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The economic impact of subsidized credit on regional development: Evidence from Brazil's Northeast Constitutional Financing Fund (FNE), 2010–2022

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Abstract

This study evaluates the economic effects of Brazil's Northeast Constitutional Financing Fund (FNE) on growth and employment in the SUDENE region from 2010 to 2022. Using a generalized propensity score (GPS) dose-response model, we find that FNE credit significantly increases GDP, GDP per capita and employment, with larger effects in less developed states. The analysis reveals non-linear impacts, with diminishing marginal returns at higher credit levels, highlighting the role of the FNE in mitigating regional disparities. These findings provide actionable insights for policymakers in credit-constrained regions.

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1. Introduction

Regional disparities represent a persistent challenge to Brazil's economic development, with the Northeast lagging behind the Southeast in important socioeconomic indicators such as GDP and employment rates (Baer, 2013; Azzoni, 2020). The Northeast Constitutional Financing Fund (FNE) addresses these inequalities by providing subsidized credit to productive sectors, aiming to stimulate economic growth and job creation (Resende, 2010; Silva et al., 2009). Although credit policies are widely employed as development tools, evidence on their heterogeneous impacts in regions with different levels of development remains limited (Banerjee & Duflo, 2014).

This study evaluates the impact of FNE credit on economic growth and employment in the region of the Northeast Development Superintendency (SUDENE) from 2010 to 2022. Unlike previous research using traditional methods, we apply a generalized propensity score (GPS) dose-response model (Hirano & Imbens, 2004), allowing for a robust estimation of the effects of credit while controlling for unobserved factors. Our findings reveal that FNE credit boosts GDP, GDP per capita and employment, with greater impacts in less developed states and a non-linear pattern of diminishing marginal returns as the volume of credit increases, consistent with theoretical insights (Beck et al., 2010).

Unlike sector-specific or municipally focused initiatives, the FNE integrates regional targeting, long-term planning and subsidized interest rates on a broad scale, making it a distinctive instrument in Brazil's policy toolkit.

These results advance the literature on regional development and credit policies by offering new evidence of the FNE's role in mitigating disparities. They also provide actionable insights for optimizing credit allocation strategies. The article proceeds with a review of the literature on subsidized credit and regional development, followed by methodology, empirical results and policy implications. The article proceeds with a literature review, methodology, empirical results and concludes with policy implications and future research directions.

2. Literature review

The relationship between subsidized credit and economic growth has been widely explored, with evidence suggesting its potential to address market failures in underdeveloped regions. Resende (2010) highlights the role of Brazil's constitutional funds, such as the FNE, in reducing regional disparities by promoting growth and employment, although the effects may vary according to local conditions. Cecchetti and Kharroubi (2012) provide a broader theoretical basis, demonstrating that credit expansion exhibits non-linear effects on growth, with diminishing marginal returns as credit volumes increase. This non-linearity is in line with the hypothesis that the impacts of the FNE may weaken in more developed areas. Similarly, Macedo (2017) finds that FNE credit significantly boosts economic activity in the Northeast, particularly in less dynamic economies, pointing to heterogeneous effects between regions. These studies highlight the importance of examining both the scale and distribution of credit impacts, a gap that this article addresses through an advanced econometric approach.

Similar programs have been implemented internationally with varying degrees of success. For instance, India's Priority Sector Lending aims to channel credit to underdeveloped sectors; Mexico's FIRA supports rural financing; and China's rural credit cooperatives serve low-income populations. These experiences offer comparative insights and underscore the uniqueness of FNE's scale and regional targeting strategy.

3. Methodology

This study adopts a quantitative approach to assess the impact of FNE credit on economic growth and employment in the SUDENE states from 2010 to 2022. Data on annual FNE credit volumes, GDP, GDP per capita and employment levels come from the Banco do Nordeste do Brasil (BNB), IBGE and SUDENE. The central econometric method is the generalized propensity score (GPS) dose-response model (Hirano & Imbens, 2004), which estimates continuous treatment effects while controlling for unobserved factors. The treatment variable (T) is the volume of FNE credit per state, and the outcome variables (Y) are GDP, GDP per capita and employment. The control variables (X) include the Human Development Index (HDI), population, illiteracy rate and sector composition, selected on the basis of their influence on credit allocation and economic performance (Resende, 2010). The HDI and illiteracy rate capture socioeconomic conditions that affect credit absorption, while population and sectoral composition account for scale and structural differences between states. The GPS is estimated in three stages: (i) modeling the conditional distribution of covariates provided by the treatment, (ii) calculating the GPS and (iii) estimating the dose-response function to assess non-linear effects.

