Infrastructure-driven development: the local social impact of a large hydropower plant in the Amazon

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Abstract

The Brazilian Amazon is marked by attempts at infrastructure-driven development. The construction of the Belo Monte dam, the third-largest in the world, brought chaotical and rapid urbanization to surrounding cities. This paper answered whether the Belo Monte dam impacted the level of violent crime in the region after Altamira was ranked as the most violent city in Brazil in 2015. Following a difference-in-difference approach, I explore the timing of the Belo Monte dam construction and the distance from the construction site to identify the causal effect of unplanned urbanization on homicide rate. In two exogenous shocks, the beginning (2011) and the end of the construction (2015), I estimated a significant rise in the homicide rate in closer cities. The results are driven by criminal activity, with drug trafficking being one of the channels behind the rising homicide rate. The homicide victims are mainly the young male population causing a significant loss of human capital. Increased drug trafficking and rising homicide rate even after the construction indicate that the Belo Monte dam may have a long-term effect on the violence level in the region. Violence imposes high social costs and may jeopardize future growth in the Amazon.

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1. Introduction

Large-scale infrastructure projects are meant to achieve progress and growth. Dams, especially, can improve agriculture production through irrigation and reduce poverty by causing development (Duflo & Pande, 2007). Additionally, constructing hydropower plants can potentially increase economic activity and tax revenue in the surrounding cities (de Faria, Davis, Severnini, & Jaramillo, 2017). However, the debate around the construction of dams lacks systematic empirical evidence on how these projects distribute their costs and benefits.

Going in the same direction as Duflo and Pande (2007) and de Faria et al. (2017), this paper aims to provide evidence on how a large dam affects the welfare of the local population. I focus on Brazil, which has approximately 70 percent of its energy hydropower generated (ANEEL, 2019). With 1,361 hydropower plants in operation, 32 in construction, and 111 in the planning stage, Brazil is among the top three countries producing the most hydroelectric power. While hydropower can provide clean energy demanded by a growing nation, each dam also represents socioeconomic impacts on communities around the reservoirs. Whether this type of policy's distributional and productivity implications are fairly distributed across the population remains widely questioned.

Many social impacts caused by hydroelectric dams are reported in the literature, with few studies examining local impacts in developing countries (de Faria et al., 2017; Fearnside, 2001, 2014; Jackson & Sleigh, 2000; Sovacool & Bulan, 2011). The economic activity created by a large dam construction is sudden and has the effect of attracting many people. Between workers and displaced people, cities grow and experience rapid urbanization. When the cities in question are in developing countries, urban size and weak governments can cause institutional failure (E. L. Glaeser, 2014).

Most of the studies focused on qualitative evaluation except for de Faria et al. (2017), which examined the relationship between hydropower development and the socioeconomic conditions in Brazilian counties. Despite no significant effect on many social indicators, they found a negative impact on access to piped water and electricity, which could be explained by the growth in irregular housing. This result reinforces the findings of Duflo and Pande (2007) that state-level redistributive institutions failed to ensure the distribution of productive gains between the winners and losers of dam constructions.

I focused on the impact of the Belo Monte Hydroelectric Power Plant, the third largest in the world, constructed in the Pará State, Brazil. My analysis concerns the sudden change imposed by a large project on rapid and unplanned urbanization. I exploit the timing and distance of the construction of the dam to evaluate whether Belo Monte increased the violent crime level in its area of direct and indirect impact. By applying a difference-in-difference approach, I estimate the effect on the homicide rate during the construction of the Belo Monte dam (2011-2015) and after its conclusion (2016-2017). My regressions included all municipalities in the Pará state and control for municipalities fixed effects, time specific dummies, and covariates correlated with violent crime.

Using a panel dataset from 2007 to 2017, my main results show that Belo Monte dam construction led to a significant increase in the homicide rate in the municipalities included in the area of direct impact (ADI). The increase in violent crime persisted after its conclusion, indicating a negative inheritance of Belo Monte for the welfare of the region. The area of indirect impact (AII) does not present the same results as the ADI, which reinforces the theory that areas closer to the dam are the ones that bear the highest costs. The results are robust to a set of checks that include serial correlation, the homicide rate time series trend, and the parallel trend assumption.

Following the literature on the economics of crime, I gather covariates that are related to determinants of violence. My results prove that homicides are related to criminal activity and not motivated by other factors. Using illicit drug seizures, I show that the presence of drug trafficking organizations is one of the channels behind the rising homicide rate.

The evidence provided in this paper shows that the social cost of the Belo Monte dam includes a significant loss of young lives and a possible long-term violent conflict among drug trafficking organizations. These results align with the literature and show that policymakers and regulatory agencies should consider institutional capabilities when starting a large-scale project. The results are especially important for Brazil, which plans to build more than 40 hydroelectric dams in the Amazon region.

The remainder of the paper is structured as follows. Section 2 provides the context of the Belo Monte dam and violence in Brazil. Section 3 gives an overview of the related literature. Section 4 presents the data used in the analysis. Section 5 describes my empirical strategy. Section 6 presents the results on the Belo Monte dam and violence. Section 7 shows the robustness of the model. Finally, Section 8 concludes the paper.

2. Context: Belo Monte dam and violence in Brazil

2.1 Belo Monte dam

The government intended to integrate the Amazon region into national development goals. The project for the construction of the Belo Monte dam dates to 1975 with the Hydroelectric Inventory Studies for the Xingu river hydrographic basin. However, problems with other hydropower plants in the Amazon, such as Tucuruí and Balbina, were marked by lack of transparency, displacement of people, and flooding of indigenous territories weighted against the construction of Belo Monte. Also, the World Bank and other international organizations stopped funding large dams out of concern for environmental costs. Still, the country continues to grow, and after nationwide blackouts in 2001, the Belo Monte dam project was revised and entered into the Growth Acceleration Program of the Brazilian Federal Government (Moran, 2016).

Before the construction, much was discussed about the environmental costs of the Belo Monte dam (Fearnside, 1999). Nevertheless, less attention was given to the unpreparedness of all levels of government to deal with the negative social impacts of large-scale infrastructure projects. The dam construction attracted around 45,000 formal workers between 2011 and 2014, the equivalent of 46 percent of the Altamira population in 2010 (Miranda Neto, 2015). Analysis of spatial distribution shows an increase in urban land cover in the region around the construction between 2011 and 2016 (Feng et al., 2017). Improvements do not follow the sudden increase in population, given the lack of official figures for the number of inhabitants[1]. For instance, intergovernmental transfers depend on the official population size, which follows the official projection based on the 2010 census that completely disregards Belo Monte induced in-migration and resettlement in the region. The construction represented an overall loss of living conditions for the local population, with worse public health services (Grisotti, 2016), a lack of sanitation infrastructure (Gauthier & Moran, 2018), as well as housing and food inflation (Acevedo Marin & da Costa Oliveira, 2016; Bro, Moran, & Calvi, 2018; Calvi, Moran, Silva, & Batistella, 2020). The social costs of dam construction are often not well documented in the literature in the Global South. Still, they are described in the energy boomtown studies for the Global North (England & Albrecht, 1984; Freudenburg, 1981) and in the resource curse literature (van der Ploeg, 2011).

[1] According to the 2010 population census Altamira had about 99,075 inhabitants and official projection for 2015 was 108,382 inhabitants. However, the Municipality of Altamira estimated 148,224 inhabitants already in 2012 based on access to medical and hospital services (Neto & Herrera, 2016).

2.2 Violence in Brazil

In 2015, Altamira, one of the cities in the area of the direct impact of Belo Monte, was ranked as the most violent city in the country (Daniel Cerqueira et al., 2017). Although there was some speculation about the role of Belo Monte in the increase in violence in the region, it is necessary to take into consideration that Brazilian poorer states, as well as medium and small municipalities, have been experiencing an increase in the number of homicides (Daniel Cerqueira et al., 2019; Scorzafave, Justus, & Shikida, 2015).

One example of this countrywide trend is that in 2017 Brazil broke its record by having 63,880 people murdered, meaning 175 deaths per day, with 30.7 homicides per 100,000 inhabitants (Daniel Cerqueira et al., 2019). The level of violent crime in Brazil varies widely across regions and states, but the higher incidence occurs in places with lower levels of human development (Daniel Cerqueira et al., 2016).

The available evidence suggests that in urban areas, homicides are linked to illegal drug trafficking and disputes among criminal gangs (Daniel Cerqueira et al., 2019; Daniel Cerqueira et al., 2017). Homicides are also related to a wide variety of other violent crimes, such as robberies and kidnapping, besides a close connection between homicides and other forms of violent crime (Heinemann & Verner, 2006). Recent evidence also indicates that labor market conditions affect crime levels (Britto, Pinotti, & Sampaio, 2022; Dix-Carneiro, Soares, & Ulyssea, 2018).

3. Related literature

While developed countries have stopped building dams because of increasing concerns about environmental and social impacts, developing countries are in the other direction investing in large hydropower plants to boost development. Hailed as a clean form of renewable energy, hydropower dams are being promoted as a pathway to social development and environmental protection (Lees, Peres, Fearnside, Schneider, & Zuanon, 2016; Wang, Tseng, & Zheng, 2015). In the case of Brazil, indirect benefits of building hydropower plants are promoted by the policymakers and include improved infrastructure, such as roads, schools, hospitals, and economic compensation (de Faria et al., 2017; Eletrobras, 2009; Lees et al., 2016).

There is no unique conclusion on whether economic, social, and environmental benefits materialized (Ansar, Flyvbjerg, Budzier, & Lunn, 2014; de Faria et al., 2017; Fearnside, 2006, 2015; Jackson & Sleigh, 2000; Tilt, Braun, & He, 2009). An important question that remains to be answered is how the costs and benefits of large dams are distributed between local communities and energy users (Bro et al., 2018; Duflo & Pande, 2007; Koch, 2002; Patil, Ghosh, & Kathuria, 2017; Soito & Freitas, 2011).

Another critical impact to be considered in hydropower developments in tropical regions, like the Amazon Basin, is the deforestation at the dam construction site and surrounding areas to open roads and create settlements. Deforestation is likely to impact the production of electric energy due to climate variability (Stickler et al., 2013), and environmental changes consequently produce social impacts as they result in loss of livelihood and poverty (Castro-Diaz, Lopez, & Moran, 2018; Soito & Freitas, 2011). For instance, as the riverine ecosystems decline in quality, so does the welfare of the local communities that depend on fisheries for food and income generation. Likewise, the study by Duflo and Pande (2007) about irrigation dams in India found that rural poverty increased in the district where the dam was built. Even with an increase in agricultural production and a decline in rural poverty in areas located downstream from the dam, the policy was considered cost-ineffective as it did not offset the negative impacts on the dam's own district.

