# Heritage Tourism and Economic Development:

## An Input-Output Analysis for Minas Gerais, Brazil

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**Abstract**

Considered one of the first Brazilian architectonic and cultural movements, the baroque style of Minas Gerais is a fundamental piece of the Brazilian identity. After efforts to value and promote it, the style has become one of the main Brazilian touristic products, symbolized by UNESCO's classification of sites in the cities of Ouro Preto, Congonhas, and Diamantina as World Cultural Heritage. Thus, tourism in baroque regions in Minas Gerais is nowadays an important part of the local economies. This article proposes to analyze the importance of tourism characteristic activities (TCAs) in these regions. To do so, we used the Brazilian 2018 I-O table and employment and export data to build a regionalized I-O for these regions under the Interregional Input Output Adjustment System (IIOAS) framework. This allows us to analyze the impacts of a hypothetical extraction of the TCAs through both interregional and intraregional lenses. Our results showed that the TCAs have a variable weight in local economies, ranging from 0.75 percent to 65 percent of the cities' Gross Value of Added (GVA) and averaging at 10 percent. Comparing the impacts of a simultaneous extraction with those of local extractions region by region, it was possible to identify as well that tourism activities have a relatively bigger impact on the local economies rather than on a regional scale, which points out to a modest interdependence in the supply chain of the baroque cities' touristic sector. In addition to providing an analysis of the tourism industry in the local economy of Minas Gerais which can further aid policy making, we also contribute to the literature by creating a novel regionalized setting with hypothetical extraction of a cross-sector industry, which was possible by estimating TCAs' shares in the I-O matrix sectors.

**Keywords**: Brazil, input-output matrix, tourism economy.

**JEL Codes**: R15, R12, Z32.

# 1 Introduction

According to the United Nations World Tourism Organization 2019 Report, the tourism sector was responsible for 7 percent of global exports in 2018 and ranked as world's third largest export category in 2017, reflecting an upward trend in the last decade driven by economic growth worldwide. However, tourism is an important industry not just for its gross figures, but also as a means for economic development, entrepreneurship, and trade diversification (UNWTO 2019). In the economic literature, the role of tourism gave rise to the tourism-led growth hypothesis (TGLH), proposed by Balaguer and Cantavella-Jordá (2002), which proposes that developing an economy's tourism industry fosters economic growth and, as a consequence, economic development through spillover effects. While many economic activities can be categorized in one specific sector, this is not the case of the tourism industry: According to Lopes (1990), tourism links different industries in its value chain, which further promotes welfare gains through income and employment stimuli. In Brazil, tourism characteristic activities (TCAs) are spread in nine groups: Transport, accommodation, food services, goods and real estate rental, travel agencies, arts, culture, sports, and recreation (FJP 2017).

In Brazil, the average individual expenses with travel in 2021 was of R$[1] 1,292 with accommodation, R$ 501 with food, and R$ 442 with transportation. In the same year, the Southeast was the most visited region in the country, responsible for 40.9 percent percent of tourists received (domestic and international), followed by the Northeast (28.2 percent), the South (17.3 percent), the Center-West (7 percent) and the North (6.6 percent). While these numbers are roughly similar to each region's share of Brazilian population, Southeastern states also received most of the interstate visitors flow: São Paulo alone represented 20.6%, while Minas Gerais (both states in the Southwest) accounted for 11.4% (Ministry of Tourism 2021).

According to the Minas Gerais Tourism Observatory (Gerais 2022), the value added of TCAs in the state had a real growth of roughly 106.5 percent from 2010 to 2019, reaching R$ 22.3 billion in that year, while sales went from R$ 305.2 billion to R$ 571.5 billion (87.3 percent growth). These figures, however, do not reflect exclusively the tourism industry, but the integrity of the tourism characteristic activities. In fact, one of the greatest challenges of studying tourism economy is the difficulty to distinguish between tourist and non-tourist expenses in some activities (such as food services), as we discuss further along this paper.

The state of Minas Gerais is home to a wide range of touristic attractions: from natural landscapes, as the Grande Sertão Veredas National Park, to the high-end gastronomy and the cultural scene of the state capital, Belo Horizonte. However, historical cities are the biggest mark of the state's tourism: in the state's last tourism demand research, 45.3 percent of the respondants cited as the main reason of their trip "Visiting places and festivals of great historical and cultural value" (Gerais 2017)[2].

In part, this is the result of a process of recovering the 18th century heritage to forge a national identity. This movement began in the late 19th century but intensified with the modernist movement in the first half of the 20th century (Portes 2014). During the 17th century, the state went under a rapid colonization process in

[1] Brazilian Reais average exchange rate in 2021 (R$/US$): 5.3950 (IPEA 2023)

[2] The survey interviewed more than 8 thousand tourists in 84 municipalities of the state in 2021.

search of gold and other minerals. They were characterized by a local version of the baroque style, mixing local materials and characteristics to the style imported from Portugal. According to Pinto (2006), this style is marked especially by sacred (catholic) art, such as churches, chapels, sanctuaries, and oratories. Unesco (2019) recognizes Minas Gerais' baroque as a World Cultural Heritage. From the 16 sites recognized by the organization in Brazil, four are in Minas Gerais and three of them are linked to baroque: the Historical Town of Ouro Preto, the Senhor de Bom Jesus de Matosionhos Sanctuary in Congonhas, and Diamantina's Historical Downtown. To this day, many buildings and landmarks from that time are still preserved, most of them in 12 towns: Barão de Cocais, Catas Altas, Caeté, Congonhas, Diamantina, Mariana, Ouro Preto, Sabará, Santa Bárbara, São João del Rei, Serro, and Tiradentes.

Currently, the state government develops a series of efforts to promote local tourism. One of them was the creation of *Observatório do Turismo*, a dashboard with data monitoring and periodic reports on the tourism economy of the state (Gerais 2022). However, despite its cultural importance and these efforts, there is still a lack of understanding with respect to the dimension of the tourism sector in the economy of Minas Gerais — especially in the baroque cities, one of its main touristic attractions. In this paper, we use the Input-Output approach to analyze the relevance of the tourism characteristic activities in the value chain and as a means of generating output, employment, and income, from both state and local perspectives. We do so using the Interregional Input-Output Adjustment System (IIOAS) framework, a methodology to disaggregate I-O tables for subnational entities in the absence of local-level data (Eduardo Amaral Haddad, Gonçalves Júnior, and Nascimento 2017). Our interregional matrix is divided in 20 sectors and 15 regions, encompassing the 12 baroque cities, the state capital, the rest of the state, and the rest of Brazil. One of the main advantages of a regional I-O framework is its ability to identify structural relationships between sectors an regions of an economy: this can be a powerful tool for policy making, by showing how each sector can respond to investment stimuli.