This study sets out to examine an extension of the propensity score method to deal with the continuous variable representing the values of FNE loans. While the traditional method is limited to the binary variable of treatment, this work uses the generalized propensity score (GPS) dose-response method proposed by Imbens (2000) and Hirano and Imbens (2004). This method makes it possible to compare treatment and control groups with similar characteristics, considering treatment as a continuous behavioral variable. The dose-response function is estimated to obtain the probability of receiving each level of treatment. According to Hirano and Imbens (2004), the GPS method produces reliable and more robust estimates than simple regression estimates. GPS also has a balancing property similar to the traditional propensity score method, with the probability of $T=t$ in a stratum with the same GPS value ($r(T,X)$) not depending on the value of X , known formally as weak ignorability:

$$X \perp 1 \{ T = t \} \mid r(t,X)$$

Considering the practical implementation of the GPS methodology, in the first stage we consider that the treatment, T_i , conditional on the control variables X_i , is normally distributed.

$$T_i \mid X_i \sim N(\beta_0 + \beta_1' X_i, \sigma^2) \quad (1)$$

You can estimate β_0 , β_1 and σ^2 using maximum likelihood and obtain the value of the probability density function associated with the observed value of the treatment variable, i.e. the GPS, given by:

$$\hat{R}_i = \frac{1}{\sqrt{2\pi\hat{\sigma}^2}} \exp\left(-\frac{1}{2\hat{\sigma}^2} (T_i - \hat{\beta}_0 - \hat{\beta}_i' \wedge X_i)^2\right) \quad (2)$$

In the second stage, the conditional expectation of Y_i given T_i and estimated ri is modeled as a flexible function of two arguments (Hirano and Imbens, 2004). The authors suggest using the quadratic approximation using ordinary least squares:

$$E[Y_i | T_i, R_i] = \alpha_0 + \alpha_1 T_i^2 + \alpha_2 T_i + \alpha_3 R_i + \alpha_4 R_i^2 + \alpha_5 T_i R_i \quad (3)$$

Equation (3) shows the relationship between the observed outcome, the treatment e the probability of receiving each level of treatment. Given the parameters $\hat{\alpha}k$ estimated in the second stage, the average of the potential outcomes for each treatment level t is estimated.

$$\hat{E}[Y(t)] = \frac{1}{N} \sum_{i=1}^N \left(\hat{\alpha}_0 + \hat{\alpha}_1 t + \hat{\alpha}_2 t^2 + \hat{\alpha}_3 \hat{r}(t, X_i) + \hat{\alpha}_4 \hat{r}(t, X_i)^2 + \hat{\alpha}_5 t \hat{r}(t, X_i) \right) \quad (4)$$

For each treatment level t there is information on an average potential result $[Y(t)]$, which is then used to estimate the dose-response function. It is then possible to estimate the effect of a marginal increase ($\epsilon > 0$) in the amount of treatment on the variable of interest.

While the GPS approach helps mitigate unobserved heterogeneity, residual endogeneity or omitted variable bias may still affect estimates. Future refinements could incorporate instrumental variable methods or sector-specific controls to strengthen causal inference.

4. Results and Discussion

Table 1 shows the descriptive statistics of the variables used in the study. A wide dispersion is evident in all the variables, indicating a notable heterogeneity between the states analyzed. For example, there is considerable variation in variables such as employment, credit, human development index (HDI), population, illiteracy rate, occupation and GDP, with values varying significantly from minimum to maximum in each case. This dispersion highlights the diversity between the states.

Table I – Descriptive Statistics

Variable	Mean	SE	Minimum	Maximum
Employment	1,310,599	1,262,016	352,870	5,148,435
Credit	1.66	1.53	0.11	9.23
HDI	0.713	0.04	0.64	0.80
Population	7,330,058	5,575,361	2,111,645	21,380,803
Illiteracy Rate	13.28	4.40	3.83	21.26
Occupation Rate	0.17	0.04	0.09	0.25
GDP	124,322,435	132,951,679.2	19,670,255	645,701,888

Source: Author's elaboration based on IBGE and FNE data

Before applying the GPS dose-response model, initial estimations were carried out using linear regression models with fixed effects, which indicated a positive and statistically significant influence of the credit granted by the FNE on GDP per capita and the level of

