Effects of the Open University of Brazil on the higher education of Brazilian public school teachers

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Abstract

This paper analyzes the contribution of the Open University of Brazil (OUB) to the higher education formation of public basic education teachers. We employed staggered difference-in-differences models, considering the initiation of activities by the treatment group, which comprised municipalities that implemented OUB program. The results indicate that the average treatment effect in municipalities that adopted OUB was positive and statistically significant concerning the rates of higher education attainment among teachers in basic education, when compared to similar municipalities in observable characteristics that never received the policy. The effects were more pronounced for teaching degree formation, and they increased with duration of time that municipalities remained under treatment. The evidence suggests that the OUB, despite not being a policy exclusively dedicated to teacher training, contributed to the improvement of teacher qualification levels, aligning with the objectives outlined in the Brazilian National Education Plan and the Sustainable Development Goals.

Keywords: Demand for schooling; Distance education; Human capital; Policy evaluation; Teacher training.

Subject classification codes: I21, I23, I24, I28, J24, C32

1. Introduction

Adequate teacher training is a crucial factor within educational public policies, as it significantly influences the quality of the teaching-learning process. International evidence, as highlighted by Béteille and Evans (2019), Marioni, Freguglia, and Menezes-Filho (2019), and Hanushek (2009), indicates that well-qualified teachers tend to yield better academic outcomes among students. While teacher qualification is not the sole determinant of academic success, Bruns and Yarrow (2015) underscore that the low quality of teachers in developing or underdeveloped countries hinders progress in these regions.

In pursuit of enhancing educational indicators, teacher qualification has been encouraged and fostered in various nations (Organization for Economic Cooperation and Development [OECD], 2021), exemplified by initiatives such as the expansion of higher education in several countries (Schofer, Ramirez & Meyer, 2021; Lagarda, Gallardo & Hernandez, 2021; Nunes, 2018; OECD, 2015). Additionally, on a global scale, nations strive to align with the Sustainable Development Goals (SDGs) established by the United Nations (UN) in 2015. This document sets the target for nations to increase the number of qualified teachers by 2030, particularly in less developed and developing countries, including utilizing international cooperation to achieve this objective (UN, 2022).

With the promulgation of Law No. 9,394 (1996), the Guidelines and Bases of Education (LDB), completion of higher education became the minimum educational requirement for teachers in Brazilian basic education. Consequently, the National Education Plan (PNE), starting in 2004, set goals for the implementation of this requirement, which were not fully achieved and were reestablished in the PNE for the 2014-2024 decade: 100% of elementary school teachers must possess or acquire a higher education degree and a graduation in the subject they teach. Therefore, improving access to higher education in all regions was a challenge for the government, as the vast Brazilian territory was considered a barrier to implementing traditional higher education everywhere. Faced with this situation and the development of information and communication technologies (ICT), the Guidelines and Bases of Education Law explicitly authorized the use of distance education (DE) for higher education.

Considering the specificities of the Brazilian territory, its educational disparities, and the goals outlined in the Brazilian National Education Plan (PNE), the Open University of Brazil (OUB), established by Decree No. 5,800 in 2006, aimed to expand and internalize higher education through distance learning, with a focus on enhancing the qualifications of public school teachers. Similar initiatives for the expansion of higher education were also implemented in various countries (Schofer et al., 2021; Lagarda et al., 2021; Krasnova & Shurygin, 2019; Shohel & Banks, 2010; Wuryaningsih et al., 2019; Senturk, 2021), many of which were concentrated on teacher training and developed through distance education (OECD, 2015; Burns, 2011).

Despite the significant initiatives undertaken by OUB, few studies have examined its effects on the qualification levels of teachers. Nunes (2018) and Quintas-Mendes (2019) assessed the impact of OUB on teacher education, employing descriptive statistics to analyze enrollment and academic completion data, thereby reporting partially positive outcomes. No other studies were identified that comprehensively addressed the effects of the policy across municipalities while employing advanced quantitative methods.

The hypothesis of this study posits that the expansion of higher education provision, directed predominantly (approximately 65% of the provision) towards teacher education through the OUB, in municipalities without public higher education, has increased the level of qualification of elementary school teachers in the areas covered by the policy. Thus, this article examined the contributions of the implementation of OUB on the higher education formation of public elementary school teachers, measuring its effects on the following variables related to the education of elementary school teachers: the percentage of teachers with a higher degree (in any area of knowledge) and the percentage of teachers with a teaching degree.

To analyze the effects of the policy, we applied the Difference-in-Differences (DID) models proposed by Callaway and Sant'Anna (2021), a method that considers the staggered treatment and dynamic effects of the policy. The three treatment groups consisted of municipalities that received at least one OUB center in the years 2007, 2008, or 2009. The control group was composed municipalities that were never subject to the policy (OUB center). We constructed a panel covering the period from 2005 to 2019, including all municipalities (both treatment and control), incorporating sociodemographic (Brazilian Institute of Geography and Statistics - IBGE) and educational (National Institute for Educational Studies and Research - INEP) information. Considering the possibility of spillover effects of the policies, the DID model was estimated using a control group composed of municipalities more distant from the OUB center and, consequently, less likely to be affected by the policy.

The results indicate that OUB had a positive and significant effect on higher education attainment among teachers in municipalities that received OUB center, compared to teachers in similar municipalities that did not receive the policy. The study also suggests that the longer municipalities were exposed to the treatment, the greater the effects of the policy.

This article contributes to the literature on the evaluation of policies related to the expansion of higher education (Schofer et al., 2021; Lagarda et al., 2021; Truong & Nguyen, 2021) and teacher education, encompassing studies such as Dai, Xu, and Zhu (2022), Nunes (2018), and Guedes and Quintas-Mendes (2019). Within the context of evaluating OUB, it stands out as the first to employ the staggered Difference-in-Differences model (Callaway & Sant'Anna, 2021), considering spillover effects, and expanding the temporal scope of research on this policy. Consequently, the results provide evidence of OUB's contribution to achieving teacher education goals outlined in the Brazilian National Education Plan and global policies of the United Nations (SDGs). Furthermore, the lessons learned from OUB may have relevance for teacher education policies in other developing countries facing similar challenges in teacher qualification.

Our paper is initially structured with this introduction, laying the groundwork for the subsequent sections. Followed by an overview of the policy background and a theoretical discussion. The data and methods section explains our research design, methodology, and analytical approaches. We then present the results, detailing empirical findings. Finally, the conclusions summarize key insights and implications.

