CARLOS ANDRES CHARRIS VIZCAINO

RELATIONSHIP BETWEEN GOVERNMENT'S CAPACITY TO TAX AND INFANT HEALTH IN BRAZIL: EVIDENCE FROM THE TAX CAPACITY PROGRAM PMAT

Thesis presented to the Universidade Federal de Viçosa, as part of the requirements of the Graduate Program in Applied Economics, for obtaining the title of *Doctor Scientiae*.

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“We keep moving forward, opening new doors, and doing new things, because we’re curious and curiosity keeps leading us down new paths.“.

(Walt Disney)

Abstract

VIZCAINO, Carlos Charris, D.Sc., Universidade Federal de Viçosa, April, 2021. **Relationship Between Government's Capacity to Tax and Infant Health in Brazil: Evidence from the Tax Capacity Program PMAT**. Advisor: José Gustavo Feres. Co-advisor: Bladimir Carrillo Bermudez.

This thesis studies the effect of changes in the government's tax-capacity on infant health outcomes. We exploit a program that invests in the tax capacity of Brazilian municipalities.Using variations in the timing of program uptake, we study the effects of this policy on infant health. We find (I) that the program is robustly correlated with improvement in tax revenues, public spending on education and health, night-lights density, the total number of health sector workers, high school dropouts rates, and the homicide rate per 1000 inhabitant and (II) the policy also improved infant health outcomes measured by low birthweight (LBW) and infant mortality. Summarizing, our results indicate a positive effect of the implementation of the tax capacity program on child health, and these results can be explained by the improvement observed in the fiscal and development outcomes, and mother's health behavior. Given the existence of a large "fiscal gap" between local expenditure responsibilities and local tax revenues, our results are important to consolidate the decentralization process.

Keywords: Tax capacity. Infant mortality. Infant health at birth. Public spending.

Resumo

VIZCAINO, Carlos Charris, D.Sc., Universidade Federal de Viçosa, abril de 2021. **Relação entre a Capacidade Tributaria do Governo e Saúde Infantil no Brasil: Evidências do Programa de Capacidade Tributária PMAT**. Orientador: José Gustavo Feres. Coorientador: Bladimir Carrillo Bermudez.

Esta tese estuda o efeito das mudanças na capacidade tributária do governo sobre os resultados da saúde infantil. Explora-se um programa que investe na capacidade tributária dos municípios brasileiros. Usando variações no tempo de adoção do programa, estuda-se os efeitos dessa política na saúde infantil. Encontra-se (I) que o programa está fortemente correlacionado com a melhoria nas receitas fiscais, gastos públicos com educação e saúde, "night-lights density", número total de trabalhadores do setor de saúde, taxas de abandono do ensino médio e taxa de homicídio por 1000 habitantes e (II) a política também melhorou os resultados de saúde infantil medidos pelo baixo peso ao nascer (BPN) e mortalidade infantil. Resumindo, os resultados indicam um efeito positivo da implementação do programa de capacidade tributária na saúde infantil, e esses resultados podem ser explicados pela melhora observada nos resultados fiscais e de desenvolvimento, e no comportamento de saúde materna. Dada a existência de um grande “fiscal gap” entre as responsabilidades das despesas locais e as receitas fiscais locais, assim os resultados são importantes para consolidar o processo de descentralização.

Palavras-chave:: Capacidade tributária. Mortalidade infantil. Saúde infantil ao nascer. Gasto público.

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1 Introduction[1]

Every day the idea that social programs are vital for economic development of a nation is getting stronger. This is reflected in the increasing number of governments around the world whose social policies rely on 'conditional' welfare programs in many different areas, such as child support, nutrition assistance, education, family planning, maternity grants, and, in general, low-income support. There is empirical evidence highlighting the importance of the public investments in infrastructure (transport, and communication, among others) to propel the economic development of these countries (DUFLO et al., 2011; EASTERLY; REBELO, 1993). Therefore, public spending plays an important role in the creation and execution of these social and investment programs with the aim of guaranteeing access to essential goods and services for all strata of society. However, in many cases, the misallocation of public monies prevents this from happening. The issue of the efficient use and source of financing of public spending has gained importance in discussions regarding good fiscal management practices [2]. Answers to questions such as: Do governments spend increases in tax revenues in an efficient manner? Do increases in governments' capacity to tax unequivocally lead to improvements in spending on public goods and services? Does public spending save lives? are still open.

The Brazilian context is particularly appealing because it is characterized by having a decentralized political-administrative system (in place since the late 1980s), which allows high participation of municipal governments in the provision of public goods [3]. Thus, all local governments are important players in fundamental sectors such as health or education. It is the competence of the municipalities, according to art. 30 of the Federal Constitution of 1988, to organize and provide public services of local interest, as well as provide health care services and maintain early childhood and elementary education programs, with technical and financial cooperation from the Union and the State, among others. According to the data on public accounts of the National Treasury Secretariat (STN, in its acronym in Portuguese), expenses with the functions of education and health are, for the most part, the responsibility of the municipal government. In the case of spending on education, in 2018, Municipalities were responsible for 42 %, States for 31 % and the Union for 27 %, while for health expenses were 40 %, 28 % and 32 %, respectively. With regard to other groups, such as sanitation, the expenses of the municipalities

1 This work was carried out with the support of the Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES) - Financing Code 001. I am also grateful for excellent research assistance and advices by José Gustavo Féres and Bladimir Carrillo.

2 Examples of this are the work related to the economic effects of foreign aid (BAUER et al., 1976; DEATON, 2013) or decentralization (FAGUET, 2014; OATES, 2005).

3 In the area of health, for example, the process of decentralization of the 80s promoted greater political participation by municipalities in decision-making on local health priorities and favored new mechanisms for financing and transferring responsibilities for the direct execution of health services, especially primary care.From 2000 to 2006 the share of municipal spending in health financing increased from 22% in 2000 to 28% (VAZQUEZ, 2011)

were approximately 77 % of the total directed to the function, against 18 % of the State and 5 % of the Union.

The composition of spending at the municipality level is defined through the following groups: (i) personnel (legislative, judicial, and administrative spending, among others), (ii) debt repayments, (iii) public services -the most important being health, basic sanitation, education,and infrastructure-, and (iv) investments in works and equipment. The last two categories absorb approximately half of the budget and represent categories in which the municipalities have greater investment autonomy.

Regarding the financing of the expense, each Brazilian municipality can elaborate its collection rules in its own Tax Code, provided that it respects the rules of the Constitution of the Federative Republic of 1988 (CF) and the National Tax Code - CTN. The 1988 Constitution granted municipalities the responsibility to collect three taxes: ISS (Tax on Services of Any Nature), IPTU (Property and Urban Territorial Tax) and ITBI (Tax on the transmission of real estate)[4].These tax revenues represent approximately 1.5 percent of the national GDP. In a budgetary sense, tax revenues are about 26 percent of the municipality's total revenue. Despite its economic importance, there are problems regarding the local government's capacity to tax. Among these, it is possible to highlight: deficiency in the identification and registration of potential taxpayers, little institutional memory, and weak methods for setting the tax rate (GADENNE, 2017; AFONSO, 2007).

In order to remedy this situation and, thus, increase the the municipalities' tax revenues, the National Bank for Economic and Social Development (BNDES) launched in 1998 a program of investment in tax capacity called *Programa de Modernização da Administração Tributária e da Gestão dos Setores Sociais Básicos* (PMAT program). The PMAT was specifically designed to increase the fiscal efficiency of municipalities, guaranteeing them an additional flow of stable resources to finance local expenditures and investments. Through the program, municipalities obtain loans that should be used to modernize, mainly, their tax administration, in addition to the basic social sectors: health, education and social assistance. Some actions that can be financed by PMAT in relation to tax administration are:

1. Updating tax records and investing in training human resources and computer equipment (for example, purchase of specialized software) for analyzing and crossing administrative data;

2. Acquisition of inspection support equipment (popular vehicles, tablets and georeferenced information systems, among others);

[4] The Brazilian constitution grants substantial responsibility to municipal governments regarding the administration of public spending and revenues. In education, for example, Article 212 of the Federal Constitution determines that states and municipalities are required to invest 25 percent of their tax and transfer revenues. On the other hand, Constitutional Amendment 29 determines that state and municipalities should invest in the health care system a 12 and 15 percent of tax revenue and constitutional and legal transfers, respectively.

3. Acquisition of furniture and equipment to improve both the physical infrastructure of the operations area and the service (eg, internet payment systems). This in order to reduce taxpayer costs to meet their tax obligations.

Given these insights, I define the research objective as assessing the impacts of the PMAT program on infant health outcomes, namely birth weight, infant mortality, and prematurity. Our identification strategy exploits the timing of the implementation of the tax capacity program to identify its impact on the health outcomes and compares treated and untreated municipalities in a differences-indifferences framework. The infant health measures used in this thesis are a compelling dimension of welfare to study the consequences of the program. First, relative to measures of adult health, infant health is likely to be more responsive to short and medium changes in circumstances. This is due to the fact that a child's health is considered more fragile in utero and during the first year of life than during the subsequent years (DOBBING, 1976; BARKER, 1990; DIETERT et al., 2000; SELEVAN; KIMMEL; MENDOLA, 2000; GUZELIAN et al., 1992). Second, the first year of life is an especially vulnerable one, and so losses of life expectancy and thus welfare may be large and have inter-generational consequences.Third, there is a consensus that malnutrition in utero, commonly proxied by low birth weight (weight > 2,500 grams), is an important contributor to poor infant health and, consequently, increasing the risk of mortality during the first year of life (ALMOND; CHAY; LEE, 2005; BLACK; DEVEREUX; SALVANES, 2007). Additionally, infant mortality is an outcome of interest of the policymakers to monitor and design health programs due to it is a sensitive indicator of the availability, utilization, and effectiveness of health care (TRIBUNE, 2002).

The general objective of this thesis is to assess empirically the relationship between local tax capacity, public expenditures, and associated living standard outcomes, measured by infant health, among others outcomes, for Brazilian municipalities over the 1998–2017 period.

Specifically, I intend to:

1. Evaluate the impacts of the PMAT program on local tax revenues, and public spending per capita in health, and education;

2. Investigate whether there was a subsequent impact on living conditions among the adopting municipalities. For this, I evaluate the relationship between PMAT and Night-lights Density, the number of public health system personnel (per capita), high school dropouts, and the homicide rates per 100,000 inhabitants.

3. Evaluate the impacts of the PMAT program on low birth weight rate (defined as birth weight less than 2,500grams),and the under-1 infant mortality rate.

The thesis has the following structure: In section 2, I do a review of the literature related to the research topic. Additionally, I present a basic theoretical model that explains the relationship to be studied. Section 3 gives background information on the fiscal responsibility of municipalities, information on the PMAT program, and the Brazilian infant health context. Section 4.1 describes the data and the research resign. Section 5 shows our main results. Lastly, in section 6, I present the conclusions.

2 Related literature and Conceptual Framework

2.1 Can Health shocks during early life shape future abilities and health trajectories—and thereby future earnings?

The last decades have seen a fruitful debate regarding the causes of inequality and the persistence of the intergenerational correlations in economic status. There is a substantial evidence that birth endowments contribute significantly to the perpetuation of low socioeconomic status and inequality between individuals. Poor nutrition in utero, commonly proxied by low birth weight, is believed to weak human capital formation. Therefore, children born with poor health exhibit lower income, reduced educational attainment, and worse cognitive abilities as adults (BLACK; DEVEREUX; SALVANES, 2007; FIGLIO et al., 2014; OREOPOULOS et al., 2008). This is important knowing that poor families are disproportionately exposed to a great number of stressful events in their lives that negatively affects initial endowments of their newborn. In an influential study, Currie (2011) concludes: *"...Poor and minority children are more likely to be in poor health at birth, partly because their mothers are less able to provide a healthy fetal environment. Poor health at birth is associated with poorer adult outcomes, which in turn provide less than optimal conditions for the children of the poor"*.

The view that health at birth can have causal effects on human capital comes from the so-called "fetal origins" hypothesis. This theory, introduced by the British physician and epidemiologist David Barker, establishes that inadequate nutrition in utero leads to adaptations that increases the risk of certain chronic health conditions, such as diabetes, hypertension, and cardiovascular diseases (BARKER, 1997). The fetal origins hypothesis,therefore, postulates that health effects of fetal conditions are persistent over time. This long-term effect of early life health shocks arises via "fetal programming." The programming takes place when events in utero -critical periods of development- lead to permanent change in the structure or function of the organism (LUCAS, 1991).

