rules out these confounding factors by netting out locality mean effects.

5.2 Telesecundaria effects on education

Table 2 presents the estimates from the difference-in-differences specification (2) on enrollment in different schooling levels. I also investigate the heterogeneity of the difference-in-differences effects by age at the first telesecundaria construction in the locality, and provide evidence that the common trends assumption is likely to hold for the education outcomes (Figures 6a through 6d). I estimate that the construction of an additional telesecundaria per 100 children encourages 13 individuals to enroll in lower secondary education, and causes an average increase of 0.75 years of education among individuals that could have attended it (Table 2). There are also statistically significant effects of the telesecundaria construction on the probability of enrolling into upper secondary education (grades 10 - 12) and tertiary education, suggesting that the program have effects beyond the targeted education level.

Lower secondary enrollment. I first analyze whether the construction of a telesecundaria increases the secondary education enrollment rate of cohorts that had access to it

[32] Or with respect to a randomly assigned placebo year if they never had a telesecundaria constructed.

[33] Cite many invalid IVs paper

when they finished primary education. Column 1 in Table 2 shows that an additional telesecundaria per 50 students increases lower secondary enrollment by 10.3 percentage points, and it is statistically significant at 1% level. This is an economically meaningful change, representing a 15.8% increase from the mean enrollment rate of 65%. A similar increase in lower secondary graduation rate (Column 2) suggests that the completion rate in this type of schools is quite high, consistent with reports of the *Secretaría de Educación Pública* (SEP) of a 8.68% dropout rate in telesecundarias (DGME, 2010). The postive effects on enrollment validate that interventions providing free access to lower secondary education through school construction investment can successfully raise educational achievement at the targeted level.

I now investigate the heterogeneity of the DiD effects by age at the first telesecundaria construction. Formally, Let TS_l be the average density of telesecundarias in locality l across all years with some telesecundaria presence. Let τ be the individual's age when the first telesecundaria was constructed in their locality. Then, the DiD equation (2) becomes

$$Y_{ilc} = \alpha + \sum_{\tau \in [27,-3], \tau \neq 17} \beta_\tau TS_l \times 1[\text{Age at TS constr}_l = \tau] + \gamma_l + \lambda_c + \mathbf{X}_{ilc} + \varepsilon_{ilc} \qquad (7)$$

where all other parameters are defined as in equation (2). β_τ is the DiD coefficient estimate of the outcome on individual's exposure to telesecundarias at age 12 as a function of the timing of the telesecundaria construction in the locality. All the effects are relative to the effect of the program for 17 year-old individuals at the time of telesecundaria introduction.

Figure 6a and Figure 6b report the estimated DiD effects from equation (7) on lower secondary enrollment and graduation rates. The horizontal axis shows the age at the construction of the first telesecundaria in the individual's locality, and the vertical axis the DiD estimated effect for the age group, β_τ, with the 95% confidence interval. All the effects are relative to the normalization age, 17 years-old, which is set to zero. Each point estimate can be interpreted as the causal effect of the construction of an additional telesecundaria per 50 children for each age group relative to the effect of the construction for 17 years-old in a given locality.

Individuals aged 17 to 27 when the first telesecundaria was constructed in their locality were too old to attend from it. As expected, the estimated effects of telesecundaria construction on lower secondary enrollment for this age range are indistinguishable from zero, suggesting that the exposure to telesecundarias is not correlated with secondary school enrollment decisions for individuals too old to benefit from them. This provides additional evidence that the parallel trends assumption is likely to be satisfied. On the other hand, the estimated effects on lower secondary enrollment among individuals younger than age 12 at the time of the first telesecundaria construction in their locality are positive and statistically significant. The effects are also larger in magnitude for younger cohorts, implying that students were systematically more likely to pursue secondary education some years after telesecundaria was first introduced than the cohorts first exposed to the program. This may reflect the fact that additional secondary education institutions were constructed over time in the same locality, so a larger proportion of individuals enrolled in them[34], or that other factors correlated with the timing of the telesecundaria construction made more attractive the enrollment in secondary education.

Lastly, the estimated effects of telesecundaria for individuals ages 13 to 16 are smaller but statistically distinguishable from zero, gradually increasing for the younger cohorts. I consider the cohorts aged 13 to 16 as partially treated for the following reasons. First, may have started school at later ages, or have repeated some grades[35], which would make some students slightly older than 12 eligible to attend telesecundarias when they were first constructed. Second, given the discrepancies between the different data sources of school foundation dates, it is plausible that some imputed dates of telesecundaria construction differ from the real one by one or two years, which would incorrectly classify slightly older cohorts as untreated. The partially treated individuals are classified as untreated in the reduced-form effects, so the estimates are lower bounds of the true effects[36].

Enrollment in higher education. Explicit evidence on the causal effects of the program on student learning is beyond the scope of this paper due to lack of data availability. As a first step, in this section I provide evidence on the positive effects of the program on enrollment in institutions of higher education levels. Although I cannot reject the possibility that telesecundarias provide low quality education, it is encouraging to find that telesecundaria graduates continue to pursue further education in significant numbers.

In particular, the construction of an additional telesecundaria per 50 children increases the likelihood of pursuing upper secondary education by 1.2 and tertiary education by 0.6 percentage points (Table 2, Columns 3 and 4). The effects are sizeable for both education levels, representing increases of 3.6% and 5% respectively, and both effects are statistically significant at 1% level[37]. The effects are insignificant for individuals too old to benefit from the telesecundaria construction, and they are positive and increasing with the years since the first telesecundaria construction (Figures 6c and 6d). Hence, the first cohorts being exposed to telesecundarias were more likely to attend lower secondary education than older cohorts,

[34] Figure X in Appendix X shows the same estimates only for rural localities, where there was almost always only one telesecundaria constructed and the schools served relatively similar sized localities (with less than 2,500 habitants). The effects are relatively constant effects for younger cohorts.

[35] In the 2016-2017 academic year, 13.2% of 9th graders in telesecundaria were 17 years-old or older. Additionally, 16.9% repeated some grades since primary school (INEE, 2017)

[36] Table X in the Appendix shows the reduced-form estimates defining partially treated cohorts as treated

[37] Spillover effects on enrollment in education levels higher than the targeted by the program have also been documented by (Duflo et al., 2017) and (Akresh et al., 2018).

but as likely to pursue higher education. After a few years, lower secondary graduates in localities with telesecundarias started to attend higher education institutions in increasingly larger numbers. One hypothesis consistent with this pattern is a supply increase of upper secondary institutions nearby due to an increasing demand for further education. This would occur if other secondary institutions are gradually built nearby, creating enough demand to build upper secondary education institutions within reach.

A summary measure of the changes in enrollment rates for all education levels is the difference in average years of education. The construction of an additional telesecundaria per 50 children increases the average years of education of fully treated cohorts by 0.2 years from a population mean of 8.22, and the effect is statistically significant at the 1% level (2, Column 5)[38]. The event study in Figure 6e summarizes the heterogeneous findings by age at telesecundaria construction for the enrollment rates: There are no significant effects for cohorts too old to benefit from the program, and the average years of education discretely increase after the first telesecundaria is constructed. For individuals with access to telesecundarias, the average educational attainment gradually increases over time, probably reflecting the fact that more lower secondary and higher secondary institutions become available over time.

5.3 Telesecundaria effects on labor market outcomes

Table 10 reports the estimated results from the difference-in-differences specification (2) on labor market supply and labor market income. I find that the construction of an additional telesecundaria per 50 children increases the extensive margin of the labor supply by raising the labor market participation rate and decreasing the unemployment rate. It also increases the probability of receiving economic compensation for the job by 1.9 percentage points, and raises the average hourly wage by 14.5%. Table 4 provides suggestive evidence of two potential channels for the earnings increase, showing that the telesecundaria construction shifts individuals away from subsistence agriculture towards the services sector, and that they are less likely to engage in informal occupations with vulnerable and unstable working conditions.

Labor market supply. I first examine changes in the likelihood of participating in the labor market. The labor market participation rate increases by 3.3 percentage points for an additional telesecundaria per 50 children. This represents a 5.2% increase in the average

[38]Note that the estimated effect size depend on the definition of treatment density; if the treatment was defined as the construction of an additional telesecundaria per 100 or 1000 children, the coefficient magnitudes would be different. The comparison of the effect sizes of the telesecundaria construction with other programs should be done transforming the measures as needed, or using measures invariant to the definition, such as the returns to an additional year of education (Section 6).

labor market participation rate, statistically significant at the 1% level (Table 10, Column 1). The effects are larger for younger cohorts, whereas they are indistinguishable from zero for cohorts too old to have benefited from attending telesecundaria (Figure 7a). This result is important when interpreting the labor market returns of the program, since the new workers[39] are likely not a random sample of the population. Because of the endogenous change of the composition of the workers' pool, I provide two distinctive sets of labor market results. Panel A in Table 10 reports the effect estimates of telesecundaria construction on labor market outcomes for all individuals in the population. These are the causally interpretable reduced-form results. Panel B in Table 10 reports the effect estimates of the program on labor market outcomes for the subpopulation of workers. Although these estimates are not causally interpretable, they are still informative to understand the type of individuals likely affected by the school construction program.

Among individuals participating in the labor market, the increase in telesecundaria density is associated with a 1% percentage point decrease in the unemployment probability (Table 10, Column 2). There is also a statistically significant increase of 14.7% in the hours worked among individuals with access to telesecundarias (Table 10, Panel A, Columns 3 and 4), all coming through the increase in labor force participation. The effects heterogeneity by age at telesecundaria introduction display similar patterns, with no significant impacts for cohorts too old to benefit from it, and positive and increasing effects for younger cohorts, although not always statistically different from zero (Figures 7b, 7c and 7d). Within the subsample of workers, there are no changes in the hours worked, likely due to the fact that the hours are highly clustered around 40.

Note that there are more concerns related to the violation of the common trend assumption for labor market outcomes than for education outcomes. For example, telesecundarias could be systematically constructed in localities that are prioritizing economic development and gradually improving the labor market prospects of its habitants. Since these policies would be correlated with the timing of telesecundaria construction, the reduced-form DiD coefficients would be overestimating the returns of the telesecundaria construction. In this case, the figures displaying the estimated effects by age would show some sort of positive trend prior to the telesecundaria construction, reflecting the gradual improvement of the labor market conditions prior to the telesecundaria introduction. However, the education outcomes could still show no pretrends, since it is difficult to improve educational attainment without access to nearby schools. The absence of pretrends for labor market outcomes mitigates the concerns related to this type of confounding factor.

[39]Following the ENOE definition, I identify as a worker any individual conducting some type of work in the formal or informal market and either receiving or not receiving economic compensation for it.

Labor market income. Next, I examine the effect of telesecundaria construction on earnings. Among all individuals, having access to an additional telesecundaria per 50 children increases the probability of being a wage earner among the exposed individuals by 1.9 percentage points over an average of 45%. (Table 10, Panel A, Column 5). Among workers, though, the probability decreases by 2.9 percentage points. Both magnitudes are significant at the 1% level. The main income variable is the inverse hyperbolic sine transformation of hourly wages (Table 10, Column 8)[40]. For completeness, I also report the estimated hourly wage effects in Mexican pesos (MXN) (Columns 6) and on the logarithmic transformation (Columns 7). The construction of an additional telesecundaria per 50 children increases the average hourly wage of the exposed cohorts by 14.5%. The effect is statistically significant at the 1% level. The effects heterogeneity by age at the first telesecundaria construction in a given locality in Figure 7e reveal the same pattern as in previous figures: There are no effects of telesecundaria construction on individuals too old to have benefited from the program, and the effects on long-run wages are positive for individuals that were 12 years-old or younger when the telesecundaria was first introduced, with the effects increasing for younger individuals.

The effects on the labor market outcomes show a remarkable persistence over time. The median age of individuals in the sample is 32.5 years-old, with an interquartile range of 21 to 42 years-old. Hence, the estimated effects of the program are captured on average 20 years after the potential enrollment to lower secondary education. To my knowledge, this is one of the first papers to capture such a long-run effects of secondary school enrollment on labor market outcomes.

Potential channels. An important channel through which the telesecundaria construction may have positive effects in labor market outcomes is by providing specific skills and knowledge useful to access new occupations and economic sectors. Additionally, as in many developing countries, a large proportion of individuals works in the informal sector. Next, I investigate whether these two mechanisms could partially explain the positive labor market effects of the program.

The construction of an additional telesecundaria per 50 children causes a 2.3 percentage point net decrease of the proportion of people working in agriculture, and a 4.3 percentage point net increase in people working in services, both significant at the 1% level (Table 4,

[40]The hourly wage variable displays a long thick upper tail, common in wealth data, which would skew the estimates due to extreme values. With an average labor market participation of 60%, the income variable also has many zeros, making the logarithmic transformation an imperfect choice. I address both issues by using the inverse hyperbolic sine transformation (IHS). The inverse hyperbolic sine transformation is $log(y + (y^2 + 1)^{1/2}$ (Burbidge et al., 1988), deals with extreme values and solves the problem of $log(0)$ being undefined of the logarithmic transformation.

Panel A, Columns 4 and 5)[41]. The small increases in the share of individuals working in construction, manufacturing and commerce likely reflects the overall increase in labor force participation. Among workers, there is a decrease in the probability of working in agriculture and commerce, and an increase in the probability of working in services, all significant at the 1% level (Table 4, Panel B, Columns 3 through 5). This reinforces the suggestive evidence that telesecundaria construction caused a sectoral shift in the workers' occupations[42].

With respect to the type of employers, the construction of an additional telesecundaria per 50 children causes an overall 3.7 percentage point increase in the proportion of individuals working for formal companies or institutions (Column 6), 2.3 percentage point decrease in the proportion of individuals working in subsistence agriculture (Column 8) and a 1.5 percentage point net *increase* of individuals working in economic units in the informal sector (Column 9). All these effects are highly statistically significant. Non-agricultural economic units in informal sector are those operating using household resources without being a formal business, so that income and economic resources used in the business are not independent from the ones in the household. The complementary definitions of labor market informality speak more to the job informality notion of vulnerable and unsecure labor conditions. An additional telesecundaria per 50 children increases the proportion of individuals with health care benefits through their employers by 3.3 percentage points, statistically significant and economically meaningful, representing a 18% increase over the baseline. Lastly, there is an overall 0.7 percentage point decrease of individuals working in informal occupations (Column 10), defined as the with vulnerable conditions due to the nature of the economic unit they work for, and those whose relationship with the economic unit is not formally recognized by the employer. Although statistically significant at the 5% level, this effect is economically small.

Taken together, these results suggest several channels through which telesecundarias may affect labor market outcomes. First, they cause an overall decrease in the proportion of individuals working on subsistence agriculture among those with telesecundaria access. Given that telesecundarias increased the overall labor market participation, a net decrease suggests that individuals shifted away from agriculture. Given the magnitudes of the effects on the other labor market sectors and types of employers, the results suggest that workers shift especially towards the services sector, either working for formal companies or institutions, or working in informal family businesses. There is a also net small decrease of individuals working under vulnerable and insecure labor conditions, which becomes large and highly

[41] The services sector includes jobs in the hospitality industry, government, education, health and professional services, among others.

[42] This sectoral shift is consistent with evidence that large primary school construction programs raise the likelihood of being employed outside the agricultural sector (Karachiwalla and Palloni, 2019). In contrast, Delesalle (2019) provides evidence of *increased* likelihood of working in agriculture.

significant when looking at the workers' subsample, and there is an overall increase of individuals with health care benefits provided through the employers. These two other pieces of evidence suggest that individuals' working conditions may improve as a result of having access to telesecundarias, although the evidence is less definitive.

Note that the shift away from subsistence agriculture and towards the formal sector could also artificially inflate the returns to the program. Individuals working for formal companies are more likely to be regularly paid a fixed salary in a given period. This could improve their record keeping, allowing them to accurately report their earnings during the labor market survey, which could look like an earnings increase.

6 Returns to education

The objective of secondary and tertiary education is to provide students the skills and resources they will need to become productive workers. Following the pioneering work of Becker (1964) and Mincer (1970), in this section I argue that an important mechanism through which telesecundaria construction affects labor market outcomes is through human capital acquisition, which increases workers' productivity[43][44].

6.1 2SLS estimates

Table 5 reports the estimated returns from equation (3) following the instrumented difference-in-differences strategy detailed in Section 4 (even columns). For comparison purposes, I also report the estimated returns using an Ordinary Least Squares (OLS) specification (odd columns). The estimates are computed along two margins: the labor market returns of attending lower secondary education (Panel A), and the returns of an additional year of education (Panel B). The instrument used is the binary measure of telesecundaria density $AboveTS_{lc}$, described in Section 4[45]. I report the returns for all individuals in the sample (Columns 1-6), and only for individuals engaged in an economic activity (Columns 7-12). The main dependent variable is the inverse hyperbolic sine transformation of hourly wages. For completeness, I also report two additional measures of the returns, in levels (Mexican Pesos), and the logarithmic transformation of the variable.

Enrolling in lower secondary education after the construction of an additional telesecundaria per 50 children results in a 117% increase in average hourly wage (Panel A, Column

[43] Heckman et al. (2018) provides a recent overview on the evolution of the research studying the relationship between education and human capital accumulation and labor market outcomes.

[44] MOTIVATE INTRO BETTER

[45] Table X in Appendix X shows the returns to education using the continuous measure of telesecundaria exposure as instrumental variable.

6) for the complier subpopulation. This is a large magnitude and economically significant at 1% level. Since individuals pursue several grades in lower secondary education, and some continue into higher secondary education, it is important to also look at the returns for additional years of schooling. An additional year of education after enrolling in telesecundarias increases income by 16.4% (Panel B, Column 6). The results are very similar using the logarithmic transformation of wages. Restricting the analysis to only the worker subpopulation, there is a 19.3% increase in average hourly wage (Panel A, Column 12) attributed to enrolling in lower secondary education, whereas the return of an extra year of education after enrolling in telesecundarias among workers is 3%, although neither of these magnitudes are statistically significant. Taken together, the estimates of the returns to education suggest that enrolling in lower secondary education has positive returns in the labor market, mostly coming through increase in labor market participation. There is also suggestive evidence that enrolling in lower secondary education after the telesecundaria construction is rewarded within the labor market, but the results are not conclusive.

The estimated returns of the intervention are in line with other estimates in the post-primary education literature in developing countries using IV specifications. Duflo et al. (2017) find that having access to secondary education after winning a scholarship lottery increases total earnings by 19%, with the effects coming from the increased probability of working. (Bianchi et al., 2019) find that individuals earned on average 55% more after participating in a computer-assisted learning program with remote lessons, and the effects came through being more likely to be employed in occupations that focus more on analytical and cognitive skills, instead of manual and physical skills. My findings suggest a combination of these two mechansims in the telesecundaria context: individuals earn higher wages due to an increase in labor force participation, and on shifting from the agriculture into the services sector.

The estimated returns using the IV-DiD specification are substantially larger than the OLS estimated returns (Table 5, odd columns)[46]. Several factors could contribute to this difference. First, the OLS specification estimates the return of an additional year of education, while the IV-DID specification estimates the return of an additional year of education *after* enrolling into telesecundarias. Descriptive OLS estimates of a Mincerian equation for Mexico report a rate of return to an extra year of primary education around 8%, wheras the return for an extra year of secondary education and of college are around 10% and 11% (Morales-Ramos, 2011)[47]. This education level differential could contribute to the disparities

[46] CITE oreopoulos2006estimating

[47] The worldwide average of the return to schooling is around 10 percent a year, although they are higher in low or middle income economies. Regarding postprimary education, the private rate of secondary education worldwide is around 7.2%, and the rate of return to tertiary education is around 15.2% (Montenegro and Patrinos, 2014).

between the estimated returns, but it is not enough to explain all the differences between estimates. Second, the IV-DiD specification estimates a LATE for the complier subpopulation, which may not be representative of the full population. The LATEs of interventions targeting disadvantaged subpopulations tend to be larger than the corresponding OLS estimates, generally because they only influence the educational decision of individuals with high marginal returns (Card (1995); Ichino and Winter-Ebmer (1999)). For example, the opportunity costs to schooling in localities with telesecundarias may be higher than average, since they are mostly established in disadvantaged areas where children's help in agriculture or family business may be more necessary. In this case, the benefit from attending telesecundarias for the compliers must be bigger than the lost income of the children's labor, selecting only the high return individuals into secondary education. Lastly, the differences between the estimated returns could be simply due to measurement error.

