Initial Conditions and School Performance: An Analysis of Mãe Coruja Pernambucana Program *

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Abstract

This study examines the impact of the Mãe Coruja Pernambucana Program (PMCP), a social policy targeting pregnant women and young children in vulnerable areas of Pernambuco, Brazil, on long-term educational outcomes. We assess whether early-life interventions influenced 5th-grade student performance using data from the Pernambuco Educational Assessment System (SAEPE) between 2008 and 2018. To estimate the program's effect, we apply the Synthetic Difference-in-Differences (SDID) method, comparing municipalities that adopted the program early with those never treated. Our results show a marginally significant improvement in mathematics scores, with an estimated gain of 3.54 points on the SAEPE scale. No significant effect was found for Portuguese. Placebo tests support the robustness of the findings. These results are consistent with literature on learning dynamics, suggesting that early-life interventions can be especially effective in cumulative subjects like mathematics. Conversely, Portuguese skills appear less influenced by initial conditions. This study adds to the limited evidence on the long-term educational effects of prenatal and early childhood programs in Brazil and underscores the potential of multisectoral policies to promote human capital beyond immediate health outcomes. **Key words: Initial Conditions, Education, Learning Dynamics**

Abstract

Este estudo analisa o impacto do Programa Mãe Coruja Pernambucana (PMCP), uma política social voltada para gestantes e crianças pequenas em regiões vulneráveis de Pernambuco, Brasil, sobre resultados educacionais de longo prazo. Avaliamos se intervenções na primeira infância influenciaram o desempenho de alunos do 5º ano, utilizando dados do Sistema de Avaliação Educacional de Pernambuco (SAEPE) entre 2008 e 2018. Aplicamos o método de Diferenças em Diferenças Sintéticas (SDID) para estimar o efeito médio do programa, comparando municípios que aderiram ao PMCP na primeira fase de implementação com aqueles nunca tratados. Os resultados indicam um impacto positivo e marginalmente significativo nas notas de Matemática, com um ganho estimado de 3,54 pontos na escala SAEPE. Nenhum efeito estatisticamente significativo foi identificado para Português. Testes placebo reforçam a robustez dos achados. Esses resultados estão alinhados à literatura sobre dinâmicas de aprendizagem, indicando que intervenções precoces podem ser mais eficazes em disciplinas cumulativas, como Matemática. Em contraste, o desempenho em Português parece menos dependente das condições iniciais de vida. Este estudo contribui para a escassa evidência sobre os efeitos educacionais de longo prazo de programas pré-natais e da primeira infância no Brasil, destacando o potencial de políticas multissetoriais para promover o capital humano além dos indicadores imediatos de saúde.

Palavras-chave: Condições Iniciais, Educação, Dinâmicas de Aprendizagem

Classificação JEL: I18, I14, I24, I20

Área de Submissão: 12 – Desigualdade, Pobreza e Exclusão Social

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1. Introduction

This paper examines the effects of the Mãe Coruja Pernambucana Program (PMCP) on children 's school performance. The PMCP was created in 2007 and implemented in 2008, becoming a state public policy with Law No. 13, 959 in 2009. Today, the program operates in 105 municipalities across Pernambuco, supporting pregnant women and children through an intersectoral network involving 11 state departments. It provides prenatal care, professional training, inclusion in social programs, education, citizenship empowerment, and access to health and cultural services. Its primary goal is to ensure maternal and child well-being while promoting early childhood development.

Early childhood, defined as the first five years of a child's life, is considered the most critical period for developing human skills. The literature highlights this stage as the most effective and cost-efficient for reducing inequalities, breaking the cycle of poverty, and fostering skill development Carneiro and Heckman (2003).

Recent literature has consistently emphasized that early childhood, particularly the first years of life, represents a critical window for the development of cognitive and socioemotional skills. According to the "life course" approach, this period offers a unique opportunity for interventions that can significantly influence long-term outcomes Conti et al. (2019). This framework posits that biological, behavioral, and psychosocial factors throughout the life cycle influence health and human capital development. A key premise is that skill formation is dynamic and cumulative: the acquisition of early skills increases the productivity of subsequent investments Currie and Rossin-Slater (2015).

Building on this model, Cunha and Heckman (2007) propose a skill formation technology emphasizing the complementary and self-reinforcing nature of early investments. Their findings suggest that returns on early childhood interventions are typically higher than those made later in life. Empirical evidence supports this claim. For instance, Heckman et al. (2010) examined the Perry Preschool Program in the United States, which provided educational support to disadvantaged children. The study documented long-term benefits such as higher educational attainment, lower crime rates, and improved employability, underscoring the role of high-quality early childhood education in fostering both cognitive and non-cognitive development.

The broader literature on early conditions and future outcomes has more recently expanded the notion of the most effective time frame for the implementation of public policies beyond the post-birth period, placing some emphasis on the importance of the gestational phase for child development and the improvement of their outcomes in subsequent stages of their life cycle. A series of studies point to a correlation between prenatal care and improved school performance in children, considering the development of cognitive skills as a key channel for transmitting this effect Henrichs et al. (2011); Brownell et al. (2016).

Over the years, based on the consolidation of evidence from this literature and the success and effectiveness of pioneering public interventions, numerous programs have emerged worldwide aiming for long-term social benefits through actions that ensure a higher-quality early childhood and gestational period for the individuals targeted by these policies.