The social impacts of a hydropower plant incorporate the strain put on local infrastructure, health, and housing, caused by the influx of workers (Soito & Freitas, 2011) and the consequences such as sexually transmitted diseases (Grisotti, 2016) and drug use (von Sperling, 2012). Social cohesion is also negatively affected by the displacement of local communities that lived in the reservoir area as well as the encroachment by outsiders (Brown, Tullos, Tilt, Magee, & Wolf, 2009; Jackson & Sleigh, 2000; von Sperling, 2012).

In the Belo Monte case, the hydropower plant acted as a catalyst for urban agglomeration. It attracted formal workers for the construction of the dam and people to be employed in indirect jobs created around the construction, coupled with displaced communities allocated within the closer cities. According to Edward L. Glaeser and Sacerdote (1999) model, a city size increase is likely to increase crime rates. Moreover, under-developed regions[2] tend to have weaker institutions, making it even more challenging to deal with the impacts of large infrastructure projects (E. L. Glaeser, 2014).

Edward L. Glaeser and Sacerdote (1999) investigate why cities have more crime. They decompose the connection between cities and crime into three categories. First, cities lower the costs of crime by reducing the probability of arrest; dense urban areas have a much larger number of suspects. Second, the cities' density produces higher returns to crime by creating proximity between potential wealthy victims and poor criminals. Third, urban areas attract crime-prone individuals. The same larger market size that makes cities appealing to firms also makes cities more appealing to drug dealers and thieves. Moreover, the authors argue that residents' preferences may be altered by city attributes, via social interactions and neighborhood effects, which make them more prone to crime (E. L. Glaeser, Sacerdote, & Scheinkman, 1996).

Social interactions are a key channel through which neighborhood crime is linked to individual criminal behavior (Damm & Dustmann, 2014). A critical remark in the literature is that the

[2] For an overview of socioeconomic indicators in Pará and the rest of Brazil see Figure C1 (Suplementary Materials).

concentration of at-risk youth together in the same environment leads to higher crime levels. Therefore, neighborhood segregation increases crime by fostering social interactions among disadvantaged youth (Billings, Deming, & Ross, 2019) and negatively affects the future economic performance of the segregated groups (Cutler, Glaeser, & Vigdor, 2008).

Lastly, urbanization poses even more challenges for developing countries. Poorer countries tend to have weakly institutionalized contexts and fewer resources to deal with urban density externalities, such as congestion, contagious disease, and crime (E. L. Glaeser, 2014). The same weak government poses a problem in controlling the spread of criminal organizations (Dell, Feigenberg, & Teshima, 2019).

4. Data

My unit of analysis is the administrative unit below a Brazilian state, a municipality. My sample includes all municipalities in the Pará state[3] for the period between 2007 and 2017. The outcome variable is the number of homicides per 100,000 inhabitants, which indicates the incidence of violence (Fajnzylber, Lederman, & Loayza, 2002a, 2002b). All the mortality data employed in this paper come from death certificates and provide information on the cause of death, date, and place of occurrence.

I used variables related to the determinates of violent crime, which are available annually at the municipality level. The selected variables are meant to control employment level (number of formal employment, average earnings), socioeconomic conditions (number of cash-transfer program recipients, child mortality, GDP per capita), education (high school dropout rate),

[3] I use only the state where the Belo Monte dam is located (Pará) since the police (deterrence effect) is organized at the state level. Furthermore, municipalities are more homogeneous within one state.

urbanization (suicides and mortality due to traffic accidents), and police effectiveness (police records of drug seizures)[4].

The treatment and control groups are defined based on the distance to the dam. The treatment group was determined in the environmental impact assessment (EIA) before the construction of the Belo Monte (Eletrobras, 2009). The EIA defined which cities would be directed impacted by the dam and the ones that would suffer an indirect influence. The studies pointed to two different areas for impact assessment, and these two groups of cities are shown in Figure 1. They are named in the model as Area of Direct Influence (ADI), with five municipalities[5] and Area of Indirect Influence (AII), with seven municipalities[6]. The two groups formed the target region of the Xingu Sustainable Regional Development Plan (PDRSX).

Figure 1 – Municipalities impacted by Belo Monte dam – ADI and AII (Pará state)

I decided to use more than one control group to test whether there are spillovers of violence and the model's robustness when the state capital is excluded. The first control group includes all other municipalities except the treated ones. The second control group is conceived to avoid the spillover of violence since geographic proximity may lead to concerns that the control group might be contaminated. Surrounding municipalities are excluded from the second control group. For instance, the AII region will be excluded when the ADI is the treated area.

[4] Dataset details are in Table A1 (Appendix)

[5] Altamira, Anapu, Brasil Novo, Senador José Porfírio and Vitória do Xingu

[6] Gurupá, Medicilândia, Pacajá, Placas, Porto de Moz, São Félix do Xingu and Uruará

Lastly, I propose a third control group that excludes the closest municipalities, the state's capital, and its metropolitan region. The different levels of characteristics that are determinants of violence, such as socioeconomic conditions and urbanization level, could affect the treatment effect. I use this third control group as a robustness check for the qualitative results of the treatment effect and to have an equal control group to compare the ADI and AII. The control groups are shown in Figure 2.

Figure 2 – Control Groups for the ADI and AII (Pará state)

5. Empirical strategy

Following a difference-in-difference (DiD) approach, I explore the timing of Belo Monte dam construction and the distance from the construction site to identify the causal effect of unplanned urbanization on the violent crime level. Given the previous discussion, I focus on two different moments: the start of the construction (June 2011) and the subsequent rapid urbanization of the region, and the end of construction followed by a massive layoff (November 2015). The first difference is over time, and the second difference is between closer and farther away municipalities.

The model to be estimated is the following difference-in-difference regression:

$$Homicide_{it} = \alpha + \beta_1 \cdot (D_{2011 \leq t \geq 2015} \times treated_i) + \beta_2 \cdot (D_{2016 \leq t \geq 2017} \times treated_i) + z'_{it}\delta + \theta_i + \gamma_t + \varepsilon_{it}$$

where Homicide is the homicide rate for municipality i in year t; $D_{2011 \leq t \leq 2015}$ is a dummy variable equal to 1 for the years between 2011 and 2015; $D_{2016 \leq t \leq 2017}$ is a dummy variable equal to 1 between 2016 and 2017; treated is a dummy variable equal to 1 if the municipality is in the impacted regions; z_{it} is a set of municipality-level control variables; θ_i is a municipality fixed effect; γ_t is a time fixed effect; ε_{it} is a random term; and α , β_1 , β_2, and δ are parameters to be estimated.

One concern is that the dam's construction also affects the municipality's characteristics which are determinants of violent crime. Therefore, the control variables are themselves outcome variables. According to Angrist and Pischke (2009), controlling for outcome variables can be misguided, giving origin to the potential problem of 'bad controls'. The control variables should be measured before the variable of interest is determined. Hence, I decided to use as control variables the interactions between pre-treatment values (2010) with time dummies instead of directly controlling for their contemporaneous values.

This procedure would control for pre-treatment municipality characteristics that are time-variant and potentially correlated with violent crime and other covariates. The set of control variables that are interacted with time dummies are number of formal employment, average earnings (ln), number of cash-transfer program recipients (*Bolsa Família*), child (before age five) mortality rate, GDP per capita (ln), high school dropout rate, drug trafficking crime records, suicides and mortality due to traffic accidents. Also, it is critical to include an interaction between pre-treatment values of homicide rate (2010) and time dummies to account for criminal inertial. The model allows different dynamics of violence conditional on municipality characteristics before the implementation of Belo Monte dam.

To address concerns related to the trend in the homicide time series, I run a specification that allows the treatment to affect both the level and the trend of the outcome variable to assess whether the trend could be affecting the violence level. Additionally, I tested if the results were driven by a spurious regression and use the lagged values (t-1) of the homicide rate as control variable instead of the interaction mentioned above. I also test whether the parallel trend assumption holds by creating a pre-intervention placebo variable for years before Belo Monte, followed by a graph plotting a flexible DiD regression with leads and lags.

Additionally, since the size of the population is directly related to the variance of the homicide rate, all regressions are weighted by population size. The standard errors are clustered at the municipality level to avoid underestimation due to autocorrelation in the residuals (Bertrand, Duflo, & Mullainathan, 2004).

6. Results

For descriptive purposes, in Figure 3, Panel A and B, plot the yearly homicide rate for the municipalities in the state of Para between 2007 and 2017, disaggregated by treated areas and their respective controls. The panels indicate the two shocks: first, in June 2011, when the construction of Belo Monte started, and second, between November 2015 and January 2016, when the construction ended and a massive layoff took place (Oliveira, 2017).

In Figure 3, panel A, the ADI has a similar trend to the control groups in 2009 and 2010. Although the homicide rate in the control groups continues to increase over time, the ADI experienced explosive growth in violence. In the AII, panel B, the parallel trend assumption in homicide rate before 2011 does not seem to hold. For this reason, the results concerning AII are included in the Section E in the appendix.

Figure 3 – Homicide rate in the impacted areas of Belo Monte dam (2007-2017)

6.1 Main results

Table 1 presents the main results for the area of direct influence of the Belo Monte dam and all three different control groups. The column titles indicate which control group is used. For each control group, the results are shown without and with interactions of time dummies with pre-intervention values of the set of covariates plus homicide rate[7].

All columns show a significant effect on violence in both shocks, the start (Treated ADI x Post 2011) and the end of the construction (Treated ADI x Post 2016). On average, the five municipalities included in the ADI experienced an increase in violent crime during the Belo Monte dam construction, followed by a more intense increase after its conclusion.

Control group 2 is a robustness check for violence spillovers between treatment and control municipalities. If there is such violence spillover, the coefficients on columns 3 and 4 should be higher than the ones in columns 1 and 2, respectively. Once surrounding municipalities are excluded from the control group, the coefficients should capture the effect of the Belo Monte dam on violent crimes more accurately. The small difference between columns 2 and 4 suggests the presence of some spillovers and an underestimation when using control group 1. Control group 3 is a robustness test for the previous coefficients, as it does not include a larger number of surrounding municipalities (Figure 02, Panel A) and the metropolitan region. The results in columns 5 and 6 continue to show strong qualitative and quantitative results of the impact of the Belo Monte dam on the homicide rate in the ADI.

Table 1 – Main Results for the ADI – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

It is also worth noting that in columns 2, 4 and 6 when I include the set of interacted controls, there is a significant change in point estimates in both shocks. Therefore, a difference between

[7] For robustness purposes, I estimate the model using the contemporaneous values of the set of covariates and the results are in Table D2 (Appendix).

treated municipalities and control groups is driven by differential pre-intervention characteristics. To analyze what characteristic is affecting the behavior of homicide rates, I separated the set of covariates into groups of variables relating to the determinates of crime and estimated different specifications accounting for each of them separately.