Validity of the estimates. The common trends is the main assumption needed to interpret the estimates from equation (2) as causal estimates of constructing additional telesecundarias. The exclusion restriction and monotonicity assumptions are additionally required if wanting to interpret the estimates from equation (3) as the LATE effects of attending lower secondary education on labor market outcomes.

The exclusion restriction requires that the only way the construction of telesecundarias affects labor market outcomes is through its effects on the probability of enrolling in secondary education[48]. The policies with potential to confound the estimates have to systematically coincide with telesecundaria construction in many localities, and affect only cohorts young enough to attend telesecundarias, and *not* older cohorts within the same locality. The construction of higher education institutions satisfy these criteria: A few years after expanding lower secondary education access through telesecundarias, the government may construct a higher secondary education institution for the lower secondary graduates. Then, the cohorts with telesecundaria access would also have access to higher education institutions, while the older cohorts would not benefit from either investment. If this policy confounds the estimates, the reduced-form effect would be a combination of having access to telesecundarias and to higher education afterward. Section 7 empirically investigates this hypothesis.

The potential endogenous selection of individuals in or out of sample[49] caused by the telesecundaria construction challenges the interpretation of the estimated effects in (3) as the causal effects of attending lower secondary education. If the highest ability individuals that attended telesecundarias permanently migrated to pursue further studies or find better

[48]Formally, $Y(d,z)_{ilc} = Y(d)_{ilc}$ for all d, z.

[49]As explained in Section 3, one limitation of the ENOE survey is that it doesn't have data on the locality of birth, only on the locality of residence. I am assuming that individuals are living in the same locality they were in their teenage years.

economic opportunities in large cities, the estimates of the returns would be biased downward. Alternative migration arguments can be made for overestimated results. I discuss the migration concerns in Section 8. [50]

The monotonicity assumption requires that all individuals are weakly more likely to attend lower secondary education after more telesecundarias are constructed in their locality[51]. The assumption is empirically not testable. Intuitively, it makes sense it is satisfied for the binary endogenous variable of lower secondary enrollment, D^S, since the construction of a telesecundaria weakly expands the choice sets of available lower secondary options. If there are individuals switching from brick-and-mortar schools to telesecundarias after a telesecundaria construction, the monotonicity assumption for the years of education could be violated if the switchers end up receiving less years of education in the telesecundarias, than they would have received in the brick-and-mortar schools.

7 Decomposition of the returns

In this section, I investigate two potential mechanisms related to human capital acquisition that could be responsible for the large returns. On the one hand, telesecundarias may provide large payoffs in the labor market by increasing workers' productivity through human capital acquisition[52]. On the other hand, it could be that attending telesecundarias is not rewarded in the labor market but students still use them as a door to accessing upper secondary education, vocational training or college degrees. These higher education levels could be the ones providing large returns in the labor market[53].

In order to differentiate between these two pointential channels, I first lay out a simple model of sequential schooling choices under the presence of horizontal and sequential schooling alternatives. I use the theoretical framework to consider the implications of constructing different types of schools, identify mechanisms that could rationalize the results, and to derive empirical predictions consistent with the model. Second, I empirically investigate how much of the returns come from attending telesecundarias, and how much come from pursuing higher education. I find that attending a telesecundaria accounts for almost 90% of the total returns.

[50] Add general equilibrium effects suggested by Seema. Clarify exclusion restriction in terms of (1) switchers, (2) exclusion of more secondary school.. The extent to which these are a concern in this setting is discussed in Section 8.

[51] Formally, $Pr(D^T(1)_{ilt} \geq D^T(0)_{ilt}) = 1$.

[52] Note that even if telesecundarias do not provide human capital that increases productivity, there could still be positive returns if there are "sheepskin" or signaling effects (Spence, 1973). Although plausible in theory, there is limited empirical evidence on signaling mechanisms of high school diplomas (Clark and Martorell (2014); Jepsen et al. (2016)).

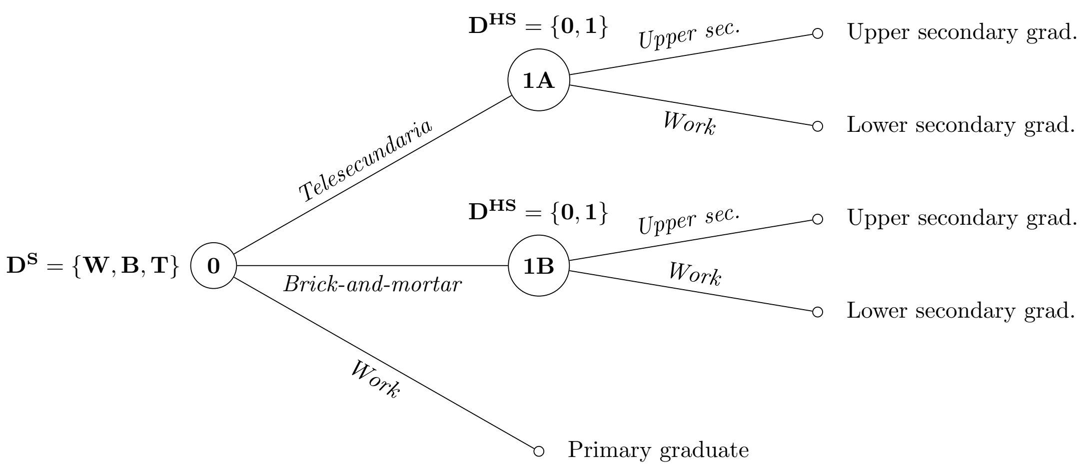
[53] John: What the problem is. How do I solve it

7.1 Theoretical framework of sequential educational choices

This section develops a simple model of schooling choices, based on sequential models of educational choices (Heckman et al. (2016), Heckman et al. (2018)) and on models with choices between schooling substitutes (e.g., Kline and Walters (2016), Mountjoy (2018)[54] Following Charles et al. (2018), I derive a set of sufficient conditions on the utility functions that guarantee a single equilibrium that is consistent with the empirical patterns. First, I consider the baseline case where there are only brick-and-mortar schools available. Second, I analyze how the individuals' behavior optimally changes when a telesecundaria gets constructed by deriving a new set of sufficient conditions and performing comparative statics. Finally, I also analyze how the equilibrium conditions change when an upper secondary school becomes available.

In this setting, individuals, indexed by $i \in N$, have completed primary education and face a set of sequential choices related to their education. First, individuals choose whether to enter the labor force and work (W) or whether to attend lower secondary education by enrolling into a brick-and-mortar school (B) or into a telesecundaria (T). Let D^S identify the discrete choice between these three alternatives: $D^S = \{W, B, T\}$. In a second stage, individuals that have completed lower secondary education choose whether to pursue further education by attending upper secondary education or to enter the labor force, $D^{HS} = \{0, 1\}$. The decision tree in Figure 1 graphically shows the two stages of these sequential schooling decisions, and the five potential outcomes associated with them.

Figure 1: Sequence of schooling decisions



Notes: This figure shows the two stage of the sequential schooling decisions, and the five potential terminal nodes: Primary graduate, lower secondary graduate (either through brick-and-mortar or telesecundaria schools), and upper secondary and beyond (either through brick-and-mortar or telesecundaria schools).

[54] There must be more relevant cites).

Individuals choose the alternative that maximizes their long-run utility. For the purposes of the model, I assume that the benefits of all alternatives are homogeneous across all individuals, $B_i^s = B^s$, for $s \in \{W, T, B, HS\}$. This simplification rules out a mechanism of selection based on underlying ability or motivation. This is a simplifying assumption that helps illustrate the dynamics of the model, that it is not needed in the empirical estimation[55]. I assume that attending a brick-and-mortar school has higher benefits than attending a telesecundaria, since it is generally perceived to be of better quality. With the benefit of working normalized to zero, B^B and B^T are the premium of attending each type of secondary education compared to working. The direct cost of attending a brick-and-mortar or an upper secondary institution is the distance to the nearest school, k_l^m, for $m \in \{B, HS\}$, and it is the same for all individuals in a given locality. In contrast, individuals only consider attending a telesecundaria if it is built in the same locality they live[56]. I assume that there are no tuition costs, since private schools are not common in the period of interest. The indirect cost of post-primary education is a stochastic cost, $c_i \sim U[0, 1]$, and reflects the individual opportunity cost of enrolling to school, for example by capturing whether students are required to help in the fields or in the family business. The utility functions for each alternative are[57]:

$$U_i^B(k_l^B, k_l^{HS}, c_i) = B^B - k_l^B - \eta c_i + \rho \cdot \max\{B^{HS} - k_l^{HS}, 0\} \tag{8}$$
$$U_i^T(k_l^B, k_l^{HS}, c_i) = B^T - c_i + \rho \cdot \max\{B^{HS} - k_l^{HS}, 0\} \tag{9}$$
$$U_i^W(k_l^B, k_l^{HS}, c_i) = 0 \tag{10}$$

where $\eta > 1$ reflects the fact that the opportunity cost for attending a brick-and-mortar secondary school is higher than for attending a telesecundaria. This is consistent with a setting where brick-and-mortar schools only have a full-time option, whereas telesecundarias offer a more concentrated schedule. The utility functions incorporate two simplifying assumptions: (1) the probability of enrolling in upper secondary education after graduating from both types of lower secondary schools is the same and (2) the benefit from attending upper secondary school after going through either types of lower secondary schools is the same[58]. Each individual optimally chooses the option that provides the highest long-run

[55] Discuss. Q: What do papers on distance to schooling argue about selection on ability?

[56] This assumption is based on the fact that telesecundarias are schools with very limited capacity (between 15-30 students), mainly serving individuals from the same locality

[57] Add extra condition for U_i^T.

[58] Justify assumptions

utility:

$$D_i(c_i) = (D_i^s(c_i), D_i^h(c_i)) = arg \max_{s\in\{W,B,T\}, h\in\{0,1\}} U_i^s(k_l^B, k_l^T, k_l^{HS}, c_i)$$

I first consider the baseline case where individuals only have access to brick-and-mortar schools[59]. A single-crossing condition between U_i^B and U_i^W is a sufficient condition that results in an equilibrium with some individuals optimally choosing to work and some optimally enrolling in lower secondary education through brick-and-mortar schools, as seen in the empirical data[60]. Figure 8 graphically shows U_i^B and U_i^W, displaying the single-crossing condition. C^o_{SW} identifies the stochastic cost of the individual indifferent between attending a brick-and-mortar school or working when there are no telesecundarias available. Individuals with lower opportunity costs than C^o_{SW} will choose to attend secondary education, and individuals with higher opportunity costs will prefer to enter the labor force.

After a telesecundaria is constructed, attending a telesecundaria becomes a feasible option for individuals living in the locality. A single-crossing condition between the utility of working and the utilities of each secondary school alternative, and U_i^B and U_i^T crossing only once in the positive utility area, are the two sufficient conditions that guarantee a single equilibrium consistent with positive shares in the three post-primary alternatives. C^*_{SW} in Figure 8 identifies the opportunity cost of the individual indifferent between attending lower secondary education and working when telesecundarias are available. C^*_{BT} in Figure 8 identifies the opportunity cost of the individual indifferent between enrolling in a brick-and-mortar or a telesecundaria. Shifts in C^*_{SW} reflect changes in the extensive margin of secondary education enrollment, whereas shifts in C^*_{BT} reflect changes in the trade-off between lower secondary school modalities.

I assume that the benefits of attending a telesecundaria, a brick-and-mortar school or an upper secondary institution do not change when telesecundarias are constructed (i.e., $B^m[A^T = 0] = B^m[A^T = 1]$, for $m \in \{T, B, HS\}$). This assumption rules out externality or general equilibrium effects. To interpret the empirical results, I also assume no general equilibrium effects or externalites[61]. This is a common assumption in the literature of the returns to education[62]. The plausibility of this assumption in the context of the paper is discussed in Section 8. Additionally, I assume that the telesecundaria construction does not affect the distance of the closest upper secondary education institution. This assumption rules out a positive correlation between the construction of a telesecundaria and of upper

[59] For simplification purposes, I assume that individuals have a brick-and-mortar school in their locality ($k_l^B = 0$), but the results carry through if brick-and-mortar schools are at nearby localities.

[60] Intuitively explain what a single-crossing condition is

[61] Justify

[62] Cite some papers. See Section 7.

secondary institutions nearby[63]. Under these assumptions, the construction of a telesecundaria in a locality only affects the utility functions by reducing the transportation cost to this type of schools ($\Delta k_l^T < 0$). This increases the utility of attending telesecundarias, resulting in an upward shift of $U^T(c_i)$ (Figure 8), whereas it does not affect the utility of the other alternatives.

Intuitively, the construction of a telesecundaria improves access to secondary education, resulting in an increase of the binding opportunity cost between working and attending lower secondary school, $C^*_{SW} > C^o_{SW}$. This results in an increase in the share of individuals enrolled in lower secondary education, and a decrease of children out of school. Individuals enrolling in lower secondary education with a relatively high opportunity cost ($c_i \in [C^*_{BT}, C^{**}_{SW}]$), will choose to attend the telesecundaria, whereas those with lower stochastic costs ($c_i < C^*_{BT}$) will choose to attend a brick-and-mortar school. Hence, some individuals that would have attended a brick-and-mortar school might now find optimal to attend the telesecundaria, decreasing the total share of students attending brick-and-mortar schools. Hence, the first prediction of the model is that the construction of a telesecundaria induces people to attend telesecundarias from two different counterfactuals: those that would have worked and those that would have attended a brick-and-mortar school if the telesecundaria had not been constructed. Note that the model assumes that the benefits of telesecundaria are constant between these two groups of compliers, since the only difference explicitly modeled are differences in opportunity costs.

Importantly, this model accounts for the fact that the benefits and costs of attending higher education directly influence the decision of attending lower secondary education. In particular, they only affect the extensive margin of enrolling in lower secondary education or working, C^*_{SW}, but do not affect the trade-off between telesecundarias or brick-and-mortar schools (C^*_{BT}). As a concrete example, Figure 9 graphically shows that a decrease in the distance to the nearest upper secondary institution shifts U_i^B and U_i^T by the same amount. This results in an overall increase of individuals enrolled in lower secondary education, but does not shift the proportion of individuals attending a brick-and-mortar school. Therefore, easy access to upper secondary institutions may increase the enrollment rate in *lower* secondary education, keeping everything else constant. This is because, in a dynamic framework, there may be *continuation value* of attending a given educational level, even if individuals do not directly benefit from it[64]. Section 7.2 examines how much of the estimated returns are due to lower secondary education, and how much of the returns are due to higher educational

[63]This assumption is not necessary, but simplifies the comparative statics. If instead I assume that the construction of a telesecundaria makes more likely the construction of an upper secondary institution nearby, the main conclusions of the comparative statics still hold.

[64]Note that the continuation value concept is different from option value effects, where individuals learn about their individual ability through course grades, which could affect their ability to decide whether to pursue further education (Stange, 2012).

levels.

7.2 Direct or continuation effects of telesecundaria?

In this section, I first present evidence of effects heterogeneity of telesecundaria construction by differential access to upper secondary school institutions (Table 11 and Figure 11). I remain agnostic about whether the returns differ by secondary education modality[65]. This decision is consistent with the theoretical framework in Section 7.1, which does not explicitly model the choice between different types of upper secondary education. As expected, the heterogeneity effects on education outcomes show that the telesecundaria construction increases enrollment rates in the targeted education level everywhere, but there are only spillovers increasing attendance in upper secondary and tertiary institutions if individuals have nearby access to them. Next, I empirically decompose the returns of telesecundaria into the direct effect of attending telesecundarias and the effect of pursuing higher education, an option available to individuals after completing lower secondary education. Following the dynamic treatment effects setting from Heckman et al. (2016) and Heckman et al. (2018), and using arguments from the literature on identification of counterfactual-specific effects, I propose an alternative econometric strategy to separately identify the direct and continuation effects of attending telesecundaria in a dynamic treatment effects setting with a binary endogenous variable and a binary instrument. I find that direct returns of telesecundaria are almost 90% of the total estimated returns, whereas the remaining 10% are returns of higher educational levels.

Reduced-form evidence. I use a data-driven approach to identify individuals that had nearby access to upper secondary institutions. I compute the distance as the crow flies from the locality centroid to the nearest open upper secondary institution when the individual was 15 years-old, and compute the average enrollment rate for each distance bin. The enrollment rate monotonically decreases as the distance increases until 10 km. (Figure 10), suggesting that individuals' willingness to enroll in upper secondary institutions decreases as the distance to the nearest institution increases up to 10 km. After that, the enrollment rate is uncorrelated with the distance. I select 10 km. as the cutoff for whether individuals had nearby access to an upper secondary institution, being consistent with the prediction of the theoretical framework of a negative relationship between the attractiveness of upper secondary education and the distance to the nearest institution. With the selected cutoff,

[65]In Mexico, there are three main upper secondary education modalities, with typical age range 15 to 17: General *bachillerato*, mostly geared toward pursuing tertiary education (42.8% of enrollment), technical and professional programs, similar to vocational training programs (18.8% of enrollment), and technological *bachillerato*, which includes 60% of general subjects and 40% of vocational training subjects (33.8% of enrollment) (SEP, 2014)

62.5% of the individuals in the sample have access to upper secondary institutions in less than 10 km[66].

I first investigate whether the reduced-form effects of telesecundaria construction from Section 5 differ depending on whether individuals had nearby access to upper secondary institutions. Table 11 reports the two-way fixed effects DiD coefficients (equation 2) and Figure 11 the effects by age at the year of the first telesecundaria construction (equation 7) separately for individuals with and without access to upper secondary education nearby. The interpretation of the graphs is the same as in Figures 6 and 7. There are significant increases in lower secondary enrollment rates when a telesecundaria is constructed in both groups, and individuals are 2.4 percentage points more likely to enroll in lower secondary education if they also have access to upper secondary education. Assuming the only difference across the two locality types is access to upper secondary education, this fact provides evidence in favor of the continuation value channel. The average positive effects of telesecundaria construction on upper secondary and tertiary enrollment rates all come from the subsample of individuals with upper secondary education access nearby, with in fact very small negative effects on higher education attainment otherwise, although not always significant. Overall, telesecundaria construction causes a 0.4 increase in average years of education for both groups, but it causes an additiona 0.4 increase when individuals have access to nearby upper secondary schools.

The heterogeneity effects for labor market outcomes are more informative than the education results, since ex-ante it is less predictable whether effects may differ between the two groups. An additional telesecundaria per 50 children increases the average labor market participation rate and decreases the average unemployment probability for both groups, but the magnitudes are larger for individuals with access to upper secondary education institutions. Among individuals without upper secondary school access, the average labor market participation rate increases by 1.1 percentage points and the unemployment rate decreases by 0.4 percentage points, with both magnitudes significant at 1% level. The effects among individuals with upper secondary school access are an additional 4.9 percentage points on labor market participation, significant at 1% level, and an additional decrease of 0.5 percentage points on unemployment, although barely significant. Lastly, there are average positive and significant effects of telesecundaria construction on hourly income for both groups: average wages of individuals without upper secondary access increase by 7.3%, and and by 21.2% for individuals with access to upper secondary education.

[66] Figure 10 shows the share of individuals with access to upper secondary education depending on the distance cutoff used. 22.2% of individuals in the sample would be classified as "having access" to upper secondary education if the distance cutoff for nearby secondary institutions open is 1 km. The percentage of individuals with access increases as the cutoff distance for having access increases, with around 66% of the sample having an open upper secondary institution in less than 20 km.

In summary, in places without infraestructure to pursue further education, the construction of an additional telesecundaria per 50 children increases the average hourly wage by 7.3%. Given that the effects on labor market participation are not large, it is unlikely that significant compositional changes of the labor force are entirely driving the results. Hence, the results suggest that attending lower secondary education through telesecundarias has some direct returns in the labor market. On the other hand, the construction of an additional telesecundaria per 50 children increases hourly income on average by 21.2% among individuals with access to upper secondary institutions afterward. If the only difference across these two groups was the access to nearby upper secondary institutions, the 13.9% difference in wages could be attributed to the differential access to further education. In the next section, I explicitly decompose the estimated returns in Section 6 into the returns of attending lower secondary education and the returns of pursuing upper secondary education afterward.

