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# **THE OIL AND GAS COMPLEX IN THE BRAZILIAN ECONOMY AND ITS STATES**

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## **Abstract**

This paper presents the results of a research conducted to measure the importance of the oil and gas complex in the Brazilian economy and in its states.

Initially, the efforts were concentrated in the construction of an interregional input-output system for the 27 states of the Brazilian economy at the level of 42 industries, for the year of 2002.

Using this system it was possible to make an analysis of the role played by the oil and gas complex in the Brazilian economy and its states. First it is made an analysis of the economic flows linked with the oil and gas production, and then it is made an estimation of the Gross Domestic Product (GDP) value generated by the oil and gas complex in the Brazilian economy and its states. It is also made an analysis in detail of the productive chain of the oil and gas, starting from the suppliers of inputs to the oil and gas production, going through the production itself and the various stages of refining and processing, and ending at the measuring of the services and distribution activities.

The results show that the oil and gas complex has a share of around 10.4% of the Brazilian GDP, while the share in the GDP of the states can go from less than 1% to 27%.

*Keywords: Oil and Gas, Gross Domestic Product (GDP), Input-Output*

## Resumo

Este trabalho teve como objetivo mensurar a importância do complexo relacionado com a extração de Petróleo e o Gás dentro da economia Brasileira, como um todo, e dentro de cada Unidade da Federação.

Inicialmente, os esforços buscaram a construção de um sistema inter-regional de insumo-produto dividido em 42 setores produtivos, considerando as 27 Unidades da Federação, para o ano de 2002.

Através das matrizes de insumo-produto foi possível avaliar o papel que o complexo de óleo e gás desempenha na economia brasileira e em suas regiões. Primeiramente, foram analisados os fluxos econômicos ligados à extração e produção de petróleo e gás, em seguida, buscou-se estimar o Produto Interno Bruto (PIB) gerado a partir deste complexo, destacando-o dos demais setores da economia. O método analisa em detalhes as interligações da cadeia produtiva do Óleo e Gás (O&G), incluindo assim os setores fornecedores de insumos, o próprio setor de extração de O&G, a indústria de transformação (refino e processamento dos principais produtos que usam derivados do petróleo) e os setores de serviço, comércio e distribuição correlacionados. Ou seja, além do setor propriamente dito, considerou-se também as atividades que alimentam e são alimentadas pela produção destes combustíveis.

Os resultados mostram que o PIB do complexo do óleo e gás representa aproximadamente 10.4% do PIB Brasileiro. Ao mesmo tempo, observa-se que sua participação no PIB das unidades da federação varia entre menos de 1% a 27%.

*Palavras-chave: Petróleo e Gás, Produto Interno Bruto (PIB), Insumo-Produto*

## **1. Introduction**

The productive chain of oil and gas is one of the most complexes in the economy. At the same time, it is an important demander for machinery and equipments industry and the supplier of the most important energetic inputs. The chain is also peculiar in several aspects related to its technological profile. Oil is a mineral resource composed by a wide mix of substances. From its processing, several goods are extracted, like gasoline, diesel, kerosene, house gases, fuel and lubricant oil, paraffin wax, and chemical composts. These elements are crucial inputs for several sectors, like ink industry, axes, plastic, oil extraction and vegetal fats, resins, pneumatics, rubber, matches, photo films and fertilizers.

This paper presents the results of a research conducted to measure the importance of the oil and gas complex (Oil & Gas Complex) in the Brazilian economy and in its states. Initially, the efforts were concentrated in the construction of an interregional input-output system for the 27 states of the Brazilian economy at the level of 42 industries, for the year of 2002. Using this system it was possible to make an analysis of the role played by the Oil & Gas Complex in the Brazilian economy and its states. Firstly, it is made an analysis of the economic flows linked with the oil and gas production, and then it is made an estimation of the GDP value generated by the Oil & Gas complex in the Brazilian economy and its states. It is also made an analysis in detail of the productive chain of the oil and gas, starting from the suppliers of inputs to the oil and gas production, going through the production itself and the various stages of refining and processing, and ending at the measuring of the services and distribution activities.

The paper is divided into four sections. Firstly, it is presented an overview on the Brazilian oil chain, considering its characteristics and its recent institutional changes.

The second topic explains how the Oil & Gas Complex GDP was measured, considering the value added to the complex supplier and supplied sectors, and to the extraction and production sector itself. Calculation also includes trading, distribution and services related to the oil and gas derivatives.

General results regarding the interregional system including 42 productive sectors and 27 regions are briefly presented next. The highlight is the GDP estimations associated with the Oil & Gas Complex. A descriptive analysis is placed to size up the

importance of the sector to the national and to the regional context. Finally, the conclusions obtained through the analysis are presented.

### *1.1 Oil and Gas extraction - historical overview<sup>1</sup>*

Brazil has a great potential for oil and natural gas fields, due to its 4 millions squared kilometers in onshore sedimentary fields and about one million in offshore areas, gathering 29 basins. Besides, Brazil has a very large territory and the difficulty of access to many regions represents a challenge to the organization of its oil sector.

The birth of the oil industry in Brazil has its milestone in 1938, when President Vargas created the National Petroleum Counsel – CNP. In that decade, the whole consumption of oil was imported, summing about 38 thousand barrels a day<sup>2</sup>. CNP<sup>3</sup> was an organism directly linked to the Presidency of Brazil and its goal was to set up the long run guidelines for the development of the Brazilian oil industry, including prices policies, priorities for investments and geological studies, supplying and distribution policies, among others.

In the following years, several studies were performed to evaluate the economic potential of the Brazilian sedimentary basins, with the purpose of finding evidences that could justify investment in the exploration of resources. Initially, efforts have been concentrated in the coast of Bahia, in the Northeast of Brazil, resulting in the discovery of important fields. This region has become the first basin to be explored in Brazil and remained as the most important until the beginning of 70's.

The second historical landmark in the Brazilian oil industry happened in 1953 with the inauguration of Petrobras – Brazilian Petroleum, a state owned corporation created to perform activities of research, exploration, development and production of oil and gas in Brazil. In this context, the state monopoly was set up due to the lack of private capital and its unwillingness to undertake a high risky activity. There were also political resistances to open the sector to foreign firms. Petrobras, therefore, has become the manager of this monopoly, expanding progressively its activities toward other steps of the productive chain, like processing and distribution. In the middle of 50's, Petrobras' productive capacity summed 3,000 barrels a day, which was insufficient to

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<sup>1</sup> See DIAS LEITE (1997).

<sup>2</sup> Source: Brazilian Institute of Petroleum.

<sup>3</sup> CNP was suppressed in 1997 and replaced by the National Counsel for Energy Policy – CNPE.

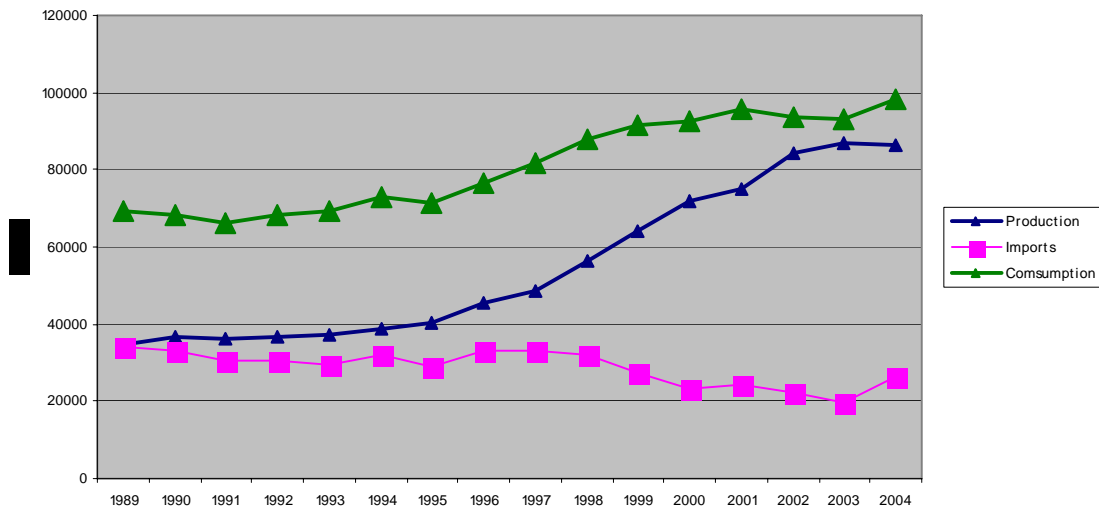
cover the increasing national consumption. This public corporation also undertook oil imports, whose monopoly it granted in 1963. Thereby, the supply of oil for the Brazilian market was composed, in most part, by imports. Meanwhile, national production was responsible for less than 15% of national consumption.