2. The Lack of Teacher Training and the Policy of the Open University of Brazil

In 2006, when the Open University of Brazil (OUB) was established by Decree No. 5,800 (2006), public school teachers, particularly those in elementary education, faced a significant shortage of higher education training. Approximately 58% of these teachers had completed higher education, with only 54% holding an undergraduate degree in education (INEP, 2007). This low qualification among teachers mirrored disparities in the availability of higher education across regions. Only 15% of slots were allocated in the Northeast and 4.7% in the North, with nearly half situated in Brazilian capitals, proportions significantly below their respective populations. This hindered access to higher education for a substantial portion of the population, especially in rural areas.

In response to these challenges, the (OUB) had the objectives of prioritarily offering initial and continuing education courses for basic education teachers; [...] expanding access to public higher education; reducing disparities in the provision of higher education across different regions of the country. OUB is managed through a consortium involving Coordenação de Aperfeiçoamento de Pessoal de nível superior (CAPES), Higher Education Institutions (IES), and municipalities and states, responsible for maintaining support centers.

Between the years 2007 and 2018, 890 UAB centers were established across 779 municipalities in a staggered manner, spanning all regions of Brazil. Collectively, OUB centers offered 450,979 slots in undergraduate programs, 319,615 slots in specializations, and 81,973 slots in various other improvement and supplementary training courses. OUB activities required federal investments in operational costs and scholarships, totaling approximately R$ 3.6 billion between 2006 and 2020 (Brazilian Open Data Portal, 2021).

Although OUB courses are open to the public, there were well-defined target audiences, particularly public elementary school teachers (Nunes, 2018; Guedes & Quintas-Mendes, 2019). In fact, the initial OUB announcements reserved a percentage (50%) of slots in the selection process for educators, and approximately 70% of higher education courses were geared towards teaching roles.

Despite OUB's significant efforts to expand access to higher education, the policy faces various criticisms and experiences high dropout rates in courses (Oliveira et al., 2018), particularly in Teaching programs (average of 23%). These factors stimulate discussions about the system's ability to have a significant effect on the training of public elementary school teaching staff. Therefore, to address this gap in OUB studies, this work analyzed the OUB's effect on the rates of higher education completion for teachers working in the public school.

3. Related Work

The training of teachers is crucial for the quality of an educational system (Béteille & Evans, 2019), and consequently, it is a consistently addressed topic in the agendas of educational public policies. Evidence suggests that more qualified teachers can influence improved outcomes among their students (Marioni et al., 2019; Rockoff, 2004). Nevertheless, numerous other economic, social, familial, and psychological factors of the student (Hanushek, 2020) are also important in explaining academic success.

Education has been an effective means of providing the knowledge, skills, and attitudes necessary to refine human resources and consequently develop nations. Bruns and Yarrow (2015, p. 02) assert that 'the low average quality of Latin American and Caribbean teachers is a limiting factor on the progress of education in these regions,' highlighting the relevance of developing educational policies for teacher preparation. Therefore, many nations have invested in the qualification of teachers as a pathway to the holistic improvement of educational systems (OECD, 2021), following the mechanism of human capital theory (Schultz, 1971).

Research associates the expansion of higher education with improvements in social indicators. In China, Dai et al. (2022) analyzed the significant expansion of higher education in 1992/93 as a natural experiment and observed a positive and statistically significant effect on China's teaching market, both in terms of quantity and quality of teachers. Schofer et al. (2021), using a transnational longitudinal data panel, found that the increase in higher education is positively associated with key dimensions of rationalization, globalization, societal mobilization, and the expansion of the service economy. Similarly, Lagarda et al. (2021) identified a positive impact on the increase in per capita income due to higher coverage and educational rates driven by Mexican educational policies from 2004 to 2015.

In addition to traditional higher education, there has been an expansion of distance learning courses. Many countries have implemented open universities (Western Governor's University, Hong Kong Open University, Virtual technological Monterrey of Mexico University, Cyber Teacher Training Center in South Korea, University of Phoenix, The Open University-UK, University of west Indies Distance Education Center, Ghana Untrained Teachers Diploma Program in Basic Education, Open University of Portugal, among others) or distance education centers with the aim of expanding access to higher education and serving populations traditionally excluded from tertiary education (Burns, 2011). The advancement of Information and Communication Technologies (ICT) has contributed to the development of educational strategies (Gatti, 2019), particularly the use of Distance Education (DE), due to its

ability to overcome geographical barriers that hindered the delivery of educational programs to remote areas, traditionally centralized in capitals or major cities.

Developing countries have implemented distance learning teacher training programs, mainly for continuing education (OECD, 2015), to address low qualifications (Burns, 2011). However, in Brazil, there are practicing teachers without initial education, necessitating adjustments to comply with new National Curricular Guidelines (BNCC), which prescribe undergraduate degree courses, second undergraduate degree courses, and pedagogical training courses for non-licensed graduates (Dourado, 2016; Todos Pela Educação, 2021).

Therefore, practicing teachers are encouraged through policies like that of the Open University of Brazil to attain adequate education through various paths. In this sense, OUB may have a medium-term effect on teacher education, as practicing teachers, once graduated, will already be in the market and will prompt changes in the teacher education indicators of the schools where they work more quickly.

However, for recent graduates who have not yet entered the teaching job market, this timeframe may be longer, as they still need to secure a position in this market. Maciente, Nascimento, Meyer, and Servo (2015) used data from ENADE and RAIS and found that less than 50% of graduates with a teaching degree (the year following graduation) have employment in the field they studied. Additionally, the phase of insertion and the beginning of the teaching career is complex, both due to the difficulty of entering the teaching market and the determination of success or dropout among professionals (Huberman, 2000). Furthermore, the World Bank (2016) reports that the low attractiveness of the teaching profession in Brazil may hinder the entry of well-qualified graduates into the teaching market, as they may choose different careers than teaching. These facts demonstrate that the path for recently graduated professionals to have a significant effect on the education of public teaching staff may take more time to materialize.

The search for studies related to the evaluation of teacher education policies revealed a scarcity of quantitative research measuring the effect on teacher education levels. However, some qualitative studies were found that highlighted the importance of distance teacher training programs for the development of teaching competencies and skills.

