Socio-economic impacts of a maritime industrial development area (MIDA) model in Latin America: the case of the Açú Port-Industrial Complex

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Abstract

Maritime industrial development areas (MIDAs) have been designed as important models to promote regional industrialization and accelerate its economic growth. The Port-Industrial Complex (PIC) of Açú is considered the most audacious and great initiative in South America. Its chosen location was a rural and barely populated municipality in the Southeastern Brazil, where farming population was subjected to land expropriation for the creation of an industrial district. Thus, the present study aimed to evaluate direct impacts of PIC installation and operation on the life quality of human population. For that, demographic (population size, live births) and economic indicators (royalties, gross domestic product, gross domestic product *per capita*) were compiled between 2000 and 2020 and statistically analyzed for temporal changes. Significant positive trends were found for all the five socioeconomic indicators, but annual variations were overall more pronounced for economic than demographic indicators. Installation and operation of Açú PIC brought undeniable local positive impacts and caused significant increases in population size, royalties, and gross domestic products. However, the rates of changes varied in scale and time for each indicator, reflecting additive interferences of local, regional, and even global events and governmental policies over the socioeconomic status of the human population affected by MIDA project.

Keywords South America · Economic growth · Population development · Port complex · Time series analysis

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1 Introduction

Maritime industrial development areas (MIDAs) are spatial tools designed to accelerate the economic growth and alleviate regional disparities in coastal areas throughout the world (Wang et al. 2018). Industrial complex development in most of the seaports worldwide has been driven by a combination of technological and institutional developments, and the sites where these complexes of industrial seaport were located are known as MIDAs (Kuipers 2017). Due to the combination of ports and industry, MIDAs are generally regarded as important instrument to promote the industrialization and as growth poles to foster regional development (Wang et al. 2018). These areas comprise large backport sites to meet the concept of port industry, reflecting a close relationship between ports (i.e., shipping) and industry (i.e., manufacturing). Depending on the country, different names have been used to assigned the areas where MIDAs are developed, such as Zones Industrielles Portuaires (ZIP in France), Seaside Industrial Zones (SIZ in Japan), Industrial Zones close to Port (IZP in China), and Port-Industrial Complex (PIC in Brazil). The availability of new facilities and technologies, together with relative low costs for feedstock and energy, has led to a competitive advantage of MIDA-type petrochemical complexes from 1950 to 1960s in the ports of Western Europe and Japan (e.g., Vigarié 1981; Wang et al. 2014; Kuipers 2017). However, the effectiveness of MIDAs is highly sensitive to government policies and global economic conditions (Wang et al. 2018; Chen et al. 2019).

Only three enterprises following the MIDA typology have been developed on the Brazilian coast that cover three different regions of the country: Suape located in the Northeast region (Pernambuco State), Açú situated in Southeast region (Northern coast of Rio de Janeiro State), and Itapoá located in the South region (Santa Catarina State). The Açú Port-Industrial Complex (PIC) stands out as the largest private port-industry complex in Latin America, the first port in Brazil with vessel traffic service, comprising a total area of 130 km² with 90 km² of retro-area for installation of industries and companies—16 companies are already installed. The port has the largest offshore supply base in the world, with 16 berths developed to serve Brazilian pre-salt development, and four terminals—iron ore terminal, multicargo terminal, only private crude oil terminal, and onshore terminal (T2)—allowing the linkage between the largest regional market with global economy (Açú Port 2019). The installation of Açú PIC has been attributed to economic, social, aesthetic, and environmental changes in the municipality of São João da Barra (SJB) and its peripheral regions.

Before the installation of Açú PIC, the Industrial Development Company of the State of Rio de Janeiro (CODIN, in Portuguese) created the Industrial District of São João da Barra (DISJB), in a rural and barely populated zone, to attract companies to the new venture. The municipality of SJB was chosen for the implantation of Açú PIC because it was one of the few places in the Southeastern Brazil that still had a vast area without industrial and urban occupation, and due to the large number of disabled farms and the current demand of port structures for retro-areas (Quinto et al. 2011). Other

important factors leaning favorably to the choice of DISJB for MIDA implantation were the low cost of the properties acquired (i.e., old farms) and the proximity to the large urban centers and the main oil exploration basins such as the Campos Basin, where almost 80% of the Brazilian oil is extracted, and the Espírito Santo Basin.

All the socioeconomic impacts caused by Açú PIC implementation and operation in the municipality of SJB were related to direct or indirect processes that could have affected positively and/or negatively the local population. The direct impacts refer to the areas straightly affected by the project, which includes changes in local manufacturing production, employment, income, asset rates, subsistence activities, public services, and social and psychological indicators of human well-being (e.g., stress, security, leisure). Indirect impacts occur in areas secondarily affected by the developments, being broader than direct impacts, such as changes in economic activities, shifts in the population structure within a region, and changes in the tertiary sector (Araújo et al. 2009). Deterritorialization is amongst of the major impacts that large enterprises have on local populations. The deterritorialization of families, in general members of family farmers, occurs due to the interest of industries and companies in territorializing the space occupied by these families (Lima and Vasconcelos 2013; Espindola and Guerra 2018; Silva et al. 2020). Following the creation of DISJB, the actions for family's expropriation began together with other land-based interferences conducted by the companies that idealized and worked on the Açú PIC construction through direct negotiation with land owners. The total polygon of the industrial district comprised 93 plots with resident families. However, only 68 plots were targeted for the expropriation by CODIN, and among them, 53 families were indeed expropriated and resettled in the Vila da Terra neighborhood, an area formerly used as a sugar cane field (Secretary of Agriculture of SJB 2017).