This allowed us to calculate local backward, forward, and total linkages for the 20 sectors, with special attention to the TCAs, and identifying each region's key sectors. We found that transportation is the only TCA that is a key sector in Minas Gerais, while real estate and administrative activities, which are also TCAs, are also key sectors in the rest of Brazil. Finally, we performed hypothetical extraction simulations of the TCAs, both in intermediate consumption and final demand. Thirteen scenarios were constructed: the impact of a simultaneous extraction of the TCAs in the twelve regions and other 12 simulations specific to each town. This allows us to analyze the impact of TCAs in both an interregional aspect — how well the sectors are integrated across regions — and an intraregional one, i.e., the relative importance of TCAs in local economies.

In economic literature, the I-O framework is widely used to analyze the impact of the tourism industry. Surugiu (2009) analyzed the impact of tourism (identified as the sector of Hotels and Restaurants) in the economic growth of Romenia between 2000 and 2005. While the sector's output and employment multipliers have increased, value added and earnings multipliers were smaller in 2005 than in 2000. Forward linkages were also calculated, indicating a very low dependency on the rest of the economy. Latiff, Mohd, and Daud (2020) examined the relationship between tourism and other industries in Malaysia, using the country's tourism satellite account (TSA), with focus in the New Key Economic Area (NKEA). The conclusion pointed that while growth in the tourism industry mostly benefits non-NKEA industries, it is an important source of economic growth in the country. West and Gamage (2001) partially relaxed the linearity assumption, frequently imposed in I-O studies, to analyze the tourism industry in Victoria, Australia, distinguishing between types of tourists: day-trippers, interstate, intrastate, and international visitors. Abuamoud, Ibrahim, and Hijawi (2019) investigated the economical impacts of the tourism sector in North Jordania in 2017, estimating revenue generation from economic sectors related to tourism from a survey conducted by the authors with visitors in the study area. Atan and Arslanturk (2012) analyzed Turkey's I-O table to identify if tourism's interactions with other industries could increase national economic growth. The authors found that no activity related to tourism can be considered a key sector, however, backward linkages were high for travel agencies, supporting and auxiliary transport services, restaurant, and hotels. Li et al. (2019) focused on Beijing's tourism impact relative to other sectors with respect to emissions, for which they used the region's I-O table and TSA. The authors found that indirect impacts are more responsible than direct impacts in generating $CO_2$ emissions. Especially, Transportation accounted for 91.65% of tourism income in 2012 and 38.75% of its emissions in the same year. Khanal, Gan, and Becken (2014) studied the relative importance of tourism in Laos between 2003 and 2008. The authors captured part of the country's transition from a period of high reliance in agriculture an industry to other where services played a major role: this benefited the tourism related sectors, which were amongst those with highest increase both in monetary figures and linkage measures.

In Brazil, several studies have also studied tourism economics through I-O analysis. Camargo et al. (2008) disaggregated tourism between transportation, food services, accommodation, and leisure to analyze these sector's impact in income and employment generated in 2004. From a regional point of view, Souza, Guilhoto, and Neto (2016) examined the economic performance of income and employment of tourism sector in the Northeast region, analyzing its intersectorial relationships for 2009. Carvalho (2008) investigated the impacts of Portuguese tourists in the state of Pernambuco, observing average expenditures of non-residents and its distributions between the state's subsectores. Eduardo (2022) constructed an I-O table to analyze TCAs in Campo Grande, capital of Mato Grosso do Sul, highlighting the ecotourism as the main sustainable activity. Penna et al. (2022) used the state of Ceará's I-O table and TSA and found that the tourism industry has a high potential in the local economy due to its elevated output and wage multipliers.

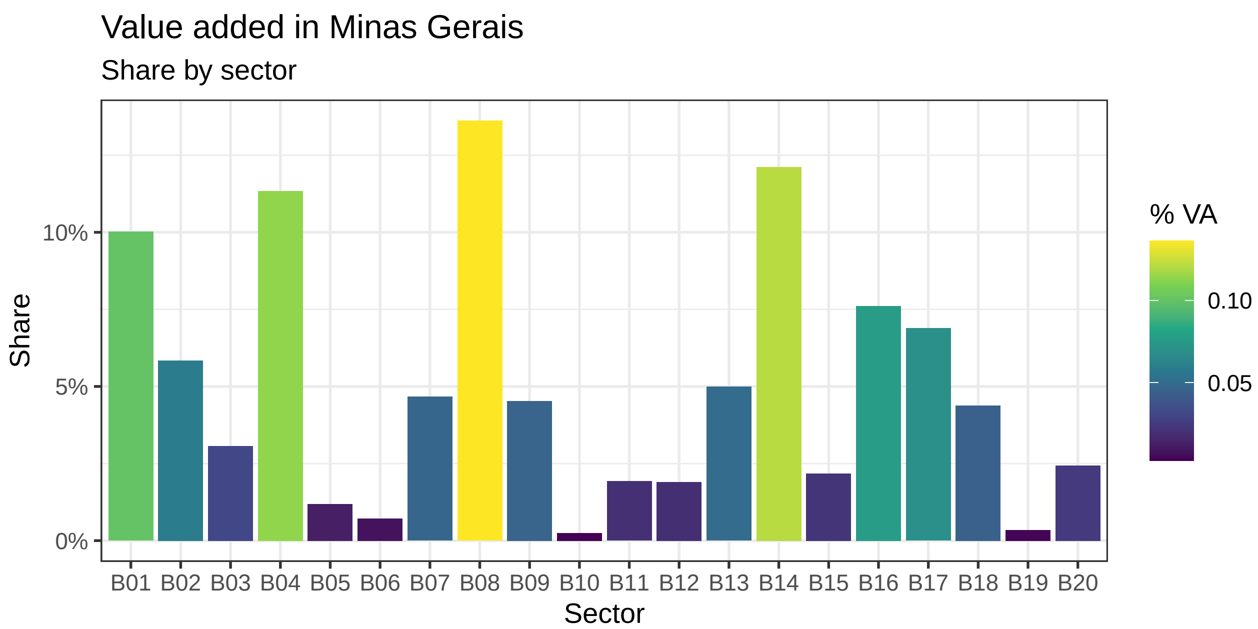
The remainder of this paper is structured as follows: Section 2 provides background information about the local economy, Section 3 explains the methodology and data adopted, Section 4 contains the results, and Section 5 concludes the work with final remarks.

# 2 Background

## 2.1 The State of Minas Gerais

With 585.5 milion square kilometers, 21.4 million inhabitants in 2021, and a GDP of R$ 682.8 billion in 2020, Minas Gerais is the 5th largest state of Brazil, the second most populous, and has the third biggest GDP (IBGE 2023, 2022b). As we can see in Figure 1, the state has a diversified economy, however, sectors B01 (Agriculture, forestry, and fishing), B04 (Other manufacturing), B08 (Wholesale and retail trade), and B14 (Real estate activities) alone accounted for 47 percent of the value added in 2018. Historically, the state has been highly dependent on agriculture and mining industries. Nowadays, however, retail and services (roughly defined by sectors B08 to B20) have a relatively higher importance, being responsible for more than 63% of the value added in 2018.