Clearly, early health endowment has effect on human capital accumulation. For example, poor health among school age children is likely to result in school absenteeism, increasing failure rates, repletion of school years, and drop-out rates. In addition, individuals with long-term diseases have less inventive to make investments in skill acquisition because the stream of returns from the investment last less (FORTSON, 2011; JAYACHANDRAN; LLERAS-MUNEY, 2009; OSTER; SHOULSON; DORSEY, 2013). Due to the implications on the human capital of early-life health shocks, economists have become interested in the fetal origins hypothesis. These studies generally estimate the impacts of exogenous exposure to an environmental stressor during pregnancy, such as influenza epidemic, local environment caused by accidents, and changes in diseases environment induced by disease-eradication interventions. Using the unexpected 1918 Influenza Pandemic as a natural experiment in a cohort analysis, for instance, Almond (2006) showed that the pandemic had a long-term negative effect on health, labor, and education outcomes of the cohorts exposed - in utero- to this shock. Specifically, cohorts in utero during the pandemic completed fewer years of schooling (15 percent less likely to graduate from high school), were more likely to have a physical disability, displayed lower income (wages of men were 5–9 percent lower), lower socioeconomic status, and were more dependent on government transfers. In this spirit, Barreca (2010), using instrumental-variables identification strategy and historical data from the United States, estimated the long-term economic impact of in utero and postnatal exposure to malaria. He found that exposure to this disease had considerable negative effects on educational attainment and poverty later in life. Overall, these studies have undoubtedly advanced our knowledge of the mechanisms behind the relationship between early conditions and human capital formation.

A natural question is what measure to use to capture fetal nutrition or more generally health at birth. Such an indicator would be a key input to the implementation of policies aimed at reducing inequalities at birth. While the aforementioned studies exploit historical events that altered the in utero environment to investigate their impacts on human capabilities, they typically do not use any measure of initial endowments. The fetal origins hypothesis originally postulated variation in fetal nutrition as the relevant biological mechanism rather than maternal sickness during pregnancy. Maternal sickness could affect child's human capital through changes in family socioeconomic status, making it difficult to isolate the importance of in utero conditions. A series of studies has proposed to use birth weight as an objective measure of birth endowments. Birth weight is determined by fetal growth rate at a given gestation length, which in turn is largely influenced by nutrition (KRAMER, 1987). This fact makes birth weight an appealing measure.

Medical literature has established a strong link between low birth weight and health problems such as cerebral palsy, deafness, epilepsy, blindness, asthma, and lung disease (BROOKS et al., 2001; LUCAS; MORLEY; COLE, 1998; MATTE et al., 2001; NELSON; GRETHER, 1997; PANETH, 1995). Low birth weight has been also shown to be a strong predictor of impaired development of the brain. Children born with very low birth weight are more likely to suffer from attention deficit, dyspraxia, and impaired learning (MARLOW; ROBERTS; COOKE, 1993; MARLOW; ROBERTS; COOKE, 1989). Abernethy, Palaniappan & Cooke (2002) provide some pieces of evidence that these learning disabilities among lower birth weight children stem from differences in global brain growth and the development of brain structures related to memory. These findings have been taken as an indication that birth weight is a good overall measure of health at birth.

Not surprisingly, the use of birth weight as a target of social policy has become increasingly popular in many countries. The National Institutes of Health in United States provides incentives to innovative research focused on prevention of low birth weight. Reducing the incidence of low birth weight has been a major motivation for the introduction of important social programs such as the Women, Infants, and Children (WIC) program for nutrition of low-income pregnant women in United States. International agencies such as The World Bank have invested considerable resources in policy efforts to reduce the incidence of low birth weight in developing countries. As an illustration, we can mention the $100 million loan provided by The World Bank for the Tami Nadu Integrated Nutrition Project II in South India. The idea behind focusing on birth weight as a central target of policy is that if these interventions are effective in preventing low birth weight then they potentially help children while they are still in the womb. As complementary strategies, many countries, including Brazil, have implemented an array of policies to mitigate the consequences of low birth weight. Most commonly, these consist of extra medical treatment provision to children who are born with a weight below 1,500 grams. Specific recommendations by the medical community include the provision of specialized nutritional supplements, additional neonatal examinations, as well as the use of artificial lung surfactant to treat respiratory distress syndrome among low birth weight babies. Some of the technologies used to treat these neonates can have high concentrated costs.

Given all the above, it is pertinent to verify in the economic literature the effects of birth weight on health outcomes, education, poverty, and the labor market outcomes. The paper of Almond, Chay & Lee (2005) is among the first studies to provide credible estimates of the effects of low birth weight, finding that lower birth weight babies are more likely to die within one year. Behrman & Rosenzweig (2004) estimated the effects of birthweight on schooling attainment and on adult body mass, height, and earnings. Using information on the birthweights of monozygotic (MZ) female twins collected from a sample from the Minnesota Twins Registry, they found multiple results. First, for both OLS estimates and the within-MZ estimates, there is a significant positive relationship between fetal growth and schooling attainment. Nevertheless, for the cross-sectional estimates, they found that if there is no control for genetic and family background endowments, the impact estimated is underestimated by 50%. Finally, their within-MZ twin estimate indicates that efforts taken by a mother to increase fetal growth such that birthweight is increased by 1 lb. at birth (an increase in fetal growth of 0.4 oz./week) would result in almost a third of a year more of schooling for her child.

Second, their estimates indicate that intrauterine nutrient consumption does not have any persistent effects on adult Body Mass Index (BMI, defined as kilograms divided by meters squared)—increasing birthweight is not a cause of adult obesity. The within-MZ estimate of the impact of birthweight on BMI is essentially zero (the estimated point was 0.292 and not significant). This suggests that increasing birthweight, for given genetic endowments, does not result in obesity of the child later in life . Third, their within-MZ estimate of effect of birthweight on wages shows that an increase in child's birthweight by a 1 lb. lead to an increase in her adult earnings by over 7%. This is no surprise due to the positive relationship estimated between birthweight and schooling attainment. They also find evidence that augmenting birthweight among lower birthweight babies, but not among higher-birthweight babies, has significant labor market payoffs.

In the same line, Black, Devereux & Salvanes (2007), applying within twin techniques - e.g., twin fixed effects- using administrative data on the population of Norway linked to birth records, estimate the effect of birth weight on short-run outcomes (measured by one-year infant mortality and Five-Minute APGAR Score) and longer-run outcomes such as height, IQ at age 18, earnings, and education. They found, in overall, that lower birth weight babies have worse outcomes, both short-run in terms of one-year mortality rates and longer run in terms of educational attainment and earnings. Specifically, a 10 percent increase in birth weight would reduce one-year mortality by approximately twenty-eight deaths per 1,000 births. For long-run outcomes, their twin fixed effects estimates show: (i) a 10% increase in birth weight leading to a .57 centimeter increase in height and a .11 increase in BMI .(ii) an increase in birth weight by 10 percent will increase the IQ score (measured on a scale from one to nine) by .06. (iii) an increase in birth weight of 10 percent increases the probability of high school completion by a bit less than 1 percentage point. (iv) A 10 percent increase in birth weight raises full-time earnings by about 1 percent. This suggests, in Norway context, that 10 percent more birth weight is about as valuable in the labor market as a quarter of a year of education.

There are other examples of papers that have tried to verify the effects of birth weight on short and long term outcomes in health, labor market and education. For instance, Almond et al. (2010) analyze the mortality consequences of incremental increases in medical expenditures for at-risk infants in the United States from 1983 to 2002. In particular, Almond et al. (2010), in a regression discontinuity design, compare newborns with a birth weight of 1,510 grams with those with 1,490 grams, which are essentially identical as those born with 1,510 grams except for the extra medical attention they receive. Thus, Almond et al. (2010), find that children just below 1,500 grams have a 1 percentage point lower infant mortality rate compared to children just above 1,500 grams. Relative to mean 1-year mortality of 5.5% just above 1,500 g, the implied treatment effect is sizable, suggesting large returns to promoting the types of medical interventions triggered by Very Low Birthweight (VLBW) classification.

Bharadwaj, Løken & Neilson (2013), in a similar analysis to that of Almond et al. (2010), analyze (comparing newborns with a birth weight of 1,510 grams with those with 1,490 grams) the effect of improved neonatal and early childhood health care on mortality and long-run academic achievement in school. Using administrative data on vital statistics and education records from Chile and Norway, they found that children who receive extra medical care at birth have lower mortality rates and higher test scores and grades in school. These gains are in the order of 0.15–0.22 standard deviations. These results suggest that early life health interventions providing extra medical care in both Chile and Norway, two countries at very different stages of development, led to higher academic achievement in school.

In a recent study, Bharadwaj, Eberhard & Neilson (2018) study the effect of birth weight on long-run outcomes such as permanent income, income at different stages of the lifecycle , later life health (adult morbidity, mortality, and take-up of sickness benefits) and educational outcomes . Bharadwaj, Eberhard & Neilson (2018), using the traditional twins and siblings fixed effects approach, found that birth weight has a significant and economically positive on income and income across large parts of the lifecycle. They also found that birth weight is positively related to the probability of high school completion, meaning having at least 12 years of schooling (10 percent increase in birth weight increases the probability of high school completion by 7 percentage points). In the case of health outcomes, Bharadwaj, Eberhard & Neilson (2018) show that lower birth weight twins are more likely to make use of social insurance programs like sickness pay. They also find that birth weight significantly matters for hospitalization due to various causes such as heart disease.

Finally, in the Brazilian context, Bermudez et al. (2017) linked, using unique personal identifiers, information on the death certificate of babies who died in their first year of life with information recorded in Brazilian birth certificates (The Brazilian National System of Information on Birth Records-SINASC) to estimate the effect of birth weight on infant mortality from 2006 through 2012. Bermudez et al. (2017) used the traditional within-twin identification strategy and he found that lower birth weight babies exhibit higher rates of mortality within one year of birth. Specifically, very low birth weight babies (less than 1,500 grams), have 4 percentage points higher risk of death within one year. This effect gradually decreases when considering babies with a birth weight in the categories of 1,500-2,500 and 2,500-3,000 grams (0.4 and 0.2 percentage, respectably) and it is statistically not significant for the latter category. Additionally, Bermudez et al. (2017) shows that the effect of birth weight remains statistically significant when considering other definitions of mortality such as neonatal mortality, seven-day mortality and one-day mortality. In overall, the author concludes that these effects are much larger than those derived from the US and Norwegian context.

2.2 Child Health and Public Goods Provision

The main contribution of this paper is to provide a rigorous, empirical analysis of a program that invests in the tax capacity of local government on infant health outcomes. As will be shown later, this program had positive and significant effects on public spending. At this point, it is natural to ask the following question: Does public spending save lives? a revision of the historical improvement in infant health in countries developed indicates two mechanisms that prompted this change: (I) Improvement in nutrition levels; (II) public health and medical technological progress (CUTLER; MILLER, 2005; CUTLER; DEATON; LLERAS-MUNEY, 2006; ALMOND; HOYNES; SCHANZENBACH, 2011, among other). On the one hand, the former mechanism is directly related to growth in income. On the other hand, the education system, basic sanitation programs, and immunization system are related to public spending. Thus, assessing the government's capacity to provide public goods and their subsequent effects on health in developing countries, it is important for policy makers to redirect their objectives to improve the socioeconomic status of the population. In a relatively recent paper, Bhalotra (2007), using variations in health expenditure between Indian states, showed a negative and significant impact of health expenditure on infant mortality at the rural level. The long run elasticity estimated is around -0.24.

In the same line,but in a cross-countries analysis, Farag et al. (2013) estimate the effect the health spending on infant and child mortality. Using data from 133 low and middle-income countries (e.g. Bolivia,Cameroon, Cape Verde, China, Colombia, and Brazil) for the years 1995, 2000, 2005, and 2006, they find a negative relationship between infant and under-5 child mortality with estimated elasticities (in absolute value) between 0.13 - 0.33 and 0.15 - 0.38, respectively. Likewise, they find a negative effect on infant and child mortality. Crémieux, Ouellette & Pilon (1999) find similar results but at the country level. Using homogenous province-specific Canadian data, their results show that lower health care spending is related to a statistically significant increase in infant mortality and a decrease in life expectancy.

Gonçalves (2014), with a logic similar to our paper,evaluates whether the use of participatory budgeting in Brazilian municipalities has a effect on the pattern of municipal expenditure and thereby on living conditions measured by infant mortality rates. The main results were: (I) The participatory budgeting affected the pattern of local government expenditures. This mechanism increased the proportion of the public budget spent on health and sanitation by 2–3% points. (II) This change in spending pattern was accompanied by dropped in infant mortality rates. Specifically, municipalities that adopted participatory budgeting showed a significant decrease in infant mortality rates between 1 and 2 infants for every 1,000 resident infants. Gonçalves (2014) concludes that increase the interaction between service users and elected officials in budgetary policy has effects on the pattern of use of public spending and living standard outcomes. Kiross et al. (2020),using a panel data of 46 countries in sub-Saharan Africa, find that both public and external health care spending have effects positive on infant and neonatal mortality. Martinez (2019),using a cadastral update and changes in the world price of oil as a source of exogenous variation in tax and non-tax revenues ,respectively, find that increases in tax revenues have a positive effect on the provision of public services (educational enrolment, infant mortality health insegurance and water quality) . He shows that this effect is at least ten times larger than the effects of an equivalent increase in oil royalties. Finally, Paxson & Schady (2005) estimated that the fall in in Peru's GDP of approximately 30% in 1987–1990 generated a drop in government health expenditure (58%), and at the same time a increase in infant mortality (2.5 percentage points).

2.3 Conceptual Framework

Grossman & Joyce (1990) and Rosenzweig & Schultz (1982)) are two seminal papers that presented the concept of infant health production functions. Under this framework, infant health is assumed to be a function of several factors. First, baseline health status. Second, the time spent on activities that increase health (exercise, cooking, sleeping, time to go to visits to the doctor, among others). Third, health related goods (e.g. healthy food).