Interventions targeting the early years have also proven effective in low-income contexts. Attanasio et al. (2020), analyzing a home-visitation program in Colombia based on the Jamaican early stimulation model Gertler et al., found that weekly sessions focused on

mother-child interactions significantly improved child development and maternal behavior. Similarly, Baker-Henningham et al. (2005) demonstrated that training mothers to respond sensitively and provide structured home environments helped mitigate developmental delays in impoverished households. In Brazil, Carneiro et al. (2021) showed that adverse prenatal events, such as maternal illness during pregnancy, negatively affected children's cognitive outcomes and school performance years later. These findings highlight the formative role of health and family conditions even before birth.

One example is the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in the United States, a nutritional supplementation program for pregnant women and children up to five years old. Chorniy et al. (2018) analyzed WIC's effects from the perspective of the long-term impacts of prenatal care on children's lives. Their findings indicate lower rates of grade repetition and a reduced incidence of ADHD and other common childhood mental disorders among individuals who entered the WIC program during the gestational phase.

A strong example of a public policy based on this evidence in Brazil is the Primeira Infância Melhor (PIM) program in Rio Grande do Sul. Launched in 2003, PIM aims to support early childhood development in the state by assisting mothers from pregnancy until their child reaches six years of age. The program provides support to families, particularly those in socially vulnerable situations, through regular home visits. Studies have shown that PIM has contributed to positive outcomes, including reductions in malnutrition rates and school violence Nishimura and Mesquita (2018); Junior et al. (2021).

Extending these insights to educational outcomes, Barros et al. (2001) argue that cognitive ability plays a central role in determining the returns to education in Brazil. Their analysis suggests that the effect of schooling on future earnings is not uniform but depends on prior learning and preparedness, reinforcing the importance of ensuring that children enter school developmentally ready to learn. In a similar vein, Felfe and Lalive (2018) found that expanding access to high-quality childcare in Germany improved reading and math outcomes, especially for children from disadvantaged backgrounds. This mirrors patterns observed in developing countries, where unequal access to early education tends to exacerbate initial disadvantages.

In the Brazilian context, several studies have documented the positive effects of preschool attendance on later academic performance. Felício, Vasconcellos et al. (2007), using data from SAEB 2003 and Prova Brasil 2005, employed both propensity score matching and fixed effects models to address selection bias and endogeneity. They found proficiency gains in mathematics and Portuguese ranging from 6.6% to 9.6% attributable to preschool attendance. Likewise, Reyna (2019) used quantile regression to show that students who had attended preschool outperformed their peers across all proficiency levels, with impacts increasing along the distribution. For example, the effect on mathematics proficiency ranged from 2.68 points at the 10th quantile to 6.88 points at the 90th.

Beyond early childhood education, programs targeting foundational skills during primary schooling have also demonstrated significant impacts. Faria and Chein (2016) evaluated the Intervenção Pedagógica/ Alfabetização no Tempo Certo (PIP/ATC) program in Minas Gerais, which aimed to improve literacy and numeracy through coordinated pedagogical strategies involving schools, teachers, and families. Using a difference-in-differences approach with Prova Brasil data, the authors identified notable gains in both mathematics

and Portuguese, with impacts ranging from 5 to 8 points depending on the year and subject.

Longitudinal studies provide further insights into academic development dynamics. Brooke et al. (2014), drawing on GERES data, observed that time is the strongest predictor of student proficiency in both Portuguese and mathematics, though the growth patterns differ. While Portuguese learning tends to decelerate, mathematics proficiency accelerates after an initial lag—highlighting the importance of formal instruction. The study also found widening achievement gaps in mathematics between students in public and private schools, suggesting that institutional factors play a particularly strong role in this subject area.

This is supported by Moraes et al. (2021), who argue that mathematics learning is inherently sequential and cumulative. Early conceptual understanding is critical; students who fall behind in foundational skills often face compounding difficulties in later grades. These early gaps not only hinder future academic performance but also undermine students' confidence and motivation. The authors emphasize the need for early identification and targeted intervention to promote numeracy development.

Caldwell and Bradley (1979) found that the quality of the home environment, especially factors measured by the Home Inventory (e.g., availability of books and toys, reading encouragement), strongly correlates with later academic performance. Bassetto (2019) similarly identified household income and maternal education as significant predictors of children's academic outcomes, particularly among students with lower proficiency. Machado (2008), analyzing SAEB data, concluded that family background variables exert greater explanatory power on student achievement than school-level factors, such as infrastructure, class size, or teacher training. These findings are echoed in studies by Barros et al. (2001), Barbosa and Fernandes (2001), and Soares et al. (2020), all of which highlight the central role of family in shaping educational trajectories.

Taken together, the literature suggests that although PMCP may lack a focused pedagogical component for early childhood, its comprehensive approach—encompassing health, nutrition, and family support—may still produce positive educational outcomes, especially in mathematics. This study hypothesizes that the program's indirect effects on key family background variables are capable of improving school performance among participating children, thereby compensating for its limited emphasis on early education itself.

