INCLUDING TOURISM IN THE INPUT-OUTPUT MATRIX OF CEARÁ USING THE TOURISM SATELLITE ACCOUNT[1]

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This paper makes a first contribution by developing a methodology capable of introducing a specific tourism sector into input-output tables (IOTs) using data from an original IOT and a tourism satellite account. A new IOT is built for the economy of Ceará, Brazil, by applying the proposed methodology. An additional contribution of the paper is what we call "the pull index". This index can synthesize the indices of forward and backward linkages and their dispersions in a single result. It also can be seen as an alternative index to point out key-sectors for the economy. The results have shown that tourism in Ceará has the fifth highest pull index, being the seventh sector in terms of employment and income multipliers.

Keywords: input-output matrix; tourism; regional economics; linkages indices.

INCLUINDO O TURISMO NA MATRIZ INSUMO-PRODUTO DO CEARÁ

Este artigo faz uma primeira contribuição ao desenvolver uma metodologia capaz de introduzir um setor específico de turismo numa matriz insumo-produto (MIP) usando dados de uma MIP original e de uma conta satélite de turismo. A metodologia proposta é aplicada à economia do Ceará, Brasil. Uma contribuição adicional do artigo é o que chamamos de "índice de tração". Este índice sintetiza os índices de ligações para frente e para trás e suas dispersões em um único resultado. Ele também pode ser visto como um índice alternativo para identificar setores-chave para a economia. Os resultados mostraram que o turismo no Ceará possui o quinto maior índice de tração, sendo o sétimo setor em termos de multiplicadores de emprego e renda.

Palavras-chave: matriz insumo-produto; turismo; economia regional; índices de ligações.

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1 INTRODUCTION

Tourism can be seen as a set of economic activities distributed between various industries to satisfy the tourist demands. In this way, measuring its participation or assessing its impacts is relatively more complex compared to traditional industries.

Tourism growth observed in the last two decades can be at least partially explained by technological improvements in transport, per capita income growth, populational aging, greater market integration, and economic openness (Fochezatto, Schaidhauer and Bohnenberger, 2018). In this context, tourism is frequently seen as an alternative to promote economic development through job and income creation (Smeral, 2005).

The Brazilian Northeast shows attributes that make it stand out as a tourist destination compared to other options in Brazil (Ribeiro et al., 2017). Therefore, this segment has been used as a strategy for local development and the reduction of regional inequalities (Ribeiro, Andrade and Motta, 2014; Haddad, Porsse and Rabahy, 2013). Among the northeastern states, Ceará is one of the main tourist destinations due to its natural, cultural, and religious characteristics. Considering this, tourism-based development policies have been implemented since the early 1990s by the state and national governments (Oliveira, 2008).

Despite being potentially responsible for income, employment, tax revenue generation, and improvements in the Brazilian economic structure (airports improvements, for example), the tourism segment is a relatively unexplored research subject at national and local levels. Such a lack of interest lies in how we single out goods and services directly consumed by tourists from those consumed by residents, as well as single out workers attending exclusively tourists. For this reason, data seasonally related to the number of visitors, their overnight stays, and the total expenditures do not provide enough guidance to analyze the economic impact of tourism. Furthermore, Brida, Pereyra and Such Devesa (2008) argue that the total economic impact of tourism is the sum of its direct, indirect, and induced effects, of which the last two are more difficult to estimate.

Considering the input-output analysis (IOA) approach, in addition to the initial increase in production and its consequently increasing in intermediate consumption – IC (direct effects), the other industries also demand additional inputs to fulfill the increase in the input supply for the directly affected sectors (indirect effects) and the household consumption due to the income generated in previous stages – induced effects (Miller and Blair, 2009).

The data presented in the input-output table (IOT) and the supply and use table (SUT) provide metrics for traditional industries that can be associated with the tourism segment. Some of them are known in the literature as linkage-based

indicators, which pinpoint how connected and interconnected rests a given sector (the intersection in-between) with the whole economy. Furthermore, policymakers can advocate the use of income, wage, employment, tax, and product multipliers, in addition to the backward and forward linkage indices, for strategic planning and allocating funds to this sector.

The Tourism Satellite Accounts (TSA) feature a complementary set of information related to the segment, making it possible to analyze the contribution of tourism to the economy in macroeconomic terms, in addition to its relationship with other industries. The TSA is an extension of regional economic statistics that thoroughly analyzes the impacts of tourism on an economy. It segments tourism-related expenditures and revenues into different categories, such as accommodation, transportation, and food, and integrates this data into the Regional Account. The TSA measures the economic impacts of tourism, such as contributions to Gross Domestic Product (GDP), job creation, and tax revenue, and provides information on tourism flows, such as tourist arrivals and popular destinations.

Considering the importance of the tourism industry in the local economy, the Institute of Research and Economic Strategy of Ceará (Instituto de Pesquisa e Estratégia Econômica do Ceará – Ipece) developed an IOT and a TSA for Ceará (from now on IOT-CE and TSA-CE, respectively) for the year of 2013. To our knowledge, based on structured data in accordance with international guidelines, such IOT/TSA exemplifies the first regional mapping out, which locally focused takes tourism seriously.

This article combines information from 2013 IOT-CE and TSA-CE following a hypothesis of constant returns to scale (CRS) to disaggregate the main tourism-related activities of the supply side, consequently, to get these breakdowns together in what could be framed as a real "tourism sector". Thus, conceived and properly merged into the IOT-Ceará, multipliers, linkage indicators, and several other metrics are calculated providing us a better understanding of this sector. By adding a sector of tourism in the IOT, it is possible to verify not only the linkage degree between sectors, but also the way this linkage occurs, that is, whether supply/demand of outputs/inputs is concentrated in one sector or distributed along sectors.

The present study also contributes to tourism economics by unifying the Rasmussen-Hirschman linkage and dispersion indexes to obtain what we call the "pull index", which summarizes the linkage indices by applying measured weights obtained from the dispersion indices. The suggested metric integrates, in a single index, all underlying ideas behind the previously mentioned, assessing the role played by any sector, indicating key ones.

Section two provides a concise overview of the limitations related to the identification and evaluation of tourism. Section three presents methodological

directives, which allow us to identify the tourism sector in IOT-CE. The pull index is explained in section four. We calculate several economic indicators of Ceará, which are in section five. Section six concludes.

2 REVIEW OF THE LITERATURE

The tourism economic literature usually uses a standard characterization of activities called Tourism Characteristic Activities (TCAs), which includes activities from various traditional industries. Therefore, specific studies focus on defining this set, separating the portion that is effectively consumed by tourists from those activities, and assessing its size in the whole economy.

To take a case in point, although the list is not exhaustive, Lage and Milone (1991) illustrate a range of economic activities tied to this segment: transport services (road/water/air/supporting transport services), accommodation services (hotels, inns, flats), food-serving services (restaurants, bars, snack bars), cultural or other recreational services (theaters, concert halls etc.). Lundberg, Krishnamoorthy and Stavenga (1995) point out economic sectors tied to tourism: hotels, restaurants, air transportation, rent-a-car market, and travel agencies. Nevertheless, estimates derived just from sectoral division tend to overestimate the role of tourism, as a portion of these goods and services may be consumed by non-tourists. In this sense, the Applied Economic Research Institute (Instituto de Pesquisa Econômica Aplicada – Ipea) has developed a methodological framework to determine "tourist demand coefficients" which quantify the share of TCAs that are effectively consumed by tourists (Sakowski, 2013).

FJP (2017)[6] provided, in a slightly more fashion, the value added (VA) of Minas Gerais TCAs for the period 2010-2014. Concerning only the supply side, and in line with National and Regional Accounts portrayed by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE), through such disaggregation, a sort of filtering process was applied that leaves out activities not closely related to tourism. In the last resort, relative shares were reached, which can be further applied to both production value (PV) and IC, so that the difference between them ends up distinguishing the VA of TCAs. Similarly, Gonçalves, Faria and Horta (2020) estimated the VA of TCAs in Brazilian states using payroll data to distinguish tourism activities and as a proxy for production.