Following Grossman & Joyce (1990), we assume that parents maximize the following intertemporal utility function:

$$U = f(X, Y, H) \tag{2.1}$$

This equation indicates that a family gets utility from three types of goods: H the health of each of its children (or child in utero); (Y) goods that do affect infant (growth of the fetus) and/or maternal health (e.g. medicines, vaccines and food), and X which are health-neutral (have no effect on H, such as books).

The child health production function is given by:

$$H = f(Y, Z,) \tag{2.2}$$

where F_y, F_z, F are nonzero and Z is the purchased market inputs such as medical services (general medical care during pregnancy or particular prenatal care procedures/advices), which affect U through their effects on H. is the component of child (fetal) health due to genetic or environmental conditions uninfluenced by parental behavior and preferences. The child health production function has the property that it is imbedded in the constrained utility maximization behavior of the family.

The problem facing the family is: To maximize 2.1 given 2.2 subject to the budget constraint, given by 2.3

$$I = XP_x + YP_y + ZP_z \tag{2.3}$$

where I is exogenous income and $P_x, P_y and P_z$ are, respectively, the prices of the health-neutral good, X, health-related consumer good, Y, child health investment goods. Expressions 2.1– 2.3 can be manipulated to yield health input demand functions of the form

$$X = D_x(P_x, P_y, P_z, I, \mu) \tag{2.4}$$

$$Y = D_y(P_x, P_y, P_z, I, \mu) \tag{2.5}$$

$$Z = D_z(P_x, P_y, P_z, I, \mu) \tag{2.6}$$

The effects of changes in the prices of the three types of goods on the level of child health can be derived from these equations, noting that

$$dH = F_y dY + F_z dZ + F_\mu d\mu \tag{2.7}$$

From 2.2, these effects can be written as:

$$dH/(dP_x) = F_y dY/(dP_x) + F_z dZ/(dP_x) \tag{2.8}$$

$$dH/(dP_y) = F_y dY/(dP_y) + F_z dZ/(dP_y) \tag{2.9}$$

$$dH/(dP_z) = F_y dY/(dP_z) + F_z dZ/(dP_z) \tag{2.10}$$

where $d\mu/(dP_i) = 0$, for i= x,y,z . Expressions 2.8-2.10 indicate that price effects on child health depend on the effects of changes in prices on the demand for health production inputs as well as on the marginal products of these inputs in the production of health. In 2.10, if $F_y > 0$ (goods that benefit health) and since Z considers intensive inputs in time, a reduction in wages would increase the demand for Z and decrease the demand for Y $(dY/(dP_z) < 0)$ leading to an ambiguous effect on child's health. Therefore, the existence of credit constraints and other market imperfections, which lead families to make an incomplete consumption smoothing, make health vulnerable to negative economic shocks (income effect greater than effect substitution).

Now an expansion of government expenditure would affect health and health behavior through the demand equation 2.4 -2.6. Suppose an increase in public spending is reflected in the creation of more social programs. Thus, such programs may reduce the prices of the health inputs, through direct subsidization, or indirectly by increasing access. In the latter case, making services or inputs more readily available, i.e., by placing services in a remote area, reduce the time or travel costs to use the service. In addition, public programs may provide information on how to produce health more efficiently. This might include information on new inputs or on efficient practices with conventional inputs - when to breastfeed, how to sterilize baby formula, etc. - which yield greater survival rates for given total expenditures.

3 Background

3.1 Public expenditures: Decentralization Process; and Evolution and Composition of Expenditures

By law, the municipal government has been responsible for the provision of goods and services. However, before the constitutional charter of 1988, the types of goods and services supplied were basically: Public lighting, roads, public transportation, services related to garbage treatment (collection, disposal, among others), management of sewerage networks, urban infrastructure, and water services (not available for all municipalities). There were a few cases in which the local administration exercised some activity in the education sector (mainly in primary education) and primary health care, however, compared to the presence of the central government, and even the federal government, this participation was Irrelevant (GONÇALVES, 2014; COLLINS; ARAUJO; BARBOSA, 2000).

With the advent of the 1988 Constitution of the Federative Republic, the scenery changed. Without totally eliminating the presence of federal and state governments, the municipalities began to take a greater role in the administration of the education and health sectors, and to carry out this process received large transfers from upper levels of government. Figure 1 shows the distribution of total municipal spending by categories for the years 1990, 2006, 2012, and 2017. We observe, firth, that the Education category has the highest share of spending during the period analyzed, accounting for 27.35%, 26.35%, and 32.72% of the budget in 1990, 2006, and 2017, respectively. Second, the share of the Health sector increased from 13.28% to 23.41% between 1990 to 2017. Third, the sectors Housing, Legislative, and other expenditures -which includes the remaining classes- were the losers in this period. Overall, this pattern in the budget share by categories reflects the Brazilian decentralization process.

3.2 Introduction of the Fiscal Capacity Program

By law, Brazilian local governments are authorized to collect and set the rates of urban property tax, services tax, and property transfers tax (IPTU, ISS, and ITBI, by their acronym in Portuguese, respectively)[1]. These tax revenues represent approximately 1.5 percent of the national GDP. In a budgetary sense, tax revenues are about 26 percent of the municipality's total revenue. Despite its economic importance, there are problems regarding the local government's

[1] The Brazilian constitution grants substantial responsibility to municipal governments regarding the administration of public spending and revenues. In education, for example, Article 212 of the Federal Constitution determines that states and municipalities are required to invest 25 percent of their tax and transfer revenues. On the other hand, Constitutional Amendment 29 determines that state and municipalities should invest in the health care system a 12 and 15 percent of tax revenue and constitutional and legal transfers, respectively.

capacity to tax. Among these, it is possible to highlight: deficiency in the identification and registration of potential taxpayers, little institutional memory, and weak methods for setting the tax rate (GADENNE, 2017; AFONSO, 2007).

In order to remedy this situation and thus increase the municipalities' tax revenues, the Brazilian Development Bank (BNDES) launched in 1998 an investment program in taxation capacity called "Programa de Modernização da Administração Tributária e da Gestão dos Setores Sociais Básicos" (PMAT program). The PMAT was specifically designed to increase the fiscal efficiency of municipalities, guaranteeing them an additional flow of stable resources for the financing of local expenditure and investment. Through the program, local governments obtain loans that must be used to modernize, mainly, their tax administration, in addition to the basic social sectors: health, education, and social assistance. Some actions that can be financed through PMAT regarding tax administration are: i) Updating tax registers and investing in human resources training and computer equipment (e.g., purchase of specialized software) to analyze and cross-check administrative data. ii) Acquisition of inspection support equipment (popular vehicles, tablets, and georeferenced information systems, among others). iii) Acquisition of furniture and equipment to improve both the physical infrastructure of the operations area and customer service (e.g., systems for payments via internet). This with the objective of reducing the taxpayer's costs to comply with their tax obligations.

For our results to be interpreted in causal terms, it is key to establish that the timing of PMAT adoption appears to be exogenous. The request to belong to the PMAT program by the municipalities is voluntary. After submitting the application to BNDES, the applying municipalities wait a couple of months or four years to receive the loan and start the program. [2] To verify this difference between the application date and the program start date, Figure 2 displays the distribution between the municipalities of these two dates. We observe substantial heterogeneities with respect to the application date and the start date. Specifically, the distribution of the first is smoother than the second date. This difference is largely explained by the considerable changes in allocated resources to evaluate applications for access to the program loan. The first change occurred between 2002 y 2005 when was contracted the public bank Banco do Brasil to speed up the process of evaluating the documents of the candidate municipalities to receive the treatment. In the first years of the PMAT program, the BNDES was the only one responsible for verifying and evaluating the requests, for which it took approximately two years on average to provide a response. The second change occurred in 2007 when Caixa General joined the analysis process to help with the administrative backlog.Thus, in general, the logic of timing of the program's implementation is as follows: Municipalities have the power to choose when to apply but the program start date will depend on the technical analysis capacity of BNDES, Banco do Brasil, and Caixa General. Put differently, the program start date is largely out of municipalities' hands.

[2] In our sample, about 94 percent of the municipalities applying between 1998 and 2001 waited more than a year to receive a response.

Since the application date is determined by the municipality, it is necessary to analyze the probabilities associated with the selection within the program. This is important to clear any doubts about substantial differences in important factors between treated and untreated municipalities. If these two groups differ in those variables, it may increase the risk of differential trends in the outcomes of interest driven by other factors.

These results are shown in Table 2. Richer, bigger, and more urban municipalities, and those municipalities located closer to a treated area are more likely to apply to the program. We also test whether mayors in their second term increase the chance of being treated. Mayores in this condition are less likely to apply. This correlation may reflect a behavioral effect because they anticipate a null short-term effect of the program on revenues. Table 2 shows that the probability of the municipality being treated decreases with a second term from the mayor.

3.2.1 Infant health in Brazil

3.2.1.1 Parental Characteristics and Birthweight in a Brazilian Population

The Brazilian context is particularly appealing because it is characterized by high incidence of infant mortality and LBW. The country has experienced important gains in infant mortality during the last 20 years. Between 1996 and 2010, an array of policies aimed at cutting down neonatal deaths in Brazil resulted in infant mortality reductions of 60 percent. Still, infant mortality rates remain strikingly high if compared to that of countries such as Japan or Norway[3].

Data from the World Bank reveals that the number of infants dying before reaching one year of age is 15 per 1,000 live births, which is as much as eight times relative to that in Norway. According to Mendonça (2001), Szwarcwald & Castilho (1995) and Bermudez et al. (2017) the incidence of low birth weight may be the principal responsible for infant mortality in Brazil. Per year, about of 30,000 babies have a weight less than 2,500 grams, or 8 percent of all births. This average is considered high when compared to the countries of Europe and North America that present an average of 6.4% and 7.7%, respectively. Compared to Latin America, Brazil is slightly below the regional average, which is 9.6% (ranging from 8.5% in Chile to 16% in Ecuador). Additionally, these countries also have in common as well many other socioeconomic characteristics, such as poor labor market conditions and high levels of inequality. One could therefore expect that changes in economic conditions to have more severe effects on health at birth and post neonatal health outcomes, with potentially larger welfare implications, in such settings.

To have a panoramic view of the problem of LBW in Brazil, Table 1 displays the

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[3] According to Unicef, current infant mortality rates in Barbados, Cuba, Chile, Costa Rica, Guadeloupe, U.S. Virgin Islands, Martinique ,Puerto Rico, Argentina and Uruguay are estimated to be between 10 and 8 deaths or less per 1,000 live births, and only Haiti, Bolivia Paraguay, Venezuela and Guyana have higher rates of around 21 to 45 per 1,000. The same report highlights infant mortality rates for Russian Federation, Spain, Portugal, United States, India, and China of 8,3,4,7,39, and 9 per 1,000 live births, respectively.

percentage of born babies with LBW who died or survived grouped in categories according to Maternal and neonatal characteristics between the years 1996 to 2017. A higher prevalence of deaths (55%) was found among male LBW neonates, about 42 percent of the dead babies weighed less than 999 grams at birth, and were categorized as extremely premature (40.6%). It is possible to perceive that the highest proportion of dead babies come from women between 20 and 34 years old (60.80 %) with white skin (49.8 %) and with some degree of education (79.4 %).

3.2.1.2 Infant mortality in Brazil: Evolution and Historical Contexts

In past decades, Brazil presented high infant mortality rates mainly associated with easily preventable causes of death, such as infection and malnutrition. Until the end of the 1970s, it was believed that high mortality rates would be associated with characteristics typical of developing countries, for example, high income inequality, high unemployment rates and low economic growth. However, after the 1980s, the infant mortality rate in these countries continued to fall even in times of major economic crises to fall. Thus, other factors could therefore be more relevant to explain this context.

Moreira et al., (2012), for example, points out that, even in the 1970s, the worsening of the epidemiological context and social pressure for better living conditions led to the emergence of the first initiatives aimed at reducing child mortality in the country, such as the creation of the Maternal and Child Program that would become several other initiatives carried out in the 1980s. For example, in 1981 the National Breastfeeding Incentive Program (PNIAM, acronyms in Portuguese) was created in order to encourage breastfeeding. Another program called the Comprehensive Child Health Care Program (PAISC) was created in 1984 with the objective of preventing diseases and recovering the health of children aged zero to five years. In addition to these policies, the creation of the Unified Health System in 1988 and the Family Health Program in 1994 have improved health conditions in Brazil and, consequently, contributed to the reduction of infant mortality.

In more recent years, infant mortality prevention policies have received greater attention, according to Moreira et al. (2012). The "Mãe-Canguru" Method, which devoted more attention to low birth weight newborns and Neonatal Screening, through the National Neonatal Screening Program (PNTN acronyms in Portuguese), for example, gained strength in the early 2000s. Still in 2006, the "Pacto pela Vida", which is one of the axes of the set of reforms proposed by the "Pacto pela Vida", had as a priority objective the reduction of infant and maternal mortality.

Thus, Figure 3 shows that in the past decades, the country has experienced continuous reductions in this indicator, especially after the 1990s. Currently, the country has registered the lowest levels of infant deaths. This sharp drop in infant mortality follows the same behavior when we analyze the regional trend. Less developed regions such as the Northeast and North, however, historically express higher levels when compared to more developed regions like the South and Southeast (Figure 3).State interventions through public policies that expanded investments in health, the infrastructure of the water and sewage supply network, increased family education and reduced fertility are examples of the factors that can explain this reduction, as they highlight (COSTA et al., 2003). In addition, Programs implemented in the mid-1980s, such as the Comprehensive Women's Health Care Programs (PAISM), Oral Rehydration Therapy (ORT), National Immunization Program (PNI) are examples of successful actions that have contributed to reducing of infant mortality in Brazil.