In this scenario the Mãe Coruja Pernambucana Program (PMCP) was created. In 2017, the Government of the State of Pernambuco, in partnership with the Maria Cecília Souto Vidigal Foundation, published the book *Mãe Coruja Pernambucana* Governo do Estado de Pernambuco (2017). This material serves as a compendium of information about the PMCP, covering its creation, formulation, implementation strategy, target audience testimonials, operational model, methodology, and program structure. The book also includes a chapter exclusively dedicated to impact analyses, assessing the program's effects on a range of maternal and child health indicators influenced by the PMCP. The analyses presented in the book identified significant impacts of the PMCP on several indicators by comparing municipalities that benefited from the program with those that did not. These effects included increased access to prenatal care and cesarean deliveries, a reduction in teenage pregnancy, and a rise in the prevalence of exclusive breastfeeding. Positive impacts were also observed in reducing mortality rates, after applying adjustments for initial conditions using a difference-in-differences model. This approach selected non-beneficiary municipalities with similar initial socioeconomic conditions, addressing potential selection bias in the

program's evaluation.

Additionally, Cabral (2016) conducted one of the few econometric studies evaluating the impact of the program on maternal and infant mortality indicators in the state. The study found significant positive effects on infant mortality rates in the municipalities covered by the program, as well as an increase in the proportion of prenatal care consultations provided to pregnant women benefiting from the PMCP. Furthermore, a growing effect on these indicators was observed over the duration of the municipality's participation in the program, with a substantial impact starting from its first year of implementation.

Few additional studies have assessed the potential impacts of the PMCP, and most existing research has focused primarily on maternal and child health and mortality indicators. The lack of impact evaluations beyond mortality rates presents a valuable opportunity to assess the program from the perspective of child development, particularly through long-term outcomes such as academic performance. This leads to the central question of the present study: Has the Mãe Coruja Pernambucana Program had any effect on children's school performance?

The main finds of our study show a positive and significant impact on mathematical proficiency, 3.54 points in the SAEP scale, suggesting that early interventions such as the PMCP can yield lasting benefits in subjects that build progressively over time. This result aligns with the theoretical expectations and empirical findings of Moraes et al. (2021) and Brooke et al. (2014), which emphasize the cumulative nature of mathematics learning. By contrast, no measurable effect was observed for Portuguese proficiency, consistent with the view that language skills tend to be less dependent of the early-life conditions.

The findings of this study aim not only to contribute to the specific literature on the PMCP, which lacks analyses beyond its impacts on mortality rates and maternal and child health, but also to a broader body of research evaluating the long-term effects of prenatal and early childhood interventions on individual development. Since the PMCP operates on multiple fronts, there may be two distinct sources of impact from the program: actions focused on prenatal care and actions aimed at early childhood. These two sets of interventions can even be assessed separately within this study to better identify the transmission channels through which the effects on children exposed to the program were produced. Specifically, this paper uses data from the municipal level and an empirical strategy based on the Synthetic Control Method, to achieve this purpose.

In addition to this introductory section, the present study is structured into five more sections. Section 2 presents the institutional framework of the PMCP, offering a more detailed overview of the program. Section 3 discusses the database, including descriptive analyses and the empirical strategy adopted. In Section 4, the estimation results are presented and interpreted. Finally, Section 5 outlines the conclusions and final remarks of the study.

2. Mãe Coruja Pernambucana Program

Implemented in 2008, the PMCP aimed to reduce the high rates of infant and maternal mortality in the state of Pernambuco, as part of a state public policy focused on expanding primary health care. Later, in 2012, the program was separated from this broader policy, operating independently with its own budget and being institutionalized by the state government.

The PMCP was established based on an intersectoral and decentralized management model, integrated across all stages: planning, implementation, monitoring, and evaluation, covering local, regional, and state levels. The central coordination involves two offices (the Governor's Office and the Office of Strategic Projects), the Governor's Special Advisory Office, and nine secretariats, namely: Health; Education; Social Development, Child and Youth; Women's Affairs; Planning and Management; Agriculture and Agrarian Reform; Micro and Small Business, Labor and Training; Culture; and Tourism, Sports and Leisure.

The PMCP seeks to ensure women's reproductive rights and children's rights. It aims to support a healthy pregnancy and child development process. Furthermore, the program carries out actions that go beyond purely clinical care, aiming to strengthen family emotional bonds, promote food and nutritional security for mothers and children, and foster the socioeconomic autonomy of families. The network of PMCP actions is multidisciplinary, based on the understanding that infant mortality is a multicausal phenomenon with various determinants. Therefore, the program extends beyond health to include educational and cultural policies with a community-focused approach.

Specifically, the PMCP promotes and carries out:

- Education and culture circles;
- Professional qualification courses for mothers;
- Workshops on food and nutritional security;
- Inclusion in social programs through Regional Social Assistance Centers;
- Distribution of baby kits to pregnant women;
- Incentive for prenatal care;
- Childbirth and postpartum care;
- Reorganization of the childbirth care network;
- Promotion of breastfeeding;
- Monitoring and promotion of child vaccination;
- Access to birth registration;
- Monitoring of child growth and development.

The program's implementation focused on the structuring of the "Cantos da Mãe Coruja" (Mother Owl Corners), which are welcoming spaces where pregnant women are registered. These spaces serve as local cells of the PMCP, with state-selected professionals acting as program coordinators in the municipalities. It is within these units that monitoring begins once a pregnancy is diagnosed. This monitoring includes registration and tracking throughout prenatal care, childbirth, and postpartum. Children are followed from birth until the age of five, along with their families.

In addition to registration and monitoring, professionals at the Cantos da Mãe Coruja are responsible for coordinating the actions of the various state and municipal secretariats involved in the program within the municipality. Their goal is to enhance the effectiveness of government and organized civil society efforts to improve the living conditions of pregnant women, children, and their families. In cases where pregnant women have difficulty traveling, professionals must create alternatives to ensure they received prenatal care through Programa Saúde da Família (PSF) clinics, Centro de Referência de Assistência Social (Cras), and the Instituto Pernambucano de Agronomia (IPA).

