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The Ferriferous Quadrilateral of Minas Gerais: an analysis of its productive structure in the period 2010 to 2019

O quadrilátero ferrífero de Minas Gerais: uma análise sobre sua estrutura produtiva no período de 2010 a 2019

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Abstract
The objective of this paper is to analyze the behavior of variable employment for selected sectors within the production structure of municipalities belonging to the Quadrilátero Ferrífero (QF) region - Minas Gerais. These sectors are linked to Technologies of Information and Communication, Smarts Cities and Activities that Characterize Tourism (ACTs). A specific aim of this study is to capture possible changes in the set, between the years 2010 and 2019, which benefit the productive diversification of this region. For this, the following regional economy techniques will be used: differential-structural method (shift-share); coefficients of specialization and localization. The main results show little or no regional advantage and / or specialization for sectors linked to TICs, except for the Education sector.
Keywords: ferriferous quadrilateral, shift-share, location and expertise.

Resumo
Este artigo teve como objetivo analisar o comportamento da variável emprego para setores selecionados dentro da estrutura produtiva dos municípios pertencentes à região do Quadrilátero Ferrífero (QF) – Minas Gerais. Tais setores estão ligados às Tecnologias da Informação e Comunicação, ao conceito de Cidades Inteligentes e às Atividades que Caracterizam o Turismo (ACTs). O intuito específico deste estudo é captar possíveis mudanças setoriais, entre os anos de 2010 e 2019, que beneficiem a diversificação produtiva desta região. Para isto, utilizaram-se as seguintes técnicas de economia regional: método diferencial-estrutural (shift-share); coeficientes de especialização e localização. Os resultados principais mostram pouca ou nenhuma vantagem regional e/ou de especialização para setores ligados às TICs, exceção ao setor de Educação.
Palavras-chave: quadrilátero ferrífero, shift-share, localização e especialização.

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1 Introduction

Ouro Preto is a city that was recognized as a historical heritage of humanity by UNESCO in the 1980s and Mariana, its neighbor, was likewise recognized as a national historical heritage. Both cities are located in the central region of Minas Gerais state (Southeast region of Brazil). Although these cities are nationally and internationally recognized for their historic-cultural tourism, from an economic point of view, the mining is responsible for about 80% of their GDPs (Nascimento Medeiros, Batella Medeiros, & Medeiros, 2018; Cavalcanti et al., 2019; Viana et al., 2020). Thus, The local mining places these municipalities on the list of those that belong to the so-called Quadrilátero Ferrífero (QF) – *Ferriferous Quadrilateral (FQ)* - a region that stands out for its extraction and processing of ore in the state of Minas Gerais and in Brazil.

The position of relevance in the mineral production of Minas Gerais state is a result of the abundance of this type of commodity since the formation of its productive structure, which dates back to the period of colonial Brazil. Comparatively, the economic exploitation of tourism is a relatively recent phenomenon. Even more recent is the discussion on agricultural and livestock activities, in a production model based on sustainable (agroecological) principles. However, the debate on regional economic resilience and productive diversification in the cities that are part of the FQ has gained greater prominence since the end of 2015 when the so-called '' Barragem de Fundão'' a tailings dam, owned by the Samarco mining company, in Mariana (Faria Silva, Ferreira Da Silva, & Tupy, 2019; Viana et al., 2020). This fact was highlighted in 2019 with the collapse of another tailings dam, this last one belonging to Vale company, in the city of Brumadinho.

These events have consequently contributed to deepening the economic crisis that had been established since 2008. However, the whole scenario that took place evolved from being a strictly economic crisis and took on broader forms and, therefore, with greater urgency to be debated and resolved by the decision-makers, institutions and civil society. Consequently, these issues led to new proposals that strengthen, for example, tourism, family farming and agroecology, activities that can be strongly interconnected. Another point that should be highlighted refers to the moment experienced in the year 2020 which extends through the year 2021, in which the world went through the biggest health crisis experienced, so far, in this century (pandemic caused by Sars Cov 2 - Covid 19). The disease, which was initially identified in China, quickly spreaded all over the world. It was a direct consequence driven by the ease of moving among the different countries. Therefore it is not yet known how long the economic crisis related to the pandemic will still last.

This problematic scenario exposes how urgent the need of alternatives that value sustainable development is, hence adjustments to the capitalist production model must be mandatory in order to avoid problems for the future generations such as the ones we experience nowadays (if that is na actual concern). Consequently, the guiding question of this research is: what changes effectively happened in the productive structure of sectors linked to technology, tourism, family agriculture and culture in the Ferriferous Quadrilateral (FQ) region of Minas Gerais - Brazil between 2010 and 2019? The hypothesis to be taken into account is: despite there have been phenomena that point to the need for greater diversification of the productive structure of this region, there has not been a significant change that speeds up the aforementioned diversification process. This occurs not only from an economic point of view, but also in terms of gaining social welfare through smart structures (smart cities).

2 Paths towards sustainability

A relevant data published by the ‘’Global Footprint Network’’ is that the world population consumed, just in 2006, almost 1.5 planets Earth per year. Steenbock et al. (2013) uses the work of Ewing et. al. (2009) to warn that this meant that the world population used, in just one year, resources that the planet would be able to replace in eighteen months. Regarding to this finding, the proposal of an economic growth that provides decent living conditions for future generations, as well as the well-being of current generations, has been gaining relevance not only from a perspective of growth, but also from economic development guided by sustainability (sustainable development).