Conflicts with the farming population were evidenced in the literature due to land expropriation for the implementation of Açú PIC (Alvarenga 2013; Pedlowski 2013), as well as conflicts generated by negative impacts of PIC on other sectors (e.g., fishing, tourism, leisure) (Monié 2016). Despite the discussion about the conflicts generated through the expropriation process, little is known about changes in life quality and welfare of SJB population. Considering the rapid transformations arising from the construction and operation of Açú PIC in the SJB municipality, the present study aimed to assess socioeconomic indicators from three different phases of the port-industrial complex (i.e., before, during enterprise construction and installation, and along the operation phase). These phases were addressed in order to properly evaluate the direct impacts caused by Açú PIC on the quality and way of life of human population from SJB. For that, five different variables of demographic and economic indicators were retrieved between 2000 and 2020 from open access databases and analyzed for temporal changes along the last two decades.

2 Material and methods

2.1 Study area

The Açú Port-Industrial Complex (PIC) (21° 51' 10" S, 41° 01' 14" W) is located at the South Atlantic coast of Brazil, Northern of Rio de Janeiro state, in the municipality of São João da Barra (territorial area of 452.396 km²). The Açú Port is strategically positioned in an area that give access conditions to maritime and logistical support to oil companies operating offshore and to provide maritime transportation of iron ore for exportation, as well as other minerals (e.g., coal and bauxite) (Piquet et al. 2020). Açú Port surroundings are constituted by (1) the major oil basins (Campos, Espírito Santo, and Santos) and the largest oil producer region in Brazil—Campos Basin that accounts for 89% of total country's reserves (Bruhn et al. 2003); (2) the mouth of Paraíba do Sul River—a river basin of 57.000 km² located in the south-eastern Brazil (São Paulo, Minas Gerais, and Rio de Janeiro states) and representing an important hydrological resource that has undergone extensive land use changes related to industrial, agricultural, and urban activities (Ovalle et al. 2013); and (3) the municipalities of São Francisco do Itabapoana (territorial area of 1118.037 km²) and Campos dos Goytacazes (territorial area of 4032.487 km²), which is the largest municipality in the Rio de Janeiro state. Therefore, the geographical proximity of Açú PIC with oil and gas enterprises installed in Campos dos Goytacazes that provide technologically complex goods and services to major oilfield operators in the region seemed to favor the formation of an industrial agglomeration and promoting innovative activities (Silvestre and Dalcol 2009).

Historically, the Northern coast of Rio de Janeiro was considered one of the poorest regions in the state that depended on government financial support to keep an agriculture-based economy (e.g., sugar and ethanol) and low productive agriculture and artisan fishing (Rodrigues and Lemos 2011). São João da Barra is a small municipality with an index human development of 0.671, where only 37.3% of habitations have adequate sanitary sewage and 20.5% of urban housings on public roads have adequate urbanization—presence of manholes, sidewalks, pavements, and curbs (IBGE –Instituto Brasileiro de Geografia e Estatísticas 2000). In 2003, the poverty incidence reached 30.94% of São João da Barra population (i.e., for a poverty headcount ratio at US\$ 5.5 a day that is the typical line applied by the World Bank for upper-middle-income countries) and Gini index was 0.42 (IBGE –Instituto Brasileiro de Geografia e Estatísticas 2007).

2.2 Data acquisition

The open access electronic databases available from three Brazilian public institutions were searched to obtain secondary data of socioeconomic indicators related to demography (e.g., population size, number of child mortality, and number of live births), education level (i.e., basic education development index), employment (i.e., number of busy people), economy (e.g., royalties income, gross domestic product, and gross domestic product *per capita*), and vehicle fleet size and composition for

the municipality of São João da Barra (SJB). Historical data availability was variable for each of the nine socioeconomic indicators: 21 records (i.e., covering the whole time span) were retrieved for the royalties income; 19 records (i.e., missing data for 2017 and 2019 years) were retrieved for population size; 18 records (i.e., missing data for 2018, 2019, and 2020 years) were retrieved for the number of live births, gross domestic product of SJB, and gross domestic product *per capita*; 13 records were retrieved for employment (i.e., missing data for 2000–2005, 2019–2020); 12 records were retrieved for the number of child mortality (i.e., missing data for 2000–2005 and 2018–2020), and vehicle fleet size and composition (i.e., missing data for 2000–2005, 2008, 2019–2020); and seven records were retrieved for education level (i.e., missing data for 2000–2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020).

Considering data availability, two criteria were established to select the socioeconomic indicators for the application of statistical analysis in order to provide the broadest and continuous coverage between the 2000–2020 period (i.e., 21 years of time span) and to test representative data of each enterprise period (i.e., 2000–2007: before the PIC, 2008–2014: during the construction and installation, and 2015–2020: during operation): only indicators with a minimum of 12 historical records and, at least, three records by period. Based on the established criteria, five variables were chosen for the application of statistical analysis: population size (i.e., number of individuals), number of live newborns, royalties income (in Brazilian reais—R\$), gross domestic product (in Brazilian reais—R\$), and domestic product *per capita* (in Brazilian reais—R\$). Data of all the other socioeconomic indicators (i.e., number of child mortality, education level, employment, and vehicle fleet size and composition) are provided as Supplementary Material (Table S1).