Decomposition of the direct and continuation effects. In a general dynamic treatment effects setting, Heckman et al. (2016) and Heckman et al. (2018) define, characterize and estimate treatment effects that take into account the effect of moving to the next node of a schooling decision tree (*direct effect*), and the benefits associated with the further schooling that such movement opens up (*continuation effect*). The decomposition of the returns to attending lower secondary education through telesecundarias into direct and continuation effects allows for a more informed assessment of the policy implications of constructing telesecundaria-like schools in other settings: Small direct and large continuation effects would suggest that upper secondary institutions are complementary investments and they need to be constructed in the same area as lower secondary schools in order to achieve persistent positive returns. On the other hand, large direct effects could potentially justify expanding access to lower secondary education in a developing country context without having to simultaneously invest in higher education institutions.

Heckman et al. (2016) prove that the Wald estimator of a Mincerian model with years of schooling as treatment can be decomposed into a weighted sum of changes in outcomes for people stopping at different years of schooling. Following arguments from Kirkeboen et al. (2016), Kline and Walters (2016), Hull (2018) and Mountjoy (2018), I show the same decomposition in the specific setting of a binary treatment and binary instrument. For simplicity, I suppress the individual, locality and cohort indices. The instrument $Z^T_{lc} \equiv Z^T$ is a binary variable indicating the intensity of telesecundaria construction for cohort c in locality l, $AboveTS_{lc}$[67]. Let $S \in \{0, 1, 2\}$ be the three terminal choices of schooling from the theoretical framework: Primary education (0), lower secondary education (1) and upper

[67]See Section 4 for details

secondary education and beyond (2). Let $S(Z^T)$ identify the potential terminal choice of schooling depending on the exposure to telesecundarias, and $Y(S, Z^T)$ the potential outcome depending on the treatment and instrument status. Assume that the standard IV assumptions of independence, exclusion and monotonicity hold. I additionally assume that there are no individuals that would have stopped at lower secondary education without telesecundaria availability, and decide to pursue upper secondary education when they have access to telesecundarias (no upper-switchers assumption)[68]. As before D^S is an indicator for whether the individual enrolled in lower secondary education. Then, the Wald estimator of the effect of enrolling in lower secondary education on income can be decomposed as follows:

$$
\begin{aligned}
\beta = &\ \frac{E[Y|Z^T=1]-E[Y|Z^T=0]}{E[D^S|Z^T=1]-E[D^S|Z^T=0]} \\
= &\ \underbrace{E[Y(1)-Y(0)|S(0)=0,S(1)=1]}_{\text{Direct effect }(\delta)} \\
&+ \underbrace{\frac{Pr(S(0)=0,S(1)=2)}{Pr(S(0)=0,S(1)\geq 1)}}_{\mu}\underbrace{E[Y(2)-Y(1)|S(0)=0,S(1)=2]}_{\text{Continuation effect }(\kappa)} \\
\beta = &\ \delta + \mu\cdot\kappa
\end{aligned} \tag{11}
$$

See Heckman et al. (2018) for details on the decomposition. For completeness, I provide the proof of the decomposition in Appendix C. An analogous expression can be derived in the IV-DiD case with the appropriate modifications of the IV assumptions outlined in Section 6. The direct effect (δ) is the effect of attending lower secondary schooling compared to just finishing primary schooling for the complier subpopulation[69]. The continuation effect (κ) is the effect of pursuing at least upper secondary education compared to stopping at lower secondary school for the complier subpopulation. μ is the fraction of individuals that pursued upper secondary education among the compliers[70] Equation (11) states that the LATE of attending lower secondary education is the sum of the direct and the continuation effects, with the latter being scaled by μ.

I modify the econometric framework to incorporate the two sequential endogenous choices from the theoretical framework, enrolling in lower secondary education, $D^S = \{0, 1\}$,and

[68]Formally, $Pr(S(0) = 1, S(1) = 2) = 0$. This additional assumption is not necessary to secure identification and cannot be tested, but makes the decomposition easier to interpret and to estimate using the proposed econometric strategy.

[69]The compliers are individuals induced to enroll in secondary education due to the availability of telesecundarias that would have not pursued any secondary education with the instrumental variable switched off.

[70]$\mu \cdot \kappa$ would be the continuation value as defined in Heckman et al. (2016) and Heckman et al. (2018).

enrolling in upper secondary education, $D^{HS} = \{0, 1\}$:

$$Y_{ilc} = \alpha_0 + \alpha_1 D^S_{ilc} + \alpha_2 D^S_{ilc} \times D^{HS}_{ilc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc} \tag{12}$$

where all other variables are defined as in equation (3). The endogenous variable $D^S_{ilc} \times D^{HS}_{ilc}$ captures the sequential nature of the two schooling choices[71]. Rearranging the above equation, it is easy to see the relationship between the net returns and the decomposition in (11) that separates them into direct and continuation effects,

$$Y_{ilc} = \alpha_0 + \underbrace{(\alpha_1 + \alpha_2 D^{HS}_{ilc})}_{\equiv\beta} D^S_{ilc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$$

Estimating the above equation with lower secondary enrollment D^S_{ilc} as single endogenous regressor results in equation (3), which estimates the LATE of lower secondary enrollment β. The two endogenous variables separate β into two different magnitudes, α_1 and α_2, where the latter is scaled by the proportion of individuals that pursue higher secondary education.

To separately identify the direct and continuation effects, I modify the strategy of interacting a single instrument with baseline covariates to generate additional sources of variation, commonly used in the counterfactual-specific effects literature (Kline and Walters (2016); Hull (2018)). Intuitively, this strategy uses the heterogeneity in the first stage effects across baseline covariates to separately identify the effects of the endogenous variables. Let H be a binary baseline covariate that separates the sample in two groups depending on its value. With the appropriate modifications of the assumptions, it is straightforward to show that the decomposition in (11) also holds conditioning on the value of H,

$$\beta(H) = \delta(H) + \mu(H)\kappa(H)$$

Assume that the treatment effects are homogeneous across all values of H (i.e., $\delta(H) = \delta$ and $\kappa(H) = \kappa$ for all H). Under this assumption, and for two different values of H, H_0 and H_1,

$$\hat{\beta}(H_0) = \delta + \hat{\mu}(H_0)\kappa \tag{13}$$

$$\hat{\beta}(H_1) = \delta + \hat{\mu}(H_1)\kappa \tag{14}$$

The returns $\hat{\beta}(H_0)$ and $\hat{\beta}(H_1)$ can be empirically estimated using the LATE framework in

[71] Adding D^{HS}_{ilc} as an individual parameter in the regression would make it perfectly collinear with $D^S_{ilc} \times D^{HS}_{ilc}$, since the only way of attending upper secondary education is having completed lower secondary school first. If, instead, the treatment to decompose was the returns to attending telesecundarias, with the endogenous variables D^T and $D^T \times D^{HS}$, the coefficient on the single D^{HS}_{ilc} would capture the effect of upper secondary for individuals that attended a brick-and-mortar school.

Section 6 separated for each H group. The population shares $\hat{\mu}(H_0)$ and $\hat{\mu}(H_1)$ can be nonparametrically identified using the first stage results. Then, (13) and (14) is a system of two equations and two unknowns. Taking the difference between both equations and rearranging,

$$\kappa = \frac{\hat{\beta}(H_1) - \hat{\beta}(H_0)}{\hat{\mu}(H_1) - \hat{\mu}(H_0)}$$

The identification of δ and κ requires that the denominator is nonzero, $\hat{\mu}(H_1) - \hat{\mu}(H_0) \neq 0$.

To summarize, the use of H as a baseline covariate that separates the sample into two strata guarantees identification of the direct and continuation LATEs under two assumptions. First, the direct and continuation effects are the same for the complier subpopulation with $H = 0$ and the complier subpopulation with $H = 1$. Second, the share of individuals deciding to continue studying upper secondary education among the complier subpopulation is different for individuals with $H = 0$ than for individuals with $H = 1$.

I implement this identification argument by using an instrumental variable approach with two instrumental variables. The baseline covariate H generating the additional source of variation is the binary variable indicating whether individuals have access to higher secondary education in 10 km, $H_{lc} \in \{0, 1\}$[72]. The covariate must generate variation in upper secondary enrollment in response to the telesecundaria construction across individuals. The two instruments are the binary measure of telesecundaria intensity, $AboveTS_{lc}$, and its interaction with H, $AboveTS^T_{lc} \times H_{lc}$. Then, the first stage equations are:

$$D^S_{ilc} = \pi_0 + \pi_T AboveTS_{lc} + \pi_H AboveTS_{lc} \times H_{lc} + \varphi H_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \nu_{ilc} \tag{15}$$

$$D^S_{ilc} \times D^{HS}_{ilc} = \rho_0 + \rho_T AboveTS_{lc} + \rho_H AboveTS_{lc} \times H_{lc} + \varphi H_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \nu_{ilc} \tag{16}$$

If the LATE assumptions are satisfied, the share of individuals pursuing upper secondary is different across H groups, and the direct and continuation effects are homogeneous across H groups, then $\hat{\alpha}_1$ and $\hat{\alpha}_2$ are unbiased causal estimates of the direct and continuation effects of telesecundaria, i.e., $\hat{\alpha}_1 = \delta$ and $\hat{\alpha}_2 = \kappa$.

The validity of the LATE assumptions for Z^T_{lc} is discussed in Section 6. Table 11 provides evidence consistent with the differential proportion of upper secondary seekers assumption, since telesecundaria construction significantly increases the upper secondary enrollment probability only in areas with upper secondary access. Table 7 reports the first stage results. As expected, there is a strong first stage of the binary version of the telesecundaria density

[72]This is the variable used to show the reduced-form evidence on the effects heterogeneity by upper secondary school access.

treatment, $AboveTS_{lc}$, on lower secondary enrollment (Column 1), even after controlling for upper secondary school access. The effect of having access to upper secondary enrollment increasing lower secondary enrollment as well (Column 2 and 3) suggests that a continuation value could be at play. Additionally, there are strong first stage effects of both instruments on upper secondary enrollment as well (Columns 4 through 6).

Table 8 reports the net returns to lower secondary education estimated using the IV-DiD specification in equation (3) (Column 1), and estimated results of the returns decomposition in equation (12) (Column 2). I find that almost 90% of the net returns of lower secondary education come from the direct effects of enrolling in lower secondary education, and the remaining 10% come from having the opportunity to pursue upper secondary education afterwards.

As discussed in Section 6, the estimated net returns of lower secondary education through telesecundaria enrollment are a 117.2% increase in the long-run hourly wage (Table 5, Column 1). The average estimated direct effect of enrolling in lower secondary education through telesecundarias is a 104.1% increase in hourly wages for the complier subpopulation, compared to individuals with just primary school. This effect is statistically significant at the 1% level. The returns of attending higher secondary education after telesecundaria enrollment are an additional 189% increase in wages compared to the returns of just completing lower secondary education. Even though the returns of attending higher secondary education are significantly larger than those of attending lower secondary education, their contribution to the net effects of lower secondary enrollment is only 10% since the proportion of compliers that continue studying by enrolling in higher secondary education is small.

8 Alternative explanations

The theoretical and econometric models specify several restrictions on potential channels and mechanisms at play in order to interpret the estimates as the returns to lower secondary education. In this section, I outline alternative mechanisms to human capital formation, and discuss the extent to which they may be driving the results in this setting.

The main limitation of the analysis is that the estimates are sensitive to endogenous migration due to telesecundaria construction. Although I focus the analysis on adults that live in their state of birth, I do not observe whether they migrated within the same state[73]. Migration could bias the results if access to telesecundarias affects the composition of in-migrants or out-migrants. On the one hand, out-migration of individuals with the highest

[73] In the period of 2005-2010, 6.6% of the population moved within Mexico, 3.5% were interstate migrants and 3.1% were intrastate migrants. Localities with more than 15,000 habitants received . Almost 50% of migrants worked in the services sector, 20% in commerce, and 17% in industry, and only 5% in agriculture. (CONAPO, 2014).

returns of lower secondary education to pursue higher education or better work opportunities would underestimate the returns of the program. I cannot evaluate this claim given lack of migration data at the locality level. On the other hand, the telesecundaria construction could attract families motivated to invest on their children, which would upward bias the results. However, with localities with more than 15,000 habitants receiving around around 75% of the total migration within Mexico (CONAPO, 2014), is unlikely that this mechanism accounts for all the estimated effects.

Another potential channel that could influence the results is the presence of externalities and general equilibrium effects, which could bias the estimates in an unknown direction. On the one hand, the construction of additional telesecundarias could increase school competition for existing schools, which could result in an overall quality improvement of education, also benefiting brick-and-mortar students and biasing the estimates downward. On the other hand, a significant influx of new lower secondary school graduates in the labor market could affect the work opportunities of older cohorts, most likely by increasing competition in higher-paying occupations or sectors, which would upward bias the estimates.

- FOOTNOTE: Use Goldin and Katz, Katz and Murphy: GE effects: imagine that the elasticity of substitution between high-skill and low-skill workers is X. Back-of-the-envelope calculation : How big the telesecundaria construction be (Implied change in the wage premium)

- Moretti: Concentration of high-skilled workers. How much spillovers are from having people educated in the local market?

- Bob Topel: Chapter in the handbook of labor economics (look for it!)

A third factor to consider is the interaction of telesecundaria with Progresa/ Oportunidades, a large conditional cash transfer (CCT) program that began in 1997 and has been widely studied due to the randomized implementation during the early years[74]. Progresa/Oportunidades targets poor households in rural communities, and its main feature is that it conditions monetary transfers to children regularly attending schools. With about 70% of its beneficiaries in 2013 from rural areas (Parker and Todd, 2017). In 2015, around 59% of telesecundaria students benefited from INEE (2016). Additionally, in 2015 almost 60% of telesecundaria students benefited from th Prospera/Oportunidades conditional cash transfer (CCT) program, against around 23% of brick-and-mortar lower secondary students (INEE, 2016). To mitigate the concerns about the interaction between the CCT and the telesecundaria effects, Table X in Appendix X reports the main results including only localities with telesecundarias constructed before 1990. The main results still hold, indicating that the Progresa program does not account for all the effects.

[74] See Parker and Todd (2017) for a recent review on the evidence on the program effects.

9 Discussion and conclusions

The use non-conventional tools to solve challenges and constraints in the provision of education often raises concerns about the resulting quality of the education provided. Descriptive reports show that telesecundaria students tend to perform poorly in standardized assessments compared to students from brick-and-mortar schools[75]. This type of observational evidence is often used to argue that telesecundarias provide low-quality education, without taking into account the socioeconomic differences across student populations. In this paper, I provide evidence of the positive effects of schools using televised lessons as an alternative to face-to-face instruction on educational attainment and long-run labor market outcomes. I find that telesecundaria construction significantly increases enrollment in lower secondary education among cohorts with access to it, and that some individuals continue to pursue higher secondary and tertiary education afterwards. As adults, they are more likely to work as adults, earn higher wages, and are less likely to work in agriculture, shifting towards the service sector. I estimate that enrollment in lower secondary education after telesecundaria construction increase wages by 117.2%, and that an extra year of education after the telesecundaria construction has an average return of 16.4%.

It is important to interpret the positive results of the intervention taking into account that the compliers are a non-random sample of the population. Given that telesecundarias are small schools and seen by many as providers of lower quality education than brick-and-mortar schools, individuals that enrolled in lower secondary education only after telesecundarias became available likely were constrained in some way before. The theoretical framework identifies the distance to the nearest school and a relatively high opportunity cost of schooling as deterrents to enroll in brick-and-mortar schools. These get relaxed when a telesecundaria gets constructed in the individual's locality, and it is plausible that the benefits of enrolling in secondary school for this subpopulation are particularly large. The results are more difficult to interpret under alternative theories regarding the complier subpopulation. For example, in a Roy model style of selection on ability, we would expect that the compliers are on average of lower ability than individuals that would have enrolled in lower secondary education even without a telesecundaria nearby. In this setting, the estimated results would imply that pursuing post-primary education still have large benefits for low ability individuals, contradicting recent evidence on heterogeneity of returns based on underlying ability (e.g., Heckman et al. (2018)).

The distinct feature of telesecundarias is the transmission of all lessons through television broadcastings, which are taught by remote teachers. It can be considered one of the most primitive versions of technology-aided instruction. Even though the popularity of online

[75] For example, in PISA 2003, 94.4% of telesecundaria students had insufficient math competency in math, compared to the 58% of brick-and-mortar students or the OECD average of 21.4% (INEE, 2005)

learning courses has dramatically over the last decade, there is limited rigorous research on their effectiveness. Recent reviews suggest that providing technological inputs alone does not generally improve student learning (Bulman and Fairlie (2016); Escueta et al. (2017)). However, some computer-assisted learning (CAL) and behavioral interventions show considerable promise, especially if using programs to personalize instruction to student needs (Banerjee et al. (2007); Muralidharan et al. (2019)). In telesecundarias, the delivery of contents differs greatly from these successful programs, being a one-size-fits-all lesson remotely transmitted that cannot even be adapted to the overall classroom pace and level. One hypothesis that can reconcile the long-term effects of the intervention with the existing literature is the "blended environment" of telesecundarias, where televised lessons are complemented with in-class discussions, work and peer interaction as in conventional classrooms. This is in line with (Escueta et al., 2017), which reports that "the effects are generally on-par with those of full in-person courses, which suggests that appropriate combination of online and in-person learning may be cost effective".

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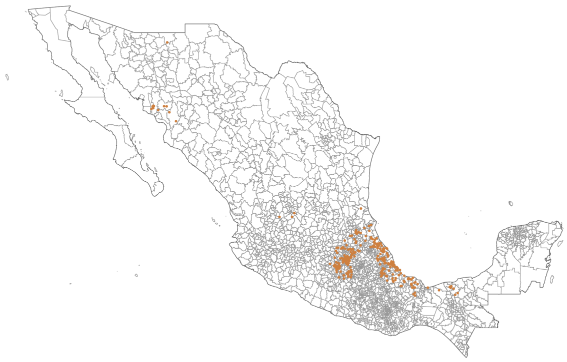
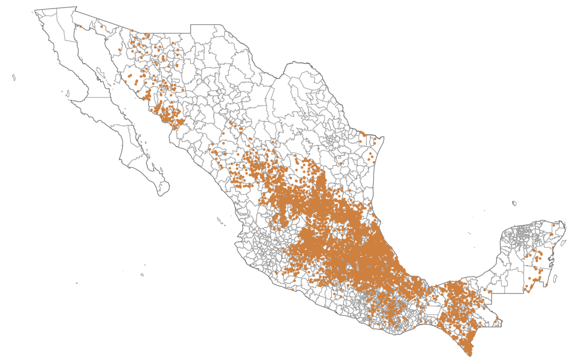
Figure 2: Expansion of telesecundarias (1968-2014)

(a) 1975



(b) 1985



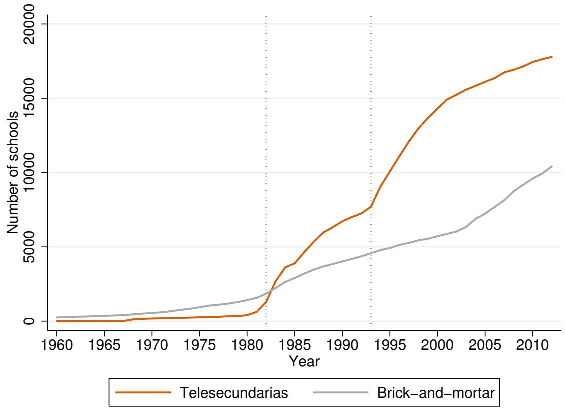
(c) 1995

(d) 2014

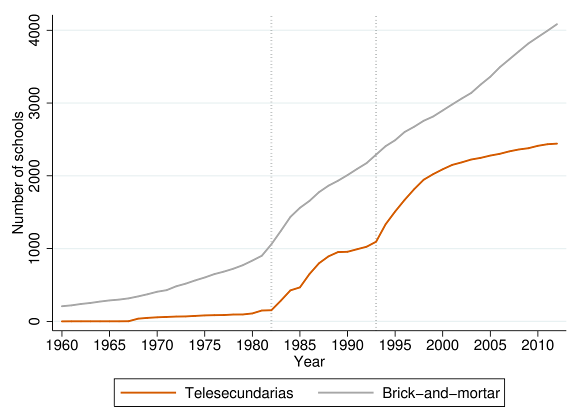
Notes: Telesecundaria expansion for the 1968-2014 period. Geographical frontiers correspond to municipalities, and each orange dot to a single telesecundaria. *Source*: Author graphs based on the school registry data from the Ministry of Education in Mexico.