Table 2 shows the results using control group 2, the main control group. Columns 1 and 9 are the same as columns 3 and 4 of Table 1. The set of covariates is separated and included in different columns: column 2 contains the education variable (high school dropout rate), column 3 includes urbanization variables (suicides and mortality due to traffic accidents), column 4 holds constant socioeconomic conditions (number of cash-transfer program recipients, child mortality, GDP per capita), column 5 includes employment variables (number of formal employment, average earnings), column 6 includes drug trafficking variable, and column 7 contains the homicide rate in 2010 interacted year dummies. Column 8 shows the coefficients when all covariates are included, excluding the homicide rate. Overall, the only characteristic that affects point estimates is a different initial level of urbanization across treated and control municipalities.

For the quantitative implication, considering the coefficients in column 4 of Table 1, the coefficients can be read as changes in homicide rate per 100,000 inhabitants during the construction of Belo Monte dam and after its conclusion, indicating average increases of, respectively, 38.11 per 100,000 inhabitants between 2011 and 2015, 58.14 after 2016. Comparing these with pre-Belo Monte average homicide rate in the ADI, the construction period raised the violent crime level by 163 percent and the two years following the massive layoff had an average increase of 248 percent. These are significant increases considering that the control municipalities also experienced a rise in violence levels, as shown in the descriptive statistics in Table B1 in the appendix.

Table 2 – Covariates – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

To support the theory of an increase in violent criminal levels in the ADI of the Belo Monte dam, I break down the dependent variable by victims' characteristics. Restricting the analysis to specific demographic characteristics also helps shed light on how violence affects different groups. Table 3 presents the results and shows that the violence increase affected mainly men, especially young males aged 15 to 29 years. Additionally, it is possible to observe the progression of homicides by firearm and homicides that occurred in the public way (excluding the possibility of domestic violence). Table 3 shows the average level of each subgroup before the construction of the Belo Monte dam (2007-2010), allowing the estimation of the proportional effect (compared to the pre-intervention value) in the first and second shock.

Table 3 – Victims characterization – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

6.2 Discussion

The results shown in Table 1 and Table 3 show that the Belo Monte dam affected the violent crime level in closer municipalities. The coefficients seem to follow the literature on the economics of crime. The first increase in violence (2011-2015) is driven by urbanization and its negative externalities. The second increase (2015-2016) incorporates the effect of higher unemployment, criminal inertia, and social interactions. The results undoubtedly prove that violence is not related to domestic violence or family disputes but criminal activity in the region[8].

Although there is no official data about the number of migrants the region received, it is possible to get a perspective of the size of the influx of people by looking at the number of formal employments in Figure 4, Panel A and B. The number of formal workers is only a fraction of the number of migrants the region received, given that other formal and informal employments follow the economic boom experienced in the region. The first figure shows the average level of formal jobs in the five municipalities (ADI) affected by the dam; the second one shows the level in the city of Altamira. It is important to show the data for Altamira since it was the one that concentrated formal employment related to the dam's construction[9]. I analyzed the data used as a proxy for urbanization level (suicides and mortality due to traffic accidents), and there is a significant increase in urbanization level during and after the dam construction; results are shown in Table D1 (supplemetary materiasl). As the literature indicates, rapid urbanization may generate crime as an externality by lowering the probability of arrest, bringing together rich and poor, and thus increasing the returns to crime (E. L. Glaeser, 2014).

Figure 4 – Number of formal employment in the ADI and Altamira (2007-2017)

Urban land cover increased in Altamira between 2011 and 2016 as shown by Feng et al. (2017). I collected satellite images of Altamira to show the new neighborhoods created during the

[8] Other types of violence (domestic violence and rape) in the region are reported in Figures D1 and D2 (Appendix)

[9] I also run a DiD regression for Altamira to estimate the impact of the Belo Monte dam on homicide rate and the results are in Table D4 (Appendix)

dam's construction to accommodate the displaced people that lived in the reservoir area. Besides the influx of workers, the region also had to incorporate *ribeirinhos* that used to live from natural resources along the Xingu River. Figure D3 and D4 in the appendix shows the city of Altamira in 2010 and 2014. One visible characteristic in Figure D4 (2014) is the urban sprawl which segregated those local communities from the rest of the city. Some of the problems these new residents face are related to their localization. First, they are far from the river where they used to fish and grow food, making them urban poor and dependent on social aid (Brum, 2018). Second, the new housing arrangement did not respect their previous way of living by putting together opposing tribes and communities (Daniel Cerqueira et al., 2017). Social Capital is found to be reduced in both resettled and host populations, which nurtures violence and conflict within a community, according to the literature (Mayer, Lopez, Cavallini Johansen, & Moran, 2022; Mayer, Lopez, Leturcq, & Moran, 2022)

The increase in population and income in the region is followed by the rise in illicit drug seizures, used as a proxy for the level of drug trafficking. Figure 5, Panel A and B show the annual seizure rate per 100,000 inhabitants in the ADI and Altamira. It is possible to observe explosive growth in the cities affected by the Belo Monte compared to the rest of the Pará state. To investigate the role of drug trafficking in the ADI and Altamira, I run a DiD regression and use the variable illicit drug seizures as outcome. The results are shown in Table 4. Drug trafficking in the ADI increased during the construction period, and in the years following the massive layoff the difference in the level of drug trafficking between control and treated municipalities is not statistically significant. However, in Altamira, drug trafficking increased during and after the construction of Belo Monte compared to 2010. The results prove that drug trafficking and the presence of criminal organizations are at least partially responsible for the increase in homicide rates in the region. Brazil has many criminal organizations that fight for market share, creating more violence in the cities where they are present (Biderman, De Mello, De Lima, & Schneider, 2019). That seems to be the case for the ADI once the dam construction raised the income level (Ferreira, 2019; McCoy & Lopes, 2019).

Figure 5 – Drug trafficking rate in the ADI and Altamira (2010-2017)

Table 4 – Drug Trafficking in the ADI and Altamira, 2010-2017, Difference-in-Difference

The years following the end of construction continue to have high levels of violent crime, which a worse job market and unemployment could explain. From Figure 4, it is possible to see a decrease in job opportunities. Even though some of the workers are migrants that could have gone back to their hometowns, Belo Monte construction company information says that at least 3,332 of the workers dismissed at the end of 2015 were residents of Altamira (Oliveira, 2017). This result is in line with the recent evidence that the probability of committing crimes increases on average by 23 percent for workers displaced by mass layoffs, with a 55-58 percent increase in drug-related crimes and a 32 percent increase in homicides (Britto et al., 2022).

Also, the previous level of violence (during the construction period) affects the violence in the following years. This phenomenon is called by Fajnzylber et al. (2002b) of criminal inertia, where the past incidence of crime in society affects the individual's decision to commit a crime by reducing the costs of carrying out criminal activities, lowering the perceived probability of arrest, and weakening civic moral values. Moreover, the effect of social interactions among young people is likely to have enhanced their involvement in crime, according to official government report (Daniel Cerqueira et al., 2019).

7. Robustness check

Despite the evidence shown in the previous section, there could still be some concerns about the trend included in the homicide rate. To assess how much the trend is responsible for the violence increase, I allow the treatments to affect both the level and trend of the dependent variable by interacting each treatment with a linear time trend equal to zero in the first year of treatment. Column 1 of Table 5 suggests that during the construction of Belo Monte dam in the first period, there was a higher increase in the homicide rate than in the trend. In the second period, after the end of the construction, there was a significant increase compared to the previous level (2011-2015), and the trend is not significant. However, the homicide rate time series has only two years after the construction (2016-2017), and the qualitative effect of the second trend may not be accurately estimated.

Due to this time limitation in the dataset, I document further whether the trend, and consequently serial correlation, may bias the results. To avoid a spurious relationship, I re-estimate the same specification from Table 1, column 4, but now using the set of covariates with the lagged values of homicide rate (t-1) instead of its pre-intervention value (2010) interacted with year dummies. The results are presented in column 2 of Table 5. Qualitative results are similar to the main model in Table 1, but the quantitative results are smaller. The point estimate has changed since it accounts for the homicide time series trend. Nevertheless, the effect of Belo Monte dam on the violence level is robust and not driven by a spurious correlation.

As a final test of the model and the DiD approach, I test the parallel trend assumption to rule out the possibility that the treatment variables capture distinct pre-existing dynamics of violence in the ADI. If this were the case, a placebo indicating pre-Belo Monte years would detect whether homicides in the ADI were already increasing a couple of years before the construction started. The results of this exercise are in column 3 of Table 5. I included a dummy for 2009-2010 interacted with ADI municipalities, Pre-Belo Monte variable. The coefficient for the pre-intervention period is very small and not statistically significant. Therefore, there is no evidence that the treatment effects capture the differential dynamic behaviour of homicide rates before the Belo Monte dam.

Table 5 – Testing trend and parallel trend assumption – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

Continuing the tests on the parallel trend assumption, I estimated flexible DiD regression with leads and lags, where the treated municipalities are interacted with year dummies. The interaction terms are meant to measure the deviation in trends in each period and detect the specific timing of the differential behavior of homicides across treated and control municipalities. The ten coefficients estimated, with their respective confidence intervals, are plotted in Figure 6. The homicide rate level is not statistically different from zero in the years before Belo Monte. The difference in homicide rates across treated and control municipalities are statistically significant from 2012, one year after construction started. There was a small decrease in point estimate in 2016, the first year after the massive layoff that marked the end of the construction, followed by a new increase in 2017.

Figure 6 – Timing of the effect, ADI (2008-2017)

I tested the robustness of the model further and placed the results in the appendix. Table D5 presents the results using Driscoll-Kraay robust standard errors, which test for arbitrary forms of spatial correlation (Driscoll & Kraay, 1998). Moreover, I tested if the treatment effects of

Belo Monte dam could be biased by the increased violence in mahogany areas, as Chimeli and Soares (2017) presented in their paper about the use of violence in illegal markets. The results are shown in Table D6 and the coefficients are negative or very small and not significant.

8. Conclusion

This paper sheds light on how development policies could have unexpected consequences. The results presented are in line with previous literature and shows that while urbanization is followed by an increase in income, it also has negative externalities. Without strong institutions that can cope with those externalities, urbanization can bring chaos and welfare loss. My results are relevant to other developing countries where violence is a systemic issue and plan to implement large-scale projects that have the potential of creating boomtowns.

Adding to the previous finding of de Faria et al. (2017) that hydropower plants in Brazil generate only short-term economic development, this paper shows that the economic boom also represents, at least, a short-term increase in violent crime. Since violence and crime hinder growth (da Mata, Deichmann, Henderson, Lall, & Wang, 2007), Belo Monte dam and the Xingu Sustainable Regional Development Plan (PDRSX) failed to deliver local development and may have caused a systemic problem in the region.