There is a growing literature that uses multipliers provided by standard IOTs to assess impacts for tourism/events by considering exogenous shocks of tourist expenditure estimates. The Ipece has published a series of studies using this approach to evaluate the impacts of additional tourism inflows related to specific events (2013

6. João Pinheiro Foundation (Fundação João Pinheiro – FJC).

Fifa Confederations Cup) and the operation of tourism infrastructure equipment ("Acquario" Ceará and Ceará's Event Centre) using estimates of additional tourist expenditures distributed through various industries (Ipece, 2012a; 2012b; 2013).

In a similar approach, Haddad, Porsse and Rabahy (2013) builds the interregional matrix of domestic tourism expenditure flows to investigate the potential of the tourism industry in reducing interregional inequalities in Brazil. The results reveal significant positive impacts within economies in the poorer region and negative effects in the wealthier region. Using data from the Ministry of Tourism, Ribeiro, Andrade and Motta (2014) estimate the tourist expenditure of 2009 in Sergipe and assess its impacts on the local economy. Ribeiro et al. (2017) expanded the previous analysis to evaluate the effects of tourism expenditure in all states of the Brazilian northeast. The results found suggest that the segment can be used as a mechanism to reduce interregional inequalities.

Some studies develop strategies to incorporate a tourism sector into existing IOTs to assess impacts and industry linkages. Casimiro Filho and Guilhoto (2003) adapted an IOT for the Brazilian economy in 1999 to differentiate between tourist and non-tourist sectors. As a result, they found six segments for the former group. However, by considering full sectors, they suffer from the same limitations as Lage and Milone (1991) and Lundberg, Krishnamoorthy and Stavenga (1995). To avoid these limitations, Takasago et al. (2010) used data from Ipea on the tourism workforce to disaggregate tourism-related industries and assess their importance in Brazil. Takasago and Mollo (2011) also apply this methodology to evaluate the capacity of tourism for economic growth and job creation in Distrito Federal. Both studies emphasize the value of this approach as an alternative in the absence of TSA. Similarly, the relative share of the tourism workforce in the Northeast region (Ipea data) was accurately disaggregated by Souza, Guilhoto and Silveira Neto (2016).

Other studies evaluate the impacts of tourism considering TSA expenditure data as a stimulus in IOA. In this approach, it is essential that both sets of data be compatible. Smeral (2005) argues that the TSA data can be used to estimate the direct impacts of tourism, and a complementary IOT analysis is needed to capture indirect effects. Figini and Patuelli (2022) use this approach to examine the importance of the tourism segment for a group of countries in the European Union. A tourism multiplier is obtained by the ratio between the resulting impacts for which detailed tourism expenditures in the TSA.

Considering the availability of IOT and TSA data for Ceará and the limitations of the existing literature, a framework to estimate an augmented IOT with a specific tourism sector by combining information from both tools. This approach enables a straightforward calculation of tourism multipliers and sectoral linkages. In addition, an alternative approach for analyzing key sectors is proposed.

3 BUILDING A TOURISM SECTOR

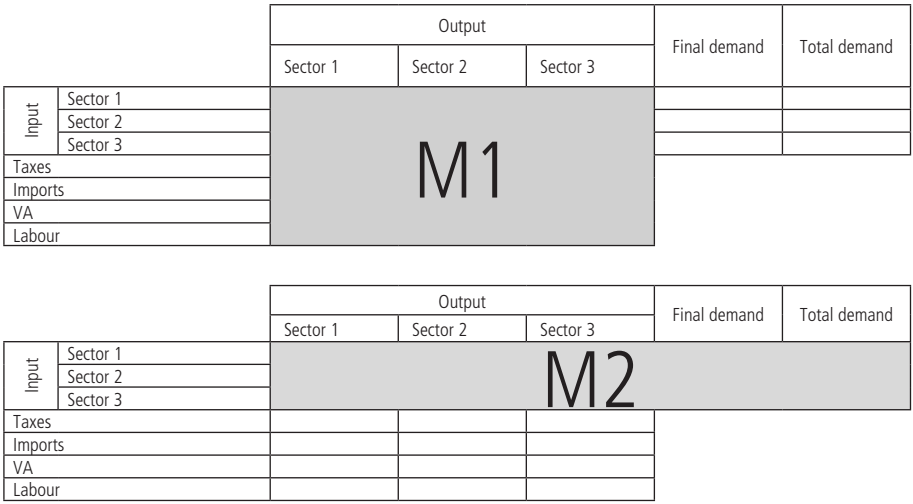
Conceived as economic metrics, income, wages, employment, taxes, and output multipliers, along with backward and forward linkages, should be considered when tourism-related policies are planned. The previous section suggests that most studies regarding tourism impacts in Brazil can be divided into two approaches. The first approach involves the alignment of tourism expenditure data with input-output models to assess its impacts. The second tries to uncover the details of TCA to observe its importance to the economy. There is a lack of studies on the use of TSA in Brazil, largely attributed to data unavailability.

The present study aims to develop a new IOT for Ceará with a specific sector for tourism activities, using data from TSA-CE and IOT-CE combined with a CRS hypothesis. TSA serves as a methodology to uncover the TCA's input-output effects of the demand side, while CRS, viewed as the economic underpinning behind this disaggregation, refers to the effects of the supply side. This makes it possible to host TSA and IOT.

An IOT presents two major sources of information: i) a matrix, M1, which includes IC, taxes, sectoral imports, and VA for each sector in each column; and ii) a row matrix that includes IC, total product and demand components, which we will call M2.

Isolating a specific activity is challenging but is possible using TSA data and the CRS hypothesis. The first makes it possible to partition rows and columns to maintain system stability. For example, $\gamma y_j = f\left(\gamma x_{1j}, \dots, \gamma x_{nj}\right)$ suggests that if we double the number of inputs ($\gamma = 2$), then the output must double. Similarly, if we partition the number of inputs in the production process ($0 \leq \gamma \leq 1$) then the product must be proportionally partitioned.

FIGURE 1
Typical M1 and M2 representations



Authors' elaboration.

This same reasoning can be easily applied to IOT, using statistical information tied to TSA scale parameters. Then parts of certain sectors may be detached within the production system, and these detachments may ultimately join into a specific sector, about which there was no initial information.

According to IBGE's productive structure, tourism and health are not specific sectors. This makes it difficult to calculate certain important indicators, such as income, employment, and tax multipliers, or backward-forward linkages. Instead, by using the CRS hypothesis and TSA data, the calculation of these indicators becomes easier.

An algorithm is developed that gathers information from both TSA-CE and the original IOT-CE, incorporating a tourism sector into the latter. The estimated IOT is organized on a sector-by-sector basis, with 32 activities.[7] The parameters related to CRS were obtained as follows: first, we framed the production supply observed in the TSA in a way that is compatible with IOT sectors. Furthermore, the relationship between this sectoral production and the final sectorial demand of the economy was observed.[8]

7. A Matlab code is disponible under request.

8. A question remains open: TSA output values tied to accommodation services sector were superior to those found in the IOT. Thus, we kept 100% of the allocation of this service to the tourism sector.

TABLE 1
Constant returns to scale parameters

	Tourism (supply)	Ceará (demand)	%
Public administration, safety, education and health publics and social security	1,666	28,556	5.8
Financial activities, insurance, and related services	41	5,900	0.7
Professional, scientific, and technical, administrative activities and complementary services	711	5,900	12.1
Sale and motor vehicles and motorcycles repairing	101	20,742	0.5
Manufacturing of food products	15	7,720	0.2
Manufacture of textile products, clothing and accessories, footwear, and leather goods	307	10,442	2.9
Food-serving services	3,067	5,418	56.6
Accommodation services	834	533	100.0
Transport, storage, and mail-order houses	1,768	7,144	24.7
Total	**8,510**	**92,354**	**9.2**

Source: IOT (available at: https://www.ipece.ce.gov.br/tabela-de-recursos-e-usos-e-matriz-de-insumo-produto-regionais-para-economia-cearense/; access: 3 Mar. 2022) and TSA data (available at: https://www.ipece.ce.gov.br/wp-content/uploads/sites/45/2018/12/Conta_Satelite_de_Turismo_CSTRCE2.pdf; access: 3 Mar. 2022).
Authors' elaboration.