Figure 3: Number of schools

(a) All localities



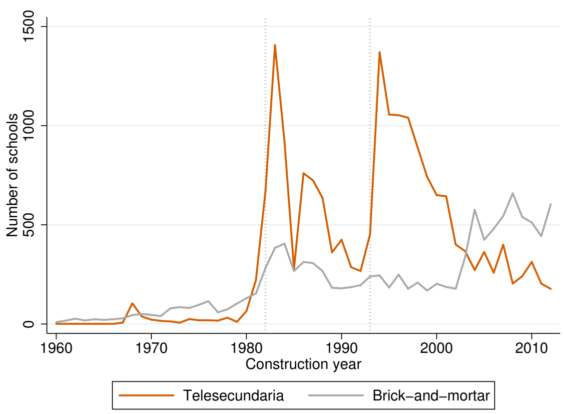
(b) ENOE localities



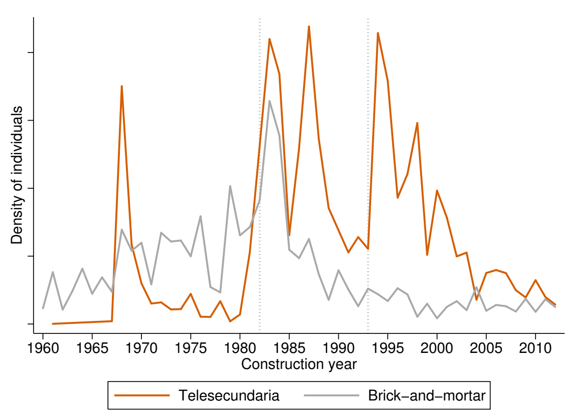
Notes: This figure reports the average number of schools opened by year in all localities in Mexico with less than 15,000 habitants (Panel (a)) and restricted for only the ENOE localities used in the analysis (Panel (b)).

Figure 4: School construction dates

(a) School-level



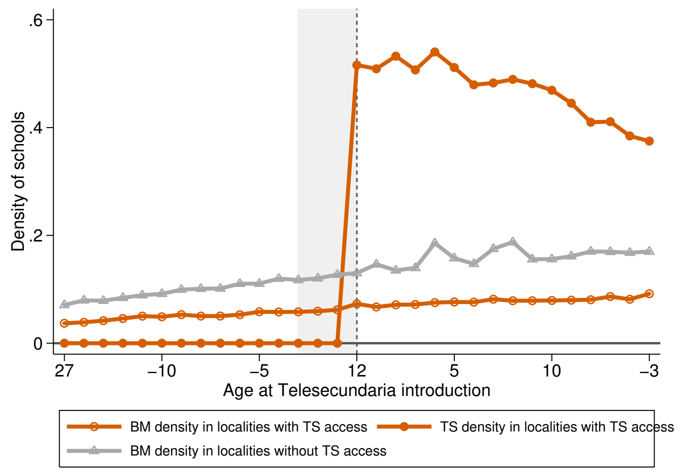
(b) Individual-level



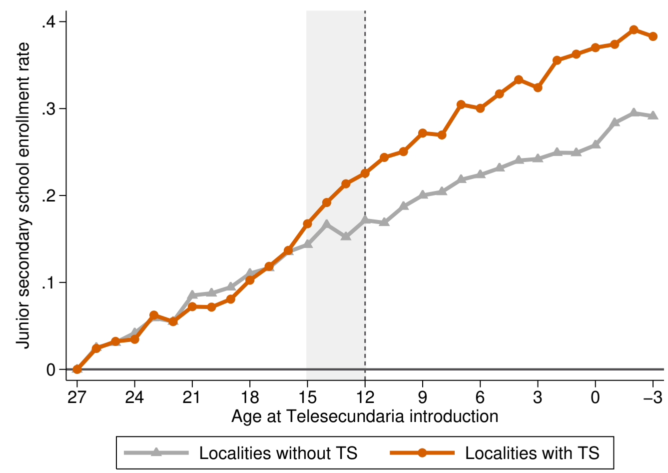
Notes: This figure shows the distribution of the construction dates grouped by telesecundarias and brick-and-mortar for all localities with less than 15,000 habitants in Mexico. Panel (a) displays the distribution of construction years at the school-level, and Panel (b) the distribution of individuals by dates of the first school opened in their locality.

Figure 5: Evolution of outcomes relative to age at telesecundaria introduction

(a) Density of schools

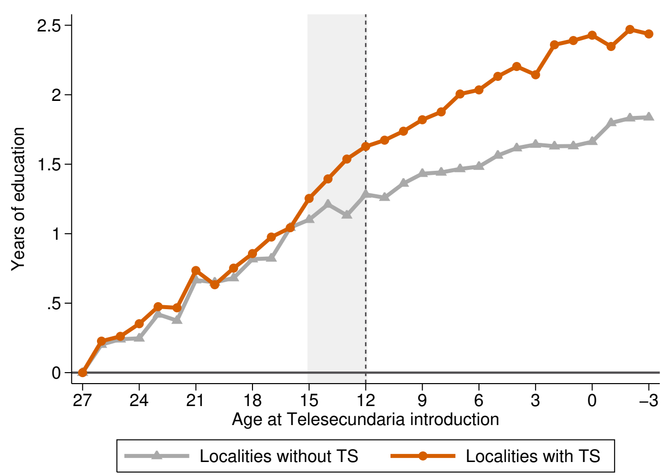


(b) lower secondary enrollment

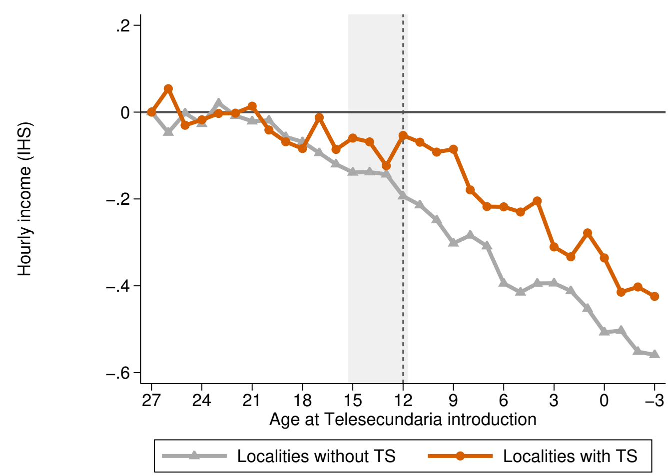


ju

(c) Years of education

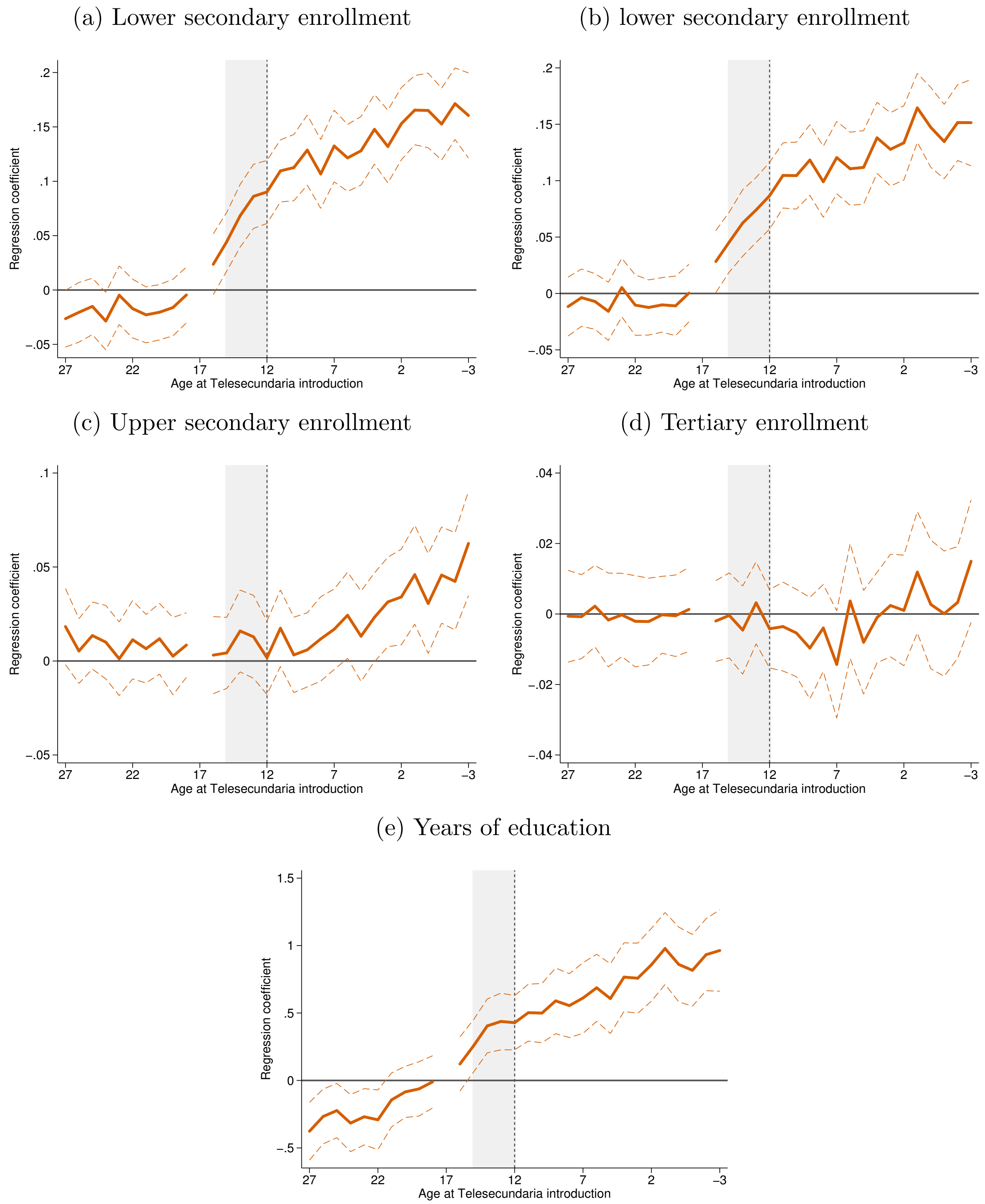


(d) Hourly income (Inverse hyperbolic sine)



Notes: This figure presents descriptive population trends of the average lower secondary enrollment rate (Panel (b)), average years of education (Panel (c)) and average hourly income (Panel (d)) in localities that never had a telesecundaria (blue) and localities that eventually had one (red). The averages are computed with respect to the age of individuals the year the first telesecundaria was constructed in their locality. Localities that never had telesecundarias eceive a random placebo year that follows the distribution of construction years in the sample. The mean value of the outcome is normalized at zero at the age of 27 for both groups.

Figure 6: Effects of telesecundaria construction on education outcomes

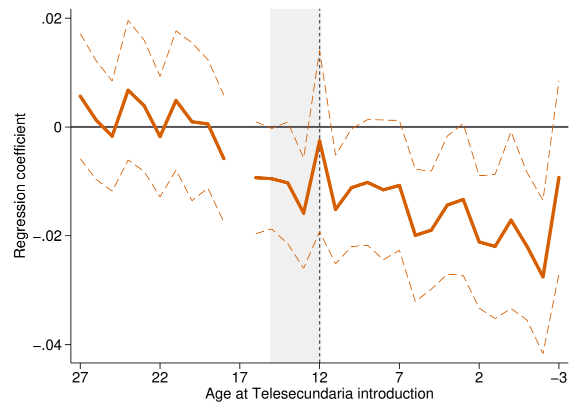


Notes: This figure presents the reduced-form estimates of the difference-in-differences specification for different outcomes, computed by age at the year of telesecundaria construction. See equation (7) for details. Coefficient estimates are shown with a solid line, and 95% confidence intervals with a dashed line. All effects are computed with respect to age 17, the baseline year.

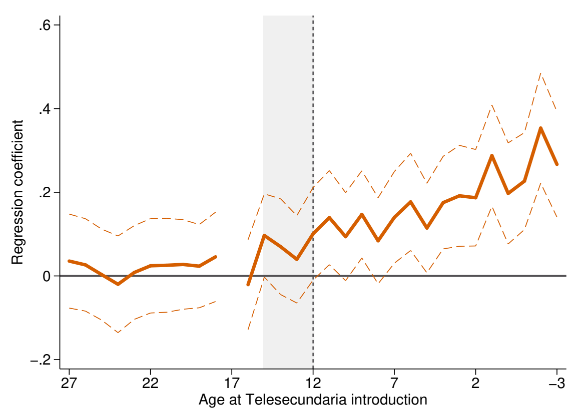
Figure 7: Effects of telesecundaria construction on labor market outcomes

(a) Labor market participation

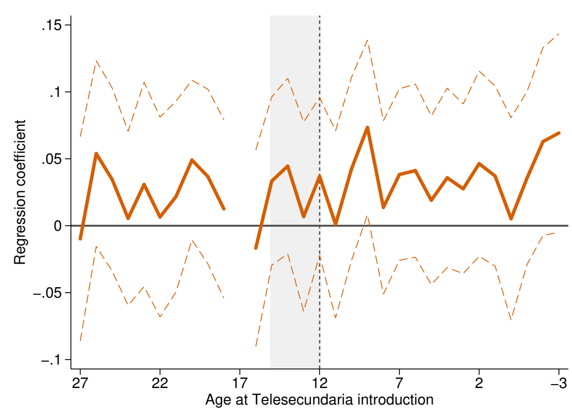
(b) Unemployment



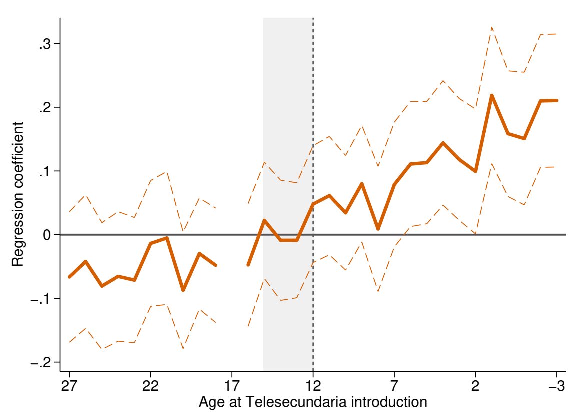
(c) Hours worked (IHS)



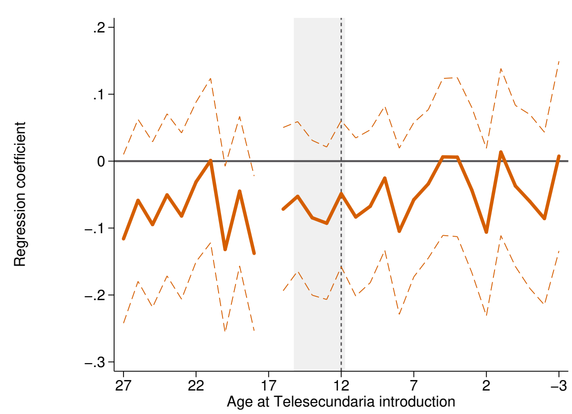
(d) Hours worked, workers (IHS)



(e) Hourly wage (IHS)

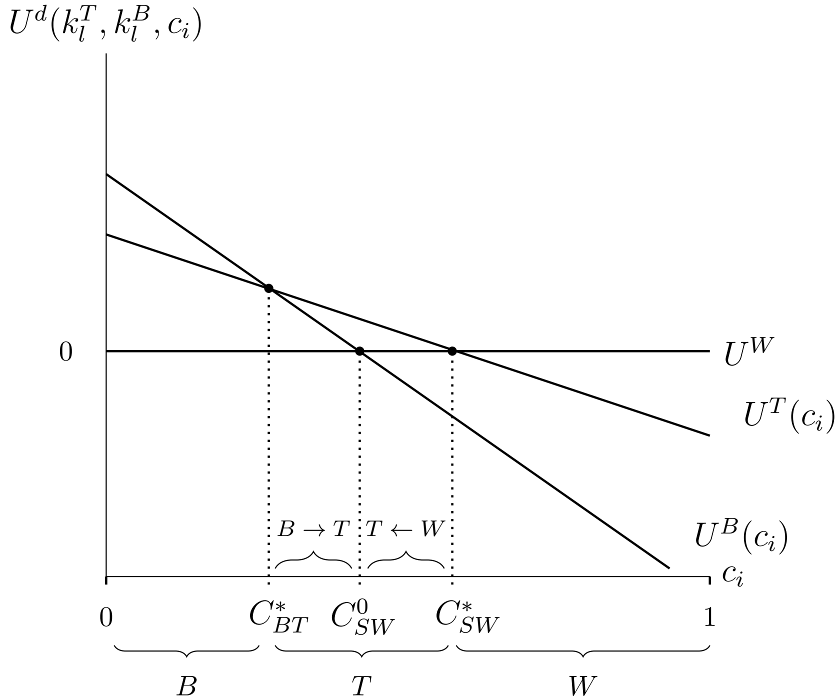


(f) Hourly wage, workers (IHS)



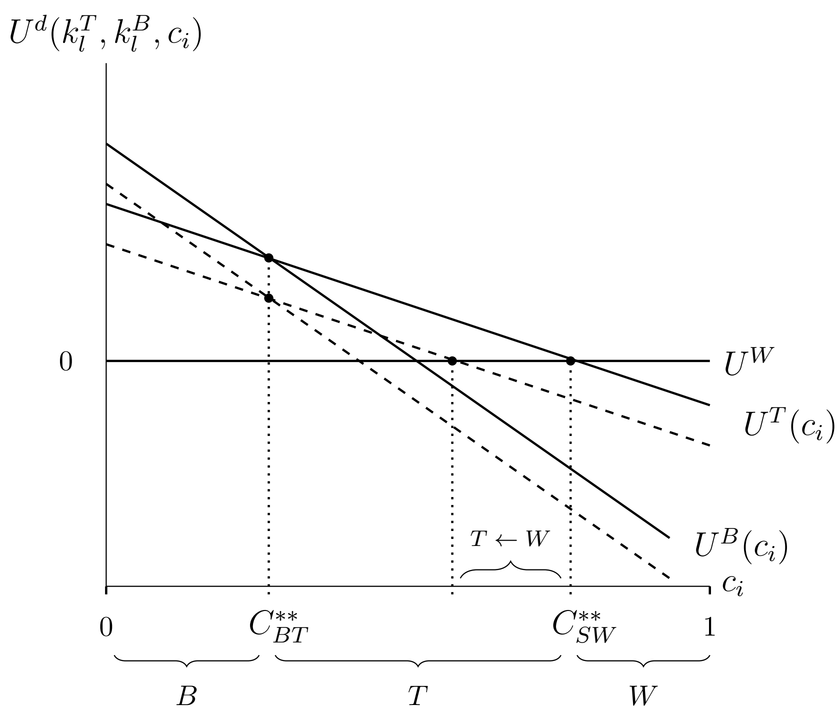
Notes: This figure presents the reduced-form estimates of the difference-in-differences specification for different outcomes, computed by age at the year of telesecundaria construction. See equation (7) for details. Coefficient estimates are shown with a solid line, and 95% confidence intervals with a dashed line. All effects are computed with respect to age 17, the baseline year.