2.1. Registration and Monitoring

The program welcomes women who are users of the Unified Health System (SUS) upon confirmation of pregnancy. This is the only prerequisite for registration. To enroll, the pregnant woman must go to the Canto Mãe Coruja in her municipality, bringing her SUS Pregnancy Card and an ID. Women who are up to five months pregnant are registered and monitored by the Canto Mãe Coruja professionals. If the pregnancy is more advanced, the registration will be reviewed upon proof of at least four prenatal consultations through SUS. After confirming at least seven prenatal care consultations, registered pregnant women become eligible to receive the Baby Kit, which contains items to assist with hygiene, health, and comfort for the mother and newborn. Children whose pregnancy and delivery were supervised by the State become part of the program and can be monitored until the age of five.

2.2. Implementation

The selection of regions and municipalities where the program would be implemented followed specific criteria, also considering the eleven Regional Health Management Offices (GERES) responsible for the state's 185 municipalities. The main criteria were infant mortality rate, Human Development Index (HDI), and Child Development Index (CDI). Municipalities with an infant mortality rate equal to or higher than 25 deaths per 1,000 live births and low HDI and CDI levels were prioritized. Additionally, if at least 50% of the municipalities within a GERES had an infant mortality rate above 25 deaths per 1,000 live births, the program would be implemented across all municipalities in that GERES.

Based on these parameters, implementation began in the microregion of Araripina (Araripe Hinterland), followed by the Moxotó Hinterland (VI GERES). Thus, 24 municipalities were included in the PMCP's first implementation phase. Over the years, the program expanded and currently operates in 105 of the state's 185 municipalities, following the established division of the State's Regional Health Management Offices (GERES), with priority given to municipalities within the VI and IX GERES due to their high infant mortality rates.

3. Database

3.1. Data

To measure educational performance, data were collected from the Sistema de Avaliação Educacional de Pernambuco (SAEPE), an annual assessment that evaluates the academic performance of public school children in the state of Pernambuco in the subjects of mathematics and Portuguese. The SAEPE proficiency scale for 5th-grade students is the same as

that used by the Sistema de Avaliação da Educação Básica (SAEB), ranging from 0 to 500 points. This performance indicator is derived using Item Response Theory (IRT).

The database provided by SAEPE aggregates students' individual proficiencies by educational stage through an arithmetic average of all students assessed, the average school proficiency for each evaluated stage in each year the exam is administered. Therefore, for each assessed school, the data includes the average proficiency, calculated as the arithmetic mean of individual student proficiencies for each educational stage between 2008 and 2018. The database also includes other school-level information, such as the municipality and Gerência Regional de Educação (GRE) to which each school belongs, as well as the number of students who took the exams at each evaluated stage.

3.2. Descriptive Analysis

This section presents a descriptive analysis of student proficiency outcomes in Mathematics and Portuguese, using graphical evidence from Figures 1 through 3 to explore trends and distributions of test scores between treated and control schools from 2008 to 2018. The aim is to assess both the effectiveness of program targeting and the evolution of academic performance over time.

We used SAEPE data for 5th-grade students in elementary school, starting from 2008, the year the program was implemented. Based on the ages of the children who participated in the PMCP, it is expected that the program's effect can be detected beginning in 2018, through the average school proficiencies published that year. The treatment group consists of schools located in municipalities that joined the PMCP in 2008, in order to capture the effect on children exposed to the program since gestation—that is, individuals who were exposed to all components of the program. The control group, in turn, consists of schools in municipalities that never joined the program, thereby isolating individuals who were never exposed to any of the PMCP's actions.

Figure 1 displays the trajectory of average proficiency scores in both subjects, disaggregated by treatment status. In both Mathematics and Portuguese, treated schools consistently demonstrate lower average scores throughout the entire period, suggesting that before the intervention, the schools of the treatment group had initially weaker academic performance. This pattern shows that municipalities with lower access to healthcare will probably have greater educational needs.

Despite the persistent gap, both the treated and control groups show a general upward trend in proficiency. From 2008 to 2016, performance gains are relatively modest for both groups. However, a notable acceleration in score growth is observed after 2016, especially in 2017 and 2018. This period aligns with the expected timeline for the program's long-term results, given that children exposed both in utero and after birth are beginning to take the SAEB test. Nevertheless, treated schools remained below control schools throughout the period, indicating that although the gap may have slightly narrowed, full convergence had not been achieved by 2018.

The graphics in Figure 2 further explores Mathematics proficiency by showing the distribution of average school-level scores for treated and non-treated schools across four key years: 2010, 2014, 2016, and 2018. In the earlier years (2010 and 2014), the distribution for treated schools is skewed to the left, reflecting their lower baseline performance. This visual evidence complements the averages shown in Figure 1 and strengthens the case for effective