Following these percentages, we set sectorial return to scale parameters (γ_j) and applied the algorithm aggregating relatively input-output shares, as for the tourism sector. In other words, we disaggregated the M1 and M2 matrices according to these percentages, and then we aggregated the breakdowns in the so-called "tourism sector".

The pay-off is considerable here: we get consistent vectors concerning total demand (related to the economy in a wholly) and demand (related to intra-intersectoral outputs). But we face a problem: How demand is distributed among its components seems suspicious, because it doesn't perfectly match the TSA information.

To deal with this, two approaches can be implemented: Since the matrix is still balanced, one can proceed directly with the analysis of the generated IOT, disregarding the mismatches with the TSA demand vectors, if these mismatches are small. The other alternative would be to fix the demand vectors according to the TSA (which would unbalance the IOT) and apply a RAS method to the matrix to rebalance it.

Note that this issue does not prevent us from appropriately calculating the direct/indirect backward/forward linkage indices. On the other hand, induced multipliers, which directly depend on the household consumption vector, can vary according to the intensity of the resources valued in this vector. Even so, it is possible to compare the induced effects generated in the original IOT (without the

tourism sector) with those generated by the IOT under the CRS hypothesis (with the tourism sector). If these effects are relatively close, then there is evidence that the valuation of the demand vectors via the CRS approach, although not perfectly aligned with that of the TSA, should not produce spurious results.

4 METHODOLOGY AND THE PULL INDEX

Considering Leontief's basic model and following Rasmussen (1956) and Hirschman (1958), it is possible to estimate both the backward and forward linkage indices. The former relatively evaluates how much an industry would demand inputs from the economy, and the latter appraises how much the production of an industry is demanded as input in the economy.

Let ℓ_{ij} be an element of Leontief inverse matrix, $L = (I - A)^{-1}$; L^* be the average of all elements of L; L_{*j} and L_{i*} be the sum of the j-th column and i-th row, respectively. Then, the indices are as follows:

1) Backward linkages index:

$$U_j = [L_{*j}/n]/L^* \tag{1}$$

2) Forward linkages index:

$$U_i = [L_{i*}/n]/L^* \tag{2}$$

Since such indexes are normalized, values greater than one suggest above-average sectors, therefore key sectors that tend to induce economic growth.[9] In addition, since they are normalized, these indices are independent of measurement units, allowing intersectoral, interregional, and intertemporal comparisons.

According to Miller and Blair (2009), key sector classification in the manner of Rasmussen-Hirschman criteria means that sectors whose backward or forward linkages are greater than 1 are indeed key sectors suited to economic growth. McGilvray (1977) suggests that this classification should be more restrictive and that key sectors should be considered as those that have both backward and forward linkage indices greater than 1.

As the indicators are normalized, we must pay attention to those sectors with forward-backward linkages greater than 1. Thus, in general, sectors can be classified in four ways, as shown in the table 2.[10]

9. Criticisms addressed to these indices lies in the fact they do not consider different levels of production in each economic sector, which is considered when we employ Pure Indices of Interindustry Linkages.

10. In short, we get: i) weakly linked with other sectors, or generally independent on other sector (U_i and $U_j < 1$); ii) generally linked or dependent on other sectors (U_i and $U_j > 1$); iii) dependent on intersectoral supply (only $U_i > 1$); and iv) dependent on intersectoral demand (only $U_j > 1$).

TABLE 2
Industries description by backward and forward linkages indexes

		Forward linkage	
		Low (< 1)	High (> 1)
Backward linkage	Low (< 1)	Generally independent	Dependent on inter-industry demand
	High (> 1)	Dependent on interindustry supply	Generally dependent

Source: Miller and Blair (2009).
Authors' elaboration.

We can also verify how the linkage effects spread across the economy with the dispersion indices. Dispersions as for backward and forward linkages indices are determined, respectively:

$$V_j = \frac{\sqrt{\sum_{i=1}^{n} \frac{\left(\ell_{ij} - \left(L_{*j}/n\right)\right)^2}{n-1}}}{L_{*j}/n} \tag{3}$$

and

$$V_i = \frac{\sqrt{\sum_{i=1}^{n} \frac{\left(\ell_{ij} - \left(L_{i*}/n\right)\right)^2}{n-1}}}{L_{i*}/n} \tag{4}$$

A low dispersion value of the backward linkage index (V_j) means that the impact of a variation in the production of the sector under analysis will uniformly stimulate the others. In other words, the smaller the value of V_j is, the more sectors are related to intermediate demand induced by j. On the contrary, a high dispersion value suggests that the stimulus will be concentrated in a few sectors. Therefore, if a sector has a high value for U_j (greater than 1) and a concomitant low value for V_j, besides having great backward linkage, it will also have an extensive reach across multiple sectors in the inverse matrix.

Similarly, a low dispersion value of the forward linkage index (V_i) means that this sector will be uniformly demanded by the others. Thus, the smaller the value of V_i, the more sectors in which i will act as supplier. In contrast, a high value indicates that the inputs demanded from this sector will be concentrated in a few sectors. Consequently, if a sector has a high value of U_i (greater than 1) and a low value of V_i, in addition to the significant backward linkage, it will also reach many sectors in the inverse matrix.

Although not directly discussed throughout the literature, this idea permeates the field of influence concept: How each linkage in a sector gets along with the others depends on the coefficients of variation; thus, sectors with high dispersion indices tend to generate more misshapen vectors for the matrix of the

field of influence, while vectors with low dispersion indices tend to generate more homogeneous vectors.

In fact, a key sector should be listed as one in which U_i and U_j exceed unity and in which V_i and V_j are relatively low. Notice that it is possible to propose an index that aggregates all the Rasmussen-Hirschman indices presented above. Such an index is equal to the sum of forward and backward linkage indices, multiplied by one minus the ratio between the sectoral dispersion and the maximum sectoral dispersion, (V_i^+ and V_j^+), that is,

$$T_i = U_i\left(1 - \frac{V_i}{V_i^+}\right) + U_j\left(1 - \frac{V_j}{V_j^+}\right) \tag{5}$$

From equation (5), it is observed that the greater the relative sectorial dispersion, the less weight is given to the linkage index within the pull index. Such an index is new and has not yet been presented in the literature. This innovation has the advantage of synthesizing, in a single index, the whole idea behind the indicators presented above.

We also present impact direct, total, and induced multipliers for sectors.[11] The term "multiplier" is used to define the ratio between the total effect on the economy for a given initial stimulus made. They can be obtained with respect to effects on the product, tax revenue, employment, and household income, among others. Finaly, the appendix also presents a methodological note and an ordered field of influence matrix.

5 RESULTS

Comparisons between some items of the TSA and the results obtained using the CRS hypothesis for the tourism industry are outlined below.

11. See Miller and Blair (2019) for a detailed discussion of these multipliers.

TABLE 3
Comparison between TSA and CRS

	TSA[1]	TSA (%CE)	CRS[1]	CRS (%CE)
Total output	8,510	5.2	8,631	5.2
IC	3,632	8.9	2,618	6.4
Gross added value	4,878	5.1	5,056	5.3
Remunerations	1,806	3.5	2,871	5.6
Gross operating surplus and gross mixed income	3,028	7.1	2,137	5.0
Taxes subsidies on products and imports	652	12.5	327	6.3
Factor labor	240,809	6.6	245,850	6.7
GDP	5,486	5.8	5,336	5.6
Export	6	0.0	315	1.3
Households' consumption	6,585	7.9	3,823	7.3
Government expenditures	1,666	6.0	1,616	5.8
Sum of the final demand vectors	8,257	5.0	8,631	5.2

Source: IOT (available at: https://www.ipece.ce.gov.br/tabela-de-recursos-e-usos-e-matriz-de-insumo-produto-regionais-para-economia-cearense/; access: 3 Mar. 2022) and TSA data (available at: https://www.ipece.ce.gov.br/wp-content/uploads/sites/45/2018/12/Conta_Satelite_de_Turismo_CSTRCE2.pdf; access: 3 Mar. 2022).
Authors' elaboration.
Note: [1] Amounts in R$ 1 million of 2013.

