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Authors: Martin Foureaux Koppensteiner, Jesse Matheson

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Secondary School Enrolment and Teenage Childbearing: Evidence from Brazilian Municipalities

Martin Foureaux Koppensteiner† Jesse Matheson‡

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Abstract

This article investigates whether increasing secondary education opportunities influences childbearing among young women in Brazil. We examine a novel dataset reflecting the vast expansion of secondary education in Brazil between 1997 and 2009 and exploit variation in the introduction of schools across 4,884 municipalities to instrument for school enrolment. Our most conservative estimate suggests that for every 9.7 students enrolled there is one fewer teenage births. These findings are robust to a number of specifications and sensitivity tests. Our estimates imply that Brazil's secondary school expansion accounts for 34% of the substantial decline in teenage childbearing observed over the same period. We further look at heterogeneous effects across a number of municipal characteristics and discuss what these results suggest about the mechanisms underlying the school-childbearing relationship.

JEL Codes: I20, I26, J13

Keywords: Secondary education, teenage childbearing, Brazil

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†Department of Economics, University of Surrey, and IZA, Bonn. Email: m.koppensteiner@surrey.ac.uk.
‡Corresponding author. Department of Economics, University of Sheffield. Email: j.matheson@sheffield.ac.uk.

1. Introduction

A 2012 report by the World Bank on teenage pregnancy stresses the correlation between teenage childbearing and socioeconomic variables including poverty, inequality, public health expenditure and female labor force participation. The report shows that, despite substantial reductions in teenage pregnancy rates in virtually all countries, we continue to see rates differ vastly between high- and low-income countries, with Brazil—as a middle-income country—being placed somewhere in the middle of the distribution.

Improved access to education, not explored in detail in the World Bank report, potentially provides an important channel through which teenage pregnancy and the above socioeconomic variables are correlated. Casual observation suggests a strong negative relationship between school availability and teenage childbearing in Brazil. We plot this relationship over time for Brazil in Figure 1. Starting from 12,684 secondary schools in 1997, the number of schools increased by more than 57%, to 19,964, in 2009. Over the same period, the number of births by teenage girls[1] decreased by 19%. Evidence based on a cross-section shows a very similar picture. In Figure 2, we present the state-level relationship between school density and rate of teen childbearing. There is a clear negative relationship suggesting that a secondary school enrolment increase of 10 students per 100 teenage females is associated with a decrease in births of 1.8 births per 100 teenage females (based on weighted linear fit).

In this paper, we investigate whether the negative association between secondary school availability and teenage childbearing is based on a causal relationship. We do this by looking at the effect of secondary school enrolment on teenage childbearing, using the expansion of secondary school across 4,885 Brazilian municipalities as a source of exogenous variation in enrolment. Our main results show that, on average, enrolling an additional student in secondary education decreases teenage childbearing by 0.127 births; in other terms, there is one fewer teenage pregnancies for every 7.9 additional students enrolled in secondary school. These estimates are robust to a number of different specifications and robustness checks. Back-of-the-envelope calculations based on our estimates suggest that approximately 34% of the total decline in teenage childbearing observed in Brazil since 1997 (Figure 1) can be attributed to the expansion of secondary schools.

[1] In this paper we define 'teenage' as ages 15–19 to match with the target entry age into secondary school.

We also test for heterogeneous effects by municipality characteristics. While we find no evidence that local economic factors play a role in mediating the schooling-childbearing relationship, we find that population density and measures of concentration matter. Specifically, while we estimate a significant negative effect in less dense and more rural municipalities, the estimated effects are significantly larger in high-density and more urbanized municipalities.

Brazil is particularly well suited for studying our research question. The school expansion that we examine constitutes one of the largest expansions of secondary schools on record. We use information from 13 waves of the annual Brazilian school census, containing detailed information on the universe of Brazilian schools, to create a new dataset reflecting the availability of secondary schools in every Brazilian municipality between 1997 and 2009. We combine this information with vital statistics data from Brazil capturing the universe of live births including information on the age of mothers at date of conception over the same period, creating a rich and unique dataset. Because we have information on schools and births for a very large number of municipalities, this allows us to obtain precise estimates and investigate heterogeneous effects along a number of municipality characteristics. To our knowledge, this is the first paper to document and utilize data on the rapid growth of secondary schools across Brazil over the two decades starting in the 1990s.

In this paper, school 'access' is improved through a reduction in geographic distance, thereby reducing the cost associated with school enrolment and attendance.[2] There is very limited evidence on how reducing the cost of attending school effects teenage fertility. Duflo, Dupas and Kremer (2015) provide a rare exception, using experimental evidence from Kenya. They find a large, negative impact on the fertility of young women from the provision of free primary school uniforms. A more established literature looks at the relationship between time spent in education and teenage childbearing. Berthelon and Kruger (2011) find that a 20 percentage-point increase in the municipal share of full-day schools (as opposed to half-day schools) decreases the probability of adolescent motherhood by 3.3% in the context of secondary schools in Chile. Several papers use variation from changes to mandatory schooling laws. Black, Devereux and Salvanes (2008) look at variation in teen births resulting from changes to minimum dropout age laws in the US and Norway. Relative to a minimum school-leaving age of 15, they estimate a reduction in teenage childbearing of 4.7% for a school-leaving age of 16 and an 8.8% for a school-leaving age of 17. Monstad, Propper and Salvanes (2008) find that the change in the mandatory dropout age in

[2] This follows a rational similar to that in Currie and Moretti (2003) who look at college attendance in the US.

Norway led to postponement of births from teenage years to the mid-thirties. For the UK, Geruso and Royer (2018) estimate that an extra year of schooling—induced by a change in the minimum leaving age—led to a 30% reduction in births at ages 16 and 17. On the contrary, for a UK policy allowing young women to leave school six-months earlier, James and Vujic (2019) do not find that the shortened education leads to a change in teenage motherhood.

We make two key contributions to the existing literature. First, we provide estimates for an explicitly different population margin than do existing studies that use changes in mandatory schooling laws. While mandatory schooling laws work by constraining individual choice sets (requiring school attendance regardless of other obligations), school expansions work by reducing the cost of attending school. The resulting group of 'compliers' in our study is strictly different from the compliers in mandatory schooling law studies. In our case, 'compliers' are those for whom the perceived return to schooling is relatively high, whereas compulsory schooling laws elicit changes from the bottom of the education distribution (Brunello, Fort and Weber, 2009; Fort, Schneeweis and Winter-Ebmer, 2015).[3] Estimates based on mandatory schooling laws may not be informative for the margin of the population explored in our setting or indeed in other settings where access to schooling changed. Despite the stark difference in the approach chosen in this paper, our estimates are similar, in sign and magnitude, to the findings of studies using compulsory schooling laws in high-income countries (Black, Devereux and Salvanes, 2008; Monstad, Propper and Salvanes, 2008), providing additional evidence on the role education plays for teenage fertility decisions.

The second contribution comes from our focus on a middle-income, as opposed to high-income, country. This enables us to study a recent and rapid expansion of secondary schools over a relatively short time period, which is not possible in the context of high income countries, where such expansions have taken place decades earlier and often in a more gradual fashion.[4] We are therefore able to provide the first quantification of the role of expanding education access in the substantial reduction of teenage fertility rates observed across many middle-income countries over the last two decades. The expansion of secondary schooling in Brazil provides a blueprint for

[3] Further, the observed effect of mandatory schooling laws on fertility is found to be context-dependent. Using changes in mandatory schooling laws, Fort, Schneeweis and Winter-Ebmer (2015) they find a negative relationship between education and fertility in England, but no such relationship for Continental Europe.

[4] This limits in many instances the data that is available on the rollout of school expansions in these settings. Brazil provides a great setting for our study by being able to investigate the largescale school expansion making use of high-quality administrative data for the entire country.

understanding the effect of the expansion of the educational system on fertility. The estimates provided here are therefore of relevance for a large group of low- and middle-income countries currently experiencing or on the brink of similar expansions of their educational systems.

The remainder of this paper is organized as follows: In Section 2 we provide the background on the provision of secondary education in Brazil. In Section 3, we discuss the data to be used in the main analysis. In Section 4, we introduce the empirical strategy and present the results. In Section 5, we present a number of robustness checks. In Section, 6 we present and discuss heterogeneous effects along a number of different municipality characteristics. Section 7 concludes the article.

2. Background information

Over the last two decades, many low- and middle-income countries have undergone an expansion of their secondary education system, driven by improvements in primary school completion and an increased demand for a more highly skilled workforce (World Bank, 2005). In Brazil, secondary schooling was an overlooked part of the education system until the beginning of the 1990s (Guimarães de Castro and Tiezzi, 2004). Secondary education was highly geared to the elites in preparation for entrance to higher education and was considered of little relevance for the education of the broader population. Following the end of the military dictatorship, the introduction of the constitution of 1988 made access to secondary education a key aim on the political agenda, mandating it to be available (although not mandatory) for all those completing primary education. Significant changes were made in 1996, when the government of Fernando Henrique Cardoso passed the General Education Law (Lei de Diretrizes e Bases da Educação Nacional (LDB) 1996). The LDB outlined the progressive universalization of access to free secondary education through gradually increasing access to state-funded public secondary schools (Marchelli, 2010). Following the rapid expansion of primary education, which was virtually universal by the early 1990s, secondary education started to expand (Moore, DeStephano, Terway and Balwanz, 2008; Di Gropello, 2006; De Felizio, 2009). The number of students in secondary schools increased from under 6.4 million in 1997 to 8.3 million in 2009 (INEP, 2003; INEP, 2011). This increase is mirrored by a steep increase in education expenditure; between 2000 and 2009, Brazil reported the largest increase in education spending as a percentage of total public expenditure for 33 countries for which data is available (OECD 2012).

Secondary education in Brazil, which typically lasts for three years, is principally the responsibility of the 26 states and is preceded by primary schooling—compulsory for children aged six to 14 years—lasting nine years. Of the 11,007 public secondary schools in 1997 for the municipalities in our study, 97% were under state control. State secretariats of education are responsible for the regulation and general management of secondary schools, including the recruitment of teachers and curriculum content (JBIC, 2005). There is no minimum age for initial enrolment to secondary school, but it is targeted at age 15, and students must have completed primary school first.[5] There is no maximum age limit and, because of frequent late enrolment and grade retention in primary schools, age-grade mismatch at secondary school is frequent (Foureaux Koppensteiner, 2014). In 2010, about 30% of students in the first grade of secondary school were above the target age (IBGE, 2012).

The expansion of the secondary system reflects the additional demand brought on by increased primary education enrolment numbers and completion rates (Guimarães de Castro and Tiezzi, 2004). In unison with the secondary school expansion, efforts were undertaken, through new curricular guidelines, to broaden the secondary curriculum towards more professional education, moving away from exclusively preparing for access to the higher education system (MEC, 2002; De Moura Castro, 2009). Thus, secondary schools have been changing their appeal for a larger segment of the Brazilian population.

The secondary school expansion resulted in a 57% increase in the number of secondary schools, from 16,562 in 1997 to 25,964 in 2009. This was driven primarily by a 68% increase in the number of publicly funded schools, from 11,007 to 18,526. There was also a notable 34% increase in the provision of private secondary education, from 5,555 to 7,438.

The school expansion had a non-trivial impact on school access across Brazilian municipalities. In particular, there was a remarkable increase in the availability of schools to the poorer northern states of Brazil.[6] In Figure 3, we depict the change over time in the number of secondary schools relative to what was available in 1997. The figure shows a steady increase over time in the number of schools for municipalities of all population sizes. The changes was relatively

[5] Recently primary education has been extended to 9 years and starts at the age of 6. For the most of our analysis before the mid-2000, primary education started at the age of 7 and lasted for 8 years.
[6] In appendix figure A1a, we map the observed school expansion between 1997 and 2009.

large in medium-large municipalities. In 1997, 316 municipalities, representing 6.5% of all Brazilian municipalities, had no secondary school. By 2009, this number had dropped to 12.

3. Data

The primary data used in this study comes from two sources: the Brazilian school census (Censo Escolar) and Brazilian vital statistics data from the Ministry of Health. In addition, we use auxiliary data, including population estimates for Brazilian municipalities from the Brazilian Census Bureau, and municipal expenditure data from a variety of sources. We discuss these data below, followed by a discussion of the minimal comparable areas that are used to link administrative units, Brazilian municipalities, over time. Descriptive statistics for the key variables in our analysis are reported in Table 1.