The northern states of Brazil have been known to be routes for international drug trafficking, and the ADI is now included in those routes (Daniel Cerqueira et al., 2019; Ferreira, 2019). Rapid urbanization in the ADI and Altamira raised drug trafficking, which challenges long-term development. Once drug gangs are established, the violence that started as an urbanization externality can be long-lasting. Future research should look into the social long-term effects of large-scale projects, especially those in underdeveloped regions.

Data availability imposed obstacles for this study since proxy variables used as covariates have their limitations. The lack of data was even one of the issues that contributed to the negative consequences of Belo Monte. Policymakers could have anticipated the need for timely data to effectively implement and monitor the PDRSX. Without an extra budget, the municipalities could not cope with the rapid increase in population size. Although the PDRSX plan included the obligation for Belo Monte owner company to invest in public infrastructure (e.g., schools and hospitals), these were not delivered in time. Another issue was the lack of resources dedicated to improvements in public security planned in the PDRSX (Oliveira, 2017). New projects should thoroughly consider the social component of sustainable development and develop a comprehensive plan to avoid predictable externalities, as in the Belo Monte case.

Belo Monte dam was set to be an example that the exploitation of Amazon resources could be combined with local sustainable development. The results of this paper raise doubts about the development plan implemented and produce evidence that could help inform decisions on the other infrastructure projects planned for the Brazilian Amazon. The increase in violence represents a loss of human capital, even more so since, generally, young people are the most affected. Violence imposes important social costs and may jeopardize future growth in the Amazon. Without proper institutions and resources, development projects can end up intensifying social losses.

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Table 1 – Main Results for the ADI – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

VARIABLES	(1) Control 1	(2) Control 1	(3) Control 2	(4) Control 2	(5) Control 3	(6) Control 3
Treated ADI x Post 2011	26.69**	37.28***	26.86**	38.11***	26.70**	34.61***
	(10.51)	(10.67)	(10.54)	(10.68)	(10.46)	(11.49)
Treated ADI x Post 2016	44.02***	56.70***	44.06***	58.14***	47.80***	57.31***
	(12.26)	(11.21)	(12.30)	(11.18)	(12.23)	(13.85)
Constant	29.13***	29.16***	29.37***	29.40***	23.85***	23.83***
	(3.376)	(1.483)	(3.474)	(1.516)	(1.960)	(1.628)
Municipality FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X
Set of covariates		X		X		X
Observations	1,571	1,571	1,494	1,494	1,219	1,219
R-squared	0.806	0.875	0.806	0.876	0.719	0.783

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, mortality by traffic accidents, suicides, drug trafficking, and homicide rate. The columns titles indicate which control group is used. The control groups vary to account for spill over and to exclude the metropolitan region of the state capital: Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Table 2 – Covariates – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

VARIABLES	(1)	(2) Education	(3) Urbanization	(4) Socioeconomic	(5) Employment	(6) Drug traff.	(7) Homicide	(8)	(9) Main result
Treated ADI x Post 2011	26.86**	26.83**	33.94***	27.14**	26.83**	26.62**	26.88**	38.67***	38.11***
	(10.54)	(10.61)	(12.42)	(11.37)	(10.36)	(10.67)	(10.82)	(10.89)	(10.68)
Treated ADI x Post 2016	44.06***	43.95***	53.34***	44.99***	47.04***	46.66***	44.09***	59.30***	58.14***
	(12.30)	(12.35)	(14.59)	(12.92)	(11.33)	(12.31)	(12.67)	(11.76)	(11.18)
Constant	29.37***	29.37***	29.37***	29.37***	29.36***	29.37***	29.38***	29.40***	29.40***
	(3.474)	(3.430)	(3.490)	(3.514)	(3.479)	(3.491)	(2.317)	(1.799)	(1.516)
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X	X	X	X	X	X	X
Education (2010)		X						X	X
Urbanization (2010)			X					X	X
Socioeconomic (2010)				X				X	X
Employment (2010)					X			X	X
Drug trafficking (2010)						X		X	X
Homicide rate (2010)							X		X
Observations	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494
R-squared	0.806	0.807	0.818	0.816	0.814	0.811	0.832	0.861	0.876

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, mortality by traffic accidents, suicides, and homicide rate. The set of covariates is separated by characteristics determinants of violent crime: Education (high school dropout rate), Urbanization (suicides and mortality due to traffic accidents), Socioeconomic Conditions (number of cash-transfer program recipients, child mortality, GDP per capita), Employment level (number of formal employment, average earnings), drug trafficking, plus homicide rate. All control variables are pre-intervention (2010) values interacted with year dummies. All columns use the control group 2 that is formed by all municipalities except the ADI and the AII to account for violence spillover.

Table 3 – Victims characterization – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

	Homicide	Female Homicide	Male Homicide			Homicide (ages 15-29)	Male Homicide (ages 15-29)		
	All	All	All	By firearm	Public way	All	All	By firearm	Public way
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Treated ADI x Post 2011	38.11***	1.017	77.67***	48.43***	37.61***	139.9***	239.4***	147.1***	198.8***
	(10.68)	(2.091)	(21.32)	(13.56)	(9.785)	(23.36)	(48.19)	(43.87)	(24.41)
Treated ADI x Post 2016	58.14***	7.019	118.4***	77.76***	50.92***	187.7***	309.9***	254.2***	270.1***
	(11.18)	(4.981)	(18.85)	(16.62)	(9.820)	(27.81)	(50.41)	(60.57)	(31.65)
Constant	29.40***	3.994***	59.92***	38.44***	29.36***	143.3***	224.8***	122.4***	178.0***
	(1.516)	(0.330)	(3.218)	(2.211)	(1.553)	(5.062)	(8.050)	(6.205)	(7.416)
Avg. level (ADI) 2007-2010	23.45	5.55	50.32	27.30	19.58	109.63	169.76	90.50	187.99
Proportional effect during the construction (2011 – 2015)	163%	0	154%	177%	192%	128%	141%	163%	106%
Proportional effect after the construction (2016-2017)	248%	0	235%	285%	260%	171%	183%	281%	144%
Municipality FE	X	X	X	X	X	X	X	X	X
Year FE	X	X	X	X	X	X	X	X	X
Set of covariates	X	X	X	X	X	X	X	X	X
Observations	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494	1,494
R-squared	0.876	0.538	0.877	0.897	0.839	0.888	0.890	0.913	0.805

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants) by demographic group. The denominator is the is the total population of each subgroup. All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, drug trafficking, mortality by traffic accidents, suicides, and homicide rate. All columns use control group 2 which is formed by all municipalities except the ADI and the AII to account for violence spillover.

Table 4 – Drug Trafficking in the ADI and Altamira, 2010-2017, Difference-in-Difference

VARIABLES	(1) Control 2	(2) Control 2
Altamira x Post 2011		89.26***
		(5.266)
Altamira x Post 2016		21.40***
		(7.684)
Treated ADI x Post 2011	58.50**	
	(23.87)	
Treated ADI x Post 2016	8.946	
	(13.77)	
Constant	50.19***	50.25***
	(1.851)	(1.768)
Municipality FE	X	X
Year FE	X	X
Set of Covariates	X	X
Observations	1,088	1,056
R-squared	0.735	0.738

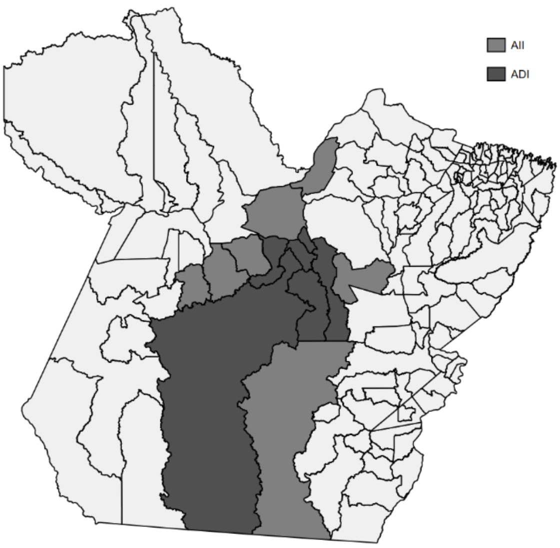
Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is illicit drug seizures (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam or Altamira interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, mortality by traffic accidents, suicides, and homicide rate. Both columns use the control group 2 that is formed by all municipalities except the ADI and the AII to account for violence spill over.

Table 5 – Testing trend and parallel trend assumption – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

VARIABLES	Linear trend (1)	Lagged values (2)	Pre-Intervention (3)
Treated ADI x Post 2011	21.68***	31.57***	38.36***
	(8.269)	(10.20)	(9.607)
Treated ADI x trend (2011-2015)	8.214***		
	(1.923)		
Treated ADI x Post 2016	45.46***	45.60***	58.38***
	(11.32)	(11.23)	(10.62)
Treated ADI x trend (2016-2017)	25.35		
	(25.15)		
Pre-Belo Monte (2009-2010)			0.489
			(6.053)
Constant	29.40***	37.16***	29.40***
	(1.518)	(2.555)	(1.517)
Municipality FE	X	X	X
Year FE	X	X	X
Set of Covariates	X	X	X
Observations	1,494	1,357	1,494
R-squared	0.878	0.882	0.876

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, drug trafficking, mortality by traffic accidents, suicides, and homicide rate (homicide rate pre-intervention values interacted with year dummies in columns 1 and 3. Column 2 includes the lagged values (t-1) of homicide rate). Treated ADI x trend is an interaction between treatment municipalities, post intervention and linear time trends equal to zero in the first year of treatment. Pre-Belo Monte placebo is a dummy for 2009-2010 interacted with treated ADI municipalities. Column 2 includes the same set of covariates, but the homicide rate included as control variable is the lagged value (t-1). All columns use the control group 2 that is formed by all municipalities except the ADI and the AII to account for violence spill over.

Figure 1 – Municipalities impacted by Belo Monte dam – ADI and AII (Pará state)

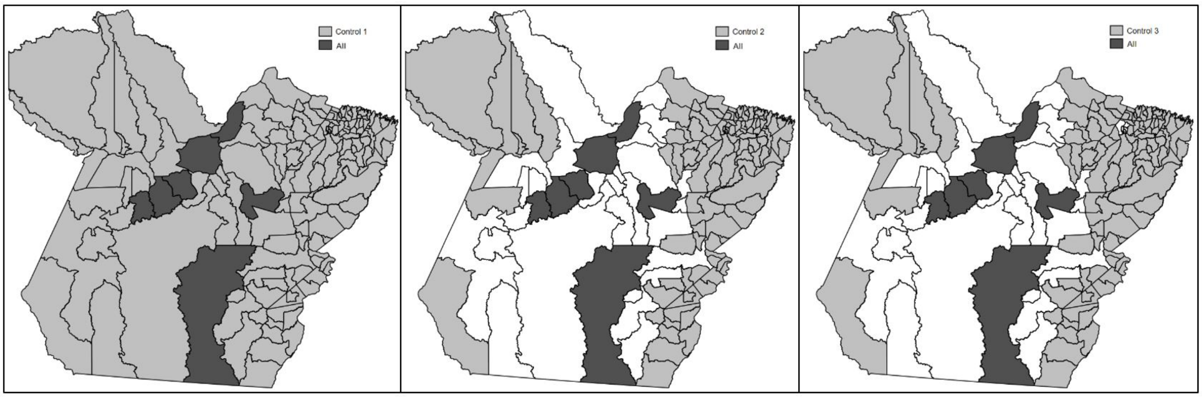


Note: The Environmental Impact Assessment (EIA) defined which cities would be impacted directly and indirectly by the dam. The area of direct influence (ADI) consists of 5 municipalities and the area of indirect influence (AII) has 7 municipalities.