2.3 Statistical analysis

Time series tendency for the selected socioeconomic indicators (≥ 18 and ≤ 21 records) were tested using the non-parametric Mann–Kendall and Sen's methods for a monotonic trend based on Kendall's tau statistic and applying correction for data continuity. These methods are widely used to determine whether there is a positive or negative trend in time series data with their statistical significance (e.g., Yue and Wang 2004; Hamed 2008; Ye and Kameyama 2020). Time series analyses were performed at the significance level of 0.05 using the software XLSTAT 2020.2.

Posteriorly, in order to properly distinguish the impacts caused by the port-industrial complex on the socioeconomic indicators, the secondary data were grouped into three different phases: (1) 2000–2007: before the enterprise, (2) 2008–2014: during the construction and installation of the enterprise, and (3) 2015–2020: during operation of the Açú PIC. Generalized linear models (GLMs) were applied on those five socioeconomic variables which are expected to respond to the three different phases of MIDA enterprise. These tested variables presented at least three records by period (i.e., before the enterprise, during the construction and installation, and during the operation of Açú PIC). A repeated-measure design was used, considering annual counts since the first available data (i.e., year 1—2000) as continuous

predictor, and the phases as crossed and fixed factor, to deal with possible temporal autocorrelation and unbalanced observations among years and periods (Lindsey 1997). Tukey post hoc tests for unbalanced designs were applied for comparisons among phases whenever significant differences ($p < 0.05$) were recorded. All the variables assessed in experimental trials were $\log_{10}$ transformed. Gaussian distribution was chosen for all GLM performed, and a 95% confidence interval ($p < 0.05$) was assumed. Statistical analyses were performed using the software Statistica 13.3 (Tibco).

3 Results

Time series tendencies were evaluated on the historical data to detect changes in socioeconomic indicators over time which was expected to reflect the local effects of MIDA enterprise on the life quality and welfare of the population of São João da Barra municipality. Significant (Mann–Kendall, $p < 0.001$) positive trends were observed for all the five socioeconomic indicators, irrespectively of the data nature (e.g., demographic or economic; Table 1). However, annual variations were overall more pronounced for economic than in demographic indicators, as showed by the values of Kendall's tau correlations (Table 1) and the patterns found for each time series (Figs. 1, 2, 3, 4, and 5).

Population size was the variable most fitted to the model, showing low interannual oscillations (Fig. 1). Despite the increased population growth rates observed between 2007 and 2010, a quite linear increment with time was observed for this demographic indicator during most of the study period. GLMs revealed significant differences for population size among the three Açú PIC phases ($F_{2,15} = 4.38$, $p = 0.03$). The greatest values were recorded in the operation phase, followed by intermediate values during the installation phase, and the lowest values found before the enterprise establishment (Tukey post hoc test, $p < 0.001$; Fig. 1).

The number of live births was the most variable demographic indicator over time (Fig. 2). Time series indicated a cycling pattern of ups and downs for the number of alive newborns and greater interannual variations between 2000 and 2008 than in

Table 1 Detailed results of Mann–Kendall trend test applied on the socioeconomic indicators of demographic and economic changes of São João da Barra municipality through time

Data	Variable	Kendall's tau	<i>S</i>	<i>p</i> value	Sen's inclination	Time series tendency
Demographic	Population size	0.988	169	< 0.0001	495.8	Positive
	Live births	0.634	97	< 0.0001	21.3	Positive
Economic	Royalties income	0.562	118	< 0.0001	5,378,616.7	Positive
	Gross domestic product	0.712	109	< 0.0001	379,951.0	Positive
	Gross domestic product <i>per capita</i>	0.699	107	< 0.0001	10,501.9	Positive

Fig. 1 Time series of population size (number of individuals, $\bar{X}$ represented by ♦) and box-and-whisker plots for the three distinct phases of port-industrial complex of Açú in the municipality of São João da Barra. The number of replicates ($n=19$) was determined by historical data availability. Sen's slope is indicated by the orange full line. Median (full line inside the box), mean (+), standard deviation, and whiskers (1–99 percentile) are shown in box-and-whisker plot. Different letters represent significant statistical difference between Açú PIC phases (Tukey post hoc test, $p < 0.05$)

comparison with 2009 and later. No significant difference was found for this indicator among Açú PIC phases (GLM; $F_{2,14} = 0.35$, $p = 0.71$).

The total royalties income (R\$) increased with time according to time series tendency, but this economic indicator was rather variable through time (Fig. 3). There was a trend of gradual and linear growth of royalties from 2000 until 2007, which contrasted with a huge increase from 2008 to 2011 followed by wide interannual variations after that. GLMs revealed significant differences for the total income of royalties among the three Açú PIC phases ($F_{2,17} = 8.89$; $p = 0.002$), with the highest values recorded in the installation and operation phases than before the enterprise establishment (Tukey post hoc test, $p < 0.001$; Fig. 3).

A similar pattern was found for the gross domestic product of SJB, which also varied considerably through time (Fig. 4). A tendency of gradual and linear growth of gross domestic product of SJB was also observed from 2000 until 2007, but this indicator raised significantly from 2008 to 2011 and became more variable after 2014. GLMs revealed significant differences for municipal gross domestic product among PIC phases ($F_{2,14} = 17.69$, $p < 0.001$), and greatest values were recorded for the installation and operation phases in relation to the period before the beginning of the enterprise (Tukey post hoc test, $p < 0.001$; Fig. 4).