Figure 1: Average Performance in SAEPE

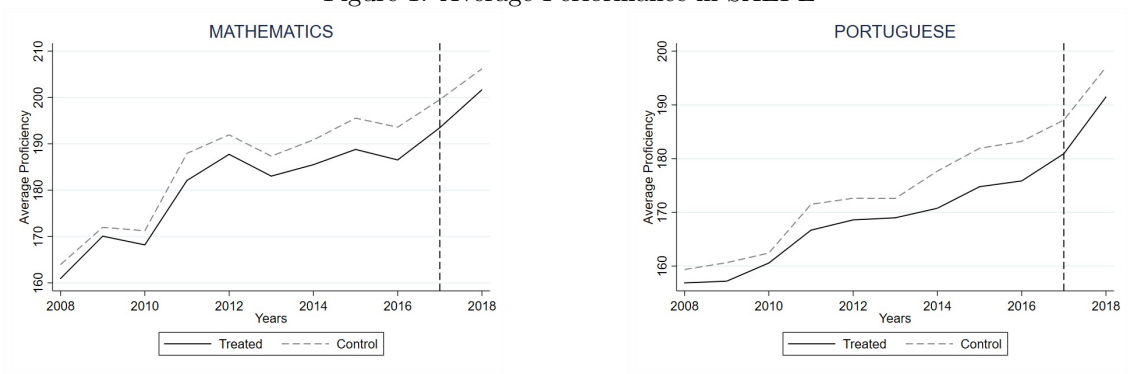

Figure 2: *
SAEPE 2008-2018

targeting. Over time, particularly by 2018, the distributions begin to converge. While the treated schools still trail the control group slightly, the gap appears to have diminished, which suggests that the treatment may have had an effect in the long term.

In the same way, Figure 3 provides the same analysis for Portuguese proficiency. Again, the earlier years show a clear separation between treated and control schools, with the treated group clustered at lower average scores. As time progresses, the distributions shift rightward for both groups, suggesting overall improvement. By 2018, the distribution for treated schools more closely resembles that of the control group, though a small performance gap remains. These changes in distribution imply that the intervention may have contributed not only to raising average scores but also to reducing performance disparities between treated and non-treated schools.

ogether, these descriptive results point to two key conclusions. First, the program appears to have successfully helped kids not only during the first child period, but also to achieve greater academic results, especially in math, as evidenced by the consistently lower starting points of the treated group. Second, although treated schools have shown substantial improvements over time—particularly in the latter years of the observation period—a measurable gap in proficiency remains when compared to control schools. This indicates progress but not full convergence. Importantly, the narrowing of both average scores and score distributions suggests that the program may have contributed to reducing educational inequality.

While these descriptive patterns are encouraging, they do not establish causality. Further empirical analysis using rigorous econometric techniques is required to identify the magnitude and statistical significance of the program's effects. Nevertheless, the descriptive evidence presented here offers a strong initial indication that the intervention not only achieved its main goal — reducing mother and child mortality rates — but may also have helped promote more equitable academic outcomes.

Figure 3: Distribution of Proficiencies: Mathematics

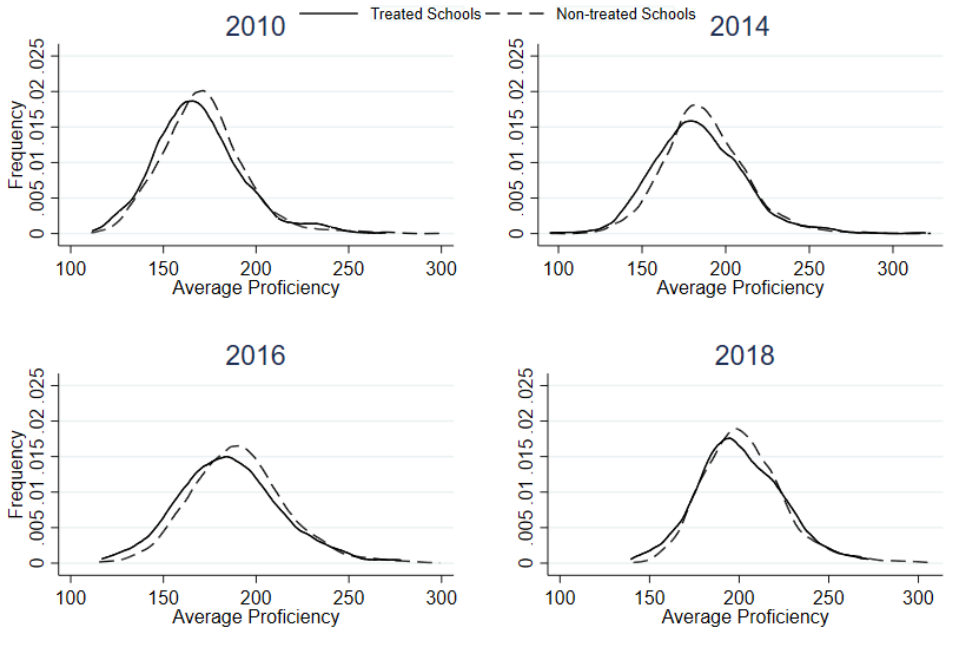

Figure 4: *
SAEPE 2008-2018

4. Empirical Strategy

As highlighted in the descriptive analysis of the graphs in Figure 1, certain divergences between the treatment and control group curves are observed in the pre-treatment periods, both for math and Portuguese test scores, albeit in different years. This behavior of the outcome variable for the treatment and control groups indicates that the parallel trends assumption does not consistently hold prior to the intervention. Furthermore, the initial implementation strategy of the program, as discussed in Section 2, was based on prioritizing areas with more alarming maternal and child health indicators. In this sense, the PMCP's preference for regions facing greater socioeconomic vulnerability complicates the selection of a valid counterfactual within the pool of untreated units.

