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BLUE WATER TURNS BLACK: ECONOMIC IMPACT OF OIL SPILL ON BRAZILIAN NORTHEAST

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SUMÁRIO

ABSTRACT

The international literature is in consensus about the negative impacts that oil spills have on the economy and environment. Since late August 2019, crude oil stains have appeared on the beaches of the Brazilian Northeast. Five months on, this could be considered the most severe environmental disaster of this type, with a scope of more than 3,000 km; 1,013 locations across 130 municipalities were directly affected by the accident. However, the economic impacts are still unknown. Here, we show that the coastal areas of Piauí, Rio Grande do Norte and Ceará were the worst affected in terms of gross domestic product and employment, assuming tourism and fishing to be directly affected economic activities. Simultaneously, we found that interior counterparts of the country were marginally affected, because they accommodated part of the affected areas' demand loss. Our results can help plan better measures to mitigate the negative impacts of this kind of disaster and identify the most vulnerable areas for government and private assistance. We anticipate our article will provide the first economic estimations of the recent oil spill in Brazil. Furthermore, our economic simulation model can be adapted to assess oil spill economic impacts in any country in the world.

Keywords: oil spill; environmental disaster, Brazilian Northeast, Computable general equilibrium

Código JEL: Q25, Q51, C68

1. INTRODUCTION

One of the main tourist attractions of Brazil, which is recognised worldwide, is its beautiful beaches which stretch along a 7,367 km coastline. Since late August 2019, crude oil stains have appeared on beaches in the Northeast region.[1] Five months after the beginning of the most massive Brazilian environmental disaster, according to IBAMA,[2] 1,013 affected locations across 130 municipalities located in all nine northeast states and two southeast states were identified, as shown in Figure 1.

FIGURE 1
Locations affected by oil spills in Brazil

Source: IBAMA.

Federal investigators estimate that 2,500 tons of crude oil was spilled from an unknown source in the Brazilian northeast coast.[1] The environmental impacts on marine fauna caused by this type of disaster are often immeasurable because oil spills contaminate, for instance, coral reefs, fishes, reptiles, and mammals. From an economic point of view, various communities that depend on fishing and tourism are directly affected as beaches have become banned for swimming or simply less attractive to tourists due to oil contamination.[3–6] This effect is magnified because tourism[7] and fishing are indirectly linked to other economic sectors.

This paper aims to estimate the economic impacts of the oil spill on tourism and fishing in the Brazilian Northeast. To do so, we have designed simulations based on a dynamic interregional computable general equilibrium (CGE) model fed from information on specific sectoral activities relating to tourism and fishing in the directly affected areas.

Our main contribution, therefore, is to provide original estimates of oil spill impacts on important economic activities for the Brazilian Northeast with detailed regional information. To our knowledge, there is no study estimating the impact of the oil spill on tourism and fishing in Brazil. Our results can provide insights for policymakers charged with creating supportive regional strategies.

2. TOURISM, DEVELOPMENT AND ENVIRONMENTAL DISASTERS

Tourism is one of the main economic activities in the world. According to the WTTC,[8] tourism accounted for 10.4% of the world gross domestic product (GDP) and 10% of total employment in 2018. On the other hand, Pforr argues that tourism is susceptible and vulnerable to an economic crisis and environmental disasters. [9]

International literature is in consensus about the negative impacts that oil spills have on tourism. Some estimates include an 11% drop in tourist activity in France;[10] a 30% drop in hotel bookings during summer holidays in southern Brittany,[11] which represented an economic loss of EUR 500 million;[12] a EUR 210 million decline in Galicia tourism activity;[13] a US $ 5.5 million loss in the US tourism industry, and other similar disasters in the Republic of Korea, Italy, and the United Kingdom[4] due to oil spills of different magnitudes and causes.

These impacts can be enhanced if they occur in regions with poorly diversified economies and which are, consequently, more dependent on tourism, such as the Brazilian Northeast. This region is one of the least developed and most unequal areas of the country.[14,15] Given its tourism potential, especially in the sun and beach segment, the Northeast has been using tourism as a development strategy since the 1990s through its programmes PRODETUR NE I, PRODETUR NE II and PRODETUR Nacional.[16–18] All of these studies have found positive impacts of the mentioned programmes.[16–18]

For instance, Ribeiro et al.[7] and Haddad et al.[19] have shown that domestic tourism contributes to decreasing regional inequalities in Brazil. More specifically, Ribeiro et al. [7] concluded that domestic tourism spending contributes to the reduction of intraregional inequality. For these reasons, oil spills on the Northeast’s beaches can have considerable effects on tourist and fishing activities and, consequently, on regional economy and inequality, mainly during high season in December and January.