The purchases of foreign oil were well succeeded in complementing the national supply until the beginning of 70's, when the first oil shock generated a strong deterioration of the Brazilian trade balance. In face of it, the Government and Petrobras both intensified their efforts to reduce the dependence of imported oil, through two main guidelines: enhancing the exploration in other basins and increasing the research of alternative sources of energy, mainly the so called Pro-Alcohol, a program that created incentives to the development of alcohol-moved cars.

Another front by which the Brazilian government tried to mitigate the problem was through the *Risky Contracts*. By this mechanism, a foreign enterprise could get the right to undertake exploratory research in some area. If successful, the firm could extract and sell the resource, paying to the Government royalties of 20% on the value of the output; in the case of failure, the firm should give the area back to the government, assuming alone all the losses with the investment. However, these contracts did not have the desired effect, since only 243 contracts were signed between 1975 and 1988, when the new Constitution vetoed new leases to the private sector. Only one contract (gas) was well succeed.

In 1974, Petrobras discovered oil in the offshore basin of Campos, in the southeastern state of Rio de Janeiro. Since then, this basin has become the largest Brazilian oil province and the pioneer in exploration under deep waters. Today, it is responsible for about half of Brazilian oil production.

In the long run, these efforts were very well succeeded, as we can see in the Graph 1.1. Brazilian oil production is increasing over time and imports have decreased softly. The production is closer to the domestic consumption and self-sufficiency was reached in April 2006.



Source: Brazilian Ministry of energy

**Graph 1.1: Production, imports and consumption of oil in Brazil**

Since the middle of 90's, the Brazilian oil and gas industry has been undergoing deep institutional changes (VILHENA, 1997), mainly in the exploration and production of crude oil and natural gas. With the purpose of attracting the largest possible amount of investment in the sector and to take advantage from the Brazilian basins, the Federal Government has begun to design a new regulatory environment to the oil industry. The core of the changes consisted in allowing private sector to undertake activities of exploration, development, processing, production and import of oil and natural gas, aiming to break the state monopoly over these activities, enhancing competition and rising the part of the Government in the rent from natural resources.

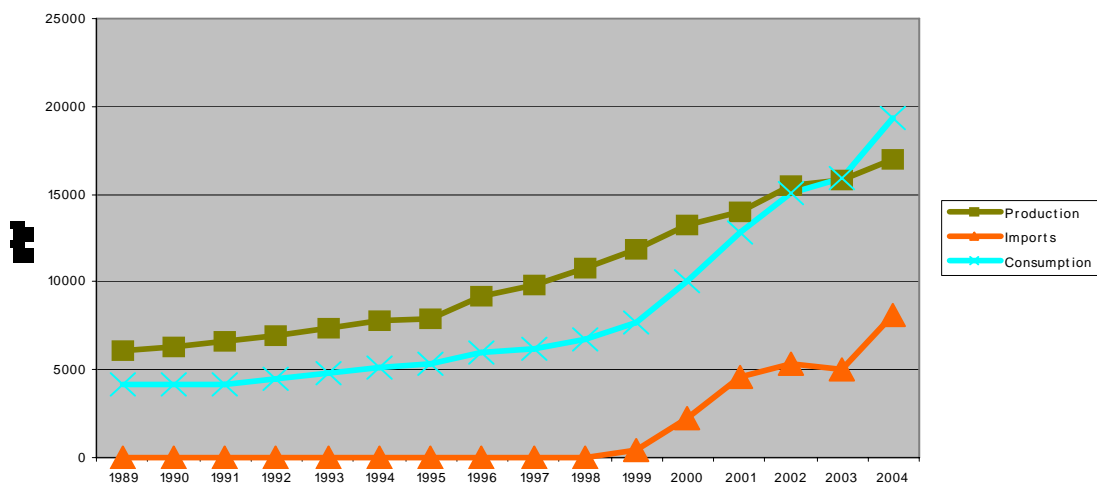
In 1995, the Brazilian Congress approved a Constitutional Amendment that extinguished the 40 years Petrobras' monopoly in exploration, production and processing of crude oil<sup>4</sup>. This reform can be inserted in a broader context, characterized by meaningful changes in mineral policy of developing countries, with the purpose of attracting more investment (OTTO, 1998). From the middle of 80's to the middle of 90's, several Asian, African and Latin American countries have created more favorable laws for the participation of private and foreign capital in their oil and gas sectors. Moreover, in those years, rich countries have raised their investment in less developed countries, as consequence of the absence of homeland opportunities. These new

<sup>4</sup> Up until then, only the distribution was allowed to private firms.

investments were possible due to new technologies that reduced exploratory costs and enhanced profits of oil corporations. This interaction of international factors and the new regulatory policy became attractive to invest in oil sectors in developing countries like Brazil. Summing up, these countries transformed their systems from *full state monopoly* to a *regime of concessions* to private firms.

The openness of the sector can be considered well succeed, because these days dozens of firms operate exploratory activities onshore and offshore Brazilian basins. Several foreign corporations, like Shell, Texaco and El Paso, also take part in these activities.

It is important to emphasize that these institutional changes were also well succeed in improving the use of natural gas as energy source. The new law also regulates natural gas. Graph 1.2 illustrates the increasing production, consumption and imports (mostly from Bolivia<sup>5</sup>) in Brazil, mainly after the approval of the Petroleum Law (1997), whose goal is to modernize the energetic matrix towards the use of natural gas. In this context, the number of conversions from regular engine to natural gas-moved cars (GNV) has grown up at an average rate of 90% from 1996 to 2005<sup>6</sup>. Today, the estimated number of natural gas-moved cars in the Brazilian fleet is above one million<sup>7</sup> and the daily consumption of GNV is<sup>8</sup> about 5.8 millions of m<sup>3</sup>.



Source: Brazilian Ministry of energy

**Graph 1.2: Consumption, production and imports of natural gas in Brazil**

<sup>5</sup> In May 2006, Bolivia nationalized Petrobras' assets in this country. The future of Brazil-Bolivia relationship concerning gas supplies is still unclear, since the Bolivian Government signaled the desire of reviewing contracts.

<sup>6</sup> Source: Anfaeva.

<sup>7</sup> Source: Brazilian Institute of Petroleum.

<sup>8</sup> Source: Brazilian Institute of Petroleum for December 2005.



## 1.2. Refining and distribution

While the new regulatory environment has been well succeed in creating competition in exploration and production, the refining is an important shortage in the Brazilian oil industry, since the most part of Brazil's refineries (11 among 13) belongs to Petrobras. Therefore, despite the free price in the Brazilian refineries (which is on since January 2002), Petrobras still has a stunning influence on the price of oil derivatives in Brazil and it is able to practice a predatory price policy with the purpose of creating a barrier to entry. Another problem is that the most part of refineries are old fashioned and do not perform well in refining domestic oil, which has a worse quality than the Middle West's one, which technology Brazilian refineries were designed for.

The Table 1.1 summarizes the composition of the oil processed in the Brazilian refineries, according to its origins, from 2002 to 2004. Today, about 90% of the oil processed is domestic and the self-sufficiency is close to be reached<sup>9</sup>.