Qualitative or mixed-methods evidence suggests that the implementation of distance learning teacher training can contribute to the qualification and updating of in-service teachers (Dashtestani, 2020; Krasnova & Shurygin, 2019; Shohel & Banks, 2010). These actions also contribute to the development of competencies and pedagogical practices (Lee, Lim & Lai, 2020; Strakova & Cimermanova, 2018), 21st-century skills, especially digital competencies

(Senturk, 2021; García & Hernández-Sánchez, 2020; Wuryaningsih et al., 2019), and the reduction of qualification inequalities among teachers in low socioeconomic level schools and rural areas (Maher & Prescott, 2017).

However, some studies also indicate serious issues in distance education courses, such as a lack of technological infrastructure, technical problems, insufficient practical content in classes, communication and interaction difficulties, low quality, and a lack of institutional support and assistance (Araújo et al., 2021; Ribeiro & Silva, 2021; Dashtestani, 2020). These factors end up discrediting the courses, demotivating students, and consequently reducing success rates.

The search for articles on the Open University of Brazil in major databases (Web of Science and Scopus) resulted in 64 studies covering a variety of topics. The systematic review by Santos, Jung, and Gevehr (2021) highlighted the existence of many articles discussing distance education but still few articles analyzing the policy of the Open University of Brazil. Therefore, due to the relevance and scope of this public policy, the authors consider that conducting more research on the subject is important for understanding the development and implications for society.

Regarding research on the evaluation of OUB, there is a significant interest among researchers in analyzing the effects of policy on social, economic, and professional variables, including effects on the labor market and professional performance (Russo, Fonseca & Simonetti, 2012; Barros, 2019); socio-economic effects (Ferrugini & Castro, 2015); effects on the democratization of access to higher education (Mendonça et al., 2020), interiorization of higher education (Santos, Mccoy & Silva, 2020), and regional development (Souza et al., 2014; Hermenegildo et al., 2014).

Nevertheless, among the articles that attempted to assess the effects of OUB, only two of them analyzed the influences of the policy on the qualification of teachers, which was the main objective of the policy. Nunes (2018) analyzed OUB data (vacancies, enrollments, and completion) from 2006 to 2015 and concluded that the policy had high costs due to high dropout rates and the inability to keep students studying, resulting in low levels of efficiency and effectiveness. Therefore, the program partially achieved its goals of teacher training. Completion rates are even lower in specific subject licentiate courses (physics, chemistry, etc.), typically aimed at serving high school. Therefore, the author suggested that the training promoted by university benefited elementary school teachers more than high school teachers and that the low interest in the teaching profession may have triggered the retention problem, hindering the achievement of higher policy performance.

Guedes and Quintas-Mendes (2019) analyzed the impact of OUB on the expansion and democratization of higher education in the state of Sergipe. In this research, basic descriptive statistical analysis (mean, standard deviation, frequency) of variables related to students and courses offered by the Federal University of Sergipe between 2012-2015 was used. The authors concluded that despite high student dropout rates, OUB managed to train teachers in 56 municipalities in the state and in 18 municipalities in neighboring states (Alagoas and Bahia), partially achieving its goals of democratizing access to higher education.

Although the previously mentioned authors (Nunes, 2018; Guedes & Quintas-Mendes, 2019) reported their results and highlighted that OUB was partially effective in achieving its goal of training teachers, this work stands out from others by analyzing changes in specific variables related to the education level of teachers in the covered municipalities. It seeks to implement a quantitative approach using advanced methods for public policy evaluation (Callaway & Sant'Anna, 2021), considering the specificities of the policy (staggered adoption and treatment heterogeneity) and comparison groups (counterfactual). Moreover, this research also covers a broader area (Brazil) and a longer period (2005-2019), factors that increase the chances of capturing the effects of an educational policy that requires a considerable time to consolidate. Thus, this research can more robustly indicate the changes that the policy caused in the indicators of teacher education in the municipalities that received OUB.

4. Data and Methods

4.1 Database

The data used comprised a comprehensive database from multiple official sources, covering social, economic, demographic, and educational factors in the municipalities analyzed, as shown in Table 1.

Table 1: elaboration of research variables

VARIABLES	LABEL	SOURCE
OUB	Year in which the municipality first received the OUB; 0 if the municipality has never received the policy.	CAPES, data requested by the federal government's FalaBr website
higherdegree	Percentage of teachers who have higher education (any course) and work in elementary education.	Basic Education Census – INEP (2005 to 2019)
teachingdegree	Percentage of teachers who have a teaching degree to work in elementary education	
population	Municipality's population.	IBGE (2000 and 2010 census)
hdi	Municipality's Human Development Index, which the closer to 1 (one) the better the municipality's HDI will be.	ATLAS BR
gdp	Gross Domestic Product per capita	IBGE

north	Dummy for the North region	
northeast	Dummy for the Northeast region	
midwest	Dummy for the Central-west region	
southeast	Dummy for the Southeast region	
south	Dummy for the South region	
private	Dummy for municipality with a private higher education institution	Higher Education Census (INEP)
parfor	Dummy for municipality with students who graduated from the teacher training program (PARFOR)	CAPES, data requested by the federal government's FalaBr website

Source: compiled by the authors (2023)

The extensive database includes 15 periods (2005 to 2019). The years prior to the implementation of OUB (2005 and 2006) were necessary to verify the hypothesis of parallel trends in the variables of interest. Initially, all 5570 Brazilian municipalities were considered for the sample, but for the adjustment of the methods used, 5015 municipalities remained in the sample (each year). The exclusions from the sample of municipalities occurred because some municipalities received centers, but, before 2019, these were closed (0.70%), or at no time did these centers offer higher education courses (0.07%). Municipalities without information for all variables (7%) were also excluded. Additionally, municipalities with a public higher education network (3%) before the start of OUB (year 2006) were excluded, as the presence of municipalities with public educational institutions could interfere with the estimation of effects.

The sample considered municipalities that initiated the activities in one of the program's first three years (2007, 2008, and 2009) as treatment groups, which included 72% of the municipalities that joined OUB between 2007 and 2018. This decision regarding the sample occurred because the number of municipalities entering the program in these first three years was quite representative, and because this sample from the initial years may bring together municipalities with more similar policy intensities over the 13 years, as OUB activities were developed differently in each municipality. The control group was formed by those municipalities that never received the policy.

Despite the periods after the enactment of the LDB and the first National Education Plan (2004-2014) showing a trend of growth in teacher training rates, due to the requirements imposed by these two laws, in the early OUB periods (2007-2009), Brazil was still undergoing a critical period in the inequality of higher education and teacher training offerings. Therefore, municipalities that started activities during this period may have been more influenced by the policy.