Figure 1: Value Added in Minas Gerais in 2018 across I-O table sectors.




## 2.2 The Baroque Circuit

The 12 municipalities marked by the baroque style are mostly clustered in the central region of the state, where gold extraction was concentrated in the 18th and 19th centuries. As a policy to promote local tourism, the state government has created several touristic routes that remount the historical Estrada Real, the roads used during colonial times to export gold, diamond, and other products to Portugal. Serro and Dimantina are part are part of *Caminho dos Diamantes* (Diamonds Route), while Barão de Cocais, Caeté, Catas Altas, and Sabará are on *Caminho do Sabarabuçu*, and Tiradentes and São João del Rei are on *Caminho Velho*, the old route to reach the Port of Paraty in the state of Rio de Janeiro (Real 2022). Figure 2 shows the baroque cities in blue and Belo Horizonte in grey for reference.

As Table 1 shows, there is a diversity in terms of population, output, and municipal human development index

Figure 2: Map of the Baroque cities in the state of Minas Gerais, Brazil.


(HDI-M) across the cities in the baroque circuit. For instance, Sabará and Caeté are part of the Belo Horizonte Metropolitan Region (BHMR), with a great part of their working population (especially in Sabará) commuting every day to work in the capital.

Table 1: Descriptive data for the baroque regions, the state capital, and the rest of Minas Gerais[3].

| Code | Region | Population | % MG | GVA (R$M) | % MG | HDI-M |
|---|---|---|---|---|---|---|
| R01 | Belo Horizonte | 2,530,701 | 11.82% | 71,892 | 12.69% | 0.810 |
| R02 | Barão de Cocais | 33,232 | 0.16% | 723 | 0.13% | 0.722 |
| R03 | Caeté | 45,364 | 0.21% | 575 | 0.10% | 0.728 |
| R04 | Catas Altas | 5,465 | 0.03% | 501 | 0.09% | 0.684 |
| R05 | Congonhas | 55,863 | 0.26% | 2,281 | 0.40% | 0.753 |
| R06 | Diamantina | 47,924 | 0.22% | 686 | 0.12% | 0.716 |
| R07 | Mariana | 61,830 | 0.29% | 3,832 | 0.68% | 0.742 |
| R08 | Ouro Preto | 74,824 | 0.35% | 5,978 | 1.05% | 0.741 |
| R09 | Sabará | 137,877 | 0.64% | 2,947 | 0.52% | 0.731 |
| R10 | Santa Bárbara | 31,873 | 0.15% | 1,159 | 0.20% | 0.707 |
| R11 | São João del Rei | 90,897 | 0.42% | 1,951 | 0.34% | 0.758 |
| R12 | Serro | 20,915 | 0.10% | 192 | 0.03% | 0.656 |
| R13 | Tiradentes | 8,160 | 0.04% | 118 | 0.02% | 0.740 |
| R14 | Rest of MG | 18,267,025 | 85.31% | 473,863 | 83.62% | 0.667 |

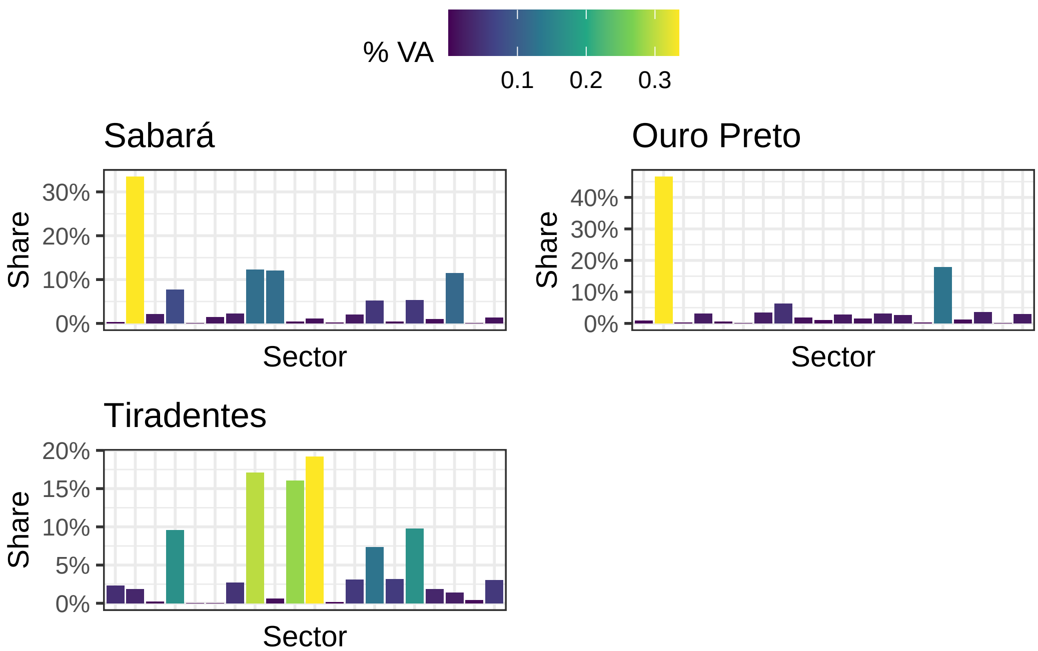
The productive structure also varies between the baroque cities. One useful example is to compare three very different cities: Sabará, Ouro Preto, and Tiradentes. Although the three of them have many baroque characteristic buildings and landmarks, Sabará is not particularly known as a touristic destination, while Ouro Preto and Tiradentes are the two most famous touristic products in Minas Gerais. But how does that reflect on each city's gross value added (GVA) composition?

Sabará, the biggest of them, shows a high dependency on Extractive industries ($B02$), accounting for more than 30 percent of the city's GVA in 2018, while sectors $B08$ (Wholesale and retail trade), $B09$ (Transportation and related services), and $B18$ (Human health and social work) account for an additional 36 percent. While this shows that the historical dependency on mining exports persists, service-related activities are already a vital part of the city's economy.

Ouro Preto — the former capital of Minas Gerais (until 1897) and the core of gold mining in the 17th century — has an even higher reliability on extractive industries: they represented more than 40 percent of its GVA in 2018, while the second most important sector, public administration ($B16$), was responsible for less than half of it (17.90 percent). Together, tourism characteristic activities (as described further in Table 2) are responsible for 19.26 percent of Sabará's GVA (mostly due to transportation), but only 8.50 percent in the case of Ouro Preto.