The gross domestic product *per capita* increased almost linearly and at low rates through time until 2007 (Fig. 5). This indicator undergone a significant increase from 2008 to 2011 and became rather variable after 2014. GLMs revealed

Fig. 2 Time series of the number of live births ($\bar{X}$ represented by ♦) and box-and-whisker plots for the three distinct phases of port-industrial complex of Açú in the municipality of São João da Barra. The number of replicates ($n=18$) was determined by historical data availability. Sen's slope is indicated by the orange full line. Median (full line inside the box), mean (+), standard deviation, and whiskers (1–99 percentile) are shown in box-and-whisker plot

significant differences for gross domestic product *per capita* among the Açú PIC phases ($F_{2,14}=17.65$, $p<0.001$). Highest values were recorded for the installation and operation phases in relation to the period before the establishment of MIDA enterprise (Tukey post hoc test, $p<0.001$; Fig. 5).

4 Discussion

Our study provided, for the first time, evidences that the major MIDA initiative ever developed in Brazil has led to positive effects at local scale, as indicated by the socioeconomic indicators for the municipality directly affected by this enterprise. Despite the controversial findings previously recorded (e.g., Prado 2014; Teixeira 2015), our study detected clear positive impacts of a MIDA model conducted in a developing country on the life quality of local human population. However, these impacts varied in scale and time for each indicator addressed, reflecting additive interferences of local, regional, and even global events and governmental policies over the socioeconomic status of the people affected directly by the installation and operation of Açú Port-Industrial Complex (Açú PIC). Our results are in agreement with the perceptions of local residents and traders related to socioeconomic impacts of Açú PIC at São João da Barra (Monteiro et al. 2021). Local actors revealed a positive perception with the increase in employment and socioeconomic and infrastructure development, which have overcome potential negative impacts,

Fig. 3 Time series of royalties income, in Brazilian reais (R\$), ($\bar{X}$ represented by $\blacklozenge$) and box-and-whisker plots for the three distinct phases of port-industrial complex of Açú in the municipality of São João da Barra. The number of replicates ($n=21$) was determined by historical data availability. Sen's slope is indicated by the orange full line. Median (full line inside the box), mean (+), standard deviation, and whiskers (1–99 percentile) are shown in box-and-whisker plot. Asterisk indicates significant statistical difference (Tukey post hoc test, $p < 0.05$)

such as population increase, increase in the traffic, and territorial expropriations (Monteiro et al. 2021). Moreover, the perceptions of public managers evidenced a better life quality for local population and an increase in employment, infrastructure, education, health, and socioeconomic development resulting from the installation of Açú PIC (Monteiro et al. 2021). However, given the complexity of Açú PIC operations, commercial relations with local companies are fragile, especially those expenses with the acquisition of equipment and skilled labor, which was neither hired nor will be hired locally, which greatly limits the capacity to induce these investments in the local/regional economy (Piquet et al. 2020). Demographic indicators were apparently more sensitive to the Açú PIC effects at local scales, and therefore less sensitive to national and global policies, than the economic ones. Population size was the most sensitive among all the five socioeconomic indicators to depict changes over time and through the phases of Açú PIC (as indicated by the highest values of Kendall's tau correlation and the results of GLM, respectively). The combined results of time series trend and comparisons among enterprise phases revealed that the rates of population growth were slow until 2007, but raised considerably few years after the installation beginning of Açú PIC (i.e., the steepest slope observed for the population size curve) and stabilized at rates that were quite similar to those recorded before 2007. Despite the gradual increase in population size with Açú PIC phases (i.e., before < installation < operation phases), time series trend indicates that the rates of population growth were much more affected by the apparently

Fig. 4 Time series of gross domestic product, in Brazilian reais (R\$), ($\bar{X}$ represented by $\blacklozenge$) and box-and-whisker plots for the three distinct phases of port-industrial complex of Açú in the municipality of São João da Barra. The number of replicates ($n=18$) was determined by historical data availability. Sen's slope is indicated by the orange full line. Median (full line inside the box), mean (+), standard deviation, and whiskers (1–99 percentile) are shown in box-and-whisker plot. Asterisk indicates significant statistical difference (Tukey post hoc test, $p < 0.05$)

heavier improvements on logistic support and fundamental services performed soon after the beginning of the enterprise installation (i.e., in the first 3 years) than the later years and during the operation phase. Our results seem to reinforce the statement of Piquet et al. (2020) about the nature of Açú Port project, where the port infrastructure and industrial complex for export requires low internalization of its activities after the implementation and, therefore, a limited capacity to generate favorable chains for the dynamization of the local economy, tending only to induce the creation of small businesses or services that require less personnel qualified. Moreover, the total number of job positions in SJB has increased 126% from 2006 (i.e., before the enterprise) to 2017 (i.e., during Açú PIC operation), which means in absolute numbers 5.013 new job positions (Castro and Piquet 2019). PIC implementation has also promoted an expressive increase in the income of formal workers, ultimately resulting in the creation of higher quality jobs, characterized by better remunerations, with the guarantee of labor rights, when compared to existing job positions before PIC (Castro and Piquet 2019). However, such trend should be validated through comparisons with those observed for nearby cities (e.g., Campos dos Goytacazes and São Francisco do Itabapoana), since it could be also reflecting the effects of governmental policies towards human welfare operating at both regional and national scales.