**Table 1.1: Origin of oil processed in the Brazilian refineries**

<b>Year</b>	<b>2004</b>	<b>2003</b>	<b>2002</b>
<b>Brazil</b>	<b>75,84%</b>	<b>80,20%</b>	<b>79,20%</b>
Campos' Basin	46,02%	64,50%	62,80%
Other offshore basins	21,03%	2,40%	1,40%
Onshore basins	8,79%	13,30%	15,00%
<b>Imports</b>	<b>24,16%</b>	<b>19,80%</b>	<b>20,80%</b>
Middle East	5,73%	6,30%	5,70%
Africa	17,79%	9,90%	12,60%
Central and South America	0,51%	0,70%	2,50%
Australia	0,13%	2,90%	-
<b>Total</b>	<b>100,0%</b>	<b>100,0%</b>	<b>100,0%</b>

Source: Ministry of Mining and Energy

The Table 1.2 shows the composition (%) of oil derivatives produced in national refineries, in equivalent barrels of oil. As one can see, diesel has the biggest share, representing these days about 40% of refined oil, since its importance to transportation in Brazil (which has a high degree of road). Gasoline, on the other hand, represents 18% of refined oil.

<sup>9</sup> Last April, Petrobras announced self-sufficiency. However, experts believe this situation is fragile and unsustainable, since the economy is showing signals of recovery.

**Table 1.2: Composition of processed oil in the Brazilian refineries**

In equivalent barrels of oil	2002	2003	2004	2005
<b>Asphalt</b>	2,03%	1,39%	1,64%	0,99%
<b>Coke</b>	1,99%	1,96%	1,80%	2,50%
<b>Gasoline</b>	18,49%	17,45%	16,40%	17,71%
<b>Airplane's gasoline</b>	0,07%	0,07%	0,07%	0,07%
<b>Liquid Oil Gas – GNP<sup>10</sup></b>	5,95%	6,20%	6,03%	6,65%
<b>Lubricants</b>	0,86%	0,88%	0,75%	0,76%
<b>Naphtha</b>	8,09%	8,27%	7,62%	7,31%
<b>Fuel Oil</b>	19,82%	19,05%	18,91%	17,19%
<b>Diesel</b>	36,47%	37,92%	40,08%	40,24%
<b>Other Non-energy</b>	1,28%	1,49%	1,43%	1,48%
<b>Paraffin</b>	0,15%	0,14%	0,15%	0,13%
<b>Airplane's kerosene</b>	3,76%	3,95%	4,07%	4,03%
<b>Illumination's kerosene</b>	0,24%	0,20%	0,11%	0,06%
<b>Solvents</b>	0,69%	0,78%	0,79%	0,72%
<b>Other Energy</b>	0,14%	0,25%	0,15%	0,16%

Source: ANP

The retail supply comprehends two parts strongly connected each other: the distribution and resale. Both activities have always been allowed to private firms, despite the retail prices were liberalized only in the middle of 1990's.

The distribution comprehends the transportation from refineries to the deliverers (gasoline stations) or to domestic consumption (canalized and bottled liquid gas for domestic consumption, the so-called GLP). Nowadays, 276 liquid and gas products deliverers are registered at National Petroleum Agency – ANP.

The resale is considered a public utility activity and is performed by thousands of gas station spread all over the country. This activity technically comprehends the retail sale of fuels, lubricants and bottled liquid gas and it is required authorization from ANP to perform them. Since January 2002, prices are free in all the productive chain. There is no longer any kind of price control, maximum or minimum values, or the need of authorization to readjust prices. Thereby, retail prices are a positive function of international prices<sup>11</sup>.

Finally, despite the decreasing participation, (see Table 1.3), the Brazilian energetic matrix still depends heavily on oil, due to the importance of road

<sup>10</sup> Used for domestic cooking.

<sup>11</sup> Sometimes, Petrobras was accused of artificially controlling prices with political purposes, as in 2002 Presidential Election.

transportation in the economy. At the same time, the participation of natural gas has been increasing, reaching 9% in 2004. As it was said before, this is due to the deregulation and the new institutional environment in Oil & Gas Complex in Brazil.

**Table 1.3: Brazilian energetic matrix**

Type	2000	2001	2002	2003	2004
<b>Nonrenewable Energy</b>	<b>59.0</b>	<b>60.7</b>	<b>58.8</b>	<b>56.3</b>	<b>56.1</b>
Oil and derivatives	45.5	45.4	43.0	40.1	39.1
Natural Gas	5.4	6.5	7.4	7.7	8.9
Mineral Coal and Derivatives	7.1	6.9	6.5	6.7	6.7
Uranium and Derivatives	0.9	2.0	1.9	1.8	1.5
<b>Renewable Energy</b>	<b>41.0</b>	<b>39.3</b>	<b>41.2</b>	<b>43.7</b>	<b>43.9</b>
Water and Electricity	15.7	13.6	14.0	14.6	14.4
Wood and Vegetable Coal	12.1	16.6	9.9	9.9	13.2
Sugar's Cane Derivatives	10.9	18.8	8.8	4.4	13.5
Other renewable	2.3	2.4	5.5	8.8	2.7
<b>TOTAL</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

Source: Ministry of Mining and Energy

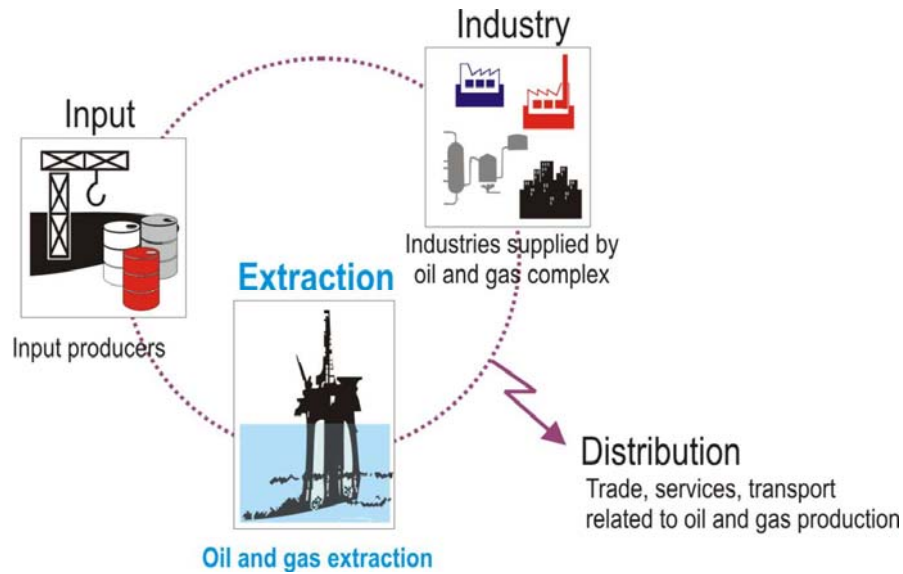
## 2. Methodology to measure the Oil & Gas complex

By assuming the importance of the Oil & Gas Complex in the Brazilian economy, this study measured the total GDP of the productive chain associated to the oil and gas extraction sector through input-output models<sup>12</sup>.

The theoretical concept is based on the intensity of both forward and backward linkages that each sector produces in the entire economic system. Basically, the goal is to consider the oil and gas extraction sector itself as well as the fuel production supplied

<sup>12</sup> The most recent official input-output data released for the Brazilian economy is for 1996 (IBGE, 1996). The present study makes initially use of a national input-output system estimated for 2002 using the methodology developed by GUILHOTO AND SESSO FILHO (2005). The new system was then expanded to an interregional input-output model for 27 Brazilian regions (26 Brazilian states and the Federal District). The process to obtain correct information about the production and consumption of each federation unit was costly and demanded the analysis of many statistical sources. Furthermore, the determination of the interregional flows ran over the use of many algebraic methods as the locational coefficient (ISARD, 1998), the RAS technique (MILLER AND BLAIR, 1985) among others. Successive tests were used to evaluate the coherence of the estimations of the interregional and intersectoral flows.

to other sectors and supplier activities of the oil industry. Thus, the GDP of the Oil and Gas Complex is estimated for its four components: inputs to oil extraction, the extractions sector itself, processing industries and distribution (Figure 2.1).



**Figure 2.1: The Oil and Gas complex**

The methodology used is presented below. Further methodological discussions can be found in FURTUOSO, BARROS AND GUILHOTO (1998), GUILHOTO, FURTUOSO AND BARROS (2000), and FURTUOSO AND GUILHOTO (2003).

