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BELO MONTE AND AMAZON LABOR MARKETS: A CAUSAL IMPACT ANALYSIS

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GT 04: Amazônia no Século XXI: avanços, retrocessos e novas perspectivas nas políticas socioambientais no contexto de COP30

Abstract

This study investigates the Belo Monte Hydropower Plant's causal effects on formal labor markets in the Brazilian Amazon. Using a robust quasi-experimental difference-in-differences design with Propensity Score Matching, we analyzed employment, income, and sectoral concentration in affected municipalities. Findings show significant, time-concentrated increases in formal employment and real income during the construction phase, mainly in Altamira and Vitória do Xingu. However, these positive impacts show limited post-construction persistence, indicating a transient advancement. This research provides vital empirical evidence on socio-economic transformations from mega-infrastructure projects in sensitive regions. Results contribute to discourse on 21st-century Amazonian socio-environmental policy advancements, setbacks, and new perspectives, informing strategies for COP30.

Palavras-chave: Belo Monte, Labor Market, Amazon, Socio-environmental Policy, Impact Assessment.

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Highlights

- The Belo Monte Hydropower Plant generated a significant but temporary boom in formal employment and income during its construction phase.
- The positive labor market impacts were largely concentrated in the directly affected municipalities, Altamira and Vitória do Xingu.
- Beyond the construction-driven labor market changes, the study observed minimal significant long-term effects on other socio-environmental indicators.
- The findings underscore the complex, often short-lived socio-economic transformations by mega-projects, offering critical insights for future socio-environmental policies and sustainable development in the 21st-century Amazon, particularly relevant for COP30 discussions.

INTRODUCTION

The Amazon biome, an ecological treasure spanning approximately 4.2 million km² within Brazil, is globally recognized for harboring an unparalleled biological diversity and concentrating a significant portion (62%) of the nation's surface freshwater resources (AMAZONIA 2030, 2021; MAPBIOMAS, 2024). Despite its immense natural capital, this region faces persistent threats from a confluence of anthropogenic activities and, at times, regressive public policies. Large-scale infrastructure projects, exemplified by the Belo Monte Hydropower Plant, represent a critical dimension of these transformative processes. Conceived as a pivotal component of Brazil's energy matrix and regional integration strategies, Belo Monte's implementation has ignited intense debates regarding its multifaceted socio-environmental implications, establishing it as a paradigmatic case study for understanding development trajectories in the Amazonian frontier (JOHANSEN, MAYER, MORAN, 2024). Over the past two decades, the Amazon has been systematically targeted by territorial integration strategies aimed at facilitating the expansion of logistical corridors for the outflow of agricultural commodities and mineral resources. This development model has been intrinsically linked to the construction of extensive infrastructure, including hydropower dams, waterways, and highways. Such interventions, while often justified by national development imperatives, frequently engender profound alterations to local ecosystems and socio-economic fabrics. The historical trajectory, particularly during periods marked by policy reversals and the weakening of environmental protection mechanisms, further accentuates the urgency of rigorously evaluating the long-term consequences of these strategic interventions, thus highlighting both advancements and retrogressions in regional development paradigms (SCIENCE PANEL FOR THE AMAZON, 2021).

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Against this complex backdrop, this study undertakes a rigorous empirical evaluation of the Belo Monte Hydropower Plant's specific impacts on the formal labor market in the directly affected municipalities of Altamira and Vitória do Xingu. By meticulously analyzing changes in formal employment relationships, real average income, and patterns of sectoral concentration, we aim to provide a data-driven assessment of the advancements and retrogressions in socio-environmental policies within the 21st-century Amazon. This inquiry is exceptionally timely and relevant, given the upcoming COP30 in Belém-PA in November 2025. The conference serves as a critical platform for projecting future scenarios and institutional arrangements, necessitating comprehensive reflections on policies related to deforestation, protected areas, land and territorial planning, mining, biodiversity conservation, and climate change adaptation within the Amazonian context, thereby fostering new perspectives for socio-environmental governance. Our findings aim to contribute meaningfully to these crucial policy dialogues.