We estimated the difference-in-differences model for the dependent variables: “higherdegree” and “teachingdegree”, which correspond, respectively, to the percentage of

teachers with higher education (any type of course) and with a teaching degree in the analyzed municipalities.

4.2 Methodological Approach

The OUB policy presents specificities that complicate the definition of the evaluation strategy since it was not uniformly implemented; that is, municipalities did not all join in the same year and experienced different treatment intensities (varying types of courses and numbers of available slots). Most municipalities received only one center, while some received more than one (such as Manaus, Fortaleza, João Pessoa, São Luís, Salvador, Rio de Janeiro, and São Paulo).

The courses offered were in a distance education (blended) modality, which did not require daily attendance at the course's center in the municipality. Anyone approved in the selection process could participate, regardless of their place of residence or work. In theory, the program's design envisions the local support center aims to serve the local population of the municipality and neighboring areas, thereby promoting the occurrence of spillover.

The phased implementation of OUB necessitated the application of an advanced Difference-in-Differences model (Callaway & Sant'Anna, 2021), accounting for the staggered onset and heterogeneity of the treatment. Additionally, models were estimated, considering the distance of municipalities to the centers, with the aim of capturing spillover effects on the results.

4.2.1 Differences-in-Differences with Event Study

According to OUB/CAPES data, we observed a gradual and consistent implementation of the policy across municipalities. This situation may introduce an element of heterogeneity in traditional panel data regression models with two-way fixed effects (TWFE). When the treatment effect is not homogeneous, applying these conventional approaches may lead to biased estimates (Athey & Imbens, 2021; Goodman-Bacon, 2021).

The differences-in-differences method proposed by Callaway and Sant'Anna (2021) is widely employed in policy evaluation due to its design, which allows for variation in the onset of treatment and the duration of treatment and conditions the assumption of parallel trends on pre-determined covariates. This methodological strategy utilizes an estimator robust to treatment heterogeneity, circumventing the limitations associated with two-way fixed effects regressions (TWFE) or event study regressions when there are variations in the treatment effect (Goodman-Bacon, 2021).

To estimate the results with differences-in-differences, data were organized into a panel encompassing all Brazilian municipalities with data for all 15 periods (2005 to 2019), assuming

an independent and identically distributed sample (assumption - random sample). The average treatment effect on the treated (ATT) estimated by the Callaway and Sant'Anna (2021) method requires the assumption of treatment irreversibility, meaning that treated units remain treated. Therefore, we excluded 39 centers that closed their activities by the year 2019.

We define D_t as a binary variable equal to 1 when a municipality implements a OUB support center in year t and 0 otherwise, with $t = 1,2, \ldots, T$. The term G_g is equal to 1 if the municipality is treated for the first time on date g and 0 otherwise. We assign a value of 1 to C for municipalities that never received OUB. We calculate a propensity score ($Pg(X) = P\ (Gg = 1|X,\ Gg + C = 1)$), representing the probability of a municipality being treated given covariates (X) and belonging to the group of municipalities that adopted the treatment on date g or to the control group (C).

The average treatment effect on the treated group, denoted by $ATT\ (g,\ t)$ (equation 1), is a function of the treatment group (g) and the period (t), where g refers to the group of municipalities whose first year of treatment is t. With the basic assumptions met (parallel trends conditional on covariates, staggered treatment, irreversibility of treatment, and covariate overlap), we obtain the estimate of $ATT\ (g,\ t)$ for each group (equation 2).

$$ATT(g,t) = \mathrm{E}\left[[Y_{t(g)} - Y_{t(0)}|G = g\right] \quad (1)$$

$$ATT(g,t) = \mathrm{E}\left[\left(\frac{G_g}{\mathrm{E}[G_g]} - \frac{\frac{p_g(\mathrm{X})C}{1-p_g(\mathrm{X})}}{\mathrm{E}\left[\frac{p_g(\mathrm{X})C}{1-p_g(\mathrm{X})}\right]}\right)\left(Y_t - Y_{g-1}\right)\right] \quad (2)$$

The term p represents the weights, normalized propensity scores. Therefore, in this estimation, we employed a reweighting procedure to balance the covariates of the treatment (g) and control (C) groups. The estimator by Callaway and Sant'Anna (2021) is doubly robust in this case because it utilizes both the regression approach of Heckman et al. (1998) and the propensity score approach of Abadie (2005). The additional robustness only requires the correct specification of the outcome evolution modeling or the propensity score model but not necessarily both (Callaway and Sant'Anna, 2021).

Due to treatment selectivity, given that each municipality can choose when to apply to receive OUB, Callaway and Sant'Anna (2021) suggest estimating the specific $ATT(g,t)$ for each treated group (equation 3) and subsequently calculating their average for the post-treatment period, as per equation 4.

$$\bar{\theta}_{s(g)} = \frac{1}{T-g+1}\sum_{t=2}^{T}\{t \geq g\}ATT(g,t) \quad (3)$$

$$\theta_s = \frac{1}{g=2} \bar{\theta}_{s(g)} P = (G = g) \quad (4)$$

In this study, $\bar{\theta}_{s(g)}$ and θ_s were the main estimated parameters of interest. However, as we anticipate that the effects are dynamic—meaning that over time, the effects of OUB become increasingly significant on teacher training in the post-treatment period—we also estimated the Average Treatment Effect on the Treated (ATT) for an event study. Callaway and Sant'Anna (2021) propose measuring the ATT (g, t) for each treated group for different exposure times (e) (equation 5). Additionally, we estimated a summarized measure of all values (e) (equation 6):

$$\bar{\theta}_{D(e)} = \sum_{g=2}^{T} \sum_{t=2}^{T} \{t - g + 1 = e\} ATT\ (g,t)\ P = (G = g | t - g + 1 = e) \quad (5)$$

$$\theta_D = \frac{1}{T-1} \sum_{e=1}^{T-1} \bar{\theta}_{D(e)} \quad (6)$$

In the estimated specifications, we examined the hypothesis of pre-treatment parallel trends. This entails investigating whether municipalities, both treated and untreated, exhibit similar trends before the implementation of OUB, diverging only after the policy initiation, particularly following the completion of the first cohorts of higher education courses. This method assumes the validity of parallel trends, and to address this assumption, we integrated the conditionality of these trends into a set of covariates during the pre-treatment period (as presented in Table 1). The validation of this hypothesis implies evidence that the changes were induced by the policy rather than other factors.