The total GDP value of the Oil & Gas Complex is divided into 4 aggregates: I) inputs; II) the sector itself; III) industrial processing; and IV) distribution, trade and services.

The value added at market prices is given by the sum of the value added at basic prices with indirect net taxes less the financial dummy, resulting in:

$$VA_{MP} = VA_{BP} + INT - FDu \quad (1)$$

where:

- $VA_{MP}$  = Value added at market prices
- $VA_{BP}$  = Value added at basic prices
- $INT$  = Indirect net taxes
- $FDu$  = Financial dummy

To estimate the GDP of **Aggregate I** one uses the information available in the input-output tables regarding the input values acquired by the extraction of Oil and Gas sector. The columns with input values are multiplied by the respective coefficient of value added ( $CVA_i$ ).

The Coefficients of the Value Added for each sector ( $CVA_i$ ) are obtained by dividing the Value Added at Market Prices ( $VA_{MP}$ ) of a given sector by its respective output ( $X_i$ ), i.e.,

$$CVA_i = \frac{VA_{MP}}{X_i} \quad (2)$$

Thus, the methodology allows the elimination of the double-counting issue. In that sense the GDP of the **Aggregate I** is given by:

$$GDP_I = \sum_{i=1}^n z_{ik} * CVA_i \quad (3)$$

$i = 1, 2, \dots, n$  are the economic sectors

where:

$GDP_I$  = GDP of aggregate I (inputs)

$z_{ik}$  = total input value of sector  $i$  to the extraction sector  $k$

$CVA_i$  = value added coefficient of sector  $i$

The estimates for the **Aggregate II** (the sector itself - Oil and Gas extraction) considers the value added generated by the respective sectors, subtracting the values used as input from the value added of these sectors. Thus the double-counting is again eliminated. Then one has:

$$GDP_{II} = VA_{MP_k} - z_{kk} * CVA_k \quad (4)$$

where:

$GDP_{II}$  = GDP of aggregate II

and the other variables are defined as previously.

To define the composition of the **Aggregate III** (Oil and Gas based industries) several indicators were adopted as for instance: a) the main demanding sectors of oil and gas products obtained by input-output matrix estimation; b) the share of Oil and Gas

input in the intermediate consumption; and c) the economic activities carrying out the first, second and third transformation of crude oil materials.

In the estimation of **Aggregate III** (Oil and Gas Based Industries) one adopted the summation of the value added generated by the oil and gas sectors subtracted from the value added in these sectors that have been used as input in the Aggregate II. As previously mentioned, this subtraction is done to eliminate the double-counting in Oil & Gas Complex GDP estimates, as so, one has that:

$$GDP_{III} = \sum_q \left( VA_{MP_q} - z_{qk} * CVA_q \right) \quad (5)$$

where:

$GDP_{III}$  = GDP of aggregate III

and the other variables are defined as previously.

In the case of **Aggregate IV**, regarding the Final Distribution, one considers the aggregated value of the Transportation, Commerce and Service sectors. Out of the total value obtained for these sectors only the part corresponding to the share of the products (oil and gas refined) is designated to the Oil & Gas Complex in the final product demand. The approach adopted in the estimation of the final distribution value of the industry can be represented by:

$$GFD - INT_{FD} - IP_{ED} = DFD \quad (6)$$

$$VAT_{MP} + VAC_{MP} + VAS_{MP} = TM \quad (7)$$

$$GDP_{IV} = TM * \frac{FD_k + \sum_{q \in k} FD_q}{DFD} \quad (8)$$

where:

$GFD$  = global final demand

$INT_{FD}$  = indirect net taxes paid by the final demand

$IP_{FD}$  = imported products by the final demand

$DFD$  = domestic final demand

$VAT_{MP}$  = value added of the transportation sector at market prices

$VAC_{MP}$  = value added of the commerce sector at market prices

$VAS_{MP}$  = value added of the service sector at market prices

$TM$  = trading margin

$FD_k$  = final demand of extraction sector

$FD_q$  = final demand of the oil and gas based industry sectors

$GDP_{IV}$  = GDP of aggregate IV

The Oil & Gas Complex GDP for each sub-complex is given by the sum of its aggregates as:

$$GDP_{Oil\ and\ Gas} = GDP_I + GDP_{II} + GDP_{III} + GDP_{IV} \quad (9)$$

where:

$GDP_{Oil\ and\ Gas}$  = Oil & Gas Complex GDP

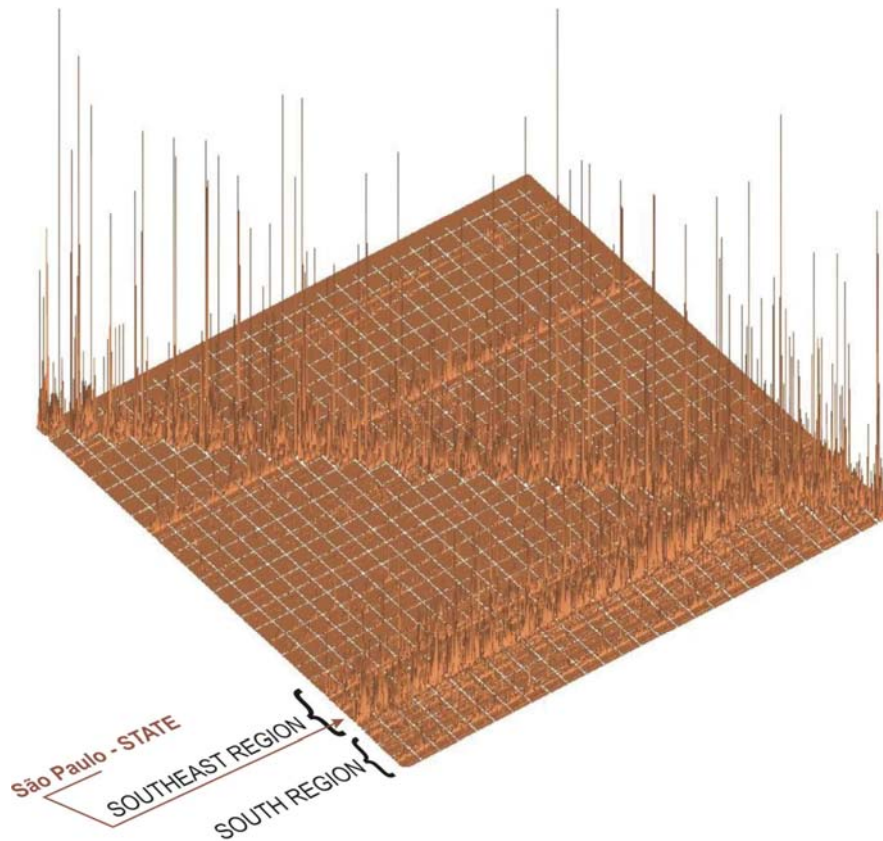
and the other variables are as previously defined.

### 3. Results

#### 3.1 Productive relations in the Brazilian economy

Figure 3.1 presents the Leontief inverse matrix estimated for the year of 2002, considering all federative unities of Brazil and its economical activities divided into 42 productive sectors.

To interpret Figure 3.1, we should consider that the larger the technical coefficient the bigger the peak in the three-dimensional space. Each quadrate corresponds to one matrix, sized-up by 42 lines and 42 columns, and each matrix links one region to another. Thus, the figure is formed by 27 matrix lines (27 regions – 26 states and the federal district) linking to 27 matrix columns (the same 27 regions), composing a square-shaped system of 1134 lines and columns. So the coefficients matrix of figure is formed by one million and three hundred thousand cells approximately.



Source: Research Data

**Figure 3.1. Three-dimensional visualization of the Leontief inverse matrix**

The matrices that form the main diagonal in Figure 3.1 represent the technical coefficient of a federal unity within itself. In this way, it is observed that there is a high interaction among the productive sectors in the same state.

Some matrix lines outside the main diagonal also have enhanced peaks, they occur in the states that related the most with the others. A special importance is noted in the relationship originated in the state of Sao Paulo and some other states in the South and Southeast regions. Since these states are the most relevant to the system as a whole, they appear enhanced in the three-dimensional space, which highlights the strong dependence of other states to the South and Southeast states.