In general, regarding CRS, most of the results associated with the tourism sector align with those of TSA-CE. Our methodology suggests a smaller IC and a more equitable income distribution between wages and capital returns. As highlighted in section three, some inconsistency regarding demand components is expected and is observed here: exports are overvalued, and household consumption are undervalued over our proposal. As we highlight, this may be a second-order problem if the difference between the induced effects under our approach and the standard IOT is very small in the multiplier analysis.

Table 4 presents backward and forward linkages (L), their respective dispersions (D), and the pull index (P). As a comparison criterion, these were calculated for both original input-output matrix – IOM (disregarding tourism sector) and modified IOM (considering tourism sector formed through the CRS hypothesis). The results are ranked according to the proposed pull index.

From table 4, it is observed that the tourism sector has strong linkage indices, both forward (1.26) and backward (1.01). Tourism ranks fourteenth by the backward linkage index and sixth by the forward linkage index. Regarding dispersion indices, the sector has the eleventh lowest backward dispersion index (4.21) and the fifth lowest forward dispersion index (3.36). This ensures a pull index of 0.79 for the tourism sector, placing it fifth according to this criterion.

Appendix A provides an ordered field of influence matrix for the IOT with tourism included. The matrix indicates that tourism ranks sixth on the buyers' side and fourteenth on the sellers' side, which is consistent with previous results.

These findings differ somewhat from the literature, which often emphasizes tourism as a core activity but not necessarily as a major provider of inputs across the economy. Here, tourism shows its potential to provide widespread economic inputs. If one considers the pull index, which captures the relative importance and spillover effects of both sides, the relative significance of the tourism industry increases.

In summary, the inclusion of the tourism sector changes the ranking of some sectors, especially those close to tourism in terms of the pull index. However, most sectors maintain similar positions, indicating that, although tourism is an important sector, its inclusion based on the proposed methodologies does not drastically alter the economic structure initially observed in the original matrix.

TABLE 4
Linkage, dispersion and pull index for the Ceará economy

Sectors	Tourism not included					Tourism included				
	Backward		Forward		P	Backward		Forward		P
	L	D	L	D		L	D	L	D	
Trade and repair of motor vehicles and motorcycles	0.96	4.50	2.44	1.87	1.85	0.96	4.50	2.46	1.86	1.86
Professional, scientific and technical activities, administrative and complementary services	0.96	4.64	1.95	2.34	1.33	0.96	4.60	1.78	2.53	1.18
Transportation, storage and mail	1.03	4.36	1.73	2.62	1.18	1.03	4.28	1.49	2.97	0.97
Financial activities, insurance and related services	1.13	4.33	1.52	3.24	0.93	1.13	4.33	1.50	3.27	0.92
Tourism	-	-	-	-	-	*1.01*	*4.21*	*1.26*	*3.36*	*0.79*
Electricity and gas, water, sewage, waste management activities and decontamination	1.20	4.65	1.55	3.60	0.80	1.20	4.64	1.51	3.69	0.76
Extractive industries	1.01	4.16	1.07	3.95	0.61	1.01	4.14	1.07	3.92	0.62
Information and communication	1.24	4.19	1.19	4.37	0.61	1.24	4.17	1.19	4.37	0.61
Refining of petroleum and coke and alcohol and other biofuels	1.24	3.46	0.75	5.80	0.48	1.24	3.45	0.75	5.78	0.48
Manufacture of food products	1.14	3.90	0.89	5.04	0.47	1.15	3.90	0.90	4.99	0.48
Arts, culture, sport and recreation and other service activities	1.13	3.69	0.81	5.20	0.48	1.13	3.70	0.81	5.21	0.47
Beverage manufacturing	1.10	3.96	0.83	5.26	0.41	1.11	3.95	0.85	5.16	0.42

(Continues)

(Continued)

Sectors	Tourism not included				P	Tourism included				P
	Backward		Forward			Backward		Forward		
	L	D	L	D		L	D	L	D	
Metallurgy	1.08	4.06	0.88	5.02	0.42	1.09	4.06	0.88	5.02	0.42
Accommodation services	1.07	3.86	0.78	5.33	0.40					
Manufacture of non-metallic mineral products	1.04	4.19	0.87	5.03	0.38	1.04	4.19	0.86	5.05	0.38
Food services	1.04	3.99	0.86	4.84	0.45	1.05	3.98	0.79	5.27	0.38
Agriculture	0.86	5.02	0.98	4.39	0.33	0.86	5.02	0.98	4.41	0.33
Manufacture of wood products, except furniture, cellulose, paper and paper products and printing services and reproduction of recordings	0.99	4.43	0.87	5.04	0.33	0.99	4.43	0.87	5.04	0.33
Construction	1.00	4.47	0.88	5.06	0.32	1.00	4.47	0.88	5.09	0.31
Real estate activities	0.80	5.24	1.00	4.20	0.33	0.80	5.24	0.98	4.28	0.31
Manufacture of chemical products	0.99	4.48	0.86	5.13	0.30	0.99	4.48	0.86	5.13	0.30
Manufacture of motor vehicles, trailers and bodies and other transport equipment	1.03	4.16	0.77	5.60	0.30	1.03	4.16	0.77	5.59	0.30
Administration, defense, education and public health and social security	0.92	4.51	0.83	4.99	0.30	0.93	4.51	0.83	5.04	0.29
Manufacture of computer equipment, electronic and optical products, machines, appliances and electrical materials	0.97	4.34	0.77	5.53	0.26	0.98	4.34	0.77	5.52	0.26
Manufacture of pharmaceutical and pharmaceutical products	0.98	4.33	0.76	5.60	0.26	0.98	4.32	0.76	5.59	0.26
Private education and health	0.95	4.48	0.78	5.44	0.25	0.95	4.48	0.78	5.44	0.24
Manufacture of rubber and plastic products	0.92	4.63	0.80	5.31	0.23	0.92	4.63	0.80	5.31	0.23
Maintenance, repair and installation of machines and equipment	0.89	4.69	0.79	5.26	0.23	0.89	4.69	0.79	5.27	0.22
Manufacture of textile products, clothing and accessories, footwear and leather artifacts	0.95	4.65	0.81	5.43	0.22	0.95	4.64	0.81	5.44	0.22
Manufacture of metal products, except machines and equipment	0.89	4.76	0.79	5.31	0.21	0.89	4.76	0.79	5.31	0.21
Manufacture of machines and equipment	0.89	4.66	0.75	5.57	0.19	0.90	4.66	0.75	5.57	0.19
Other industrial activities	0.88	4.72	0.74	5.61	0.17	0.88	4.72	0.74	5.61	0.17
Domestic services	0.74	5.66	0.74	5.66	0.02	0.74	5.66	0.74	5.66	0.02

Authors' elaboration.
Obs.: L – linkage; D – dispersion; P – pull index.

Tables 5 to 9 display the multipliers for product, income/salaries, state sales tax (Imposto sobre Circulação de Mercadorias e Prestação de Serviços – ICMS), VA, and employment. The methodology used for disaggregation/aggregation, based on the assumption of CRS, may lead to misaligned demand component vectors when compared to those in the TSA. So, it was expected that differences in the household consumption vector would result in divergent induced effects when comparing the two data sets.

Our findings reveal that the induced effect for the output multiplier is, on average, 1.23% higher in the data set that includes tourism. As for other multipliers, the induced effects are, on average, 4% lower for wages, 0.16% lower for ICMS, 0.23% higher for employment, and 1.79% lower for VA. These differences are considered acceptable for the analysis and demonstrate a short level of misalignment in the demand components.