Finally, Tiradentes' GVA composition is significantly different from the two previous cities. The extractive industry accounts for less than two percent of the city's value added, while TCAs altogether are responsible for 46.86 percent of it — 35 percent in the food services and accommodation sectors alone, indicating that the tourism industry plays a major role in the city's economy. Albeit a very smaller city both in population and output, this also reflects Tiradentes' position as a consolidated tourism destination.

Figure 3: Value added in Sabará, Ouro Preto, and Tiradentes across the I-O table's 20 sectors.




[3] Population estimatives for 2021 (IBGE 2022a), GVA for 2018 obtained from the I-O table, and 2010 municipal HDI data gathered from Brasil (2022).

# 3 Methodology and Data

The input-output matrices are static representations of the economy that allows one to observe the intersectorial relationships of the economy (Miller and Blair 2009), through the direct and indirect connections of its value chain. Despite being a photograph of specific moments, these matrices reveal basic structural relationships from the co-variations in price, production, investment, and income (Guilhoto 2011).

This framework is highly valuable in the light of our goal, as it allows us to go beyond a simple analysis of the TCAs' weight on the local economies and grasp how these industries are related to the other sectors from the local, state, and national point of views, through different metrics such as linkage indexes and hypothetical extraction.

The remainder of this section explains the interregional Input-Output setting (3.1), the different metrics adopted (3.2 and 3.3), and the simulation procedure (3.5).

## 3.1 Input-Output Framework

We follow Eduardo Amaral Haddad, Gonçalves Júnior, and Nascimento (2017) and use the Interregional Input-Output Adjustment System (IIOAS), disaggregating the Brazilian I-O Matrix in 15 regions: the 12 touristic municipalities ($R02$-$R13$), the state capital ($R01$), the rest of the state ($R14$), and the remainder of Brazil, subtracting Minas Gerais (14). While constructing a tourism satellite account (TSA) would be desirable, the level of information provided is not enough to do so. Moreover, even if we had access to a TSA for Minas Gerais, an aggregate-level satellite account would not allow us to analyze separately the tourism activity in the baroque circuit; hence, the IIOAS approach is a great alternative to analyze in detail the regions of interest.

Because there is no information on exactly how much of each good is consumed per region, we begin by constructing trade matrices for each industry between all regions. To do so, we assume that production and utility functions are homogeneous everywhere, such that industry $i$ would take the same level and type of inputs to produce a given output either in region $j$ or $k$ and the average household demands the same goods in both regions. While an approximation, this procedure is consistent with available data for the national level. A growing number of recent studies are adopting this approach with success, such as in E. Haddad (2014) for a trade analysis in Lebanon, as part of a CGE model for Egypt (Eduardo Amaral Haddad et al. 2016) and Morocco (Eduardo Amaral Haddad, Hattab, and Ali 2017), Eduardo A. Haddad, Araújo, and Perobelli (2020) to analyze the I-O structure of urban concentrations in Brazil, McCord and Rodriguez-Heredia (2022) for regional GDP in Paraguay, Seibert and Perobelli (2022) in the Brazilian Center-West agribusiness, Sanguinet, Azzoni, and Alvim (2022) for emissions in Latin America, and SUDAM (2022) for an I-O table of the Legal Amazon in Brazil.

From the supply side, let $DOMSUP$ be the domestic supply, $TOTSUP$ the total supply, and $EXP$ the exports, such that $TOTSUP := DOMSUP + EXP$. Using exports data available for each region and product, we can accurately allocate aggregate exports. Then, we use labor data to distribute domestic supply data between regions. For instance, if industry $k$ in region $i$ has 15% of that industry's laborers, then it will receive 15% of domestic sales. In turn, export data are more easily identifiable and allocated between regions accorded to their official exports statistics by product. Hence, reconciliations are done assuming that $EXP$ is always correct, adjusting $DOMSUP$ to meet $TOTSUP$.

Departing from the canonical I-O framework (Miller and Blair 2009),

$$X := Z + F, \tag{1}$$

let $s = 20$ be the number of sectors, $r = 15$ the number of regions, and $n = s \cdot r$. Then, the IIOAS system is defined as

$$\begin{bmatrix} x_1^1 \\ x_2^1 \\ \vdots \\ x_s^r \end{bmatrix} = \begin{bmatrix} z_{11}^{11} & z_{12}^{11} & \cdots & z_{1s}^{1r} \\ z_{21}^{11} & z_{22}^{11} & \cdots & z_{2s}^{1r} \\ \vdots & \vdots & \ddots & \vdots \\ z_{s1}^{1r} & z_{s2}^{1r} & \cdots & z_{ss}^{rr} \end{bmatrix} + \begin{bmatrix} f_1^{1,C} & f_1^{1,G} & f_1^{1,GFCF} & f_1^{1,\Delta S} & f_1^{1,EXP} \\ f_2^{1,C} & f_2^{1,G} & f_2^{1,GFCF} & f_2^{1,\Delta S} & f_2^{1,EXP} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ f_s^{r,C} & f_s^{r,G} & f_s^{r,GFCF} & f_s^{r,\Delta S} & f_s^{r,EXP} \end{bmatrix}, \tag{2}$$

where $x_k^h$ is region $h$'s total demand for sector $k$ and $z_{jk}^{hi}$ is the intermediate consumption of products from region $h$'s sector $j$ by region $i$'s sector $k$. Final demand vectors $f$ are divided (for each $r$ and $s$) between household consumption ($C$), government purchases ($G$), gross fixed capital formation ($GFCF$), stock variation ($\Delta S$), and exports ($EXP$).

## 3.2 Linkages

Rasmussen's (1956) and Hirschman's (1958) linkages are measures of the degree of dependency between sectors and regions: the backward linkage indicates how much a sector $k$ requires from other sectors and the forward linkage showing other industries' demand for $k$ in their production process.

The first step is to calculate the technical coefficients, which are each sector's intermediate consumption share of the final demand:

$$\begin{aligned} \hat{x}_k^i &:= 1/x_k^i \\ A &:= Z \cdot (\hat{X}) \therefore \\ Z &= AX \end{aligned} \tag{3}$$

Then, Equation 1 can be rewritten as

$$\begin{aligned} X &= AX + F \therefore \\ X &= LF, \end{aligned} \tag{4}$$

where $L := (I - A)^{-1}$ is Leontief's inverse matrix.