Figure 8: Construction of a telesecundaria



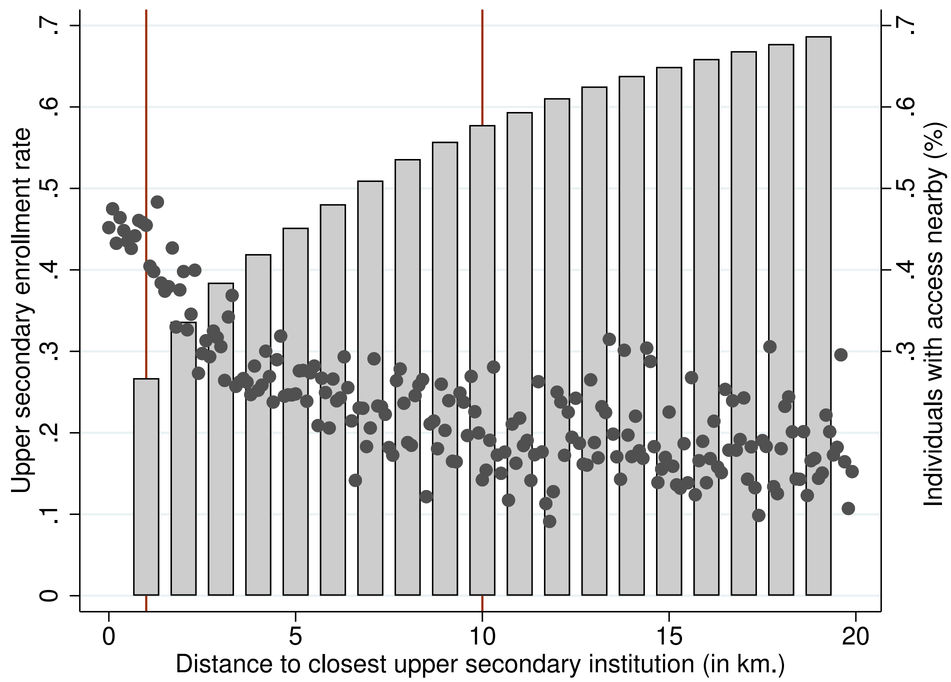
Notes: *TO BE COMPLETED*

Figure 9: Construction of a higher secondary school



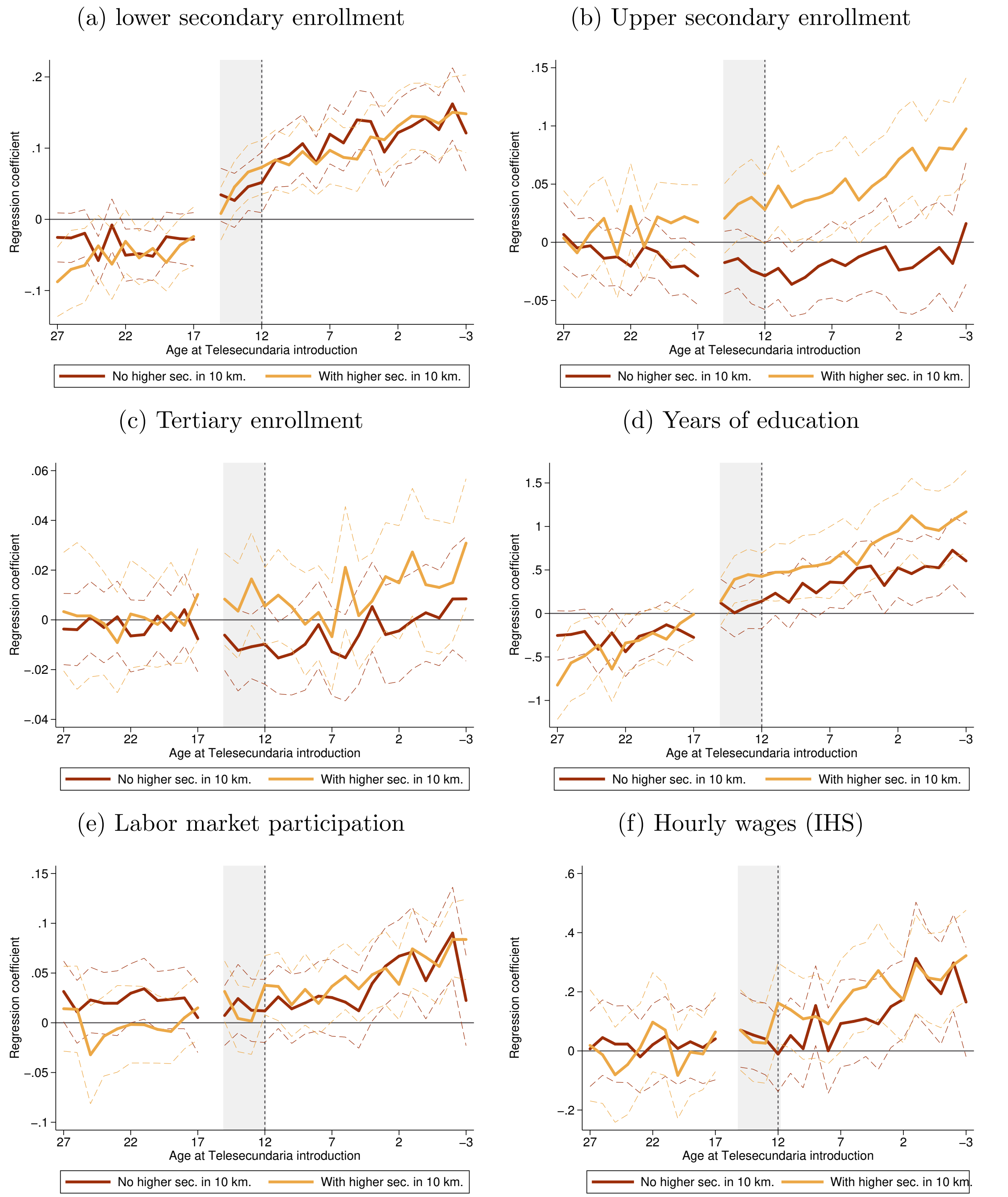
Notes:

Figure 10: Optimal cutoff for distance to upper secondary school



Notes: This figure presents a scatterplot of the correlation between upper secondary enrollment rate (left axis) and the distance to the closest upper-secondary institution (in km.). It also shows a bar graph of the share of individuals with nearby access to upper-secondary education (right axis) if a given distance to closest upper secondary institution (in km.) is used as a cutoff for the definition of "nearby access".

Figure 11: Effects of telesecundaria construction on labor market outcomes, by access to upper secondary institutions



Notes: This figure presents the reduced-form estimates of the difference-in-differences specification for different outcomes, computed by age at the year of telesecundaria construction. See equation (7) for details. Coefficient estimates are shown with a solid line, and 95% confidence intervals with a dashed line. All effects are computed with respect to age 17, the baseline year.

Table 1: Summary Statistics

	< 100,000 hab.		All	
	Mean	SD	Mean	SD
Individual Characteristics				
Female	0.52	0.50	0.52	0.50
Age	32.48	12.78	32.31	12.60
Years of Education	8.62	4.11	9.64	4.12
Junior Secondary Ed. Enrollment Rate	0.66	0.48	0.75	0.43
Upper Secondary Ed. Enrollment Rate	0.33	0.47	0.44	0.50
Tertiary Ed. Enrollment Rate	0.12	0.33	0.19	0.39
Labor Force Participation Rate	0.63	0.48	0.64	0.48
Unemployment Rate	0.05	0.21	0.05	0.22
Weekly Hours Worked	41.06	18.61	41.39	18.02
Hourly Income (MXN pesos)	11.88	27.12	14.14	39.93
Hourly Income of Workers (MXN pesos)	19.81	32.70	23.16	49.01
Sector: Construction	0.09	0.29	0.09	0.28
Sector: Manufacturing	0.16	0.37	0.16	0.36
Sector: Commerce	0.17	0.38	0.19	0.39
Sector: Services	0.36	0.48	0.44	0.50
Sector: Agriculture	0.20	0.40	0.10	0.30
Type: Company/Institution	0.48	0.50	0.60	0.49
Type: Paid Domestic	0.04	0.21	0.04	0.20
Type: Informal Sector	0.28	0.45	0.25	0.43
Type: Subsist. Agriculture	0.20	0.40	0.10	0.30
Informal Occupation Rate	0.39	0.49	0.33	0.47
Social Security Access Rate	0.30	0.46	0.41	0.49
Observations	896274		1794042	
Schooling Access				
Has Access to Secondary Schools	0.67	0.47	0.83	0.38
Has Access to Telesecundarias	0.21	0.41	0.34	0.47
Has Access to Brick-and-mortar Schools	0.58	0.49	0.78	0.41
Number of Secondary Schools (if access)	6.11	7.24	43.40	52.02
Number of Telesecundarias (if access)	1.67	1.14	4.40	4.77
Number of Brick-and-mortar (if access)	6.43	7.05	43.88	50.57
Secondary Schools per 50 Children (if access)	0.30	0.63	0.19	0.41
Telesecundarias per 50 Children (if access)	0.42	0.77	0.14	0.47
Brick-and-mortar per 50 Children (if access)	0.19	0.47	0.14	0.29
Total Population in 1990	20120.33	25899.32	209246.23	259013.59
Observations	896274		1794042	

Variable means displayed to the right of the variable name. Standard deviations displayed next to the mean. Individual-level data from all quarters of the 2005-2016 ENOE waves, with only the first observation for each individual. Summary statistics computed at the individual level for all localities and for localities with less than 100,000 habitants.

Table 2: Effects of Telesecundaria Construction on Educational Attainment

	Junior Secondary		Higher Education		Years of Education
	Enrollment	Graduation	Upper Secondary	Tertiary	
	(1)	(2)	(3)	(4)	(5)
Above Median TS Density	0.135***	0.118***	0.015***	0.004	0.960***
	(0.007)	(0.007)	(0.005)	(0.002)	(0.060)
Dependent Mean	0.66	0.60	0.33	0.12	8.62
Observations	896274	896274	896274	896274	896274

Notes: This table illustrates the reduced-form effects of telesecundaria access on educational attainment. The table reports the estimated coefficients of β from the estimation of the two-way fixed-effects difference-in-differences equation (2), with the specification: $Y_{ilc} = \alpha + \beta AboveTS_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$. It uses as dependent variable an indicator for enrollment and graduation in junior secondary education (Columns 1-2), for enrollment in upper secondary and tertiary education (Columns 3-4), and total years of education (Column 5). See Section 3 for a description of the outcome variables. Above median TS density is an indicator capturing the intensity of telesecundaria exposure, and identifies the locality-cohort observations with above median telesecundaria density. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample includes all individuals living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Effects of Telesecundaria Construction on Labor Market Outcomes

	Labor Supply				**Labor Income**			
	Active	Unemployed	Hours Worked		Wage Earner	Hourly Wage		
			(log)	(IHS)		(Pesos)	(log)	(IHS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: All Individuals								
Above Median TS Density	0.032***	-0.013***	0.135***	0.158***	0.021***	2.655***	0.148***	0.169***
	(0.005)	(0.002)	(0.017)	(0.020)	(0.005)	(0.193)	(0.015)	(0.018)
Dependent Mean	0.63	0.05	2.12	2.51	0.45	11.88	1.37	1.65
Observations	896274	563401	896274	896274	896274	896274	896274	896274
Panel B: Workers								
Above Median TS Density			0.008	0.008	-0.027***	2.312***	0.037**	0.031
			(0.008)	(0.009)	(0.006)	(0.254)	(0.016)	(0.020)
Dependent Mean			3.54	4.18	0.76	19.81	2.28	2.76
Observations			537546	537546	537546	537546	537546	537546

Notes: This table illustrates the reduced-form effects of telesecundaria access on labor market supply (Columns 1-4) and on labor market income (Columns 5-8). The table reports the estimated coefficient β from the estimation of the two-way fixed-effects difference-in-differences equation (2), with the specification: $Y_{ilc} = \alpha + \beta AboveTS_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$. It uses as dependent variable an indicator for labor market participation (Column 1), unemployment (Column 2) the log and inverse hyperbolic sine transformations of weekly hours worked (Columns 3-4), an indicator for earning a wage (Column 5), and hourly wage in Mexican pesos, and its log and inverse hyperbolic sine transformations (Columns 6-8). See Section 3 for a description of the outcome variables. Above median TS density is an indicator capturing the intensity of telesecundaria exposure, and identifies the locality-cohort observations with above median telesecundaria density. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample in *Panel A* includes all individuals living in localities with less than 100,000 habitants, and the sample in *Panel B* includes only workers living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 4: Effects of Telesecundaria Construction on Labor Sectors and Informality

	Labor Market Sectors					**Labor Market Informality**					
						Types of Employers					
	Construction (1)	Manufact. (2)	Commerce (3)	Services (4)	Agriculture (5)	Company/Instit. (6)	Domestic (7)	Agriculture (8)	Informal (9)	Informal Occup. (10)	SS Access (11)
						Panel A: All Individuals					
Above Median TS Density	0.005***	0.005**	0.003	0.052***	-0.030***	0.046***	0.007***	-0.030***	0.015***	-0.016***	0.038***
	(0.002)	(0.002)	(0.002)	(0.004)	(0.003)	(0.004)	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)
Dependent Mean	0.06	0.10	0.10	0.22	0.12	0.29	0.03	0.12	0.17	0.39	0.18
Observations	896274	896274	896274	896274	896274	896274	896274	896274	896274	896274	896274
						Panel B: Workers					
Above Median TS Density	0.003	-0.007	-0.020***	0.040***	-0.020***	0.017***	0.008***	-0.020***	-0.005	-0.047***	0.028***
	(0.003)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)	(0.003)	(0.005)	(0.005)	(0.005)	(0.005)
Dependent Mean	0.09	0.16	0.17	0.36	0.20	0.48	0.04	0.20	0.28	0.65	0.30
Observations	537546	537546	537546	537546	537546	537546	537546	537546	537546	537546	537546

Notes: This table illustrates the reduced-form effects of telesecundaria access on the participation on labor market sectors (Columns 1-5) and on labor market informality (Columns 6-8). The table reports the estimated coefficient β from the estimation of the two-way fixed-effects difference-in-differences equation (2), with the specification: $Y_{ilc} = \alpha + \beta AboveTS_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$. Columns 1-5 use as a dependent variable an indicator identifying whether the individual work in a given labor market sector: Construction (Column 1), manufacturing (Column 2), commerce (Column 3), services (Column 4) or agriculture (Column 5). Columns 6-9 use as a dependent variable an indicator for whether the individual works for a given type of employer: Formal company or institution (Column 6), paid domestic work (Column 7), subsistence agriculture (Column 8) or informal sector (Column 9). Column 10 uses as a dependent variable an indicator for whether the individual works in an informal occupation, and Column 11 for whether the individual has access to health insurance benefits through their employer. See Section 3 for a description of the outcome variables. Above median TS density is an indicator capturing the intensity of telesecundaria exposure, and identifies the locality-cohort observations with above median telesecundaria density. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample in *Panel A* includes all individuals living in localities with less than 100,000 habitants, and the sample in *Panel B* includes only workers living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5: Labor Market Returns to Junior Secondary Education

	All Individuals						*Only Workers*					
	Wage (Pesos)		Wage (log)		Wage (IHS)		Wage (Pesos)		Wage (log)		Wage (IHS)	
	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS	OLS	2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A. Treatment: Junior Secondary Education Enrollment												
Enrolled in Junior Sec.	4.291***	18.594***	0.173***	1.032***	0.188***	1.179***	7.132***	15.490***	0.276***	0.270**	0.298***	0.237
	(0.138)	(1.394)	(0.009)	(0.112)	(0.011)	(0.135)	(0.206)	(1.896)	(0.013)	(0.122)	(0.015)	(0.147)
First-stage F-stat.		392.95		392.95		392.95		313.42		313.42		313.42
Dependent Mean	11.88	11.88	1.37	1.37	1.65	1.65	19.81	19.81	2.28	2.28	2.76	2.76
Observations	896274	896207	896274	896207	896274	896207	537546	537441	537546	537441	537546	537441
Locality FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Cohort FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Panel B. Treatment: Years of Education												
Years of Education	0.981***	2.627***	0.043***	0.146***	0.047***	0.167***	1.345***	2.380***	0.041***	0.042**	0.043***	0.036
	(0.024)	(0.195)	(0.001)	(0.016)	(0.002)	(0.019)	(0.031)	(0.291)	(0.002)	(0.019)	(0.002)	(0.023)
First-stage F-stat.		256.58		256.58		256.58		198.36		198.36		198.36
Dependent Mean	11.88	11.88	1.37	1.37	1.65	1.65	19.81	19.81	2.28	2.28	2.76	2.76
Observations	896274	896207	896274	896207	896274	896207	537546	537441	537546	537441	537546	537441
Locality FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Cohort FE	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes

Notes: This table illustrates the labor market returns to junior secondary education through telesecundaria enrollment. The table reports the estimated coefficient β^{LATE} from the estimation of the instrumented difference-in-differences equation (3) in even columns, with the specification $Y_{ilc} = \alpha + \beta D^S_{ilc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$. In odd columns it reports the estimated coefficient β from an Ordinary Least Squares (OLS) regression with the specification: $Y_{ilc} = \alpha + \beta D^S_{ilc} + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$, where the parameters are defined as in equation (3). It uses as dependent variable hourly wage in Mexican pesos, and its log and inverse hyperbolic sine transformations (Columns 6-8). See Section 3 for a description of the outcome variables. The treatment in *Panel A* is an indicator for enrollment in secondary education, and the treatment in *Panel B* is the total years of education. The instrumental variable is $AboveTS_{lc}$, an indicator capturing the intensity of telesecundaria exposure, and identifies the locality-cohort observations with above median telesecundaria density. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample in Columns 1-6 includes all individuals living in localities with less than 100,000 habitants, and the sample in Columns 7-12 includes only workers living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 6: Effects of Telesecundaria Construction by Access to Upper Secondary Education

	(1)	(2)	(3)	(4)
	Panel A: Education Outcomes			
	Junior Sec. Enroll.	Upper Sec. Enroll.	Tertiary Enroll.	Years of Education
Above Median TS Density	0.117***	-0.015**	-0.004	0.599***
	(0.011)	(0.007)	(0.004)	(0.080)
Above Median TS Density × Upper Sec. Nearby	0.011	0.061***	0.021***	0.360***
	(0.015)	(0.010)	(0.006)	(0.116)
Dependent Mean	0.66	0.33	0.12	8.62
Observations	896207	896207	896207	896207
	Panel B: Labor Market Outcomes			
	Active	Unemployed	Hours Worked	Hourly Wage
Above Median TS Density	0.008	-0.007**	0.039	0.070**
	(0.007)	(0.003)	(0.031)	(0.028)
Above Median TS Density × Upper Sec. Nearby	0.043***	-0.004	0.190***	0.131***
	(0.010)	(0.004)	(0.045)	(0.038)
Dependent Mean	0.63	0.05	2.51	1.65
Observations	896207	563297	896207	896207

Notes: This table illustrates the reduced-form effects of telesecundaria construction by upper secondary school access on education outcomes (Panel A) and labor market outcomes (Panel B). The table reports the estimated coefficient β from the estimation of the two-way fixed-effects difference-in-differences equation (2), all regressors interacted with a binary indicator for whether individuals had access to upper secondary institutions in 10km. See Section 3 for a description of the outcome variables. Above median TS density is an indicator capturing the intensity of telesecundaria exposure, and identifies the locality-cohort observations with above median telesecundaria density. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample includes all individuals living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 7: First-stage Effects of School Construction on Education Enrollment

	Junior Secondary Enroll.			**Upper Sec. Enroll.**		
	(1)	(2)	(3)	(4)	(5)	(6)
Above Median TS Density	0.133***		0.149***	0.014***		-0.016**
	(0.007)		(0.009)	(0.005)		(0.006)
Upper Secondary School Nearby	0.048***	0.036***	0.051***	0.033***	0.029***	0.027***
	(0.005)	(0.005)	(0.005)	(0.004)	(0.004)	(0.004)
Above Median TS Density × Upper Sec. Nearby		0.106***	-0.023**		0.028***	0.042***
		(0.007)	(0.010)		(0.006)	(0.007)
Dependent Mean	0.66	0.66	0.66	0.33	0.33	0.33
Observations	896274	896274	896274	896274	896274	896274