In general, the total multipliers (sum of simple and induced) for each sector in both IOTs are close. The most significant differences are observed in the arts, culture, sport and recreation and other service activities industry, with a 1.7% increase in the employment multiplier and a 3.6% reduction in the income multiplier. Consequently, the sector ranking according to their multipliers changes little when comparing the total multipliers of the two matrices (tourism included and not included), regardless of the multiplier analyzed. The similarity between multipliers and linkages in both IOTs suggests that a substantial part of the original IOT is preserved under the methodology proposed.[12]

TABLE 5
Output multipliers: IOT tourism not included and IOT tourism included

	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Domestic services	1.00	2.00	3.00	1.00	2.02	3.02
Financial, insurance and related services activities	1.53	1.27	2.80	1.53	1.29	2.82
Administration, defense, education and public health and social security	1.25	1.52	2.77	1.25	1.54	2.79
Arts, culture, sport and recreation and other service activities	1.54	0.96	2.50	1.53	0.99	2.52
Information and communication	1.68	0.75	2.43	1.68	0.76	2.44
Private education and health	1.29	1.04	2.33	1.29	1.06	2.34
Professional, scientific and technical, administrative activities and complementary services	1.30	0.98	2.28	1.30	0.99	2.29

(Continues)

12. The analysis can be complemented through the use of pure linkage index and/or the use of Cella/Clements technique (Sonis et al., 1995). The approach is based on Miyazawa's concept of "internal" and "external" multipliers (Miyazawa, 1966).

(Continued)

	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Tourism	-	-	-	*1.36*	*0.87*	*2.23*
Accommodation services	1.46	0.75	2.21	-	-	-
Transport, storage and mail-order houses	1.39	0.78	2.17	1.39	0.79	2.18
Refining of petroleum and coke and of alcohol and other biofuels	1.68	0.42	2.10	1.68	0.43	2.11
Motor vehicles, trailers and bodies and other transport equipment	1.40	0.68	2.08	1.40	0.69	2.08
Food products	1.55	0.52	2.07	1.55	0.53	2.08
Sale and repair of motor vehicles and motorcycles	1.30	0.73	2.03	1.30	0.74	2.04
Textile products, clothing and accessories, footwear and leather goods	1.28	0.74	2.03	1.28	0.75	2.04
Electricity and gas, water, sewage, waste management and decontamination activities	1.63	0.40	2.03	1.63	0.41	2.03
Beverage manufacturing	1.50	0.52	2.02	1.50	0.53	2.03
Pharm chemicals and pharmaceuticals	1.32	0.63	1.95	1.32	0.63	1.96
Extractive industries	1.37	0.57	1.95	1.37	0.58	1.96
Construction	1.35	0.59	1.94	1.35	0.60	1.95
Food-serving services	1.42	0.52	1.94	1.42	0.53	1.94
Non-metallic mineral products	1.41	0.50	1.91	1.41	0.50	1.91
Wood products, other than furniture, of cellulose, paper and paper products and engraving printing and reproduction services	1.34	0.54	1.88	1.34	0.55	1.89
Computer equipment, electronic and optical products, machinery, appliances, and electrical materials	1.32	0.53	1.86	1.32	0.54	1.86
Machinery and equipment	1.21	0.63	1.84	1.21	0.64	1.85
Metallurgy	1.47	0.36	1.83	1.47	0.36	1.83
Metal products, except machinery and equipment	1.20	0.62	1.82	1.20	0.63	1.83
Rubber and plastic material products	1.24	0.57	1.81	1.24	0.57	1.82
Chemicals manufacturing	1.34	0.41	1.75	1.34	0.41	1.75
Other industrial activities	1.20	0.53	1.72	1.20	0.53	1.73
Machine maintenance, repair and installation. and equip	1.21	0.43	1.64	1.21	0.44	1.65
Agriculture	1.17	0.31	1.47	1.17	0.31	1.48
Real estate activities	1.08	0.07	1.16	1.08	0.07	1.16

Source: Input-output simulations.
Authors' elaboration.

TABLE 6
Income/wages multipliers: IOT tourism not included and IOT tourism included

	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Domestic services	1.00	0.47	1.47	1.00	0.49	1.49
Administration. defense. education and public health and social security	0.76	0.35	1.11	0.76	0.37	1.13
Financial. insurance and related services activities	0.63	0.30	0.93	0.64	0.31	0.94
Private education and health	0.52	0.24	0.76	0.52	0.25	0.78
Professional. scientific and technical. administrative activities and complementary services	0.49	0.23	0.72	0.49	0.24	0.73
Arts. culture. sport and recreation and other service activities	0.48	0.22	0.70	0.49	0.24	0.73
Tourism	-	-	-	*0.43*	*0.21*	*0.64*
Transport. storage and mail	0.39	0.18	0.57	0.39	0.19	0.58
Accommodation services	0.38	0.18	0.55	-	-	-
Information and communication	0.37	0.18	0.55	0.37	0.18	0.56
Textile products. clothing and accessories. footwear and leather goods	0.37	0.17	0.54	0.37	0.18	0.55
Sale and repair of motor vehicles and motorcycles	0.37	0.17	0.54	0.37	0.18	0.54
Motor vehicles. trailers and bodies and other transport equipment	0.34	0.16	0.50	0.34	0.17	0.51
Machinery and equipment	0.31	0.15	0.46	0.32	0.15	0.47
Pharm chemicals and pharmaceuticals	0.31	0.15	0.46	0.31	0.15	0.47
Metal products. except machinery and equipment	0.31	0.15	0.46	0.31	0.15	0.46
Construction	0.30	0.14	0.44	0.30	0.14	0.44
Extractive industries	0.29	0.13	0.42	0.29	0.14	0.43
Rubber and plastic material products	0.28	0.13	0.41	0.28	0.14	0.42
Wood products. other than furniture. of cellulose. paper and paper products and engraving printing and reproduction services	0.27	0.13	0.40	0.27	0.13	0.41
Computer equipment. electronic and optical products. machinery. appliances and electrical materials	0.27	0.12	0.39	0.27	0.13	0.40
Other industrial activities	0.26	0.12	0.39	0.26	0.13	0.39
Beverage manufacturing	0.26	0.12	0.38	0.26	0.13	0.39
Food-serving services	0.26	0.12	0.38	0.26	0.13	0.39
Food products	0.26	0.12	0.38	0.26	0.13	0.39
Non-metallic mineral products	0.25	0.12	0.37	0.25	0.12	0.37

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	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Machine maintenance. repair and installation. and equip	0.22	0.10	0.32	0.22	0.11	0.32
Refining of petroleum and coke and of alcohol and other biofuels	0.21	0.10	0.31	0.21	0.10	0.31
Chemicals manufacturing	0.20	0.10	0.30	0.20	0.10	0.30
Electricity and gas. water. sewage. waste management and decontamination activities	0.20	0.09	0.29	0.20	0.10	0.30
Metallurgy	0.18	0.08	0.26	0.18	0.09	0.27
Agriculture	0.15	0.07	0.22	0.15	0.07	0.23
Real estate activities	0.04	0.02	0.05	0.04	0.02	0.05

Source: Input-output simulations.
Authors' elaboration.

TABLE 7
ICMS multipliers: IOT tourism not included and IOT tourism included

	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Beverage manufacturing	0.008	0.000	0.008	0.008	0.000	0.008
Computer equipment, electronic and optical products, machinery, appliances and electrical materials	0.005	0.000	0.005	0.005	0.000	0.005
Metal products, except machinery and equipment	0.004	0.000	0.004	0.004	0.000	0.004
Wood products, other than furniture, of cellulose, paper and paper products and engraving printing and reproduction services	0.003	0.000	0.003	0.003	0.000	0.003
Rubber and plastic material products	0.002	0.000	0.003	0.002	0.000	0.003
Motor vehicles, trailers and bodies and other transport equipment	0.002	0.000	0.002	0.002	0.000	0.002
Machinery and equipment	0.002	0.000	0.002	0.002	0.000	0.002
Other industrial activities	0.002	0.000	0.002	0.002	0.000	0.002
Metallurgy	0.001	0.000	0.001	0.001	0.000	0.001
Textile products, clothing and accessories, footwear and leather goods	0.001	0.000	0.001	0.001	0.000	0.001
Chemicals manufacturing	0.001	0.000	0.001	0.001	0.000	0.001
Non-metallic mineral products	0.001	0.000	0.001	0.001	0.000	0.001
Food products	0.001	0.000	0.001	0.001	0.000	0.001
Food-serving services	0.001	0.000	0.001	0.001	0.000	0.001
Domestic services	0.000	0.001	0.001	0.000	0.001	0.001