Figure 4 shows the evolution of the infant mortality rate per 1000 deaths. The data show that infant mortality historically differs depending on the characteristics of the child, the pregnancy or the child's mother. Historically, for some groups child mortality is prevalent. For example, male children, of low birth weight or whose gestation is less than 28 weeks have a higher incidence of infant mortality when compared to other groups. In addition, children of mothers with no schooling, whose pregnancy occurred outside the mother's age range between 20 and 34 years old or being in the third pregnancy, historically also experience a higher infant mortality rate compared to other groups. On the other hand, infant mortality among different race groups does not seem to differ much between them in recent years. In addition, the data reveal that infant mortality in some groups may be increasing over the years, as occurs among those born to mothers who are in their third pregnancy or among those children of mothers without schooling.

4 Data and Research Design

4.1 Data

To investigate the effects of the program on fiscal, development and infant health outcomes, we combined several data sources. The key treatment or policy variable is the year that each municipality implemented the PMAT program, which available from BNDES database on this program. This database provides the date on that the municipality applied and started the program. We have this information for three hundred fifty-one local governments that started the tax capacity program between 1999 and 2015[1]. The BNDES data are combined with two microdata sets on births and deaths from the DATASUS (Departamento de Informática do Sistema Único de Saúde) of the Brazilian Ministry of Health.These data are merged with other municipality-level data from several sources, which will be explained in more detail below. Table 3 describes in more detail the sources of all these variables.

4.1.1 Vital Statistics Data

To assess PMAT's overall impacts on infant health, we use the Brazilian Vital Statistics microdata, available for the 1998-2017 period. These data are recorded,separately, in the Brazilian National System of Information on Birth Records (SINASC) and the Brazilian National System of Mortality Records (SIM). The SINASC microdata includes information on the exact date of birth, weeks of gestation, sex, birth weight, APGAR scores, and maternal characteristics such as marital status, age and education. The main advantage of this data is that the information is collected by the medical facility where the birth takes place using medical records. In the case of home births, the information is collected in a notary's office at birth registration [2].The SIM microdata provide comprehensive information on date of death, cause of death, birth date, race, gender, and some demographic characteristics of the mother such as municipality of residence, education and age. Law Decree 6.015/1973 does not allow any burial without a death certificate. This likely explains why coverage rates are remarkably high for the standards of developing country vital registries: about 96 percent of all annual deaths[3] [4].We focus on infant mortality from all causes to maximize power. Then, we collapse the data into municipality-year cells covering the 1998-2017 period. The municipality of reference in the panel is the municipality where the mother lives, so we are

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[1] These municialities PMAT represent about 40 percent of the total Brazilian population.

[2] Although this type of birth is likely to generate noise in our results, it is comfortable to know that the fraction of these births is low. In our data, less than 1 percent of the babies were born at home.

[3] Information on death coverages are available at <http://www2.datasus.gov.br/DATASUS/index.php?area=0901&item=1&acao=26&pad=31655e.htm>, last accessed on April 9th, 2019.

[4] The coding for cause of death follows the International Statistical Classification of Diseases and Related Health Problems 10th Revision (ICD-10), created by the The World Health Organization (2004).

able to capture the shock that the child was subjected to during the gestational period and the first 12 months of life. Taken together, these data contain information on approximately 963,444 infant deaths and 59 million births.

4.1.2 Other data

We obtain annual tax and non-tax revenue, and spending in education and health at the municipality level from the Ministry of Finance (Ministério da Fazenda – Secretaria do Tesouro Nacional). We collapse these data to municipality-year cells covering the years 1998 to 2017. We collect municipality level data on the percentage of households in rural area, unemployment rate, High school dropouts rate, and the number of workers employed in health sector from the 1991,2000 and 2010 Brazilian Censuses. In addition, we use the 2000 censu microdata to estimate per capita household income inequality (GINI index).For complementary results, we use luminosity intensity as proxy of economic activity at municipality level. Data came from the Defense Meteorological Satellite Program's Operational Linescan System (DMSP/OLS) provided by the National Oceanic and Atmospheric Administration (NOAA) since the 1970s. Unfortunately, digitized maps are available from 1992 to 2013, therefore we build a panel from 1997 to 2013. Briefly, the process of capturing the brightness data is as follows: Each satellite observes each place on Earth every night between 8:30 to 10:00 pm local time. Then, this information is saved in a digital number, which has a range from 0 to 63 with a resolution of 30 arc-second area pixel, or approximately 0,86 square kilometers at the equator. We sum up all the digital numbers across pixels for each Brazilian municipalities for each year. Then, following Henderson, Storeygard & Weil (2012), we take the natural log of this sum plus 0.001 in order to construct the economic activity variable.

Finally, we use information on mayoral elections by municipalities available from the year 2000 in the Brazilian Superior Electoral Court (by its acronym in Portuguese,TSE) to construct variables of local policy characteristics such as the Herfindahl index of political competition constructed from the vote share of all parties running in the last municipal elections.

4.2 Research Design

We employ a differences-in-differences design to estimate the effects of PMAT program on fiscal, development, and infant health outcomes. To identify the effect of PMAT on these outcomes, we exploit the timing of the tax capacity program adoption. Our benchmark specification is the following:

$$y_{it} = \alpha + \beta \ \mathbb{1}\mathbf{PMAT}(t-k)_{it} + \delta \ \text{time} \times \mathrm{Z}_i + \delta \mathrm{P}_{it} + \lambda_i + \gamma_t + \xi_{it} \tag{4.1}$$

where y_{im} is the dependent variable of interest for municipality i in year t. $\mathbf{PMAT}(t-k)_{it}$ is a dummy equal to one if the municipality i in year t implemented of PMAT program k year ago ($k \leq t$). The coefficient β measures then the effect of PMAT on the outcomes of interest. Z_i is a vector of covariate that is interacted with a linear time trend, include a set of pre-intervention municipality characteristics (measured only at one point in time before PMAT adoption). When analyzing the effects of the program on infant health outcomes, we control for maternal characteristics. P_{it} contains tow variables: (i) the Herfindahl index of the share of terms that each political party governed a municipality, and (ii) a dummy variable that is equal to one if the mayor of municipality i is on his/her second turn. To control any unobservable time-invariant factors at municipality levels such as initial conditions and persistent municipality characteristics (e.g. infrastructure, area-specific risks diseases, among other) we use municipality fixed effect (λ_i). ξ_{it} is a random term; and α is parameters. We use in all specifications robust standard errors adjusted for clustering at the municipality level to account for serial correlation (BERTRAND; DUFLO; MULLAINATHAN, 2004). When the dependent variable is an infant health outcome, all our models use the number of births as weight.

The key identifying assumption is that in the absence of the PMAT, municipalities in the treatment and control groups would have experienced the same trends in the outcome of interest. The identifying assumption would be violated only if there were differential trends in time-varying determinants of outcomes across treated and untreated areas. For example, if poorer municipalities were converging to richer ones in terms of income or any other potential determinant of infant health, then it may lead to overestimates of the program's impacts on infant health. To account for this problem, we use a vector of pre-treatment municipality characteristics interacted with a linear time trend in our baseline specification (BAILEY; GOODMAN-BACON, 2015; CARRILLO; FERES, 2019).

5 Empirical Results

5.0.1 Relationship between PMAT and Fiscal and Development outcomes

To investigate the degree to which a change in government's capacity to tax introduced by PMAT program can improve infant health, we begin by examining the program effects on tax revenues and some development indicators. Table 4 reports these regression results. For each outcome, we report estimates from three specifications with different controls. Column (1) is based on a specification that adjusts only for municipality and year fixed effects. The remaining columns control in the following ways: column 2 with political characteristics (political competition- Herfindahl index-, and mayor's second term), time trends interacted with pre-treatment municipality characteristics (IFDM Health, IFDM Education, GDP per capita, Gini Index, unemployment rate, the share of services in GDP, Rural Household Rate, distance to the capital, temperature, rainfall, semiarid region dummy, altitude, life expectancy, the average level of education, and population in 1998) and the log changes in tax revenues between 1996 and 1998, and column 3 adds political party fixed effects. Finally, with the aim of increasing the comparability of the municipalities and thus minimize the risk of differential trends in unobservables, we use the propensity score matching to identify similar pairs and then estimate the equation 4.1 across the matched sample. These results are shown in column 4.

The first four columns in panel A report the impact of having PMAT in municipality on tax revenues per capita (Annual, 2017 R$). These columns indicate a positive, strong and statistically significant effect of the tax capacity program on local tax revenues. In general, the results are extremely robust across specifications, including controlling for interactions between linear time trends and a set of pre-treatment characteristics, political characteristics, and political party fixed effects (column 3). The coefficient only suffers a slight decrease when we reweight observations by the inverse propensity score (column 4), which could suggest that unbalanced treatment characteristics introduce a small bias. From the estimated coefficient in column 1, we see that municipalities with PMAT program experimented a increase of Rs 26.07 in its local tax revenues. Overall, our treatment effect estimated is between Rs 21 to Rs 30.

A natural question is whether these increases in tax revenues translate into greater provision of public goods by local governments. To answer this question, we estimate the effects of the PMAT program on public spending (per capita) on education and health, the number of workers employed in jobs related to health system (as a fraction of the population),the share of youth aged 14–18 out of school (high school dropouts), and the Homicide Rates per 100,000 Inhabitants. We use homicide rates calculated using the microdata from SIM -DATASUS as a proxy for the overall incidence of crime.For this analysis, We use the categories X85–Y09 of the ICD-10. We supplement these results analyzing the program effects on light density, which has been used as a proxy of local economic activity. Panels B and C in Table 4 present the result for the average effect of PMAT on the share of government spending in education and health, respectively. We find evidence of an economically and statistically significant positive effect of the PMAT program on these two fiscal outcomes (about 2 and 3 percent, respectively). These results are important because they speak to the municipality government's ability to provide public goods.

To give more evidence on this point, we estimated our regressions using information from demography census 1991, 2000 and 2010 on high school dropout and the share of health sector workers. Table 5 shows these results. Overall, PMAT municipalities experienced an improvement both in high school dropout rate and the share of health sector workers. For example, panel B in column 2 reports that the estimated coefficient of -0.035 implies a decrease of 3.5 percent of high school dropout rate. Panel D from Table 4, we document a positive association between PMAT and local development measured by light density at night. Finally, panel E shows that the application of the program helped reduce the homicide rate. This pattern is not driven by differences in pre-treatment local characteristic, unobservable time-invariant factors or by observable politic, fiscal and economic variables. In sum, we find evidence that the tax capacity program improved both local development and the capacity of the local government to provide public goods.

5.1 Relationship between PMAT and Infant Health

5.1.1 Results for Overall Infant Health Outcomes

We now examine the effects of policy on infant health, namely low birth weight, and infant mortality. As seen in the previous section, given that PMAT led to improvements in fiscal outcomes, local development, the total number of health sector workers, and high school dropouts rates, one could plausibly expect positive effects on infant health. In addition, as shown in detail below, PMAT led to an increase in prenatal visits, which indicates that the program could also affect infant health outcomes through this channel.

Table 6 presents regression results from estimating several variants to equation 2.1, where the dependent variables are the log of the fraction of children with birthweight below 2,500 grams (Panel A), the log of infant mortality rate (Panel B), and the log of the share of births with seven or more prenatal visits (Panel C). In addition to the controls used in the specification of column 3 of Table 4, we also control for maternal characteristics. These include the share of births by mothers with less 25 years old, the proportion of births by married mothers, the proportion of births by mothers without education, and the share of births by black mothers (column 4). As a robustness test, we also run difference-in-difference regressions that reweight the observations by the inverse of the propensity score and use an alternative definition of the dependent variables, columns 5 and 6, respectively.

Overall, our finds suggest positive and significant effects of the policy on child health. For low birthweight (LBW), from the bivariate relationship in column 1 Panel A, we see that PMAT municipalities experienced, on average, a drop in LBW rate of approximately 1.13 percent comparate to non-PMAT municipalities. As seen in the other columns, the inclusion of additional controls has a minimal effect on the point estimate. For example, in our preferred specification (column 4) that includes, among other controls, maternal characteristics, the coefficient of interest hardly changes in magnitude (-0.0113 versus -0.0146) and statistical significance. The magnitude of the effect on LBW rate is strikingly similar to that estimated in Almond, Hoynes & Schanzenbach (2011), which estimate a reduction of -1.02 percentage point due to the introduction of the Food Stamp Program (FSP) in the United States, and by Dehejia & Lleras-Muney (2004), which find a decrease of 0.50 percent for every one percent increase in the unemployment rate in the US labor market.[1]

Table 6 also presents the result for infant mortality. The mortality estimated effects are extremely robust through specifications and statistically significant at less than 5 percent. This notable stability in our results provides reassuring evidence that these are unlikely to be driven by differential trends across treated and comparison municipalities. The point estimate, column 4, indicates that PMAT municipality experienced, on average, a decrease in the infant mortality rate of approximately 2.5 percent comparate to non-PMAT municipalities. As specified above, a possible mechanism through which the health effect of the program could arise is the use of the health service in the prenatal period (prenatal visits). Panel C displays these results. Under our full specification, the PMAT program is associated with an increase of 6.2 percent point in births with more than seven prenatal visits (column 4). We present complementary results in Table 7. We find that PMAT adoption is significantly associated with a decrease in prematurity rate and births with low 5 minutes APGAR. Summarizing, our results indicate a positive effect of the implementation of the tax capacity program on child health, and these results can be explained by the improvement observed in the outcomes studied in tables 4 and, 5 and prenatal visit.