The results for the GDP estimation of the Oil and Gas Complex are presented in the next section.



### ***3.2. Oil & Gas Complex GDP***

According to the theoretical bases used in this study, the analysis connected to the Gross Domestic Production (GDP) can be developed in various levels of desegregation due to the fact that the Oil & Gas Complex can be divided into four principal aggregates: a) **inputs** (inputs that are supplied to the extraction sector); b) **the sector itself** (the oil and gas extraction sector); c) **based industry** (industry of oil and gas transformation); and d) **final distribution** (including the commerce, transport and services).

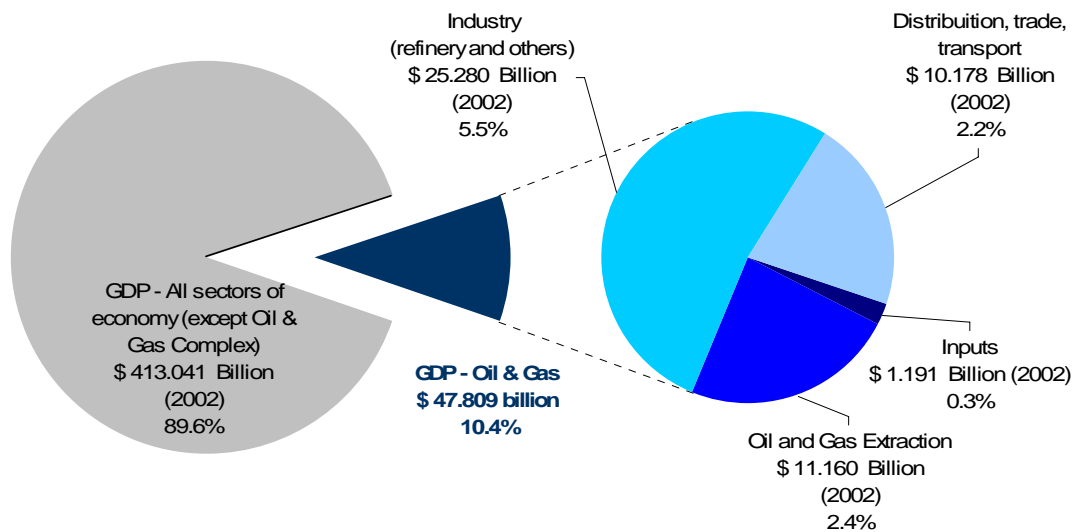
The estimation of each of the four aggregates for Brazil as a whole is also extended to each of the 27 federation unities of the Brazilian economy.

#### ***3.2.1. Oil & Gas Complex GDP participation in Brazil***

The Graph 3.1 indicates the participation of the Oil & Gas Complex in the Brazilian GDP. The graph also presents the share of the four aggregates used in the calculation of Oil & Gas Complex's GDP.

The Oil & Gas Complex GDP corresponds to approximately 10.4% of the total GDP of Brazil, for the year of 2002. From this total, half of them concentrate on **industry of transformation**, the most important component of the complex. The second most important is the oil and gas **extraction sector itself** with values near to those of **distribution and service**.

The **input** component represents 0,29% of the Brazilian total GDP and 2,5% of the Oil & Gas Complex GDP. It does not include the values related to investments, as for example, all the machines production and equipments necessary to build an oil extraction platform. The component that evaluates the **inputs** GDP referred to the services performed to the companies, to the industrial utility services, to the manufacture of machines, equipments and replacement metallurgic products, to the maintenance and to the other products considered as input to the oil and gas extraction sector.



Source: Research Data

**Graph 3.1. Oil & Gas Complex on the national GDP, billions dollars of 2002.**

The **industry of transformation** represents 52.8% of the total complex GDP. It is composed by the industrial group: a) refinery; b) petrochemical and basic oil-chemistry; c) resin, elastomer and filament manufacture; d) pneumatics and rubber industry; e) oil-derived chemical products; and f) plastic industry. These activities are important not only for Oil & Gas Complex, but also for the whole economic system. Consequently, this industrial set is the most influential in the Oil & Gas complex GDP.

The **Oil & Gas extraction** component contains three economical activities: a) crude oil extraction; b) gas extraction; and c) related services. According to the results, the percentage of participation associated with this component is close to the distribution component, which is composed by trade and transport margins related to Oil and Gas derivatives.

### *3.2.2. Oil & Gas Complex GDP participation on the federation unities*

The Oil & Gas complex GDP in each federation unit can be studied through the use of the interregional input-output system.

Table 3.1 presents the total GDP and the Oil & Gas complex GDP associated to each state and the Federal District (billion dollars of 2002). The percent values correspond to sharing between complex Oil & Gas GDP and state total GDP.

Considering the absolute values, the Oil & Gas complex GDP is especially relevant for the Southeastern and the Northeastern states. All together, they respond for 84% of the national Oil and Gas GDP, highlighting in decreasing order: Rio de Janeiro, Sao Paulo, Bahia, Minas Gerais and Rio Grande do Norte. The share of the South (12.3%) and the production of Amazonas state (Northern region) are also considerable.

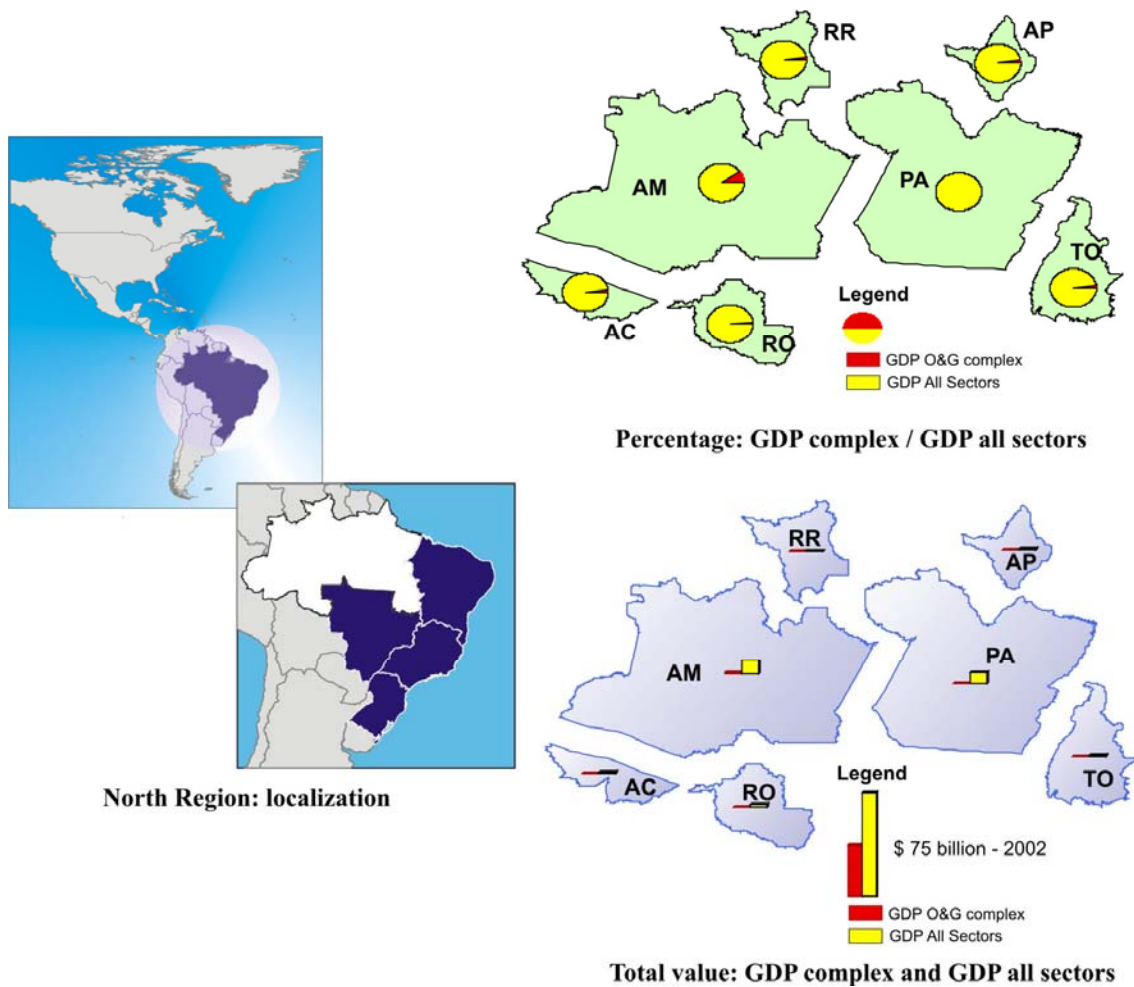
The Oil & Gas Complex share on the total state GDP ranges from 0.8% (Pará) to 26.9% (Rio de Janeiro). The dependence of Rio de Janeiro's economy on the Oil and Gas Complex deserves to be highlighted, due to the Campos basin, located in this state. Bahia and Rio Grande do Norte also have both high percentage rates, since they are important producers.