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	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Administration, defense, education and public health and social security	0.000	0.001	0.001	0.000	0.001	0.001
Tourism	-	-	-	*0.000*	*0.000*	*0.001*
Financial, insurance and related services activities	0.000	0.000	0.000	0.000	0.000	0.000
Arts, culture, sport and recreation and other service activities	0.000	0.000	0.000	0.000	0.000	0.000
Professional, scientific and technical, administrative activities and complementary services	0.000	0.000	0.000	0.000	0.000	0.000
Sale and repair of motor vehicles and motorcycles	0.000	0.000	0.000	0.000	0.000	0.000
Accommodation services	0.000	0.000	0.000	-	-	-
Private education and health	0.000	0.000	0.000	0.000	0.000	0.000
Construction	0.000	0.000	0.000	0.000	0.000	0.000
Information and communication	0.000	0.000	0.000	0.000	0.000	0.000
Transport, storage and mail-order houses	0.000	0.000	0.000	0.000	0.000	0.000
Pharm chemicals and pharmaceuticals	0.000	0.000	0.000	0.000	0.000	0.000
Machine maintenance, repair and installation, and equip	0.000	0.000	0.000	0.000	0.000	0.000
Extractive industries	0.000	0.000	0.000	0.000	0.000	0.000
Refining of petroleum and coke and of alcohol and other biofuels	0.000	0.000	0.000	0.000	0.000	0.000
Agriculture	0.000	0.000	0.000	0.000	0.000	0.000
Electricity and gas, water, sewage, waste management and decontamination activities	0.000	0.000	0.000	0.000	0.000	0.000
Real estate activities	0.000	0.000	0.000	0.000	0.000	0.000

Source: Input-output simulations.
Authors' elaboration.

TABLE 8
VA multipliers: IOT tourism not included and IOT tourism included

	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Domestic services	1.000	1.182	2.182	1.000	1.202	2.202
Administration, defense, education and public health and social security	0.903	0.898	1.800	0.903	0.914	1.817
Financial, insurance and related services activities	0.900	0.749	1.650	0.900	0.763	1.663

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	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Professional, scientific and technical, administrative activities and complementary services	0.903	0.578	1.481	0.902	0.587	1.490
Private education and health	0.811	0.615	1.426	0.811	0.627	1.438
Arts, culture, sport and recreation and other service activities	0.808	0.565	1.373	0.811	0.587	1.398
Sale and repair of motor vehicles and motorcycles	0.903	0.432	1.335	0.903	0.439	1.342
Information and communication	0.868	0.442	1.310	0.866	0.448	1.314
Tourism	-	-	-	*0.797*	*0.514*	*1.311*
Accommodation services	0.812	0.444	1.256	-	-	-
Transport, storage and mail-order houses	0.707	0.462	1.169	0.708	0.470	1.178
Extractive industries	0.777	0.338	1.115	0.780	0.346	1.125
Food-serving services	0.774	0.308	1.081	0.773	0.313	1.086
Real estate activities	0.977	0.043	1.020	0.977	0.044	1.021
Agriculture	0.826	0.181	1.007	0.826	0.184	1.010
Construction	0.653	0.350	1.004	0.653	0.356	1.009
Pharm chemicals and pharmaceuticals	0.632	0.369	1.000	0.632	0.375	1.007
Textile products, clothing and accessories, footwear and leather goods	0.533	0.438	0.971	0.533	0.446	0.980
Beverage manufacturing	0.647	0.309	0.956	0.647	0.314	0.961
Machine maintenance, repair and installation, and equip	0.692	0.256	0.949	0.692	0.261	0.953
Non-metallic mineral products	0.641	0.294	0.936	0.642	0.299	0.941
Machinery and equipment	0.545	0.372	0.917	0.545	0.378	0.923
Motor vehicles, trailers and bodies and other transport equipment	0.489	0.402	0.892	0.489	0.409	0.899
Wood products, other than furniture, of cellulose, paper and paper products and engraving printing and reproduction services	0.553	0.321	0.874	0.553	0.327	0.880
Food products	0.553	0.307	0.860	0.553	0.312	0.865
Other industrial activities	0.533	0.310	0.844	0.534	0.316	0.849
Metal products, except machinery and equipment	0.460	0.368	0.828	0.460	0.374	0.834
Rubber and plastic material products	0.462	0.334	0.796	0.462	0.340	0.802
Electricity and gas, water, sewage, waste management and decontamination activities	0.547	0.237	0.783	0.547	0.240	0.787
Computer equipment, electronic and optical products, machinery, appliances and electrical materials	0.376	0.315	0.691	0.376	0.321	0.697

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	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Chemicals manufacturing	0.352	0.240	0.592	0.353	0.244	0.598
Metallurgy	0.337	0.210	0.547	0.338	0.214	0.552
Refining of petroleum and coke and of alcohol and other biofuels	0.272	0.248	0.521	0.274	0.253	0.527

Source: Input–output simulations.
Authors' elaboration.

TABLE 9
Employment multipliers: IOT tourism not included and IOT tourism included

	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Domestic services	204	52	256	204	51	256
Accommodation services	96	19	115	-	-	-
Arts, culture, sport and recreation and other service activities	66	25	90	64	25	89
Agriculture	76	8	84	76	8	84
Private education and health	36	27	63	36	27	63
Sale and repair of motor vehicles and motorcycles	40	19	59	40	19	59
Tourism	-	-	-	*36*	*22*	*58*
Professional, scientific and technical, administrative activities and complementary services	31	25	57	31	25	56
Food services	43	13	56	43	13	56
Administration, defense, education and public health and social security	17	39	56	17	39	56
Textile products, clothing and accessories, footwear and leather goods	35	19	54	35	19	54
Transport, storage and mail	29	20	49	29	20	49
Financial, insurance and related services activities	12	33	45	12	33	45
Construction	28	15	43	28	15	43
Machinery and equipment	27	16	43	27	16	43
Metal products, except machinery and equipment	27	16	43	27	16	43
Motor vehicles, trailers and bodies and other transport equipment	25	18	43	25	18	43
Food products	28	13	41	28	13	41
Rubber and plastic material products	26	15	40	26	15	40
Pharm chemicals and pharmaceuticals	24	16	40	24	16	40

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	Tourism not included			Tourism included		
	Simple	Induced	Total	Simple	Induced	Total
Information and communication	18	19	37	18	19	37
Other industrial activities	23	14	37	23	14	37
Wood products, other than furniture, of cellulose, paper and paper products and engraving printing and reproduction services	22	14	36	22	14	36
Non-metallic mineral products	23	13	35	23	13	35
Computer equipment, electronic and optical products, machinery, appliances and electrical materials	17	14	31	17	14	31
Beverage manufacturing	16	14	30	17	13	30
Machine maintenance, repair and installation, and equip	16	11	28	16	11	28
Extractive industries	11	15	26	12	15	27
Refining of petroleum and coke and of alcohol and other biofuels	12	11	23	13	11	23
Chemicals manufacturing	11	10	22	12	10	22
Electricity and gas, water, sewage, waste management and decontamination activities	10	10	20	10	10	20
Metallurgy	11	9	20	11	9	20
Real estate activities	2	2	4	2	2	4

Source: Input-output simulations.
Authors' elaboration.

6 CONCLUSIONS

As pointed out by Coelho (1991), the standard way to analyze the role of tourism in GDP is by examining tourist consumption. This approach is necessary due to the significant difficulty in defining what constitutes tourist supply and production. Tourism, by its very nature, involves a degree of nuance and immateriality in the provision of services, making it challenging to establish an explicit definition.

The consumption-based approach aligns with the "subjective school" of thought, as opposed to the "sectoral school", which attempts to quantify tourist activity through production (tourist supply). Whether directly or indirectly, tourist consumption generates VA that can be compared with the overall VA to the economy (GDP). Therefore, researchers often investigate the contribution of VA from tourism relative to the total VA to the Brazilian economy in each period.

The state of Ceará stands out in data availability for presenting his own IOT and TSA. These data sets support the sectoral school and then the CRS hypothesis was used to disaggregate a part of production tied to TCAs outlined

in the IOT-CE. The results were aggregated in what can be called the "tourism sector". This approach generates a new IOT, whose structure is very similar to the former matrix, but with a tourism sector well defined, making it possible to explore a series of relevant questions.