METHODS

To robustly estimate the causal impact of the Belo Monte Hydropower Plant on the labor market dynamics of affected municipalities, this study employed a quasi-experimental design centered on a difference-in-differences (DiD) approach (CALLAWAY, SANT'ANNA, 2021; IGELSTRÖM et al., 2022). The fundamental premise of this methodology is to construct a credible counterfactual: to estimate what the trajectory of the formal labor market in the "treated" municipalities (Altamira and Vitória do Xingu) would have been in the absence of the hydropower plant's construction. This is achieved by comparing the changes observed in the treated group over time with the changes observed in a carefully selected "control" group of municipalities that did not experience the intervention but exhibited similar pre-treatment trends and characteristics. This design mitigates biases arising from unobservable time-invariant factors and common temporal trends, thereby enhancing the internal validity of the causal inferences.

The identification of both treated and control municipalities adhered to precise selection criteria to ensure the comparability and validity of the analytical framework. Altamira and Vitória do Xingu were unequivocally designated as treated municipalities due to their direct and

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substantial exposure to the socio-economic transformations brought about by Belo Monte. For the construction of the control group, a rigorous exclusion strategy was implemented: municipalities with medium to large-scale (>20 MW) hydropower plants that became operational after 2000 were systematically excluded to isolate the specific effects of Belo Monte from other similar interventions. Furthermore, municipalities with populations exceeding 500,000 inhabitants were removed from the potential control pool to maintain demographic comparability and prevent the inclusion of urban centers with significantly different labor market structures. To enhance the covariate balance between the treated and control groups, Propensity Score Matching (PSM) was subsequently applied (ROSENBAUM, RUBIN, 1983). This technique involved pairing each treated municipality with multiple control municipalities based on their pre-treatment probabilities (propensity scores) of receiving the "treatment," calculated from a rich set of pre-intervention covariates, thereby creating a synthetic control group that closely resembled the treated units before the intervention.

The empirical analysis utilized a comprehensive array of socio-economic and environmental variables to capture the multifaceted impacts of the hydropower plant. Labor market indicators included the annual quantity of formal active employment relationships, the real average income associated with formal employment, and the Hirschman-Herfindahl Index (HHI) for sectoral concentration, which provides a measure of labor market diversification. Additionally, dynamic indicators such as monthly admissions and resignations were analyzed. To contextualize these labor market changes within broader development trends, the study also incorporated key social indicators: infant mortality rates, mortality rates due to aggressions, the number of hospital beds per 100,000 inhabitants, school dropout rates at both elementary and high school levels, and the Índice de Desenvolvimento da Educação Básica (IDEB) scores. Environmental change was assessed through the percentage of municipal area covered by forests. The integrity and reliability of the data were ensured by sourcing all variables from authoritative Brazilian official databases: the Relação Anual de Informações Sociais (RAIS), the Cadastro Geral de Empregados e Desligados (CAGED), the Departamento de Informática do Sistema Único de Saúde (DATASUS), the Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira (INEP), and the Instituto Nacional de Pesquisas Espaciais (INPE).

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RESULTS AND DISCUSSION

The descriptive analysis of the formal labor market in the municipalities directly impacted by the Belo Monte Hydropower Plant, notably Altamira and Vitória do Xingu, reveals a discernible pattern of economic activity closely tied to the project's timeline. As depicted in **Figure 1**, a significant upward trend in the quantity of formal active employment relationships is evident, culminating in a pronounced peak between 2013 and 2015. This period precisely coincides with the most intensive phase of the plant's construction, indicating a direct correlation between the project's development and a surge in local labor demand.

