POSSIBLE IMPACTS OF THE CLOSURE OF ACTIVITIES RELATED TO COAL EXTRACTION IN THE SOUTHERN REGION IN BRAZIL:

AN ESTIMATE FROM THE INPUT-OUTPUT MATRIX

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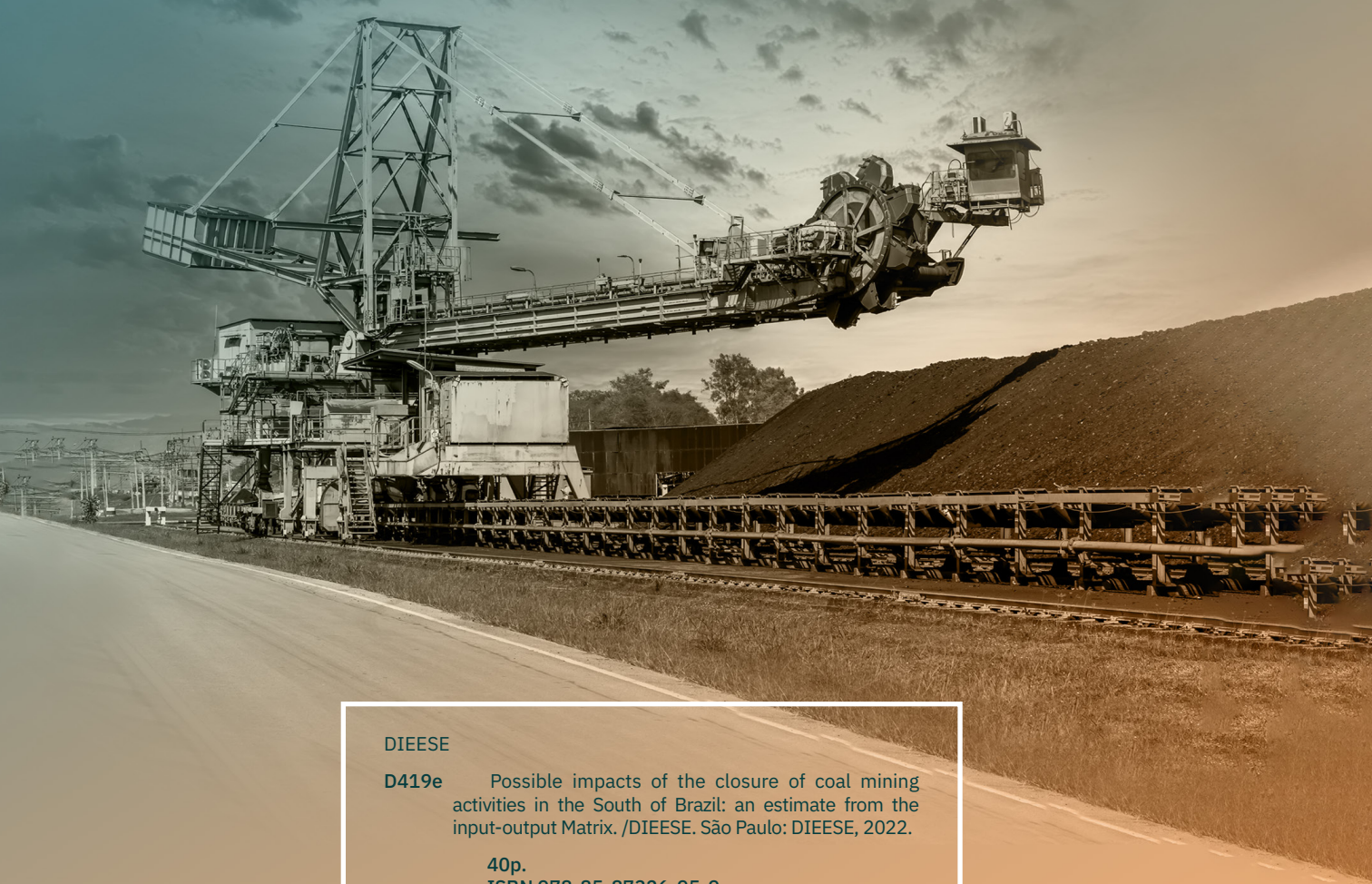

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SUMMARY

1. Introduction

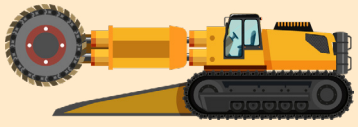
Energy sources are at the center of the “global warming” debate, with its effects already being present in the world: according to reports presented by the Intergovernmental Panel on Climate Change (IPCC) [1] the increase in climate extremes projects negative effects on all spheres of life on the Planet, many as a result of the use of non-renewable and polluting energy sources.

1 According to the report presented by the group (created in 1988) in early August 2021, the average temperature of the planet, due to human action, increased by 1.07 degree Celsius, already causing imbalance in the climate reflected in the greater occurrence of extreme weather events. For more see: https://g1.globo.com/natureza/aquecimento-global/noticia/2021/08/09/influencia-humana-e-responsavel-por-alta-de-107c-na-temperatura-global-estima-relatorio-do-ipcc-orgao-da-onu.ghtml

The use of fossils and non-renewable inputs, in a general context of increased consumption and reduced life cycles of products in general, is pointed as one of the main responsible factors for this acceleration of climate extremes. Given this context, efforts to reduce the use of materials directly linked to these raw materials, as well as energy generation, have been constantly discussed, with the adoption of goals such as those agreed upon in the "Paris Agreement" in 2015. However, there is still a long way to go to meet these goals, even because this environmental transition is considered divergent by many governments, in a context of pressure for post-pandemic economic growth (which many studies even attribute to another effect of climate change[2]) marked by the worsening of social issues.

Such changes include changes in the consumption of many products and inputs, especially oil derivatives and coal, fuels used on a large scale around the world. Oil is used in numerous applications in industry, such as plastics and cosmetics, in addition to its use as an energy source in cars, industrial processes, electricity generation, among others. Coal, on the other hand is still widely used in industrial processes and as an energy source. Both are responsible for a significant part of carbon emissions. It is noteworthy, for example, that 75% of the energy generated in the world, in 2019, had non-renewable sources as its origins, which highlights the importance of discussing a greater diversification of energy sources towards those considered less polluting and/or renewable.

2 The IPCC document from 2007 had already warned about possible problems to human health directly related to climate change, given the spatial change of disease vectors. For more see: https://www.unicamp.br/unicamp/inex.php/ju/artigos/ambiente-e-sociedade/mudancas-climaticas-e-covid-19-perspectivas-futuras-para



Another widely discussed aspect, and one on which there is still little consensus, is whether these productive transformations will be achieved through a "Fair Transition" that ensures a balance between environmental, economic and social demands, especially by reducing social inequalities and ensuring that no worker is left out of his or her right to subsist[3]. It is urgent to face these challenges, even if it is assumed that there is asymmetry in responsibilities for the destruction of the environment among countries (not all pollute and pollute at the same intensity).

In Brazil, despite its image of a country linked to nature, the reality is different: growing fires, deforestation, inadequate land use and the use of many polluting fuels and inputs are present in the National context. On the other hand, in addition to a clear progress in search of replacement of various energy sources made over the years, such as the use of ethanol or biodiesel to replace oil, there are still efforts in the production of clean energy, such as hydroelectric plants (although they cause non negligible secondary environmental problems), wind and solar energy, among others. In the year 2019, while the use of non-renewable energy sources in the world averaged 75%, in Brazil, this percentage was 17%, that is, 83% of energy sources in the country are considered "clean".