Figure 2 – Control Groups for the ADI and AII (Pará state)

Panel A. Area of direct impact (ADI) of Belo Monte dam and control groups

Panel B. Area of indirect impact (AII) of Belo Monte dam and control groups

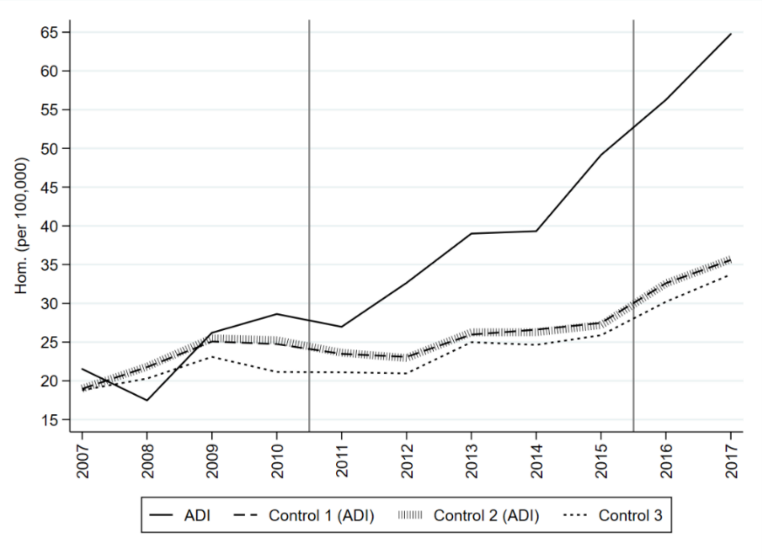


Note: The control groups vary to account for spill over and to exclude the metropolitan region of the state capital. In Panel A, from left to right, Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted area (ADI + AII), the border municipalities and the metropolitan region.

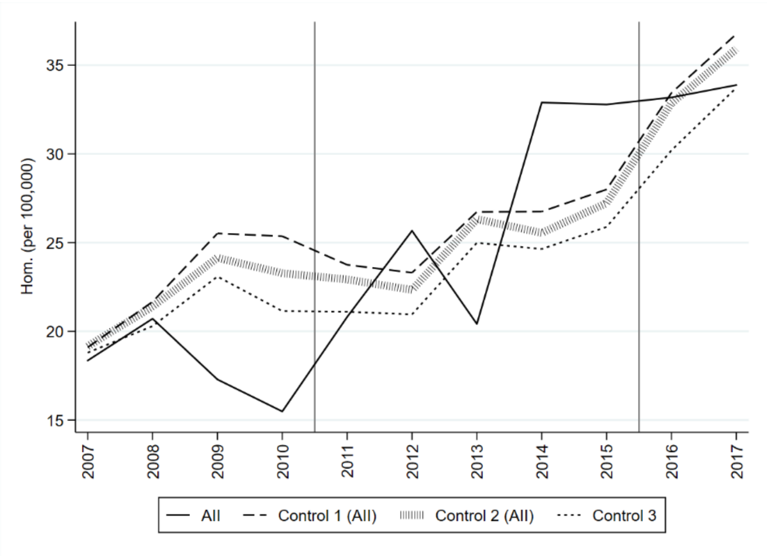
In Panel B, from left to right, Control 1 is formed by all municipalities except the AII, Control 2 is formed by all municipalities except the AII, ADI and border municipalities, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region. The Control 3 includes the same municipalities for the ADI and AII.

Figure 3 – Homicide rate in the impacted areas of Belo Monte dam (2007-2017)

Panel A. Homicide rate in the area of direct impact (ADI)



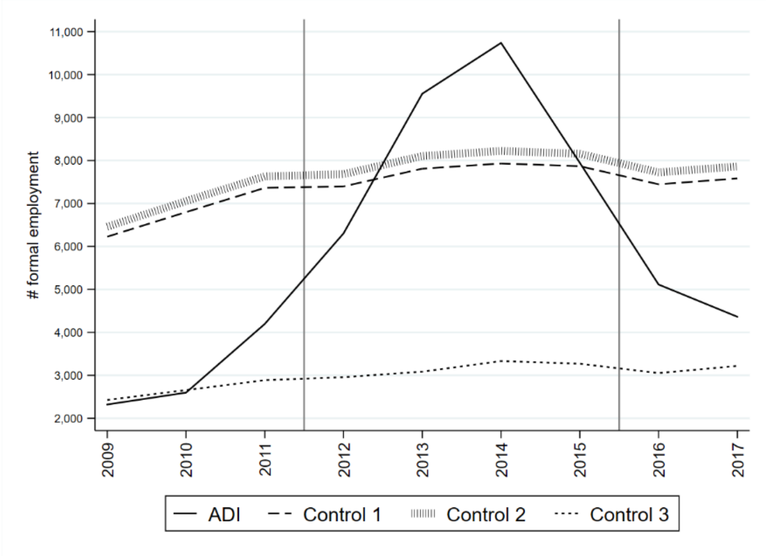
Panel B. Homicide rate in the area of indirect impact (AII)



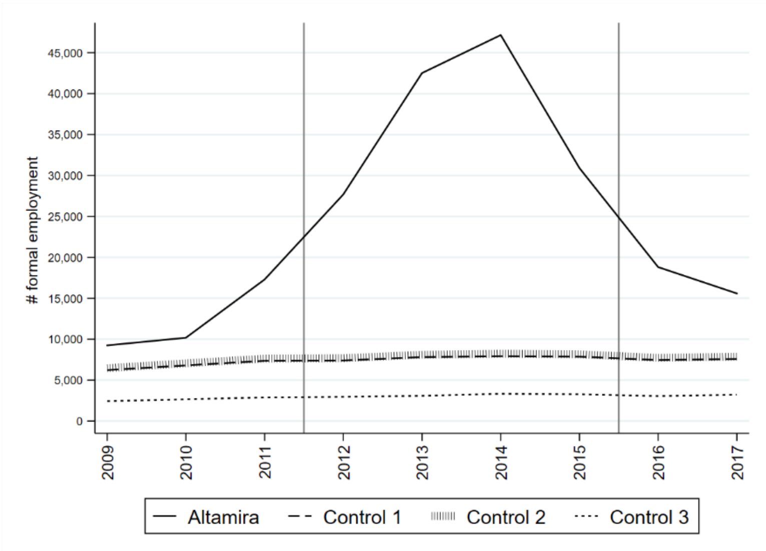
Notes: The control groups vary to account for spill over and to exclude the metropolitan region of the state capital. In Panel A (ADI), Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region. In Panel B (AII), Control 1 is formed by all municipalities except the AII, Control 2 is formed by all municipalities except the AII, ADI and border municipalities, and Control 3 is formed by all municipalities except the impacted areas (ADI+AII), border municipalities and the metropolitan region. First shock is in June 2011 when the construction started (Post 2011, 2011-2015) the second shock is between November 2015 and January 2016, when it happened a massive layoff (Post 2016, 2016-2017).

Figure 4 – Number of formal employment in the ADI and Altamira (2007-2017)

Panel A. Number of formal employment in the area of direct impact (ADI)



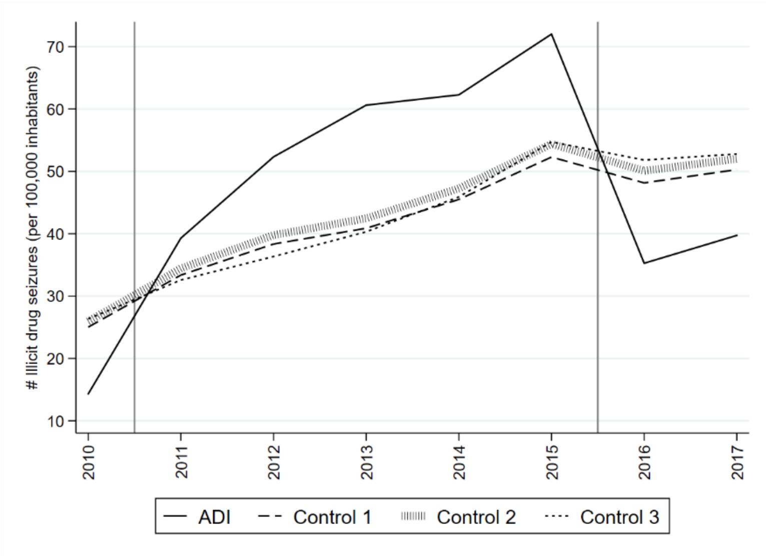
Panel B. Number of formal employment in Altamira



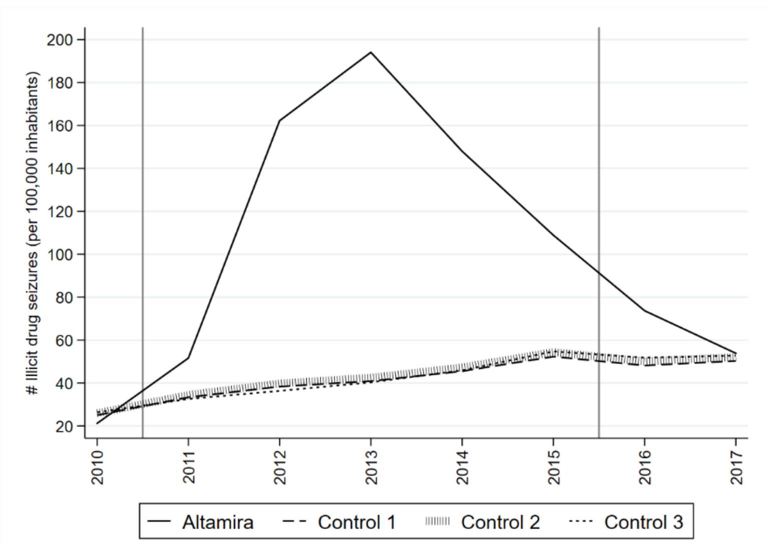
Notes: The control groups vary to account for spill over and to exclude the metropolitan region of the state capital. In Panel A and B, Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Figure 5 – Drug trafficking rate in the ADI and Altamira (2010-2017)