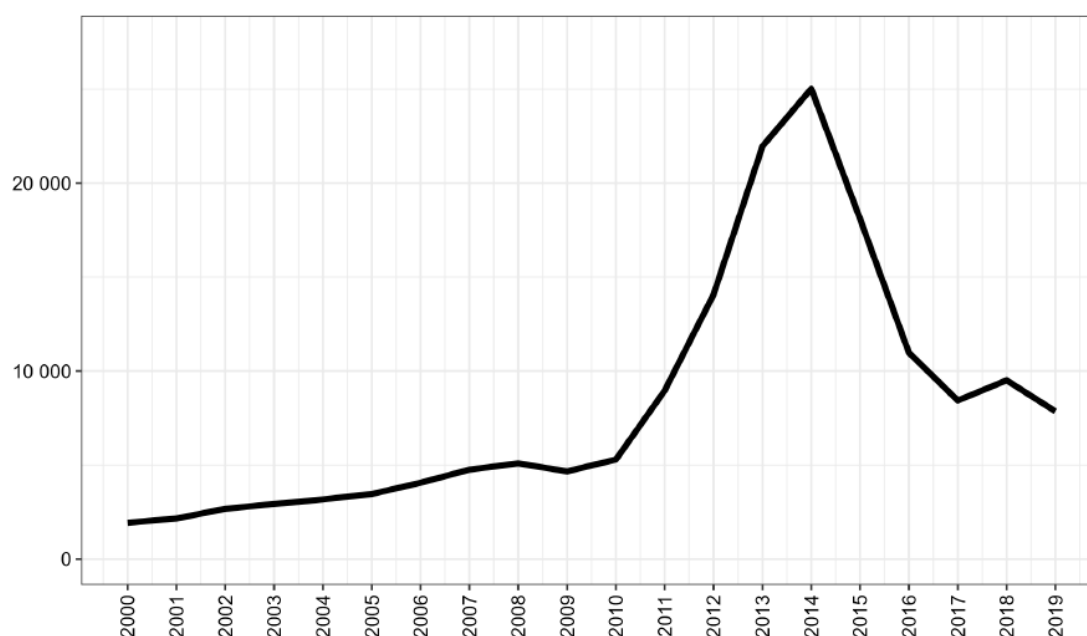


Figure 1 Evolution of the quantity of formal active employment relationships as of 12/31 - average selected municipalities, 2000-2019. Source: Authors' own elaboration.

The core of our inquiry, the causal effect analysis using the Difference-in-Differences methodology, provides more definitive insights. As shown in **Figure 2**, the Belo Monte Hydropower Plant exerted a statistically significant, positive, and notably time-concentrated average treatment effect on the treated (ATT) for the quantity of formal active employment relationships.

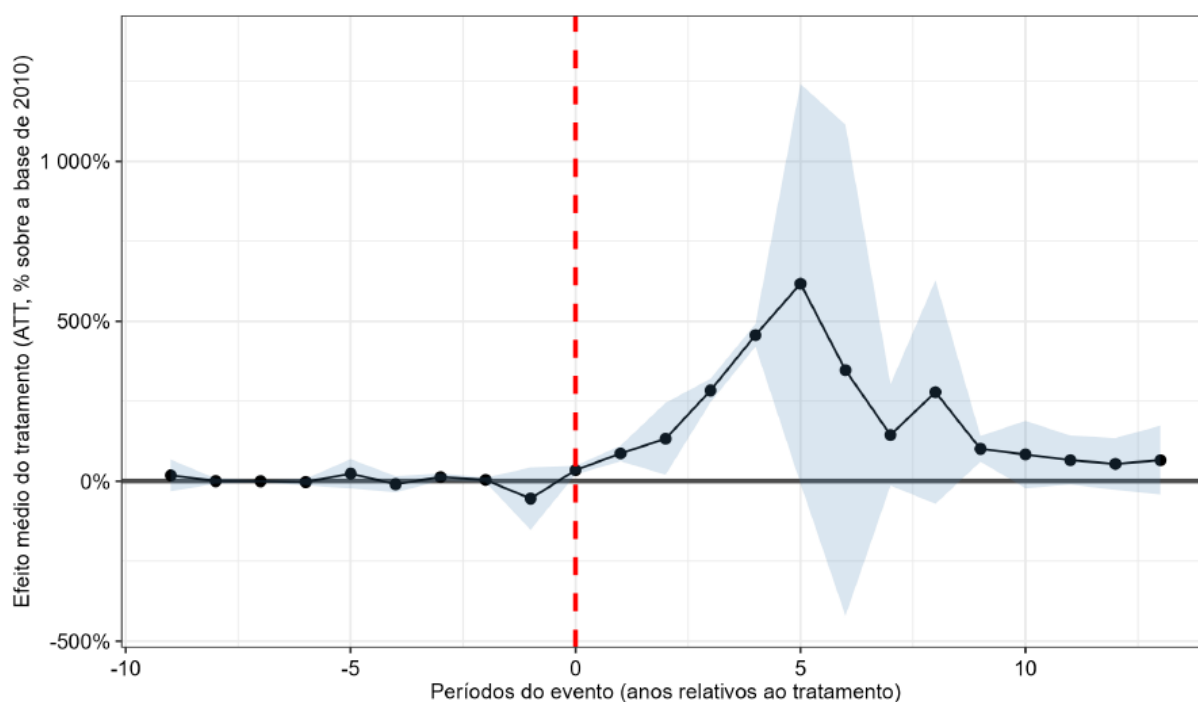


Figure 2. Average effect on the quantity of formal employment relationships. Source: Authors' own elaboration.