It is important to note that non-renewable sources 9coal and derivatives, oil and derivatives, natural gas and nuclear) have low participation in the electric matrix of Brazil, unlike what occurs in the world (DIEESE,2021).

3 The concept of Fair Transition and international debate are systematized in a publication by DIEESE and WWF that can be accessed through the link: https://www.dieese.org.br/outraspublicacoes/2021/carvaoMineral.html

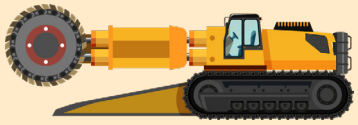
The recent period in the country registered changes in rainfall patterns, causing drought in several locations, affecting the levels of reservoirs and promoting a reduction in the generation of hydroelectric energy. Since the demand for electricity in Brazil is relatively inelastic (that is, it does not fall in the same proportion as a price increase resulting from a fall in supply), the Brazilian Government has been betting on contracting new thermoelectric plants, which generally use fossil fuels, to cover this generation deficit. That is, while several countries are looking for ways to increase their sources considered "clean", the Brazilian Government, due to lack of planning and little concern with the environmental issue and climate problems, has opted for fossil fuels.

This becomes clear in decree 540/2021 issued by the Ministry of Mines and energy which details the "Program for the sustainable use of the national mineral coal[4] and also by the incentive to the implementation of gas thermoelectric plants included in law 14.182/21 which deals with the privatization process of Eletrobrás.

Considering that coal extraction and processing activity is concentrated in municipalities of the Southern region of the country and is part of the history of the local economy and culture, it is essential to evaluate its economic and social importance in order to ensure , in case of cessation of the activity, fair energy transition processes, through which eventual productive transformations ensure not only better environmental conditions, but above all, bring guarantees that the economy, employment, wages and other social conditions will be improved in the transition process.

Without these guarantees, the simple elimination of activities linked to the extraction and production of coal-based energy would constitute a typical case of "unfair energy transition" since it would not offer any compensation for its economic and social aspects, only environmental commitments.

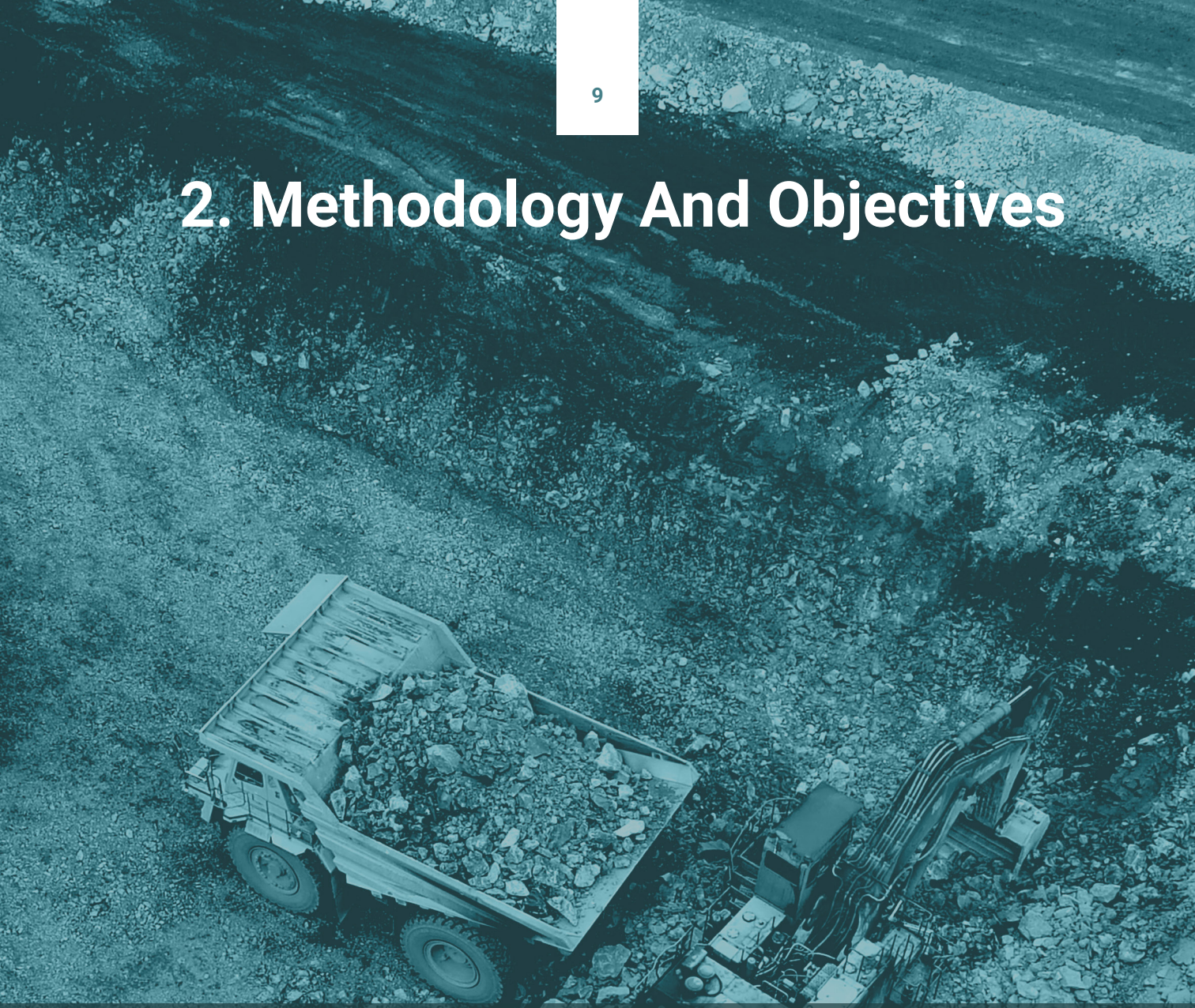
4 https://www.gov.br/mme/pt-br/assuntos/noticias/mme-publica-detalhamento-do-programa-para-uso-sustentavel-do-carvao-mineral-nacional/programa-para-uso-sustentavel-do-carvao-mineral-nacional.pdf



Thus, given the challenged posed to coal extraction, as well as the energy generation based on it, this study aims to measure the size of the segment[5] of the domestic, viewing the possible impacts of an eventual closure of these activities in the country, especially in terms of jobs, tax collections and value added.

5 Although there is also the use of coal in industrial processes, in blast furnaces, this will not be the object of study, because besides using predominantly imported product, it is not yet subject, initially, to the discussion of “Fair Transition” of the end of coal in Brazil, which would focus more specifically on the end of extraction activities and energy production in thermoelectric plants from the domestic product.

2. Methodology And Objectives



To estimate the importance of the domestic coal sector, this study uses the input-output Matrices (IPM) instrument developed by Leontief (1988). This model enables a more accurate observation of inter-sectoral relations, showing a “photograph” of the economy based on its economic relations, always considering equality between supply/production and demand.

As can be seen in Chart 1, the IPM gathers information on production from its providers and demanders. On the demand side, it is possible to observe transactions between economic sectors used as intermediate consumption of inputs, the demand for final goods by investment, government and household consumption, in addition to goods exported abroad. On the supply side, one can observe the origin of the supply, that is, whether it is domestically produced or imported. From the point of view of the value added generated in the production process, the number of occupation by each sector, the payment of salaries, the generation of profits, taxes, imports, among others, is observed.

Considering the division of IPM into a table of transactions, one can divide them into three quadrants where:

- **The first (1st)** refers to intermediate consumption, or the money flow in each economic activity.