Panel A. Drug trafficking rate in the area of direct impact (ADI)

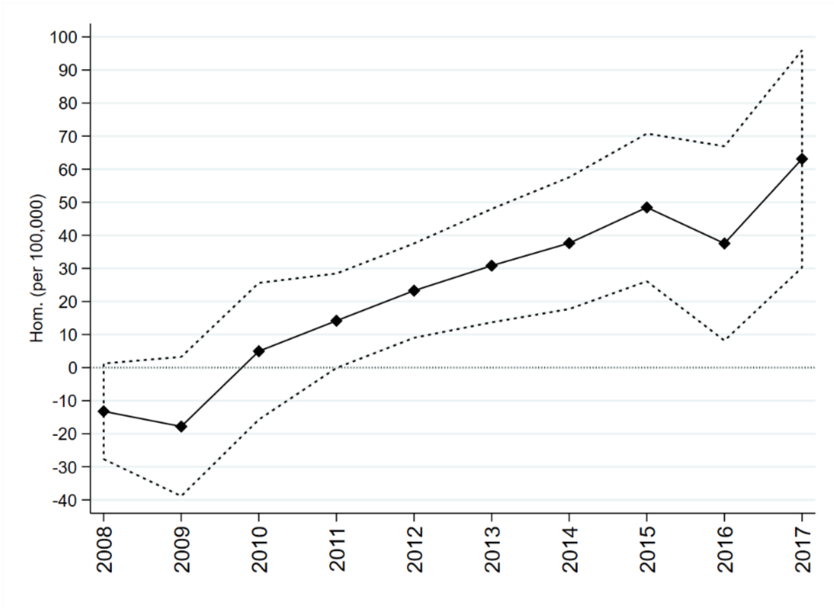


Panel B. Drug trafficking rate in Altamira



Notes: The control groups vary to account for spill over and to exclude the metropolitan region of the state capital. In Panel A and B, Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Figure 6 – Timing of the effect, ADI (2008-2017)



Notes: 95 percent confidence interval

Appendix for "Infrastructure-driven development: the local social impact of a large hydropower plant in the Amazon"

Appendix A – Dataset

Table A1 – Main dataset

Variable	Notes	Source	Frequency	Period
Homicide	all deaths are selected by cause of death ICD 10: X85-Y09(assault) Rate: homicides per 100,000 inhabitants per year	DATASUS Ministry of Health (Death certificates)	Annual	2007-2017
Population	Estimates of municipal-level resident population, calculated with reference date on July 1 of each calendar year.	SIDRA/IBGE	Annual	2007-2017
Population by gender and age groups	Population estimates by gender and age	DATASUS Ministry of Health	Annual	2007-2017
High school dropout rate	Dropout rate of students in the secondary school (ages 15-17)	INEP Ministry of Education	Annual	2007-2017
Number of families in the Bolsa Familia	Number of registered families in the program of conditional cash transfer program, Bolsa Familia	MDS Ministry of Social Development	Annual	2009-2017
Formal Employment	Total number of formal employment	ME (RAIS) Ministry of Economy	Annual	2009-2017
Average earnings	Formal Worker Average Remuneration at current prices (R$)	ME (RAIS) Ministry of Economy	Annual	2009-2017
GDP	Municipality gross national product at current prices (R$)	SIDRA/IBGE	Annual	2007-2016
Child mortality	Mortality before age five Rate: deaths per 1,000 children per year	DATASUS Ministry of Health (Death certificates)	Annual	2007-2017
Suicide mortality	Intentional self-harm, selected by cause of death ICD 10 X60-X84 Rate: deaths per 1,000 individuals per year	DATASUS Ministry of Health (Death certificates)	Annual	2007-2017
Traffic mortality	Mortality due to traffic accidents, selected by cause of death ICD 10 V01-V89 Rate: deaths per 1,000 individuals per year	DATASUS Ministry of Health (Death certificates)	Annual	2007-2017

Domestic Violence	Female homicide (ICD 10: X85-Y09) occurred inside the residence Rate: homicides per 100,000 female inhabitants per year	DATASUS Ministry of Health (Death certificates)	Annual	2007-2017
Rape	Police records of crime registered as rape Rate: rapes per 100,000 inhabitants per year	SEGUP/PA Secretary of Public Security and Social Defense of the state of Pará	Annual	2010-2017
Drug trafficking	Police records of crime registered as drug trafficking	SEGUP/PA Secretary of Public Security and Social Defense of the state of Pará	Annual	2010-2017

Appendix B – Descriptive Statistics

Table B1 presents descriptive statistics for the treated ADI and its control groups. First, it is noteworthy that the standard deviations are high due to municipality heterogeneity. The homicide rate before the Belo Monte dam, 2007-2010, is similar across treated municipalities and the control groups but becomes very different afterward. The variable measuring education, high school dropout rate, seems to follow the same trend in all groups, including having the same level before 2011. On the other hand, variables measuring urbanization level, suicide, and mortality by traffic accidents, show the growth of the cities after Belo Monte. Both variables increase in the years following the start of the construction

Socioeconomic conditions vary across treatment and control groups before the intervention. The ADI has lower GDP per capita, even when the state capital is excluded (control 3), a lower number of cash-transfer program recipients, and a slightly higher child mortality in

the years before the Belo Monte project. However, observing those variables' progression over the years makes it possible to see the socioeconomic impact of Belo Monte in the region. The GDP per capita increased three times during construction, which did not happen in control municipalities. In addition, the rise in child mortality indicates the overall deterioration in the level of health in the region. Drug trafficking was very low in ADI before Belo Monte but increased six times during the contrition years.

Comparing the ADI to the control group 3, which excludes the metropolitan region, shows the impact of Belo Monte on the level of formal employment. While they both have the same initial level, the following periods show the increase and decline in the number of formal workers in the ADI. From formal employment data, it is possible to conclude that there was a significant increase in the number of people living in the ADI during the construction, even though there is no official number about how many migrants the region received.

Table B1 – Descriptive statistics for the periods of 2007-2010, 2011-2015 and 2016-2017 – ADI

	ADI			Control 1			Control 2			Control 3		
	2007-2010	2011-2015	2016-2017	2007-2010	2011-2015	2016-2017	2007-2010	2011-2015	2016-2017	2007-2010	2011-2015	2016-2017
Homicide rate	23.45 (17.88)	37.42 (33.40)	60.52 (43.26)	22.64 (27.79)	25.33 (23.24)	34.10 (28.86)	22.89 (28.13)	25.26 (23.31)	34.13 (29.03)	20.83 (25.67)	23.51 (20.69)	31.96 (27.53)
High school dropout rate	19.80 (7.46)	19.39 (5.62)	11.57 (3.70)	19.87 (7.89)	17.63 (6.59)	14.80 (5.26)	19.98 (7.95)	17.73 (6.49)	14.84 (5.22)	19.94 (7.96)	17.84 (6.47)	14.99 (5.12)
Child mortality rate	3.74 (1.78)	4.40 (1.95)	4.23 (1.94)	3.57 (1.67)	3.15 (1.46)	3.14 (1.51)	3.62 (1.68)	3.19 (1.48)	3.18 (1.52)	3.52 (1.77)	3.10 (1.50)	3.04 (1.58)
GDP per capita (R$)	5,445.72 (1,416.42)	15,971.09 (12,406.79)	25,900.72 (24,846.99)	6,277.76 (6,925.44)	10,577.24 (12,490.84)	13,022.35 (9,224.28)	6,335.69 (7,091.275)	10,715.93 (12,780.85)	13,149.97 (9,405.43)	5,580.11 (5,460.79)	9,537.34 (10,381.19)	12,213.01 (8,336.60)
Bolsa Família recipients	3,080.20 (2,857.26)	3,502.92 (2,806.14)	4,199.00 (3,437.35)	4,656.54 (7,626.53)	5,968.59 (9,195.00)	6,431.41 (10,496.00)	4,729.97 (7,817.16)	6,037.58 (9,426.28)	6,487.75 (10,763.17)	3,564.03 (2,871.52)	4,691.67 (3,671.04)	5,018.61 (3,994.04)
Suicide mortality rate	0.017 (0.025)	0.038 (0.044)	0.087 (0.106)	0.024 (0.037)	0.029 (0.038)	0.036 (0.046)	0.024 (0.037)	0.029 (0.038)	0.036 (0.046)	0.023 (0.038)	0.027 (0.038)	0.034 (0.048)
Road traffic mortality rate	0.20 (0.17)	0.33 (0.19)	0.36 (0.22)	0.16 (0.16)	0.21 (0.18)	0.21 (0.18)	0.16 (0.16)	0.21 (0.18)	0.21 (0.18)	0.16 (0.16)	0.21 (0.18)	0.22 (0.19)
Drug Trafficking	5.8 (8.58)	32.72 (59.59)	18 (28.34)	17.67 (66.48)	30.38 (101.20)	28.78 (63.87)	18.44 (68.14)	31.71 (103.68)	29.90 (65.34)	10.29 (16.17)	17.65 (27.0)	21.0 (29.83)
Formal employment	2,459.30 (3,836.06)	7,747.76 (13,867.97)	4,738.50 (6,670.85)	6,465.87 (32,270.79)	7,618.89 (36,458.98)	7,462.96 (34,901.69)	6,705.65 (33,100.26)	7,899.61 (37,392.19)	7,735.55 (35,796.30)	2,541.94 (3,654.98)	3,106.45 (4,484.48)	3,135.66 (4,523.20)
Avg. earnings (R$)	1,100.77 (226.75)	1,716.73 (688.03)	2,073.10 (450.47)	895.24 (252.36)	1,314.08 (376.57)	1,842.64 (361.54)	901.24 (252.27)	1,314.06 (379.31)	1,837.45 (368.39)	862.57 (195.59)	1,259.56 (333.24)	1,777.97 (330.14)

Notes: Cell values report variable means with standard deviations shown in parentheses. Number of formal employment, average earnings and number of cash-transfer program (*Bolsa Família*) recipients are available for 2009–2017, drug trafficking (police records) is available for 2010-2017, and GDP per capita is only available for 2007-2016. Homicide rate is the homicides per 100,000 inhabitants per year. Child mortality rate is mortality before age five per 1,000 children per year. Suicide and road traffic mortality are deaths per 1,000 individuals per year. The control groups vary to account for spill over and to exclude the metropolitan region of the state capital: Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region. The periods represent: 2007-2010, pre-Belo Monte, 2011-2015, period of the construction of the dam, and 2016-2017, after the construction and massive layoff.