It was based on this concept of economic development that, in 1987, the Brundtland Report of the World Commission on Environment and Development was produced. The report presents reasons to show the incompatibility between sustainable development and the consolidated production and consumption patterns of the second half of the 20th century, drawing attention to the need for a new relationship between human beings and the environment (Reiniger, Wizniewsky, & Kaufmann, 2017). Sustainability, in the understanding of Caporal and Costabeber (2004), should be seen, studied and proposed as a permanent search for new points of balance between different dimensions that may conflict with each other in concrete realities. The ecological dimension is perhaps the most evident in the essays and experiments on agroecology. It is, above all, related to the entire agricultural production process and the way we interact with nature.

In addition to the ecological dimension, there is a social, economic, political and ethical dimension. The social dimension represents one of the basic pillars of sustainability, as it gives meaning to an equitable appropriation and usufruct of production by the various segments of society. The economic dimension measures the economic gains and losses of the production process, as well as being responsible for the search for strategies for insertion in local, regional or global markets (Reiniger, Marielen, & Kaufmann, 2017).

The political dimension is related to the participative and democratic processes that are developed in the context of agricultural production and rural development, with the networks of social organization and representation of the different segments of the rural population. And, finally, the ethical dimension is imbricated with the solidarity of people with their families and with the other members of the communities in general. Still in the ethical dimension, the responsibility of individuals towards ecosystems is expressed in the relationship of conservation and conscious usage of natural resources. (Reiniger, Marielen, & Kaufmann, 2017).

Pérez (2019) identifies possible uses associated with nature environments, the first being ecotourism, which generates economic opportunities, investments in infrastructure and an increase in local pride; transferring money from visitors to managers of this areas also helps to finance the management of natural areas and; it also favors the development of experiences to bring the citizens closer to a natural world. The second use associated with the natural environment is education, given that wild areas can serve as natural classrooms where different groups can learn about the functioning of the natural world, the natural and cultural values of these places and the importance of the care and conservation of them. Finally, a third use of the natural environment pointed out by Pérez (2019) is the production of ecosystem goods and services. The most common goods are linked to the production or natural purification of water; protection from floods or natural disasters; erosion prevention; conservation of soil fertility and biological pest control.

Another concept that has been explored from the perspective of sustainability is the ‘’smart city’’. For Capdevila and Zarlenga (2015, p.2) “cities can be conceptualized as complex ecosystems, where different actors with different interests are obliged to collaborate to ensure

a sustainable environment and an adequate quality of life". For these authors, a smart city can be described as a city that uses Information and Communication Technologies (ICTs) to increase the quality of life of its inhabitants, contributing to sustainable development. When looking for quality of life and sustainable development, economic development, social inclusion, security, sustainability, infrastructure, transport, housing, among others, must be addressed simultaneously.

On the smart city concept, Rizzon et. al. (2017, p. 126), it is said that:

> (...) has obtained width in the scientific debate when Giffinger et al (2007) provided a model of Smart City, understood as a city composed of six characteristics: smart economy; smart people; smart governance; smart mobility; intelligent environment and; intelligent life.

Regards to these aforementioned characteristics, the Smart City concept adheres to a more holistic view in which technologies (hardware and software infrastructure), people (creativity, diversity, education) and institutions (policy and governance) are approached simultaneously (Nam & Pardo , 2011; Lee et al., 2013).

It is known that the interactions among technology, people and institutions are different among different countries and even within the countries themselves, it must be assumed that there is no uniqueness in the solutions proposed by a smart city. As highlighted by Zygiaris (2013) cited by Tambelli (2018, p.12):

> (...) solutions related to the smart city are often presented in a universal way, as if it were possible for any city to integrate technologies into its infrastructure, regardless of its political, social, technical, cultural, demographic circumstances, etc.

With that being said, this concept has reached developing countries and has brought about discussions in the scientific community and beyond. About the obstacles to reach a city with an intelligent structure and how this intelligence can contribute to the development, in its various aspects, of these cities. One of these obstacles is directly or indirectly related to the productive structure of cities and regions. A little complex structure, that is, linked to concentration in a few sectors, which in many cases are not intensive in technologies, education, culture.

Regarding to the concepts discussed above, the present study, applying regional economics technique, will evaluate the productive structure of the *Ferriferous Quadrilateral (FQ)* - region of Minas Gerais - in the period from 2010 to 2019, to identify possible changes in this structure that favor productive diversification and sustainable local development.

3 Methodology

3.1 Database

This research made use of the database on formal jobs from the Annual Social Information Relation (RAIS) of the Ministry of Economy for the years 2010 and 2019, considering that this is a very dynamic period in internal and external events involving the political, socioeconomic and environmental dimensions, such as the 2008 economic crisis; the rupture of two mining waste dams in Minas Gerais; the strengthening of the the smart cities concept, etc.

The municipalities chosen for the study were: Congonhas, Itabirito, Tiradentes, Ouro Preto, Mariana, Ouro Branco, São João Del Rei. All belonging to the region known as Ferriferous Quadrilateral (FQ) - Quadrilátero Ferrífero (QF) -, located in Minas Gerais, Brazil.

The analyzed sectors were from the National Classification of Economic Activities (CNAE 2.0), Division category, in which the sectors are arranged in two digits (01 to 99). Of these 99 sectors, the results were analyzed only from those sectors that are considered by the Innovation Survey (PINTEC) of the Brazilian Institute of Geography and Statistics (IBGE) to be more intensive in innovation, as well as those related to health and education (sectors that are present in the concept of smart cities) and the most representative in the set of activities that characterize tourism (ACTs).

These sectors were: 35 (electricity, gas and other utilities); 36 (water collection, treatment and distribution); 37 (sewage and related activities); 38 (waste collection, treatment and disposal); 39 (decontamination and other waste management services); 42 (infrastructure works); 55 (accommodation); 56 (food); 58 (editing and editing integrated into print); 61 (telecommunications); 62 (information technology services activities); 63 (information service activities); 71 (architecture and engineering services); 72 (research and scientific development); 74 (other professional, scientific and technical activities); 85 (education); 86 (human health care activities) and 91 (activities related to cultural and environmental heritage).