3.1 Schooling data

We use 14 waves of the Brazilian school census, collected annually for the Ministry of Education by the Anisio Teixeira Institute of Research on Education (INEP) provide an outstanding source of administrative data on the universe of schools in Brazil (Glewwe and Kassouf, 2012). The school census includes detailed information on the universe of public and private schools in Brazil, such as enrolment by grade, age and sex, information on the number of classes, the physical characteristics of the schools, as well as information on teachers.[7] We use this information to create a dataset on the number of secondary schools, the number of classrooms and the number of students between 1997 and 2009, collapsing the data by municipality and year. We define the introduction of a school as a school with a new school identifier appearing in the school panel.[8] Information on municipality codes allows us to locate every school in Brazil to the corresponding municipality. The school census also provides information on primary school enrolment, the availability of nursery classrooms, pre-school classrooms and the location of school in rural or urban areas, which we use as control. In Table 1, we show that there are on average three secondary schools per municipality; the vast majority of secondary schools are publicly provided and the number of schools is much higher in urban areas than in rural municipalities.

[7] These data can be downloaded at the website of INEP (http://portal.inep.gov.br/microdados).
[8] We restrict the school count to schools that are active in a given year and report a positive number of enrolled students to limit measurement error in the school panel.

3.2 Childbearing data

Data on birth outcomes come from the microdata of Brazilian vital statistics, which cover approximately 45 million births occurring between 1997 and 2009. Vital statistics data are based on birth certificates issued by health institutions or midwifes attending homebirths and are collected through the states' health secretariats. The vital statistics microdata are publicly available through the System of Information on Life Births (SINASC) of the IT department of the Brazilian public health system (DATASUS). These data provide information on the age and municipality of residence for the mother, as well as gestational length of the pregnancies, and the mother-reported race of the child.

For each year, we collapse these data to create a summary measure of births by municipality and mother's age at conception. We calculate age at date of conception using information on gestational length recorded in the birth certificates. The annual data are then merged to provide a municipal panel of births by mother's age at conception.[9] Brazilian vital statistics data show excellent coverage of all occurring births; information from the 2010 population census shows that more than 99% of all births occurring between 2000 and 2010 were registered and entered into the vital statistics data we use. The advantage of using vital statistics data to learn about fertility in the population comes from the universal coverage of the data for the entirety of Brazilian municipalities over the period of interest. Information about the residence of the mother during pregnancy is particularly important, as information on the place of birth may be misleading if there is a discrepancy between place of residence of the mother and the place of occurrence of birth, which is more likely for relatively small municipalities that do not have clinics with birth facilities.

Figure 4 displays the distribution of births per 1,000 women in Brazil by age of conception (in years) from 1997 to 2009. The figure reveals a peak in fertility in the early 20s, with a substantial fraction of these births occurring before women reach age 20. This confirms that childbearing rates are not only substantially higher in Brazil compared to countries such as the US, the UK or Germany, but overall fertility happens at a much earlier age. Around 22% of the 45 million births occurring over this period were births by teenage mothers. Brazil's childbearing rate for women aged 15–19 is 84 per 1,000, clearly above the OECD average (for example 45, 29 and 10 per 1,000 women in the US, UK and Germany respectively), but below many low-income

[9] Using date of conception rather than date of birth of the child, allows us to capture the time when fertility decisions are taken and relate this to the timing of the introduction of schools.

countries for which data is available (for example, the highest recorded rate of teen pregnancies is 207 per 1,000 women in Niger).[10]

3.3 Auxiliary data

Population estimates

The Brazilian Census Bureau (IBGE) provides official population estimates for each municipality based on the 1990 and 2000 census and the 1996 and 2006 population counts. These data provide population estimates by sex and age group that we use in all the regressions to account for cohort sizes.

Municipality controls

We also use a rich set of municipality-level time-varying controls on the characteristics of the municipalities from a variety of sources. These include municipality GDP, and the fraction of municipality level expenditure on education, health, welfare, transportation and housing, provided by IBGE. In addition, we use information the number of Bolsa Família[11] recipients and the total amount of Bolsa Família payments in the municipality. These data are available annually for the 1997–2009 period.[12] We provide details on the source of these data in the appendix.

3.4 Minimal comparable areas

Brazilian municipalities are our primary unit of observation. There are currently 5,570 municipalities in Brazil, and they constitute the country's smallest administrative divisions, similar to US counties. We link information on the availability of schools with the vital statistics data using unique municipality identifiers. Over our period of interest, a number of municipality boundaries were redefined. Specifically, 533 new municipalities are introduced in 1997, 54 new municipalities are introduced by 2001 and an additional 58 again by 2010.[13] To account for this, we create minimal comparable areas. IBGE (2011) provides information on the origins of municipalities since 1996, which we use to build stable geographic area definitions. If, for

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[10] Age specific fertility rates, as pregnancies per 1,000 women aged 15–19 for the period 1995–2010 (UN World Population Prospects 2015).

[11] Bolsa Família is a cash transfer program of the Brazilian government for poor Brazilian families conditional on meeting requirements regarding school attendance and completion of vaccination schedules.

[12] The Bolsa Família programme was introduced in 2004. Data for municipal GDP is available from 1999.

[13] The majority of new municipality boundary changes arise from splitting larger municipalities in two or more municipalities.

example, two municipalities were created by splitting one municipality, the two new municipalities are recoded to the same minimal comparable areas. This results in 4,885 of such units. For simplicity, we will continue to refer to our units of observation as municipalities throughout this article.

4. Empirical strategy and results

4.1 Empirical strategy

We want to estimate the relationship between an increase in the secondary school enrollment and teenage childbearing in a municipality. We focus on enrollment for a municipal cohort[14] at age 15 and birth outcomes in subsequent teenage years. The primary analysis is based on the following two equations for municipality i in year t:

$$B_{it} = \alpha E_{it-4} + \gamma PE_{i,t-5} + \boldsymbol{X}'_{it}\boldsymbol{\Lambda} + \delta_t + \delta_t^s + \eta_i + \epsilon_{it}. \quad (1)$$

$$E_{it-4} = \beta S_{it-4} + \pi PE_{i,t-5} + \boldsymbol{X}'_{it}\boldsymbol{\Pi} + \lambda_{t-4} + \lambda_{t-4}^s + \zeta_i + \mu_{it-4} \quad (2)$$

Equation (1) is equation of interest. B_{it} is the cumulative number of births conceived between age 15 and age 19, in municipality i, by the cohort that is age 19 in year t. Specifically, where b_{it}^a is the number of live births conceived by mothers of age a in municipality i and year t:

$$B_{it} \equiv b_{it}^{19} + b_{it-1}^{18} + b_{it-2}^{17} + b_{it-3}^{16} + b_{it-4}^{15}.$$

On the right-hand-side of (1), E_{it-4} is the number of students enrolled in secondary school enrolment in municipality i in year $t-4$. $PE_{i,t-5}$ is the number of students enrolled in the final-year primary classes.[15] $\boldsymbol{X_{it}}$ is a vector of municipal controls including the number of pre-schools, total male and female cohort population size, total and per-recipient Bolsa Família transfers, and—both in logs and four-year log-differences—municipal GDP and public spending (welfare, education, health, transportation, and housing). Unobservable heterogeneity captured by a year

[14] Our data do not allow us to link individuals over time. Therefore, cohort is defined according to year-of-birth and municipality. As we will discuss in Section 5.4, the extent to which we are able to identify the same underlying population year-on-year is challenged by migration. With this in mind, we use the term cohort to reflect all individuals with the same date-of-birth, living in the same municipality.

[15] The first observation for $PE_{i,t-5}$ (at $t = 2001$) is constructed from the 1996 wave of the Brazilian School Census.

fixed effect, δ_t, a state × year specific shock δ_t^s, a municipal fixed effect, η_i, and an time-varying municipal component ϵ_{it}.

We address the potential endogeneity of E_{it-4} in Equation (1) by using the number of secondary schools available in year $t-4$, S_{it-4}, as an instrument. More specifically, we use the predicted values from Equation (2), $\hat{E}_{it-4}$, in Equation (1). Given that municipal fixed effects are controlled for, the identifying variation will come from within-municipality changes in the number of secondary schools. The resulting estimate, $\hat{\alpha}$, reflects the effect of an increase in school enrollment for resulting from the expansion of secondary schools between the years 1997 and 2005.[16]

The assumption to identify α is that the introduction of schools across Brazilian municipalities is uncorrelated with the unobservable components of variation in municipal childbearing. Formally, $E(\epsilon_{it}|S_{it-4}) = 0$. We subject this assumption to a number of tests in sections 4.2 and 5. The remarkable stability of our results suggests that this assumption is highly plausible.

4.2 Main results

Estimates for Equation (1) are presented in Table 2. The coefficient of interest, α, is reported in the first row [Secondary enrolment (t-4)], the first-stage coefficients corresponding to the regression of enrolment on secondary schools (β from Equation (2)) is reported in the second row [Schools (t-4)], and estimates for control variables in $\boldsymbol{X_{it}}$ and $PE_{i,t-5}$ are reported in the remaining rows. All regressions include year and municipality fixed effects, municipality-clustered standard errors are reported in parenthesis. As the R-squared corresponding to the instrumental variable estimate is not readily interpretable, we report the within-variation R-squared corresponding to the reduced form regression of birth outcomes on number of schools in period t-4, in the row labeled R2 (reduced form).

A unit increase in municipal secondary school enrolment is associated with a 0.125 unit decrease in childbearing (column 1). Put another way, 1.0 fewer teenage births are observed for every 7.9 students enrolled in secondary education. This estimate is not sensitive to the inclusion of a full set of controls ($\hat{\alpha} = -0.127$, column 2).

[16]In an earlier version of this paper we regress B_{it} directly on the number of schools in year t-4. This is difficult to interpret, as a "school" is not a well-defined unit of measurement and can vary in size across municipalities. However, results are qualitatively similar to those reported here.

The estimated effect of enrolment on childbearing is robust to sample restrictions that weaken the identifying assumption. We exclude the 34 largest municipalities, ensuring that results are not due to a few very large municipalities (column 3).[17] We further restrict the sample to municipalities that received a new school in the period 1997–2009 (column 4), and municipalities that received a new school during the period 1997–2005 (column 5). The final restriction only includes municipalities that received a school within the period from which the identifying variation is drawn. This specification has the relatively weak identification assumption that only the timing of school introduction is exogenous. The change in estimates when we restrict the municipalities is marginal, varying between -0.127 and -0.105. The most conservative of these estimates suggest that one fewer teenage births are observed for every 9.7 students enrolled in secondary education.

The stability of our estimates across these various specification supports the assumption that school introductions are conditionally exogenous with respect to teenage childbearing. If there are municipal-specific time varying unobservable that both influence birth outcomes and are correlated with school introductions, then the estimates are expected to change as we restrict to municipalities to those that are more "similar" in terms of school introductions.

The first stage results suggest that the school expansion had a non-trivial effect on secondary enrolment. A new secondary school increasing enrolment in the first-year secondary enrolment by just over 100 students for the full sample, and about 50 students when we exclude the largest municipalities. All of the F-statistics for the excluded instrument are large ($F > 10$). The difference in the first stage effect of schools on enrolment emphasizes the importance of our estimation strategy, relative to looking at the effect of schools directly. Although schools in smaller municipalities lead to a smaller increase in student enrolment than those in larger municipalities, the per-unit of enrolment effect on childbearing is roughly the same.

Overall, controlling for municipal GDP, expenditures, and state×year shocks increases the within R-squared by 3.4 percentage points. The effect of municipal GDP and GDP growth are both significant, although with opposite signs. Few of the municipal expenditure variables are statistically significant. However, it is interesting that education spending stands out. For the

[17] The 34 cities with a population above 500,000 stand out from the vast majority of municipalities with their very large populations and extreme population density, making these municipalities not easily comparable to the majority of municipalities in Brazil.

restricted samples in columns 4 and 5 a percentage point increase in the annual growth rate of education spending is associated with up to 25.5 fewer cohort births.

5. Robustness

The interpretation of the estimates in Table 2 as a causal effect of municipal secondary enrolment on municipal teenage childbearing depends on the identifying assumption that the secondary school expansion is conditionally exogenous, $E(\epsilon_{it}|S_{it-4}) = 0$. Here we explore the key treats to this assumption. We find that the evidence supports our identifying assumption.