5.1.2 Results for Infant Health by Sex, Race and Maternal Education

One might argue that principal health results mask important forms of heterogeneities that could explain these effects. To explore this issue, Tabla 8 reports the results from the estimating equation 4.1 by maternal education and the baby's sex, and race. Maternal education and the baby's race will serve as proxies determining the family's socioeconomic status (SES). The estimated coefficients do not show evidence that the PMAT program affected the children differently depending on sex. In contrast, we only find a significant reduction in infant mortality rate by race. This estimated point is higher for non-whites compared to whites (-0.1105 versus -0.0439). When we stratify the sample by mother's education (none, some, and high education), we

[1] Another comparison, no less important, is with the work of Bozzoli & Quintana-Domeque (2014), which estimate how prenatal economic fluctuations affected birth weight in Argentina during the episode of the economic collapse in the early 2000s. Their estimate point is -0.067, which is something similar to ours.

only find effects on infant mortality rate. The pattern observed in the results is an improvement in infant mortality rates for mothers with a lower educational level. In general, the policy succeeded in improving children's health for the most vulnerable population (Low-SES families).

5.2 Threats to Internal Validity

In this section we explore potential threats to the validity of the basic patterns documented above.

5.2.1 Pre-trends Analysis and Timing of Exposure Effects

The results above rely on the common trend assumption that municipalities in the treatment and control groups would have similar trends in the absence of the program. This assumption would be violated only if there were differential trends in time-varying determinants of health outcomes across PMAT and Non-PMAT Municipalities. We now conduct a pre-trends analysis to show that our results are very unlikely to be the result of pre-existing differential trends.

To further assess the plausibility of this assumption, we employ a flexible event study-like specification. In doing so, we modify the estimating equation 4.1 to include indicators for j years before, and after the adoption of the PMAT program:

$$y_{it} = \alpha + \sum_{j=0}^{17} \beta^{\tau}_{post}\ \mathbb{1}\left(t \geq \tau_{start}\right) \times \mathbf{PMAT}_{jit} + \sum_{j=-7}^{-2} \beta^{\tau}_{pre}\ \mathbb{1}\left(t \leq \tau_{start}\right) \times \mathbf{PMAT}_{jit} + \delta\ \text{time} \times \text{Z}_i + \delta \text{P}_{it} + \lambda_i + \gamma_t + \xi_{it} \quad (5.1)$$

where $\mathbb{1}(t \geq \tau_{start})$ is an indicator equal to one if municipality i in year t started the program j years ago $(j \geq 0)$. The indicator $\mathbb{1}(t \leq \tau_{start})$ is equal to one if PMAT Municipality will start the program in j years $(j < 0)$. The rest of variables are the same as in equation (2.1). Now the parameters of interest are $\beta^{\tau}{'s}$, which allow us to transparently and non-parametrically to evaluate how the outcomes of interest evolve over the years surrounding the program start date (τ_{star}) and thus examine the timing of the impacts. Table 9 present these results. The comparison year in this regression is $j = 1$. On the one hand, the results indicate that before the start of the program, there is no statistically significant trends both in the low birth weight rate (column 1) and in infant mortality (column 2) correlated with the implementation of the PMAT. The point estimates are small and statistically insignificant at the conventional levels of significance. It yields support for the identification assumption that the outcomes in PMAT and non-PMAT municipalities would have been the same in the absence of the program. On the other hand, overall, both low birth weight rates and infant mortality rates decline around the fifth period period after starting the program and then stabilize during the rest of the post-program period.

In order to make a comparison in the timing of the program, Table 9 also reports the result of event-study for tax revenues (column 4). We conclude, first, there is no evidence of different trends between PMAT and non-PMAT municipalities. Second, the improvement in health outcomes after the program starts is in line with the increase in tax revenues observed in column 4.

5.2.2 Selection due to Miscarriage or Stillbirth

Because our data on infant mortality is based on those infants who survived the prenatal period and therefore do not include fetal deaths, an important source of selection bias is miscarriage or stillbirth. Suppose that in reality the PMAT program led to *a deteriorate* in infant health so that those who survive under worse circumstances actually have better health outcomes. In this case, our results would be biased towards a spurious decline in infant mortality or low birth weight rate. Put differently, what appears to be a PMAT-induced improvement in infant health may be the exact opposite due to fetal selection. Alternatively, if the program did lead to improvements in infant health, then selection due to miscarriage or stillbirth would be of less importance because it most likely leads us to underestimate the true gains in health.

To address this issue, we take advantage of the fact that the Ministry of Health collects data on fetal deaths since the 1980s at detailed geographical level. Therefore, we directly examine whether and how the PMAT program affected fetal deaths. Specifically, we rerun our the specification of the equation 5.1 using the log fetal deaths rate as dependent variable. We find a difference-in-differences coefficient that is negative and highly significant after the first three years of starting the program (column 3 of Table 9). The PMAT program led to a *reduction* in fetal deaths that is larger in magnitude in PMAT municipalities. This suggests that our baseline estimates are likely to lower bounds of true effects. Overall, the timing of the impacts is largely consistent with the dynamics for infant mortality and low birth weight shows in Table 9.

5.2.3 Selective Fertility

A possible concern with the validity of our results is that changes in economic circumstances as consequence of the PMAT program may induce some women to change fertility decisions. This in turn may change the composition of the sample, an issue of particular concern if more advantaged mothers are more likely to give birth after program adoption. A simple and direct test would be to explore whether the PMAT program is associated with significant changes in the number of births across locations. To perform this exercise, We run the specification of the equation 4.1. The results are shown in Table 10. If women systematically changed fertility choices in response to the trade reform, one would expect to observe significant changes in the number of births during the post-liberalization period. Columns (1) through (4) look at the total number of births, birth rates, log birth rates, and log births. There is no evidence of meaningful effects on any of these variables. The estimated coefficients are small in magnitude and far from being statistically significant.

We supplement these results using the Brazilian Household Sample Survey identified at the municipality level (PNAD, for its acronym in Portuguese), which is available several years before and after the reform and provides information on birth histories for all women. Specifically, we use fifteen waves of this survey covering seventeen years (1998–2015) to compute several variables of interest. In this period, we identified 802 municipalities and more than a million (1.367.484) women between 15 and 49 years old. The PNAD asks women on the data of birth of their last birth. Our key dependent variable of interest is an indicator for giving birth in the reference year. As robustness check, we also show results for giving birth in other previous years. These results are displayed in columns (1)-(5) of Table 11. Consistent with the aggregate data from the civil registry, there is no evidence of a meaningful relationship between the trade reform and the likelihood of having children.

As a final check, we examine whether the characteristics of the mothers in treated and untreated areas changed over time at comparable rates. Specifically, we investigate whether the PMAT program is associated with changes in a number of maternal characteristics such as household head status, literacy, years of education, marital status, age, urban/rural location, and race. This exercise provides more direct evidence on whether the composition of women giving birth changed following the implementation of the program. These results are shown in Table 12. On the one hand, we find that the PMAT program "deteriorated" the composition of the sample through the years of the mother's education. However, this does not raise concern as less educated women are expected to have children with poor health compared to more educated mothers and, therefore, this would bias our estimate down to zero. On the other hand, we find that the program is not associated with changes in the other maternal characteristics, suggesting that the composition of women giving birth was not systematically altered during the post-PMAT period.

Summarizing, the substantial improvement in infant health is unlikely to reflect changes in fertility choices.

5.2.4 Selective Migration

As seen previously, the PMAT program had an effect on the economic conditions of the municipality, therefore, a possible concern is selective migration: different families could move away from untreated areas to PMAT municipalities.Out-migration could introduce in bias in our estimates if changes in economic conditions alter the composition of "stayers", those who do not move to other areas in response to the economic shock. If more advantaged parents with healthier infants are more likely to migrate out of their municipalities, then our results would understate the true decline in infant mortality and low birth weight case number.Alternatively, if less advantaged parents move away from affected areas, our analysis is likely to overestimate the magnitude of true effects.

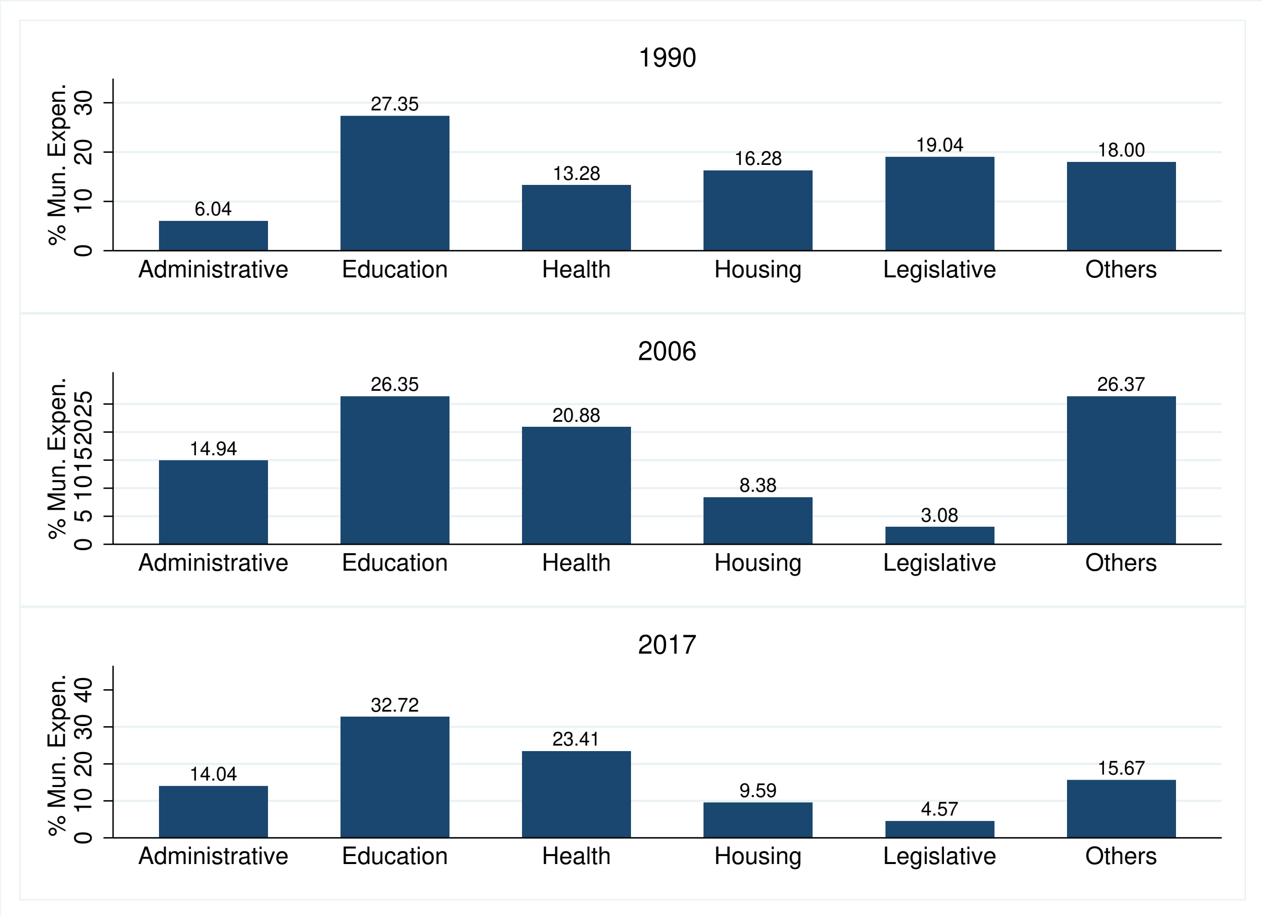
In this section, we address this problem using a broader set of measures using Census data. We use decennial censuses conducted between 1991 and 2010 and look at the PMAT effect on total migrants by age range and sex. Table 13 shows the results. From column 2 to 4, regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. In panel A, we estimate the effect of the program on the rate of migrants. The estimator through the specifications is small in magnitude and not statistically significant. For example, for the PMAT municipalities with more time with the program (column 3), the estimator is -0.0052 (Standard error = 0.0320) which is small. This pattern is repeated in the other outcomes,which evidence that endogenous migration is not a major issue.