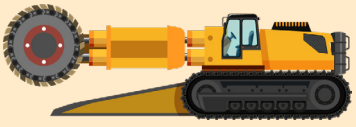
- The second (2nd) relates to the breakdown of final demand (f) by items (I = investment, X = exports, VE = stock variation, CG = government consumption, CF = household consumption), in which fi is the value of the production of activity i destined for final demand.

- **The third (3rd)** quadrant disaggregates imports and values added, distributed in wages and taxes, among others. Total production is represented by **g**, where **gi** is the production of sector **Ai** and **gj** is the production of sector **Aj**.

Table 1: Table of Transactions and Respective quadrants.

<table>
<tr><td rowspan="2">Activities</td><td>A1</td><td>A2</td><td>Aj</td><td>An</td><td>I</td><td>X</td><td>VE</td><td>CG</td><td>CF</td><td>f</td><td>Total Production</td></tr>
<tr><td colspan="10"></td><td>G</td></tr>
<tr><td>A1</td><td></td><td></td><td></td><td></td><td colspan="5" rowspan="4">2</td><td rowspan="4">fi</td><td rowspan="4">Gi</td></tr>
<tr><td>A2</td><td></td><td>1</td><td></td><td></td></tr>
<tr><td>Ai</td><td></td><td></td><td>gij</td><td></td></tr>
<tr><td>An</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Imports – M</td><td colspan="4" rowspan="5">3</td><td colspan="5" rowspan="5"></td></tr>
<tr><td>Value Added - y’</td></tr>
<tr><td>Wages</td></tr>
<tr><td>Taxes and subsidies</td></tr>
<tr><td>Surplus</td></tr>
<tr><td>Total production - g’ (transposed)</td><td colspan="4">gj</td><td colspan="5"></td></tr>
</table>

Source: prepared based on Feijó and Ramos (2013), page 324.



Given this information, the input-output model is built through linear algebra operations based on the identities of the National accounts. The central idea of the model is to calculate production from the proportion of intermediate inputs demanded directly and indirectly, used for the production of goods used to meet final demand.

The proportions of the uses of inputs are called technical coefficients of production (a_{ij}), and are as follows:

$$a_{ij} = \frac{g_{ij}}{g_j} \qquad (1)$$

In which the value is produced in the activity ***i*** and consumed in the activity j to produce a monetary unit (g_j) of ***j*** output of the sector. That is, it is possible to establish a relationship between the value of production and intermediate inputs:

$$g_{ij} = a_{ij} \times g_j \qquad (2)$$

When considered the sum of the rows in quadrant I in Table 1 above, it gives us the value of production of each activity:

$$g_i = \sum_j^n + g_{ij} + f_j \qquad (3)$$

Where n is the number of sectors of the economy. Using equation (2) and (3), the result would be:

$$g_i = \sum_j^n (a_{ij} x\ g_{ij}) + f_i \qquad (4)$$

In matrix notation, in which A represents the matrix of direct technical coefficients of production, we would have:

$$g = A \times g + f \quad (5)$$

By solving the model to ***g***, we have:

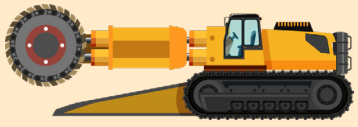
$$g - A \times g = f \quad (6)$$

$$g = (I-A)^{-1} f \quad (7).$$

The Matrix $(I-A)^{-1}$ represents the inverse Leontief matrix Z or matrix of total technical coefficients, as in:

$$g = Zf \quad (8).$$

This includes the direct coefficients present in A and the indirect coefficients calculated from the power series derived from the inverse.



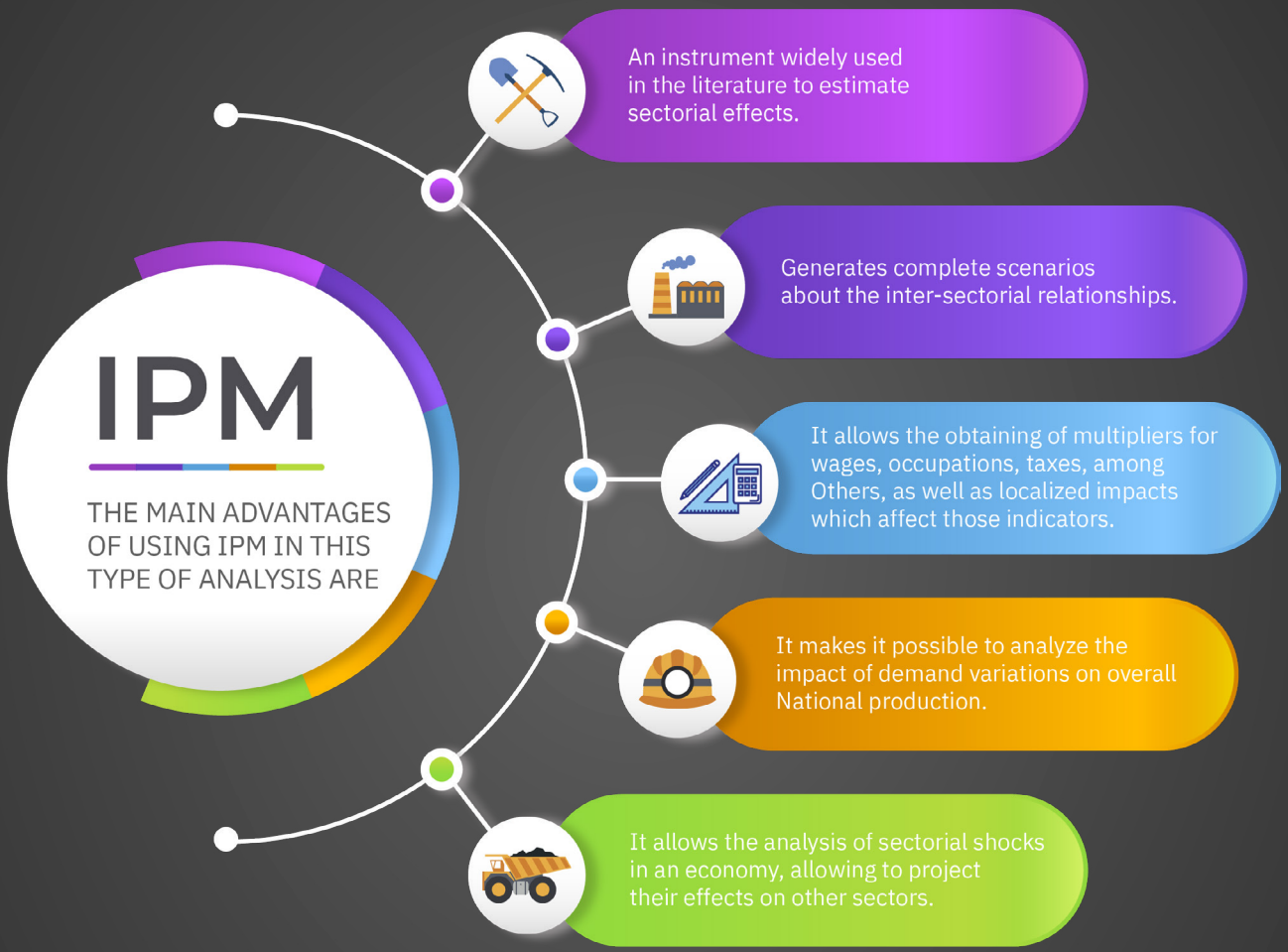
As described by Feijó Ramos (2013), the main assumptions of the IPM system are:

- **Homogeneity:** each product is supplied only by a single economic activity, with a unique production technology and each activity makes only one product for intermediate consumption.