This method incorporates covariates representing relevant demographic, social, economic, and educational characteristics for decisions related to implementation of public policies. The Human Development Index (HDI) assesses three dimensions of human development: income, education, and health. The Gross Domestic Product (GDP) per capita measures municipal economic activity divided by the person. Population is a variable that reflects the population size, while the region dummies indicate demographic specifics of the Brazilian territory. The variables "private" and "parfor" control for alternative access to higher education or public programs promoting higher education and teacher training (FIES, PROUNI, and PARFOR). We calculate the propensity score using these variables to balance treatment and control groups based on their observed characteristics, thereby enhancing the reliability of the comparison between them.4.2.2 Analysis of Spillover Effects

We are concerned with the influence of the OUB treatment on units beyond those directly receiving a OUB center, as, despite the center being assigned to a municipality, students

attending that center may not necessarily reside or work in that specific municipality. In this regard, Guedes and Quintas-Mendes (2018) demonstrated that in the context of Sergipe, OUB reached students from other municipalities beyond those residing in the center's municipality. Hence, estimating the effects of the Open University on teacher graduation rates in municipalities with a OUB center compared to those without the policy (control group) may introduce bias in the results, given a potential violation of the Stable Unit Treatment Value Assumption (SUTVA).

To comprehend the potential spillover effect of OUB and alleviate potential distortions in the estimates, we requested data from CAPES and universities that offered undergraduate courses in collaboration with policy (through 80 requests filed through FALABR) regarding the residence of students who completed the courses. However, institutions responded to only 39 of the 80 requests, many of which had incomplete information. The universities claimed the unavailability of such information or the inability to disclose it due to data confidentiality when denying the requests.

Table 2: proportion of graduating students based on residential distance to OUB center municipality

Distance (KM) from residence to OUB[1]	MIDWEST	NORTHEAST	NORTH	SOUTHEAST	SOUTH
0	33,76%	35.41%	75.5%	30.4%	42%
1-50	36.26%	34.49%	11.4%	39.01%	38.49%
51-100	12.80%	15.01%	8.20%	19.34%	6.23%
101-150	4.50%	5%	4.10%	6.31%	0.90%
151-200	3.80%	2.80%	0.00%	1.50%	1.13%
>200	8.70%	7.60%	0.80%	3.42%	1.81%

Source: research data (2023)

Nota[1]. the distance, measured in kilometers, was calculated using a straight-line projection. The data were sourced from information pertaining to graduates from five universities that provided data for analysis (UFG, UFPB, UNIR, UFLA, and UFSC), each representing a distinct geographical region of Brazil.

Considering the data available from the universities, we observed that not all students who completed the course resided in the municipality of the OUB center. The distance from the student's residence to the center varied significantly. However, most students who completed the course lived closer to the center. On average, 75% of students lived within 50 km of the center where they graduated, and apparently, the North and South regions experienced the lowest spillover levels (Table 2).

Therefore, we used a Geographic Information System (QGIS) to generate a distance matrix between the municipalities that did not receive the OUB and that nearest municipality that received a center. We identified that municipalities without a center are, on average, 40 km away from a OUB center, although this distance varies, reaching up to 462 km.

In this analysis, we estimated the policy effects using the differences-in-differences method, adopting a distance-ring approach like employed by Butts (2021) and Lindo et al. (2020). Initially, we examined the overall effect of OUB (Model I), comparing municipalities that received the policy with those that did not, regardless of distance. Subsequently, we assessed the effects of OUB on treated municipalities compared to those located more than 50 km away from a center, which consequently have a lower likelihood of being affected by the policy (Model II).

Although municipalities located 51 km or more from the center still account for an average of 21% of OUB graduates (Table 2), this distance was used as a control because greater distances significantly reduce the number of municipalities in the sample, affecting the balance of groups and adherence to the assumption of parallel trends. Additionally, it is relevant to note that not all OUB students became teachers or entered the teaching market. The student survey (CAPES, 2018) indicates that, on average, 30% of students are teachers in the public school system. Therefore, we believed that spillover beyond 50 km was relatively small and makes sense for the intended analysis. We also highlight that there is a tendency for teachers to work closer to their places of origin or residence, as pointed by Boyd et al. (2005).

The underlying premise is that if the effects of OUB are underestimated in the first model due to the spillover of the policy to nearby municipalities, the influence of OUB should be more pronounced when compared to more distant municipalities. The latter, having a lower likelihood of being affected by the policy, helps avoid bias in the results due to spillover effects of the policy.

5 Results

5.1 Descriptive statistics

Initially, we analyzed the descriptive statistics of the variables of interest, categorized by group and year, to comprehend temporal changes.

Table 3: descriptive statistics for variables of interest across analyzed groups over time.

	HIGHERDEGREE			TEACHINGDEGREE		
year	OUB=0 N=4701	OUB=1 N=427	t-test	OUB=0 N=4701	OUB=1 N=427	t-test
2006	65.61	61.83	3.78*	62.05	57.94	4.11*
2007	65.84	63.03	2.81*	61.23	58.01	3.22*
2008	66.29	63.75	2.54*	64.45	62.24	2.20*
2009	67.52	65.13	2.40*	65.66	63.62	2.04*
2010	69.77	67.02	2.75*	67.81	65.55	2.26*
2011	72.72	70.06	2.66*	70.48	68.41	2.07*

2012	75.18	72.95	2.22*	72.78	71.16	1.61
2013	77.61	75.31	2.30*	75.41	73.53	1.88
2014	79.13	77.07	2.05*	77.24	75.37	1.87
2015	79.68	77.94	1.74	77.74	76.25	1.48
2016	80.92	79.37	1.54	78.96	77.74	1.21
2017	82.06	80.63	1.42	80.17	79.06	1.11
2018	83.70	82.57	1.12	82.11	80.99	1.12
2019	88.84	87.61	1.23	85.01	83.68	1.33

Source: research data (2023)
Note: OUB=0 indicates that the group consists of municipalities that did not receive the OUB, while OUB=1 refers to those that received the OUB. The asterisk (*) denotes that the difference is statistically significant at the critical level of 5%.

Based on Table 3, teacher training rates were lower in municipalities that implemented the policy (1) when we compared to those that did not (0), underscoring the pronounced need for training. Between the years 2006 and 2019, there was a noteworthy increase in teacher training in both groups, indicating a potential broadening of opportunities for access to higher education and teacher training across various municipalities, in alignment with the objectives of the National Education Plan (PNE) and the recommendations of international institutions (Law No. 13.005, 2014; UN, 2022; OECD, 2021).