6 Conclusion

This paper provides direct empirical evidence on the effects of a change in tax revenues on child health outcomes. We isolate these effects by studying the introduction of a tax capacity program, launched by the Brazilian Development Bank (BNDES) in 1998, called The *Programa de Modernização da Administração Tributária e da Gestão dos Setores Sociais Básicos* (PMAT program) at the Brazilian municipalities level. The PMAT was specifically designed to increase the fiscal efficiency of municipalities, guaranteeing them an additional flow of stable resources for the financing of local expenditure and investment. Through the program, local governments obtain loans that must be used to modernize, mainly, their tax administration, in addition to the basic social sectors: health, education, and social assistance. Our identification strategy exploits the timing of the implementation of the tax capacity program to identify its impact on the outcomes of interest and compares treated and untreated municipalities in a differences-indifferences framework. We begin our analysis by measuring the relationship between PMAT implementation on tax revenues, public spending on education and health, and local economic activity using the light density at night as proxy. Having documented a strong and robust "first stage", we next evaluate whether the program is associated with changes on infant mortality and birth weight.

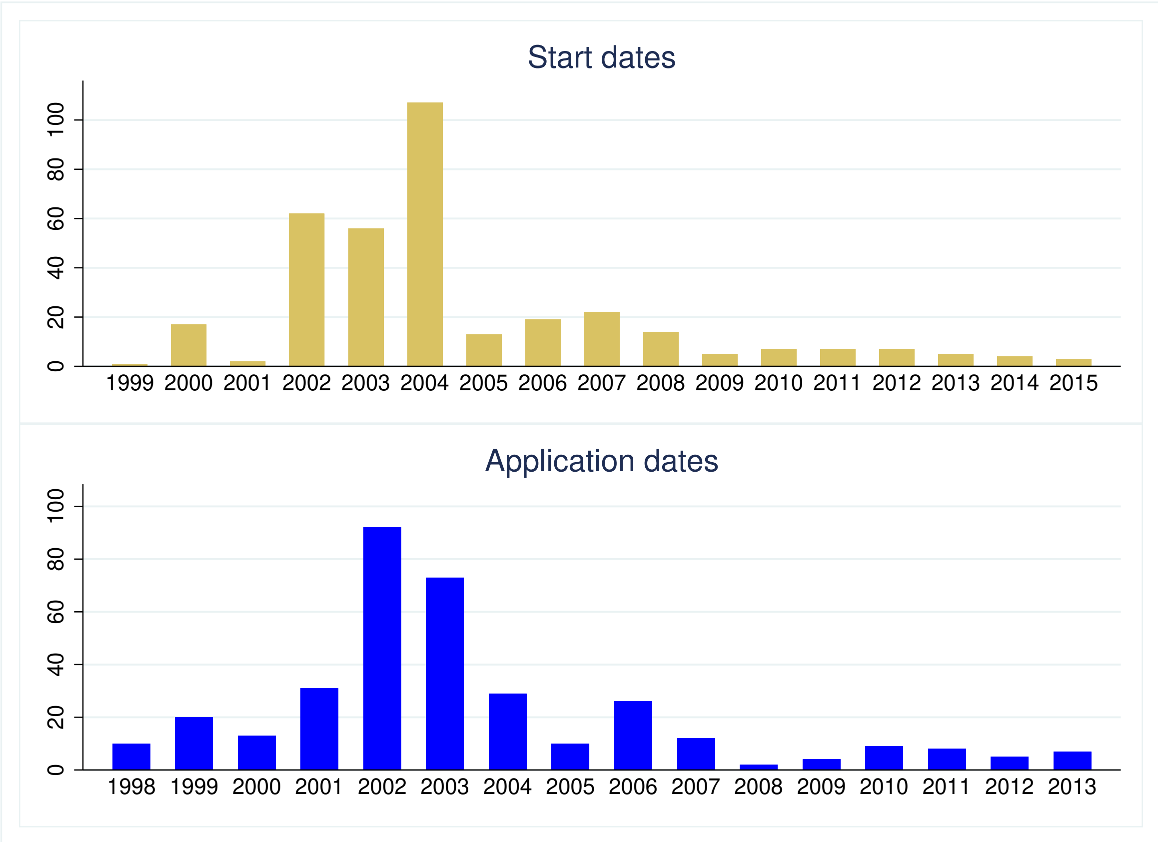
Overall,in our"first stage", we find evidence that the tax capacity program improved both local development and the capacity of the local government to provide public goods. For infant health, our finds suggest positive and significant effects of the policy on child health outcomes measured by low birthweight (LBW) and infant mortality. Summarizing, our results indicate a positive effect of the implementation of the tax capacity program on child health, and these results can be explained by the improvement observed in the fiscal and development outcomes, and mother's health behavior. Overall, from a tax administration point of view, our results highlight that local tax collection is an important piece to achieve a successful level of decentralization. These results in line with idea that “tax capacity building” is optimal for regional development as it leads to, for instance, more public investments in health infrastructure.

Figure 1 – Municipal expenditures by category



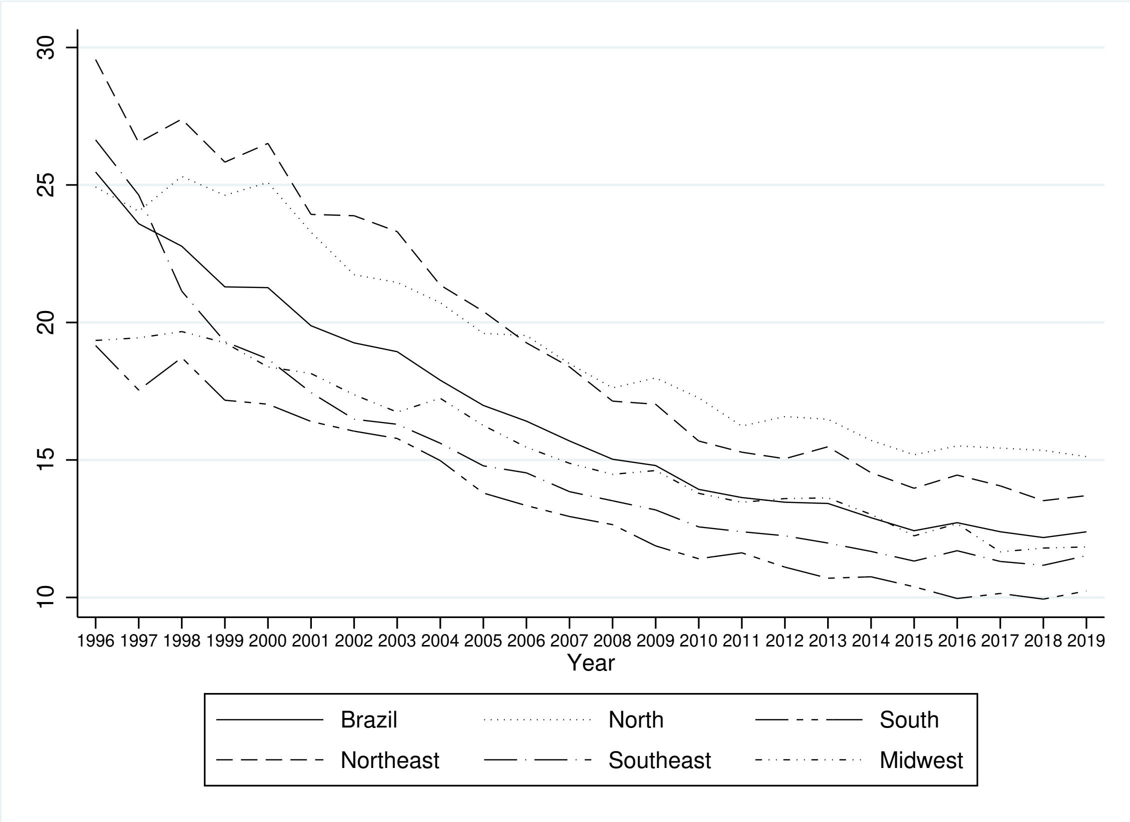
Source: FINBRA (Municipal Finance).

Figure 2 – PMAT Distribution of Application and Start Dates



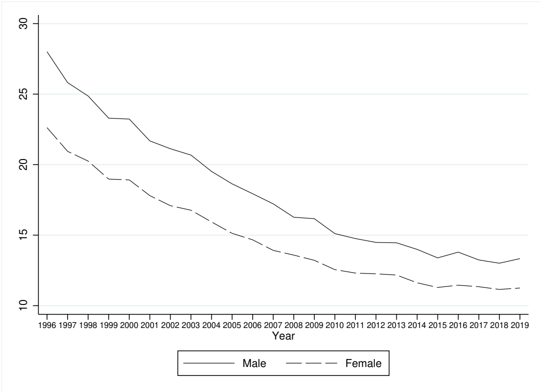
Notes: Each bar represents the number of municipalities that started (upper panel) or applied (lower panel) the PMAT in a specific year. The total size of the sample is 351 municipalities that applied to the program between 1998 and 2013.

Figure 3 – Infant mortality rate in Brazil and regions - 1995 to 2019

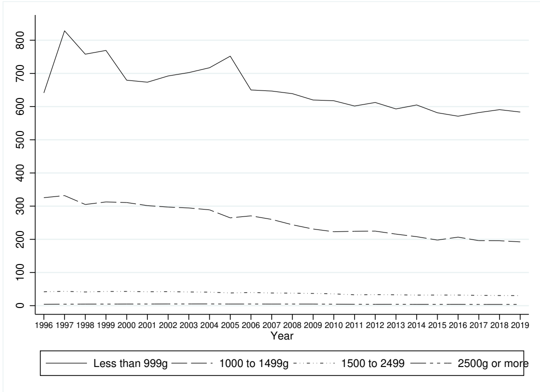


Source: Mortality Information System (SIM)

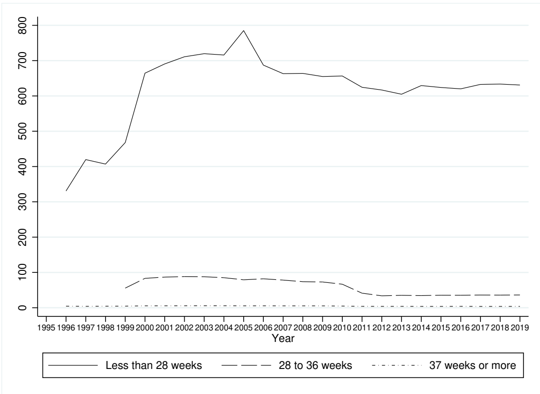
Figure 4 – Infant mortality rate by mothers' characteristics



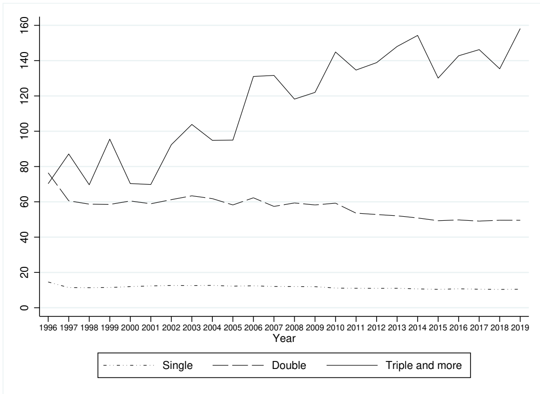
(a) Sex



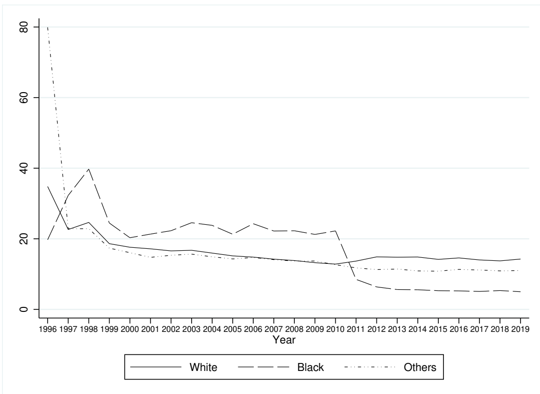
(b) Birth weight



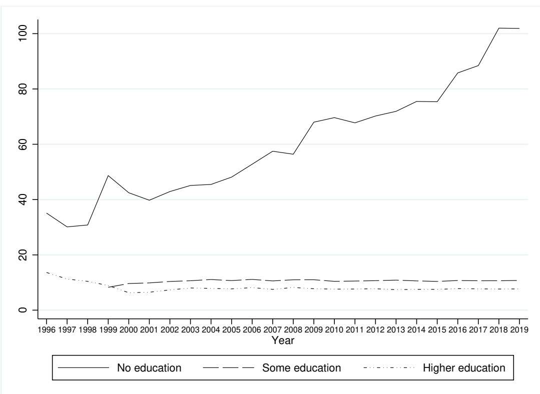
(c) Gestation length (weeks)



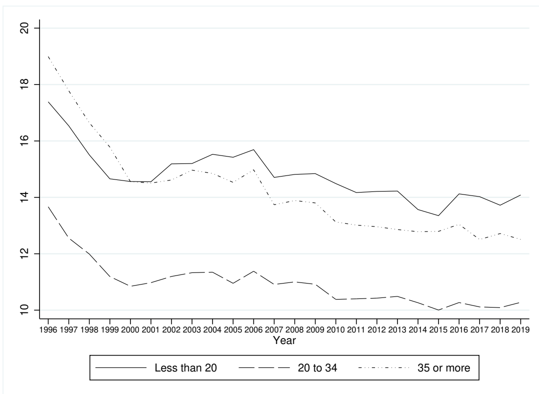
(d) Type of pregnancy



(e) Race



(f) Mother's Education



(g) Mother's Age

Source: Mortality Information System (SIM)

Table 1 – Low Birth Weight by Characteristics: 1996-2017

Maternal and neonatal characteristics	Low Birth Weight			
	Deaths		**Survivor**	
	n	%	n	%
Sex				
Female	223234	0.451	2642171	0.543
Male	272195	0.549	2225003	0.457
Birth weight				
Less than 999g	207383	0.416	112053	0.023
1000 to 1499g	117364	0.235	336532	0.069
1500 to 2499g	173905	0.349	4423157	0.908
Gestation length (weeks)				
Extreme Prematurity (<28)	169838	0.406	87514	0.045
Intermediate Prematurity [28-34]	202248	0.484	188432	0.096
Late Prematurity [34-37]	45765	0.406	1683100	0.859
Type of pregnancy				
Single Childbirth	414829	0.866	4175694	0.865
Double	60004	0.125	624164	0.129
Triple and more	4356	0.009	26016	0.005
Mother's Age				
< 20	118828	0.271	1165119	0.237
20-34	266332	0.608	3121754	0.636
>34	52807	0.121	623954	0.127
Race				
White	190223	0.498	1875207	0.462
Black	11676	0.031	162831	0.040
Other Races	180304	0.472	2021023	0.498
Mother's Education				
No education	29030	0.081	118071	0.025
Some Education	285310	0.794	3949524	0.839
Higher Education	45116	0.126	640738	0.136

Notes: Live Birth Information System (SINASC) and Mortality Information System (SIM), Brazil.