3.2 O método diferencial-estrutural

3.2 The differential-structural method

The differential-structural method consists of comparing the real growth of the variable in question, that is, what was actually verified and the theoretical one, that is, what the reference region (in this case, the QF) would have if its growth had occurred with the same rates as in the country (Rolim, 1996). However, for the study presented here, the reference will be the state of Minas Gerais and not the country itself.

The structural effect, also known as proportional, is related to the productive structure of a given region, that is, whether this structure indicates more or less dynamic sectors in relation to the country (or the state) and indicates the degree of specialization of that region in these sectors. (Haddad et al., 1989).

In the same sense, as highlighted by Rosa et. al. (2004), the structural component is the additional amount of employment that the municipality obtained as a result of its industrial composition, in which a positive variation shows that the municipality shows sectors of the economy with high growth rates. Therefore, if the structural component or structural effect unvails a positive sign, this indicates that the region or country has more dynamic sectors in its industrial park and, therefore, has a great possibility of specializing in such sectors.

On the other hand, the differential or regional effect reflects the ability of a given region to offer comparative advantages to certain sectors in relation to other regions, and such advantages come from low transport costs, subsidies and tax incentives for some sectors, reduced costs with raw materials, etc. If this effect has a positive sign, it indicates that the region has sectors or industries that have comparative advantages in relation to other regions. The total effect, that is, the sum of the structural and differential effects, if positive, shows that the region had a greater growth than it would have if it grew at the same rates as the country as a whole (Rolim, 1996).

Stiwell (1969) apud Haddad et. al. (1989), suggest a modification in the method, but persisting in its simplicity. Stiwell proposes that, initially, the reversed proportional variation should be calculated, depending on the sectoral growth rates and the industrial composition of employment in the region at the end of the period under analysis, that is, the final year is used as weight instead of the initial. Then, the difference between the reversed proportional change and the resulting net change is obtained. This difference is called modified proportional

variation and, if the latter is subtracted from the proportional variation, we have the residual differential variation.

In terms of expression, the growth in employment (and income) between periods 0 and 1 can be decomposed into three effects or variations, which are: the regional effect (R_j), the structural/proportional effect (P_j) and the differential effect (D_j)

$$\sum_i E_{ij}^1 - \sum_i E_{ij}^0 = R_j + P_j + D_j$$, being i = sectors and j = regions (Eq.1).

Where (R_j) is called regional effect or regional variation and represents the hypothetical growth rate, that is, the variation in employment in the sector of the region that would have occurred if growth had occurred at the state rate. If the real variation is greater than the theoretical variation, it means that employment in sector ''i'' in municipality ''j'' grew above the state average and that there are internal and/or external dynamic elements acting in the region in a positive way. This effect is expressed by:

$$R_j = \sum_i E_{ij}^0 (r_{tt} - 1)$$ (Eq.2)

$$r_{tt} = \frac{\sum_i \sum_j E_{ij}^1}{\sum_i \sum_j E_j^0}$$

With representing the state employment growth rate. Yet (P_j) is the effect or the proportional/structural variation, which represents the additional volume of employment (which may be positive or negative) that municipality ''j'' acquired between periods 0 and 1 due to the composition of its productive structure. If the municipality has in its productive structure sectors whose employment or income grows at rates higher than the state, the structural effect will be positive, otherwise, it will be negative. This effect is given by:

$$P_j = \sum_i E_{ij}^0 (r_{it} - r_{tt})$$ (Eq. 3)

$$r_{it} = \frac{\sum_j E_{ij}^1}{\sum_j E_{ij}^0}$$

Where is the state employment growth rate in sector ''i''. Finally, there is the effect or differential variation (D_j), which expresses the locational advantages (or disadvantages) of a sector in a given region, highlighting local specificities. If the value of this effect is positive, it means that the growth rate in certain sectors was higher in this region than in the state (on average). A negative variation implies that the growth of some sectors in this region (city) is being lower than the state average. This effect is given by:

$$D_j = \sum_i E_{ij}^0 (r_{ij} - r_{it})$$ (Eq.4)

Where $r_{ij} = \frac{E_{ij}^1}{E_{ij}^0}$ is the employment growth rate of the sector ''i'' in region ''j''. Thus, the employment growth rate will be given by:

$$\left(\sum_i E_{ij}^1 - \sum_i E_{ij}^0\right) - \sum_i E_{ij}^0 (r_{tt} - 1) = \sum_i E_{ij}^0 (r_{it} - r_{tt}) + \sum_i E_{ij}^0 (r_{ij} - r_{it}) \quad \text{(Eq.5)}$$

The modifications incorporated into the method result in the effect or reversed structural/proportional variation (T_j), which is expressed by: $T_j = \sum_i E_{ij}^1 \left[\frac{1}{r_{tt}} - \frac{1}{r_{it}}\right]$, and in the modified structural/proportional variation (M_j), given by: $M_j = T_j - P_j$. If $M_j > 0$, the region has specialized in sectors where the employment growth rate is favorable at the state level. The residual differential variation (RD_j) is expressed by: $RD_j = D_j - M_j$.

3.3 Location and specialization coefficients

To notice possible changes regarding the location and specialization of the productive structure of the municipalities belonging to the Ferriferous Quadrilateral (FQ) – QF - in the period between 2010 and 2019, the following indicators were calculated: Location Quotient (QL), Location Coefficient (CL); Redistribution Coefficient (CR), Specialization Coefficient (CE) and Restructuring Coefficient (CRR). The first three ones, according to Haddad et. al. (1989), aim at analyzing the sectors and the distribution of productive activities within a given region, as well as making it possible to identify the concentration or dispersion of jobs in a given sector, in a specific period of time.