- **Proportionality:** the volume of inputs produced by each activity has direct relationship with the level of production of that activity only.

Because of these hypotheses, it is possible to calculate the effect of exogenous “shocks” on the final demand (input) to determine the impacts on production (output), through the coefficients calculated from the inverse Leontief matrix. Thus, it is possible to observe the impacts on production due to the variation in final demand, as well as other elements of the model, such as, for example, added value, occupations, tax collection, among others.

The main advantages of using ipm in this type of analysis are:



Among the main issues of debate of this instrument, the following stand out:

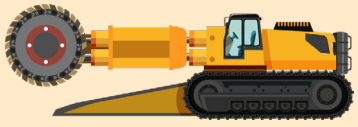
- It is “static”; these are “photographs” that generate economic scenarios limited to the year in which they were obtained;
- IPMs are generally published for years delaying the current year;
- It is assumed the existence of fixed technical coefficients and constant returns to scale;
- Supply of resources is infinite and these are used with maximum efficiency;
- Imports are competitive, i.e. it would be possible to import the goods that are no longer produced nationally.

Regarding the periodicity of publications, the Brazilian IPMs are officially published on a five-yearly basis, i.e. every five years, the latest being made available by IBGE for the year 2015. There are numerous techniques for updating the IPMs and, in this present work, the database used will be the one provided by Passoni and Freitas (2020). The most recent year of this estimation is used, which is 2018, since this methodology uses the Tables of Resources and Uses (TRU) from the National Accounts System of IBGE to update the IPMs, and the latest one available is for this year.

The basic question to be answered by this present exercise is:

Taking into consideration the 2018 IMP, updated according to Passoni and Freitas (2020), **what would be the impact on the Brazilian Economy resulting from the complete interruption of activities related to domestic coal, whether in extraction and processing or in the production of thermal plants that use this input**

This information is of fundamental importance, given that the pressure for the closure of these activities, desirable from the environmental point of view, would result in losses of employment, income and tax collection for people, companies and municipalities involved, which would require the implementation of specific public policies to ensure a fair energy transition process.



To calculate an impact estimate of what the end of coal extraction in Brazil would represent, as well as the end of the use of this product in thermoelectric power plants[6], the "Hypothetical Extraction" technique will be used, as described by authors such as Miller & Blair (2009), among others. This technique consists of ta hypothetical withdrawal of a particular economic activity, and the effects of this "extraction" are observed from the comparison of the initial scenario and after the modification.

For aggregation reasons in the system of National Accounts, the hypothetical extraction will be partial, as Dietzenbacher and Lahr (2013)[7] suggest. The coal shock will be observed through two partial hypothetical extractions:

i) related to the Mineral coal product, which would have its extraction terminated;

ii) change in the energy production technology considering that the National coal could no longer be used as an alternative for production via thermal plants[8].

Thus, based on the updated 2018 IPM, the effect of partial extraction will be observed to analyze the impacts on:

a. Occupation
b. Tax Revenue
c. Value Added
d. Wage bill
e. Social Security Collection and FGTS

6 But without considering its use in industrial processes, in which the supply of the product is met by imports; this case will not be drawn from the Brazilian economy, not being the object of study.
7 Another application to the Brazilian economy can be seen in Fernandes, Haddad and Dias. (2021).
8 It is assumed that coal would not be imported to supply the thermal plants that currently use Domestic coal.

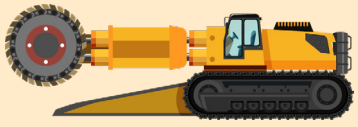
In the production matrix of the Resources Table of the System of National Accounts, mineral coal is found together with other productive activities within the activity “Extraction of mineral coal and non-metallic minerals” (activity code 0508).

Therefore, for the application of this technique, the percentage of participation of the national production of the product “Mineral coal” (product 05801) in the total national production of the activity “Extraction of mineral coal and non-metallic minerals” (activity code 0580) will be considered. For the year 2008, out of a total of R$ 19,853 million of this activity, the national production of the product “Mineral Coal” (product code 05801) was R$ 1,127 million, i.e. 5,67%. For the production of energy based on national coal, the hypothetical extraction will be carried out in the activity “Electric Power, natural gas and other utilities”. (activity code 3500).

According to Aneel data, coal-based energy production corresponded to 2,3% of the total electricity generated in 2018[9]; and the states of Santa Catarina and Rio Grande do Sul, respectively concentrated 1,02% of the total[10], this value will be the reference for this exercise.

9 Data available at : https://dados.gov.br/dataset/geracao-por-fonte , twith the National Electric Energy Agency (Aneel) as the primary source.

10 Empresa de pesquisa Energética (EPE), Balanço Energético Nacional 2019- based year 2018, table 8.1e. According to the same source of information, for the year 2018, the states of Santa Catarina and Rio Grande do Sul produced, respectively, 4,148GWh and 2,007 GWh, equivalent to 43,3% of the total coal based energy produced in the country (14,204 GWh) and 1,02% of the total electricity produced in the country (601,398 GWh). The rest is produced by thermoelectric plants located in the North and Northeast states using Imported coal.



In the hypothetical extraction, an extraction matrix is defined, which is similar to a square identity matrix with the exception of the column and row corresponding to the activity from which one wishes to extract. In the case of partial extraction, the diagonal associated to the activity to be extracted will be replaced by values between 0 and 1 (partial). In this way, the multiplication of Xj by another square matrix of production of the same dimension reduces the elements of the selected row/column. There is a "reduction" in intermediate consumption and in the relationship with other sectors carried out by the activity one wishes to "extract", impacting the reduction in production that leads to the following equation, in which one obtains a vector of total production that excludes the influence of the selected activity:

$$(I - X_j AX_j)^{-1} X_j e \quad (9).$$

where:

e: column vector that selects the nth activity;

$(I - X_j AX_j)^{-1}$: Leontief inverse matrix (Z) weighed by the extraction matrix X_j.

It is important to note, however, the following aspect:

The hypothetical partial extraction, in practice, acts as a proxy for the withdrawal of part of a sector. The simplifying assumption, as argued by Diezenbacher and Lahr (2013) is that if a sector is composed of several different economic activities within it, the assumption is that they have the same or at least similar technology.

Otherwise, if relevant technological differences between activities are found internally, the hypothetical partial extraction would not allow us to affirm, in economic terms, that there was "extraction" from the application of the proportions of participation of a given activity as performed in this work, but rather that there was only a reduction of the sector, without distinction[11].

11 Although data on coal exist at the product level, there is no algebraic solution for a model that the number of products is greater than the number of activities, as it is the case in the Brazilian System of National Accounts. For more details, see Miller & Blair (2009).

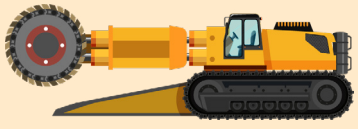
However, this technique is still the most suitable. Dietzenbacher and Lahr (2013) conduct tests and observe that there is proximity between the "total" extraction of a sector at the disaggregated level and "partial" extraction for a more aggregated sector. That is, this indicates that there is not the aggregation bias that could be expected, corroborating that, at least, at the sector level, the differences would not be large enough to generate differentiations in the calculations of hypothetical partial extraction:

> *(...) note that across the two aggregations, the corresponding results are surprisingly close. This indicates that in moving from a US economy model of 65 industries to one of (...) 15 sectors (in the year 2006), the results from partial extraction do not suffer much from aggregation bias.* (Dietzenbacher and Lahr, 2013, page 351 and 354).