This context prevents the adoption of a more traditional impact evaluation approach based on the Difference in Differences (DID) method, due to violations of the parallel trends assumption in the pre-treatment period, as well as the clear selection bias associated with the program's targeting criteria Roth (2022). To overcome the absence of parallel trends and the difficulty in selecting valid counterfactuals from the control group, the impact of PMCP will instead be estimated using the Synthetic Difference in Differences Method (SDID).

Initially introduced by Arkhangelsky et al. (2021) as a way to improve causal inference when the standard DID assumptions are too restrictive. The SDID estimator blends elements from both DID and Synthetic Control (SC) methods. DID is commonly applied when many units receive treatment and relies on assuming that treated and untreated units would have followed similar trends in the absence of treatment. By contrast, SC is typically used in

Figure 5: Distribution of Proficiencies: Portuguese

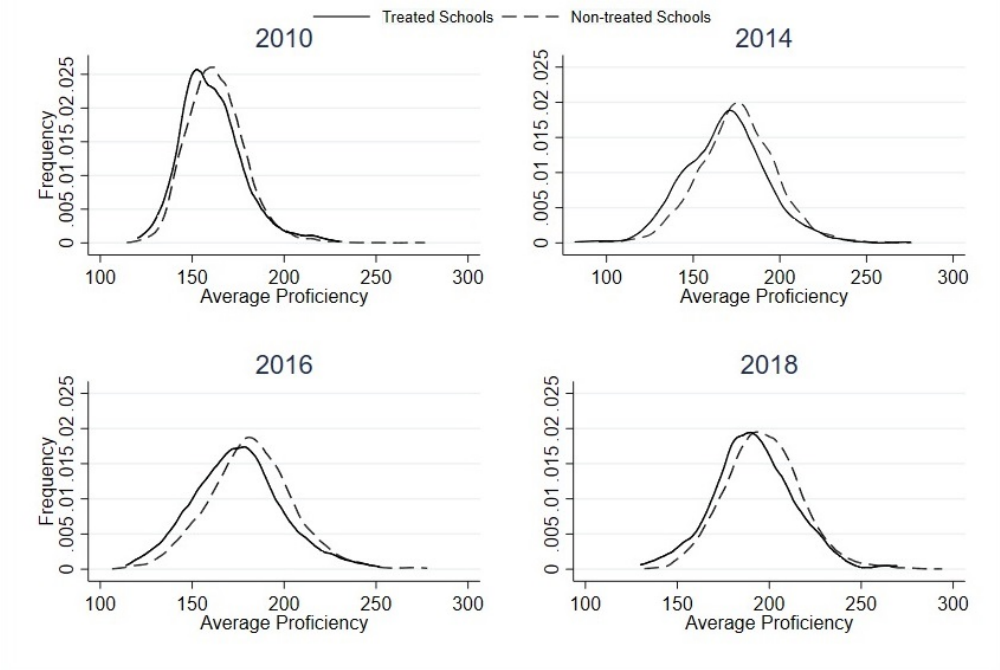

Figure 6: *
SAEPE 2008-2018

settings with few treated units and achieves balance by weighting control units to replicate pre-treatment trajectories of treated units. The SDID approach integrates these strategies by applying weights to both units and time periods, thereby refining the estimation of treatment effects.

Specifically, the SDID method begins with a balanced panel of N units and T time periods, where a subset of units is exposed to treatment after a given pre-treatment period. The method first computes unit weights that align the pre-treatment trends of the control group with those of the treated group, similar to the SC approach. It then calculates time weights to balance pre and post treatment periods. These weights are incorporated into a two-way fixed effects regression model—typical of DID—but applied in a "localized" fashion. The regression places greater emphasis on units and time periods that are more comparable to the treated group, thereby enhancing robustness by reducing reliance on poorly matched comparisons and improving precision by removing systematic, predictable components of the outcome.

Overall, the Synthetic Difference-in-Differences estimator offers a valuable contribution for empirical research in settings where treatment assignment is non-random and pre-treatment trends are not parallel. By combining the flexibility of SC with the structure of DID, SDID is particularly well-suited for applications involving multiple treated units and complex forms of heterogeneity, while maintaining robustness to violations of standard identifying assumptions.

The adoption of the SDID method is particularly well-suited to the PMCP context not only due to the methodological limitations posed by selection bias and non-parallel trends,

but also because of the program's complex and multidimensional nature. As discussed in Section 2, the broad set of actions implemented by the PMCP potentially influence various transmission channels that affect socioeconomic indicators, such as family income and quality of life. The program may, for example, impact parents' educational attainment and professional qualifications, access to and quality of education and health services (especially the latter), and the nutritional status of children and their families.

It is important to note that some school environment variables are, in principle, unaffected by the treatment and include aspects such as infrastructure, resources, and teacher quality. However, there is considerable uncertainty about the relevance of these school-level variables—particularly when compared to family background factors. Variables related to family background enjoy stronger empirical support in the literature regarding their explanatory power over student performance in standardized tests. In contrast, school effect variables tend to exhibit lower external validity, and the literature offers conflicting evidence about which aspects of school quality (e.g., inputs, teacher characteristics, administrative staff) actually influence educational outcomes Barros et al. (2001); Barbosa and Fernandes (2001); Machado (2008); Soares et al. (2020).