Data on mortality and birth rates (i.e., live births) are of great importance for the projection of the health indicators of a population. Besides providing elements for

Fig. 5 Time series of gross domestic product *per capita*, in Brazilian reais (R\$) ($\bar{X}$ represented by $\blacklozenge$) and box-and-whisker plots for the three distinct phases of port-industrial complex of Açú in the municipality of São João da Barra. The number of replicates ($n=18$) was determined by historical data availability. Sen's slope is indicated by the orange full line. Median (full line inside the box), mean (+), standard deviation, and whiskers (1–99 percentile) are shown in box-and-whisker plot. Asterisk indicates significant statistical difference (Tukey post hoc test, $p < 0.05$)

the knowledge of the health levels of a population, these indicators provide subsidies for planning the actions of health care policies in different segments of population (CNDSS-Comissão Nacional sobre Determinantes Sociais da Saúde 2008). The number of live newborns also increased with time but in a different shape than observed for population size. The number of live births was highly variable before the installation of Açú PIC, and a sharp decline (threefold decrease) was observed from 2000 to 2004. This indicator fluctuated much less after the growth experienced in 2006–2007, and its values remained above 450 live births in 2013 and thereafter. Therefore, although significant differences among the enterprise phases were apparently prevented by the wide interannual variation in the number of live newborns, the installation and operation of Açú PIC probably contributed to the raise in the values of this indicator and their stabilization in high levels after 2007. Higher numbers of pregnant women and, consequently, newborns are expected with increases in population size. Moreover, observed trend in live births together with a reduction in 36% of newborn mortality (DATA SUS - Department of Informatics of the Unified Brazilian Health Service 2020) during Açú PIC operation phase seems to be related to improvements in the life quality of local population, probably due to greater access to a better quality of health services provided. The municipality of SJB counts with 40 public health centers (e.g., 13 health basic units, six policlinics, one hospital) that did not change in number after Açú PIC installation and operation, which seems to reflect a lack of strategic planning and public investments for

the development of local infrastructure. Therefore, a better quality of health services may not be directly associated with improvements in public health unit's attendance; an increase in purchasing power of the population makes greater access to private services (e.g., health insurance). Local economic indicators are often more variable than demographic predictors, since they are more dependent of regional and global economic scenarios than the later ones (Stallings 1995). This pattern was observed for the three economic indicators addressed in our study, which generally shared a similar trend over the study period. In this sense, all of these indicators grew slowly prior to 2008, experiencing a sharp increase after that and showing marked fluctuations during the operation phase of Açú PIC, which, however, never declined back to the levels recorded before MIDA installation (i.e., before 2008). Such abrupt increment on royalty income, gross domestic product of SJB, and gross domestic product *per capita* is probably associated with establishment and operation of oil-related industries and facilities, explaining thus the simultaneous response of these economic metrics (Tramont et al. 2017). Despite these temporal similarities, royalties income, which has the best continuous and complete database among the five tested socioeconomic indicators (i.e., 2000–2020 period = 21 years-span), provided the most outstanding evidence of the external factors operating at national and global scales.

Oil-related activities can affect the dynamism of a regional development generating gains related to employment, study and development of technologies, tax incomes, and financial compensation (Raposo et al. 2019). Royalties payment (i.e., financial compensation for the right to use, explore, and commercialize oil products) is one of the oldest ways to remunerate the society for the right of using nonrenewable and scarce resources (Guerra and Honorato 2004). In Brazil, oil exploration companies are required by law to pay this compensation to the Union, the States, the Federal District, and the municipalities' beneficiaries. Brazilian Federal Constitution (1988) guaranteed municipalities the receipt of financial compensation for the exploitation of mineral, water, oil, and natural gas resources. In this way, the finances of these municipalities are dependent of money transfers from the Union and States (TCE/RJ - Tribunal de Contas do Estado do Rio de Janeiro 2016). Brazilian federal law determines that beneficiaries, both the Union and states and municipalities, must invest the incomes received as royalties payment in benefits for the local population such as improvements in energy transmission, street paving, water supply, irrigation, environmental preservation, sanitation, health, and education. Since 2000s, the municipality of SJB started to receive royalties and special participation from oil exploration (Rangel 2012), which has reached the peak from 2010 to 2014 (up to two hundred million of Brazilian reais). There was a strong dependence between the income from oil exploration (e.g., royalties and special participation) and the collection of current revenues in the municipality of SJB that reached 81.4% of dependence in 2008 (TCE/RJ - Tribunal de Contas do Estado do Rio de Janeiro 2016).

Considering the dynamics of commercial ports, there are possibilities of differentiated articulations among the capabilities located in the commercial port, in the productive system, and in the resources of the urban territory, and for an analysis focusing at three scales: at the global level, through globalization; at the meso-economic