It should be noted that, in the exercise described above, the total cumulative effect of extraction may not be fully coincident with the sum of the isolated parts due to the fact that, when considering direct and indirect effects for the activities in question, the multiplier in the matrix acquires a value less than 1 from the multiplication of both, since it involves simultaneous events and not the simple sum as it would be isolated effects.

To put it another way:

It is considered that the end of coal production and its use as a source of electricity in SC and RS will occur at the same time, and not in a staggered manner, which means that the joint quantitative effect of these two actions may be less than if they were analyzed by adding up their effects in isolation, if they did not occur simultaneously.



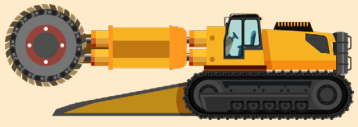
3. Economic Issues Of Hard Coal In Brazil

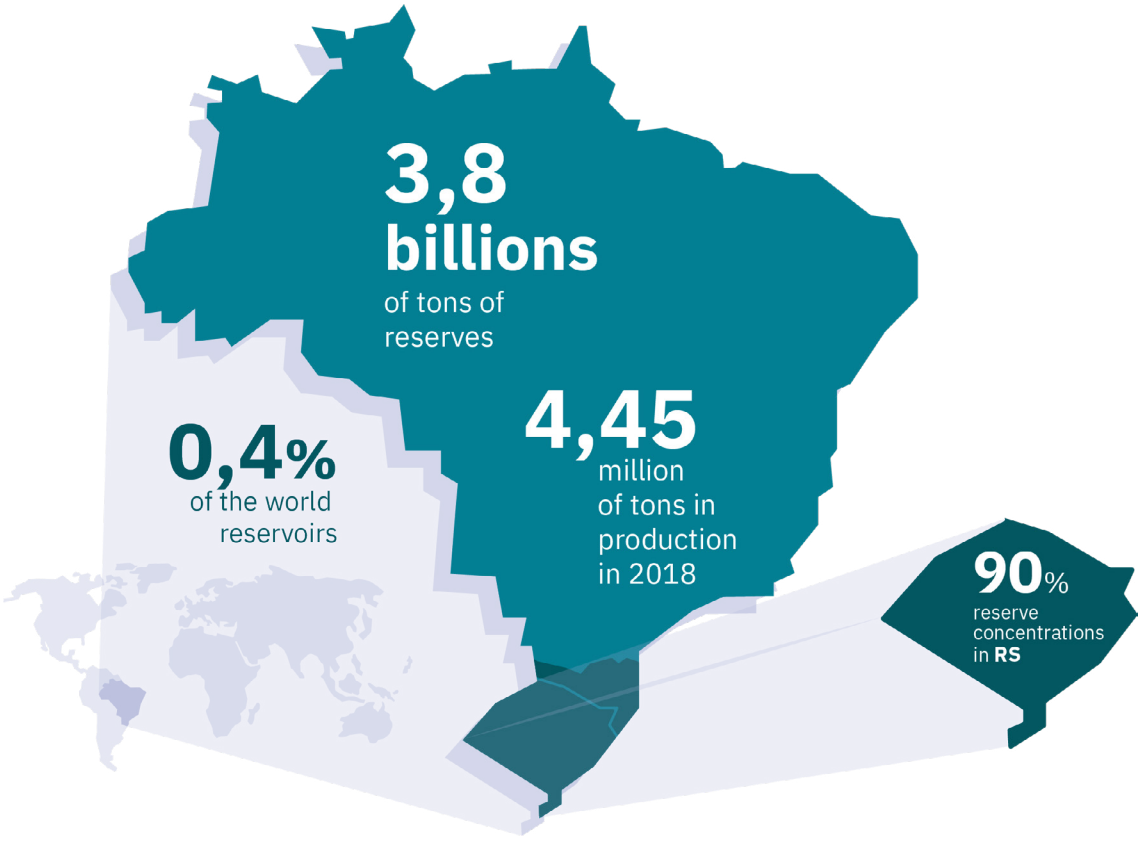
Coal has been used as a source of energy on a large scale since the nineteenth century in England, due to its use in steam engines. Since then, its use has been uninterrupted and it is an important source of energy in the world, although its use is increasingly discouraged, both for issues related to the extraction process, with great potential to harm the health of workers, and for environmental issues, since its extraction impacts many environments.

Also, because it is an element with high carbon content (can reach 95%), causing emissions amid Global Warming. Its quality depends on the region and climate where it was formed, as well as the geological evolution, so there is an important component of geographical location, not commonly found any location.

Currently the largest reserves are concentrated in the United States, China and Russia, estimated at over 800 billion tons. The largest producers are China, the United States, India, Australia, Indonesia, Russia, South Africa, Germany, Poland and Kazakhstan. The largest consumers are China, the United States, India, Russia and Germany. In Latin America, the largest producers are Colombia, Mexico, and Chile, as well as Brazil. In Brazil, the most common variety of mineral coal is the hard coal type, which has lower combustion power and a higher ash content.

Its most common use has been as a fuel in thermoelectric plants, and is also use, to a lesser extent, as “coque” (metallurgical coal) in blast furnaces, the demand for which is met by imports of coal, of varieties with greater combustion power and better energy efficiency.





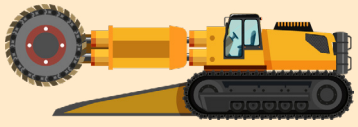
Regarding reserves, there is an evident concentration around the state of Rio Grande do Sul, with approximately 90%, with Santa Catarina concentrating almost 10% and Paraná with less than 1%; only the municipality of Candiota concentrates 38% of Brazilian reserves[12]. The total estimated coal resrves in Brazil was 3.8 billion tons, or 0,4% of the world total, in 2018. About the national production, it was 4,45 million tons in 2018[13], with its production concentrated regionally, without long production chains, usually as fuel for thermoelectric plants.

12 Source: Ministério das Minas e Energia. Accessed on 28/10/2021, available at: http://antigo.mme.gov.br/documents/36108/1006289/Boletim+do+Setor+Mineral+%E2%80%93+outubro+2020+dados+atualizados+at%C3%A9+setembro+de+2020.pdf/3c490442-f48d-4ed3-41e3-6654e17e8ba0?version=1.0

13 Source: Ministério das Minas e Energia. Accessed on 28/10/2021, available at: http://antigo.mme.gov.br/documents/36108/1006289/Boletim+do+Setor+Mineral+%E2%80%93+outubro+2020+dados+atualizados+at%C3%A9+setembro+de+2020.pdf/3c490442-f48d-4ed3-41e3-6654e17e8ba0?version=1.0

A smaller part of the coal waste (ashes) is destined for the cement and ceramics industries located in the region. Therefore, any modification of this production and consumption structure will affect mainly these two states (RS and SC), in which even this activity has a cultural and historical character.

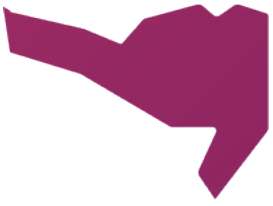
This concentration can also be observed in relation to those employed in the sector: according to data from the Annual Social Information Report (RAIS) of the Ministry of Labor and Social Security, which only include workres with a signed work permit (it does not include informal workers and self-employed workers, among others). In Brazil, in 2019, there were 3.607 workers with a signed labour permit in the activity of coal extraction and processing: of these, 71,2% were in Santa Catarina, 16,8% in Rio Grande do Sul and 7% in Paraná, with the South Region concentrating 95% of the jobs with a labor permit in the activity, according to RAIS.