5.1 Do birth outcomes predict school expansion?

One possible concern for interpreting the estimates in Table 2 is that there are unobserved municipal characteristics that are correlated with teenage births and influenced the whether or not a municipality received a secondary school. This would lead to a spurious correlation between teenage birth outcomes and the secondary school expansion. We test this possibility with two regressions. First, we regress a binary indicator for the introduction of a secondary school in year t on the lag of birth outcomes, $B_{it-1}/100$ (Panel A, Table 3). Second, we regress a binary indicator for the introduction of a secondary school on the percent change in the number of births between year t and $t-4$, $(B_{it} - B_{it-4})/B_{it-4}$ (Panel B, Table 3). Regressions also include the lagged value of primary school enrolment, $PE_{i,t-1}$, the vector of controls X_{it}, as well as state-specific time trends, municipal and time fixed effects.

These regressions support our identifying assumption that school introductions are conditionally exogenous with respect to birth outcomes. All estimates suggest that the correlation between municipal birth outcomes and future school expansion is small and statistically insignificant (Table 3).

As an additional robustness check, we perform an event study-style analysis using a subsample of the municipalities. For brevity, we report the details and results of this analysis in Appendix B. The event-framework allows us to investigate the possibility of pre-trends in birth outcomes for municipalities that received secondary schools. The resulting figures provide further evidence of no systematic trends in teenage childbearing municipalities prior to the introduction of a secondary school.

5.2 Births to older mothers.

A second challenge to identification is the possibility that the expansion of secondary schools is correlated with other municipal-level programs, not picked up by the municipal spending variables we include in Equation (1). Notice that the analysis in 5.1 above suggests that such correlated programs are unlikely to have preceded the introduction of schools.

We want to exclude that major federal and state health programs are coordinated with the expansion of schools. In particular, we are interested in programs that include family planning components, such as the Family Health Program (Programa Saúde da Família).[18] The majority of the rollout of this federal Ministry of Health program happened around the millennium; we find no evidence of coordination with the expansion of secondary school expansion, which was led by state education secretariats (Rocha and Soares 2010).

We explore this further by looking at the correlation between the secondary school expansion and births to mothers at older ages. It should be noted that there is no explicit age restriction to entering secondary education in Brazil (Foureaux Koppensteiner, 2014). Therefore, there is no age cut-off at which we can say the 'treatment' is received or not. However, the majority of secondary school students enroll between the ages of 15 and 17; the secondary school expansion is less likely to affect older individuals than younger individuals. Therefore, finding a qualitatively similar effect on births at ages 30 and older would suggest the existence of unobservables that are influencing municipal childbearing more generally.

We separately regress the number of municipal births to mothers age 15 to 40 ($b_{it}^{a}, a = 15, \dots, 40$) on the (instrumented) contemporaneous secondary enrolment. Regressions include age-specific male and female population size, but otherwise contain the same set of control variables as Equation (1). We report the resulting coefficients (normalized by dividing by the age-specific mean births) in Figure 5. The estimates for all groups over 23 years of age are statistically insignificant and small in magnitude. We interpret this as evidence that there are no unobserved municipal changes that both effect childbearing and are correlated with secondary school introductions.

[18] Another federal health programme, the School Health programme (Programa Saúde na Escola), was introduced only in 2007 at the end of our period of interest. The Stork Network (Rede Cegonha), which has a focus on maternal and child health and includes a family planning component, was launched in 2011, after our period of interest.

5.3 Selective migration

Migration presents a potential concern for our identification strategy. Notice that because B_{it} reflects the total number of births, estimates will not be impacted by flows of non-sexually active teens, only by the movement of teens who are sexually active. Specifically, migration may lead us to estimate a negative value for α if the introduction of a secondary school induces an outflow of sexually active teens. Such a migration pattern will create a spurious negative relationship between school introductions and teenage childbearing. To investigate this possibility we use migration information from the 2010 Brazilian population census to document relevant facts about migration patterns in Brazil. For brevity, we summarize the results here and report the details of the analysis in Appendix C.

Migration data from the 2010 Census suggests the following: a) females who migrate between ages 10 and 18 are significantly more likely, relative to other ages of migration and the general population, to be teenage parents; b) migrants tend to leave municipalities with low school expansion in favor of municipalities with high school expansion; c) the difference in school expansion between the destination and origin municipality is higher for teenage parents than for non-teenage parents. These stylized facts work against finding a negative relationship between secondary schools and teenage childbearing. If anything, migration may lead us to underestimate the magnitude of a negative impact of schools on teenage childbearing. Therefore, the results that we report in Table 2 should be considered a lower bound on α.

6. Heterogeneity

In Section 4, we estimate the relationship between municipal secondary school enrolment and teenage childbearing by looking at how the estimated relationship varies across municipal characteristics. In particular, we investigate two characteristics that reflect the local economic context (the municipal unemployment rate and municipal earnings return to secondary school), and two characteristics that reflect differences in the dispersion and density of the population (population per km^2 of land and proportion of rural students enrolled). These characteristics may provide some policy relevant margins about the effectiveness of the expansion of secondary school enrolment and more generally the secondary school expansion analyzed.

We start by stratifying the estimates for Equation (1) by the municipal-level return to secondary education. We use data from the public use 2010 Brazilian population census to calculate the return to secondary school as the ratio of municipal-average income for respondents with a high-school education to respondents with a primary school education. As the public use census does not identify all municipalities, we restrict the sample to the 831 that we can identify. Appendix D provides details on the calculation.

Stratifying municipalities by the median return to secondary education (2.61), we find no significant difference in the effect of enrolment on live birth conceived for mothers between 15 and 19 years of age. The coefficient for low-return municipalities is -0.123 and for high-return municipalities is -0.121 (Table 4).

We repeat the exercise when splitting the sample across the median municipal unemployment rate (5.84%). Unemployment rates reflect rates in 2000, provided by the Brazilian Census Bureau for all municipalities. Again, we find very similar effect sizes for the stratified samples. The coefficient for low-unemployment municipalities is -0.119 and for high-unemployment municipalities is -0.109. Taken together these results suggest that local economic factors do not play an important role in mediating the effect of school enrolment on underage fertility.

Next, we investigate whether the estimated effect varies by the dispersion and density of the population in Brazilian municipalities. For this exercise, we stratify the sample by the median population density, defined as the municipal population divided by municipal land size (24.9 persons/km^2). There is a statistically significant, negative effect for both high-density and low-density municipalities. However, there is a notable difference in coefficient magnitude. In high-density municipalities, a student enrolled leads to an average 0.051 unit decrease in teen births. In low-density municipalities, a student enrolled leads to an average 0.151 unit decrease in teen births. This suggests that one fewer birth is observed per 6.6 students enrolled in high-density municipalities, versus 19.6 students enrolled in low-density municipalities.

Because population density ignores to some extent the distribution of the population within each municipality, we are further interested in a simple measure of concentration. For this purpose, we make use on information provided in the later waves of the school census on the number of students enrolled in secondary school who are recorded as living in rural settings. For a large number of (urban) municipalities, all students reside in an urban setting (zero rural students). Therefore, we present the results stratified by whether there are or there are no rural students enrolled in secondary school. Similar to the results by population density, we estimate a larger effect for municipalities with students exclusively living in urban settings than we do for municipalities with a non-zero population of rural-residence students. However, for both groups of municipalities, we still estimate a substantial negative, and statistically significant, effect of enrolment on teen childbearing.

We further stratify the sample by the fraction of rural students enrolled in secondary school. We find that the larger the fraction of rural students in the municipality, the smaller is the estimated effect on underage childbearing. While our first stage estimates indicate that school expansion has a strong effect on enrolment across the different samples, we no longer find an effect in municipalities with the largest fraction of rural students. We report the results of this exercise in Table 5.

7. Discussion and conclusion

In this article, we investigate whether an increase in secondary education opportunity, through the increase in enrolment of students in secondary school, impacts the fertility decisions of teenagers in the middle-income context of Brazil.

Our estimates suggest that enrolment in secondary education as a result of the school expansion plays an important role for teenage fertility in Brazil. We estimate that, within a municipality, an additional student enrolled in secondary school will lead to an average decrease of 0.127 births to teenage mothers. This translates to an average school decreasing teenage births by 10.7% relative to the mean.[19] To understand the economic impact, consider that the number of children born to teen mothers is 20% lower for the cohort age 15 in 2005 than the cohort that is age 15 in 1997. These are sizeable and economically meaningful results; the magnitudes presented in Table 2 suggest that secondary school expansion in Brazil can explain 34% of the large decrease in teenage fertility.[20]

The data we use have the advantage of near-universal coverage of births, and significant variation from a large school expansion across 4,884 municipalities. However, there is a major restriction to the use of these data, as we cannot link birth outcomes and enrollment at an individual

[19] This is based on first-stage estimates corresponding to an average school leading to a 109.851 increase in enrolment (Table 2) and an average municipality experiencing 130.35 teen births (Table 1).

[20] In our sample, the cohort age 15 in 1997 had access to 16,562 secondary schools and, by age 19, had given birth to 708,845 children. The cohort age 15 in 2005 had access to 23,569 secondary schools and gave birth to 423,548 children (the estimated size of each cohorts is 1,765,097 and 1,900,940). Based on an average enrolment increase of 109.9 students each of the 7,007 incremental schools, the total decrease in births that we can attribute to the school expansion is $-0.127\times109.9\times7007/285297 = 0.343$.

level. Therefore, our results should not be interpreted as capturing the effect of school enrolment on an individual's outcome. Rather, we use enrolment as a measure of the availability of secondary education opportunities in a municipality. The advantage of doing this, compared to looking at the effect of schools on birth outcomes directly, is that unlike a "school" a unit of enrolment is a standardized measure across municipalities.[21]

The negative effect from expanding secondary school enrolment that we estimate is consistent with a previous literature that considers the effect of mandatory schooling laws on teenage birth outcomes (Black, Devereux and Salvanes (2008) and Fort, Schneeweis and Winter-Ebmer (2016)). There are two major differences from these papers to our context. First, in contrast to the above literature, the expansion of secondary schools in Brazil affects a very different population margin, allowing us to investigate effects for a margin of the population not necessarily affected by changes in compulsory schooling laws. Second, different from the existing literature, we focus our analysis on a middle-income country. It is this focus that ultimately allows us to consider the effect of the very rapid expansion of secondary schools over a relatively short period. As a number of middle and low income countries are still to go through expanding their secondary education system, our results are relevant to understand the (positive) externalities expanding secondary education opportunity may have through substantial reductions in underage fertility.

A possible explanation for the differences in estimates according to density/dispersion may relate to the coordinating effect that secondary schools will have in relatively rural municipalities. A coordination mechanism will work by creating opportunities for interactions between young men and women who would not have interacted in the absence of attending school. The importance of this mechanism will vary inversely with opportunities for interaction outside of school. For example, a young woman on a rural farm may only infrequently meet with young men in the local area, and will therefore have fewer opportunities to develop a relationship that could lead to childbearing. By bringing together young men and women from dispersed rural areas at regular intervals, the coordination effect of schools may have a positive influence on teenage childbearing, limiting the overall negative effect that may work through a human capital mechanism. In rural settings, schools may provide an environment in which young women and men meet and spend a

[21] Apart from our interest in school enrolment, we cannot estimate the effect of school attainment on fertility. The school census does not allow us to draw inference about school completion, as there is no direct information on which students graduate versus which students drop-out.

significant amount of time together. Such opportunities are likely to be more readily available in densely populated urban areas, than in sparsely populated rural areas. Any coordinating mechanism would be counteracting any negative effect of enrolment on childbearing in the age group. Unfortunately, in the absence of individual data on the matches and the precise residence of students, we cannot test for this potential more channel directly.

References

Berthelon, M.E. and D.I. Kruger. 2011. 'Risky Behavior among Youth: Incapacitation effects of school on adolescent motherhood and crime in Chile', Journal of Public Economics, 95, 41–53.

Black, S. E., P. J. Devereux and K. G. Salvanes. 2008. 'Staying in the Classroom and out of the Maternity Ward? The effect of compulsory schooling laws on teenage births', Economic Journal, 118: 1025–1054.

Brunello, G., M. Fort and G. Weber, 2009. 'Changes in Compulsory Schooling, Education and the Distribution of Wages in Europe', Economic Journal, 119 (536): 516–539.

Currie, J. and E. Moretti. 2003. 'Mother's Education and the Intergenerational Transmission of Human Capital: Evidence from college openings', Quarterly Journal of Economics, 118: 1495–1532.