The Specialization Coefficient (CE) and the Restructuring Coefficient (CRR) are location measures that aim to identify regional specialization and diversification in a given period. The CE compares the productive structure of municipality ''j'' with the productive structure of the reference region, which in this case will be the state of Minas Gerais. Thus, the most concentrated municipality belonging to the Ferriferous Quadrilateral (FQ) – QF - would be the one with a productive structure that differs from the state. And the CRR indicates whether there was a change in the productive structure in region ''j'' in a given period of time (Alves, 2012).

The equations that measure QL, CL and CR, respectively, are proposed in Stamm et al. (2003). Here They are:

$$QL_{ij} = (E_{ij}/\sum_j E_{ij})/(\sum_i E_{ij}/\sum_i \sum_j E_{ij}) \quad \text{(Eq. 6)}$$

$$CL_i = \frac{\sum j|(E_{ij}/\sum_j E_{ij}) - (\sum i E_{ij}/\sum_i \sum_j E_{ij})|}{2} \quad \text{(Eq. 7)}$$

$$CR = \frac{\sum j|(E_{ij}/\sum_j^{t1} E_{ij}) - (E_{ij}/\sum_j^{t0} E_{ij})|}{2} \quad \text{(Eq. 8)}$$

Where: E_{ij} = number of employees in sector ''i'' of region ''j''; $\sum_j E_{ij}$ = number of employees in sector ''i'' from all regions; $\sum_i E_{ij}$ = number of employees in all sectors of region j; $\sum_i \sum_j E_{ij=}$ number of employees in all sectors and all regions. In the specific case of the

present study, E_{ij} comprised the number of employees in each sector of the CNAE 2.0 Division in each selected municipality; $\sum_j E_{ij}$ is the number of employees in the sectors CNAE 2.0 Division as a whole for each municipality in the QF; $\sum_i E_{ij}$ refers to the number of employees in each sector CNAE 2.0 Division in the state of Minas Gerais; $\sum_i \sum_j E_{ij}$ is the total number of employees in the CNAE 2.0 sectors in Minas Gerais.

Yet, the equations that measure CE and CRR are expressed by (9) and (10), respectively:

$$CE_j = \frac{\sum i|(E_{ij}/\sum_i E_{ij}) - (\sum j E_{ij}/\sum_i \sum_j E_{ij})|}{2} \quad \text{(Eq. 9)}$$

$$CRR_j = \frac{\sum i|(E_{ij}/\sum_i^{t1} E_{ij}) - (E_{ij}/\sum_i^{t0} E_{ij})|}{2} \quad \text{(Eq. 10)}$$

In terms of interpreting the results of the calculation of each of these coefficients, the QL, as pointed out by Alves (2012), seeks to demonstrate the locational behavior of the sectors, identify the most specialized activities in the region, in addition to enabling comparison with a reference region. QL results above 1 mean that the sector is specialized, that is, it defines that the municipality stands out in a given sector in relation to the state of Minas Gerais. The inverse occurs when the value is less than 1.

The CL identifies the dispersion and concentration of economic activities, in this case through the formal jobs of the CNAE 2.0 Division in the municipalities of the FQ. The result of this indicator assumes values between zero and one, and results close to zero say that the regional distribution of the sector is similar to the set of other sectors of each region, in this case, of each considered municipality. The opposite occurs when the coefficient is closer to one, signaling the presence of a higher concentration (Stamm et al., 2003; Alves, 2012).

The CR, on the other hand, seeks to verify whether there has been a change in the distribution of a particular sector in the studied region, within a period of time. When the result of this indicator is close to zero, it means that there were no changes in the sector's distribution. However, if it is close to one, the sector presented significant spatial changes in the analyzed period (Stamm et al., 2003; Alves, 2012).

For CE, results close to zero indicate that the productive structure of the municipality is similar to that of the state. If these results are close to one, such a municipal productive structure is different from that presented in the state, that is, in this case, the municipality is more specialized than the reference region. In relation to the CRR, when the result is close to zero, it is considered that there has been no change in the sectoral composition of the region. If it is close to one, sectoral changes have been significant and the region's productive structure has changed.

4 Results and discussions

4.1 Results for the differential-structural method

The following tables show the municipal results for all sectors that had some effect other than zero. For Congonhas (Table 1) these sectors were: 38 (waste collection, treatment and disposal); 42 (infrastructure works); 58 (editing and editing integrated into printing); 61(telecommunications); 71 (architecture and engineering services); 74 (other professional, scientific and technical activities); 85 (education); 86 (human health care activities); 91 (activities related to cultural and environmental heritage). The one with the greatest total positive effect was 86 (human health care activities). And the sector that presented the greatest total negative effect was 42 (infrastructure works).

When analyzing the results of the modified method, sector 86 (human health care activities) continues to be the one with the greatest positive effect both for the reversed proportional variation and for the residual differential variation. The greatest negative effects are also found in sector 42 (infrastructure works). On the other hand, regarding to the modified proportional variation, this same sector had the greatest positive effect.

The municipality of Itabirito expressed a positive total effect for many of the analyzed sectors. These sectors were: 35 (electricity, gas and other utilities); 36 (water collection, treatment and distribution); 38 (waste collection, treatment and disposal); 42 (infrastructure works); 61 (telecommunications); 71 (architecture and engineering services); 74 (other professional, scientific and technical activities); 85 (education); 86 (human health care activities). Only sector 63 (activities providing information services) showed a negative sign.