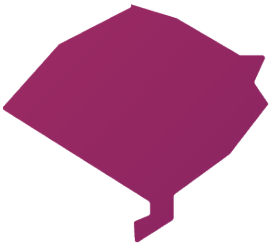
3.607

workers

with signed labor contracts in coal extraction and processing in 2019.



71,2% SC



16,8% RS

7% PR

95%

of the jobs in the activity are on The South Region

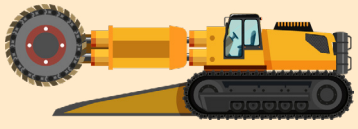
(Source: Rais/2019)

Considering the data from the 2018 IPM, updated by the criteria of Passoni and Freitas (2020), in relation to the total of its production values, the total demand for mineral coal in Brazil was R$15,397 million. Almost all of this amount was used as an input for other sectors, and only a little over R$ 220 million was demanded by end consumers.

Of the total demand for the product, in terms of value, by the Brazilian economy, domestic coal production supplied R$ 1,190 million, with production of R$ 1,127 million and a reduction in stocks of R$ 64 million. In other words, most of the demand for the product (R$14,270 million or 92,7%) was met by imports, especially from Colombia, to supply thermoelectric and steel mills located in the North and Northeast Regions of Brazil. This occurred, as previously highlighted, due to the fact that the national product is not considered the most appropriate for use in industrial blast furnaces.

The value added of "Coal extraction and non-metallic minerals" was R$ 8,151million, and the number of occupations in these two activities (which by IPM definition cannot be directly separated) was 118,276[14].

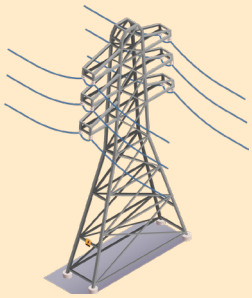
14 It should be noted here that the concept of "occupation" in the IPM, despite relating to the "labor factor" (production factor), is not directly comparable either with the concept of "occupation", as present in household surveys such as PNAD, or with the formal employment relationship described in the information from RAIS. Although it is a measure of labor, there are differences between the collection period, its nature, since RAIS is an administrative record, PNAD is a sample household survey and the IPM is related to the National Accounts using sectorial surveys. In the IPM, it is not possible to know whether it is formal or informal ties, among other aspects. Therefore, despite being a valid and usable indicator of the volume of work, ("labor factor") used in the economy, the comparison with other indicators on the labor market is not correct.



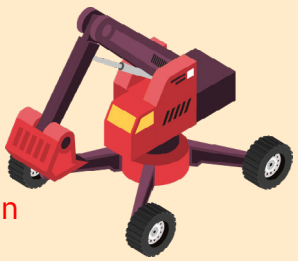
When observed the production of electric energy (Electricity, natural gas and other utilities), in which is included the generation of energy based on mineral coal, the total national production related to the activity is R$318,541 million, and the rest of the demand is met through imports, which totalize R$ 5,330 million. The added value of the activity was R$ 121,094 million and the number of occupied people in 2018 was 158,398.

ELECTRIC ENERGY IN 2018

R$ **318.541** million
(national production)



R$ **5.330** million
(imports)



R$ **121.094** million
(amount added)

158.398
(people with occupations)

3.1. Impact Of The End Of Coal Mining In Brazil

Considering the hypothesis of the end of coal extraction activities in Brazil, as well as the generation of energy based on it[15], there will be a partial extraction performed based on the methodology described in works such as that of Dietzenbacher and Lahr (2013) and Fernandes, Haddad and Dias (2021), in relation to the totals observed in the activities of "Extraction of coal and other non-metallic minerals" and "Electric power, natural gas and other utilities".

The proportions considered for this partial extraction for the year 2018 are as follows:

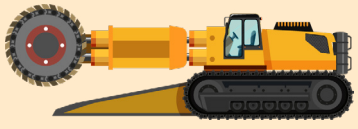
5,67%

was the share of coal production in the total national production of exploration of coal and other non-metallic minerals.

1,02%

was the share of coal as an energy source in the states of Santa Catarina and Rio Grande do Sul, in the total electricity production in the country in 2018

15 It is not the object of this paper to analyze the end of the use of coal in Brazil, but rather the end of the extraction of the product and its use as an energy source.



Thus, considering the methodology described and the indicators shown above, the results of the complete shutdown of domestic-coal related activities in Brazil would be as follows:

Table 1: Results of a hypothetical partial extraction in Brazil's 2018 IPM of the full joint closure of coal extraction and power generation activities from it, direct and indirect effects (MP I).

	Cumulative effect Total	Total Brazil with partial hypothetical extraction in IPM	Total Brazil Original	% in relation to total	Estimate of Isolated Effects*			
					Coal		Coal energy	
					Values	%	Values	%
Employment (number of occupations)	-36.191	104.340.275	104.376.466	0,035%	-16.039	44,32%	-20.152	55,68%
VA (R$ millions)	-4.344	6.011.150	6.015.494	0,07%	-1.139,64	26,23%	-3.204,36	73,77%
Taxes (R$ millions)	-1.587	992.991	994.578	0,16%	-311,20	19,61%	-1.275,80	80,39%
Salaries (R$ millions)	-1.149	2.422.298	2.423.447	0,05%	-427,78	37,23%	-721,22	62,77%
INSS + FGTS (R$ millions)	-292	514.373	514.665	0,06%	-103,89	35,58%	-188,11	64,42%

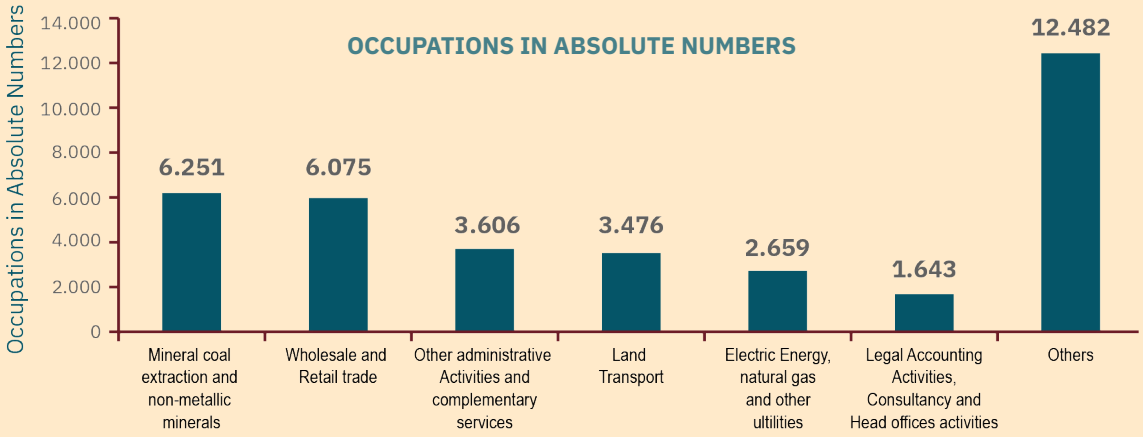
Source: Elaboration based on the IPM from Passoni and Freitas (2020).