level, within the scope of regional systems that capture the growing volumes of flows and activities of transformation; and at the local level, on the territory of the city-port (Monié and Vasconcelos 2012). The first evidences of external factors operating at national and global scales were detected after Brazil's financial recession in 2009 that was triggered by the global financial crisis in 2008 (Nanto 2009). Modest economic results were alternated with other unfavorable results that led to a low growth average in post-financial recession years (2011–2014) (IEDI – Instituto de Estudos para o Desenvolvimento Industrial 2018). Moreover, a sharp decline on royalties income was noticed between 2015 and 2016, which was also tracked by the gross domestic product and gross domestic product *per capita*, that coincided with the impeachment of Dilma Rousseff from the Brazilian presidency (Grego 2017). The second and perhaps the most striking evidence was the worst depletion in a single year ever recorded on royalties income, and soon after of its recovery from 2017 to 2019, as a reflection of the impacts of COVID-19 pandemic worldwide (Ozili and Arun 2020). It should be highlighted that Brazilian coastal and marine economies, which are dominated by marine service sector, account for 19% of the national gross domestic product (Carvalho and Moraes 2021). The regional environment in which ports operate greatly matters, since they are not isolated entities but part of a regional economy that strongly affects port performance through its evolution (Ducruet 2009). In the context of Brazilian economy, globalization processes and commercial relationships have demanded higher efficiency of national ports, especially in the Rio de Janeiro state, to facilitate the circulation of goods in one of the most urban regions of the country (Piquet 2009). Therefore, it is expected a stimulus for the expansion of new technical conditions of production in the national territories with PIC enterprises, leading to expansion of economic frontiers and influencing the process of global insertion of Brazilian economy (Piquet 2009). In this sense, although the São João da Barra municipality has undergone an irrefutable economic growth through the installation and operation of Açú PIC, the nature and dimension of this kind of enterprise (i.e., MIDA model) led to important shifts on its economic system, shifting from a slow rate and small-scale economic growth to a fast growth more dependent of large-scale events and government policies of national and global implications.

5 Conclusions

In the present study, the impacts of Açú port-industrial complex (PIC) construction and operation were evaluated on the life quality and welfare of SJB population. For that, different socio-economic indicators were retrieved from open access databases and, considering data availability, five variables were analyzed to detect tendencies in time series along two decades (2000–2020). Additionally, differences on the five socio-economic indicators among three different phases of the PIC (i.e., before, during enterprise construction and installation, and along the operation phase) have been tested in order to properly evaluate the direct impacts caused by Açú PIC. One of the main findings and conclusions of this study is that

the installation and operation of Açú PIC, which is considered the most audacious and great MIDAs initiative ever carried out in South America, brought undeniable positive impacts over the municipality of SJB directly affected by this enterprise, as indicated by our long-term analyses of five indicators of local socio-economic development.

Concerning the indicators of socio-economic development applied in the present study, demographic indicators were apparently more sensitive to the Açú PIC effects at local scales, and therefore less sensitive to national and global policies, than the economic ones. Despite the gradual increase in population size with Açú PIC phases (i.e., before < installation < operation phases), time series trend indicates that the rates of population growth were more affected by the apparently heavier improvements on logistic support and fundamental services performed soon after the beginning of the enterprise installation than the later years and during the operation phase. Moreover, live births have also exhibited a positive tendency of increase over the twenty years; however, no significant difference was found in the numbers of live births among Açú PIC phases.

Local economic indicators grew slowly prior to 2008 (i.e., Açú PIC operation), experiencing a sharp increase after that and showing marked fluctuations during the operation phase of Açú PIC, which, however, never declined back to the levels recorded before MIDAs installation (i.e., 2000–2007). However, the rates of changes differed temporally and with each of these indicators, as a reflect of the additive effects of external events and governmental policies operating in varied scales. Royalties income provided the most outstanding evidence of the external factors operating at national and global scales. Our results deserve attention, since the shifts that probably occurred in the local economic system, although being generally positive in relation to the period before the installation and operation of Açú PIC, might be also leading to an increased dependency to the external and large-scales economic scenarios and the development of trade and human services of low and none positive impacts on local people, which are historically rural and of agricultural basis.

Although the SJB municipality have undergone an irrefutable economic growth induced by Açú PIC installation and operation, the nature and dimension of this MIDAs project shifted its economic system from a slow-rate and small-scale growth to a fast growth more dependent of large-scale events and government policies of national and global implications. Similar approaches could be performed and the trends for other socioeconomic variables and nearby localities could be addressed in further studies, even that for a shorter time-span period, they would be an interesting opportunity to validate our predictions about the effects of MIDAs enterprise at broader geographic scales.

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Data availability The data that support the findings of this study are openly available in the Brazilian Institute of Geography and Statistics—IBGE at <https://cidades.ibge.gov.br>, in the SUS—Health Care System at <http://datasus.saude.gov.br>, and in the Court of Accounts of the State of Rio de Janeiro at <https://www.tce.rj.gov.br/web/guest/estudos-socioeconomicos1>.

Code availability Not applicable.

Declarations

Conflict of interest The authors declare no competing interests.