To measure the oil spill impacts on tourism, we have developed a dynamic and interregional CGE model with specific sectorial and regional detailing to assess the affected areas in the Brazilian Northeast.

3. MODEL, DATABASE AND SIMULATION STRATEGY

We used a generalized, dynamic regional CGE model applied to the Brazilian Northeast coast, providing accurate rapid estimates of economic losses. It follows the theoretical structure of the enormous regional model (TERM), developed by the Centre of Policy Studies (CoPS) in Australia.[20,21] A critical feature of our model is its small region and quarterly time representation. More refined regional divisions are desirable for several reasons. Policymakers concerned with high-impact areas or with disparities between coastal and inland regions want more detailed local results. Income, population, and sectoral employment are very different between the affected areas. Finally, environmental issues, such as oil spills, often call for smaller regions that can map natural boundaries more closely.

For a quick assessment of the economic implications of a crude oil spill, the model has quarterly temporality and embodies the latest national and regional Brazilian data for 20 sectors and 21 regions. The 21 regions[*] cover all coastal areas directly affected by the oil spill and its inland counterparts. The theoretical structure of the model holds traditional neoclassical assumptions, documented in the literature, including applications for Brazil in distinguished subjects.[14,15,22–24] Detailed information about the model and its database are in the supplementary material.

In our simulation strategy, we assume the oil spill will directly affect accommodation and food sector demand, representing both tourism-related activities and fishing. The simulation was performed for the peak season (last quarter of 2019 and first quarter of 2020), with a direct reduction of 5% in sectoral activity level for those activities. We assumed a conservative decrease in this sectorial activity level, according to the revised literature and some preliminary estimates of Brazilian official institutions. In addition, we expected the demand in those sectors to recover after one year. The dynamics allow for quarterly simulations covering a horizon of five years from the last quarter of 2019 until the third quarter of 2024.

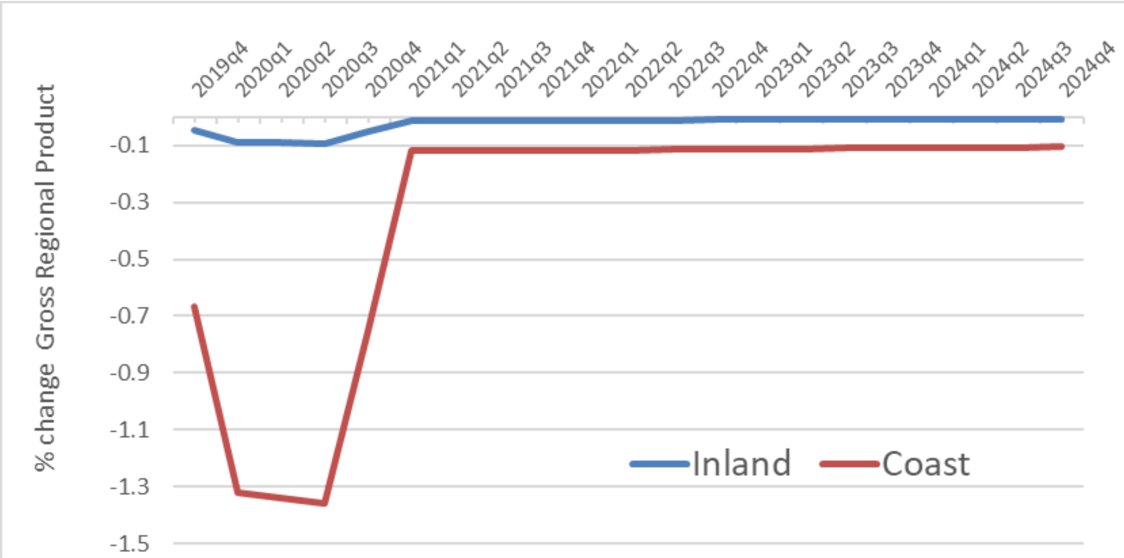
As tourism and fishing are relatively labour intensive and provide a substantial stimulus to local economies on the Northeast coast, we can expect an employment impact mainly in those sectors, as well as a demand reduction related to the expenditure pattern of the tourists. These effects are adequately captured by the model, given the intersectoral and interregional relations with final demand (households, government, and exports).