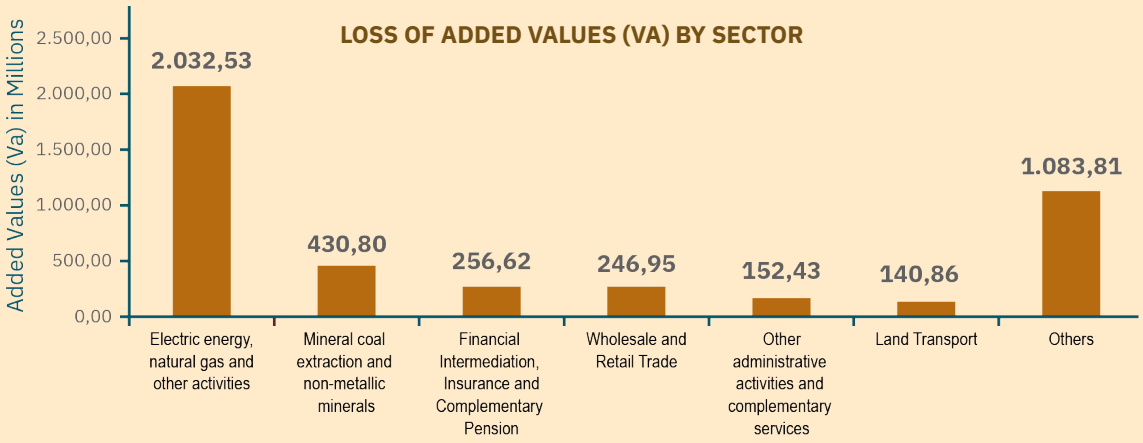
* To obtain the estimate of isolated effects, we considered the participation of each one separately, which were applied to the values of the events that, by assumption, would occur together.

As it can be seen in the Table 1, there would be a reduction of 36,2 thousand occupations in relation to the total verified in 2018 (-0,035%), of which approximately 44% would be derived from the end of coal extraction and 56% originating from the end of energy generation based on national coal, or 20,2% thousand. In the same way, there would be a reduction in the Added Value (VA), in relation to what was verified in the year, R$ 4,3 billion, a reduction in tax collection of R$ 1,6 billion, a drop in the salary mass of R$1,1 billion and a reduction in the collection INSS and FGTS of R$ 292 million. As observed, in general, the results show a strong concentration of the effects derived from the end of coal-related activities on energy production, to the detriment of extraction, with percentages on the total effect varying between 56% and 80,6%, as in the case of tax collection. Another important aspect to be highlighted is that, as hypothesized, a concentration of effects should occur around coal producing localities and power generation based on the product, especially in the states of Santa Catarina and Rio Grande do Sul, in which there is a concentration of the product activities.

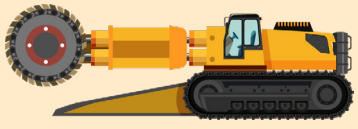
The distribution of the effects of the end of the coal-related activities, whether extraction or energy production, on the other economic sectors can be seen in the Graphs below:

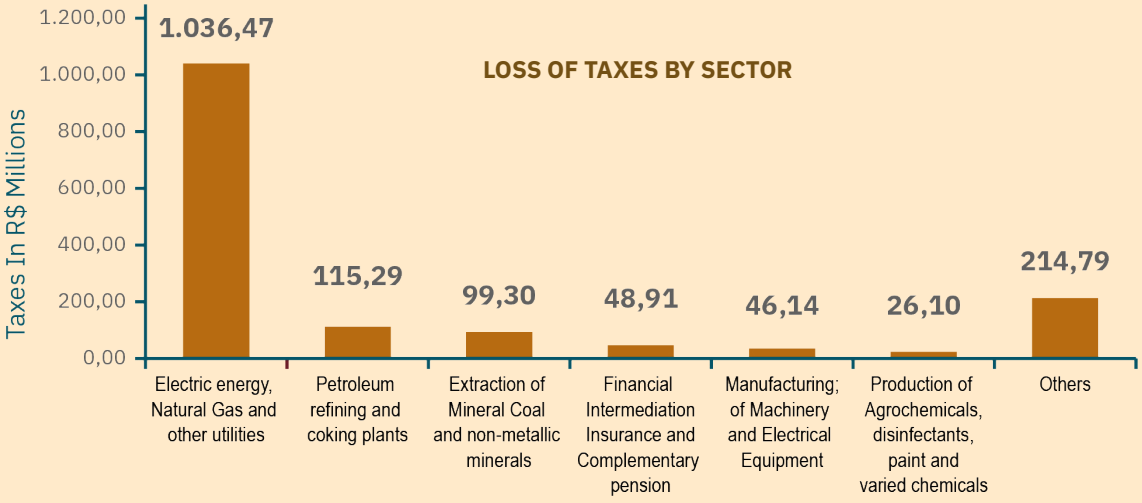
Graph 1A, 1B, 1C, 1D and 1E: sectorial distribution of hypothetical partial and simultaneous extraction of coal-related activities from the Brazilian economy, MIP 2018 (what would no longer be generated in occupations, value added, tax collection, wages and social security and FGTS).

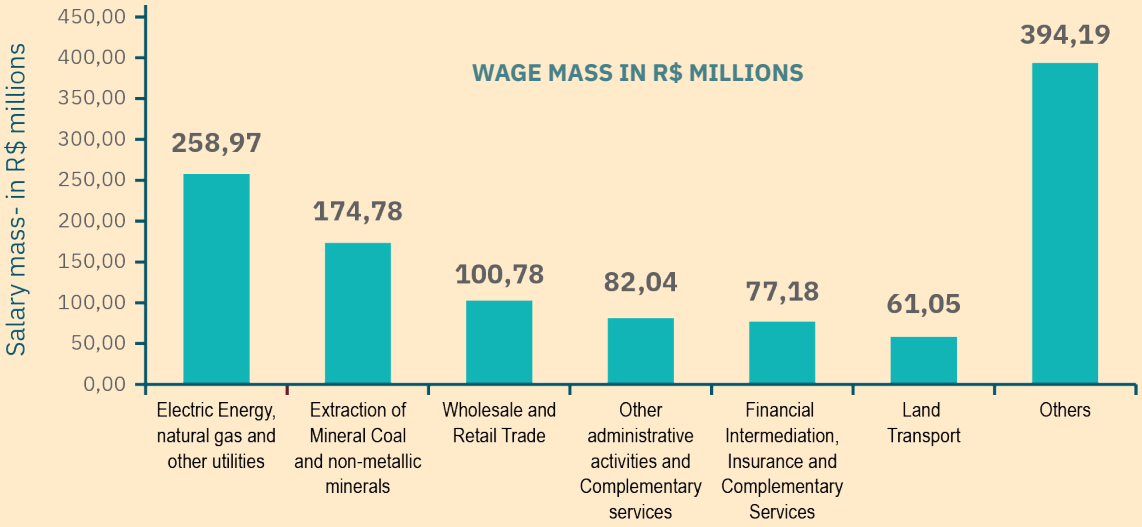


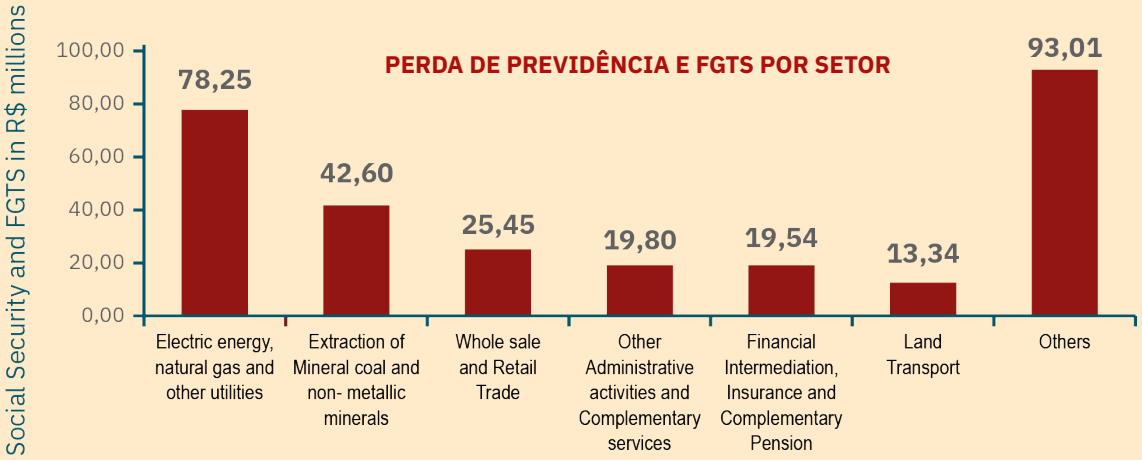


Source: Based on MPI 2018 from Passoni and Freitas. Elaborated by DIEESE.