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Table 1 - Results of the Shift-Share Effects for Employment in the years 2010 and 2019

Congonhas								Mariana							
Código	R	P	D	Efeito Total	T	M	RD	Código	R	P	D	Efeito Total	T	M	RD
38	0,00	0,00		0,00	2,33	2,33		36	5,32	2,04	41,63	49,00	2,80	0,75	40,88
42	62,09	-222,33	-681,76	-842,00	-35,20	187,14	-868,89	42	41,63	-149,05	-387,57	-495,00	-41,32	107,73	-495,31
58	0,06	-0,62	-0,45	-1,00	0,00	0,62	-1,06	58	1,39	-13,56	-8,83	-21,00	-1,30	12,26	-21,10
61	0,00	0,00		0,00	0,47	0,47		61	0,63	10,49	16,88	28,00	17,74	7,26	9,62
71	5,89	-12,03	-51,86	-58,00	-4,56	7,47	-59,33	63	1,20	-6,12	3,92	-1,00	-7,36	-1,24	5,15
74	0,95	2,71	-16,66	-13,00	0,27	-2,43	-14,22	71	1,77	-3,62	1013,85	1012,00	-135,46	-131,84	1145,69
85	15,46	53,13	-9,59	59,00	48,43	-4,70	-4,89	72	0,00	0,00		0,00	-520,75	-520,75	
86	15,08	74,08	32,84	122,00	76,66	2,58	30,26	85	25,66	88,19	81,15	195,00	95,91	7,72	73,43
91	0,06	0,14	-1,20	-1,00	0,00	-0,14	-1,06	86	22,05	108,32	28,63	159,00	107,96	-0,36	28,99
Itabirito								Tiradentes							
Código	R	P	D	Efeito Total	T	M	RD	Código	R	P	D	Efeito Total	T	M	RD
35	0,00	0,00		0,00	-1,20	-1,20		42	3,67	-13,16	-37,52	-47,00	-2,81	10,35	-47,87
36	6,08	2,34	65,58	74,00	3,58	1,24	64,34	55	22,87	18,58	185,55	227,00	25,53	6,95	178,60
38	0,70	1,23	2,07	4,00	1,34	0,11	1,96	56	12,55	51,04	123,41	187,00	70,65	19,60	103,81
42	19,45	-69,65	480,20	430,00	-187,98	-118,33	598,53	71	0,00	0,00		0,00	-1,17	-1,17	
61	0,32	5,24	-0,56	5,00	4,67	-0,57	0,01	72	0,00	0,00		0,00	-5,13	-5,13	
63	2,98	-15,14	-33,84	-46,00	-0,41	14,73	-48,57	74	0,00	0,00		0,00	0,00	0,00	
71	0,70	-1,42	38,73	38,00	-6,38	-4,96	43,69	85	0,38	1,31	14,31	16,00	3,52	2,21	12,10
74	0,32	0,90	11,78	13,00	2,46	1,55	10,23	86	0,06	0,31	6,63	7,00	1,70	1,39	5,23
85	15,27	52,48	119,25	187,00	68,41	15,93	103,32	91	0,00	0,00		0,00	1,29	1,29	
86	15,21	74,71	0,09	90,00	70,27	-4,43	4,52								

Source: Own elaboration based on data from RAIS (2021)

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The results for the modified method denoted a positive sign of greater expression for sectors 85 (education) and 86 (human health care activities) for the reversed proportional variation; 63 (information service activities) and 85 (education) for the modified proportional variation. For the residual differential variation, only sector 63 (activities providing information services) did not show a positive sign. It should also be pointed out that the sector with the greatest positive impact, in terms of total effect, was sector 42 (infrastructure works) followed by sector 85 (education). Such results indicate that Itabirito has advantages of location and specialization in strategic sectors for greater productive diversification.

For the municipality of Mariana, the sectors with results (positive or negative) were: 36 (water collection, treatment and distribution); 42 (infrastructure works); 58 (editing and editing integrated into print); 61 (telecommunications); 63 (information service activities); 71 (architecture and engineering services); 72 (Scientific R&D); 85 (education); 86 (human health care activities). The largest positive total effects were for sectors 71 (architecture and engineering services) and 85 (education), respectively. Sectors with negative effects were: 42 (infrastructure works); 58 (editing and editing integrated into printing); 63 (information service provision activities).

According to the effects of the modified method, only sectors 36 (water collection, treatment and distribution); 61 (telecommunications); 85 (education) and 86 (human health care activities) showed a positive effect for the reversed proportional variation. The largest negative effects were exhibited in sectors 72 (Scientific R&D) and 71 (Architectural and Engineering Services), respectively. For the modified proportional variation, sector 42 (infrastructure works) has a positive sign, contrasting with the negative sign for this same sector for most variations, this fact may be associated with the regional effect, which was also positive, showing that, in a way, this sector has regional advantages for this municipality.

In Tiradentes, most of the total effects were zero. Positive signs were presented by: 55 (accommodation); 56 (food); 85 (education) and 86 (human health care activities). The negative sign was only with sector 42 (infrastructure works). In the case of the reversed proportional variation, sectors 42 (infrastructure works); 71 (architecture and engineering services) and 72 (scientific R&D) showed negative signs in their results. The biggest positive sign came from sector 56 (food) followed by sector 55 (accommodation). Such sectors showed positive results for all purposes, indicating structural advantages and specialization in activities characteristic of tourism.