4. RESULTS AND DISCUSSION

The model allows us to build a business-as-usual scenario, where macroeconomic variables follow a moderate expected growth rate of 2.5% per year and, without any other exogenous change, sectoral growth follows the historical trend. Simulation results are accumulated deviations from this baseline scenario after 16 quarters. Figure 2 shows our results in the aggregated coast and inland regions in the Northeast. The impact on the coastal region is 10 to 15 times greater than the impact on inland areas.

[*] Coast of Alagoas, Coast of Bahia, Coast of Ceará, Coast of Espírito Santo, Coast of Maranhão, Coast of Paraíba, Coast of Pernambuco, Coast of Piauí, Coast of Rio Grande do Norte, Coast of Sergipe, Rest of Alagoas, Rest of Bahia, Rest of Brazil, Rest of Ceará, Rest of Espírito Santo, Rest of Maranhão, Rest of Paraiba, Rest of Pernambuco, Rest of Piauí, Rest of Rio Grande do Norte, and Rest of Sergipe

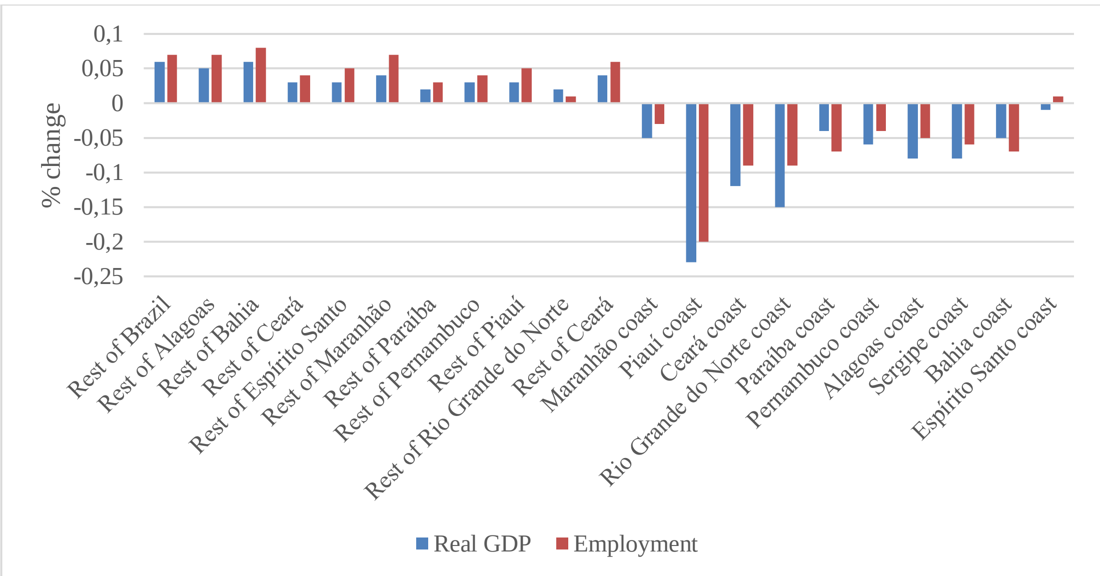
FIGURE 1
Estimated impact of oil spill in Brazil: accumulated percentage change in real gross regional product



Inland: Northeast area not on the coast. Coast: Northeast coastal region
Source: Own elaboration based on CGE simulations.

Figure 3 shows GDP and employment estimated loss for all coastal areas, with the most affected being Piauí (-0.23%), Rio Grande do Norte (-0.16%), and Ceará (-0.14%). Simultaneously, the interior counterparts are marginally affected because they accommodated part of the affected area's demand loss.