**Table 3.1. Total GDP and Oil & Gas Complex GDP in the federation unities.**

Macro Region	State	State Name	Total GDP (\$ Billion)	Oil & Gas GDP (\$ Billion)	Percentage of Oil & Gas in state GDP
North Region	RO	Rondonia	2.463	0.043	1.73%
	AC	Acre	0.756	0.020	2.58%
	AM	Amazonas	9.412	0.999	10.62%
	RR	Roraima	0.486	0.012	2.48%
	PA	Para	8.620	0.069	0.81%
	AP	Amapá	0.900	0.023	2.56%
	TO	Tocantins	1.141	0.029	2.56%
Northeast Region	MA	Maranhão	3.830	0.057	1.49%
	PI	Piauí	2.067	0.039	1.90%
	CE	Ceara	8.111	0.340	4.19%
	RN	Rio Grande do Norte	3.951	0.732	18.53%
	PB	Paraíba	4.093	0.074	1.80%
	PE	Pernambuco	12.169	0.336	2.76%
	AL	Alagoas	2.963	0.223	7.54%
	SE	Sergipe	3.262	0.461	14.14%
BA	Bahia	20.868	5.113	24.50%	
Southeast Region	MG	Minas Gerais	42.884	2.204	5.14%
	ES	Espírito Santo	8.241	0.456	5.53%
	RJ	Rio de Janeiro	57.103	15.374	26.92%
	SP	Sao Paulo	149.712	14.714	9.83%
South Region	PR	Paraná	28.990	1.787	6.16%
	SC	Santa Catarina	18.813	0.795	4.22%
	RS	Rio Grande dos Sul	36.422	3.312	9.09%
Mid-West Region	MS	Mato Grosso do Sul	5.274	0.081	1.54%
	MT	Mato Grosso	5.989	0.129	2.16%
	GO	Goiás	10.582	0.236	2.23%
	FD	Federal District	11.748	0.149	1.27%
<b>Total</b>	<b>Brazil</b>	<b>460.850</b>	<b>47.809</b>	<b>10.37%</b>	

Source: Research Data

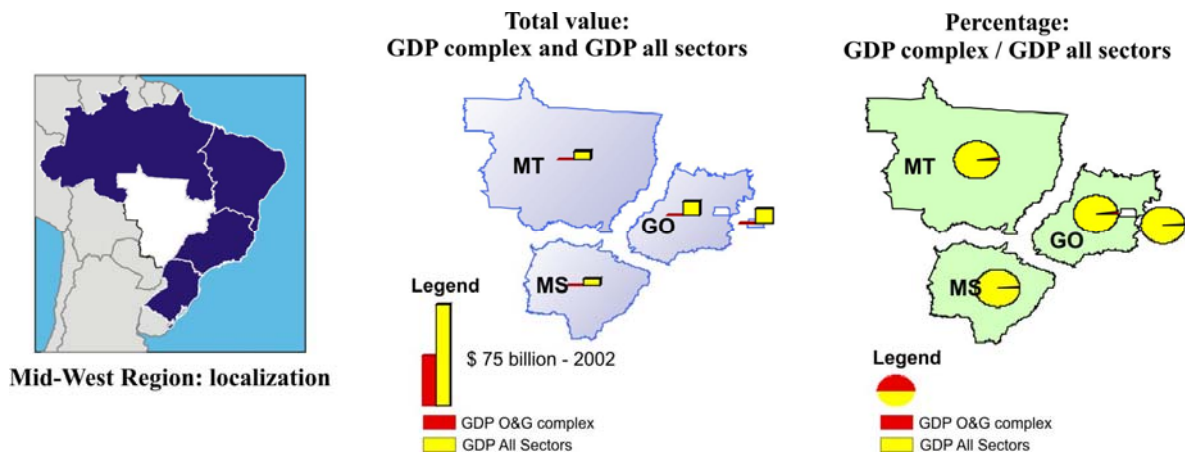
The map below (Figures 3.2 to 3.6) presents the spatial disposition of Oil and Gas Complex GDP related to each state's total GDP, both in value and percentage, by macro-region.



Source: Research Data

**Figure 3.2. Total GDP and Oil & Gas Complex GDP for the North region states.**

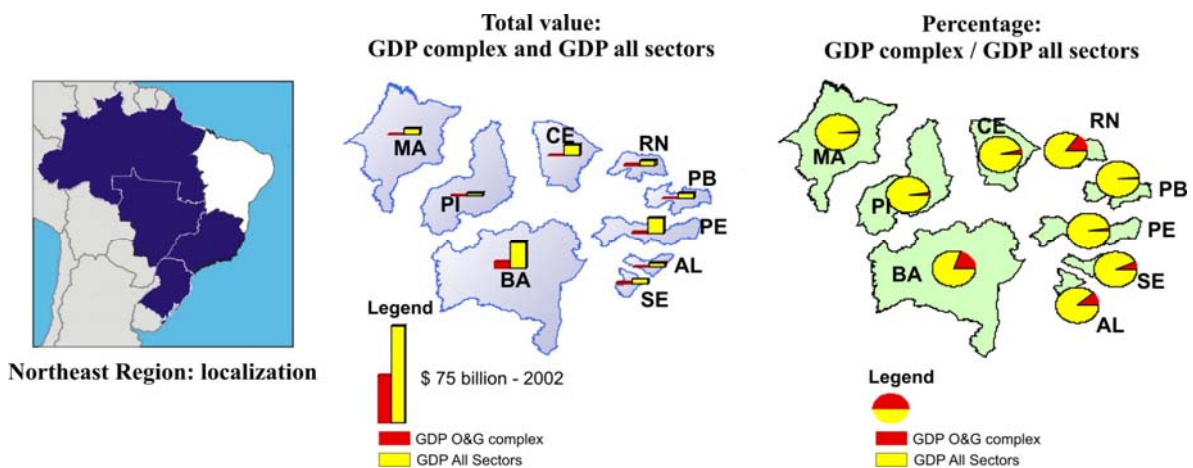
In the North region states the presence of the Oil & Gas Complex is very small. Only in the state of Amazonas (AM) the complex GDP studied is relevant, representing approximately 10.7% of the Amazonas total GDP, having in mind that in the capital of Amazonas there is an oil refinery.



Source: Research Data

**Figure 3.3. Total GDP and Oil & Gas Complex GDP for the Mid-West region states.**

In the Mid-West region states, the share of the oil complex GDP is quite under the Brazil's average (10.4%) and the absolute value of production linked to the oil and gas extraction is also low. These states do not have refineries or oil-related industries and they are geographically located far from productive units.