Simply put, sector $k$'s backward linkage is the average of the entries in $L$'s $k^{th}$ column divided by the average of the whole matrix (across rows and columns):

$$BL_k := \frac{n^{-1}\sum_{j=1}^{s} l_{jk}}{L^*}, \tag{5}$$

where

$$L^* := \frac{\sum_{j=1}^{s}\sum_{k=1}^{s} l_{jk}}{n^2}. \tag{6}$$

In the regional setup, however, one can calculate not only the aggregate linkage measures, but also between regions (inter) and within regions (intra). For instance, if there are two sectors ($A$ and $B$) and two regions (1 and 2):

$$L = \begin{bmatrix} L^{11} & L^{12} \\ L^{21} & L^{22} \end{bmatrix} = \begin{bmatrix} l_{AA}^{11} & l_{AB}^{11} & l_{AA}^{12} & l_{AB}^{12} \\ l_{BA}^{11} & l_{BB}^{11} & l_{BA}^{12} & l_{BB}^{12} \\ l_{AA}^{21} & l_{AB}^{21} & l_{AA}^{22} & l_{AB}^{22} \\ l_{BA}^{21} & l_{BB}^{21} & l_{BA}^{22} & l_{BB}^{22} \end{bmatrix}. \tag{7}$$

Thus, sector $A$'s aggregate measure, $BL_A^{agg}$, is calculated by averaging the first and third columns and dividing by the overall average. In contrast, the intraregional measure for the same sector in region 1 would be

$$BL_A^{intra,1} = \frac{2^{-1}(l_{AA}^{11} + l_{BA}^{11})}{2^{-2}\sum_{j=1}^{2}\sum_{k=1}^{2} l_{jk}^{11}}. \tag{8}$$

The same logic applies for other sectors and regions. As for the forward linkages (FL), we simply do the same operations on the rows instead of the columns.

When $BL_k > 1$, sector $k$ is more dependent on other sectors than the rest of the economy; if $FL_k > 1$, then the other industries are highly dependent on $k$. In other words, the first case states that an unitary demand increase in industry $k$ elevates other industries' final demand by more than that, while the second shows that an unitary increase in the overall demand increases industry $k$'s demand by more than one. If both backward and forward measures are greater than one, then $k$ is considered a key industry. In this paper, we focus on the intraregional linkages to analyze each city's context.

## 3.3 Hypothetical Extraction

By simulating a sudden removal of an industry from the economy, the Hypothetical Extraction Method (HEM) provides a measure of that industry's importance to the economy as a whole and to each sector. For instance, it is expected that the hypothetical extraction of a key sector would have a high impact on the rest of the economy, as their supply chains are deeply connected (Miller and Blair 2009).

As stated by Miller and Lahr (2001) and Miller and Blair (2009), there are several hypothetical extraction procedures. To put simply, let

$$A = \begin{bmatrix} A_{11} & A_{12} \\ A_{21} & A_{22} \end{bmatrix}$$

be the technical coefficients matrix in an aggregated setting with two industries. Then, one possibility is to extract only $A_{11}$ and $A_{21}$, as if sector 1 remained only as a supplier to industry 2. In this paper, however, we simulate the scenario in which touristic activities cease to exist: therefore, we perform the total extraction by removing all entries related to them (in the example above, all submatrices but $A_{22}$), replacing them with zeroes.

In addition, not only technical coefficients but also final demand components should be extracted. This simulation is adherent to a scenario in which suddenly there were no more tourists in a region — as happened in practice during the most severe months of the Covid-19 pandemic in Minas Gerais. In contrast, if final demand was not removed, we would be implicitly assuming that economical agents would be importing their consumption (Miller and Lahr 2001; Dietzenbacher, Van Burken, and Kondo 2019), which is not only a different situation, but also implausible in face of non-tradeable services[4].

### 3.3.1 HEM under IIOAS

In regional systems, HEM can also be separated between local and global effects. We do so via fifteen different simulations. In the global one, the tourism-related activities are extracted simultaneously in all regions: this provides a big-picture examination of what would happen if there was no tourist activity at all in the baroque circuit. The remaining are region-specific simulations, one by one. By doing so, we can compare region $i$'s extraction impacts not just in the economy as a whole, but also in $i$'s economy and all other regions individually. This is of special interest in this work, as it allows us to identify if the touristic activities are relatively more confined to the local economies or if there is any high regional interdependence.

### 3.3.2 Extraction coefficients

Finally, the very nature of the TCAs — spread through different sectors — requires a special treatment. While the conventional approach is to either eliminate the analyzed sector(s) entries or replace them with zeroes (as mentioned above), here we should apply a shock to each sector that contains a tourism-related business that is proportional to the tourism size in that sector's total trade. For instance, if 5% of a region's transport sector final demand is related to tourism (e.g. leisure bus and air travel), then a 5% diminish on its final demand is applied.

While it would be ideal to identify all tourism activities, this is not feasible with the available data. However, provided that our assumptions hold, extracting a fraction of sector $j$ from an I-O system with $r$ regions and $s$ sectors has the same effect of extracting 100 percent of sector $k$ of an I-O system with $s + 1$ industries. In addition, this is also a more conservative approach, which brings our simulation closer to reality than replacing a whole sector like Transportation with zeroes. The procedure is detailed in Section 3.5.

[4] While goods like appliances and garments can easily be traded between regions, some goods and especially services are non-tradeable, i.e., they can only be consumed where they are produced. This is the case of many tourism-related industries, such as restaurants and hotels. Therefore, if a city suddenly stops to receive tourists, its final demand in related sectors would go to zero, as they reflect the demand for these industries consumed in local businesses rather than goods consumed by their citizens everywhere

### 3.4 Data

To get regional data on the IIOAS framework described in Section 3.1, we departed from the Brazilian 2018 I-O Matrix with 68 sectors developed by NEREUS, the Regional and Urban Economics Lab of the University of São Paulo (USP) (Guilhoto 2021). While spatially disaggregating our data, we also collapse them from 68 to 20 sectors. This makes matrix operations computationally easier and does not imply in any loss, because the sectors of interest, that is, those related to tourism, remain as disaggregated as possible. The IIOAS intermediate consumption matrix ($Z$) has 15 regions and 20 regions, which results in a $300 \times 300$ matrix.

Table 2: Consolidated sectors in the I-O Table

| Code | Sector | TCA? |
|---|---|---|
| B01 | Agriculture, forestry, and fishing | |
| B02 | Extractive industries | |
| B03 | Food products and beverages | |
| B04 | Other manufacturing | |
| B05 | Electricity and gas | |
| B06 | Water supply, sewage, waste, and remediation services | |
| B07 | Construction | |
| B08 | Wholesale and retail trade | |
| B09 | Transportation and related services | Yes |
| B10 | Accommodation | Yes |
| B11 | Food Services | Yes |
| B12 | Information, Communication, IT and related services | |
| B13 | Finance and insurance activities | |
| B14 | Real estate activities | Yes |
| B15 | Administrative activities and additional services | Yes |
| B16 | Public Administration, defense, and social security | |
| B17 | Education | |
| B18 | Human health and social work | |
| B19 | Arts, Culture, Sports, and Recreation | Yes |
| B20 | Other service activities | |

Total domestic supply was estimated using data from the Brazilian Ministry of Labor, which requires every legal person to report how many employees they had in a given fiscal year (Brazil 2022b). Although we do not have access to the identified base, we do know the industry of each business according to their CNAE[5], the Brazilian classification of economical activities. International trade statistics are provided by Comex Stat, an

[5] *Cadastro Nacional de Atividades Econômicas*.

official database with monthly import and export figures for each region and product (Brazil 2022a), which are then categorized into the I-O table sectors.