Table 2 – Hazard Model

	Dependent variable is: PMAT Status			
	(1)	(2)	(3)	(4)
Distance to closest PMAT	-0.000364***	-0.000373***	-0.000366***	-0.000365***
	[0.000107]	[0.000109]	[0.000106]	[0.000107]
GDP per capita 1999	0.00952**	0.00766**	0.0105**	0.00702**
	[0.00845]	[0.00907]	[0.00844]	[0.0102]
Share services in GDP	-0.304	-0.304	-0.301	-0.301
	[0.231]	[0.238]	[0.233]	[0.236]
Gini 2000	0.228	0.222	0.211	0.145
	[0.471]	[0.478]	[0.474]	[0.476]
Rural population 2000	-0.488**	-0.440**	-0.500**	-0.452**
	[0.202]	[0.202]	[0.202]	[0.205]
Populatio 1998	3.76e-05***	3.54e-05***	3.79e-05***	3.66e-05***
	[6.21e-06]	[6.34e-06]	[6.19e-06]	[6.40e-06]
Total Current Transfers 1998	-0.00364	-0.00398	-0.00375	-0.00323
	[0.00287]	[0.00295]	[0.00290]	[0.00298]
Taxes pc 1998	6.02e-05	0.000114	7.29e-05	8.07e-05
	[0.000129]	[0.000117]	[0.000129]	[0.000129]
IFDM Education 2000	0.766**	0.722**	0.759**	0.738**
	[0.326]	[0.328]	[0.327]	[0.333]
IFDM Health 2000	0.352	0.472	0.349	0.338
	[0.356]	[0.361]	[0.356]	[0.359]
Average Level of Education 2000	-0.0289	-0.0389	-0.0310	-0.0227
	[0.0536]	[0.0542]	[0.0538]	[0.0551]
life expectancy 2000	0.0250**	0.0242**	0.0253**	0.0245**
	[0.0103]	[0.0105]	[0.0103]	[0.0104]
Second Term	-0.062**	-0.0500**	-0.0599**	-0.0617**
	[0.0842]	[0.0845]	[0.0843]	[0.0840]
Time	-0.00943***	-0.00903***	-0.00920***	-0.00941***
	[0.00177]	[0.00175]	[0.00186]	[0.00177]
$\Delta Taxespc_{t-1}$			0.0133	
			[0.0195]	
$\Delta Population_{t-1}$			-0.598	
			[0.711]	
$\Delta GDPpc_{t-1}$			0.139	
			[0.226]	
$\Delta Taxespc_{96-98}$				-0.00976
				[0.0186]
$\Delta Population_{96-98}$				0.0242
				[0.172]
$\Delta GDPpc_{96-98}$				0.0684
				[0.0987]
Number of observations	83,413	81,430	83,413	74,709

Notes: The dependent variable is equal to one for the year in which the municipality applied and zero for the years prior to the application. The sample includes the municipalities that applied to PMAT program between 1999 and 2013, thus eliminating the 13 municipalities that applied in 1998.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table 3 – Summary statistics

Variable	Source						
1983-2015		**Mean**	**SD**				
Log(Infant M. Rate)	DataSUS	5.02	0.44				
log(LBW)	DataSUS	6.67	0.27				
Log(Low Apgar)	DataSUS	3.20	0.67				
log(Prematurity rate)	DataSUS	6.55	0.55				
Number of prenatal visits	DataSUS	7.16	2.25				
Share of mothers under 25 years old	DataSUS	0.51	0.09				
Share of Married	DataSUS	0.49	0.12				
Share of Black Mothers	DataSUS	0.03	0.03				
Share of Mothers without Education	DataSUS	0.02	0.04				
Population	Ipea Data	32,604	193,020				
1998-2017							
Tax Revenue Per capita(Annual, 2017 R$)	Finance Ministry	122.23	230.05				
Share of Gov. Spending in Education (Annual, 2017 R$)	Finance Ministry	0.39	0.11				
Share of Gov. Spending in Health (Annual, 2017 R$)	Finance Ministry	0.28	0.09				
1998-2013							
Light sum	NOAA	6.72	1.19				
2000-2017							
Herfindahl index	TSE	0.47	0.11				
Second term	TSE	0.21	0.41				
Census Data: 1991-2010							
		1991		**2000**		**2010**	
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
Share of Health_personnel	Demographic Census	0.0053	0.004	0.001	0.0014	0.0026	0.0025
High school dropouts	Demographic Census	0.45	0.07	0.28	0.07	0.23	0.04
Before PMAT program		**Mean**	**SD**				
IFDM Health	Ipea Data	0.56	0.15				
IFDM Education	Ipea Data	0.65	0.14				
GDP per capita	Ipea Data	11.13	15.09				
Share of services in GDP	Ipea Data	0.34	0.22				
Inequality (Gini)	Demographic Census	0.55	0.068				
Rural Household Rate	Demographic Census	0.4	0.22				
Population	Ipea Data	28775.71	174741.3				
Average Level of Education	Demographic Census	4.03	1.28				
Life expectancy	IBGE	67.74	4.86				
Altitude	Ipea Data	4.12	2.92				
Distance to capital	Ipea Data	253.24	163.60				
Temperature	Ipea Data	22.40	3.62				
Rainfall	Ipea Data	1380.04	470.62				
Semiarid region	Ipea Data	0.22	0.41				
Unemployment rate	Demographic Census	11.02	6.19				

Table 4 – The effect of PMAT on Fiscal and Development Outcomes

	(1)	(2)	(3)	propensity score inversa com base em estimativas ponderadas (4)
		Panel (A): Tax revenues		
PMAT	26.0796	30.1477	30.1613	21.5155
	[6.0662]***	[6.9627]***	[7.0602]***	[9.7969]**
Number of obs.	111380	84836	84836	81068
R2	0.541	0.491	0.491	0.798
	Panel (B): Fiscal Outcomes (Share of Spending in Health Care)			
PMAT	0.0364	0.0321	0.0319	0.0323
	[0.0035]***	[0.0045]***	[0.0045]***	[0.0047]**
Number of obs.	100625	78089	78089	74637
R2	0.645	0.624	0.624	0.746
	Panel (C): Fiscal Outcomes (Share of Spending in Education)			
PMAT	0.0247	0.0295	0.0296	0.0203
	[0.0032]***	[0.0044]**	[0.0044]**	[0.0046]**
Number of obs.	100226	77725	77725	74300
R2	0.637	0.679	0.679	0.636
	Panel (D): Development Outcome (Night-lights Density) *From 1997-2013*			
PMAT	0.019	0.0198	0.0197	0.0209
	[0.0105]**	[0.0121]**	[0.0121]**	[0.0109]*
Number of obs.	88944	63202	63202	60394
R2	0.968	0.974	0.974	0.989
	Panel (E): Log(Homicide Rates per 100,000 Inhabitants)			
PMAT	-0.0303	-0.0488	-0.0575	-0.0665
	[0.0271]***	[0.0419]*	[0.0378]**	[0.0292]**
Number of obs.	109850	83906	83906	80330
R2	0.551	0.711	0.714	0.652
Municipality, year FE	✓	✓	✓	✓
Political party FE			✓	✓
Political characteristics		✓	✓	✓
Time trends interacted with:				
Basic characteristics		✓	✓	✓
$\Delta Taxespc_{96-98}$		✓	✓	✓

Notes: All regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. Political characteristics contain tow variables: (i) the Herfindahl index of the share of terms that each political party governed a municipality, and (ii) a dummy variable that is equal to one if the mayor of municipality i is on his/her second turn. Robust standard errors (reported in brackets) are clustered at the municipality level. From column 1 to 4, observations are weighted by population.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 5 – The effect of PMAT on Provision of public goods

	All Sample (1)	All Sample (2)	More than 8 years with PMAT (3)	less than than 4 years with PMAT (4)
	Panel (a): Health System personnel			
PMAT Status	0.0027	0.0021	0.0028	0.0006
	[0.0002]***	[0.0005]***	[0.0009]***	[0.0004]**
Number of obs.	15195	15137	14465	14397
R2	0.014	0.887	0.89	0.831
	Panel (b): High school dropouts			
PMAT Status	-0.0445	-0.0358	-0.0344	-0.0094
	[0.0023]***	[0.0047]***	[0.0073]**	[0.0099]
Number of obs.	15195	15137	14465	14397
R2	0.011	0.92	0.919	0.915
Municipality, year FE		✓	✓	✓
Time trends interacted with:				
Basic characteristics		✓	✓	✓
$\Delta Taxespc_{96-98}$		✓	✓	✓

Notes: Each coefficient is from a different regression. From column 2 to 4, regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. Robust standard errors (reported in brackets) are clustered at the municipality level. Observations are weighted by population. The estimated equation is: $y_{it} = \alpha + \beta\ \mathbf{Post}_t \times \mathbf{PMAT}_i + \text{time} \times \text{Z}_i + \delta_i + \gamma_t + \xi_r$. Where $\mathbf{Post}_t$ is an indicator equal to 1 if the observation is from 2010 and zero in another case.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 6 – The effect of PMAT on infant health outcomes and maternal behavior

	(1)	(2)	(3)	(4)	Inverse propensity score based on weighted estimates (5)	Alternative definitions of dependent Variable (6)
	Panel (a): log(Fraction below 2,500 Grams)					**ln(LBW)**
PMAT	-0.0113	-0.0143	-0.0153	-0.0146	-0.0114	-0.042
	[0.0062]***	[0.0061]**	[0.0062]**	[0.0063]**	[0.0088]**	[0.0119]***
Number of obs.	108053	105540	104862	104431	100236	104431
R2	0.518	0.519	0.52	0.521	0.389	0.988
	Panel (b): log(infant mortality rate)					**log (infant deaths)**
PMAT	-0.0287	-0.0316	-0.031	-0.0249	-0.026	-0.0522
	[0.0156]***	[0.0149]**	[0.0149]**	[0.0137]**	[0.0148]**	[0.0173]***
Number of obs.	87960	85956	85734	85360	82626	85360
R2	0.437	0.432	0.433	0.436	0.382	0.967
	Panel (d): log(Share With 7+ Visits)					**log (Num. With 7+ Visits)**
PMAT	0.0781	0.0671	0.0655	0.0627	0.0567	0.0352
	[0.0315]***	[0.0328]**	[0.0313]**	[0.0278]**	[0.0134]**	[0.0269]**
Number of obs.	110861	108176	107277	106832	102209	106832
R2	0.694	0.759	0.759	0.762	0.695	0.982
Municipality, year FE		✓	✓	✓	✓	✓
Political party FE				✓	✓	✓
Mother characteristics			✓	✓	✓	✓
Time trends interacted with:						
Basic characteristics		✓	✓	✓	✓	✓
$\Delta Taxespc_{96-98}$			✓	✓	✓	✓

Notes: Each coefficient is from a different regression. From column 2 to 6, regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. Maternal characteristics include average age, proportion of births by mothers with less than 25 years, proportion of births by married mothers, proportion of births by black mothers, and proportion of births by uneducated mothers. The observations are weighted by the number of births. Robust standard errors (reported in brackets) are clustered at the municipality level. With the exception of column 5, all observations are weighted by the number of births.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 7 – The of PMAT on other infant health outcomes

	(1)	(2)	(3)	(4)	Inverse propensity score based on weighted estimates (5)	Alternative definitions of dependent Variable (6)
			Panel (a): log(Prematurity rate)			**log (Prematurity)**
PMAT	-0.0904	-0.0635	-0.0648	-0.0568	-0.0507	-0.0297
	[0.0184]***	[0.0315]**	[0.0300]**	[0.0260]**	[0.0161]**	[0.0237]*
Number of obs.	87960	85956	85734	85360	82626	103143
R2	0.437	0.432	0.433	0.436	0.382	0.971
			Panel (b): log(low 5 minutes APGAR rate)			**log (low 5 min. APGAR)**
PMAT	-0.0539	-0.0391	-0.0389	-0.0455	-0.0508	-0.0665
	[0.0329]***	[0.0315]**	[0.0323]**	[0.0304]**	[0.0261]*	[0.0320]**
Number of obs.	43561	42305	42285	42077	41222	42077
R2	0.55	0.559	0.561	0.564	0.56	0.926
Municipality, year FE		✓	✓	✓	✓	✓
Political party FE				✓	✓	✓
Mother characteristics			✓	✓	✓	✓
Time trends interacted with:						
Basic characteristics		✓	✓	✓	✓	✓
$\Delta Taxespc_{96-98}$			✓	✓	✓	✓