De Felizio, F. 2009. 'O Ensino Fundamental – Desafios desde a Alfabetização até a Transição para o Ensino Médio', in: Educação Básica no Brasil: Construindo o País do Futuro, ed: F. Veloso et. al. Elsevier, Rio de Janeiro.

De Moura Castro, C. 2009. 'Desventuras do Ensino Médio e seus Desencontros com o Profissionalizante', in: Educação Básica no Brasil: Construindo o País do Futuro, ed: F. Veloso et. al. Elsevier, Rio de Janeiro.

Di Gropello, E. 2006. Meeting the Challenges of Secondary Education in Latin America and East Asia: Improving Efficiency and Resource Mobilization. Washington D.C. The International Bank for Reconstruction and Development.

Duflo, E., P. Dupas and M. Kremer. 2015. 'Education, HIV, and Early Fertility: Experimental Evidence from Kenya', American Economic Review, 105(9), 2757–2797.

Foureaux Koppensteiner, M. 2014. 'Automatic Grade Promotion and Student Performance: Evidence from Brazil', Journal of Development Economics, 107: 277–290.

Fort, M., N. Schneeweis and R. Winter-Ebmer, 2016. 'Is Education Always Reducing Fertility? Evidence from compulsory schooling reforms', Economic Journal, 126: 1823–1855.

Glewwe, P. and A. Kassouf. 2012. 'The Impact of the Bolsa Escola/Família Conditional Cash transfer program on enrollment, dropout rates and grade promotion in Brazil', Journal of Development Economics, 97(2): 505-517.

Guimarães de Castro, M.H. and S. Tiezzi. 2004. 'The Reform of Secondary Education', in: The Challenges of Education in Brazil. Ed.: C. Brook and S. Schwartzmann. Cambridge University Press, Cambridge.

Geruso, M. and H. Royer, 2018. 'The Impact of Education on Family Formation: Quasi-experimental evidence from the UK', NBER working paper 24332.

IBGE. 2011. Evolução da Divisão Territorial do Brasil 1872–2010. Available at http://www.ibge.gov.br/home/geociencias/geografia/default_evolucao.shtm.

IBGE. 2012. Estatícas do Sécolo XX. Database Appendix. Rio de Janeiro.

INEP. 2003. Sinopse Estatística da Educação Básica 1991–1995. Ministry of Education, Brasília.

INEP. 2011. Sinopse Estatística da Educação Básica 2010. Ministry of Education, Brasília.

JBIC (Japan Bank for International Cooperation). 2005. 'Sector Study for Education in Brazil', JBIC Sector Study Series 2004–No.2.

James, J. and S. Vujic. 2019. 'From High School to High Chair: Education and Fertility Timing', Economics of Education Review, 69, 1–24.

LDB (Lei de Diretrizes e Bases da Educação Nacional). 1996. Senate of the Federal Republic of Brazil. http://www6.senado.gov.br/legislacao/ListaPublicacoes.action?id=102480.

Marchelli, P.S. 2010. 'Expansão e Qualidade de Educação Básica no Brasil', Cadernos de Pesquisa 40: 561–585.

Marteleto, L. 2012. 'Educational Inequality by Race in Brazil, 1982–2007: Structural Changes and Shifts in Racial Classification', Demography 49: 337–358.

MEC (Ministry of Education). 2002. Parâmetros Curriculares Nacionais – Ensino Médio. Brasília.

Monstad, K., C. Propper and K.G. Salvanes. 2008. 'Education and Fertility: Evidence from a natural experiment', Scandinavian Journal of Economics, 110: 827–852.

Moore, A. S., J. DeStephano, A. Terway and D. Balwanz. 2008. 'The Expansion of Secondary Education and the Need for Teachers: How big is the gap?', Equip2 Working Paper, USAid.

OECD. 2012. Brazil Country Note. Education at a Glance: OECD Indicators 2012. OECD, Paris.

Rocha, R. and R. Soares. 2010. 'Evaluating the Impact of Municipality-Based Health Interventions: Evidence from Brazil's Family Health Program', Health Economics, 19: 126–158.

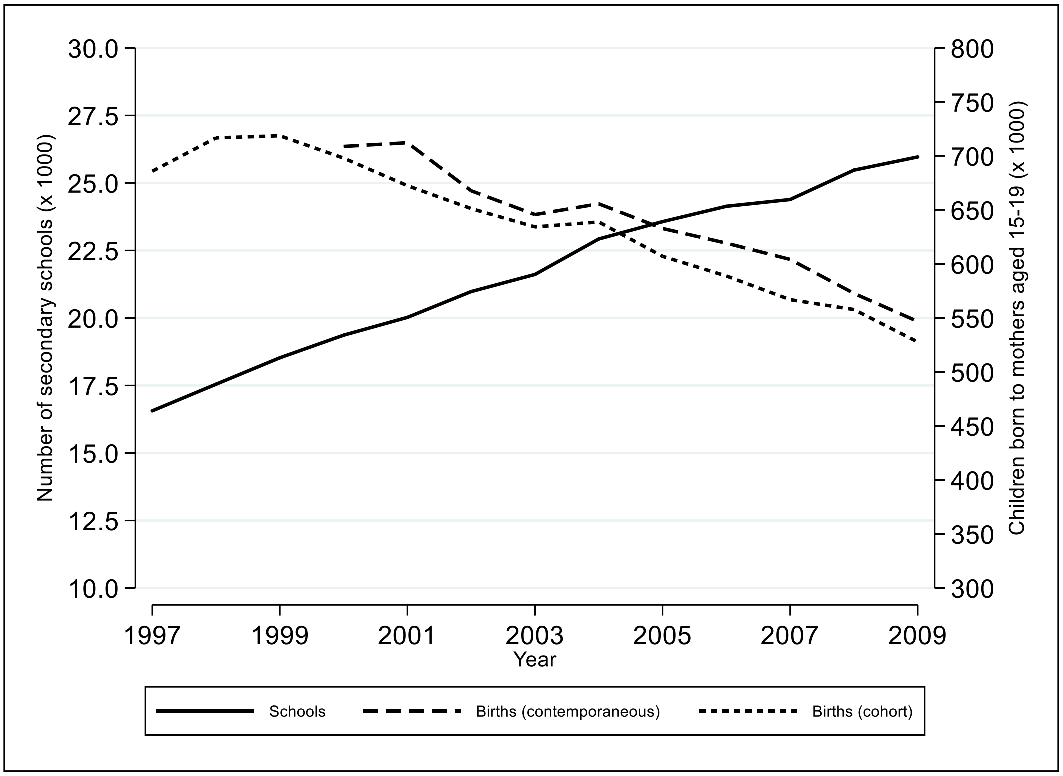
Sandler, D.H., and R. Sandler. 2014. 'Multiple Event Studies in Public Finance and Labor Economics: A Simulation Study with Applications', Journal of Economic and Social Measurement, 39: 31–57.

World Bank. 2005. Expanding Opportunities and Building Competencies for Young People A New Agenda for Secondary Education. Washington, D.C.

World Bank. 2012. Teenage Pregnancy and Opportunities in Latin America and the Caribbean. On Teenage Fertility Decisions, Poverty and Economic Achievement. Washington, D.C.

Figures

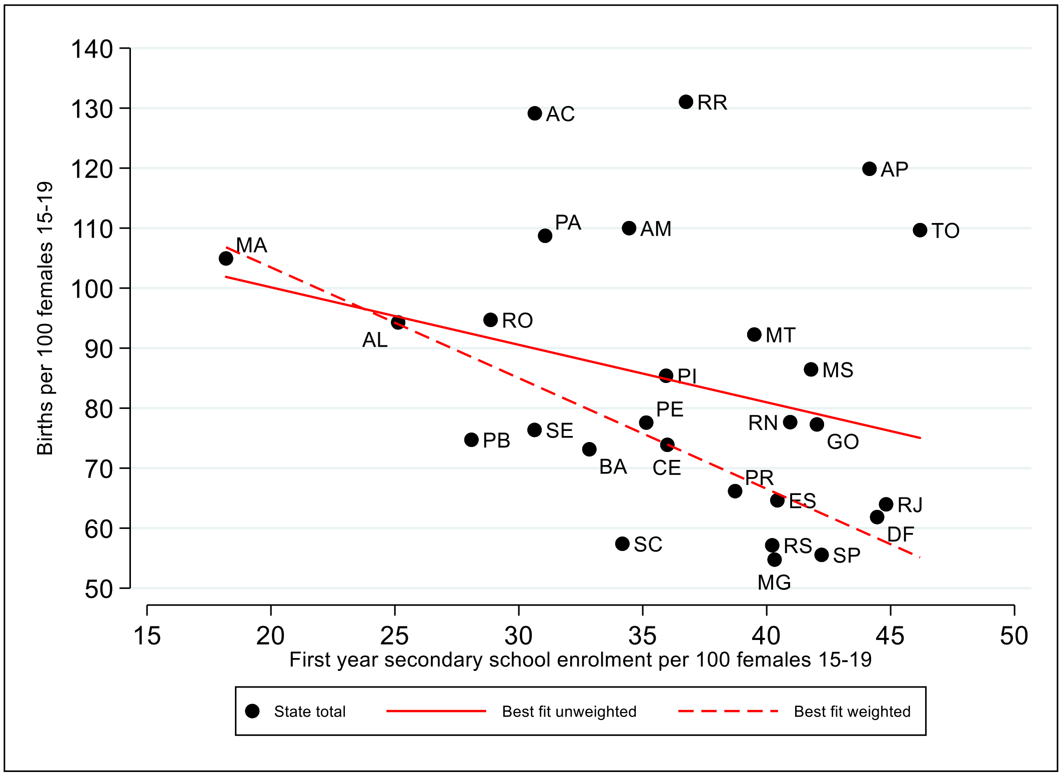
Figure 1: Secondary schools and teenage births over time, Brazil



Notes: This figure shows the annual number of secondary schools and births for the period 1997 to 2009. Contemporaneous births include all births conceived between the ages 15 to 19 in each year. Cohort births for year t reflect the sum of births to mothers aged 19 in year t, 18 in year $t-1, \ldots, 15$ in year $t-4$.

Source: School data come from the 1997–2009 waves of the Brazilian School Census; births by age of conception from Brazilian Vital Statistics.

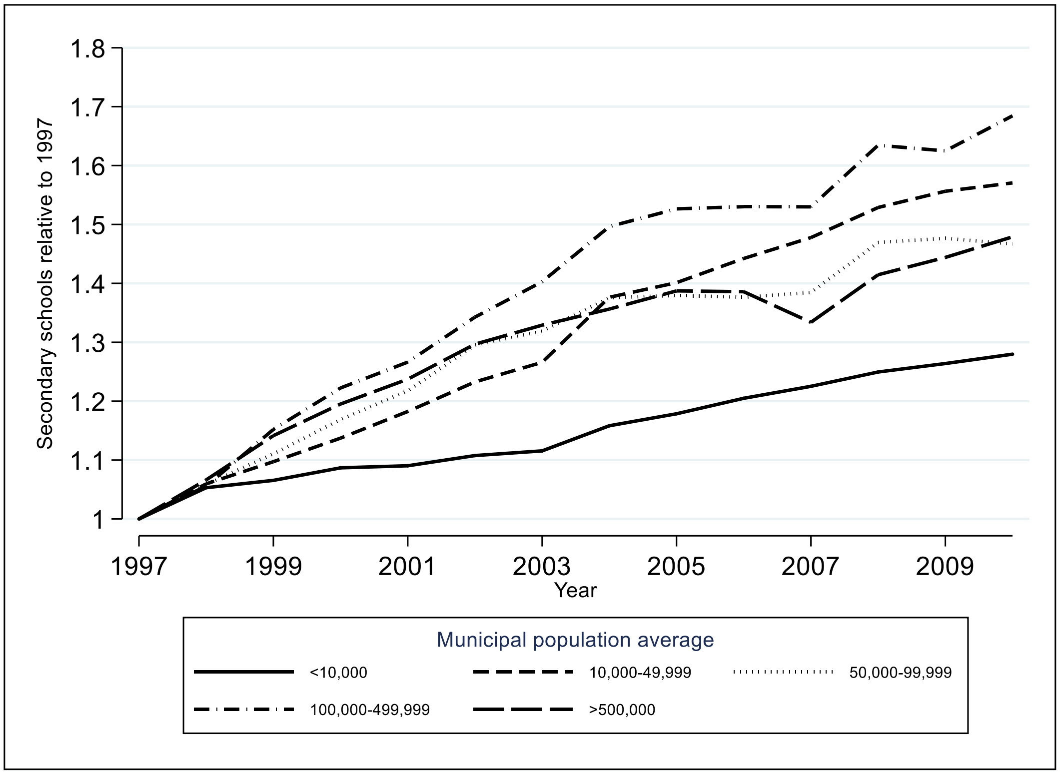
Figure 2: Secondary schools and teenage births across Brazil, 2002



Notes: Data for 2002 cross-section. Broken line shows linear fit weighted by population size, solid line shows unweighted linear fit. Births are for mothers aged 15–19.