References

- Açu Port (2019) Doing business in complex of Port of Açu. Available online at: <https://portodoacu.com.br/>. Accessed in 16th December 2020.
- Alvarenga FM (2013) Os Deserdados do Desenvolvimento: o Caso da Implantação do Complexo Portuário e Industrial do Açu e seus Impactos Socio-Territoriais. Master's Thesis in Social Politics, Universidade Estadual do Norte Fluminense Darcy Ribeiro (UENF), Campos dos Goytacazes, Brazil
- Araújo RCP, Freitas KS, Albuquerque RL (2009) Impactos Socioeconômicos do Complexo Industrial e Portuário do Pecém (CIPP) sobre os Pescadores Artesanais, São Gonçalo do Amarante-CE. In: Proceedings of the 47th Congresso da Sociedade Brasileira de Economia, Administração e Sociologia Rural, 26–30 July 2009, Porto Alegre, Brazil
- Brazilian Federal Constitution (1988) Constituição da República Federativa do Brasil. Senado Federal Press, Brasília-DF, p 292
- Bruhn CHL, Gomes JAT, Del Lucchese C Jr, Johann PRS (2003) Campos Basin: reservoir characterization and management—historical overview and future challenges. In: Offshore Technology Conference, 5–8 May 2003, Houston, Texas, United States of America. <https://doi.org/10.4043/15220-MS>
- Carvalho AB, Moraes GI (2021) The Brazilian coastal and marine economies: quantifying and measuring marine economic flow by input-output matrix analysis. *Ocean Coast Manag* 213:105885. <https://doi.org/10.1016/j.ocecoaman.2021.105885>
- Castro RH, Piquet R (2019) The Açu Port Complex and its influence on the labor market in São João da Barra, RJ. *Revista de Desenvolvimento Econômico* 3, 252–272
- Chen F, Yu S, Liu L, Lu W, Cai J (2019) Industrial- or residential-dominant development? a comparative analysis of Maritime Industrial Development Areas of Liaoning, China. *J Sustain Dev* 12: 82–100. <https://doi.org/10.5539/jsd.v12n2p82>
- CNDSS - Comissão Nacional sobre Determinantes Sociais da Saúde (2008) As causas sociais das iniquidades em saúde no Brasil. Fiocruz Academic Press, 215 p
- DATA SUS - Department of Informatics of the Unified Brazilian Health Service (2020) Available online at: <http://datasus.saude.gov.br>. Accessed in 16th December 2020
- Ducruet C (2009) Port regions and globalization. In: Notteboom TE, Ducruet C, De Langen PW (Eds) *Ports in Proximity: Competition and Coordination among Adjacent Seaports*, Ashgate, pp. 41–53
- Espindola HS, Guerra CB (2018) The ongoing danger of large-scale mining on the Rio Doce: an account of Brazil's largest biocultural disaster. In: Rozzi R, May RH Jr, Chapin III FS, Massardo F, Gavin MC, Klaver IJ, Pauchard A, Nuñez MA, Siberloff D (Eds) *From Biocultural Homogenization to Biocultural Conservation, Ecology and Ethics* 3, Springer Nature Press, pp. 97–108. https://doi.org/10.1007/978-3-319-99513-7_6
- Grego M (2017) Understanding presidential crises and impeachments: the case of Dilma Rousseff in Brazil. Bachelor thesis of Politics, Philosophy and Economics, Department of Political Science, Luiss Guido Carli - Libera Università Internazionale Degli Studi Sociali, p. 48
- Guerra SMG, Honorato F (2004) A Lei do Petróleo e a Renda Petrolífera no Brasil. In: Proceedings of the X Congresso Brasileiro de Energia, October 2004, Rio de Janeiro
- Hamed KH (2008) Trend detection in hydrologic data: the Mann-Kendall trend test under the scaling hypothesis. *J Hydrol* 349:350–363. <https://doi.org/10.1016/j.jhydrol.2007.11.009>