Appendix C – Supporting data

Table C1 – Socioeconomic indicators of the regions of Brazil and Pará state

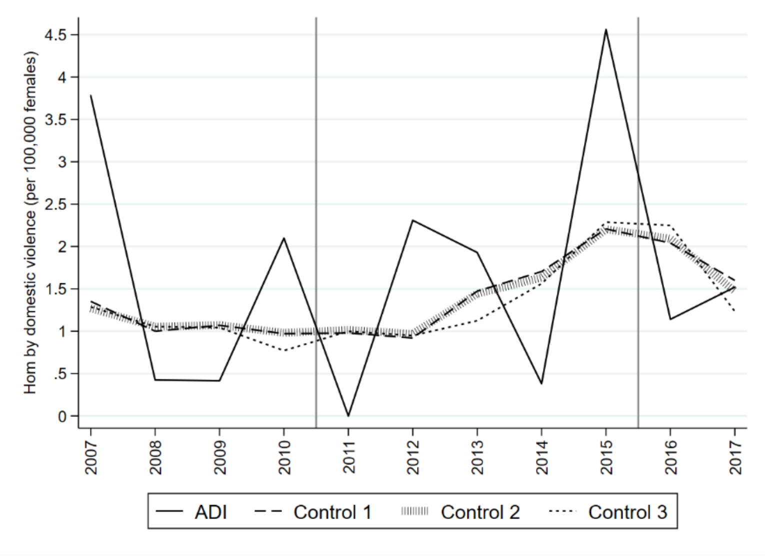
	GDP per capita	Unemployment rate	Life expectancy	Child Mortality	Access to piped water	Access to sanitation	Electricity access	Households with internet access
Brazil	30,411	11.6	76.25	14.41	85.8	66.3	99.73	74.9
North	19,043	11.7	72.65	18.32	58.9	21.8	98.8	68.4
Pará	16,690	10.2	72.48	18.21	50	15	98.9	66.4
Northeast	15,779	14.3	73.63	16.27	80.2	44.6	98.48	64
Center-west	40,412	8.5	75.56	13.76	87.5	55.6	99.85	79.6
Southeast	38,585	12.1	78.03	13.58	92.4	88.6	99.94	81.1
South	36.242	7.3	78.35	11.70	88.8	66.8	99.90	76.7

Notes: GDP per capita in current prices (2016), Unemployment rate (2018), Life expectancy (2018), Child mortality (2017), Access to piped water (2018), Access to sanitation(2018), Electricity access (2018), Households with internet access (2017).

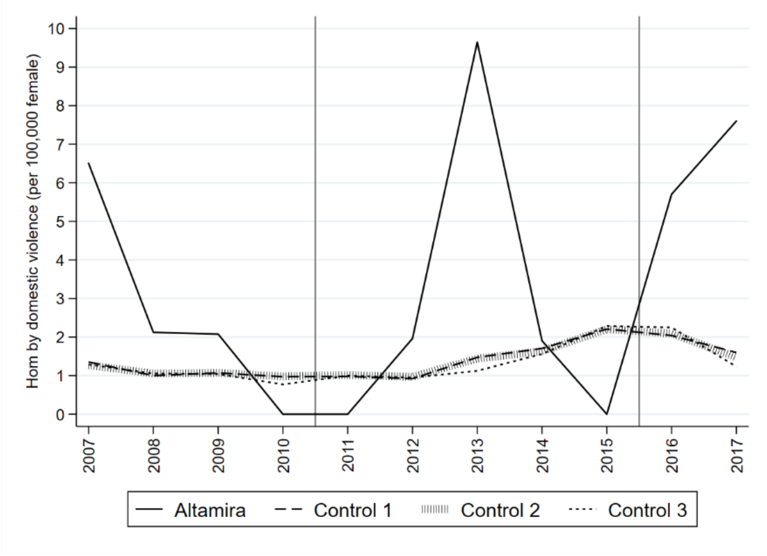
Appendix D – Additional results – Area of Direct Impact – ADI

Figure D1 – Homicide by domestic violence in the ADI and Altamira (2007-2017)

Panel A. Homicide by domestic violence in the area of direct impact (ADI)



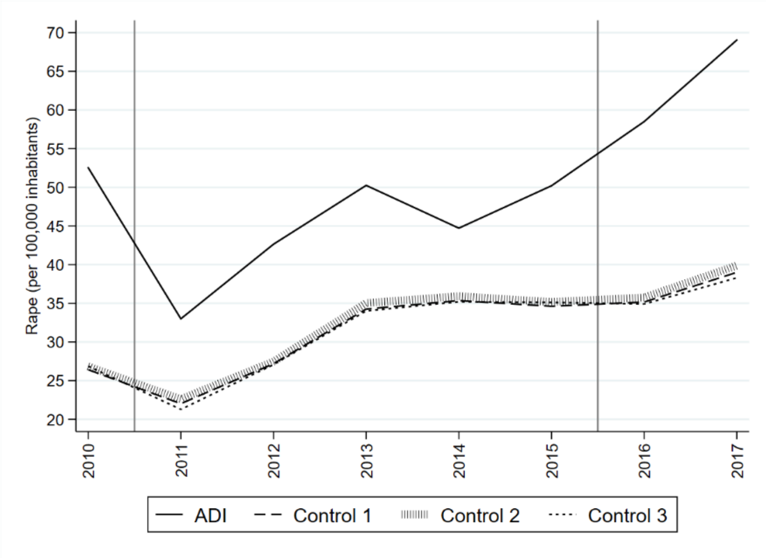
Panel B. Homicide by domestic violence in Altamira



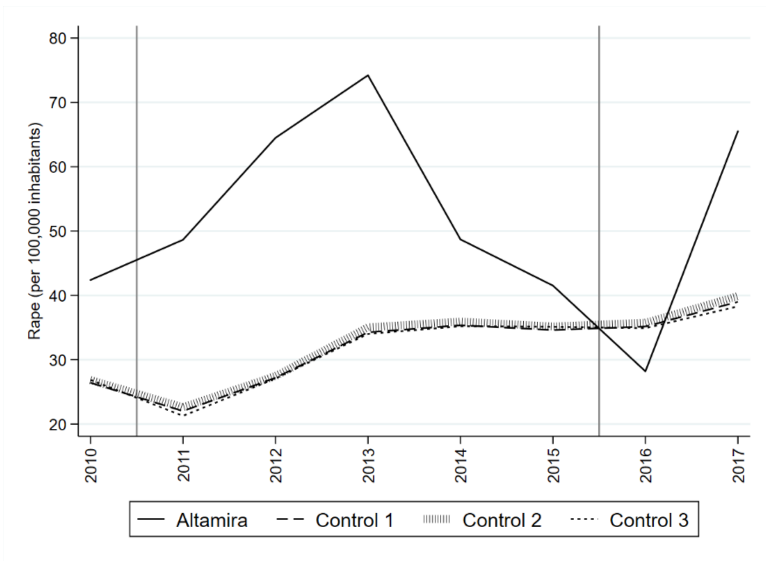
Notes: Homicide by domestic violence is a proxy variable constructed from female homicide occurred inside the residence and the rate is calculated per 100,000 female inhabitants per year. The control groups vary to account for spill over and to exclude the metropolitan region of the state capital. In Panel A and B, Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Figure D2 – Rape rate in the ADI and Altamira (2010-2017)

Panel A. Rape rate in the area of direct impact (ADI)



Panel B. Rape rate in Altamira



Notes: The control groups vary to account for spill over and to exclude the metropolitan region of the state capital. In Panel A and B, Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region

Table D1 – Urbanization in the ADI and Altamira (2007-2017)

	(1)	(2)	(3)	(3)
VARIABLES	Suicide	Suicide	Traffic accidents	Traffic accidents
Altamira x Post 2011	-0.00208		0.181***	
	(0.00565)		(0.0175)	
Altamira x Post 2016	0.00970		0.130***	
	(0.00753)		(0.0260)	
Treated ADI x Post 2011		-0.00208		0.140**
		(0.00565)		(0.0537)
Treated ADI x Post 2016		0.00970		0.126***
		(0.00753)		(0.0448)
Constant	0.0260***	0.0260***	0.156***	0.156***
	(0.00210)	(0.00210)	(0.00983)	(0.00991)
Municipality FE	X	X	X	X
Year FE	X	X	X	X
Set of covariates	X	X	X	X
Observations	1,452	1,452	1,452	1,496
R-squared	0.338	0.338	0.761	0.752

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is mortality by traffic accidents or suicides. All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the following variables: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, drug trafficking, mortality by traffic accidents and suicides (not included if the same as dependent variable). Lagged values of homicide rate (t-1) is only used as a control variable in column 3. All columns use only the years from 2009 to 2017 since some of the covariates are available only from 2009.

Table D2 – Results for the ADI using covariates with contemporaneous values (2009-2017)

VARIABLES	(1) Control 2	(2) Control 2	(3) Control 2
Treated ADI x Post 2011	24.11**	24.46**	18.41**
	(11.69)	(9.824)	(7.992)
Treated ADI x Post 2016	41.31***	23.50***	12.20
	(11.90)	(7.826)	(8.151)
Constant	51.85***	-29.03	-28.19
	(2.414)	(46.21)	(36.80)
Municipality FE	X	X	X
Year FE	X	X	X
Set of covariates		X	X
Lagged Homicide rate			X
Observations	1,088	1,087	1,086
R-squared	0.865	0.854	0.864

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the following variables: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, mortality by traffic accidents and suicides. Lagged values of homicide rate (t-1) is only used as a control variable in column 3. All columns use only the years from 2009 to 2017 since some of the covariates are available only from 2009.

Figure D3 – City of Altamira before Belo Monte dam in 2010

Source: Google Earth

Figure D4 – City of Altamira during the Belo Monte dam construction in 2014

Source: Google Earth

Table D3 – Descriptive statistics for the periods of 2007-2010, 2011-2015 and 2016-2017 – Altamira

	Altamira		
	2007-2010	**2011-2015**	**2016-2017**
Homicide rate	44.80 (10.50)	88.13 (14.17)	118.13 (47.42)
High school dropout rate	20.80 (1.51)	20.08 (2.57)	9.75 (1.34)
Child mortality rate	4.98 (0.74)	5.61 (0.67)	4.56 (0.90)
GDP per capita (R$)	7,156.63 (920.69)	26,061.74 (9,209.47)	22,492.43 (.)
Bolsa Família recipients	8,437.5 (413.66)	8,752.60 (1246,99)	10,461.50 (34.65)
Suicide mortality rate	0.044 (0.011)	0.042 (0.028)	0.072 (0.025)
Road traffic mortality rate	0.26 (0.08)	0.48 (0.08)	0.43 (0.12)
Drug Trafficking	21 (21)	139.6 (57.71)	70.5 (14.85)
Formal employment	9,712 (659.02)	33,111.60 (11,937.72)	17,197.50 (2,274.76)
Avg. earnings (R$)	950.58 (9.70)	2,632.76 (464.26)	2,374.93 (92.63)

Notes: Cell values report variable means with standard deviations shown in parentheses. Formal employment, average earnings and number of cash-transfer program (*Bolsa Família*) recipients are only available for 2009–2017, drug trafficking (police records) is available for 2010-2017, and GDP per capita are only available for 2007-2016. Homicide rate is the homicides per 100,000 inhabitants per year. Child mortality rate is mortality before age five per 1,000 children per year. Suicide and road traffic mortality are deaths per 1,000 individuals per year.