Source: School data come from the 2002 wave of the Brazilian School Census; official population estimates from the Brazilian Census Bureau; births by age from Brazilian Vital Statistics.

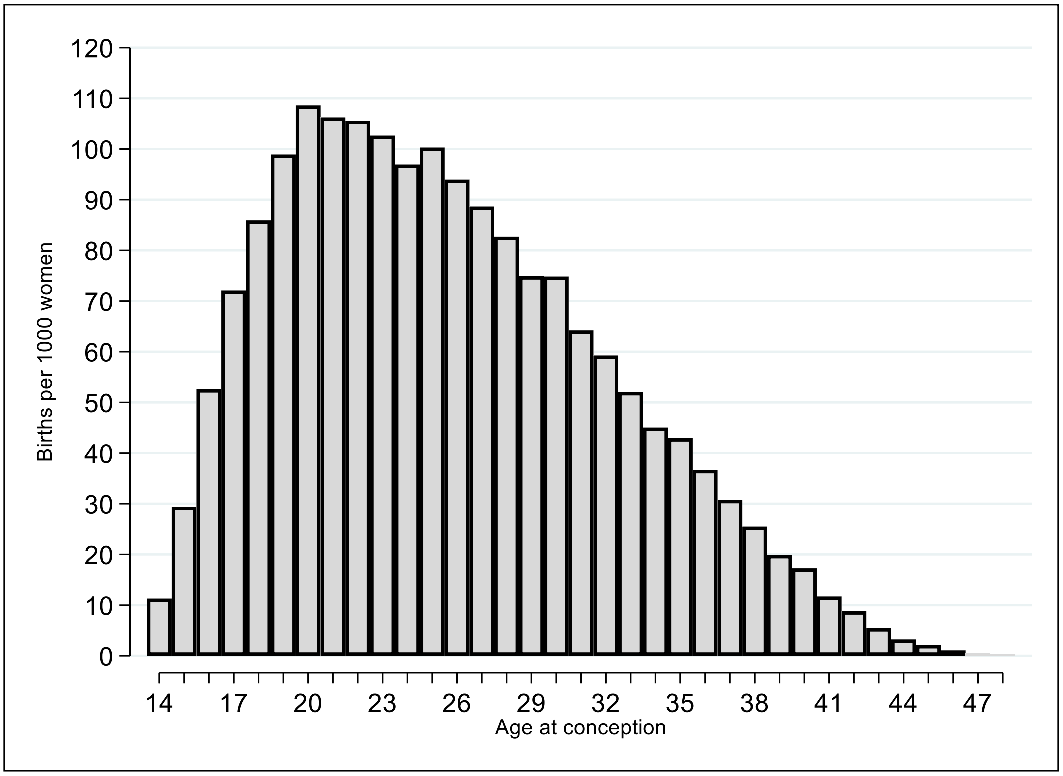
Figure 3: Change in secondary schools over time, by municipal population groups



Notes: This figure shows the number of secondary schools, normalized by the number in 1997, by municipality size. Standard classification of municipalities by size come from the National Statistical Office (IBGE).

Source: School data come from the 1997–2009 waves of the Brazilian School Census; official population estimates from the Brazilian Census Bureau.

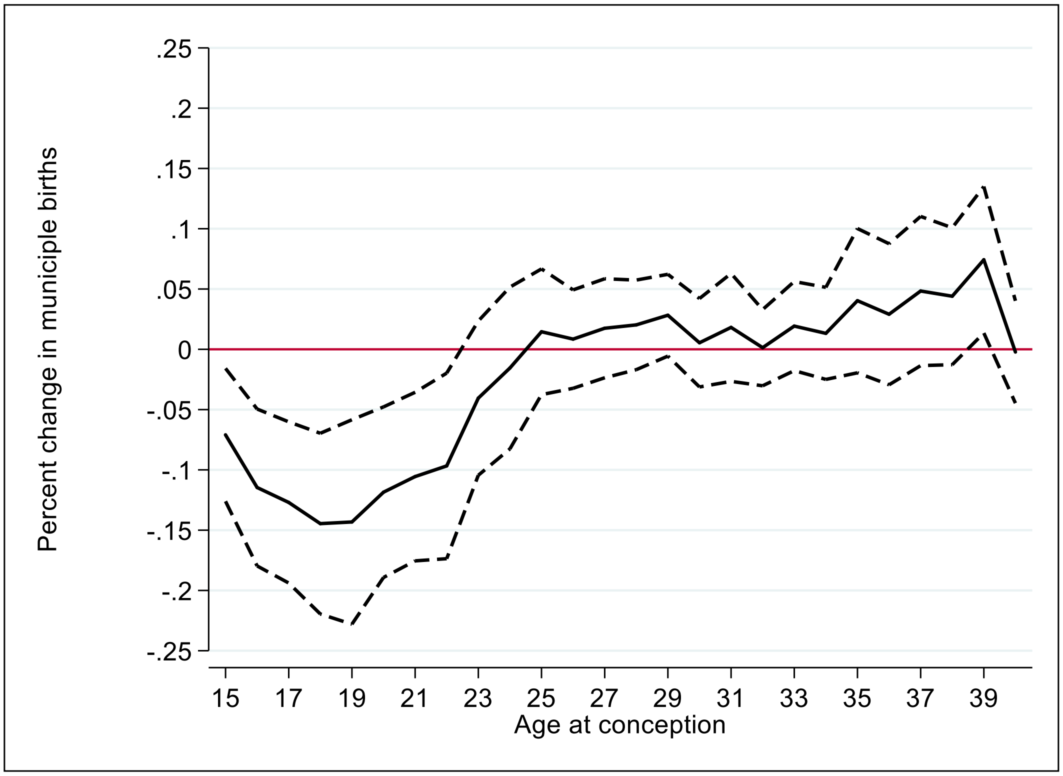
Figure 4: Birth rates by age



Notes: This figure shows ages-specific births per 1000 females for Brazilian population 1997–2009.

Source: Births by age of conception from Brazilian Vital Statistics; official population estimates from the Brazilian Census Bureau.

Figure 5: Contemporaneous secondary school enrolment and births (percent change) by age



Notes: This figure plots the coefficients from a regression of the number of live births for each age group on contemporanious secondary school enrolment (instrumented). The solid line plots these coefficients divided age-group specific means for the outcome ($\times 100$). Dashed lines show the corresponding 95% confidence interval. All regressions instrument enrolment with the number of secondary schools in the same period. Estimates condition on lagged primary school enrolment, preschool classrooms, male and female age-specific population size, municipality expenditures, municipality and year fixed effects.

Table 1: Descriptive statistics

	Full sample			Population < 500,000		
Number of municipalities	4,884			4,850		
Population	Mean	SDB	SDW	Mean	SDB	SDW
Total	35,935	(202,234)	{11,981}	25,861	(46,981)	{5,164}
Teenage (age 15–19)	3,667	(18,871)	{1,310}	2,685	(4,764)	{497}
Cohort size (females)	354	(1,965)	{169}	252	(472)	{56}
Births (aggregate cohort)†	130.35	(565.40)	{73.99}	100.35	(182.14)	{25.80}
Active secondary schools	4.34	(21.69)	{2.86}	3.28	(5.53)	{1.52}
Secondary enrolment (year 1)	682.49	(4163.08)	{475.78}	467.50	(962.82)	{202.59}
Secondary enrolment (total)	1604.67	(10191.92)	{1214.64}	1084.70	(2280.87)	{505.90}
Public schools	3.02	(11.23)	{2.10}	2.45	(3.59)	{1.26}
Private schools	1.32	(10.55)	{1.21}	0.83	(2.24)	{0.55}
Controls						
Primary enrolment, yr. 8	590.43	(3467.13)	{608.69}	419.09	(837.74)	{229.59}
Preschool rooms	53.45	(311.98)	{115.84}	39.40	(71.31)	{28.08}
Municipal GDP (per-capita)	7243.18	(7552.55)	{4004.76}	7194.34	(7534.12)	{3998.81}
Municipal GDP (log-diff)	0.09	(0.03)	{0.07}	0.09	(0.03)	{0.07}
Municipal public spending (per-capita)						
Total	547.66	(301.64)	{325.00}	548.32	(302.25)	{325.97}
Welfare	49.78	(39.54)	{41.74}	49.60	(39.35)	{41.71}
Education	237.09	(107.48)	{145.23}	237.57	(107.55)	{145.57}
Health	176.55	(89.18)	{122.28}	176.16	(88.88)	{122.26}
Transportation	48.59	(62.03)	{45.96}	48.76	(62.17)	{46.09}
Housing	78.51	(64.90)	{68.79}	78.33	(64.87)	{68.85}
Bolsa Família‡	5.89	(3.59)	{2.20}	5.92	(3.59)	{2.21}
Bolsa Família (pre-recipient)‡	71.44	(10.36)	{12.05}	71.45	(10.39)	{12.06}

Notes: Between standard deviation (SDB) reported in parenthesis, within standard deviation (SDW) reported in braces. Municipality expenditure data is reported in nominal Brazilian Reais (R$), per-capita (p.c.) and per-recipient (p.r.).Source: School data comes from Brazilian School Census 1999–2009; official population estimates from the Brazilian Census Bureau; municipal expenditures come from the Ministry of Finance. See Appendix D for links to data sources. †Aggregate cohort births reflect total cumulative birth for cohorts at age 19. ‡Reported averages and standard deviation based on years 2004 and later. The Bolsa Família programme was implemented in 2004.

Table 2: IV regression of municipal cohort births on municipal secondary school enrolment†

Outcome: Live births conceived between 15 and 19 years of age					
	(1)	(2)	(3)	(4)	(5)
Secondary enrolment (t-4)	-0.125	-0.127	-0.116	-0.109	-0.105
	(0.053)**	(0.057)**	(0.019)***	(0.018)***	(0.018)***
First stage results					
Schools (t-4)	112.835	109.851	49.585	50.735	49.984
	(34.861)***	(34.578)***	(7.233)***	(7.404)***	(7.512)***
F-stat (excluded)	10.480	10.090	46.990	46.960	44.280
Control variables					
Primary enrolment (t-5)	0.021	0.021	0.028	0.026	0.025
	(0.012)*	(0.012)*	(0.006)***	(0.006)***	(0.006)***
Pre-schools	-0.516	-0.536	-0.030	-0.029	-0.032
	(0.171)***	(0.194)***	(0.030)	(0.029)	(0.030)
Females (100s)	18.876	15.549	9.796	10.714	10.920
	(24.896)	(25.349)	(2.782)***	(2.837)***	(2.888)***
Males (100s)	-26.126	-23.821	6.208	4.760	4.121
	(28.190)	(27.356)	(3.699)*	(3.738)	(3.785)
Municipal GDP (log)		36.585	15.297	20.531	21.826
		(10.273)***	(2.618)***	(3.817)***	(4.236)***
Municipal GDP (log-diff)		-101.353	-53.475	-69.259	-71.584
		(26.645)***	(7.987)***	(10.881)***	(12.052)***
Municipal public spending (log)					
Total		-4.363	-1.152	-3.826	-4.646
		(3.967)	(1.129)	(1.861)**	(2.151)**
Welfare		0.600	0.204	0.333	0.495
		(0.569)	(0.340)	(0.404)	(0.460)
Education		5.818	1.740	4.658	5.103
		(4.448)	(1.196)	(1.848)**	(2.079)**
Health		-1.741	-1.182	-1.354	-1.139
		(1.339)	(0.812)	(1.097)	(1.189)
Transportation		-0.025	0.338	0.314	0.335
		(0.303)	(0.116)***	(0.142)**	(0.156)**
Housing		0.529	0.586	0.603	0.761
		(0.411)*	(0.194)***	(0.255)**	(0.312)**