Notes: This table illustrates the first-stage effects of telesecundaria construction on junior secondary enrollment and on upper secondary enrollment. Columns 1-3 report the estimated coefficient from the estimation of the two-way fixed-effects difference-in-differences on junior secondary enrollment, with only one instrument and with both instruments combined, as in equation (15). Columns 4-6 report the estimated coefficient from the estimation of the two-way fixed-effects difference-in-differences on upper secondary enrollment, with only one instrument and with both instruments combined, as in equation (16). See Section 3 for a description of the outcome variables. Above median TS density is an indicator capturing the intensity of telesecundaria exposure, and identifies the locality-cohort observations with above median telesecundaria density. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. Upper secondary school nearby is a binary variable H_{lc} indicating whether individuals have access to upper secondary education in 10 km. See Section 7.2 for details on the instruments. All regressions use sampling weights and include cohort and locality fixed effects. The sample includes all individuals living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 8: Decomposition of the Returns to Lower Secondary Education

	Hourly Income (IHS)	
	LATE	**Decomposition**
Junior Secondary Enrollment	1.256***	1.049***
	(0.128)	(0.153)
(Junior Sec. Enrollment) × (Upper Sec. Enrollment)		1.922**
		(0.752)
Instrumental variables	$AboveTS_{lc}$	$AboveTS_{lc}$
		$AboveTS_{lc} \times H_{lc}$
First-stage F-stat. (underid)	300.90	36.75
First-stage F-stat. (weak id)	392.07	18.72
Dependent mean	1.65	1.65
Observations	896207	896207

Notes: This table illustrates the decomposition of labor market returns into direct and continuation effects. Column 1 reports estimated coefficient β^{LATE} from the estimation of the instrumented difference-in-differences equation (3). Column 2 reports the estimated coefficients α_1 and α_2 from the estimation of equation (12). It uses as dependent variable the inverse hyperbolic sine transformation of the hourly wage. See Section 3 for a description of the outcome variable. The treatment is an indicator for enrollment in junior secondary education. The instrumental variable in the regression in Column 1 is an indicator for having an above median telesecundaria density, $AboveTS_{lc}$. See Section 4 for details on the TS density variable. The instrumental variables in the regression in Column 2 are (1) $AboveTS_{lc}$, an indicator for having an above median telesecundaria density, and (2) $AboveTS_{lc} \times H_{lc}$, an interaction between $AboveTS_{lc}$ and a binary variable H_{lc} indicating whether individuals have access to upper secondary education in 10 km. All regressions use sampling weights and include cohort and locality fixed effects. The sample nicludes all individuals living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

APPENDIX

[TO BE COMPLETED]

A Alternative specifications

Table 9: Reduced-form Effects of Telesecundaria Construction by Locality Size
Treatment: Density of Telesecundarias

	Junior Secondary		**Higher Education**			**Labor Supply**				**Labor Income**			
	Enrollment	Graduation	Upper Sec.	Tertiary	Years Educ.	Active	Unemployed	Hours Worked		Wage Earner	Hourly Wage		
								(log)	(IHS)		(Pesos)	(log)	(IHS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Panel A: Rural Localities (less than 2,500 habitants)													
TS Density (50 ch.)	0.061***	0.053***	0.003	0.001	0.289***	0.010***	-0.003**	0.037***	0.044***	0.007**	0.623***	0.048***	0.055***
	(0.004)	(0.004)	(0.004)	(0.001)	(0.030)	(0.003)	(0.001)	(0.011)	(0.013)	(0.003)	(0.102)	(0.009)	(0.011)
Dependent Mean	0.53	0.48	0.20	0.05	7.30	0.60	0.04	2.02	2.39	0.42	9.04	1.18	1.44
Observations	355042	355042	355042	355042	355042	355042	212095	355042	355042	355042	355042	355042	355042
Panel B: Rural and Low Urbanization Localities (less than 15,000 habitants)													
TS Density (50 ch.)	0.085***	0.072***	0.004	0.003**	0.546***	0.024***	-0.007***	0.090***	0.106***	0.015***	1.464***	0.098***	0.112***
	(0.005)	(0.005)	(0.004)	(0.001)	(0.036)	(0.003)	(0.001)	(0.011)	(0.013)	(0.003)	(0.112)	(0.009)	(0.011)
Dependent Mean	0.60	0.54	0.27	0.09	7.98	0.61	0.04	2.08	2.45	0.44	10.50	1.28	1.56
Observations	609232	609232	609232	609232	609232	609232	374230	609232	609232	609232	609232	609232	609232
Panel C: Rural and Urban Localities (less than 100,000 habitants)													
TS Density (50 ch.)	0.104***	0.089***	0.012***	0.006***	0.746***	0.032***	-0.010***	0.122***	0.144***	0.019***	2.075***	0.128***	0.147***
	(0.005)	(0.005)	(0.004)	(0.001)	(0.043)	(0.003)	(0.001)	(0.011)	(0.013)	(0.003)	(0.126)	(0.009)	(0.011)
Dependent Mean	0.66	0.60	0.33	0.12	8.62	0.63	0.05	2.12	2.51	0.45	11.88	1.37	1.65
Observations	896274	896274	896274	896274	896274	896274	563401	896274	896274	896274	896274	896274	896274

Notes: This table illustrates the reduced-form effects of telesecundaria access on education outcomes (Columns 1-5) and on labor market outcomes (Columns 6-13). The table reports the estimated coefficient β from the estimation of the two-way fixed-effects difference-in-differences equation (2), with the specification: $Y_{ilc} = \alpha + \beta TS_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$. It uses as dependent variable an indicator for enrollment and graduation in lower secondary education (Columns 1-2), for enrollment in upper secondary and tertiary education (Columns 3-4), and total years of education (Column 5). It also uses as dependent variable an indicator for labor market participation (Column 6), unemployment (Column 7) the log and inverse hyperbolic sine transformations of weekly hours worked (Columns 8-9), an indicator for earning a wage (Column 10), and hourly wage in Mexican pesos, and its log and inverse hyperbolic sine transformations (Columns 11-13). See Section 3 for a description of the outcome variables. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample in *Panel A* includes all individuals living in localities with less than 2,500 habitants, the sample in *Panel B* includes all individuals living in localities with less than 15,000 habitants, and the sample in *Panel C* includes all individuals living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

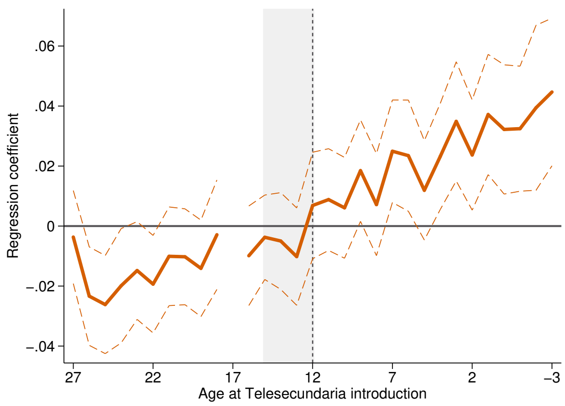
Table 10: Reduced-form Effects of Telesecundaria Construction by Locality Size
Treatment: Above Median Telesecundaria Density

	Junior Secondary		**Higher Education**			**Labor Supply**				**Labor Income**			
	Enrollment	Graduation	Upper Sec.	Tertiary	Years Educ.	Active	Unemployed	Hours Worked		Wage Earner	Hourly Wage		
								(log)	(IHS)		(Pesos)	(log)	(IHS)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Panel A: Rural localities (less than 2,500 habitants)													
Above Median TS Density	0.109***	0.095***	0.010	0.001	0.510***	0.018***	-0.005*	0.061***	0.072***	0.011*	1.117***	0.080***	0.093***
	(0.008)	(0.007)	(0.007)	(0.002)	(0.057)	(0.005)	(0.003)	(0.019)	(0.022)	(0.006)	(0.187)	(0.017)	(0.020)
Dependent Mean	0.53	0.48	0.20	0.05	7.30	0.60	0.04	2.02	2.39	0.42	9.04	1.18	1.44
Observations	355042	355042	355042	355042	355042	355042	212095	355042	355042	355042	355042	355042	355042
Panel B: Rural and low urbanization localities (less than 15,000 habitants)													
Above Median TS Density	0.138***	0.118***	0.007	0.004*	0.933***	0.032***	-0.010***	0.126***	0.149***	0.019***	2.362***	0.144***	0.164***
	(0.007)	(0.007)	(0.006)	(0.002)	(0.058)	(0.005)	(0.002)	(0.018)	(0.021)	(0.005)	(0.182)	(0.015)	(0.018)
Dependent Mean	0.60	0.54	0.27	0.09	7.98	0.61	0.04	2.08	2.45	0.44	10.50	1.28	1.56
Observations	609232	609232	609232	609232	609232	609232	374230	609232	609232	609232	609232	609232	609232
Panel C: Rural and urban localities (less than 100,000 habitants)													
Above Median TS Density	0.135***	0.118***	0.015***	0.004	0.960***	0.032***	-0.013***	0.135***	0.158***	0.021***	2.655***	0.148***	0.169***
	(0.007)	(0.007)	(0.005)	(0.002)	(0.060)	(0.005)	(0.002)	(0.017)	(0.020)	(0.005)	(0.193)	(0.015)	(0.018)
Dependent Mean	0.66	0.60	0.33	0.12	8.62	0.63	0.05	2.12	2.51	0.45	11.88	1.37	1.65
Observations	896274	896274	896274	896274	896274	896274	563401	896274	896274	896274	896274	896274	896274

Notes: This table illustrates the reduced-form effects of telesecundaria access on education outcomes (Columns 1-5) and on labor market outcomes (Columns 6-13). The table reports the estimated coefficient β from the estimation of the two-way fixed-effects difference-in-differences equation (2), with the specification: $Y_{ilc} = \alpha + \beta AboveTS_{lc} + \gamma_l + \lambda_c + \mathbf{X}_{ilc}\theta + \varepsilon_{ilc}$. It uses as dependent variable an indicator for enrollment and graduation in lower secondary education (Columns 1-2), for enrollment in upper secondary and tertiary education (Columns 3-4), and total years of education (Column 5). It also uses as dependent variable an indicator for labor market participation (Column 6), unemployment (Column 7) the log and inverse hyperbolic sine transformations of weekly hours worked (Columns 8-9), an indicator for earning a wage (Column 10), and hourly wage in Mexican pesos, and its log and inverse hyperbolic sine transformations (Columns 11-13). See Section 3 for a description of the outcome variables. Above median TS density is an indicator capturing the intensity of telesecundaria exposure, and identifies the locality-cohort observations with above median telesecundaria density. The telesecundaria density, TS_{lc} is defined as the number of telesecundarias open in locality l when individuals from cohort c where 12 years-old, scaled by the total population of individuals targeted by the program. See Section 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample in *Panel A* includes all individuals living in localities with less than 2,500 habitants, the sample in *Panel B* includes all individuals living in localities with less than 15,000 habitants, and the sample in *Panel C* includes all individuals living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 12: Effects of telesecundaria construction on labor market outcomes

(a) Labor market participation

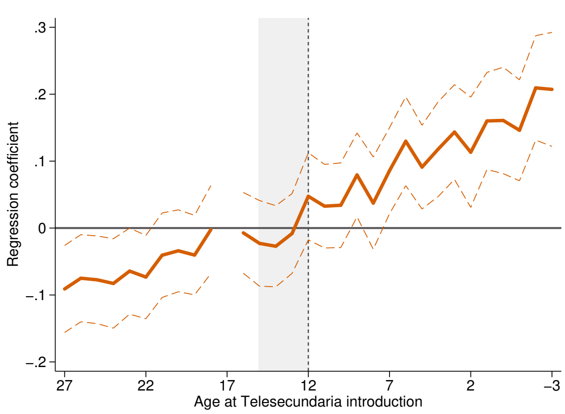


(b) Unemployment

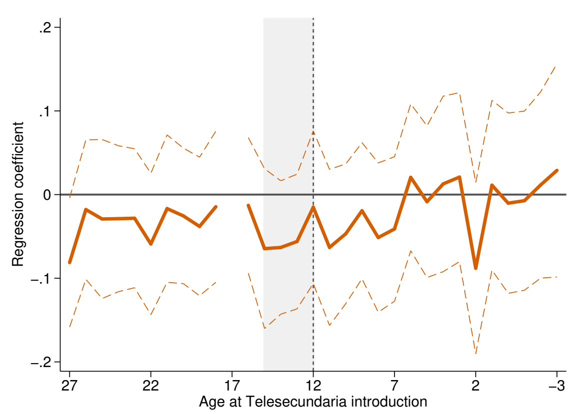
(c) Hours worked (IHS)

(d) Hours worked, workers (IHS)

(e) Hourly wage (IHS)



(f) Hourly wage (IHS)



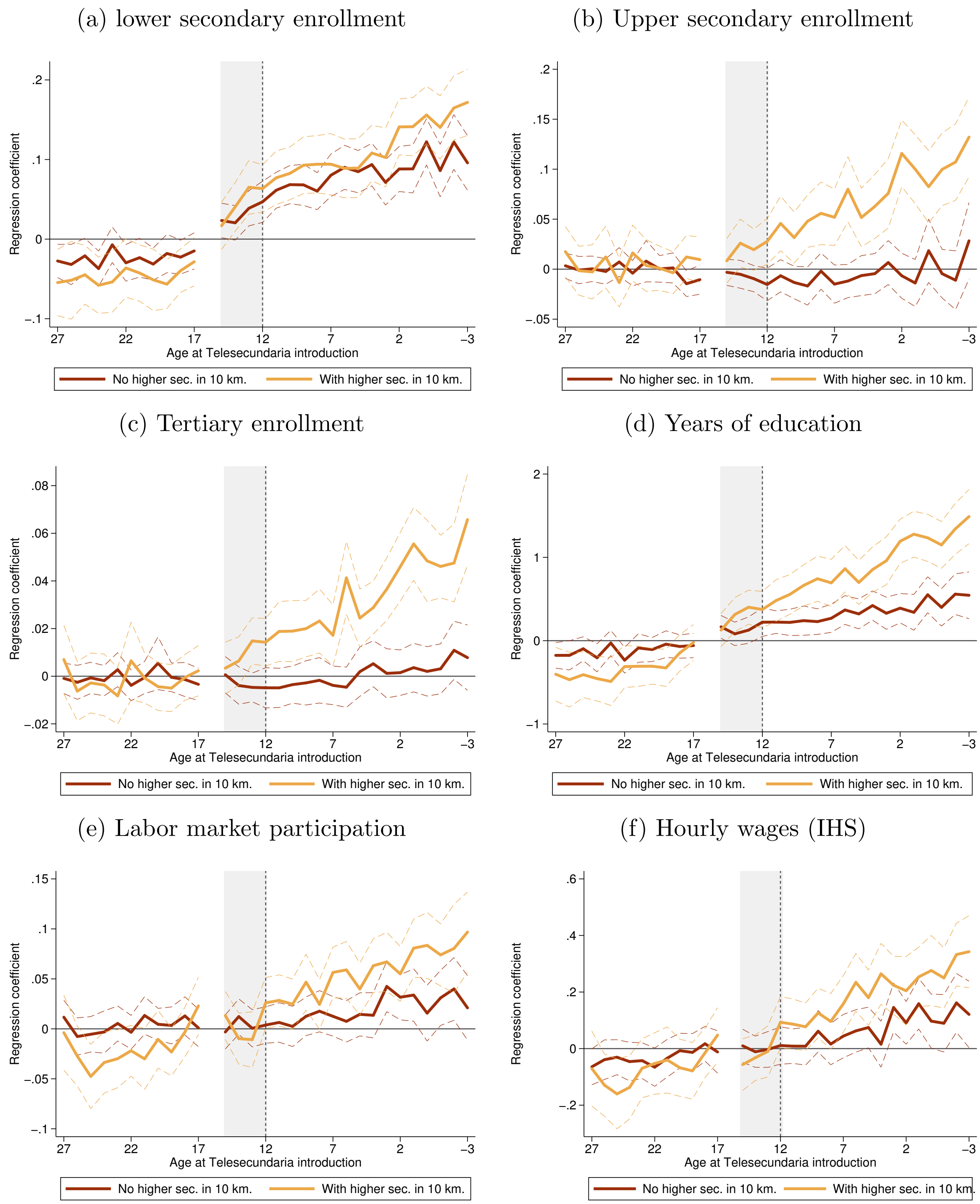
Notes: This figure presents the reduced-form estimates of the difference-in-differences specification for different outcomes, computed by age at the year of telesecundaria construction. See equation (7) for details. Coefficient estimates are shown with a solid line, and 95% confidence intervals with a dashed line. All effects are computed with respect to age 17, the baseline year.

Table 11: Effects of Telesecundaria Construction by Access to Upper Secondary Education

	(1)	(2)	(3)	(4)
	Panel A: Education Outcomes			
	Lower sec. enroll.	Upper sec. enroll.	Tertiary enroll.	Years of Education
TS Density (50 ch.)	0.079***	-0.011***	-0.001	0.392***
	(0.006)	(0.004)	(0.002)	(0.044)
TS Density (50 ch.) $\times$ Upper sec. nearby	0.023*	0.058***	0.026***	0.416***
	(0.013)	(0.008)	(0.004)	(0.098)
Dependent Mean	0.66	0.33	0.12	8.62
Observations	896207	896207	896207	896207
	Panel B: Labor Market Outcomes			
	Active	Unemployed	Hours worked	Hourly wage
Density TS (num. for 50 child.)	0.010***	-0.004***	0.043***	0.075***
	(0.004)	(0.002)	(0.016)	(0.015)
Above avg. TS density $\times$ Upper sec. nearby	0.049***	-0.005*	0.208***	0.137***
	(0.007)	(0.003)	(0.030)	(0.025)
Dependent Mean	0.63	0.05	2.51	1.65
Observations	896207	563297	896207	896207

Notes: This table illustrates the reduced-form effects of telesecundaria construction by upper secondary school access on education outcomes (Panel A) and labor market outcomes (Panel B). The table reports the estimated coefficient β from the estimation of the two-way fixed-effects difference-in-differences equation (2), all regressors interacted with a binary indicator for whether individuals had access to upper secondary institutions in 10km. See Section 3 for a description of the outcome variables. Above average TS density (50 children) identifies the locality-cohort pairs intensity of telesecundaria exposure, measured by TS_{lc}, above the sample average. See 4 for details on the treatment variable. All regressions use sampling weights and include cohort and locality fixed effects. The sample iincludes all individuals living in localities with less than 100,000 habitants. Individual controls include female, age and age^2 and interactions between them. Robust standard errors are shown in parentheses and clustered at the locality level. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Figure 13: Effects of telesecundaria construction on labor market outcomes, by access to upper secondary institutions



Notes: This figure presents the reduced-form estimates of the difference-in-differences specification for different outcomes, computed by age at the year of telesecundaria construction. The treatment is telesecundaria density per 50 children. See equation (7) for details. Coefficient estimates are shown with a solid line, and 95% confidence intervals with a dashed line. All effects are computed with respect to age 17, the baseline year.

B Data details

B.1 Education and labor market outcomes

The individual outcome level data comes from the *Encuesta Nacional de Ocupación y Empleo* (ENOE, Employment and Occupation National Survey), administered by the *Instituto Nacional de Estadística y Geografía* (INEGI, Statistics and Geography National Institute). It is a quarterly household survey on the labor market characteristics of the population, and it is constructed as a five-quarter rotating panel. I use all waves from the 2005-2016 period, keeping only the first observation for each unique individual to avoid non-random attrition in subsequent survey waves. The survey is representative at the national level, state level, and for each of the following locality size groups: localities with 100,000 and more habitants, localities with between 15,000 and 99,999 habitants, localities with between 2,500 and 14,999 habitants and localities with less than 2,500 habitants. All economic characteristics correspond to the week previous to the interview, except income, which refers to the previous month. Below I define the education and labor market outcomes used in the analysis and describe their construction.

Achievement levels. I construct the achievement level variables using the ENOE variables education level (CS_P13_1) and years of education ($ANIOS\_ESC$). The education levels are preschool, primary, lower secondary, upper secondary (preparatoria or bachillerato), teacher's degree (escuela normal), technical degree, profesional degree (licenciatura), master or PhD.