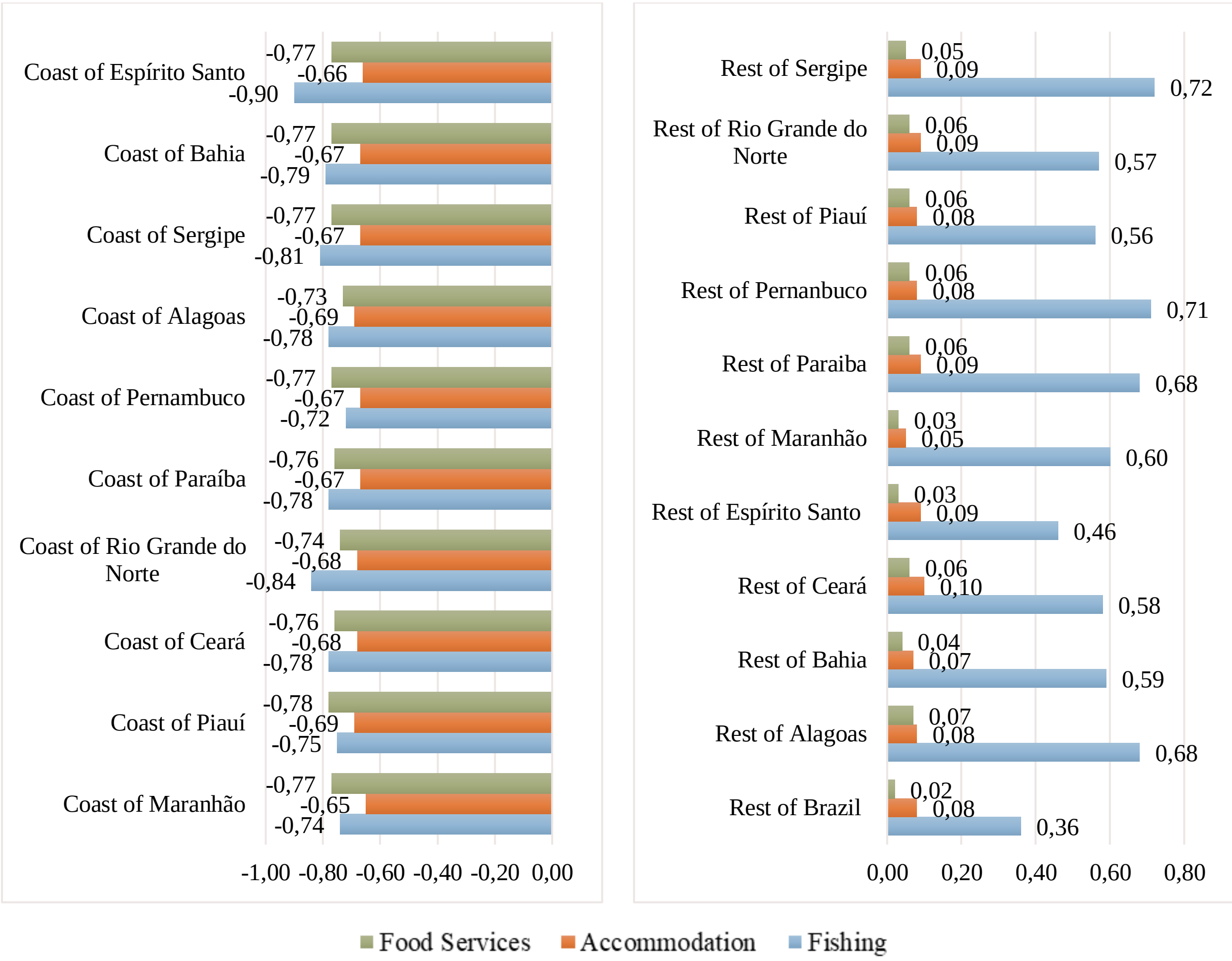
FIGURE 3
Estimated impact of oil spill in Brazil: accumulated % change in real GDP and employment (cumulative differences from baseline after 16 quarters)



Source: Own elaboration based on CGE simulations.

Between coastal areas, the differences are directly related to sectorial consumption of each economic sector; therefore, the most affected regions are the most dependent on tourism and fishing. Figure 4 illustrates this result. For instance, despite being the least affected seaside locations in terms of total GDP, Espírito Santo coastal cities present estimated losses of -0.90% for food services production, along with a -0.66% reduction in accommodation services and a -0.90% loss in fishing. Figure 4 also shows that fishing has spillover effects because its demand relocates to the countryside of the regions. Tourism-related services are local activities with adverse effects concentrated in the coastal areas.