Source: Based on MPI 2018 from Passoni and Freitas. Elaborated by DIEESE.

Observing the breakdown of data, as per charts 1A to 1E, it can be highlighted that:

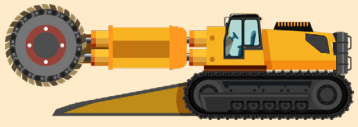
- **OCCUPATIONS:** The potential impact would be relevant in the reduction of occupations in the sector of Extraction of Mineral coal and non-metallic minerals (6.2 thousand), followed by wholesale and retail trade (6.1 thousand); other administrative activities and complementary services (3.6 thousand); terrestrial transport (3.4 thousand), electric energy, gas and other utilities (2.6 thousand); and Legal accounting, consultancy and head office activities (1.6 thousand). Each extinct occupation directly linked to coal will eliminate 3 other occupations in other sectors;

- **VALUE ADDED (VA):** the highest concentration of VA loss would be in Electricity, natural gas and other utilities, with 46,8% of the total reduction alone. Next, but at lower levels are Extraction of Mineral Coal and non-metallic minerals; Financial Intermediation; Wholesale and retail trade; Other administrative Activities and Complementary services; and Land Transport;

- **TAX COLLECTION** would be lower mainly in the Electric Power, Natural gas and other utilities, with 65.3% of the total reduction alone. Following, but distant, we have the sectors of Oil refining and Coking; Extraction of Coal and non-metallic minerals; Financial Intermediation; Manufacturing of Machinery and electrical equipment; Land transport, in addition to other sectors in even lower level individually;

- The largest **LOSS IN SALARY MASS** would occur in Electricity, natural gas and other utilities, followed by mining of coal and non-metallic minerals; wholesale and retail trade; other administrative activities and complementary services; Financial Intermediation and Land transport;

- The reduction in **SOCIAL SECURITY AND FGTS** collection from the elimination of coal-related activities in Brazil would be considerable mainly in the activity Electricity, natural gas and other utilities, followed by Extraction of coal and non-metallic minerals; Wholesale and retail trade; other administrative activities and complementary services; Financial Intermediation and Land Transport.



From a sectoral point of view, some differences should be highlighted between coal extraction, an activity inserted in the context of the exploitation of natural resources and the production of electric power from coal, which is an economic activity linked to the generation of electric power.

COAL EXTRACTION: the effects of eliminating this activity in Brazil would be concentrated mainly on the activity itself, occupations, wage bill and security and FGTS tax collection. There would be a greater dispersion of effects on the value added and tax collection, even though the activities directly related to coal would predominate. As the sector in general is characterized by more concentrated effects on activities directly related to coal, the sectors that stand out as also having a relevant impact would be Commerce and Land Transport.

The elimination of Electricity, natural gas and other utilities, in which the activity of coal-fired **power generation** is included, impacts the economy in a much more diversified manner, indicating grater dispersion of impacts on the rest of the economy, with the exception of added value and tax collection. Among the most affected sectors, Commerce is the economic segment that would have the greatest negative impact which derives from the elimination of electricity generation. In the salary mass and collection of INSS and FGTS, despite the predominance of the loss for the electric power segment, there are losses in Commerce, Financial Intermediation, Land Transport and other administrative activities, among others.

In general, one can consider that this is an activity with greater dispersion of effects when compared to the extraction of coal and non-metallic minerals.

4. Some Final Considerations

As already highlighted, to design a more than necessary process of Fair Energy Transition, it is essential to guide decisions and policy formulation, considering, in addition to environmental issues, the economic and social impacts of an eventual elimination of activities related to coal-based energy extraction and generation.

In other words, despite recognizing the environmental demands around the reduction of carbon emissions into the atmosphere and the urgency of controlling productive activities that are harmful to workers, any productive transformations based on coal must be carried out taking into account the cultural and economic roots of the coal-mining regions, because the social impact will be considerable and it is essential to plan the adoption of measures that provide economic alternatives for the region and enable the reduction , and not the expansion, of social inequalities.

Brazil, despite having sources of electric energy considered “clean” in a much higher proportion than the rest of the world, has in recent years encouraged an increase in the participation of sources considered environmentally polluting, especially thermal plants, due to the reduction in rainfall and the compromising of hydroelectric sources and greater consumption (DIEESE, 2021). This increase, in Brazil’s case, has stimulated the use of coal as an important energy source. Thus, a policy that aims to eliminate the extraction and use of coal as a source of energy generation must also take into account the supply of this source by another cleaner source so as not to compromise energy production in the country.

The objective of this study was to explore the impacts of an eventual elimination of coal extraction activities and the electricity generated through this product. Considering the input-output Matrix updated for 2018, through the Passoni and Freitas (2020) method, the hypothetical extraction method described by Dietzenbacher and Lahr (2013) and in Fernandes, Haddad and Dias (2021) was used.

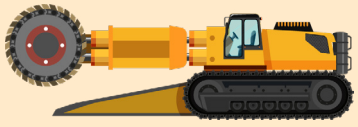
Taking into account both the participation of mineral coal production in the total segment of extraction of mineral coal and non-metallic minerals (5,67%) and of coal as a source in the total electric energy production of the States of Santa Catarina and Rio Grande do Sul in the total of the country (1,02%), applied in the activity Electric energy, natural gas and other utilities, the results indicate that the complete interruption of coal-related activities in Brazil would eliminate 36.2 thousand occupations (jobs), reduce the value added in the country by R$ 4.3 billion, reduce tax collection by R$1.6 billion, with a drop of R$ 1.1 billion in the salary mass and R$ 292 million in the collection of public social security and FGTS.

In sectors, the effects would be concentrated in the extraction and generation of electricity, but would also have considerable diffusion in other sectors, mainly in Commerce, Land Transport, Financial Intermediation, administrative and consulting activities, with the power of dispersion of impact in other sectors being greater in activities related to the generation of electricity and lower in the extraction of coal and other non-metallic minerals.

Although Regional disaggregation is not yet possible, one should consider as probable the hypothesis that the effects are predominantly concentrated, both in the regions where coal extraction is concentrated (Santa Catarina and Rio Grande do Sul), and in the localities where the electricity generating plants based on the product are located, which increases their impacts from the proportional point of view.

Thus, an eventual elimination of coal-related activities would have to be compensated for with the generation of jobs in other activities, given that the local impact of the interruption of activities will certainly be significant, affecting their economies and requiring various forms of intervention at all government levels.

In order to achieve a “Fair energy Transition”, it is necessary to consider the various impacts that such productive transformations cause in the regions where these activities, considered polluting, are concentrated. There is an entire production chain that, rooted culturally and economically, requires planning, social dialogue and strong articulation of public policies so that they do not bring greater crisis to the affected localities.



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