Lower secondary education. I define lower secondary enrollment as having completed at least some years in lower secondary education, either in lower general secondary school or in technical lower secondary school[76], which is equivalent at completing at least 7 years of education. I define lower secondary graduation as having completed at least lower secondary school or lower technical secondary school, which is equivalent to at least 9 years of education.

Upper secondary enrollment. I define higher secondary enrollment as having completed at least some courses of *preparatoria* or *bachillerato*, or some courses of upper technical education, equivalent of having completed at least 10 years of education.

[76] There are three types of technical education: a 3 year degree (9 total years of education), a 3+3 year degree (12 total years of education) and a 3+3+3 years degree (15 years of education). I classify the 3 year degree as technical secondary education, the 3+3 years as lower technical education, and the 3+3+3 as higher technical education.

Tertiary education enrollment. I define tertiary education enrollment as having completed at least some courses of tertiary technical education, a teacher's degree (*ecuelas normales* or *licenciatura*) or a college degree (either a full degree or a technical degree). It also includes individuals later pursuing a master or a PhD.

Labor market participation. The labor market participation is a binary variable classifying the individual as economically active or not. The ENOE defines the economically active population as the sum of working population and the non-working individuals actively looking for a job in the month prior to the interview. The workers are defined as individuals engaged in an economic activity in the week prior to the interview, either working in a formal job, earning some income informally, helping in land work or family business, and individuals temporarily not working (e.g., for a strike) or absent but with a secured job after the temporality finishes. I construct the labor market participation directly using the variable *CLASE1* from the ENOE dataset *SDEMT.dbf*, which classifies the population in Economically Active Population (EAP) and Non-Economically Active Population (NEAP). There are no missing values associated with this variable.

Unemployment. Unemployment is a binary variable that indicates whether an individual that actively participates in the labor market (see above) was not involved in an economic activity during the week prior to the interview but was actively looking for work during the last month. The unemployment variable is only defined for the individuals actively participating in the labor market, and has missing values for individuals not participating in the labor market. I construct it using the variable *CLASE2* from the ENOE dataset *SDEMT.dbf*. *CLASE2* classifies the population in employed, unemployed (for those economically active), and available and not available (for those not economically active because, for example, they perform houskeeping duties or are studying).

Weekly hours worked. Hours worked are the number of hours worked in a week. I obtain this information from the ENOE variable *HRSOCUP*, constructed from the survey question *P5C_THRS*. As in the ENOE, I define this variable for all individuals in the sample, with a zero value if the individual is either unemployed or not in the labor force. I winsorize the hours worked at the 99th percentile to exclude extreme and unreasonably large values that could drive the results. Due to its nature, the variable has a highly left-skewed distribution. I minimize the incidence of large values by using two variable transformations. First, I apply a logarithmic transformation of the weekly hours worked, adding a 1 to avoid the logarithm not being defined. Second, I apply an inverse hyperbolic sine transformation of the weekly hours worked[77]. Both transformations result with a smoother distribution with a spike at 0, with very similar distributions between variables. Two supplementary variables identify the weekly hours worked only for the employed individuals.

Hourly income. The hourly income variable identifies the average wage per hour worked. I use the ENOE variable ING_X_HRS, constructed by dividing the monthly income with the weekly hours worked following the formula $ING\_X\_HRS = INGOCUP/(HRSOCUP * 4.3)$. I define the variable for all individuals in the sample, imputing a 0 if the individual is not employed. Due to its nature, the variable has a highly left-skewed distribution. I minimize the incidence of large values by using two variable transformations. First, I apply a logarithmic transformation of the weekly hours worked, adding a 1 to avoid the logarithm not being defined. Second, I apply an inverse hyperbolic sine transformation of the weekly hours worked[78]. Both transformations result with a smoother distribution with a spike at 0, with very similar distributions between variables. Two supplementary variables identify the hourly income only for the employed individuals.

Labor market informality. The ENOE includes several variables that provide complementary information on the worker's informality level. I define individuals working in informal occupations as the individuals that are working in vulnerable conditions due to the nature of the economic unit they work for, and those whose relationship to the economic unit is not formally recognized by the employer[79]. I construct a supplementary variable on labor market informality based on whether the individual receives health care benefits through the job. I consider the individual to be in the informal sector if the job doesn't provide health care benefits ($P6D = 6$) or they are provided by other medical institutions ($P6D = 5$). Lastly, I follow the ENOE classification of occupations by type of employers: Companies or institutions, subsistence agriculture, paid domestic work, and informal sector. Hence, the workers in the informal sector are the employed population that works in a non-agricultural economic unit that operates using household resources but without being a formal business, so that the income, materials and equipment used for the business are not independent from the ones in the household[80].

Labor market sectors. The ENOE specifies five labor market sectors: agriculture, construction, manufacturing industry, commerce and services. The agricultural sector includes

[77] $log(w\_hours\_worked + sqrt(w\_hours\_worked^2 + 1))$

[78] $log(hourly\_income + sqrt(hourly_income^2 + 1))$

[79] This definition corresponds to the $TIL1$ variable in the ENOE dataset (see INEGI (2010), page 30 for the explanation on the definitions)

[80] This definition corresponds to the $TOSI1$ variable in the ENOE dataset (see INEGI (2010), page 30 for the explanation on the definitions)

economic activities related to agriculture, farming, logging, fishing and hunting. The services sector includes occupations in restaurants and lodging; transportation, communication and storage; professional, financial and corporative services; social services and government and international organisms.

B.2 Secondary school construction

The information on secondary school data comes from the *Secretaría de Educación Pública* (Ministry of Education). I use two different sources for lower secondary school data, the 2015-2016 school directory, and yearly school records for the 1990-2014 period. The 2015-2016 school directory is a database of all lower secondary schools in Mexico. Among other information, for each school it includes its unique identifier, address, geographical coordinates, school type, foundation date, date it was registered into the system, and closing and reopening dates, when appropriate. The registration system was created in 1981. All schools that existed prior to 1981 have the same date of registration, which makes the distinction between the foundation date and registration date relevant. The yearly school records are yearly databases of all lower secondary schools opened in a given academic year in Mexico. Among other information, for each school they include the unique school code, address, geographical coordinates, school type and total number of enrolled students. For upper secondary schools, I use the 2016-2017 school directory, a database of all upper secondary schools in Mexico from the *Secretaría de Educación Pública*, with the same features as the lower secondary school directory.

Creation of the school construction date. I combine three different sources of information to construct the school construction date: The foundation date and the registration date from the 2015-2016 school directory, and the yearly records, from which I extract the years the schools were actually operating. Although these three variables should result with the same school opening years, they don't always match, and the discrepancy levels between them widely vary depending on the state. Figure **??** shows the differences in the evolution of open schools by state depending on the source for the construction date used. I impute the school construction date by combining the three data sources with the following procedure: I first use the foundation year from the school registry as the school construction date. If it doesn't exist, I use the registration year from the same database. Lastly, if neither exist, I assign as the school construction date the first date the school was open according to the yearly records[81]. Since the registry was created in 1981, any schools constructed prior to this

[81]I specify eight alternative criteria to check that the results are robust to the criteria used for imputing the school construction date: (1) use the foundation, closure and re-opening dates derived from the yearly records, (2) use the foundation year from the school registry, (3) use the foundation year, closure and re-

date will have assigned 1981 or 1982 as the construction date. Similarly, since the yearly records started in 1990, any schools constructed prior to this date will have assigned 1990 as the first year the school was opened. When constructing the binary indicator for whether the school was open in a given year, I assign a missing value to all years prior to 1982 or 1990 depending on the case if I use either of these sources. Note that the yearly records are only valid starting in 1990, and the registration dates are only valid starting in 1982[82]. Hence, depending on the data source used, some localities or states will have different sample sizes in the analysis. Any schools without an imputed construction year at the end of the construction date assignment procedure will be categorized as never opened (with a zero for all the sample period), and are not dropped from the sample. Figure 14 shows the number of schools opened each year by state depending on the data source used to construct the variable. I combine these three sources to impute the school construction date used in the analysis.

Construction of the treatment of telesecundaria exposure. I identify the schools with unknown start dates, either because either the date is 1990 from the yearly records source, or the date is 1982 from the registration date source. I aggregate the lower secondary school construction dates at the locality and cohort level, also separating them by school type. The year that separates the cohorts as treated or untreated is the year the first telesecundaria was constructed in the locality. I identify the locality as having an unknown start date if at least one school in the locality has an unknown start date. For the difference-in-differences specification by age at telesecundaria introduction, I compute the average number of schools after the first telesecundaria is constructed, and I assign random construction years to localities that never had a telesecundaria. I assign the random construction dates following the distribution of the real construction dates across time. I do not assign a random construction year to localities with telesecundarias with unknown construction dates. I drop localities with extreme values of the average density of telesecundarias per 50 children, higher than the 99 percent.

opening dates from the school registry, (4) use the registration year from the school registry, (5) use the registration year, closure and re-opening dates from the school registry, (6) use the foundation year and, if it doesn't exist, use the registration year from the school registry, (7) use the registration year and, if it doesn't exist, use the construction date derived from the yearly records, and (8) use the foundation year and, if it doesn't exist, use the construction date derived from the yearly records. The main results are quite robust to the criteria used to assign the school construction dates, and are available upon request.

[82]If I use the registration date, I categorize as not usable any school constructed in 1982. Note that this is restrictive, since in 1981-1982 there was a telesecundaria construction boom with the introduction of this modality to new states. As a robustness check, I identify states that have reliable pre-1982 based on the coincidence between the three sources along the years and smoothness of the number of schools pre and post 1982 (see Figure 14). The states with reliable pre-1982 dates are Aguascalientes, Hidalgo, Mexico, Morelos, Sonora and Veracruz. and use the 1982 construction dates. Results are robust to this modification and available upon request.

Construction of school coordinates. I combine several sources of school coordinates to have the maximum coverage. I use the school coordinates from the school directory and the yearly school records, if available. If not, I use the locality coordinates if the locality is rural, and the locality centroid coordinates for urban localities. Lastly, I use the average of primary schools coordinates from the same locality.

Figure 14: Number of open schools by data source

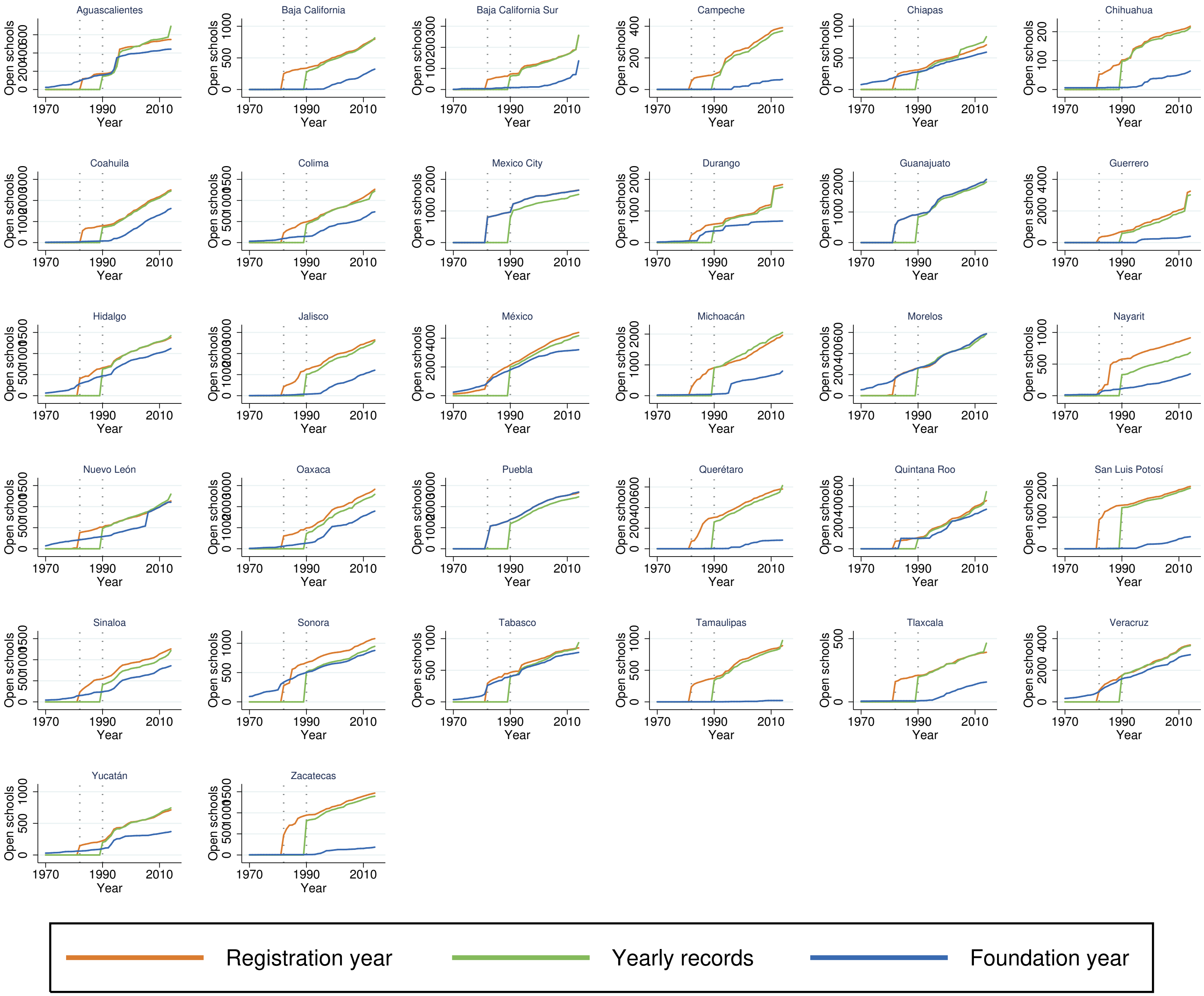


Figure 15: Final school creation dates (I)

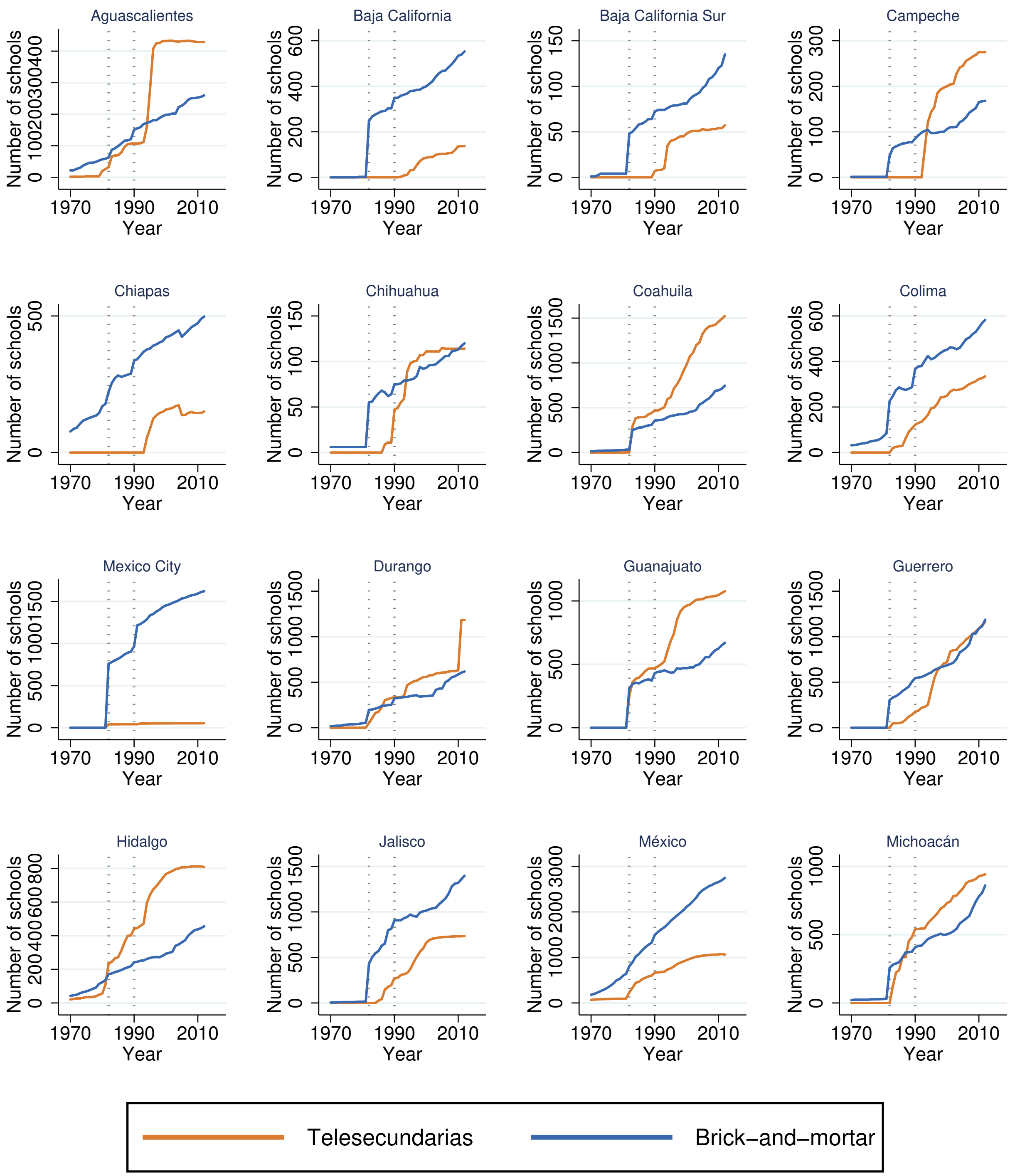
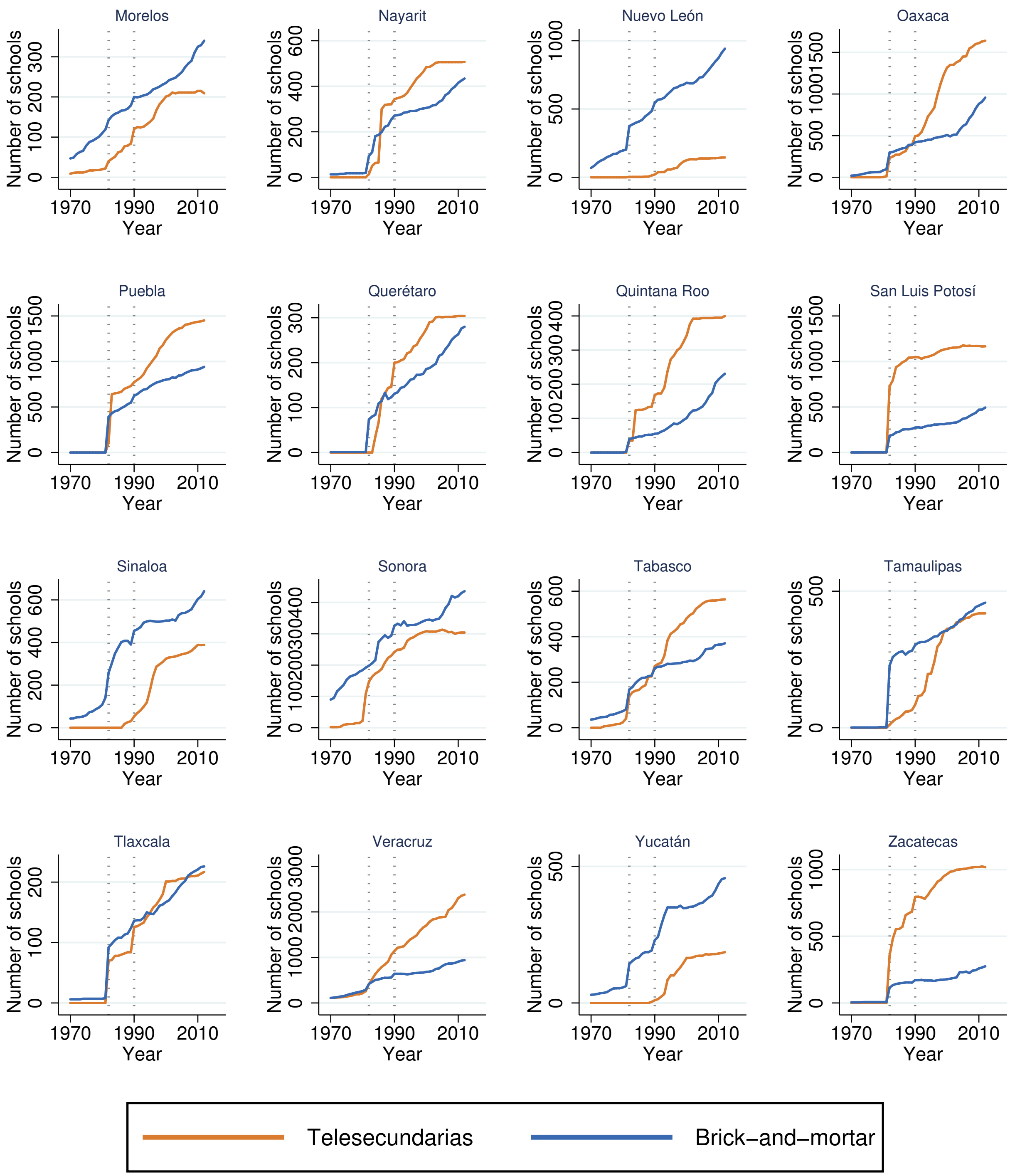


Figure 16: Final school creation dates (II)



C Proof: Dynamic treatment effects decomposition

Following arguments from Kirkeboen et al. (2016), Kline and Walters (2016), Hull (2018) and Mountjoy (2018), this appendix shows the decomposition of the LATE into direct and continuation effects from section 7.2 using a binary instrument. To simplify the notation, I decompose the Wald estimator using a binary instrument that satisfies the exclusion and independence assumptions:

$$\beta = \frac{E[Y|Z=1] - E[Y|Z=0]}{E[D^T|Z=1] - E[D^T|Z=0]} \tag{17}$$

The steps of the decomposition still apply to the IV-DiD setting.