- IBGE – Instituto Brasileiro de Geografia e Estatísticas (2000) Censo Demográfico 2000: Características Gerais da População Resultados da Amostra. IBGE Press, 173 p. ISSN: 01043145. Available online at: https://biblioteca.ibge.gov.br/visualizacao/periodicos/83/cd_2000_caracteristicas_populacao_amostra.pdf. Accessed in 10th November 2021
- IBGE - Instituto Brasileiro de Geografia e Estatísticas (2007) Pesquisa de orçamentos familiares 2002–2003: perfil das despesas no Brasil: indicadores selecionados. Coordenação de Trabalho e Rendimento. Available online at: <https://www.ibge.gov.br/estatisticas/sociais/justica-e-seguranca/19877-2002-2003.html?=&t=downloads>. Accessed in 10th November 2021
- IEDI – Instituto de Estudos para o Desenvolvimento Industrial (2018) Análise IEDI: A gravidade da crise recente para as empresas brasileiras. Available online at: https://iedi.org.br/artigos/top/analise/anali_se_jedi_2018_empresas.html. Accessed in 17th July 2019
- Kuipers B (2017) The industrial seaport. In: Geerlings, H., Kuipers, B., Zuidwijk, R. (Eds), Ports and Networks: Strategies, Operations and Perspectives, Routledge, pp. 267–282
- Lima PCV, Vasconcelos VV (2013) Large mining enterprises and their social impact. *De Jure* 12:209–226
- Lindsey JK (1997) Applying generalized linear models. Springer, 265 p
- Monié F (2016) Análise geopolítica dos conflitos territoriais na área de influência do complexo portuário e industrial do Açu – São João da Barra, RJ. *Cadernos do Desenvolvimento Fluminense* 9:69–83. <https://doi.org/10.12957/cdf.2015.26683>
- Monié F, Vasconcelos FN (2012) Evolution of relationships between cities and ports: homogenizing trends and differentiation dynamics. *Confin- Revista Franco-Brasileira de Geografia* 15:1–18. <https://doi.org/10.4000/confin.7685>
- Monteiro CA, Profeta GA, Ney VSP, Rubinsztajn IK (2021) Perception of the socioeconomic impacts of Porto do Açu in São João da Barra, Rio de Janeiro. *Estudo Debate* 28, 60–87. <https://doi.org/10.22410/issn.1983-036X.v28i3a2021.2832>
- Nanto DK (2009) The global financial crisis: analysis and policy implications. Congressional Research Service Report for US Congress, Diane Publishing, 151 p
- Ovalle ARC, Silva CF, Rezende CE, Gatts CEN, Suzuki MS, Figueiredo RO (2013) Long-term trends in hydrochemistry in the Paraíba do Sul River, southeastern Brazil. *J Hidrol* 481:191–203. <https://doi.org/10.1016/j.jhydrol.2012.12.036>
- Ozili PK, Arun T (2020) Spillover of COVID-19: impact on the global economy. *SSRN Electron J*. <https://doi.org/10.2139/ssrn.3562570>
- Pedlowski MA (2013) When the state becomes the land grabber: violence and dispossession in the name of “development” in Brazil. *J Lat Am Geogr* 12:91–111
- Piquet R (2009) Porto do Açu: vetor de crescimento para o Norte Fluminense? *Petróleo, Royalties & Região* 26:4–7
- Piquet R, Rangel HC, Castro R (2020) Transnational flows and areas in economic reconversion: case analysis of the municipality of São João da Barra. RJ. *GEO UERJ* 36:e48416. <https://doi.org/10.12957/geouerj.2020.48416>
- Prado FS (2014) A Construção de Novas Territorialidades a partir da Implantação do Complexo do Superporto do Açu em São João da Barra-RJ. Master's Thesis in Territorial Development and Public Politics, Universidade Federal Rural do Rio de Janeiro, 125 p
- Quinto LP Jr, Faria TJP, Carvalho LS (2011) Projeto Porto do Açu. Implantação de um Complexo Industrial Portuário: o caso do Porto do Açu. In: *Proceedings of the 14th Encontro Nacional da Associação Nacional de Pós-Graduação em Planejamento Urbano Regional*, 23–27 May 2011, Rio de Janeiro
- Rangel HC (2012) Complexo Portuário do Açu: Impacto do Empreendimento no Município de São João da Barra. Master's Thesis in Regional Planning and City Gestion, Universidade Cândido Mendes, Campos dos Goytacazes, Brazil
- Raposo CM, Pinto LTF, Ribeiro MSR (2019) Royalties do petróleo. Estudo Socioeconômico, Coordenadoria de Auditoria e Desenvolvimento, Tribunal de Contas do Estado do Rio de Janeiro (TCMRJ), 75p
- Rodrigues RCA, Lemos LM (2011) Logística e território no Brasil—os complexos portuários do Norte Fluminense. *Revista Geográfica da América Central* 2:1–16
- Secretary of Agriculture of SJB (2017) Report of the evolution of agriculture production in the municipality of São João da Barra from 2013 to 2017. São João da Barra City Hall, 56 p
- Silva AJ, Monteiro MDSL, Barbosa EL (2020) From modernization to deterritorialization: dynamics and dilemmas of agricultural work in the Cerrado of Piauí, Brazil. *Redes* 25:744–761. <https://doi.org/10.17058/redes.v25i2.11678>

- Silvestre BS, Dalcol PRT (2009) Geographical proximity and innovation: evidences from the Campos Basin oil & gas industrial agglomeration – Brazil. *Technovation* 29:546–561. <https://doi.org/10.1016/j.technovation.2009.01.003>
- Stallings B (1995) *Global change, regional response: the new international context of development*. Cambridge University Press, 410 p
- TCE/RJ - Tribunal de Contas do Estado do Rio de Janeiro (2016) Estudos Socioeconômicos dos Municípios do Estado do Rio de Janeiro. Available online at: <https://www.tce.rj.gov.br/web/guest/estudos-socioeconomicos1>. Accessed in 16th December 2020
- Teixeira MCS (2015) *Análise Comparativa Socioambiental dos Portos de Tipologia MIDAs: Estudo de Caso dos Complexos Portuários de Suape/PE e Açúcar/RJ*. Master's Thesis in Environmental Engineering, Instituto Federal de Educação, Ciência e Tecnologia, 101 p
- Tramont GAG, Deodato IANS, Santos VJ (2017) Indicadores sociais do município de São João da Barra: o que mudou com a implantação do Complexo Portuário do Açúcar. In: *Proceedings of the XVI Seminário de Integração da Universidade Cândido Mendes, Do Global ao Local: o Poder das Escalas sobre o Território*, 25–26 October 2017, Campos dos Goytacazes, RJ
- Vigarié A (1981) Maritime industrial development areas: structural evolution and implications for regional development. In: Hoyle BS, Pinder DA (eds) *Cityport Industrialization and Regional Development*. Pergamon Press, Oxford, pp 429–435
- Wang H, Chen T, Ma H (2018) Different institutions, distinctive trajectories? Revisiting maritime industrial development areas with cases on China's Liaoning Coast. *Growth Change* 49:165–188. <https://doi.org/10.1111/grow.12230>
- Wang W, Liu H, Li Y, Su J (2014) Development and management of land reclamation in China. *Ocean Coast Manag* 102:415–425. <https://doi.org/10.1016/j.ocecoaman.2014.03.009>
- Yue S, Wang CY (2004) The Mann-Kendall test modified by effective sample size to detect trend in serially correlated hydrological series. *Water Resour Manag* 18:201–218. <https://doi.org/10.1023/B:WARM.0000043140.61082.60>
- Ye F, Kameyama S (2020) Long-term spatiotemporal changes of 15 water-quality parameters in Japan: an exploratory analysis of countrywide data during 1982–2016. *Chemosphere* 242:125245. <https://doi.org/10.1016/j.chemosphere.2019.125245>

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