In the municipality of Ouro Branco, the following sectors showed positive or negative results: 38 (waste collection, treatment and disposal); 39 (decontamination and other waste management services); 42 (infrastructure works); 55 (accommodation); 56 (food); 71 (architecture and engineering services); 72 (Scientific R&D); 85 (education); 86 (human health care activities); 91 (activities related to cultural and environmental heritage). For the total effect, the highest positive result was for 55 (accommodation); 56 (food). The same occurs for the other effects with modifications: the highlight are the two sectors linked to tourism.

The municipality of Ouro Preto, among those analyzed, was the one that presented results for the largest number of sectors: 35 (electricity, gas and other utilities); 36 (water collection, treatment and distribution); 37 (sewage and related activities); 38 (waste collection, treatment and disposal); 42 (infrastructure works); 58 (editing and editing integrated into printing); 61 (telecommunications); 63 (information service activities); 71 (architecture and engineering services); 72 (Scientific R&D); 85 (education); 86 (human health care activities); 91 (activities related to cultural and environmental heritage). However, it is underlined that the negative results for the total effect predominated. Attention is drawn to the large negative effect for sector 85 (education). Sector 42 (infrastructure works) had the greatest positive effect. In the results of the modified effect, only in the proportional variation reversed, the sector 85 (education)

presents a positive sign, in the other effects, the results were not only negative, but were also the biggest negative effects.

For São João Del Rei, the following sectors presented positive or negative results: 36 (water collection, treatment and distribution); 38 (waste collection, treatment and disposal); 42 (infrastructure works); 55 (accommodation); 56 (food); 58 (editing and editing integrated into printing); 61 (telecommunications); 62 (information technology services activities); 63 (information service activities); 71 (architecture and engineering services); 72 (Scientific R&D); 85 (education); 86 (human health care activities); 91 (activities related to cultural and environmental heritage).

The total positive effects were with the sectors: 55 (accommodation); 56 (food); 63 (information service activities); 85 (education) and 86 (human health care activities), the latter two being the ones that showed the greatest positive results. The biggest negative effect was presented by the sector (waste collection, treatment and disposal).

For the modified effects, it was found that, in the reversed proportional variation, the greatest positive results were in sectors 85 (education); 86 (human health care activities). The most significant negative result for this effect was in sector 42 (infrastructure works. In the modified proportional variation, the positive highlight was sector 61 (telecommunications) and the greatest negative effect was sector 86 (human health care activities). Finally, regarding to the residual differential variation, sector 85 (education) was the most expressive in terms of positive results and sector 38 (waste collection, treatment and disposal) was the one with the most significant negative sign.

Overall, the results showed little or no regional and/or specialization advantage for sectors linked to ICTs, with the exception of the Education sector, which showed a positive sign in its result for many of the analyzed municipalities. It is known that many of these cities are known in Brazil and in the world for attractions related to tourist activity, however, only for the municipality of Tiradentes, the accommodation and food sectors, linked to the tourism production chain, were present with signs significant positives. This result gives evidence of the relative marginality of this activity for the region in question.

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Table 2 - Results of the Shift-Share Effects for Employment in the years 2010 and 2019

Ouro Preto								São João Del Rei							
Código	R	P	D	Efeito Total	T	M	RD	Código	R	P	D	Efeito Total	T	M	RD
35	0,13	-0,37	38,25	38,00	-7,99	-7,62	45,86	36	14,13	5,43	-29,56	-10,00	4,48	-0,95	-28,61
36	0,00	0,00		0,00	0,78	0,78		38	5,77	10,18	-103,95	-88,00	0,27	-9,91	-94,03
37	0,57	-0,17	-9,40	-9,00	0,00	0,17	-9,57	42	13,31	-47,64	13,34	-21,00	-48,21	-0,56	13,90
38	0,70	1,23	-11,93	-10,00	0,09	-1,14	-10,79	55	17,17	13,95	-17,12	14,00	12,37	-1,57	-15,55
42	11,91	-42,65	332,74	302,00	-124,98	-82,33	415,07	56	35,04	142,56	80,40	258,00	148,82	6,26	74,14
58	0,00	0,00		0,00	-10,37	-10,37		58	2,09	-20,34	-3,75	-22,00	-14,26	6,08	-9,83
61	0,51	8,39	-3,90	5,00	6,07	-2,32	-1,58	61	0,00	0,00		0,00	104,59	104,59	
63	3,55	-18,04	52,49	38,00	-38,42	-20,38	72,88	62	4,63	46,65	-52,27	-1,00	25,42	-21,23	-31,04
71	15,71	-32,08	-188,63	-205,00	-5,60	26,48	-215,11	63	0,89	-4,51	23,62	20,00	-13,90	-9,39	33,01
72	19,07	-234,21	-85,86	-301,00	0,00	234,21	-320,07	71	1,33	-2,72	0,39	-1,00	-2,61	0,11	0,27
85	109,87	377,59	-1804,46	-1317,00	66,66	-310,93	-1493,52	72	1,14	-14,01	8,87	-4,00	-35,91	-21,91	30,77
86	34,21	168,09	-114,30	88,00	133,73	-34,36	-79,95	85	111,70	383,90	501,39	997,00	441,18	57,27	444,12
91	1,84	3,98	-13,82	-8,00	2,26	-1,72	-12,10	86	71,28	350,18	-86,46	335,00	310,91	-39,28	-47,18
Ouro Branco								91	0,19	0,41	-0,60	0,00	0,32	-0,09	-0,51
38	12,29	21,70	38,01	72,00	23,81	2,11	35,90								
39	0,00	0,00		0,00	0,00	0,00									
42	3,67	-13,16	-37,52	-47,00	-2,81	10,35	-47,87								
55	22,87	18,58	185,55	227,00	25,53	6,95	178,60								
56	12,55	51,04	123,41	187,00	70,65	19,60	103,81								
71	0,00	0,00		0,00	-1,17	-1,17									
72	0,00	0,00		0,00	-5,13	-5,13									
85	0,38	1,31	14,31	16,00	3,52	2,21	12,10								
86	0,06	0,31	6,63	7,00	1,70	1,39	5,23								
91	0,00	0,00		0,00	1,29	1,29									

Source: Own elaboration based on data from RAIS (2021)

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4.2 Results for the specialization and location indicators

The information contained in Table 3 complements the analysis carried out through the application of the differential-structural method. The QL, which represents the specialization related to the state, did not present any sector with a result greater than the unity for the municipality of Congonhas. For Itabirito, the sectors with QL results greater than one were: 36 (water collection, treatment and distribution); 42 (infrastructure works); 55 (accommodation) and 56 (food).