In addition, a new index capable of indicating key sectors for the economy is proposed. This new "pull index" reconciles the Rasmussen-Hirschman dispersion and linkage indices intuitively. Based on it, we demonstrate that the tourism sector occupies the fifth place among the 32 IOT sectors that 'pull' the development of Ceará. In particular, the results guided by the index suggest that tourism pulls the economy more than traditional sectors, such as construction, extractive industries, and oil refining sector.

To ascertain the participation of the tourism sector in the economy, product, income/salary, ICMS, VA, and employment multipliers to this sector were also calculated. We found that, with respect to R$ 1.00 added to the final demand in the tourism sector, there would be an increase of R$ 2.23, which R$ 1.36 would be due to effects on the production process and about R$ 0.87 on account of household consumption. Regarding wages, tourism is the 7th sector that could contributes most in terms of income generation for the Ceará population for a given monetary incentive. In terms of ICMS, tourism sector is very close to the average of the economy. Finally, in terms of the employment multiplier, for every million increases in tourist demand, there would be a generation of approximately 58 jobs created in Ceará, of which 36 would be direct and 22 induced by income and household consumption.

In short, the approach presented here, based on the TSA regional concept in relation to the IOM, proves to be a great framework for public policy managers interested in the tourism segment. This framework provides detailed insights into how tourism connects with other economic sectors, enabling targeted interventions.

For example, the analysis can identify key sectors influenced by tourism, guiding investments in supporting infrastructure. Understanding the employment multipliers associated with tourism can inform workforce development programs to ensure the local labor force meets the increased demand from tourism activity.

Additionally, knowing the contribution of tourism to ICMS can help develop tax incentives for businesses that support tourism, boosting their growth and economic contribution. By recognizing the spillover effects of tourism on sectors like construction and manufacturing, policymakers can create comprehensive development strategies that leverage tourism to stimulate broader economic growth.

Last, but not least, a significant contribution to the literature is the proposal of the pull index, which aims to combine all the dispersion and sectoral linkage indices,

considering the relative importance of each sector. This innovative proposal is both simple and attractive, allowing for the identification of key sectors in the economy by considering both their inflows and outflows, in terms of size and dispersion.

We believe that these measures presented here demonstrate how this analytical approach can aid in creating effective, evidence-based public policies that maximize the economic benefits of tourism.

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APPENDIX A

FIELD OF INFLUENCE

The field of influence approach shows how variations in direct coefficients are distributed across the economy, enabling the establishment of the most important relationships between sectors. Additionally, the methodology demonstrated a strong association with the previous one, such that the main linkage ties coincided with the highest linkage indices.

Define E=[ϵij]E=[ϵij] as the matrix of incremental variations in direct input coefficients. Therefore, the corresponding Leontief inverse matrix will be given by: $B(\epsilon) = [I - A - \epsilon]^{-1} = b_{ij}(\epsilon)$. If the variation is small and occurs only in one direct coefficient, that is, $\varepsilon_{ij} = \begin{cases} \varepsilon > 0, & if \quad i = i_1 \; and \; j = j_1 \\ 0 & if \quad i \neq i_1 \; or \; j \neq j_1 \end{cases}$, than the influence field of this variation can be approximated by: $F(\epsilon_{ij}) = \frac{[B(\epsilon_{ij}) - B]}{\epsilon_{ij}}$, in which $F(\epsilon_{ij})$ is a square matrix representing the influence field of the coefficient a_{ij}. To determine the coefficients with the largest influence fields, it is necessary to associate a value with each matrix $F(\epsilon_{ij})$, given by: $S_{ij} = \sum_{k=1}^{n} \sum_{l=1}^{n} [f_{kl}(\epsilon_{ij})]^2$, in which S_{ij} represents the value associated with the matrix $F(\epsilon_{ij})$.

As a result, for each technical coefficient $a_{ij} \in A$, there will be an associated value S_{ij}. Therefore, the direct coefficients with the highest S_{ij} values will be those with the largest influence fields in the economy, representing the most significant linkage ties in the economic system.

TABLE A.1
Field of influence matrix

Sectors		F30	F7	F3	F11	F4	F20	F17	F12	F24	F15	F26	F5	F8	F6	F13	F16	F14	F28	F27	F2	F1	F25	F19	F18	F21	F29	F23	F22	F31	F9	F10	F32	
Trade and repair of motor vehicles and motorcycles	F1	5,60	5,60	5,41	5,16	5,10	5,10	4,98	4,89	4,71	4,68	4,64	4,63	4,57	4,53	4,49	4,46	4,46	4,40	4,39	4,34	4,32	4,28	4,27	4,17	4,14	4,03	4,01	4,00	3,97	3,89	3,60	3,33	
Professional, scientific and technical activities, administrative and support services	F2	4,06	4,06	3,92	3,74	3,70	3,70	3,62	3,55	3,42	3,40	3,37	3,36	3,31	3,29	3,26	3,23	3,23	3,20	3,19	3,15	3,14	3,10	3,10	3,02	3,00	2,93	2,91	2,90	2,88	2,82	2,61	2,41	
Electricity and gas, water, sewage, waste management activities and decontamination	F3	3,45	3,45	3,33	3,18	3,14	3,14	3,07	3,01	2,90	2,89	2,86	2,85	2,81	2,79	2,77	2,75	2,75	2,71	2,71	2,67	2,66	2,64	2,63	2,57	2,55	2,49	2,47	2,46	2,45	2,39	2,22	2,05	
Financial activities, insurance and related services	F4	3,43	3,42	3,31	3,16	3,12	3,12	3,05	2,99	2,88	2,87	2,84	2,83	2,79	2,77	2,75	2,73	2,73	2,70	2,69	2,65	2,65	2,62	2,61	2,55	2,53	2,47	2,46	2,45	2,43	2,38	2,20	2,04	
Transportation, storage and mail	F5	3,39	3,39	3,27	3,12	3,09	3,09	3,02	2,96	2,85	2,84	2,81	2,80	2,77	2,74	2,72	2,70	2,70	2,67	2,66	2,63	2,62	2,59	2,59	2,52	2,51	2,44	2,43	2,42	2,41	2,35	2,18	2,01	
Tourism	F6	2,88	2,88	2,78	2,65	2,62	2,62	2,56	2,51	2,42	2,41	2,39	2,38	2,35	2,33	2,31	2,29	2,29	2,26	2,26	2,23	2,22	2,20	2,19	2,14	2,13	2,07	2,06	2,05	2,04	2,00	1,85	1,71	
Information and communication	F7	2,70	2,70	2,61	2,49	2,46	2,46	2,41	2,36	2,27	2,26	2,24	2,23	2,20	2,19	2,17	2,15	2,15	2,13	2,12	2,09	2,09	2,06	2,06	2,01	2,00	1,95	1,94	1,93	1,92	1,87	1,74	1,61	
Extractive industries	F8	2,44	2,43	2,35	2,24	2,22	2,22	2,17	2,13	2,05	2,04	2,02	2,01	1,99	1,97	1,95	1,94	1,94	1,92	1,91	1,89	1,88	1,86	1,86	1,81	1,80	1,75	1,75	1,74	1,73	1,69	1,57	1,45	Buyers
Agriculture	F9	2,24	2,24	2,16	2,06	2,04	2,04	1,99	1,96	1,89	1,87	1,86	1,85	1,83	1,81	1,80	1,78	1,78	1,76	1,76	1,73	1,73	1,71	1,71	1,67	1,66	1,61	1,61	1,60	1,59	1,55	1,44	1,33	
Real estate activities	F10	2,23	2,23	2,16	2,06	2,03	2,03	1,99	1,95	1,88	1,87	1,85	1,85	1,82	1,81	1,79	1,78	1,78	1,76	1,75	1,73	1,72	1,71	1,70	1,66	1,65	1,61	1,60	1,59	1,58	1,55	1,44	1,33	
Manufacture of food products	F11	2,04	2,04	1,97	1,88	1,86	1,86	1,82	1,78	1,72	1,71	1,69	1,69	1,67	1,65	1,64	1,63	1,63	1,61	1,60	1,58	1,58	1,56	1,56	1,52	1,51	1,47	1,46	1,46	1,45	1,42	1,31	1,21	
Metallurgy	F12	2,01	2,01	1,94	1,85	1,83	1,83	1,79	1,75	1,69	1,68	1,66	1,66	1,64	1,62	1,61	1,60	1,60	1,58	1,57	1,55	1,55	1,53	1,53	1,49	1,48	1,45	1,44	1,43	1,42	1,39	1,29	1,19	
Construction	F13	2,00	2,00	1,93	1,84	1,82	1,82	1,78	1,75	1,68	1,67	1,66	1,65	1,63	1,62	1,60	1,59	1,59	1,57	1,57	1,55	1,54	1,53	1,52	1,49	1,48	1,44	1,43	1,43	1,42	1,39	1,29	1,19	
Manufacture of wood products, except furniture, cellulose, paper and paper products and printing services and reproduction of recordings	F14	1,98	1,98	1,92	1,83	1,81	1,81	1,77	1,73	1,67	1,66	1,64	1,64	1,62	1,61	1,59	1,58	1,58	1,56	1,56	1,54	1,53	1,52	1,51	1,48	1,47	1,43	1,42	1,42	1,41	1,38	1,28	1,18	
Manufacture of non-metallic mineral products	F15	1,97	1,97	1,90	1,81	1,79	1,79	1,75	1,72	1,66	1,65	1,63	1,63	1,61	1,59	1,58	1,57	1,57	1,55	1,55	1,53	1,52	1,51	1,50	1,47	1,46	1,42	1,41	1,41	1,40	1,37	1,27	1,17	
Manufacture of chemical products	F16	1,97	1,97	1,90	1,81	1,79	1,79	1,75	1,72	1,66	1,65	1,63	1,63	1,61	1,59	1,58	1,57	1,57	1,55	1,55	1,52	1,52	1,50	1,50	1,47	1,46	1,42	1,41	1,41	1,40	1,37	1,27	1,17	
Beverage manufacturing	F17	1,94	1,93	1,87	1,78	1,76	1,76	1,72	1,69	1,63	1,62	1,60	1,60	1,58	1,57	1,55	1,54	1,54	1,52	1,52	1,50	1,49	1,48	1,48	1,44	1,43	1,39	1,39	1,38	1,37	1,34	1,24	1,15	
		Sellers																																