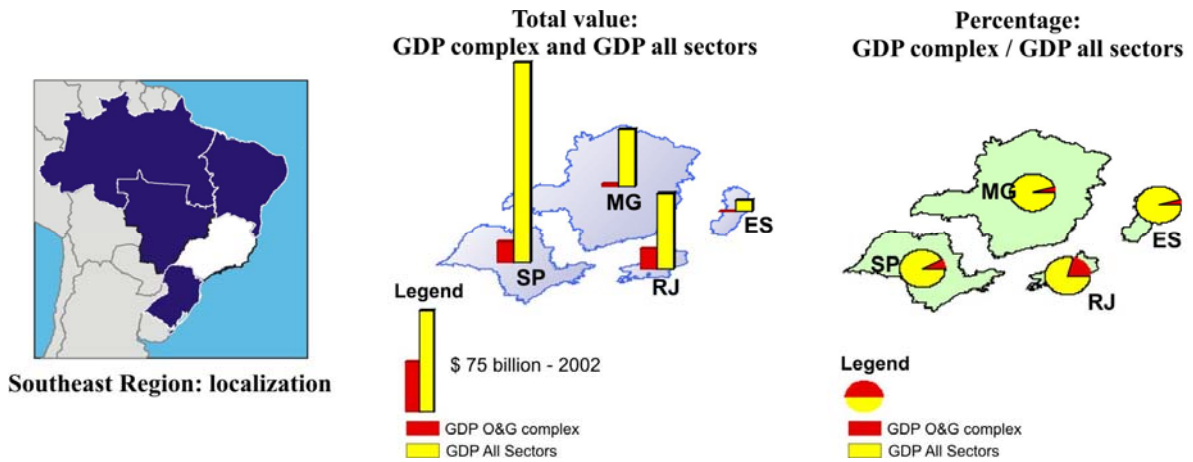


Source: Research Data

**Figure 3.4. Total GDP and Oil & Gas Complex GDP for the Northeast region states.**

As mentioned before, the Southeast and Northeast regions hold the major part of the Oil & Gas Complex national GDP. In the northeast, three principal states are

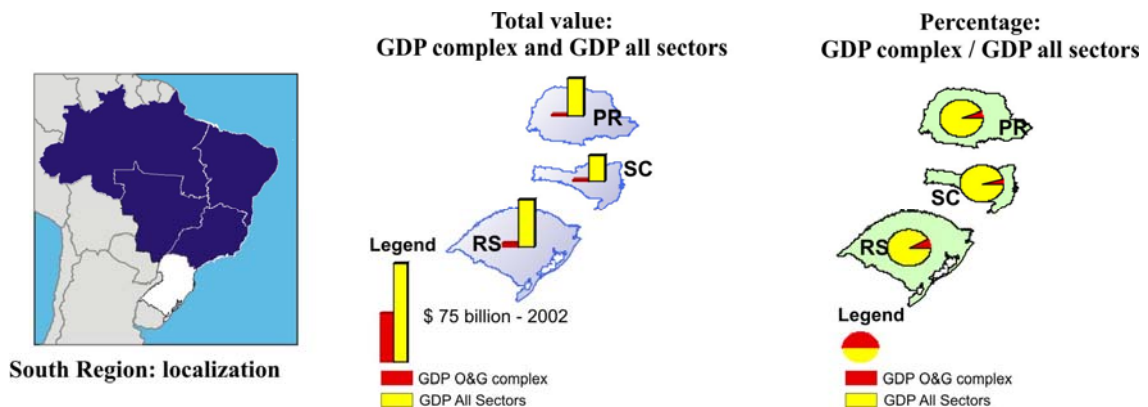
responsible for 18,4% of the Oil & Gas Complex national GDP. Bahia (BA) alone is responsible for almost 15%.



Source: Research Data

**Figure 3.5. Total GDP and Oil & Gas Complex GDP for the Southeast region states.**

The Southeastern states, however, detains the majority of the GDP related to the studied complex, responding to a share of 86.5%. Rio de Janeiro (RJ) and Sao Paulo (SP) are the ones responsible for this high proportionality, with almost US\$ 15.5 billions of 2002. Rio de Janeiro state heads in terms of absolute values of the complex GDP. Sao Paulo state is not far from it with an Oil & Gas Complex GDP estimated in US\$ 14.7 billions approximately. The Sao Paulo and Rio de Janeiro states are, therefore, the main oil producers, as well as refiners and consumers of oil and gas derivatives.

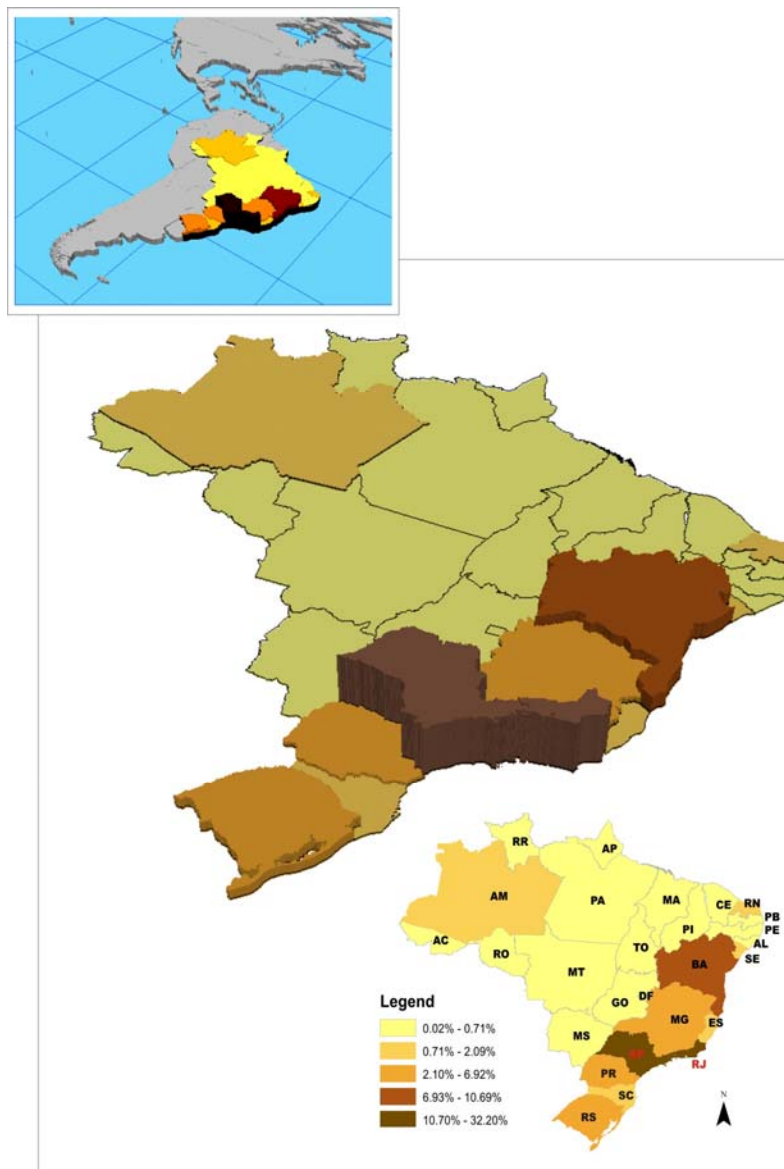


Source: Research Data

**Figure 3.6. Total GDP and Oil & Gas Complex GDP for the South region states.**

The South region states are responsible for 12% of the complex GDP share, and the Rio Grande do Sul (RS) state is the most important of them, followed by Parana (PR) and Santa Catarina (SC), Rio Grande do Sul and Parana having processing facilities.

Figure 3.7 illustrates the importance of the Oil and Gas Complex of each state for the national Oil and Gas Complex GDP. Rio de Janeiro and Sao Paulo are the most notable states, followed by Bahia.