Ouro Preto presented results above the unit for QL in the following sectors: 35 (electricity, gas and other utilities); 42 (infrastructure works); 55 (accommodation); 56 (food); 63 (activities for providing information services) and 91 (activities related to cultural and environmental heritage). For the municipality of Mariana, these sectors were: 36 (water collection, treatment and distribution); 55 (accommodation); 71 (architecture and engineering services); 72 (scientific R&D) and 74 (other professional, scientific and technical activities).

Attention is drawn to the fact that sectors directly or indirectly linked to tourist activity (accommodation, food, cultural and environmental heritage) contribute to the elaboration of strategic actions that promote other sectors related to the environment, ecology and historical heritage-cultural, and may also value the relationships of the local population with their history (Faria Silva, Ferreira Da Silva, & Tupy, 2019). In this aspect, Viana and Silva (2013) reinforce that cultural heritage, for example, refers exactly to cultural tourism, in which it reinforces the material and symbolic preservation of the place.

The municipality of Tiradentes had only three sectors with QL greater than the unit, namely: 55 (accommodation); 56 (food), 72 (scientific R&D) and 91 (activities related to cultural and environmental heritage). Such sectoral results denote the relative specialization of the municipality in activities characteristic of tourism. In Ouro Branco, the sectors that stood out were: 38 (waste collection, treatment and disposal); 42 (infrastructure works) and 55 (accommodation). Finally, the municipality of São João Del Rei had a higher QL than the unit for: 36 (water collection, treatment and distribution); 38 (waste collection, treatment and disposal); 55 (accommodation); 56 (food); 61 (telecommunications); 63 (information service provision activity); 72 (Scientific R&D); 74 (other professional, scientific and technical activities); 85 (education) and 86 (human health care activities).

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Table 3 - Location Quotient (QL), Location Coefficient (CL), Redistribution Coefficient (CR) and Specialization Coefficient (CE) according to Selected Sectors (2010 and 2019)

Código	Congonhas					Itabirito					Ouro Preto					Mariana				
	QL (2019)	CL (2010)	CL (2019)	CR (2010-2019)	CE (2019)	QL (2019)	CL (2010)	CL (2019)	CR (2010-2019)	CE (2019)	QL (2019)	CL (2010)	CL (2019)	CR (2010-2019)	CE (2019)	QL (2019)	CL (2010)	CL (2019)	CR (2010-2019)	CE (2019)
35	0,00	0,00	0,00	0,00	0,00	0,20	0,00	0,00	0,00	0,00	1,19	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
36	0,00	0,00	0,00	0,00	0,00	2,52	0,00	0,00	0,00	0,01	0,49	0,00	0,00	0,00	0,00	1,88	0,00	0,00	0,00	0,00
37	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,00	-0,02	0,00	0,00	0,00	0,00	0,00	0,00
38	0,51	0,00	0,00	0,00	0,00	0,31	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
39	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
42	0,40	0,01	0,00	-0,01	-0,01	2,26	0,00	0,00	0,00	0,03	1,34	0,00	0,00	0,00	0,01	0,47	0,00	0,00	0,00	-0,01
55	0,79	0,00	0,00	0,00	0,00	1,29	0,00	0,00	0,00	0,00	5,39	0,02	0,02	0,00	0,03	1,53	0,00	0,00	0,00	0,00
56	0,81	0,00	0,00	0,00	-0,01	1,03	0,00	0,00	0,00	0,00	1,81	0,00	0,00	0,00	0,03	0,93	0,00	0,00	0,00	0,00
58	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,59	0,00	0,00	0,00	0,00	0,08	0,00	0,00	0,00	0,00
61	0,01	0,00	0,00	0,00	0,00	0,14	0,00	0,00	0,00	0,00	0,16	0,00	0,00	0,00	0,00	0,52	0,00	0,00	0,00	0,00
62	0,00	0,00	0,00	0,00	-0,01	0,02	0,00	0,00	0,00	-0,01	0,72	0,00	0,00	0,00	0,00	0,02	0,00	0,00	0,00	-0,01
63	0,00	0,00	0,00	0,00	0,00	0,05	0,00	0,00	-0,01	0,00	4,00	0,00	0,01	0,01	0,00	0,82	0,00	0,00	0,00	0,00
71	0,28	0,00	0,00	0,00	-0,01	0,42	0,00	0,00	0,00	0,00	0,33	0,00	0,00	-0,01	0,00	8,59	0,00	0,03	0,03	0,06
72	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,03	0,00	-0,03	0,00	20,20	0,00	0,06	0,07	0,01
74	0,05	0,00	0,00	0,00	0,00	0,49	0,00	0,00	0,00	0,00	0,17	0,00	0,00	0,00	0,00	4,07	0,00	0,01	0,01	0,01
85	0,44	0,00	0,00	0,00	-0,02	0,66	0,00	0,00	0,00	-0,01	0,57	0,01	0,00	-0,01	-0,02	0,88	0,00	0,00	0,00	0,00
86	0,48	0,00	0,00	0,00	-0,02	0,47	0,00	0,00	0,00	-0,02	0,80	0,00	0,00	0,00	-0,01	0,69	0,00	0,00	0,00	-0,01
91	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	6,13	0,03	0,02	-0,01	0,00	0,00	0,00	0,00	0,00	0,00