(Continues)

(Continued)

Sectors		F30	F7	F3	F11	F4	F20	F17	F12	F24	F15	F26	F5	F8	F6	F13	F16	F14	F28	F27	F2	F1	F25	F19	F18	F21	F29	F23	F22	F31	F9	F10	F32
Public administration, defense, public education and health, and social security	F18	1,89	1,89	1,82	1,74	1,72	1,72	1,68	1,65	1,59	1,58	1,56	1,56	1,54	1,53	1,51	1,50	1,50	1,48	1,48	1,46	1,46	1,44	1,44	1,40	1,39	1,36	1,35	1,35	1,34	1,31	1,21	1,12
Manufacture of textiles, apparel, footwear and leather goods	F19	1,84	1,84	1,78	1,70	1,68	1,68	1,64	1,61	1,55	1,54	1,53	1,52	1,50	1,49	1,48	1,47	1,47	1,45	1,45	1,43	1,42	1,41	1,41	1,37	1,36	1,33	1,32	1,32	1,31	1,28	1,19	1,09
Arts, culture, sport and recreation and other service activities	F20	1,84	1,84	1,77	1,69	1,67	1,67	1,64	1,61	1,55	1,54	1,52	1,52	1,50	1,49	1,47	1,46	1,46	1,45	1,44	1,42	1,42	1,40	1,40	1,37	1,36	1,32	1,32	1,31	1,30	1,27	1,18	1,09
Manufacture of rubber and plastic products	F21	1,83	1,82	1,76	1,68	1,66	1,66	1,62	1,59	1,54	1,53	1,51	1,51	1,49	1,48	1,46	1,45	1,45	1,44	1,43	1,41	1,41	1,39	1,39	1,36	1,35	1,32	1,31	1,30	1,30	1,27	1,17	1,08
Manufacture of metal products, except machinery and equipment	F22	1,81	1,81	1,75	1,67	1,65	1,65	1,61	1,58	1,53	1,52	1,50	1,50	1,48	1,47	1,45	1,44	1,44	1,43	1,42	1,40	1,40	1,38	1,38	1,35	1,34	1,31	1,30	1,29	1,29	1,26	1,17	1,08
Maintenance, repair and installation of machinery and equipment	F23	1,81	1,81	1,75	1,67	1,65	1,65	1,61	1,58	1,52	1,51	1,50	1,50	1,47	1,46	1,45	1,44	1,44	1,42	1,42	1,40	1,40	1,38	1,38	1,35	1,34	1,30	1,30	1,29	1,28	1,25	1,16	1,07
Food services	F24	1,81	1,80	1,74	1,66	1,64	1,64	1,61	1,58	1,52	1,51	1,50	1,49	1,47	1,46	1,45	1,44	1,44	1,42	1,42	1,40	1,39	1,38	1,38	1,34	1,33	1,30	1,29	1,29	1,28	1,25	1,16	1,07
Private education and health	F25	1,78	1,78	1,72	1,64	1,62	1,62	1,59	1,56	1,50	1,49	1,48	1,48	1,45	1,44	1,43	1,42	1,42	1,40	1,40	1,38	1,38	1,36	1,36	1,33	1,32	1,29	1,28	1,27	1,27	1,24	1,15	1,06
Manufacture of motor vehicles, trailers and bodies and other transport equipment	F26	1,75	1,75	1,69	1,61	1,59	1,59	1,56	1,53	1,47	1,46	1,45	1,45	1,43	1,42	1,40	1,39	1,39	1,38	1,37	1,35	1,35	1,34	1,33	1,30	1,29	1,26	1,25	1,25	1,24	1,21	1,13	1,04
Manufacture of computer, electronic and optical products, electrical equipment, machinery, and apparatus	F27	1,75	1,75	1,69	1,61	1,59	1,59	1,56	1,53	1,47	1,46	1,45	1,45	1,43	1,42	1,40	1,39	1,39	1,38	1,37	1,35	1,35	1,34	1,33	1,30	1,29	1,26	1,25	1,25	1,24	1,21	1,13	1,04
Manufacture of pharmaceutical and pharmaceutical products	F28	1,73	1,72	1,67	1,59	1,57	1,57	1,54	1,51	1,45	1,44	1,43	1,43	1,41	1,40	1,39	1,37	1,37	1,36	1,35	1,34	1,33	1,32	1,32	1,28	1,28	1,24	1,24	1,23	1,22	1,20	1,11	1,03
Manufacture of machinery and equipment	F29	1,71	1,71	1,65	1,57	1,55	1,55	1,52	1,49	1,44	1,43	1,42	1,41	1,39	1,38	1,37	1,36	1,36	1,34	1,34	1,32	1,32	1,31	1,30	1,27	1,26	1,23	1,22	1,22	1,21	1,19	1,10	1,01
Refining of petroleum and coke and alcohol and other biofuels	F30	1,71	1,70	1,65	1,57	1,55	1,55	1,52	1,49	1,44	1,43	1,41	1,41	1,39	1,38	1,37	1,36	1,36	1,34	1,34	1,32	1,32	1,30	1,30	1,27	1,26	1,23	1,22	1,22	1,21	1,18	1,10	1,01
Other industrial activities	F31	1,69	1,69	1,63	1,56	1,54	1,54	1,51	1,48	1,43	1,42	1,40	1,40	1,38	1,37	1,36	1,35	1,35	1,33	1,33	1,31	1,31	1,29	1,29	1,26	1,25	1,22	1,21	1,21	1,20	1,17	1,09	1,01
Domestic services	F32	1,68	1,68	1,63	1,55	1,53	1,53	1,50	1,47	1,42	1,41	1,40	1,39	1,37	1,36	1,35	1,34	1,34	1,32	1,32	1,30	1,30	1,29	1,28	1,25	1,24	1,21	1,21	1,20	1,19	1,17	1,08	1,00

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