FIGURE 4
Oil Spill: sectoral impacts on value added (accumulated % change)



Source: Own elaboration based on CGE simulations.

5. CONCLUSIONS

The objective of this article was to estimate the economic impact of oil spills in the Brazilian Northeast. It is worth mentioning that our results are the first economic estimations of this accident available in the literature.

Our main results have shown that the coastal areas of Piauí, Rio Grande do Norte, and Ceará were the most affected in terms of GDP and employment loss. Moreover, for the Brazilian economy, we can see a reallocation effect between regions, which leaves the country level of economic activity unaffected. However, in terms of regional inequalities and environmental impact, the whole country loses. Our results can help to plan better measures to mitigate the negative impacts of this kind of disaster and identify the most vulnerable areas for government and private assistance. Furthermore, our economic simulation and model could be adapted to assess oil spill economic impacts in any country in the world.

At the time of publication of this article, although the investigations continue, the cause of the disaster is still unknown. Three recent letters published in *Science*[25] point to the federal government's slow response to the oil spill. This slow response tends to aggravate the economic impacts that we estimate in this article, highlighting the need for a system of rapid response by the authorities to such disasters. We expect that tourism and fishing will gradually recover as oil slicks stop reaching the Northeast's beaches. On the other hand, the environmental impact may be irreversible.

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APPENDIX A: MODEL AND DATABASE

A.1. Economic Model

The model is a dynamic multi-regional computable general equilibrium (CGE) model developed for 31 spatial units in the Northeast and the rest of Brazil. The theoretical structure of model derives from the TERM model[1,2] and is based on the Australian tradition of CGE modelling of a Johansen type,[3] originally derived from the ORANI model.[4]

A key feature of the model is its small region representation. TERM is a bottom-up multi-regional model: that is, supplies, demands, prices, and quantities are calculated for each region. It also allows us to model imperfect factor mobility (between regions as well as sectors).

In the model, each sector produces only one commodity using intermediate inputs from domestic and imported origins during the production process, as well as primary factors (capital, labour, and land). A standard multilevel production function is assumed. At the first level, a constant elasticity substitution (CES) is assumed for the choice of aggregate intermediate inputs and primary factors. At the next level, a Leontief production function is assumed for the choice of specific intermediate inputs and factors.

Household demand structures establish optimal consumption compositions by a vector selection of goods that maximizes a specific utility function under a budget constraint. Hence, for each region of the model, there is a representative household that consumes domestic and imported goods. The household demand specification is based on a combined system of preferences: CES/'linear expenditure system'.

This model operates with equilibrium equations in the locally consumed goods market (domestic and/or imported) as well as in-market factors (labour, capital, and land). Purchase prices of all users (producers, investors, households, and government) are given by the sum of the basic values with direct and indirect taxes on sales and margins.

The model applied in this analysis is dynamic. In a dynamic model, capital stocks depend on past investments and capital net of depreciation. The dynamic model is run in two closures (determination of sets of endogenous and exogenous variables in simulations): business-as-usual baseline and policy. At first, in the baseline scenario, the database is updated using observed macroeconomic variables according to IBGE data (2016–2018). The main national aggregates, such as real GDP, household consumption, investment, government expenditure, exports, and aggregate employment, are considered to be exogenous. It is assumed that regional consumption follows the regional income and government expenditure is fixed. Labour moves among regions and activities, driven by real wage changes. The model works with relative prices and the Consumer Price Index is the numeraire.

In the policy scenario, each macroeconomic variable is endogenous and aggregate employment is fixed relative to the baseline. Thus, labour can move regionally. Results of a policy scenario are reported in detail relative to a business-as-usual baseline. The simulations are implemented in the

Northeast region of Brazil. Model experiments are performed using GEMPACK[5] and RunDynam2 software.