Continued…

Municipal public spending (log-diff)					
Total		23.271	6.634	18.652	22.946
		(18.446)	(5.122)	(8.704)**	(10.248)**
Welfare		-0.268	-0.291	-0.233	-0.731
		(1.696)	(0.954)	(1.140)	(1.275)
Education		-31.471	-10.143	-22.655	-25.469
		(20.658)	(5.194)**	(8.161)***	(9.387)***
Health		5.246	3.605	3.109	1.778
		(5.889)	(3.418)	(4.426)	(4.884)
Transportation		0.254	-0.363	-0.252	-0.311
		(0.794)	(0.263)	(0.332)	(0.361)
Housing		-1.225	-1.493	-1.322	-1.587
		(1.359)	(0.697)**	(0.898)	(1.134)
Bolsa Família (log)		2.357	-5.137	-5.579	-6.554
		(7.528)	(0.948)***	(1.175)***	(1.253)***
Bolsa Família (pre recipient)		-0.025	0.171	0.225	0.236
		(0.262)	(0.042)***	(0.057)***	(0.064)***
Year effects	X	X	X	X	X
Municipality fixed effects	X	X	X	X	X
State by year effects		X	X	X	X
Other restrictions			Exclude >500k	Exclude>500k + new school 1997–2009	Exclude>500k + new school 1997–2005
R2 (reduced form)	0.679	0.713	0.364	0.382	0.396
Observations	43,956	43,956	43,650	30,627	26,631
Municipalities	4,884	4,884	4,850	3,403	2,959

Notes: This table reports the results of regressing cohort birth outcomes, from age 15 to age 19, in period t on year-one secondary school enrolment in period $t-4$. Secondary enrolment reflects, for each municipality, the number of pupils aged 15 to 18 enrolled in the first-year of secondary school. All specifications instrument enrolment with the number of secondary schools in the same period. Estimates condition on lagged primary school enrolment, preschool classrooms, male and female 19-year old population size, municipality expenditures, municipality and year fixed effects. The third to the fifth column of results omit municipalities with populations greater than 500,000 from the sample. The third and fourth columns restrict to municipalities that received at least one new school in the periods 1997–2009 and 1997–2005, respectively. Municipality-clustered standard errors are reported in parenthesis. ***, **, and * denote statistical significance at 1%, 5% and 10%.

Table 3: Regression of municipal school introduction on lagged municipal birth trends

Outcome: New secondary school indicator				
A				
Live births conceived between 15 and 19 years of age (t-1)	0.002	0.013	0.013	0.007
	(0.005)	(0.011)	(0.011)	(0.011)
Observations	43,955	43,649	30,626	26,631
Municipalities	4,884	4,850	3,403	2,959
B				
5-year growth in teen births (%)	0.000	0.000	0.000	0.001
	(0.001)	(0.002)	(0.002)	(0.003)
Observations	43,955	43,649	30,626	26,631
Municipalities	4,884	4,850	3,403	2,959
Restrictions		Exclude >500k	Exclude>500k + new school 1997–2009	Exclude>500k + new school 1997–2005

Notes: This table reports the results of regressing a binary variable, indicating a new school introduced to a municipality in year t, on the number of births in period $t-1$ (Panel A), and the growth rate in teen births over the previous 5 years (Panel B). Growth in teen births calculated as the average annual percent change in cohort births between t and t-4. Estimates condition on cohort-specific primary school enrolment, nursery and preschool classrooms, cohort-specific male and female populations, municipality expenditures, municipality and cohort fixed effects. The second, third and fourth column of results omit municipalities with populations greater than 500,000 from the sample. The third and fourth columns restrict to municipalities that received at least one new school in the periods 1997–2009 and 1997–2005, respectively. Municipality-clustered standard errors are reported in parenthesis. ***, **, and * denote statistical significance at 1%, 5% and 10%.

Table 4: IV regression of municipal cohort births on municipal secondary school enrolment by municipality characteristics

Outcome: Live births conceived between 15 and 19 years of age								
	Municipal return to secondary		Municipal unemployment rate		Municipal population density		Rural school enrolment	
	Low	High	Low	High	Low	High	Low	High
Secondary enrolment (t-4)	-0.123	-0.121	-0.119	-0.109	-0.053	-0.151	-0.185	-0.094
	(0.029)***	(0.027)***	(0.026)***	(0.022)***	(0.015)***	(0.020)***	(0.032)***	(0.019)***
First stage results								
Schools (t-4)	54.408	33.967	34.564	54.802	57.781	44.898	30.128	60.683
	(21.042)***	(4.738)***	(4.949)***	(9.748)***	(13.225)***	(7.878)***	(5.714)***	(10.327)***
F-stat (excluded)	6.69	51.41	48.77	31.60	19.09	32.48	27.80	34.53
Observations	3,780	3,699	21,960	21,681	21,978	21,672	31,374	12,222

Notes: This table reports the results of regressing cohort birth outcomes, from age 15 to age 19, in period t on year-one secondary school enrolment in period $t-4$. All specifications instrument enrolment with the number of secondary schools in the same period. Regressions are stratified according to the following characteristics: Ratio of earnings for secondary school versus non-secondary school finishers. Stratified by median value of 2.61 (see Appendix D for calculation details). Municipal unemployment rates, stratified by the median value of 5.84. Municipality population density is measured by the municipal population divided by the municipal land size (km^2), stratified by the median value of 24.9. Rural school enrolment reflects the percent of students whose residence is in a rural location. Approximately 73% of all municipalities have a value of 0. We therefore stratify by municipalities with zero and non-zero enrolment of rural students. For these municipalities with rural enrolment greater than zero, the mean rural enrolment is 31.7%. In all regressions, we instrument enrolment with the number of secondary schools in the same period. Estimates condition on lagged primary school enrolment, preschool classrooms, male and female 19-year old population size, municipality expenditures, municipality and year fixed effects. Municipality-clustered standard errors are reported in parenthesis. ***, **, and * denote statistical significance at 1%, 5% and 10%.

Table 5: IV regression of municipal cohort births on municipal secondary school enrolment by proportion of students from rural residence

Outcome: Live births conceived between 15 and 19 years of age					
	P60	P61-P75	P76-P85	P86-P95	P96-P100
Secondary enrolment (t-4)	-0.185	-0.106	-0.077	-0.083	0.002
	(0.032)***	(0.021)***	(0.027)***	(0.018)***	(0.029)
First stage results					
Schools (t-4)	30.128	76.904	65.932	43.793	47.242
	(5.714)***	(26.337)***	(17.420)***	(5.182)***	(8.647)***
F-stat (excluded)	27.80	8.53	14.32	71.41	29.85
Obs.	31,374	3,699	28,224	4,383	2,241

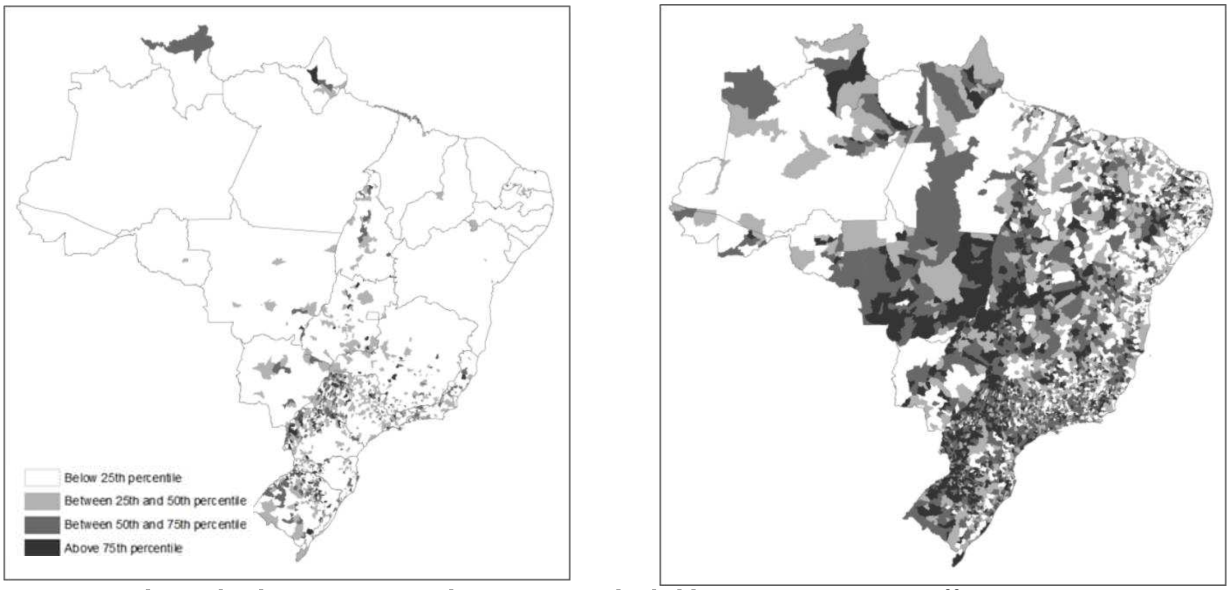
Notes: This table reports the results of regressing cohort birth outcomes, from age 15 to age 19, in period t on year-one secondary school enrolment in period $t-4$. Regressions are stratified by rural school enrolment, defined as the percent of students whose residence is in a rural location. All regressions instrument enrolment with the number of secondary schools in the same period. Estimates condition on lagged primary school enrolment, preschool classrooms, male and female 19-year old population size, municipality expenditures, municipality and year fixed effects. Municipality-clustered standard errors are reported in parenthesis. ***, **, and * denote statistical significance at 1%, 5% and 10%.

Appendix: Supplementary analysis (for online publication)

Appendix A

Figure A1a: Classroom density by percentile

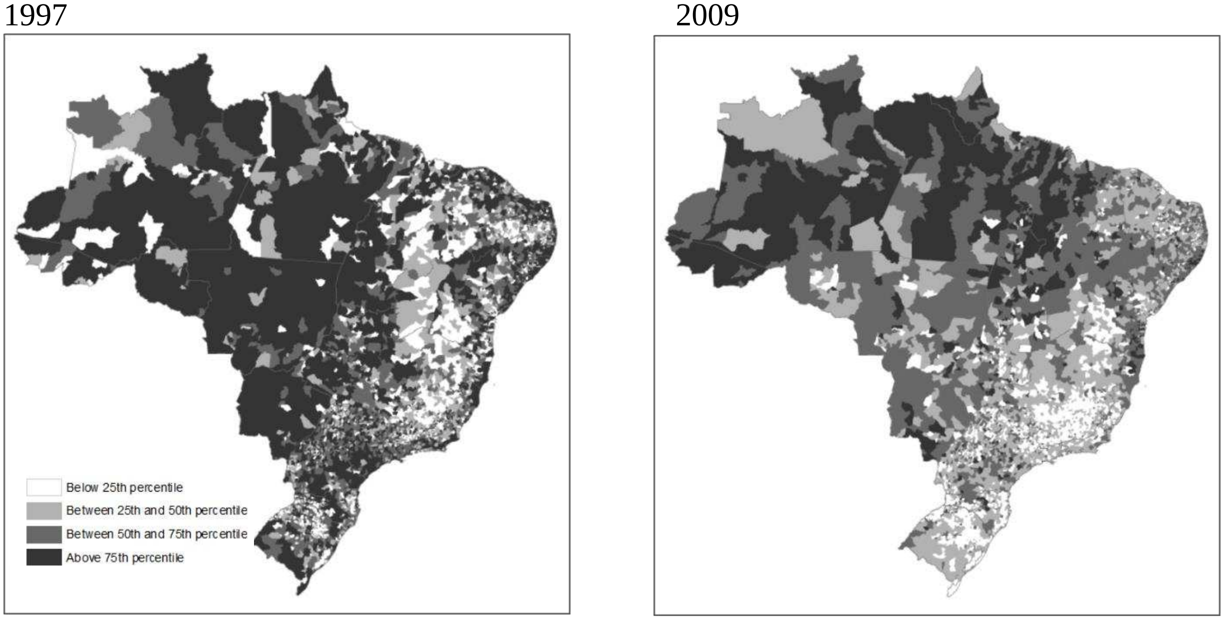
1997 2009



Source: Brazilian School Census 1997 and 2009. Percentiles held constant at 1997 cut-offs.

Figure A1b: Births rates by percentile

1997 2009



Source: Brazilian Vital Statistics. Percentiles held constant at 1997 cut-offs.

Appendix B: Event study

We conduct an event study-style analysis to examine the dynamics of teenage childbearing prior to the introduction of secondary schools. If the secondary school introduction is independent of childbearing then we do not expect to see systematic pre-trends in childbearing.