We observed that the disparities in teacher training rates between the groups were initially significant. However, over time, these differences diminished and stopped being statistically significant. This trend suggests that more robust initiatives in municipalities treated with the OUB policy may have generated discernible effects on teacher training variables (Nunes, 2018; Guedes & Quintas-Mendes, 2019).

Table 4 demonstrates that the means of the characteristics in the groups that received (1) or did not receive (0) the policy varied according to the initiation of the policy (2007, 2008, and 2009). Initially, we noted that the variable population was higher for the municipalities included in the policy. However, it is essential to highlight that Brazil comprises 5570 municipalities, with approximately 68% being small (with population fewer than 20,000) and another 18.5% having populations between 20,000 and 50,000. This demographic distribution made the control groups markedly distinct from the treated groups.

Table 4: descriptive statistics of covariates by group and inauguration year of OUB activities

	Initiation= 2007			Initiation =2008			Initiation =2009		
Variable	0 N=4886 Mean/SE	1 N=129 Mean/SE	t-test Difference[1]	0 N=4734 Mean/SE	1 N=152 Mean/SE	t-test Difference[1]	0 N=4599 Mean/SE	1 N=135 Mean/SE	t-test Difference[1]
hdi	0.52	0.55	-0.028*	0.519	0.529	-0.010	0.52	0.528	-0.009
	[0.001]	[0.008]		[0.001]	[0.007]		[0.002]	[0.008]	
gdp	7903.9	9632.1	-1728.2*	8925.3	8925.6	-0.285	10054.4	10374.1	-319.7
	[159.4	[611.7]		[196.1]	[671.0]		[214.5]	[872.4]	
populatiom	19710.1	52800.6	-33090.5*	18549.6	55864.4	-37314.8*	17356.3	68926.4	-51570.1*
	[598.6]	[8055.4]		[528.9]	[9495.1]		[478.9]	[7887.1]	
midwest	0.083	0.023	-0.059*	0.082	0.099	-0.017	0.08	0.081	0.001
	[0.004]	[0.026]		[0.004]	[0.024]		[0.004]	[0.024]	
northeast	0.32	0.31	0.008	0.320	0.257	0.063	0.31	0.504	-0.190*
	[0.007]	[0.041]		[0.007]	[0.036]		[0.007]	[0.043]	
north	0.08	0.09	-0.013	0.075	0.230	-0.155*	0.31	0.067	0.008
	[0.004]	[0.043]		[0.004]	[0.034]		[0.007]	[0.022]	
southeast	0.303	0.395	0.092*	0.305	0.243	0.061	0.08	0.119	0.192*
	[0.007]	[0.013]		[0.007]	[0.035]		[0.004]	[0.028]	
south[2]	0.217	0.178	0.04	0.219	0.171	0.048	0.22	0.230	-0.011
	[0.006]	[0.034]		[0.006]	[0.031]		[0.006]	[0.036]	
private	0.09	0.26	-0.169*	0.081	0.263	-0.182*	0.07	0.341	-0.267*
	[0.004]	[0.039]		[0.004]	[0.036]		[0.004]	[0.041]	
parfor	0.24	0.19	0.049	0.242	0.257	-0.014	0.24	0.444	-0.208*
	[0.006]	[0.035]		[0.006]	[0.036]		[0.006]	[0.043]	

Source: research data (2023)

Notes: t-tests correspond to the differences in means of the variables between the two groups in each sample; *indicates that the differences in variables between groups are statistically significant at a 95% confidence level. The Southern region was omitted from the model to prevent perfect collinearity among the region variables; standard errors in brackets.

Observing the geographical variables, we observed that municipalities in the Northeast and Southeast regions benefited the most from the policy in both years. In terms of socio-economic variables, only the 2007 group recorded a higher Municipal Human Development Index and per capita Gross Domestic Product compared to the non-contemplated groups. Also, the municipalities receiving OUB had on average a higher proportion of private higher education institutions. Additionally, the group that commenced activities in 2009 was more favored with the PARFOR program. Therefore, based on the disparities identified in our descriptive statistics, the calculation of the propensity score (Callaway & Sant'Anna, 2021), grounded in demographic, social, economic, and educational covariates, proved useful in forming treatment and control groups that were more balanced in terms of observable characteristics.

5.2 Effects of OUB on the academic level of elementary school teachers

Our estimations revealed that the average treatment effects on the treated (ATT) were positive and statistically significant (Table 5, columns 5 and 6). This finding complements the outcomes of prior studies conducted by Nunes (2018) and Guedes and Quinta-Mendes (2019). Although these earlier investigations did not quantify these effects using identical quantitative methodologies, their results implied that the effects of OUB on teacher training were partially positive.

We identified that municipalities subject to the implementation of OUB experienced an average increase of 1.45 percentage points (p.p) in graduation rates (any courses) compared to municipalities with similar observable characteristics that did not participate in the OUB policy. Concerning the average effect by group, we observed that only the 2007 group exhibited statistically significant effects. This discrepancy potentially reflects the influence of treatment intensity or development, given that the 2007 group accounted for 45% of all available slots in OUB higher education courses, with 90% of participating institutions being federal.

Table 5: Effects of the OUB on graduation rates (any courses) of elementary school teachers

	FIRST DIFFERENCES		**FIXED EFFECTS**		**DID (C&S)[1]**	
ATT	1.04	2.01***	14.95***	1.44***	1.29***	1.45***
	(1.15)	(1.04)	(0.60)	(0.61)	(0.65)	(0.68)
G2007	-0.92	2.28	15.04***	2.05*	2.01	3.55***
	(2.03)	(1.81)	(1.26)	(1.22)	(1.33)	(1.38)
G2008	0.20	1.45	13.90***	0.82	0.35	-0.14
	(0.11)	(1.66)	(0.98)	(0.99)	(0.92)	(0.89)
G2009	3.77	2.47	15.93***	1.98***	1.66*	1.05
	(1.95	(1.77)	(0.97)	(0.93)	(1.02)	(1.04)
Covariates	no	yes	no	yes	no	yes

p-value parallel trends	-	-	-	-	0.06	0.15

Source: research data (2023)
Notes. [1] Differences in Differences with Staggered Adoption (Callaway and Sant'Anna, 2022); *** p<0.01, ** p<0.05, * p<0.1

Columns 1 to 4 of Table 5 present estimates using alternative methods, and, except for fixed-effects methods without covariates, they showed results that are approximately similar to the overall Average Treatment Effect on the Treated (ATT). Such consistency suggests the robustness of our findings. As a precondition for supporting the estimated effects, we inspected the pre-treatment parallel trends' assumption. In other words, we did not reject the null hypothesis that variables of interest were similar in both groups before the treatment.