Similarly, **Figure 3** illustrates a significant positive causal effect on the real average income associated with formal employment. This robust finding confirms that the project generated substantial economic opportunities and improved income levels for formal workers during its construction phase, which can be seen as an advancement in local economic conditions. However, it is crucial to highlight that when examining other critical social indicators—including infant mortality rates, mortality rates due to aggressions, availability of hospital beds, school abandonment rates, IDEB scores, and forest cover percentage—the causal effects were largely either statistically insignificant or exhibited limited discernible patterns, suggesting a more targeted and less pervasive impact on broader socio-environmental well-being.



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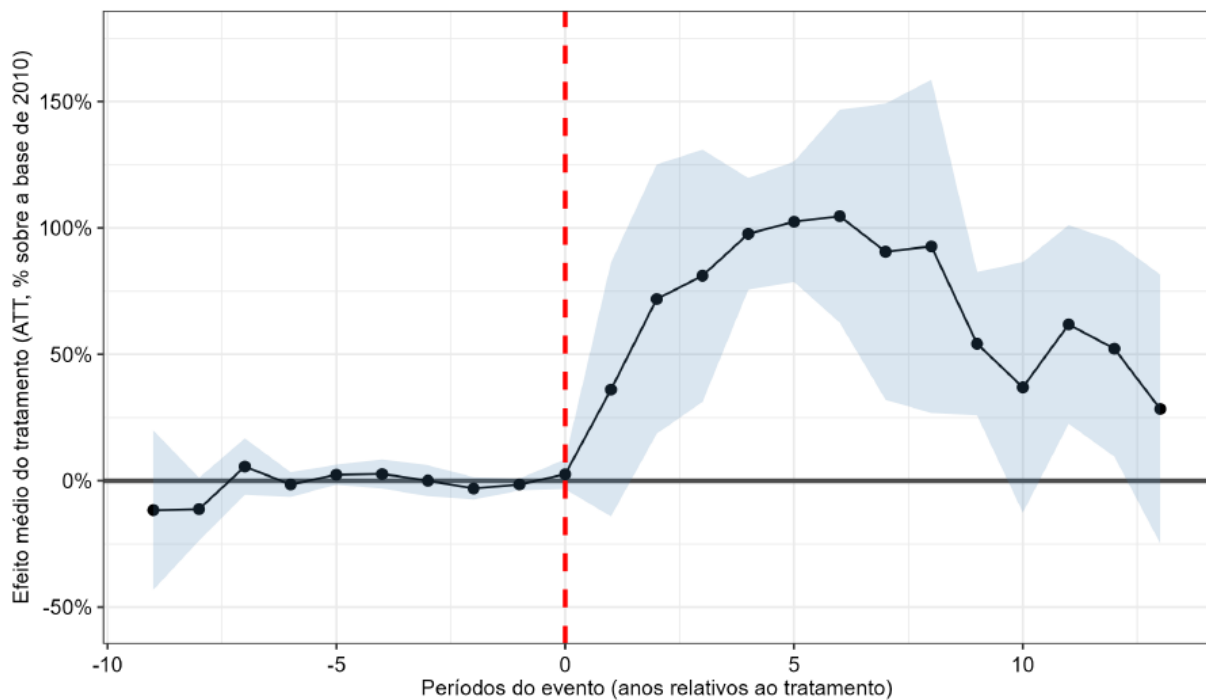


Figure 3 Average effect on the real average income of formal employment relationships. Source: Authors' own ellaboration.