The complexity in conducting an event study in our framework is that some municipalities experience multiple 'events' by having schools introduced at multiple points in time. We simplify the analysis and focus on only the first 'event' (i.e. the first observed change in the number of secondary schools). We further restrict the sample to municipalities for which the first event is after the year 2000. This restriction leaves us with a consistent sample of 1,199 municipalities, all of which are observed for at least four pre-periods. It should be emphasized that the purpose of this exercise is to examine pre-trends; we do not attempt to infer a causal relationship by comparing outcome patterns before and after school introductions.

We construct visual plots reflecting time-demeaned births relative to the periods just before and after the school change, described by:

$$b_{it}^{a} = \sum_{d=-13}^{8} \lambda_d^a 1[t - e_i = d] + \vartheta_i^a + \mu_{it}^a. \qquad (B1)$$

The outcome, b_{it}^{a}, captures the number of births for age group a in municipality i in year t. The event is given by $e_i \in [2001, 2009]$, a variable equal to the year that the first change in the number of secondary schools is observed in municipality i. The indicator function $1[t - e_i = d]$ takes a value of 1 when the difference between the current year, t, and e_i are d periods away and 0 otherwise. Municipal-specific means are captured by ϑ_i^a, and within-municipality deviations from the mean are captured by μ_{it}^a. The parameters λ_d^a reflect the average (demeaned) births for age group a d periods away from the event, $d = 0$.

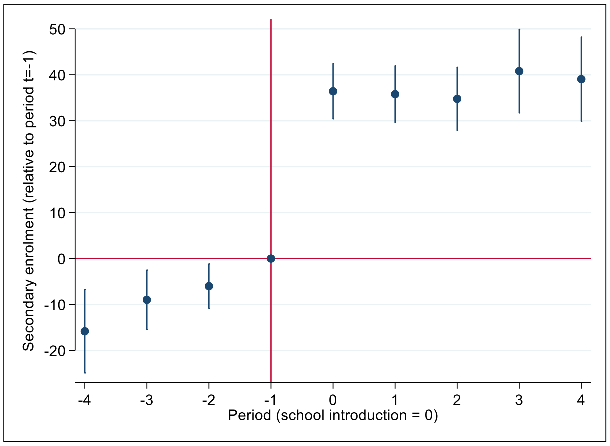
We estimate the parameters λ_d^a normalizing $\lambda_{-1}^a = 0$. These estimates, for $d \in [-4, 4]$ and $a = \{15, 16, 17, 18\}$, are plotted in figures 5b–5e. In 5a, we plot estimates of Equation (B1) with secondary enrolment (year-one), E_{it}, as the outcome. Bars around point estimates reflect a 95% confidence intervals and the vertical line is set at the reference period ($d = -1$).

In Figure 5a, we observe a clear increasing pre-trend in secondary school enrolment prior to the introduction of a secondary school. This is consistent with our expectations, as discussed in sections 2 and 4, and likely reflects the fact that the school expansion was demand driven. We also observe a large discontinuous jump from the enrolment trend at $d = 0$. We do not observe corresponding pre-trends in childbearing for any age groups (Figures 5b–5e). This supports the assumption that there are no unobservables that confound our results, and supports the interpretation of our estimates as reflecting a causal relationship.

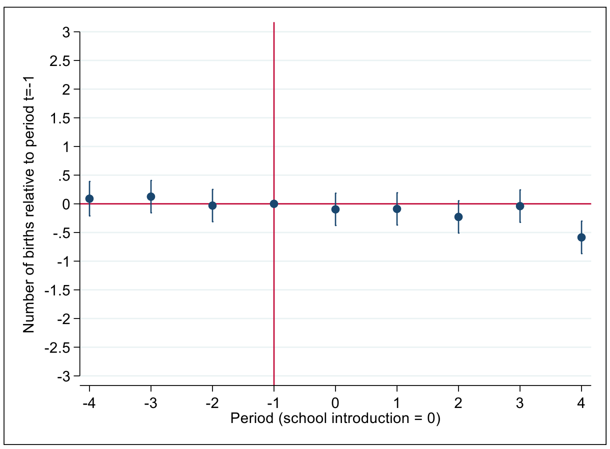
In Figure B2, we include corresponding figures for older age groups, whom we expect to be less impacted in terms of school attendance by the expansion of secondary schools. We report estimates for age of conception at 25 years and 30 years.[22] These figures do not suggest a corresponding pre- or post-trend for childbearing at older ages.

[22] Similar results are found for other older ages.

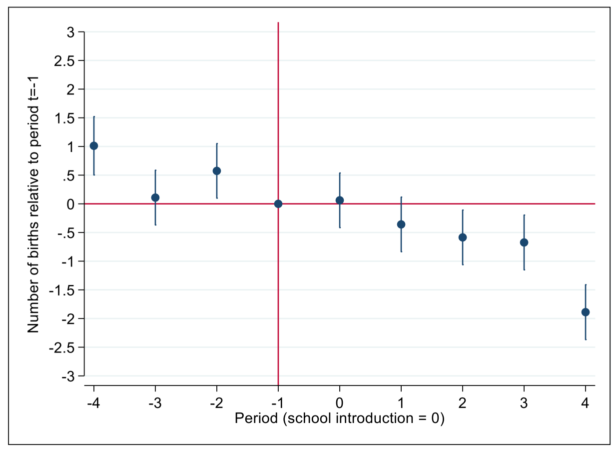
Figure B1: Event study of enrolment and births before and after school introduction



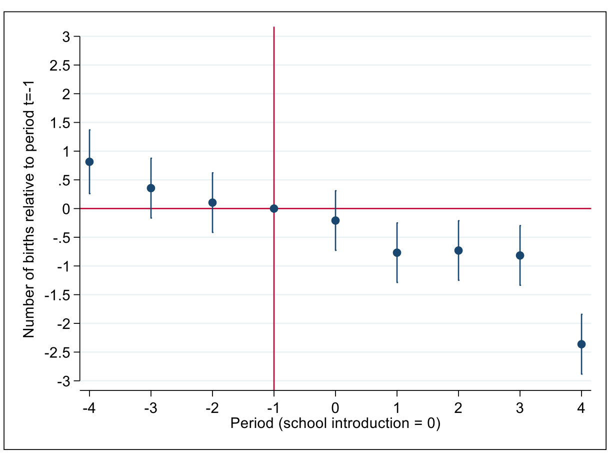
a) Secondary enrolment (year 1)



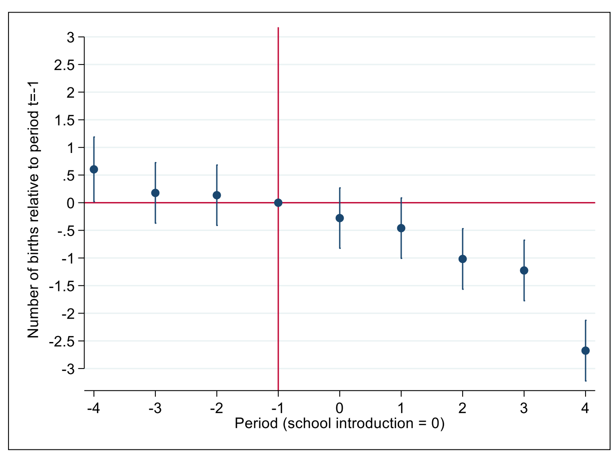
b) Births for conception age 15



c) Births for conception age 16



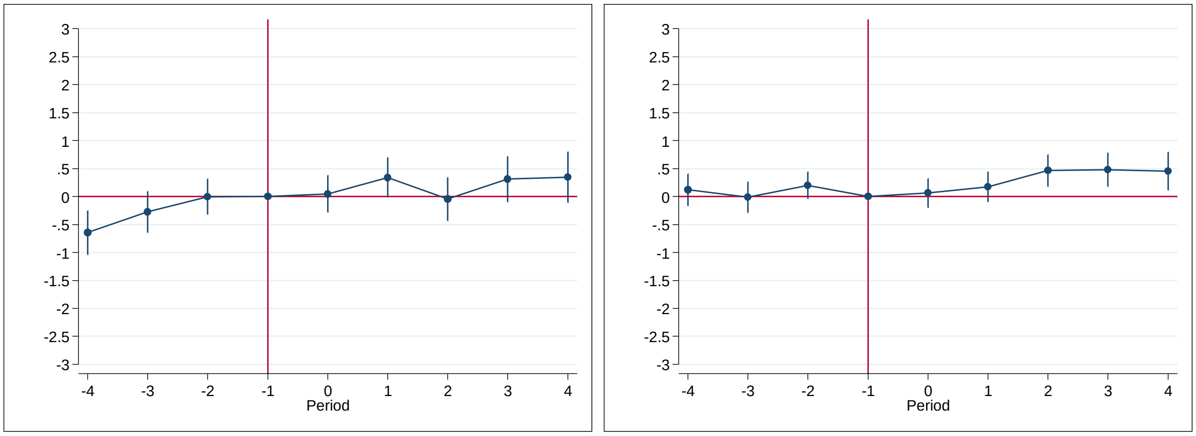
d) Births for conception age 17



e) Births for conception age 18

Notes: These figures plot the coefficients from an event study; the first observed secondary school introduction in a municipality is the "event". Details described in the text of Appendix B. The sample is restricted to 1,199 municipalities that first receive a new school after 2000. Bars indicate 95% confidence intervals. All estimates condition municipality fixed effects.

Figure B2: Event study of births before and after school introduction by age



a) Births at age 25 b) Births at age 30

Notes: These figures plot the coefficients from an event study; the first observed secondary school introduction in a municipality is the "event". Details described in the text of Appendix B. The sample is restricted to 1,199 municipalities that first receive a new school after 2000. Bars indicate 95% confidence intervals. All estimates condition municipality fixed effects.

Appendix C: Migration, teenage childbearing and school growth

In Section 4.1, we discuss the potential risk to our identification strategy posed by municipal migration flows within Brazil. In this appendix, we explore this threat using data from the 2010 Brazilian population census. The 2010 census provides detailed information, for an 11% population sample, on family structure and migration status.[23] We identify a census individual as a teenage parent if: a) a child is in the same household; b) the individual is identified as the child's parent and not a step-parent; c) the age difference between the individual and the child is not greater than 19 years. Under this strategy, individuals who are teen parents will only be identified as such if they live with their child at the time of the census.

The census provides three categories for an individual's migratory status: 1) Born in municipality and lived there the entire life; 2) Born in municipality but lived elsewhere; 3) Not born in municipality. An individual is identified as a migrant if 1) does not apply. For migrants we have information on the current municipality, previous municipality (only for migrants who moved after 2000) and the age at which they moved to their current municipality. To ensure confidentiality, the publicly available microdata do not reveal municipalities with small populations. Therefore, for migration flows, the sample analyzed a sub-set of the larger municipalities used in the main paper (831 municipalities).

Our analysis here shows the following: a) Migration taking place between 11 and 18 years of age is associated with higher rates of teenage parenthood; b) On average, the origin municipalities have a lower school growth rate than destination municipalities; c) there is a small, but positive, correlation between the relative school growth rate (of destination municipality to municipality of origin) and teenage childbearing.

In summary, this analysis suggests that any potential threat to our identification will lead us to underestimate the average effect of the school expansion on childbearing.

Migration and teenage parenthood

Here we look at the association between migration and teenage parenthood. In Figure C1 we plot, for different ages at the date of the census collection, the teenage birth rate for migrants against

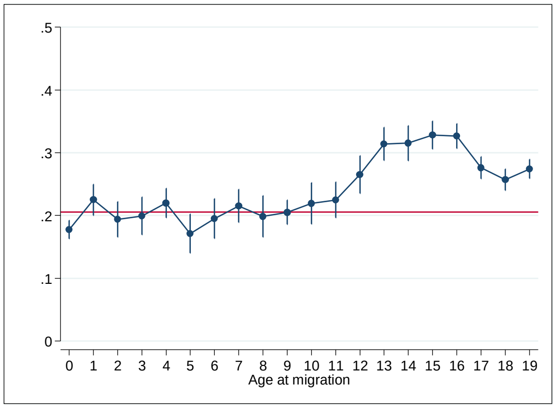
[23] While the basic questionnaire is applied to the entire population, a 'long' version of the questionnaire, which includes detailed information on migration, is applied to a sample only. The final sample is based on stratification based on municipality size. Details on the sampling can be found at http://biblioteca.ibge.gov.br/visualizacao/livros/liv81634.pdf.

age at migration. We show a selection of census ages—19, 24 and 30 for females, 19 and 24 for males—but the pattern is very consistent regardless of the chosen census age. For females, these figures suggest that migration between 11 and 18 years of age is associated with significantly higher rates of teenage childbearing than is migration at younger or older ages. Teenage birth rates for migrates at younger or older ages do not significantly differ from the non-migrating population.