Código	Tiradentes					Ouro Branco					São João Del Rei				
	QL (2019)	CL (2010)	CL (2019)	CR (2010-2019)	CE (2019)	QL (2019)	CL (2010)	CL (2019)	CR (2010-2019)	CE (2019)	QL (2019)	CL (2010)	CL (2019)	CR (2010-2019)	CE (2019)
35	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
36	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,34	0,01	0,01	0,00	0,01
37	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
38	0,00	0,00	0,00	0,00	0,00	7,01	0,01	0,02	0,00	0,02	0,05	0,00	0,00	-0,01	0,00
39	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	45,02	0,00	0,19	0,19	0,00
42	0,23	0,00	0,00	0,00	-0,02	1,82	0,00	0,00	0,00	0,02	0,43	0,00	0,00	0,00	-0,01
55	39,06	0,01	0,02	0,01	0,25	1,11	0,01	0,00	-0,01	0,00	2,03	0,01	0,00	0,00	0,01
56	5,41	0,00	0,00	0,00	0,14	0,74	0,00	0,00	-0,01	-0,01	1,22	0,00	0,00	0,00	0,01
58	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,68	0,00	0,00	0,00	0,00
61	0,00	0,00	0,00	0,00	0,00	0,16	0,00	0,00	0,00	0,00	2,36	0,00	0,01	0,01	0,01
62	0,00	0,00	0,00	0,00	-0,01	0,19	0,00	0,00	0,00	-0,01	0,48	0,00	0,00	0,00	0,00

63	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,20	0,00	0,00	0,00	0,00
71	0,54	0,00	0,00	0,00	0,00	0,44	0,00	0,00	0,00	0,00	0,13	0,00	0,00	0,00	-0,01
72	1,44	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	1,08	0,00	0,00	0,00	0,00
74	0,00	0,00	0,00	0,00	0,00	0,10	0,00	0,00	0,00	0,00	1,51	0,00	0,00	0,00	0,00
85	0,23	0,00	0,00	0,00	-0,03	0,81	0,00	0,00	0,00	-0,01	3,15	0,01	0,01	0,00	0,09
86	0,08	0,00	0,00	0,00	-0,04	0,98	0,00	0,00	0,00	0,00	1,54	0,00	0,00	0,00	0,02
91	27,03	0,00	0,01	0,01	0,01	0,00	0,00	0,00	0,00	0,00	0,73	0,00	0,00	0,00	0,00

Source: Own elaboration based on data from RAIS (2021)

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The CL, which identifies the dispersion and concentration of economic activities, assumes values between zero and one, and results close to zero say that the regional distribution of the sector is similar to the set of other sectors of each region, in this case, of each municipality considered (Stamm et al., 2003; Alves, 2012). Table 3 shows that all results were zero or very close for both 2010 and 2019.

The CR, which seeks to verify whether there was a change in the distribution of a particular sector in the studied region, within a period of time, if it presents a result close to zero, it means that there were no changes in the distribution of the sector (Stamm et al., 2003 ; Alves, 2012). As can be seen, still in Table 3, all results were zero, or close to zero. For CE, results close to zero indicate that the productive structure of the municipality is similar to that of the state. In the present study, all results were zero or close to zero.

Table 4 - Restructuring Coefficient (CRR) for Selected Sectors between 2010 and 2019

Indicador	Congonhas	Itabirito	Ouro Preto	Mariana	Tiradentes	Ouro Branco	São João Del Rei
CRR	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Source: Own elaboration based on data from RAIS (2021)

Regarding to the CRR, when the result is close to zero, it is considered that there has been no change in the sectoral composition of the region. If it is close to one, sectoral changes have been significant and the region's productive structure has changed. Table 4 shows that there was no change in the productive structure of the region between 2010 and 2019.

5 Closing Remarks

The hypothesis that there is a productive concentration, small diversification, in the municipalities of the Minas Gerais FQ region between 2010 and 2019 was confirmed from the analysis and discussion of the results obtained. This aspect, in turn, ends up inhibiting the development of other sectors such as tourism, activities related to science and technology, etc. As highlighted by Florida (2011), scholars of urban and regional growth such as Robert Park, Jane Jacobs and Wilbur Thompson have long demonstrated the role of place in the incubation of creativity, innovation and new sectors.

It is remarkable the fact that the accommodation and food activity have stood out positively only in the municipality of Tiradentes. Another relevant aspect is that although Ouro Preto was the municipality with the highest number of sectors presenting results for the shift-share method, many of these results were negative. In view of the need and urgency of planning and implementing a multidimensional economic development after the Fundão dam failure, which occurred in Mariana, but also directly affected Ouro Preto, the results found in this research are alarming.

Ouro Preto and Mariana are believed to have great potential for productive diversification and for developing/strengthening structures based on intelligence (smart city). This is due to: the existence of cultural tourism; the Federal University of Ouro Preto (UFOP) having campi in both municipalities; in addition to UFOP, Ouro Preto also has the Federal Institute of Minas Gerais (Ouro Preto campus); the possibility of expanding the tourism sector to the ecological segment, given that the two municipalities have a rich natural heritage. Taking advantage of these attributes of Ouro Preto and Mariana to make them smart and sustainable cities requires investments in education, infrastructure and ICTs as an important link for the balance between the environment, social well-being and economic growth.

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