Let $S \in \{0,1,2\}$ identify the three terminal choices of schooling from the theoretical framework, observed in the data: primary education, 0, lower secondary education, 1, and upper secondary education, 2. Let D_s be an indicator variable for the level of schooling attained, i.e., $D_s = 1$ if $S = s$, and zero otherwise. Let $Y_Z^S = Y(S,Z)$ identify the potential outcome if $S = s$ and $Z = z$.

By the instrument exclusion assumption, ($Y_s^z = Y_s$ for all $s \in \{0,1,2\}$), the observed outcome Y can be decomposed in three potential outcomes:

$$Y = Y_0 D_0 + Y_1 D_1 + Y_2 D_2$$

Then, the first component of the numerator from the Wald estimator can be decomposed in:

$$\begin{aligned} E[Y|Z=1] &= E[Y_0 D_0|Z=1] + E[Y_1 D_1|Z=1] + E[Y_2 D_2|Z=1] \\ &= E[Y_0|D_0=1, Z=1] + E[Y_1|D_1=1, Z=1] + E[Y_2|D_2=1, Z=1] \end{aligned}$$

Let $S(Z)$ identify the potential terminal choice of schooling depending on the instrument status. By the independence assumption,

$$= E[Y_0|S(1)=0]Pr(S(1)=0) + E[Y_1|S(1)=1]Pr(S(1)=1) + E[Y_2|S(1)=2]Pr(S(1)=2)$$

Based on individuals' choices depending on the instrument status, we have nine groups of individuals. The monotonicity assumption ($Pr(D_0(0) \geq D_0(1)) = 1$, $Pr(D_1(0) \leq D_1(1)) = 1$, $Pr(D_2(0) \leq D_2(1)) = 1$) eliminates the defiers ($\{S(0)=2, S(1)=1\}$, $\{S(0)=2, S(1)=0\}$ and $\{S(0)=1, S(1)=0\}$). The no upper-switchers assumption ($Pr(S(0)=1, S(1)=2)=0$) rules out $\{S(0)=1, S(1)=2\}$. Then, we have five remaining groups of individuals based on their choices: $\{S(0)=0, S(1)=1\}$, $\{S(0)=0, S(1)=2\}$, $\{S(0)=0, S(1)=0\}$,

$\{S(0) = 1, S(1) = 1\}$ and $\{S(0) = 2, S(1) = 2\}$.

Using these groups, we can further decompose the formula as:

$$\begin{aligned}
E[Y|Z=1] = {} & E[Y_0|S(0)=0,S(1)=0]Pr(S(0)=0,S(1)=0) \\
& + E[Y_1|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
& + E[Y_1|S(0)=1,S(1)=1]Pr(S(0)=1,S(1)=1) \\
& + E[Y_2|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& + E[Y_2|S(0)=2,S(1)=2]Pr(S(0)=2,S(1)=2]
\end{aligned}$$

Following analogous arguments, we can decompose the other part of the numerator as:

$$\begin{aligned}
E[Y|Z=0] = {} & E[Y_0|S(0)=0,S(1)=0]Pr(S(0)=0,S(1)=0) \\
& + E[Y_0|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
& + E[Y_1|S(0)=1,S(1)=1]Pr(S(0)=1,S(1)=1) \\
& + E[Y_0|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& + E[Y_2|S(0)=2,S(1)=2]Pr(S(0)=2,S(1)=2]
\end{aligned}$$

Then,

$$\begin{aligned}
E[Y|Z=1] - E[Y|Z=0] = {} & E[Y_1|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
& - E[Y_0|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
& + E[Y_2|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& - E[Y_0|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2)
\end{aligned}$$

Adding and substracting $E[Y_1|S(0) = 0, S(1) = 2]Pr(S(0) = 0, S(1) = 2)$,

$$\begin{aligned}
& = E[Y_1|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
& - E[Y_0|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
& + E[Y_2|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& - E[Y_1|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& + E[Y_1|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& - E[Y_0|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& = E[Y_1 - Y_0|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
& + E[Y_1 - Y_0|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
& + E[Y_2 - Y_1|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2)
\end{aligned}$$

Hence, the numerator can be decomposed as:

$$\begin{aligned}
E[Y|Z=1]-E[Y|Z=0] &= E[Y_1-Y_0|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)=1) \\
&+ E[Y_1-Y_0|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
&+ E[Y_2-Y_1|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2) \\
&= E[Y_1-Y_0|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)\geq 1) \\
&+ E[Y_2-Y_1|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2)
\end{aligned}$$

Recall that D^S is a binary indicator for whether the individual enrolled in secondary education. Then, $D^S = D_1 + D_2$. Transforming the denominator using the same arguments as above,

$$\begin{aligned}
E[D^S|Z^T=1] = &E[D_1|Z=1]+E[D_2|Z=1] \\
=&Pr(D_1=1,Z=1)+Pr(D_2=1,Z=1) \\
=&Pr(S(1)=1)+Pr(S(1)=2) \\
=&Pr(S(0)=0,S(1)=1)+Pr(S(0)=1,S(1)=1) \\
&+Pr(S(0)=0,S(1)=2)+Pr(S(0)=1,S(1)=2)+Pr(S(0)=2,S(1)=2) \\
E[D^S|Z^T=0] = &E[D_1|Z=0]+E[D_2|Z=0] \\
=&Pr(D_1=1,Z=0)+Pr(D_2=1,Z=0) \\
=&Pr(S(0)=1)+Pr(S(0)=2) \\
=&Pr(S(0)=1,S(1)=1)+Pr(S(0)=1,S(1)=2)+Pr(S(0)=2,S(1)=2)
\end{aligned}$$

Then,

$$\begin{aligned}
E[D^S|Z^T=1]-E[D^S|Z^T=0] &= Pr(S(0)=0,S(1)=1)+Pr(S(0)=0,S(1)=2) \\
&= Pr(S(0)=0,S(1)\geq 1)
\end{aligned}$$

The Wald estimator becomes

$$
\begin{aligned}
\beta &= \frac{E[Y|Z=1]-E[Y|Z=0]}{E[D^S|Z=1]-E[D^S|Z=0]} \\
=& \frac{E[Y_1-Y_0|S(0)=0,S(1)=1]Pr(S(0)=0,S(1)\geq 1)}{Pr(S(0)=0,S(1)\geq 1)} \\
&+ \frac{E[Y_2-Y_1|S(0)=0,S(1)=2]Pr(S(0)=0,S(1)=2)}{Pr(S(0)=0,S(1)\geq 1)} \\
=& E[Y_1-Y_0|S(0)=0,S(1)=1]+E[Y_2-Y_1|S(0)=0,S(1)=2]\underbrace{\frac{Pr(S(0)=0,S(1)=2)}{Pr(S(0)=0,S(1)\geq 1)}}_{\mu} \\
&= E[Y_1-Y_0|S(0)=0,S(1)=1]+\mu E[Y_2-Y_1|S(0)=0,S(1)=2] \\
&= DE+\mu CONT \quad \square
\end{aligned}
$$

D Theoretical framework of sequential educational choices

This section develops a simple model of schooling choices, based on sequential models of educational choices (Heckman et al. (2016), Heckman et al. (2018)) and on models with simultaneous choices between schooling substitutes (e.g., Kline and Walters (2016), Mountjoy (2018)). First, I consider the baseline case where there are only brick-and-mortar schools available. Following Charles et al. (2018), I derive a set of sufficient conditions on the utility functions that guarantee a single equilibrium that is consistent with the empirical patterns. Second, I analyze how the individuals' behavior optimally changes when a telesecundaria gets constructed by deriving a new set of sufficient conditions and performing comparative statics. Finally, I also analyze how the equilibrium conditions change when an upper secondary school becomes available.

In this setting, individuals, indexed by $i \in N$, have completed primary education and face a set of sequential choices related to their education. First, individuals choose whether to enter the labor force and work (W) or whether to attend lower secondary education by enrolling into a brick-and-mortar school (B) or into a telesecundaria (T). Let D^S identify the discrete choice between these three alternatives: $D^S = \{W, B, T\}$. Those individuals that have completed lower secondary education choose in a second stage whether to pursue further education by attending upper secondary education or to enter the labor force, $D^H = \{0, 1\}$. Let HS identify the schools of upper secondary education modality. The decision tree in Figure 1 graphically shows the two stages of these sequential schooling decisions, and the five potential outcomes associated with them.

Individuals choose the alternative that maximizes their long-run utility. For now, I make the simplifying assumption that the benefits of each alternative $s \in \{W, T, B\}$, B_i^s, are homogeneous across all individuals, $B_i^s = B^s$. This simplification rules out a mechanism of selection based on underlying ability or motivation. The benefits of each choice are ranked as follows: $B^B > B^T > B^W = 0$, where the benefit of working is normalized to zero. Hence, B^B and B^T can be interpreted as the premium of attending each type of secondary education compared to working. I assume that attending a brick-and-mortar school has higher benefits than attending a telesecundaria, since it is generally perceived to be of better quality. The cost of attending a given school modality $m \in \{T, B, HS\}$ is the distance to the nearest school m, k_l^m, common for all individuals in the same locality. I specify the distances to the nearest brick-and-mortar and upper secondary school as continuous parameters, $k_l^B > 0, k_l^{HS} > 0$, so the further away the school, the more costly to attend it. In contrast, individuals only consider attending a telesecundaria if they are built in the same locality (i.e., if $k_l^T = 0$)[83]. I assume that the tuition cost is zero for each school

[83]This is to account for the fact that telesecundarias are schools with very limited capacity (between 15-30 students), mainly serving individuals from the same locality. if $k_l^T > 0$, the individual will have negative

modality[84]. Additionally, there is a stochastic cost of attending post-primary education, $c_i \sim U[0,1]$, which reflects the individual opportunity cost of enrolling to school, for example by capturing whether students are required to help in the fields or in the family business. The utility functions for each alternative are:

$$U_i^B(k_l^B, k_l^T, k_l^{HS}, c_i) = B^B - k_l^B - \eta c_i + \rho \cdot \max\{B^{HS} - k_l^{HS}, 0\} \tag{18}$$

$$U_i^T(k_l^B, k_l^T, k_l^{HS}, c_i = \begin{cases} B^T - k_l^T - c_i + \rho \cdot \max\{B^{HS} - k_l^{HS}, 0\} & \text{if } k_l^T = 0 \\ < 0 & \text{otherwise} \end{cases} \tag{19}$$

$$U_i^W(k_l^B, k_l^T, k_l^{HS}, c_i) = 0 \tag{20}$$

where $\eta > 1$ reflects the fact that the opportunity cost for attending a brick-and-mortar secondary school is on average larger than for attending a telesecundaria. This is consistent with a setting where brick-and-mortar schools only have a full-time option, whereas telesecundarias offer a more concentrated schedule. The utility functions incorporate two simplifying assumptions: (1) the probability of enrolling in upper secondary education after graduating from both types of lower secondary schools is the same and (2) the benefit from attending upper secondary school after going through either types of lower secondary schools is the same. Each individual optimally chooses the option that provides the highest long-run utility:

$$D_i(c_i) = (D_i^s(c_i), D_i^h(c_i)) = arg \max_{s \in \{W,B,T\},\, h \in \{0,1\}} U_i^s(k_l^B, k_l^T, k_l^{HS}, c_i)$$

I first consider the baseline case where individuals only have access to brick-and-mortar schools. For simplification purposes, I assume that individuals have a brick-and-mortar school in their locality ($k_l^B = 0$), but the results carry through if brick-and-mortar schools are at nearby localities. The two sufficient conditions on the utility functions that guarantee a single equilibrium consistent with the empirical patterns are:

1. $U_i^B(0, c_i = 0) > 0$
2. $U_i^B(0, c_i = 1) < 0$

This single-crossing condition between U_i^B and U_i^W results in an equilibrium with some individuals optimally choosing to work and some optimally enrolling in lower secondary education through brick-and-mortar schools, as seen in the empirical data[85]. Figure **??**

utility of telesecundarias to reflect the fact that, if it is not available in the same locality, it will never be optimal to attend them.

[84] Private schools are mostly brick-and-mortar schools and in the period of interest they are not common.

[85] With no telesecundarias in the locality, no individual finds optimal to enroll in one of them.

graphically shows the utility function for the two alternatives, displaying the single-crossing condition. The equilibrium parameter C^o_{SW} identifies the stochastic cost of the individual indifferent between attending a brick-and-mortar school or working,

$$C^o_{SW} = \frac{B^B + \rho \max\{B^{HS} - k_l^{HS}, 0\}}{\eta} \tag{21}$$

Individuals with lower opportunity costs than C^o_{SW} (to the left) will choose to attend secondary education, and individuals with higher opportunity costs will prefer to enter the labor force.

After a telesecundaria is constructed, attending a telesecundaria becomes a feasible option for individuals living in the locality. Two sufficient conditions that guarantee a single equilibrium consistent with positive shares in the three post-primary alternatives, W, T, and B are:

1. $U_i^B(0, 0, c_i = 0) > U_i^T(0, 0, c_i = 0) > 0$
2. $U_i^T(0, 0, c_i = 1) < U_i^T(0, 0, c_i = 1) < 0$

This setting requires (1) a single-crossing condition between the utility of working and the utilities of each secondary school alternative, and (2) U_i^B and U_i^T crossing only once in the positive utility area. If these conditions are satisfied, the equilibrium parameters are:

$$C^*_{SW} = B^T - k_l^T + \rho \max\{B^{HS} - k_l^{HS}, 0\} \tag{22}$$

$$C^*_{BT} = \frac{B^B - B^T + k^T}{\eta - 1} \tag{23}$$

C^*_{SW} Identifies the stochastic cost of the individual indifferent between attending lower secondary education and working. Hence, movements of C^*_{SW} reflect shifts in the extensive margin of secondary education enrollment. C^*_{BT} identifies the stochastic cost of the individual indifferent between enrolling in a brick-and-mortar or a telesecundaria. Hence, shifts in C^*_{BT} reflect changes in the trade-off between lower secondary school modalities.

Let A^T be a parameter measuring the availability of telesecundarias in a locality. I assume that the benefits of attending a telesecundaria, a brick-and-mortar school or an upper secondary institution do not change when telesecundarias are constructed (i.e., $B^m[A^T = 0] = B^m[A^T = 1]$, for $m \in \{T, B, HS\}$). This assumption rules out externality or general equilibrium effects, which could affect the utility with unknown direction. The plausibility of this assumption in the context of the paper is discussed in Section 8. Additionally, I assume that the telesecundaria construction does not affect the distance of the closest upper secondary education institution. This assumption rules out a positive correlation between the construction of a telesecundaria and of upper secondary institutions nearby[86]. Under these assumptions, the construction of a telesecundaria in a locality only affects the utility functions by reducing the transportation cost to this type of schools ($\Delta k_l^T < 0$). This increases the utility of attending telesecundarias, resulting in an upward shift of $U^T(c_i)$ (Figure 8), whereas it does not affect the utility of the other alternatives. The comparative statics of the two equilibrium conditions (22) and (23) when $A^T = 1$ are:

$$C^*_{SW}(1) - C^*_{SW}(0) = \underbrace{\Big[B^T(1) - B^T(0)\Big]}_{=0} - \underbrace{\Big[k_l^T(1) - k_l^T(0)\Big]}_{<0}$$

$$+ \rho \underbrace{\Big[\max\{B^{HS}(1) - k_l^{HS}(1), 0\} - \max\{B^{HS}(0) - k_l^{HS}(0), 0\}\Big]}_{=0} > 0$$

$$C^*_{BT}(1) - C^*_{BT}(0) = \frac{1}{\eta - 1} \cdot \left(\underbrace{\big[B^B(1) - B^B(0)\big]}_{=0} - \underbrace{\big[B^T(1) - B^T(0)\big]}_{=0} + \underbrace{\big[k^T(1) - k^T(0)\big]}_{<0} \right) < 0$$

Intuitively, the construction of a telesecundaria improves access to secondary education, resulting in an increase of the binding opportunity cost between working and attending lower secondary school, $C^*_{SW} > C^o_{SW}$. This results in an increase in the share of individuals enrolled in lower secondary education, and a decrease of children out of school. Individuals enrolling in lower secondary education with a relatively high opportunity cost ($c_i \in [C^*_{BT}, C^{**}_{SW}]$), will choose to attend the telesecundaria, whereas those with lower stochastic costs ($c_i < C^*_{BT}$) will choose to attend a brick-and-mortar school. Hence, some individuals that would have attended a brick-and-mortar school might now find optimal to attend the telesecundaria, decreasing the total share of students attending brick-and-mortar schools. Hence, the first prediction of the model is that the construction of a telesecundaria induces people to attend telesecundarias from two different counterfactuals: those that would have worked and those that would have attended a brick-and-mortar school if the telesecundaria had not been constructed. Note that the model assumes that the benefits of telesecundaria are constant between these two groups of compliers, since the only difference explicitly modeled are differences in opportunity costs.

Importantly, this model accounts for the fact that the benefits and costs of attending higher education directly influence the decision of attending lower secondary education. In particular, they only affect the extensive margin of enrolling in lower secondary education or working, C^*_{SW}, but do not affect the trade-off between telesecundarias or brick-and-mortar

[86] This assumption is not necessary, but simplifies the comparative statics. If instead I assume that the construction of a telesecundaria makes more likely the construction of an upper secondary institution nearby, the main conclusions of the comparative statics still hold.

schools (C^*_{BT}). As a concrete example, Figure 9 graphically shows that a decrease in the distance to the nearest upper secondary institution shifts U_i^B and U_i^T by the same amount. Formally, let A^{HS} be a variable measuring the availability of upper secondary schools nearby. The formal comparative statics on the equilibrium conditions after the construction of an upper secondary institution are:

$$C^*_{SW}(1) - C^*_{SW}(0) = 0 + \rho \underbrace{\left[\max\{B^{HS}(1) - k_l^{HS}(1), 0\} - \max\{B^{HS}(0) - k_l^{HS}(0), 0\} \right]}_{>0} > 0$$

$$C^*_{BT}(1) - C^*_{BT}(0) = 0$$

This results in an overall increase of individuals enrolled in lower secondary education, but does not shift the proportion of individuals attending a brick-and-mortar school. Therefore, easy access to upper secondary institutions may increase the enrollment rate in *lower* secondary education, keeping everything else constant. This is because, in a dynamic framework, there may be *continuation value* of attending a given educational level, even if individuals do not directly benefit from it.