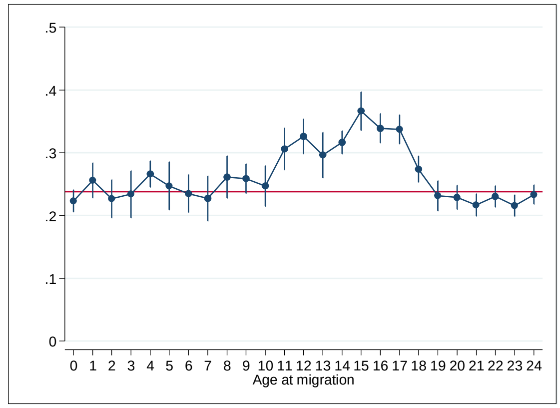
The pattern is similar for males, although smaller magnitude and noisier. This may reflect that children of teenage parents are more likely to live with the mother, leading to a tendency to under-identifying teenage fathers.

Figure C1: Teenage parenthood by age of migration

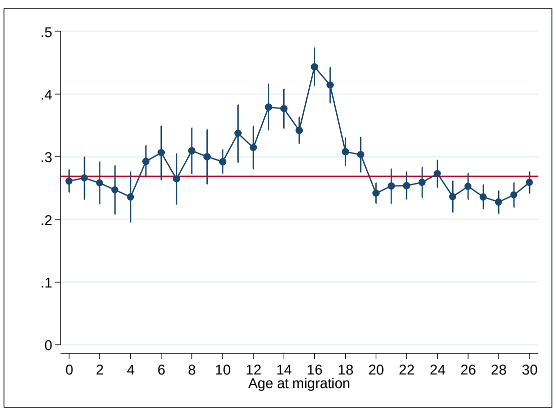
Female, 19 years old at census



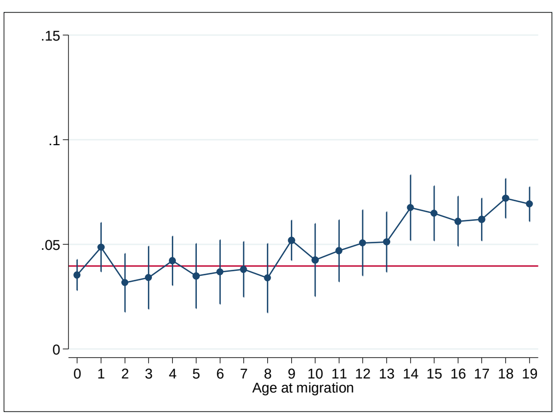
Female, 24 years old at census



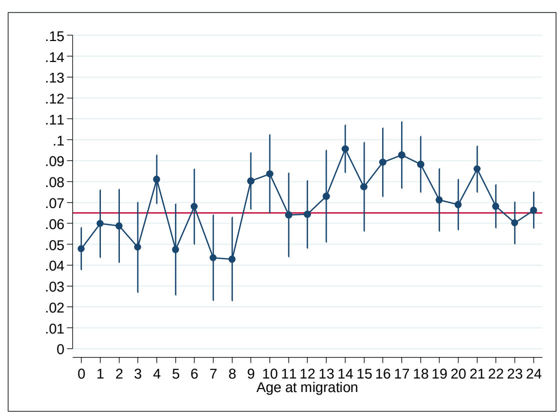
Female, 30 years old at census



Male, 19 years old at census



Male, 24 years old at census



Notes: Markers indicate mean of teenage pregnancies, bars indicate 95% confidence interval. Red horizontal line is the estimated teenage birth rate for non-migrating population of same age.

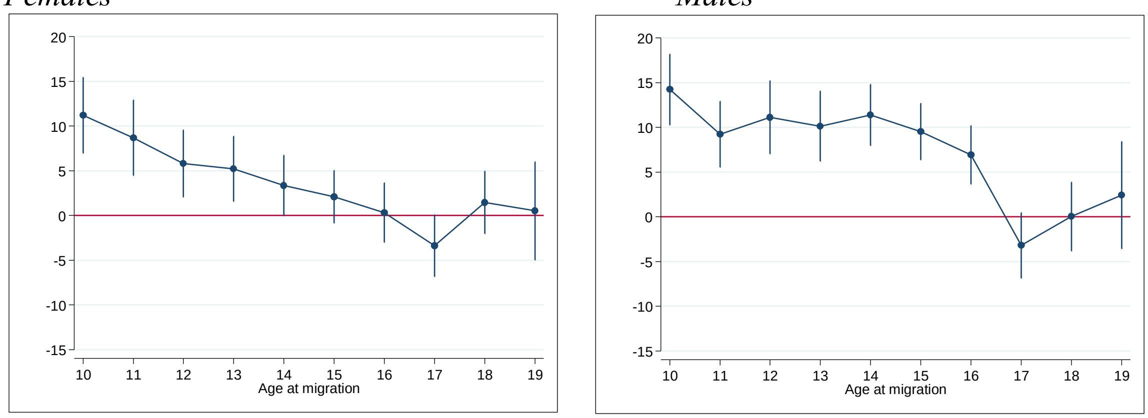
Migration flows and municipal school growth

To consider the relationship between migration and school growth we define net school growth as the difference in the school growth rate between the origin municipality and the destination municipality. The school growth rate is defined as the percentage growth in schools between 2000 and 2009. The net school growth therefore reflects the percentage point difference between the school growth rate in the origin municipality and the destination municipality.

The average net school growth rate is 4.03 percentage points, suggesting that destination municipalities have a higher average growth rate than origin municipalities. We regress the net school growth on the age at which an individual migrated, for migrants aged 15 to 19 at the 2010 census, and plot the coefficient estimates for each age at migration in Figure C2. The pattern in this figure suggests that migrants at younger ages have, on average, a higher net school growth rate than migrants at older ages.

Figure C2: Migration and net school growth

Females *Males*



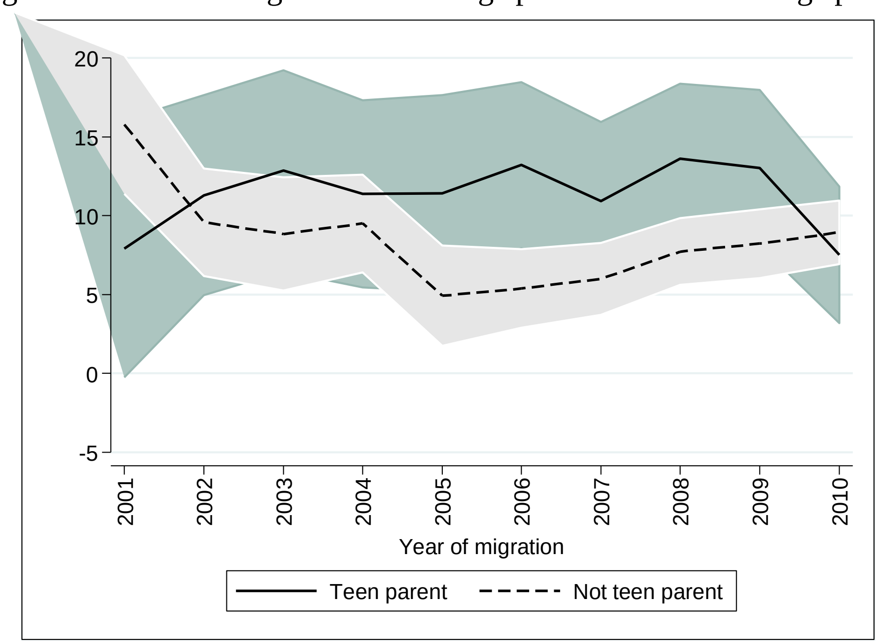
Notes: Markers indicate the percentage point difference in the school growth rate between the municipality left and the current municipality. Bars indicate 95% confidence interval.

The pattern in Figure C2 suggests that, on average, young women in Brazil, during the period considered, migrate to municipalities with higher rates of school growth than their municipality of origin.

Migration flows, municipal school growth and teenage parenthood

Finally, it may be the case that, for reasons unobserved to the econometrician, migrant households with teenagers that have a high propensity to become a teenage parent exhibit differential migration patterns then migrant households with teenagers that have a low propensity to become a teenage parent. We examine this possibility by looking at, for migrants aged 19-24 in the 2010 census, net school growth for teenage parents versus those who do not have a child present born in their teen years. This is summarized in Figure C3 and Table C1.

Figure C3: Net school growth for teenage parents and non-teenage parents



Notes: Shaded areas cover 95% confidence interval for teen parents (green) and non-teen parents (grey).

Two things appear from this analysis. First, there does appear to be a difference in net school growth between the two groups. Second, teen parents appear to, at least for latter years, have higher net school growth. This again is suggestive evidence that migration may lead us to under-estimate the true effect of interest.

Table C1: Net school growth for teenage parents and non-teenage parents

Year of migration	Non-teen parent	Teen parent	Difference	SE
2001	15.763	7.899	7.864	(4.633)*
2002	9.582	11.288	-1.706	(3.998)
2003	8.843	12.846	-4.002	(3.527)
2004	9.505	11.382	-1.876	(3.367)
2005	4.918	11.416	-6.498	(3.457)*
2006	5.386	13.206	-7.820	(3.004)***
2007	5.997	10.924	-4.927	(2.960)*
2008	7.728	13.605	-5.877	(2.720)**
2009	8.221	13.032	-4.810	(2.738)*
2010	8.944	7.516	1.429	(2.298)
Observations	46,513	13,198		

Notes: Robust standard errors corresponding to difference reported in parenthesis. ***, **, and * denote statistical significance at 1%, 5% and 10%.

Appendix D: Data

Table D1: Sources for municipal expenditure data

Variable	Notes	Source	Link
GDP	Municipality gross national product at current prices (R$)	SIDRA/IBGE	http://goo.gl/OpQffe
Municipality spending	Total local government (municipality) expenditure at current prices (R$)	IPEADATA	http://goo.gl/lSI3nz
Welfare spending	Local government (municipality) expenditure on assistance and welfare at current prices (R$)	IPEADATA	http://goo.gl/lSI3nz
Education spending	Local government (municipality) expenditure on education and culture at current prices (R$)	IPEADATA	http://goo.gl/lSI3nz
Health spending	Local government (municipality) expenditure on health and sanitation at current prices (R$)	IPEADATA	http://goo.gl/lSI3nz
Transportation spending	Local government (municipality) expenditure on public transportation at current prices (R$)	IPEADATA	http://goo.gl/lSI3nz
Public housing spending	Local government (municipality) expenditure on public public housing at current prices (R$)	IPEADATA	http://goo.gl/lSI3nz
Bolsa Família recipients	Number of Bolsa Família recipients	DATASUS	http://goo.gl/tdwW
Bolsa amount	Total Bolsa Família spending at current prices (R$)	DATASUS	http://goo.gl/tdwW

Calculation and sources for municipal characteristics

As used in Table 4 of the main paper.

Return to secondary education.

The return to secondary education is calculated using information from the long-survey of the 2010 Brazilian population census. To ensure anonymity of survey responses, not all municipalities are identified in the public-use census. For this reason, we restrict the sample to the 831 minimal comparable areas which we are able to identify. The results reported in Table 4 are similar if we instead calculate state-level returns and use all municipalities.

For each municipality we calculate the average earned income for all individuals who report their highest completed level of education as high-school (I^H) and average earned income for all individuals who report their highest completed level of education as primary-school (I^P). The return to secondary school is calculated as the ratio of these averages:

$$return^h = \frac{I^H}{I^P}.$$

The resulting distribution of returns is presented in Figure C1.

Municipal unemployment rate.

We use information on the municipal unemployment rate provided by the Brazilian census bureau IBGE based on the population census of 2000. The unemployment rate is calculated as the percentage of the population of 16 years and older that is economically active and unemployed.

Municipal population density.

We use information on the territorial expansion of municipalities in square kilometers provided by the Brazilian census bureau and create a simple measure for population density by dividing the municipal population count (in 2000) by the size of the municipality (population per km^2).

Rural school enrolment.

The 2012 school census states whether individual students' current residence is urban or rural. Based on this, for each municipality we calculate the percentage of students who live in a rural residence.

Figure D1: Distribution of secondary school labor market returns