Consistent with these findings, Franco and Menezes-Filho (2017) show that student and family characteristics - such as socioeconomic status and school delay - are among the few variables consistently significant in explaining academic performance, regardless of the panel length or specification used. In contrast, observable school-level characteristics, including those of teachers and principals, demonstrated limited explanatory power, especially in public schools. Their results suggest that the Brazilian education system largely reproduces existing social inequalities, and that what makes a good school or teacher often cannot be captured by observable attributes.

Given these issues, including high-quality predictors in the model becomes particularly challenging, as social and income-related variables are likely to be influenced by the program's interventions. This would create endogeneity concerns and compromise the validity of the estimators. Additionally, school-related indicators that are not affected by the program may have limited explanatory power for the outcome of interest, thus offering little value when used as predictors in the model.

To avoid endogeneity and the inclusion of weak predictors, a simpler specification is adopted. Only lagged values of the outcome variables (average proficiency in math and Portuguese) over the entire pre-treatment period (2008–2017) will be used as predictors.

Nevertheless, specifications that rely solely on the lagged trajectory of the outcome variable are generally considered acceptable in contexts where data constraints prevent the inclusion of good predictors or where there is no theoretical justification for their inclusion.

In the context of the PMCP, we therefore treat the situation as one of data constraints, in which no set of high-quality predictors—supported by the literature and unaffected by the program—can be identified. To prevent bias, we opt not to include covariates that may have been influenced by the intervention. Although this estimation strategy has limitations, it represents a coherent and feasible alternative to address the challenges posed by the program's design. The treated unit is defined as the annual average of test scores (Mathematics and Portuguese) from schools located in the 24 municipalities that joined the PMCP in 2008, the same treatment curves shown in Figure 1.

The control units that comprise the donor pool were constructed using the same method,

aggregating average scores at the municipal level. In the main specification, only schools located in municipalities that never joined the program were included in the donor pool, resulting in a total of 79 units.

5. Results

This section presents the main finds of the article, the analysis of the possible effects of the Mãe Coruja Pernambucana Program on the proficiency level of children evaluated in the fifth grade in 2018. Figure 4 shows the path of the treated municipalities and the synthetic control unit. It is possible to see that in math proficiency the proficiency trajectory of the treated municipalities remained below that of the synthetic control unit until 2018, when the expected treatment effects emerged, and the treated municipalities demonstrated superior performance relative to the synthetic unit. Regarding Portuguese, the proficiency trajectory of the treated municipalities remained consistently below that of the synthetic control unit prior to the anticipated onset of treatment effects. In 2018, a partial convergence between the trajectories was observed, although the proficiency of the treated municipalities continued to lag behind the synthetic unit.

Figure 7: Proficiency Trajectory

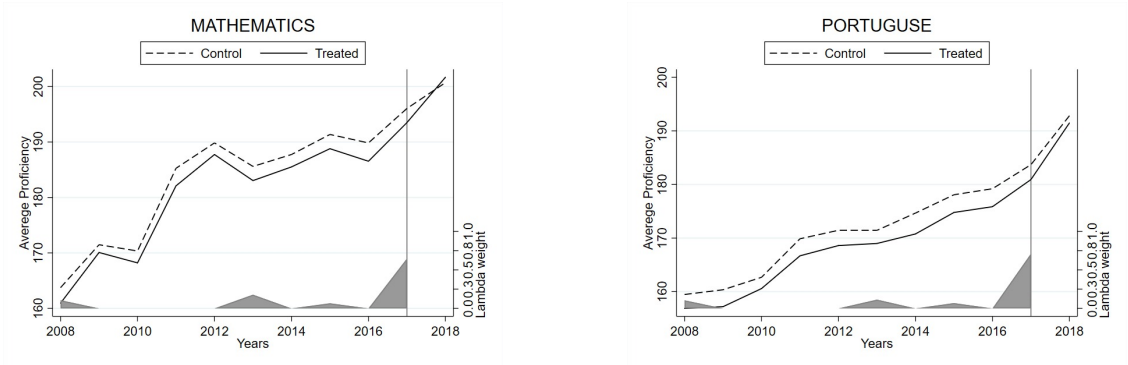

Figure 8: *
SAEPE 2008-2018

Table 1 shows the results of the synthetic Difference-in-Differences estimates. In 2018, the estimated proficiency score in mathematics for the control group was approximately 197 points, while the treated group reached around 201 points. The estimated Average Treatment Effect on the Treated (ATT) for mathematics was 3.54 points, with a p-value of 0.066. This suggests a positive and marginally significant effect of the PMCP on students' math performance. In contrast, the estimated ATT for Portuguese proficiency was 1.42, but the effect was statistically insignificant, even at the 10% level, indicating that the intervention did not produce measurable gains in Portuguese scores over the observed period.

These findings align with existing literature on learning dynamics. As Brooke et al. (2014) emphasize, mathematics proficiency tends to follow a cumulative and accelerating growth path, particularly after an initial lag, which makes it highly sensitive to structured and sustained instruction. The positive effect observed here may reflect the program's contribution to that trajectory. Moreover, the SDID results show that control units assigned

Table 1: Average Treatment Effect (ATT)

Outcome	Estimated impact
Proficiency in Mathematics	3.53826*
	(1.92114)
Average Proficiency in Portuguese	1.41502
	(1.75336)
Number of Treated Units	24
Number of Control Units	79

Note: Level of significance *p < 0.1, **p < 0.05, ***p < 0.01

to never-treated groups experienced a decline in mathematics scores, while treated units maintained or improved their proficiency, underscoring the potential long-term benefits of early interventions like the PMCP.