Notes: Each coefficient is from a different regression. From column 2 to 6, regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. Maternal characteristics include average age, proportion of births by mothers with less than 25 years, proportion of births by married mothers, proportion of births by black mothers, and proportion of births by uneducated mothers. The observations are weighted by the number of births. Robust standard errors (reported in brackets) are clustered at the municipality level. With the exception of column 5, all observations are weighted by the number of births.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 8 – The effect of PMAT on infant health according to baby's sex and race, and maternal education

	Base	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel (a): log(Fraction below 2,500 Grams)								
						Mother's education		
		Male	***Female***	***NoWhite***	***White***	**None**	**Some**	**Higher**
PMAT	-0.0146	-0.015	-0.0152	-0.0428	-0.1037	0.0647	-0.0055	0.0373
	[0.0063]**	[0.0063]**	[0.0069]**	[0.0380]	[0.0757]	[0.0476]	[0.0389]	[0.0458]
Number of obs.	104431	98580	100268	85238	86560	57541	103152	34071
R2	0.521	0.411	0.432	0.779	0.799	0.717	0.329	0.855
Panel (b): log(infant mortality rate)								
PMAT	-0.0249	-0.0381	-0.0387	-0.1105	-0.0439	-0.0377	-0.1554	-0.0279
	[0.0137]**	[0.0161]**	[0.0154]**	[0.0503]**	[0.0340]**	[0.0603]**	[0.0741]**	[0.0940]
Number of obs.	85360	73532	67393	55222	61498	17689	67725	25676
R2	0.436	0.429	0.412	0.753	0.68	0.564	0.504	0.798
Municipality, year FE	✓	✓	✓	✓	✓	✓	✓	✓
Political party FE	✓	✓	✓	✓	✓	✓	✓	✓
Mother characteristics	✓	✓	✓	✓	✓	✓	✓	✓
Time trends interacted with:	✓	✓	✓	✓	✓	✓	✓	✓
Basic characteristics	✓	✓	✓	✓	✓	✓	✓	✓
$\Delta Taxespc_{96-98}$	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Each coefficient is from a different regression. From column 2 to 6, regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. Maternal characteristics include average age, proportion of births by mothers with less than 25 years, proportion of births by married mothers, proportion of births by black mothers, and proportion of births by uneducated mothers. The observations are weighted by the number of births. Robust standard errors (reported in brackets) are clustered at the municipality level. With the exception of column 5, all observations are weighted by the number of births.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table 9 – Robustness of Infant Health effect of PMAT , pre-existing trends, Brazilian municipalities, 1998–2017

	Dependent variable is			
	ln(LBW rate)	ln(IM rate)	ln(FM rate)	Tax revenues
Program year 0	-0.0078 [0.0072]	-0.0051 [0.0130]	0.0039 [0.0317]	3.7591 [3.3817]
Program year 1	-0.0069 [0.0062]	-0.0355 [0.0154]	-0.0458 [0.0282]	10.0137 [5.5425]
Program year 2	-0.0329 [0.0067]	-0.0287 [0.0252]	-0.0279 [0.0245]	12.6023 [6.3721]**
Program year 3	-0.0171 [0.0074]	-0.0289 [0.0163]	-0.036 [0.0371]	20.1764 [7.6151]***
Program year 4	-0.0174 [0.0077]**	-0.0132 [0.0189]	-0.0356 [0.0297]**	29.4334 [9.3310]***
Program year 5	-0.0146 [0.0090]**	-0.0157 [0.0198]*	-0.039 [0.0296]***	32.1596 [9.7018]***
Program year 6	-0.0246 [0.0114]**	-0.0097 [0.0175]*	-0.0528 [0.0255]**	32.5881 [11.0019]***
Program year 7	-0.0166 [0.0092]*	-0.0156 [0.0212]**	-0.031 [0.0250]***	42.8951 [13.0753]***
Program year 8	-0.0267 [0.0108]**	0.0171 [0.0241]	-0.0318 [0.0296]***	55.2471 [13.7220]***
Program year 9	-0.0451 [0.0116]***	-0.0265 [0.0259]*	-0.0347 [0.0301]***	52.0298 [12.8347]***
Program year 10	-0.0233 [0.0109]**	-0.0135 [0.0229]	-0.0456 [0.0358]***	53.2157 [14.2861]***
Program year 11	-0.0403 [0.0110]***	-0.0233 [0.0321]**	-0.0458 [0.0302]***	59.3462 [9.5429]**
Program year 12	-0.0284 [0.0118]**	-0.0272 [0.0334]*	-0.0462 [0.0335]***	54.0047 [10.6831]*
Program year 13	-0.0375 [0.0134]***	-0.0406 [0.0370]*	-0.0402 [0.0332]***	56.8554 [10.6538]*
Program year 14	-0.0415 [0.0140]***	-0.0042 [0.0417]*	-0.0205 [0.0363]***	55.2533 [13.5292]***
Program year 15	-0.0356 [0.0139]**	-0.0291 [0.0533]**	-0.0407 [0.0337]***	40.4512 [19.1125]**
Program year 16	-0.059 [0.0244]**	-0.0391 [0.0541]***	-0.0304 [0.0474]***	46.2844 [30.9888]***
Program year 17	-0.0525 [0.0230]**	-0.0465 [0.0814]***	-0.0202 [0.0551]**	50.9562 [29.9284]***
Before program year 2	0.00219 [0.0180]	-0.00119 [0.0191]	0.0098 [0.0241]	-0.2623 [4.8375]
Before program year 3	-0.00115 [0.0130]	0.0082 [0.0198]	0.0012 [0.0382]	2.15 [7.2333]
Before program year 4	-0.0081 [0.0106]	0.00171 [0.0328]	0.0075 [0.0434]	-2.7337 [8.2849]
Before program year 5	-0.00101 [0.0107]	0.00382 [0.0244]	0.0024 [0.0300]	2.2482 [8.7035]
Before program year 6	-0.0086 [0.0099]	0.00485 [0.0273]	0.0012 [0.0284]	1.0642 [9.6968]
Before program year 7	-0.0034 [0.0065]	0.00712 [0.0300]	0.0082 [0.0396]	0.6262 [10.7184]
Number of obs.	105043	87303	78391	84479
R2	0.523	0.43	0.326	0.491

Notes: Each coefficient is from a different regression. The observations are weighted by the number of births. Robust standard errors (reported in brackets) are clustered at the municipality level. The main independent variables are: dummies indicating number of years into the program. The specification used is the equation 5.1. The comparison year in this regression is $j = 1$.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 10 – The effect of PMAT on Number of Births

	Dependent variable is			
	# births	birth rate	log(birth rate)	log(# births)
PMAT	-208.7807	0.0131	-0.033	-0.0007
	[72.7963]*	[0.0107]	[0.0076]	[0.0001]
Number of obs.	109070	109070	109070	109070
R2	0.995	0.966	0.546	0.635
Municipality, year FE	✓	✓	✓	✓
Political party FE	✓	✓	✓	✓
Mother characteristics	✓	✓	✓	✓
Time trends interacted with:				
Basic characteristics	✓	✓	✓	✓
$\Delta Taxespc_{96-98}$	✓	✓	✓	✓

Notes: Each coefficient is from a different regression. Regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. Maternal characteristics include average age, proportion of births by mothers with less than 25 years, proportion of births by married mothers, proportion of births by black mothers, and proportion of births by uneducated mothers.Robust standard errors (reported in brackets) are clustered at the municipality level.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 11 – The effect of PMAT on Fertility Decision
(Pnad analysis:1998-2015)

	Dependent variable is			
	Children up to 1 year	Children up to2 year	Children up to 3 year	Children up to 4 year
PMAT	0.0052	0.006	0.0072	0.0094
	[0.0015]	[0.0020]	[0.0024]	[0.0029]
Number of obs.	1365574	1365574	1365574	1365574
R2	0.006	0.007	0.009	0.009
Municipality, year FE	✓	✓	✓	✓
Political party FE	✓	✓	✓	✓
Time trends interacted with:				
Basic characteristics	✓	✓	✓	✓
$\Delta Taxespc_{96-98}$	✓	✓	✓	✓

Notes: Each coefficient is from a different regression. Regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health .Robust standard errors (reported in brackets) are clustered at the municipality level.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

Table 12 – The of PMAT on Mothers' Characteristics

	Dependent variable is								
	Head of Household	Illiterate	More than 12 years of Education	Years of Education	White	Nonwhite	Urban	Married	Age
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PMAT	-0.0068	0.0108	-0.0004	-0.3216	-0.0081	0.0001	-0.0418	-0.0089	-0.0588
	[0.0030]	[0.0019]***	[0.0034]	[0.0578]***	[0.0056]	[0.0024]	[0.0081]	[0.0092]	[0.0432]
Number of obs.	1365574	1365574	1365574	1365415	1365405	1365405	1365574	205941	1365574
R2	0.022	0.047	0.045	0.113	0.183	0.045	0.194	0.021	0.009
Municipality, year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Political party FE	✓	✓	✓	✓	✓	✓	✓	✓	✓
Time trends interacted with:									
Basic characteristics	✓	✓	✓	✓	✓	✓	✓	✓	✓
$\Delta Taxespc_{96-98}$	✓		✓	✓	✓	✓	✓	✓	✓

Notes: Each coefficient is from a different regression. From column 2 to 6, regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. The observations are weighted by the number of births. Robust standard errors (reported in brackets) are clustered at the municipality level. With the exception of column 5, all observations are weighted by the number of births.

***Significant at the 1 percent level.

**Significant at the 5 percent level.

*Significant at the 10 percent level.

Table 13 – The effect of PMAT on Migration Patterns

	All Sample (1)	All Sample (2)	More than 8 years with PMAT (3)	less than than 4 years with PMAT (4)
	Panel (A): Log (Total Migrant Rate)			
PMAT Status	0.001	-0.0097	-0.0052	-0.0078
	[0.0239]	[0.0226]	[0.0320]	[0.0441]
Number of obs.	15189	15131	14459	14391
R2	0.014	0.847	0.842	0.827
	Panel (B): Log(Migrant rate 25 - 55 years)			
PMAT Status	-0.0057	-0.002	-0.005	-0.0005
	[0.0235]	[0.0284]	[0.0407]	[0.0508]
Number of obs.	15185	15127	14455	14387
R2	0.011	0.826	0.821	0.809
	Panel (C): Log(Total Female Migrant Rate)			
PMAT Status	-0.0045	-0.0038	-0.0079	-0.0014
	[0.0235]	[0.0236]	[0.0334]	[0.0421]
Number of obs.	15187	15129	14457	14389
R2	0.016	0.847	0.841	0.828
	Panel (D): Log(Total Male Migrant Rate)			
PMAT Status	0.0084	-0.0023	0.0003	-0.0024
	[0.0247]	[0.0237]	[0.0341]	[0.0476]
Number of obs.	15187	15128	14456	14388
R2	0.02	0.842	0.837	0.822
	Panel (E): Log(Migrant Rate of Female 22-55 Years)			
PMAT Status	-0.0077	0.0012	0.0079	-0.0084
	[0.0231]	[0.0277]	[0.0385]	[0.0476]
Number of obs.	15178	15120	14449	14381
R2	0.001	0.823	0.817	0.805
	Panel (F): Log(Migrant Rate ofMale 22-55 Years)			
PMAT Status	-0.0072	0.0003	0.0093	-0.0093
	[0.0245]	[0.0318]	[0.0475]	[0.0565]
Number of obs.	15174	15115	14443	14375
R2	0.003	0.82	0.814	0.801
Municipality, year FE	✓	✓	✓	✓
Time trends interacted with:				
Basic characteristics	✓	✓	✓	✓
$\Delta Taxespc_{96-98}$	✓	✓	✓	✓

Notes: Each coefficient is from a different regression. From column 2 to 4, regressions control for municipality fixed effects. Basic characteristics are time-invariant variables that include pre-PMAT per capita GDP, population, mean level of education, the share of services in GDP, the share of rural population, Gini Index, unemployment rate, rural population rate, municipality area, altitude, distance to capital, temperature, rainfall, semiarid region dummy, IFDM Education ,and IFDM Health. Robust standard errors (reported in brackets) are clustered at the municipality level. Observations are weighted by population. The estimated equation is: $y_{it} = \alpha + \beta \, \mathbf{Post}_t \times \mathbf{PMAT}_i + \text{time} \times \text{Z}_i + \delta_i + \gamma_t + \xi_r$. Where $\mathbf{Post}_t$ is an indicator equal to 1 if the observation is from 2010 and zero in another case.
***Significant at the 1 percent level.
**Significant at the 5 percent level.
*Significant at the 10 percent level.

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