Further scrutiny reveals significant heterogeneity in the observed effects across the treated municipalities. While Altamira and Vitória do Xingu experienced the most pronounced positive impacts on formal employment and income, the effects were considerably less evident or absent in other municipalities often associated with the project's broader area of influence. This indicates that the benefits were highly localized, concentrating in the immediate vicinity of the construction sites. This finding also underscores a potential limitation of a standard DiD model that assumes a homogeneous treatment effect across all treated units; in reality, the proximity to and scale of direct construction activities likely played a crucial role in determining the magnitude of the local labor market response, leading to a more nuanced spatial distribution of benefits than a simple binary treatment variable might suggest.

An important aspect of this analysis is the examination of the persistence of these labor market effects. Our findings indicate that the positive impact on formal employment, while substantial during the construction phase, showed minimal to no persistence in the post-construction period. As illustrated in **Figure 1**, the employment surge quickly receded after the plant's operationalization, suggesting a temporary economic boom followed by a return to pre-

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construction labor market conditions. This boom-bust cycle is a common characteristic of large-scale, capital-intensive infrastructure projects, and its transient nature could be interpreted as a setback in terms of sustainable long-term development (RODRIGUES et al., 2009; MAYER et al., 2022). Furthermore, while there was an initial positive effect on real average income, this also appeared to be less persistent compared to the quantity of formal employment. Similarly, the study found less perceptible long-term effects on sectoral diversification, suggesting that the project did not fundamentally restructure the underlying economic composition of the affected municipalities beyond the construction period.

Finally, while acknowledging the methodological limitation of this study's analysis being restricted to only two directly treated municipalities, Altamira and Vitória do Xingu, it is crucial to emphasize the broader implications. As the largest hydropower plant built in the Amazon in recent decades, Belo Monte serves as an important example of what was not done correctly and should be improved. Specifically, the transient nature of benefits and the lack of long-term gain for the local population by the construction highlights critical lessons. Avoiding these same mistakes in future interventions is paramount, bringing important insights to the discussions of COP30 and future socio-environmental governance in the Amazon.

REFERENCES

- AMAZÔNIA 2030. **2021 Amazon Facts**. [S. l.]: Amazônia 2030, 2021. Available in: https://amazonia2030.org.br/wp-content/uploads/2021/11/Fatos-da-Amazonia-2021_ENG_04_11.pdf. Accessed on: 23 June 2025.
- CALLAWAY, B.; SANT'ANNA, P. **did: Difference in Differences** [R package version 2.1.2]. 2021. Available at: <https://bcallaway11.github.io/did/>. Accessed on: 6 jul. 2025.
- IGELSTRÖM, E. et al. Causal inference and effect estimation using observational data. **J Epidemiol Community Health**, v. 76, n. 11, p. 960-966, 2022.
- JOHANSEN, Igor Cavallini; MAYER, Adam P.; MORAN, Emilio F. Up close, it gets worse: Comparison of hydropower perceptions between impacted populations in the Amazon and those of the Brazilian population as a whole. **Energy Research & Social Science**, v. 110, p. 103455, 2024.
- MAPBIOMAS BRASIL. **Brazil's water surface will be below average again in 2023**. 2024. Available at: <https://brasil.mapbiomas.org/en/2024/06/26/superficie-de-agua-no-brasil-voltou-a-ficar-abaixo-da-media-em-2023/>. Accessed on: 6 jul. 2025.

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MAYER, Adam et al. Hydropower, Social Capital, Community Impacts, and Self-Rated Health in the Amazon. **Rural Sociology**, v. 87, n. 2, p. 393-426, 2022.

RODRIGUES, A. S. L. et al. Boom-and-Bust Development Patterns Across the Amazon Deforestation Frontier. **Science**, v. 324, n. 5933, p. 1435-1437, 12 jun. 2009.

ROSENBAUM, P. R.; RUBIN, D. B. The central role of the propensity score in observational studies for causal effects. **Biometrika**, v. 70, n. 1, p. 41-55, Apr. 1983.

SCIENCE PANEL FOR THE AMAZON. **Amazon Assessment Report 2021**. [S. l.]: SPSAS-Amazônia, 2021. Available at: <https://spsas-amazonia.biota.org.br/wp-content/uploads/2022/07/Amazon-Assessment-Report-2021-PART-III.pdf>. Accessed on: 6 jul. 2025.

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