Large-scale multi-regional CGE models have become a relevant tool for policy analysis. Such models incorporate innovations in theory, construction, and model application.[6] The distinguished and specific calibration procedure in our model, explained in the next section, ensures that it captures all the specificities in the regional economies. Therefore, even the standard specification of the model (one representative household in each region or competitive equilibrium in all markets) has specific and detailed data. Detailed information about the TERM model can be found in Wittwer's study.[2]

A.2. The database

The database of multi-regional CGE models assumes regional input–output matrices as a first point. However, even when those matrices are available, there can be some deficiencies such as: (i) limited sector disaggregation; ii) regional scale can be very aggregated, incomplete, or inconsistent (different sources of data or formats); and iii) data are not built for use in CGE models.[1] For these reasons, the model database was built using a regionalization procedure for a national CGE model developed by Horridge[1] with some adjustments using Brazilian data. Basically, from the input–output data for 2015 and a large set of regional data, we estimated an interregional trade matrix using a distance matrix and a gravitational approach. In essence, this procedure applies a gravity-type equation to estimate the trade flows between regions. Thus, interregional trade is based on the distance between regions and the interaction derived from the size of their economies. Details of the procedure for building a database can be found in Horridge[1] and Ribeiro et al.[7] for the Brazilian case. The result of this procedure is database accuracy using official data for national accounts, the input–output matrix, industrial production (PIA), international trade (SECEX: Secretariat of Foreign Trade), employment (RAIS: Annual Social Information Report), and population. The sector and regional breakdown of the model database can be seen in Figure A1.

FIGURE A1
: Regional and sectorial descriptions of model database

Regions	Sectors
Coast of Maranhão	Agriculture and Livestock
Coast of Piauí	Fishing
Coast of Ceará	Mining
Coast of Rio Grande do Norte	Food
Coast of Paraíba	Beverage
Coast of Pernambuco	Manufacturing
Coast of Alagoas	Electricity and Gas
Coast of Sergipe	Water and Sewage
Coast of Bahia	Construction
Coast of Espírito Santo	Trade
Rest of Alagoas	Cargo Transport
Rest of Bahia	Passenger Transportation
Rest of Ceará	Air Transport
Rest of Espírito Santo	Other Transport
Rest of Maranhão	Post Offices
Rest of Paraiba	Accommodation Services
Rest of Pernanbuco	Food Services
Rest of Piauí	Telecommunication
Rest of Rio Grande do Norte	Other Private Services
Rest of Sergipe	Public Services
Rest of Brazil	

Source: Author’s own elaboration.

Besides the main data, a series of parameters and elasticities are also needed. The Armington coefficient among regions was calibrated according to the estimations of Faria and Haddad,[8] while the elasticity of substitution between regions of production was obtained from Domingues et al.[9] The other information was generated by the regionalization procedure developed by Horridge[1] and detailed in Ribeiro et al.[7]

Table A1 presents the shares of economic and population data for the 21 regions in the model and the rest of Brazil.

TABLE A2
Shares of economic and population data for regions in the model

Regions	State	Share of Brazilian population (%)	Share of Brazilian GDP (%)	Share of Northeast GDP (%)
Coast of Maranhão	MA	0.9	0.2	1.0
Rest of Maranhão	MA	2.5	2.3	12.8
Coast of Piauí	PI	0.1	0.0	0.2
Rest of Piauí	PI	1.5	1.0	5.6
Coast of Ceará	CE	1.9	0.5	2.9
Rest of Ceará	CE	2.5	1.4	7.7
Coast of Rio Grande do Norte	RN	0.7	0.2	1.4
Rest of Rio Grande do Norte	RN	1.0	0.4	2.2
Coast of Paraíba	PB	0.5	0.1	0.7
Rest of Paraiba	PB	1.4	0.6	3.5
Coast of Pernambuco	PE	1.8	0.3	1.7
Rest of Pernanbuco	PE	2.8	1.7	9.8
Coast of Alagoas	AL	0.6	0.4	2.4
Rest of Alagoas	AL	1.0	1.1	6.4
Coast of Sergipe	SE	0.4	0.1	0.5
Rest of Sergipe	SE	0.7	0.6	3.6
Coast of Bahia	BA	2.2	0.8	4.3
Rest of Bahia	BA	5.2	6.0	33.6
Coast of Espírito Santo	ES	1.0	0.4	-
Rest of Espírito Santo	ES	0.9	1.0	-
Rest of Brazil	-	70.4	80.8	-

Source: Author’s own elaboration.

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