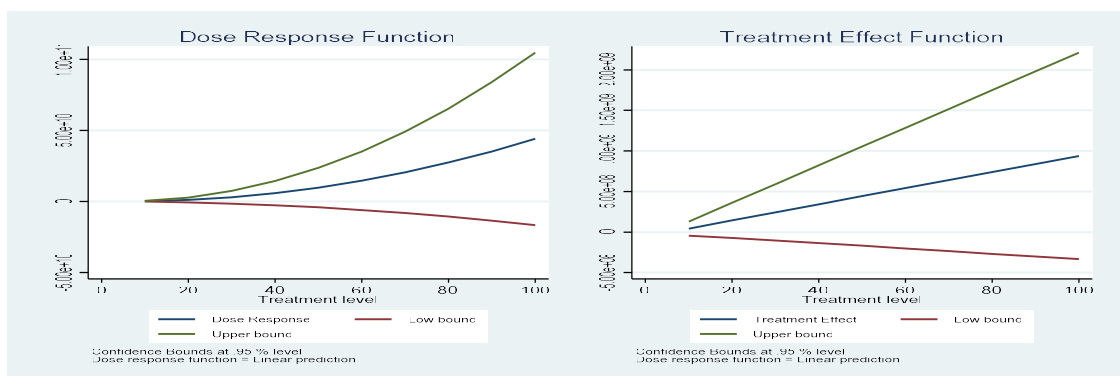
employment. These preliminary results suggested a consistent relationship between the volume of credit and economic indicators, justifying the adoption of GPS to more robustly explore marginal effects and potential non-linearities, as well as controlling for unobservable factors.

The results obtained with the application of GPS confirm and deepen this initial evidence. They reveal a positive and statistically significant impact of the credit granted by the FNE on economic growth and job creation in the states of the Northeast region. The estimates indicate that an increase in the volume of credit is associated with increases in GDP, GDP per capita and the level of employment, corroborating the initial hypothesis that the FNE acts as an effective mechanism for stimulating regional development.

The GPS estimates reveal a significant positive impact of FNE credit on economic growth and employment across SUDENE states from 2010 to 2022, with non-linearity emerging as the study's core theoretical contribution.

Figure 1 shows the dose-response function (DRF) for GDP, where a 1% credit increase boosts GDP by 0.8% in less-developed states (e.g., Piauí) but only 0.3% in more developed ones (e.g., Pernambuco), echoing Cecchetti e Kharroubi's (2012) finding of diminishing marginal returns to credit. This non-linear pattern, captured by the DRF's exponential rise and subsequent flattening, advances our understanding of FNE's effectiveness beyond linear assumptions, highlighting limits to credit expansion in dynamic economies. The treatment effect function (TEF) complements this, showing a 0.5% average GDP gain for treated states.

Figure 1: Dose-Response and Treatment Effect of FNE Credit on GDP



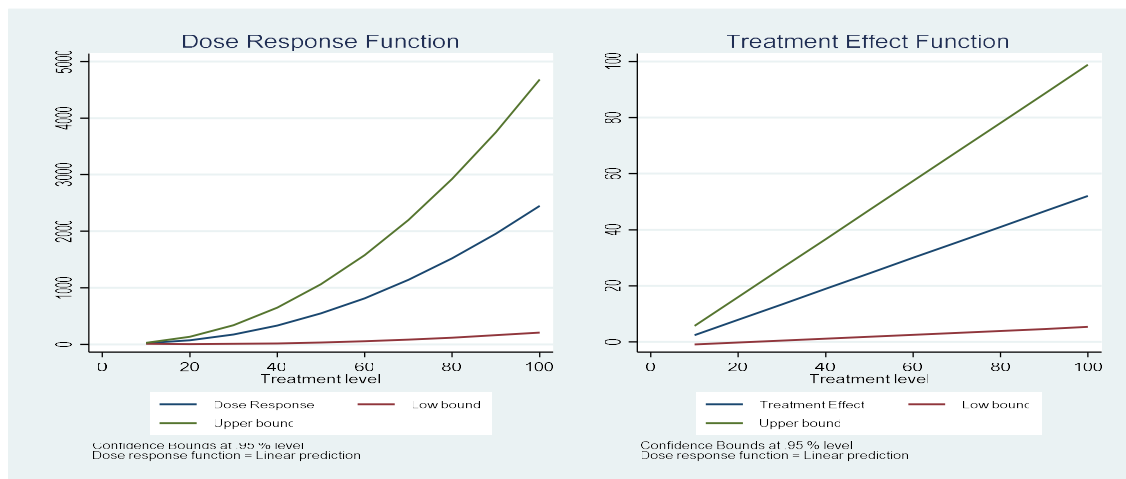
Note: Left: DRF shows the predicted GDP (in millions of reais) as the volume of credit increases. Right: TEF shows the average difference in GDP (in millions of reais) between treated and untreated states. The green lines represent estimates; the red lines indicate 95% confidence indices.

For instance, a 1% increase in FNE credit yields an average GDP gain equivalent to approximately R\$150 million in less-developed states. This practical estimate illustrates the economic relevance of targeting FNE credit more efficiently.