Regarding the average effects of OUB on teaching degree attainment, a statistically significant increase of 2.2 percentage points in the rates of higher education degree attainment among elementary school teachers was observed, as presented in Table 6.

Table 6: Effects of OUB on teaching degree rates of elementary school teachers

	FIRST DIFFERENCES		**FIXED EFFECTS**		**DID (C&S)[1]**	**DID (C&S)**
ATT	1.25	2.23***	17.01***	1.66***	1.85***	2.24***
	(1.19)	(1.11)	(0.62)	(0.63)	(0.69)	(0.71)
G2007	-0.74	2.24	16.79***	2.59**	2.09*	3.65***
	(2.10)	(1.93)	(1.28)	(1.31)	(1.34)	(1.38)
G2008	0.91	2.16	16.77***	1.78*	1.40	0.82
	(0.93)	(1.78)	(1.01)	(1.03)	(1.03)	(1.00)
G2009	3.47*	2.56	17.33***	1.30	2.14*	2.38**
	(2.0)	(1.89)	(1.03)	(0.96)	(1.14)	(1.24)
Covariates	no	yes	no	yes	no	yes
p-value parallel trends	-	-	-	-	0.07	0.38

Source: research data (2023)
Notes. [1] Differences in Differences with Staggered Adoption (Callaway and Sant'Anna, 2022); *** p<0.01, ** p<0.05, * p<0.1

Among the group effects, only the 2008 group did not exhibit statistically significant effects for this variable. This outcome is intriguing and may reflect the composition of the groups or even the way the policy was implemented. For example, in the groups that started in 2007 and 2009, most municipalities (85%) were from the Southeast, Northeast, and South regions, while the 2008 group was more evenly distributed among the regions. This assumption is associated with the fact that in the South, Southeast, and Northeast regions, there was greater teacher adherence to OUB (CAPES, 2018), reinforcing the idea of the composition of the groups in 2007 and 2009.

Furthermore, these effects may be reflecting some other circumstances related to the regions: they might have promoted greater awareness and encouraged teacher participation in the program; these regions may offer better professional incentives, such as career plans or promotion through capacity building. Moreover, the Southeast and South regions have better

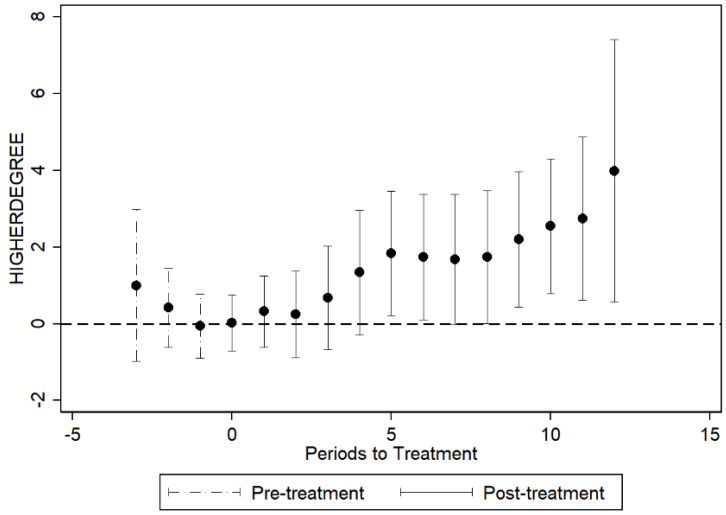
internet access infrastructure, both in terms of technology ownership and internet accessibility (IBGE, 2020), which is crucial for student development in distance education courses (OECD, 2015), such as those offered by OUB. While the average effect of University Open of Brazil on the educational attainment of teachers working in elementary education may appear small, it is crucial to emphasize that the policy was not an exclusive for practicing teachers. According to the latest OUB student survey (CAPES, 2018), 38% of the students, on average, are practicing teachers. Students could attend classes at a different center than their municipality of work or residence, and those who completed the course did not always immediately enter the teaching job market. Additionally, there was a substantial dropout rate in OUB courses, which could have been motivated by developmental issues such as a lack of infrastructure in centers, insufficient support for student retention, internet accessibility, and a lack of pedagogical support, among other factors (OECD, 2015; Nunes, 2018; Guedes & Quintas-Mendes, 2019; Araújo et al., 2021; Ribeiro & Silva, 2021).

We also underscore that based on the data, there appeared to be a trend among municipalities to comply with the minimum education requirements mandated by the LDB. This fact was achieved through supporting the education of teachers in other municipalities or establishing criteria for the selection of new teachers that required a minimum level of higher education and an education degree.

5.3 Event studies

As the variables of interest in this study depend on a time frame to materialize, averaging four years for the attainment of a higher education degree, we observed, through the event study, that the average treatment effect on the treated for the variable of higher education (any degree) followed the anticipated pattern of the policy (figure 1).

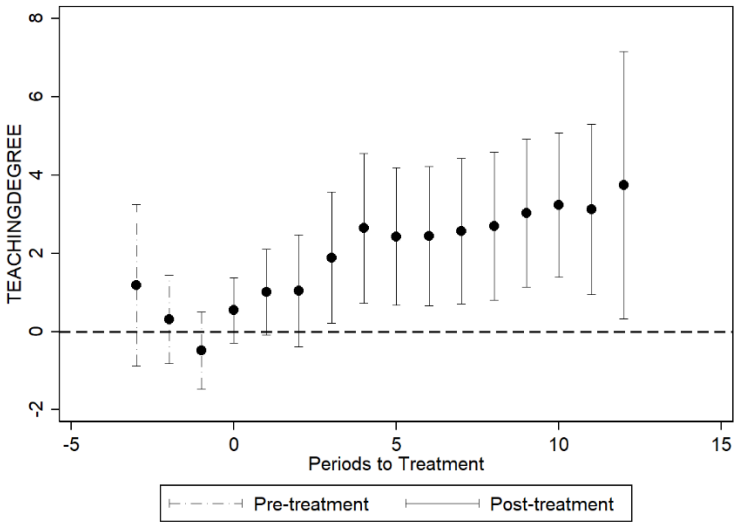
Figure 1: dynamic effects of OUB on graduation rates



Source: research data (2023)

Specifically, there was an increase in the variable of interest after the fifth year of the policy, progressively escalating as municipalities remained under treatment for a longer duration. The graphs also indicate that before the policy, the effects on the variables were not statistically significant but became significant after the training provided by the program in municipalities covered by the policy. Therefore, compelling evidence suggests that the observed effect can be attributed to the actions of the OUB.