The resulting matrix is consistent with available data, as shown in Table 3: gross value added across all regions sums to R$ 6.011 trillion, the same as Brazil's official report (IBGE 2022b). In addition, the GVA estimated for Minas Gerais' regions are roughly 9.43 percent of the national VA, also fairly consistent with the state's actual VA share for the same year (8.96 percent), as well as the state capital's GVA (1.20 percent estimated versus 1.32 percent actual).

Table 3: Summary statistics for macroeconomics aggregates in the analyzed regions.

| Code | Region | C | (%) | I | (%) | G | (%) | X | (%) | GVA | (%) | Labor | (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R01 | Belo Horizonte | 38,965 | 1.05% | 13,218 | 1.46% | 24,726 | 1.66% | 1,747 | 0.17% | 71,892 | 1.2% | 1,179,500 | 2.53% |
| R02 | B. Cocais | 357 | 0.01% | 252 | 0.03% | 114 | 0.01% | 259 | 0.03% | 723 | 0.01% | 4,635 | 0.01% |
| R03 | Caeté | 260 | 0.01% | 139 | 0.02% | 114 | 0.01% | 195 | 0.02% | 575 | 0.01% | 5,035 | 0.01% |
| R04 | Catas Altas | 62 | 0% | 29 | 0% | 78 | 0.01% | 436 | 0.04% | 501 | 0.01% | 955 | 0% |
| R05 | Congonhas | 270 | 0.01% | 394 | 0.04% | 225 | 0.02% | 0 | 0% | 2,281 | 0.04% | 17,089 | 0.04% |
| R06 | Diamantina | 318 | 0.01% | 36 | 0% | 426 | 0.03% | 11 | 0% | 686 | 0.01% | 9,138 | 0.02% |
| R07 | Mariana | 970 | 0.03% | 240 | 0.03% | 410 | 0.03% | 1,995 | 0.19% | 3,832 | 0.06% | 14,204 | 0.03% |
| R08 | Ouro Preto | 1,748 | 0.05% | 612 | 0.07% | 1,577 | 0.11% | 2,817 | 0.27% | 5,978 | 0.1% | 17,260 | 0.04% |
| R09 | Sabará | 1,602 | 0.04% | 453 | 0.05% | 517 | 0.03% | 52 | 0.01% | 2,947 | 0.05% | 21,053 | 0.05% |
| R10 | Santa Bárbara | 262 | 0.01% | 65 | 0.01% | 95 | 0.01% | 0 | 0% | 1,159 | 0.02% | 5,456 | 0.01% |
| R11 | São João del Rei | 1,101 | 0.03% | 223 | 0.02% | 887 | 0.06% | 287 | 0.03% | 1,951 | 0.03% | 20,333 | 0.04% |
| R12 | Serro | 126 | 0% | 8 | 0% | 62 | 0% | 0 | 0% | 192 | 0% | 2,122 | 0% |
| R13 | Tiradentes | 100 | 0% | 14 | 0% | 22 | 0% | 0 | 0% | 118 | 0% | 2,058 | 0% |
| R14 | Rest of MG | 318,877 | 8.62% | 82,490 | 9.14% | 88,436 | 5.93% | 74,802 | 7.3% | 473,863 | 7.88% | 3,461,992 | 7.42% |
| R15 | Rest of BR | 3,335,850 | 90.14% | 804,497 | 89.12% | 1,373,316 | 92.11% | 942,454 | 91.94% | 5,444,452 | 90.57% | 41,870,285 | 89.79% |
| - | Total | 3,700,868 | 100% | 902,669 | 100% | 1,491,004 | 100% | 1,025,056 | 100% | 6,011,150 | 100% | 46,631,115 | 100% |

## 3.5 Simulation

### 3.5.1 Extraction Coefficients

The first step of our simulation is determining the size of the extractions for each sector, which can be particularly challenging due the lack of information, e.g., there is no way of knowing exactly how much of the Food Services Industry sales of a city is due to tourism activity. In one hand, it is easier to consider "Accommodation" and "Arts, Culture, Sports, and Recreation" sectors as intrinsically linked to tourism. On the other hand, "Food Services", "Transportation", "Real estate activities", "Administrative Activities and Additional Services" encompass a great deal of non-touristic activities, such as public transit and citizens' expenses with dining; therefore, we made a sensibility analysis considering each city's unique economic characteristics and how known they are as a touristic destination. Although this approach relies on strong assumptions, we understand that our biggest contribution is to engage on the policy making debate by showing the importance for policy making of having a better understanding of the tourism industry's economic structure with closer attention to local contexts.

Table 4 displays the extraction coefficients used after our sensibility analysis, which are the same both for intermediate consumption and final demand. In sector $B10$ - "Accommodation", a survey made by the Minas Gerais State Government allowed us to use the share of guests in hotels, campings, hostels, and others, whose travel reason was leisure: this was used as a proxy for the extraction. When data was not available, we used the average of the other regions[6].

In sectors $B09$ - "Transportation" and $B11$ - "Food Services", sensibility analysis considered region size and its relative importance as a known touristic destination. Tiradentes — a rather small town but one of the most popular destinations on the state — had extraction coefficients higher than Sabará. Despite Sabará's cultural heritage, its population is seventeen times higher than the former, but tourism activity is significantly smaller. Sector $B19$ - "Arts, Culture, Sports, and Recreation", which basically comprises entertainment industry but also sports, followed a similar rationale. Finally, $B14$ - "Real estate activities" and $B15$ - "Administrative Activities and Additional Services" are sectors where tourism plays a minor role than the others. Therefore, while applying the same rational, we adopted an even higher degree of caution, using smaller coefficients.