Table D4 – Main Results for Altamira – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

				Pre-Intervention	Pre-Intervention
	(1)	(2)	(3)	(5)	(6)
VARIABLES	Control 2	Control 2	Control 3	Control 2	Control 3
Altamira x Post 2011	40.46***	51.79***	50.31***	48.96***	47.15***
	(2.397)	(4.173)	(3.438)	(5.749)	(5.067)
Altamira x Post 2016	60.13***	70.99***	69.37***	68.16***	66.21***
	(3.207)	(5.958)	(5.688)	(7.528)	(7.210)
Pre-Belo Monte				-5.655	-6.316
				(4.281)	(4.359)
Constant	29.49***	29.53***	26.61***	29.52***	26.61***
	(3.508)	(1.529)	(1.572)	(1.528)	(1.564)
Municipality FE	X	X	X	X	X
Year FE	X	X	X	X	X
Set of Covariates		X	X	X	X
Observations	1,450	1,450	1,395	1,450	1,395
R-squared	0.809	0.881	0.836	0.881	0.836

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is Altamira interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, mortality by traffic accidents, suicides, drug trafficking and homicide rate. Pre-Belo Monte placebo is a dummy for 2009-2010 interacted with Altamira. Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Further robustness check

Table D5 presents the results using Driscoll-Kraay robust standard errors, which test for arbitrary forms of spatial correlation (Driscoll & Kraay, 1998). Moreover, I tested if the treatment effects of Belo Monte dam could be biased by the increased violence in mahogany areas, as Chimeli and Soares (2017) presented in their paper about the use of violence in illegal markets. Chimeli and Soares (2017) study also used the state of Pará to document the effect of the prohibition of mahogany exploration on the homicide rate. I use their data on areas of the natural occurrence of mahogany to test if the difference across mahogany and non-mahogany areas could be the driver behind the treatment effects estimated in this paper. The results are shown in Table D6 and the coefficients (interaction between mahogany area and post intervention dummies, 2011-2015 and 2016-2017) are negative or very small and not significant.

Table D5 – Robustness check – Standard Errors Robust to Spatial Correlation (Driscoll-Kraay)

VARIABLES	(1) Control 1	(2) Control 2	(3) Control 3
Treated ADI x Post 2011	26.69***	26.85***	26.70***
	(6.293)	(6.344)	(6.380)
Treated ADI x Post 2016	44.03***	44.07***	47.80***
	(7.920)	(7.921)	(7.657)
Constant	19.28***	19.01***	24.85***
	(4.320)	(4.355)	(4.621)
Number of groups	144	137	111
Municipality FE	X	X	X
Year FE	X	X	X
Observations	1,575	1,498	1,219
R-squared	0.806	0.806	0.719

Notes: Driscoll-Kray standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of direct influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. The columns titles indicate which control group is used. The control groups vary to account for spill over and to exclude the metropolitan region of the state capital: Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Table D6 – Robustness check – Mahogany areas

VARIABLES	(1) Control 1	(2) Control 2	(3) Control 3
Mahogany area x Post 2011	-0.0429	-1.131	3.265
	(4.847)	(5.316)	(6.396)
Mahogany area x Post 2016	2.519	1.820	5.937
	(6.507)	(7.083)	(8.139)
Constant	29.16***	29.39***	23.83***
	(1.566)	(1.605)	(1.765)
Municipality FE	X	X	X
Year FE	X	X	X
Set of covariates	X	X	X
Observations	1,571	1,494	1,219
R-squared	0.866	0.867	0.759

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality has natural occurrence of mahogany with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, mortality by traffic accidents, suicides, drug trafficking, and homicide rate. The columns titles indicate which control group is used. The control groups vary to account for spill over and to exclude the metropolitan region of the state capital: Control 1 is formed by all municipalities except the ADI, Control 2 is formed by all municipalities except the ADI and the AII, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Appendix E – Results – Area of Indirect Impact – AII

Table E1 – Descriptive statistics for the periods of 2007-2010, 2011-2015 and 2016-2017 – AII

	AII			Control 1			Control 2			Control 3		
	2007-2010	**2011-2015**	**2016-2017**	**2007-2010**	**2011-2015**	**2016-2017**	**2007-2010**	**2011-2015**	**2016-2017**	**2007-2010**	**2011-2015**	**2016-2017**
Homicide rate	17.96 (20.12)	26.51 (22.13)	33.53 (26.32)	22.91 (27.81)	25.71 (23.84)	35.10 (29.97)	21.99 (26.64)	24.87 (22.56)	34.38 (29.49)	20.83 (25.67)	23.51 (20.69)	31.96 (27.53)
High school dropout rate	17.80 (6.56)	15.87 (8.18)	14.04 (6.13)	19.97 (7.92)	17.79 (6.47)	14.72 (5.20)	20.10 (7.88)	17.87 (6.41)	14.86 (5.07)	19.94 (7.96)	17.84 (6.47)	14.99 (5.12)
Child mortality rate	2.62 (1.00)	2.40 (0.88)	2.49 (1.02)	3.62 (1.69)	3.23 (1.51)	3.21 (1.55)	3.53 (1.73)	3.12 (1.49)	3.05 (1.54)	3.52 (1.77)	3.10 (1.50)	3.04 (1.58)
GDP per capita (R$)	5193.62 (1851.42)	7969.85 (3408.46)	10615.86 (4297.75)	6302.97 (6966.51)	10908.28 (12796.65)	13615.33 (10446.39)	5694.73 (5396.55)	9665.55 (10215.70)	12348.58 (8244.18)	5580.11 (5460.79)	9537.34 (10381.19)	12213.01 (8336.60)
Bolsa Família recipients	3282.50 (1177.80)	4671.51 (1409.59)	5369.00 (1565.73)	4669.31 (7695.52)	5944.80 (9279.10)	6404.22 (10591.36)	4557.18 (8194.12)	5863.76 (9851.88)	6358.60 (11419.42)	3564.03 (2871.52)	4691.67 (3671.04)	5018.61 (3994.04)
Suicide mortality rate	0.019 (0.028)	0.031 (0.037)	0.030 (0.031)	0.024 (0.037)	0.029 (0.038)	0.038 (0.050)	0.023 (0.038)	0.026 (0.038)	0.033 (0.047)	0.023 (0.038)	0.027 (0.038)	0.034 (0.048)
Road traffic mortality rate	0.13 (0.10)	0.20 (0.16)	0.21 (0.17)	0.16 (0.16)	0.21 (0.18)	0.22 (0.19)	0.16 (0.16)	0.21 (0.18)	0.21 (0.18)	0.16 (0.16)	0.21 (0.18)	0.22 (0.19)
Drug Trafficking	3.14 (5.11)	5.23 (4.14)	7.71 (6.34)	17.98 (66.93)	31.75 (102.98)	29.47 (64.38)	19.42 (73.73)	32.04 (111.6)	29.16 (68.74)	10.29 (16.17)	17.65 (27.0)	21.0 (29.83)
Formal employment	1944.29 (1162.40)	2325.29 (1475.99)	2322.79 (1527.37)	6550.67 (32505.63)	7894.06 (36794.32)	7626.17 (35159.95)	6466.58 (35727.35)	7573.90 (40253.32)	7448.51 (38530.97)	2541.94 (3654.98)	3106.45 (4484.48)	3135.66 (4523.20)
Avg. earnings (R$)	782.14 (234.40)	1314.50 (325.16)	1940.47 (169.86)	908.52 (253.79)	1328.76 (401.17)	1846.08 (373.37)	874.04 (211.10)	1274.07 (350.62)	1789.54 (351.69)	862.57 (195.59)	1259.56 (333.24)	1777.97 (330.14)

Notes: Cell values report variable means with standard deviations shown in parentheses. Formal employment, average earnings and number of cash-transfer program (*Bolsa Família*) recipients are only available for 2009–2017, drug trafficking (police records) is available for 2010-2017, and GDP per capita are only available for 2007-2016. Homicide rate is the homicides per 100,000 inhabitants per year. Child mortality rate is mortality before age five per 1,000 children per year. Suicide and road traffic mortality are deaths per 1,000 individuals per year. The control groups vary to account for spill over and to exclude the metropolitan region of the state capital: Control 1 is formed by all municipalities except the AII, Control 2 is formed by all municipalities except the AII, ADI and border municipalities, and Control 3 is formed by all municipalities except the impacted areas (ADI + AII), the border municipalities and the metropolitan region.

Table E2 – Main Results for the AII – Belo Monte dam and Homicides, 2007-2017, Difference-in-Difference

	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Control 1	Control 1	Control 2	Control 2	Control 3	Control 3
Treated AII x Post 2011	3.587	7.812**	2.816	6.981**	4.039	4.489
	(4.276)	(3.091)	(4.305)	(3.232)	(4.027)	(3.256)
Treated AII x Post 2016	-0.0534	8.673*	-0.994	9.051*	4.665	5.972
	(6.022)	(4.837)	(5.969)	(5.250)	(5.874)	(5.629)
Constant	29.11***	29.16***	27.85***	27.89***	23.23***	23.22***
	(3.353)	(1.560)	(4.048)	(1.466)	(1.958)	(1.689)
Municipality FE	X	X	X	X	X	X
Year FE	X	X	X	X	X	X
Set of covariates		X		X		X
Observations	1,571	1,571	1,296	1,296	1,241	1,241
R-squared	0.801	0.867	0.807	0.886	0.702	0.777

Notes: Robust standard errors are in parentheses (clustering at municipality); *** p<0.01, ** p<0.05, * p<0.1. Dependent variable is the homicide rate (per 100,000 inhabitants). All regressions are weighted by population. Treatment variables are dummies = 1 if the municipality is part of the area of indirect influence of Belo Monte dam interacted with post intervention dummies: post 2011, if between 2011–2015 and post 2016, after 2016. Set of covariates represents the interactions of year dummies with pre-intervention (2010) values of the following municipality characteristics that are determinants of violent crime: number of formal employment, average earnings (ln), number of cash-transfer program recipients, child mortality, GDP per capita (ln), high school dropout rate, mortality by traffic accidents, suicides, drug trafficking, and homicide rate. The columns titles indicate which control group is used. The control groups vary to account for spill over and to exclude the metropolitan region of the state capital: Control 1 is formed by all municipalities except the AII, Control 2 is formed by all municipalities except the AII, ADI and border municipalities, and Control 3 is formed by all municipalities except the impacted areas (ADI+AII), border municipalities and the metropolitan region.

Figure E1 – Timing of the effect, AII (2008-2017)