The modest results for Portuguese are also consistent with previous findings. Language acquisition, according to Brooke et al. (2014), tends to decelerate over time, and foundational skills are often acquired earlier in a student's academic trajectory. Therefore, interventions that improve early life conditions may have a smaller or more diffuse impact on Portuguese performance in later grades. This distinction highlights the need for differentiated expectations when assessing the impact of broad social programs across subject areas.

Unlike most studies on educational performance in Brazil, which focus on short-term impacts of school-based interventions, this research investigates whether improvements in early childhood conditions can yield persistent academic benefits. Rather than evaluating an educational policy directly targeting schools, the PMCP represents a broader social program aimed at supporting families during the prenatal and early childhood period. Our results suggest that such early-stage interventions can produce meaningful long-term gains in mathematics achievement—especially given the sequential nature of math learning as noted by Moraes et al. (2021)—while their effects on language proficiency may be less pronounced in later stages of schooling.

5.1. Robustness

To assess the robustness of our findings, we conducted a series of placebo tests following the approach proposed by Arkhangelsky et al. (2021). The placebo procedure consists of randomly assigning treatment status to a different set of units in order to verify whether similar effects would emerge if the treated group were selected arbitrarily. The idea is to ensure that the estimated effects in the main analysis are not the result of random variation or sample-specific characteristics.

In the baseline specification, we have 24 treated units and 79 control units, observed over 11 periods. In the robustness checks, we keep the same structure and re-estimate the model using alternative randomly selected treated groups. In specification (1), 27 out of the 103 units are randomly assigned as treated. The same number of treated units is used in specification (2), but with a different draw. In specification (3), 30 units are randomly treated.

Table 2: Robustness Checks

Outcome	(1)	(2)	(3)
Average Proficiency in Mathematics	-1.87024	-1.46602	-2.74405
	(2.10651)	(2.1571)	(2.00099)
Average Proficiency in Portuguese	0.30875	-1.47378	-0.83869
	(1.7737)	(1.89407)	(1.79628)
Number of Treated Units	24	27	30
Number of Control Units	79	76	73

Note: Level of significance *p < 0.1, **p < 0.05, ***p < 0.01

The results, displayed in Table 2, show that the placebo estimates do not replicate the magnitude or significance of the effects found in the main analysis. This provides further support for the validity of the original results.

6. Final Remarks

This study set out to investigate the impact of the PMCP (Programa Mãe Coruja Pernambucano) on the future outcomes of treated individuals by examining the average performance of schools in the 5th grade of primary education in mathematics and Portuguese, as measured by the SAEPE exams in 2018. As our empirical strategy, we employed the synthetic difference-in-differences method. The treated group comprises 24 municipalities that were the first to join the program in 2008, while the control group was constructed using a weighted average of the school-level proficiency scores of 79 municipalities that never joined the program, with weights assigned by the method.

We find a statistically significant and substantively relevant impact in mathematics, especially when compared to results from pedagogical interventions evaluated through assessments that use the same scoring scale as SAEPE, such as Prova Brasil. In absolute terms, the program increased math scores by approximately 3.54 points. In contrast, we found no statistically significant impact on Portuguese language scores.

The robustness checks reinforce the credibility of the main findings. Placebo tests using alternative randomly selected treated groups failed to replicate the effects observed in the baseline specification. This supports the conclusion that the positive impact on mathematics is not driven by random variation or sample-specific characteristics, but rather reflects a genuine effect of the program.

It is crucial to consider the established relationship between prenatal interventions and reductions in infant mortality, as well as the selection bias introduced by mortality. The survival of children who would otherwise be at high risk of death may lead to an underestimation of the average treatment effect, especially if one isolates the effect of prenatal care. The PMCP's positive effects on child survival likely ensured the survival of a segment of the population that is socioeconomically more vulnerable and thus exposed to harsher initial life conditions—key determinants of future academic outcomes. Therefore, it is plausible that, within the specific operational framework of the PMCP, prenatal assistance alone may be insufficient to produce net educational gains for the treated children. Instead, complemen-

tary interdisciplinary actions aimed at improving early-life conditions are likely necessary to achieve such outcomes.

Overall, this study contributes to the growing body of evidence on the importance of early life interventions for long-term human capital outcomes. Unlike traditional educational policies that focus on in-school factors, the PMCP targets the prenatal and early childhood period through a network of interdisciplinary actions aimed at improving the family environment and child development conditions. Our results suggest that such policies—when sustained and well-structured—can translate into meaningful academic gains, particularly in domains that build cumulatively over time, such as mathematics. These findings highlight the relevance of designing public policies that go beyond the school setting to address the broader determinants of learning and development.

However, this study is not without limitations. First, the rollout of the PMCP was not random: the program initially targeted municipalities with worse maternal and child health indicators, which raises concerns about selection bias. Although the SDID method accounts for pre-treatment trends, it is possible that these municipalities had unobserved structural disadvantages or different trajectories that could confound the estimated effects. Second, although the SDID approach helps mitigate concerns about unobserved heterogeneity, the estimates may still be influenced by time-varying factors correlated with program adoption that are not fully captured in the model. Third, our definition of treatment is based on municipal-level program entry, which does not account for individual-level exposure or variation in the intensity of participation, potentially diluting the estimated effects. Future research should seek access to more granular longitudinal data to better understand the scope, heterogeneity, and transmission channels through which early childhood programs like the PMCP affect long-term educational outcomes.

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