Table 4: Extraction coefficients by sector and region.

| | Region | B09 | B10 | B11 | B14 | B15 | B19 |
|---|---|---|---|---|---|---|---|
| R01 | Belo Horizonte | - | - | - | - | - | - |
| R02 | Barão de Cocais | 25% | 98% | 25% | 1.25% | 0.25% | 25% |
| R03 | Caeté | 25% | 100% | 25% | 1.25% | 0.25% | 50% |
| R04 | Catas Altas | 25% | 98% | 25% | 1.25% | 0.25% | 50% |
| R05 | Congonhas | 25% | 96% | 25% | 1.25% | 0.25% | 50% |

[6] This was the case of Barão de Cocais, Catas Altas, Sabará, Santa Bárbara, and Serrro.

| | Region | B09 | B10 | B11 | B14 | B15 | B19 |
|---|---|---|---|---|---|---|---|
| R06 | Diamantina | 50% | 92% | 75% | 5.00% | 1.00% | 100% |
| R07 | Mariana | 50% | 96% | 50% | 5.00% | 1.00% | 100% |
| R08 | Ouro Preto | 50% | 100% | 75% | 5.00% | 1.00% | 100% |
| R09 | Sabará | 13% | 98% | 25% | 1.25% | 0.25% | 25% |
| R10 | Santa Bárbara | 25% | 98% | 50% | 2.50% | 0.50% | 50% |
| R11 | São João del Rei | 25% | 100% | 25% | 5.00% | 1.00% | 100% |
| R12 | Serro | 50% | 98% | 50% | 5.00% | 1.00% | 100% |
| R13 | Tiradentes | 75% | 100% | 100% | 5.00% | 1.00% | 100% |
| R14 | Rest of MG | - | - | - | - | - | - |
| R15 | Rest of Brazil | - | - | - | - | - | - |

# 4 Results

## 4.1 Linkages

Table 5 contains linkages results for the analyzed regions. No TCA except Transportation and related services is a key sector for the state's fourteen regions. The majority of cities have services as key sectors, especially Wholesale and retail trade, Transportation and related services, and Finance and insurance activities; nonetheless, Construction is also a key sector for every region except Belo Horizonte and Serro.

It is worth noting that Extractive industries is only a key sector in Sabará. This indicates that despite being the main sector in a great part of the baroque cities, extractive industries are rather self-sufficient instead of highly interconnected with the rest of the economy, which results of most of the sector's production being exported as raw commodities instead of locally processed in steel industries, for example.

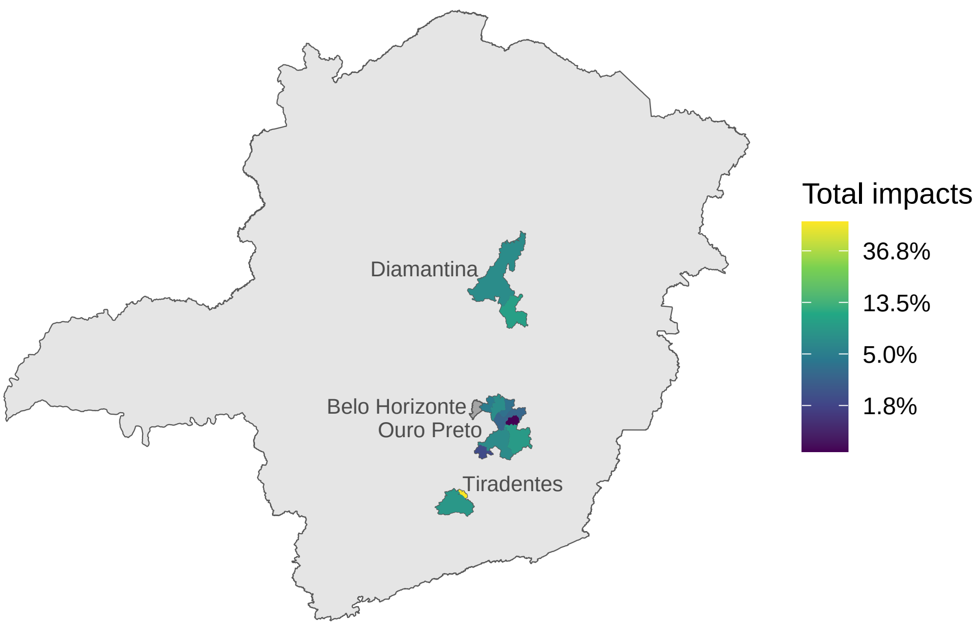
Table 5: Results of the linkage analysis for the 20 sectors ans 15 regions.

| Code | Region | B01 | B02 | B03 | B04 | B05 | B06 | B07 | B08 | B09 | B10 | B11 | B12 | B13 | B14 | B15 | B16 | B17 | B18 | B19 | B20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R01 | Belo Horizonte | | | | | Key | | | Key | Key | | | Key | Key | | | | | | | |
| R02 | B. Cocais | | | | Key | | | Key | Key | Key | | | | Key | | | | | | | |
| R03 | Caeté | | | | | | | Key | Key | Key | | | | Key | | | | | | | |
| R04 | Catas Altas | | | | | | | Key | Key | | | | | Key | | | | | | | |
| R05 | Congonhas | | | | | | | Key | Key | Key | | | | | | | | | | | |
| R06 | Diamantina | | | | | | | Key | Key | Key | | | Key | Key | | | | | | | |
| R07 | Mariana | | | | | | | Key | Key | Key | | | | | | | | | | | |
| R08 | Ouro Preto | | | | | Key | | Key | | | | | Key | Key | | | | | | | |
| R09 | Sabará | | Key | | Key | | | Key | Key | Key | | | | | | | | | | | |
| R10 | Santa Bárbara | | | | | | | Key | Key | Key | | | | Key | | | | | | | |
| R11 | São João del Rei | | | | | | | Key | Key | Key | | | Key | Key | | | | | | | |
| R12 | Serro | | | | | | | | Key | Key | | | | Key | | | | | | | |
| R13 | Tiradentes | | | | Key | | | Key | Key | | | | | Key | | | | | | | |
| R14 | Rest of MG | | | | Key | Key | | Key | Key | Key | | | | | | | | | | | |
| R15 | Rest of BR | | Key | Key | Key | Key | | Key | Key | Key | | | Key | Key | Key | Key | | | | | |

## 4.2 Hypothetical extraction

Table 6 summarizes the results for the 13 scenarios analyzed: global (simultaneous) extraction and 12 local extractions for every heritage region. The first column contains the global impacts over gross value of production (GVP), whereas the last one computes the difference between local and global ones and the intermediary columns are the results for local simulations. Intraregional impacts are computed in the diagonal of the submatrix $[B2 : B13]$, while off-diagonals are interregional values. Figure 4 gives a spatial visualization of the impacts in the simultaneous extraction.

Figure 4: Spatial visualization of the simultaneous hypothetical extraction impacts over GVP for the baroque cities.




Regarding the simultaneous extraction, the simulation shows a great heterogeneity. The impacts over regions outside of the heritage circuit (Belo Horizonte, Rest of Minas Gerais and Rest of Brazil) are, at up to 0.33 percent, practically negligible. In the historical regions, the lowest impact is observed in Catas Altas ($R04$) at less than 1 percent, while Tiradentes ($R13$) has the highest of them, at 64.67 percent. The average impact across the 12 baroque cities is of 10.39 percent. This value is highly influenced by Tiradentes, the only city impacted by more than 10 percent; in fact, the median impact is of 6.44 percent.