Figure 2: dynamic effects of OUB on teaching degree rates



Source: research data (2023)

Figure 2 depicts a slight increase in the rate of teacher licensure formation shortly after the third year. We posit that this may have occurred because OUB offered pedagogical complementation courses (granting a teaching degree to bachelor's degree holders), which require a shorter training period (on average, 24 months).

5.4 Analysis of Spillover Effects of OUB on Adjacent Municipalities

Considering the possibility of spillover effects of OUB to neighboring municipalities, our estimations of the policy's effects may be underestimated. Therefore, the overall and group-specific Average Treatment Effects (ATT) were re-estimated, considering a subset where control group municipalities were those located more than 50 km from a OUB center, as they have a lower probability of being affected.

Therefore, in Table 7, model I represents the previous estimates (overall and group-specific ATT), and model II uses as the control group comprised of municipalities located more than 50 km from OUB.

Table 7: Effects of OUB on graduation rates (any course) and teaching degree rates of elementary school teachers based on proximity to the OUB center

	HIGHERDEGREE		TEACHINGDEGREE	
	(I)	**(II)**	**(I)**	**(II)**
ATT	1.45***	3.77**	2.24***	5.64**
	(0.68)	(1.70)	(0.71)	(2.62)
G2007	3.55***	4.12*	3.65***	5.43**
	(1.38)	(2.49)	(1.38)	(2.99)
G2008	-0.14	2.24	0.82	3.80
	(0.89)	(2.26)	(1.00)	(2.64)
G2009	1.05	5.26*	2.38**	8.13**
	(1.04)	(2.88)	(1.24)	(3.95)
Covariates	yes	yes	yes	yes
p-value parallel trends	0.15	0.78	0.38	0.84

Source: research data (2023)

The effect of OUB is more pronounced when restricting the analysis to municipalities that directly received OUB and comparing them with those located more than 50 km from a center, ou seja os Effects teaching degree chegam 5.64 pontos percentuais. more than doubled. Which confirms what we had already mentioned, cities closer to OUB centers could obtain greater benefits from the program, therefore we could be underestimating the effects of the policy in previous estimates.

Despite methodological limitations, our findings support that the policy had a positive and statistically significant average effect, indicating that in municipalities benefiting from the policy public elementary school teaching staff experienced an increase in their teachers' education. These results suggest that OUB contributed to expanding educational opportunities in tertiary education, aligning with other international experiences aimed at increasing access to higher education (Schofer et al., 2021; Lagarda et al., 2021; Truong & Nguyen, 2021) and teacher training (Dai, Xu & Zhu, 2022).

Furthermore, although this study does not provide direct evidence on this aspect, we presume that OUB initiatives, through the improvement in teacher training, may have

influenced in some way the educational outcomes of students, following the mechanism proposed by the human capital theory (Schutz, 1971). Considering that teacher qualification is a positive factor in the success of educational systems (Hanusheck, 2009; Marioni et al., 2019; Beteille & Evans, 2019; Bruns & Yarrow (2015). These assumptions are relevant to the effectiveness of policy and can be explored in future research.

6 Conclusions

The Open University of Brazil (OUB) aims to broaden opportunities for access to higher education, mitigate inequalities in access throughout the Brazilian territory, and enhance the qualifications of teachers, especially in municipalities lacking public higher education and between small to medium-sized cities. Given the primary goal of the OUB to train educators, our analysis focuses on assessing the effects of the policy on the higher education attainment of teachers in the benefited municipalities.

The results indicated that the average treatment effect of the OUB was positive and statistically significant for both variables in most of the analyzed samples. In the event study, we observed that the effects of the policy on municipalities increase over the time they remain treated. Although the estimated coefficients may initially appear modest, it is crucial to consider that the program was not exclusively aimed at teachers, and not all graduates entered the public education teaching staff.

Additionally, students could enroll in courses offered by municipalities different from their residence or workplace. These aspects triggered the spillover effect of the policy, which, on the one hand, demonstrates the success of the policy design in expanding the reach of the centers to neighboring municipalities. However, from an evaluation perspective, this situation made it challenging to conduct a more precise analysis of the policy's results. When considering the spillover to the closest neighboring municipalities, we found a significant increase in the effects for the municipalities covered by the OUB compared to more distant municipalities, which are less likely to be affected by the policy.

Therefore, we understand that analyzing the effects of the Open University of Brazil is crucial for teacher training policies, as it assesses the progress of a developing public policy that requires significant investments and has altered traditional pathways associated with teacher education.

In this research, we demonstrate that the mentioned policy potentially improves the level of teacher education. However, it is essential to emphasize that, based on the obtained results and the literature review, we presume that the OUB system can implement actions to optimize

its effectiveness. These actions could range from adjusting course offerings and emphasizing specific teacher training to developing strategies to encourage student retention and ensure access to the necessary technologies for course development.

We also highlight the need for improvements in the organization and transparency of OUB data, always safeguarding anonymity but ensuring the possibility of identifying the profile of the participants in the policy. The mapping of the spillover effects of the policy, as initially planned by the policy, also emerges as a gap to be filled. This aspect represented a significant challenge for our research and ultimately became a limitation for the estimates and interpretations of the results.

In this research, a robust econometric model, considering the staggered adoption and exposure time to the policy, was valuable for evaluating a policy with significant specificities that require considerable time to yield results.

We suggest that future studies explore the effects of teachers trained through the OUB on students' educational outcomes as a measure of effectiveness. Furthermore, qualitative research on the effects of policy on teachers' competencies and skills is crucial to understanding aspects of teacher qualification that go beyond academic achievement.

Finally, our study can contribute to the literature on the evaluation of public policies related to higher education and teacher training. We emphasize that these policy evaluation studies help promote transparency in public actions and enhance policy management. The insights gained from this research may have relevance for other developing countries facing similar challenges in teacher qualification.

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