Figure 2 mirrors this for GDP per capita, while figure 3 indicates employment rising 0.15% per 1% credit increase below the 30th percentile, versus 0.05% above, with a

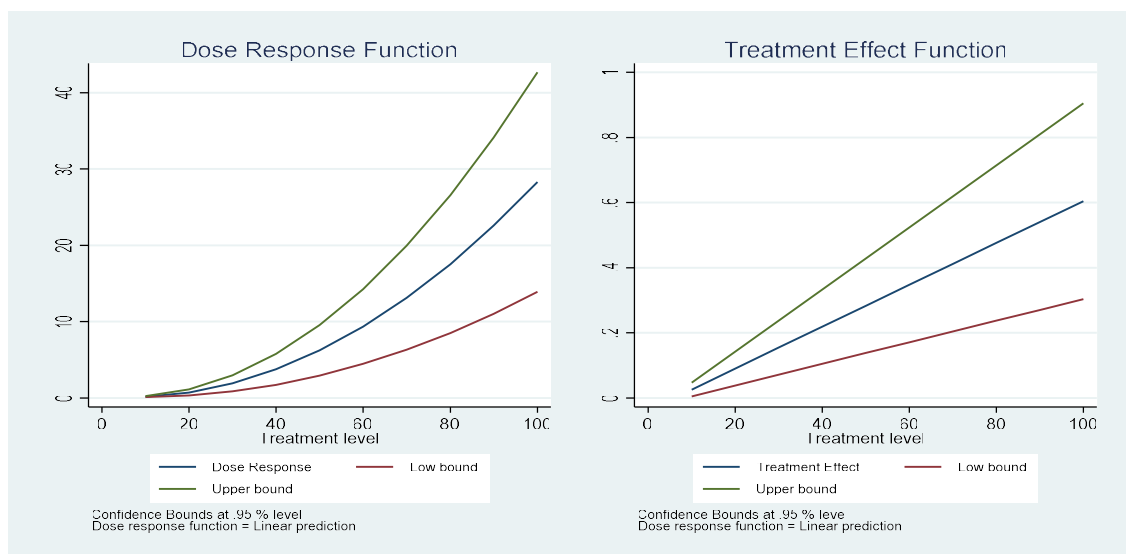
0.10% average TEF gain. Equally critical is the actionable insight of regional heterogeneity: less-developed states exhibit stronger responses, a finding underrepresented in prior work (e.g., Monte et al., 2023; Cintra, 2007). Unlike Monte et al.’s municipal focus, which missed state-level spillovers, or Cintra’s emphasis on developed areas, our GPS approach reveals that targeting resources to states like Piauí and Maranhão—up to 500 reais per capita—maximizes returns.

Figure 2: Dose-Response of FNE Credit on GDP per Capita



Note: DRF illustrates the predicted GDP per capita (in reais) as credit volume rises, with stronger initial gains in less-developed states. Green line shows estimates; red lines denote 95% confidence intervals.

Figure 3: Dose-Response and Treatment Effect of FNE Credit on Employment



Note: Left: DRF shows the predicted employment rate (%) as credit increases, with effects peaking around the 30th percentile (1.5 million reais), where less-developed states see the largest gains. Right: TEF indicates the average employment rate difference (%) between treated and untreated states. Green lines represent estimates; red lines show 95% confidence intervals.

In employment terms, the TEF implies roughly 20,000 additional formal jobs created per year in high-response states. These gains could substantially reduce labor market disparities if credit is strategically allocated.

To ensure the reliability of the GPS estimates, we conducted equilibrium tests to verify the assumption of weak ignorability, as proposed by Hirano and Imbens (2004). These tests assess whether the control variables (HDI, population, illiteracy rate and sector composition) adequately balance the treatment (volume of FNE credit) between the states. The results indicate that, within strata of similar GPS values, the covariates do not exhibit systematic differences between treated and untreated units (p -values > 0.10), supporting the validity of the model's causal inferences. This balance strengthens confidence in the estimated dose-response functions, capturing the true impact of FNE credit on economic results.

5. Conclusions

This study highlights the fundamental role of the FNE in promoting regional development, offering theoretical and practical insights. Theoretically, it advances the understanding of subsidized credit by highlighting non-linear effects, revealing limits to its effectiveness in more developed contexts. In practice, the pronounced impacts in less developed states such as Piauí and Maranhão signal a clear path for policymakers: directing credit to these areas - up to 500 reais per capita - can optimize economic and employment gains, reducing regional disparities. A fundamental limitation lies in the absence of sector-specific data, which future research could address by disaggregating the effects of credit on agriculture, industry and services to refine allocation strategies. These findings emphasize the need for tailored credit policies to unlock the full potential of regional development funds in tackling Brazil's persistent inequalities.

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