As expected, the impacts for each region are higher in the global scenario than in the local ones, as each region is impacted by their neighbors' extraction. As indicated by the last column, however, there is a small difference between local and global simulations: the highest (absolute) value is of 32.83 percent for Tiradentes, averaging at 16.61 percent. This indicates that there is a modest (albeit non-negligible) dependency in the tourism value chains across regions in the baroque heritage circuit. In other words, if for a given city the impact of obliterating the tourism industry in the twelve regions simultaneously is 20 percent bigger than the same impact estimated in the local simulation, we can say that most of tourism's gross value of production comes exclusively from local tourism.

The intraregional impacts are almost nonexistent in the local simulations — values below 0.01 percent are rounded to zero in Table 6. The scenario of extracting Ouro Preto has the most impacts over other regions, even though with modest values. The biggest of them is in the neighbor city of Mariana; conversely, when only Mariana is extracted, the biggest impacts are in Ouro Preto's GVP. This makes sense, as it is common for tourists to stay at Ouro Preto and visit Mariana during their trip or vice-versa; for instance, there's a heritage train linking the two cities. A similar situation happens with Tiradentes and São João del Rei ($R11$): extracting only the latter impacts $R11$'s GVP negatively by 0.21 percent, while the contrary situation reduces Tiradentes' GVP by 0.17 percent.

Table 6: Results of the hypothetical extractions' impacts on GVP, values in percentages.

| Code | Region | Global | R02 | R03 | R04 | R05 | R06 | R07 | R08 | R09 | R10 | R11 | R12 | R13 | Diff. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| R01 | Belo Horizonte | -0.33% | 0% | -0.01% | 0% | -0.01% | 0% | -0.01% | -0.02% | -0.04% | 0% | 0% | 0% | 0% | - |
| R02 | B. Cocais | -3.97% | -3.02% | -0.01% | 0% | 0% | 0% | -0.02% | -0.02% | -0.01% | -0.15% | 0% | 0% | 0% | -23,9% |
| R03 | Caeté | -6.62% | 0% | -5.75% | 0% | 0% | 0% | 0% | -0.01% | -0.01% | 0% | 0% | 0% | 0% | -13,07% |
| R04 | Catas Altas | -0.75% | 0% | 0% | -0.65% | 0% | 0% | 0% | -0.01% | 0% | -0.01% | 0% | 0% | 0% | -13,43% |
| R05 | Congonhas | -2.05% | 0% | 0% | 0% | -1.93% | 0% | 0% | -0.01% | 0% | 0% | 0% | 0% | 0% | -6,09% |
| R06 | Diamantina | -6.5% | 0% | 0% | 0% | 0% | -4.42% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | -31,99% |
| R07 | Mariana | -8.41% | 0% | 0% | 0% | 0% | 0% | -5.25% | -0.15% | 0% | 0% | 0% | 0% | 0% | -37,55% |
| R08 | Ouro Preto | -6.37% | 0% | 0% | 0% | 0% | 0% | -0.13% | -4.08% | 0% | 0% | 0% | 0% | 0% | -35,97% |
| R09 | Sabará | -4.82% | 0% | 0% | 0% | 0% | 0% | 0% | -0.01% | -2.96% | 0% | 0% | 0% | 0% | -38,54% |
| R10 | Santa Bárbara | -3.29% | -0.01% | 0% | 0% | 0% | 0% | -0.01% | -0.01% | 0% | -2.5% | 0% | 0% | 0% | -24% |
| R11 | S. João del Rei | -8% | 0% | 0% | 0% | -0.01% | 0% | -0.01% | -0.01% | 0% | 0% | -3.43% | 0% | -0.21% | -57,12% |
| R12 | Serro | -9.22% | 0% | 0% | 0% | 0% | -0.01% | 0% | 0% | 0% | 0% | 0% | -5.52% | 0% | -40,15% |
| R13 | Tiradentes | -64.67% | 0% | 0% | 0% | 0% | 0% | 0% | -0.01% | 0% | 0% | -0.17% | 0% | -43.34% | -32,97% |
| R14 | Rest of MG | -0.02% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | - |
| R15 | Rest of BR | -0.01% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | - |

# 5 Final Remarks

In this paper, we aimed at developing an interregional I-O system to analyze the impact of tourism characteristic activities (TCAs) from an intraregional point of view. While there are several other ways of estimating the relevance of the tourism sector in an economy, such as the time-series analysis in Balaguer and Cantavella-Jordá (2002) and Rasool, Maqbool, and Tarique (2021), the input-output framework provides a systematic analysis of the economy, indicating how economic activities are connected; moreover, the regional setting further enhances the analysis by addressing each city individually. Analyzing tourism activities through the I-O lens can be especially useful in policy making by understanding how the different sectors and regions of the economy can be affected by stimulating the tourism industry, given the current production structure, thanks to linkages and hypothetical extraction analyzes.

To estimate the regional matrix, we had to overcome two main challenges. First, the absence of data at the municipality level, which we addressed using the IIOAS method: a robust framework to estimate regional shares of economical activities that is consistent with national aggregates. Second, as TCAs are spread across different industries, applying the hypothetical extraction method is less straightforward. We approached this problem by estimating the share of each sector's trade that can be accountable to TCAs, while also paying close attention to regional differences.

From the regional point of view, there is a striking difference in results across regions. Tiradentes outstands as heavily impacted by ACTs with an impact of almost 65 percent in GVP in the hypothetical extraction. In Serro, Mariana, São João del Rei, Caeté and Ouro Preto, ACTs are also relevant, with impacts ranging between 9.22 percent and 6.37 percent: these are mostly consolidated touristic destinations, with good accommodation infrastructure and well-maintained attractions such as museums, heritage trains, and parks. In contrast, cities like Catas Altas and Congonhas are very little influenced by the extraction, with impacts on GVP of 0.75 percent and 2.05 percent respectively. Despite their cultural and architectonic legacy — in fact, Congonhas has an UNESCO World Cultural Heritage site —, they are not developed touristic destinations as the ones from the previous group.

Looking at the bigger picture, touristic activities in the baroque heritage circuit does not seems to be heavily connected to other industries in Minas Gerais, as most of them are not key industries and hypotetical extraction simulations had modest impact on the GVP of most regions. As we exposed in Section 2 and in Section 4.2, the state's economy is historically very attached to the extractive industries geared towards exports. With the development of Brazilian economy in the 20th and 21st centuries, manufacturing and service activities began to play a major role as well, in part fueled by an emerging middle class. The tourism industry is no exception, being intensely dependent on local consumer markets as international tourists still play a smaller role than domestic ones, especially in Minas Gerais (Gerais 2022). At the same time, deficient infrastructure in the form of unpaved roads, expensive air connectivity with limited regional airports, and the absence of rail service to touristic destinations can also contribute for a potentially low impact of tourism activities. In this sense, policies aimed at developing the baroque cities as a tourism product should also be integrated with regional planning of infrastructure to achieve better results.

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