Source: Research Data

**Figure 3.7. Oil & Gas Complex GDP participation of each state over the national Oil & Gas Complex GDP.**



### 3.2.3. Oil & Gas GDP components share analysis in the states

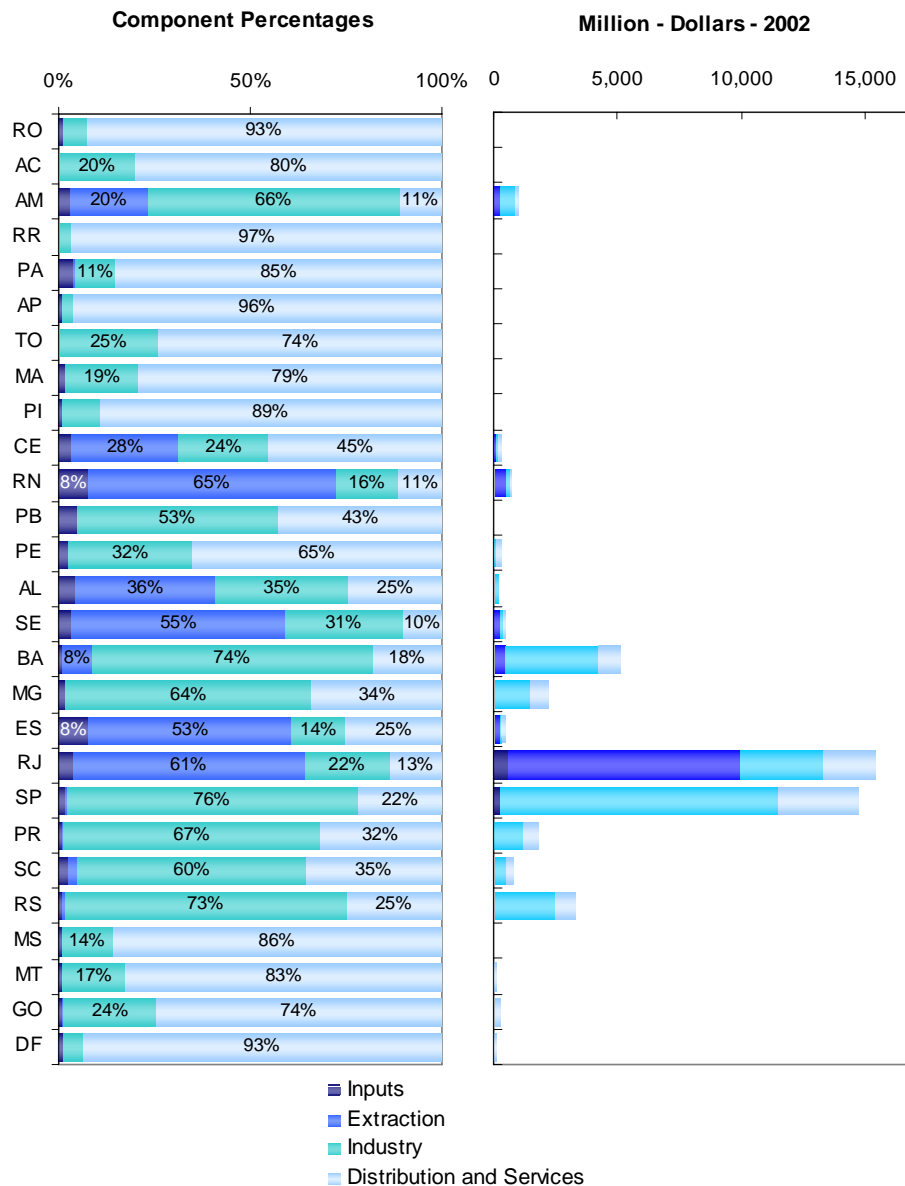
The share of the four components from the state Oil & Gas Complex GDP are indicated in Table 3.2 and in Graph 3.2.

**Table 3.2. Oil & Gas Complex GDP components in the federation unities**

Macro Regions	States	Inputs	Extraction	Industry	Distribution, trade, transport
North Region	RO	0.47	0.00	2.66	39.39
	AC	0.10	0.00	3.83	15.58
	AM	30.82	204.56	656.96	107.11
	RR	0.05	0.00	0.35	11.63
	PA	2.65	0.46	7.30	59.06
	AP	0.21	0.00	0.74	22.10
	TO	0.15	0.03	7.42	21.62
Northeast Region	MA	0.95	0.00	10.99	45.05
	PI	0.39	0.00	3.89	34.97
	CE	11.14	94.86	80.71	153.00
	RN	56.59	474.01	118.16	83.40
	PB	3.37	0.00	38.86	31.42
	PE	8.75	0.14	107.81	219.51
	AL	9.81	81.52	77.35	54.83
	SE	16.95	255.66	142.19	46.62
Southeast Region	BA	48.15	393.86	3,759.08	912.46
	MG	40.36	1.12	1,412.40	750.61
	ES	36.41	240.53	64.67	114.46
	RJ	601.79	9,313.68	3,389.53	2,069.71
South Region	SP	248.78	48.37	11,198.25	3,218.58
	PR	17.30	2.82	1,197.40	569.23
	SC	19.94	16.54	476.87	281.17
Mid-West Region	RS	29.50	31.77	2,425.11	825.24
	MS	0.62	0.06	10.99	69.52
	MT	0.99	0.00	21.57	106.67
Federal District	GO	2.32	0.51	57.84	175.83
	FD	2.08	0.00	7.83	139.45
<b>Total</b>	<b>Brazil</b>	<b>1,191</b>	<b>11,161</b>	<b>25,281</b>	<b>10,178</b>

Source: Research Data

Graph 3.2 is composed by two parts: the horizontal bars on the left side shows the share of the four components (input, extraction, industry of transformation and distribution) on the state Oil & Gas Complex composition. The bars on the right side indicate the contribution of each part, in 2002 billion dollars. The Graph 3.2 allows a better visualization of the data from Table 3.2.



Source: Research Data

**Graph 3.2. Share and values of Oil & Gas Complex components in the federal unities.**

The **input** component contributes with a reduced share (2.5% - Graph 3.1), showing a low relevance for the GDP's composition in all states (from 0.45 to 7.98%).

Concentrated in few productive states, the component **extraction** sector was responsible for 23.3% (Graph 3.1) of the Oil & Gas Complex GDP in Brazil as a whole. Only 6 states (RJ, RN, BA, SE, ES e AM) concentrates 97.5% of the oil extraction-

related GDP. Rio de Janeiro has to be noted for being responsible for 83% of all national GDP related to the extraction sector.

On the chain composition of the Oil & Gas Complex, the component **industry** of transformation participated with 52.9% (Graph 3.1) of the national value. Its importance is related to the presence of large refineries in seven states (SP, BA, RJ, RS, MG, PR e AM), which embraces basically the totality of the large refineries in the country. Those states are responsible for 95% of industry of transformation GDP. Sao Paulo alone is responsible for 44.3%, considered as the most important state in the petroleum and gas transformation process, due to 4 refineries located in its territory.

The component **distribution** and trade is responsible for 21.3% of Oil and Gas Complex GDP. In states with no extraction and/or transformation oil industry, the share of distribution in the state oil and gas complex GDP is high. In Roraima (RO), for example, this component responds for 96.7% of the state oil and gas complex GDP.

#### **4- Conclusions**

The method that determines the GDP calculation assumes four components: the input supplying, the Oil and Gas extraction sector, the industry of transformation and the sectors which are distribution and trade providers. In this case, the sector studied is the Oil extraction and the GDP is calculated based on the inter-sector enchainment data determined by the matrix flows. It includes other sector's products this sector consumes and the goods this sector supplies to the other sectors.

As the main result, it was found that the Oil & Gas Complex GDP corresponds to approximately 10.4% of the Brazilian total GDP in the year of 2002. From this total, more than a half (5.5%) concentrates on industry of transformation, which makes this component the most important of the complex. The second most important is the Oil and Gas extraction sector with 2.4% of the total national GDP. This component includes all the petroleum and gas extraction and the services provided in the oil-well and natural gas-well. Its importance on the GDP is closed to the distribution component (2.2%) formed by services, trade margin and transportation basically associated to the Oil and Gas products and derivatives.

By considering the five macro-regions, the Oil & Gas Complex GDP is especially relevant in the Southeast and in the Northeast, both responding for 84% of the Brazilian

production value. Some states have to be emphasized in this order: Rio de Janeiro, Sao Paulo, Bahia, Minas Gerais and Rio Grande do Norte. The participation of Southern states and the Amazon state has also to be considered.

Regarding to the states, the Oil & Gas Complex share in the states total GDP is between 0.8% (Para) and 27% (Rio de Janeiro). The oil and gas complex is particularly important for Rio de Janeiro, where more than a quarter of the total state GDP depends on the complex. The complex influence over state GDP is also present in other states like Bahia and Rio Grande do Norte, as cited before

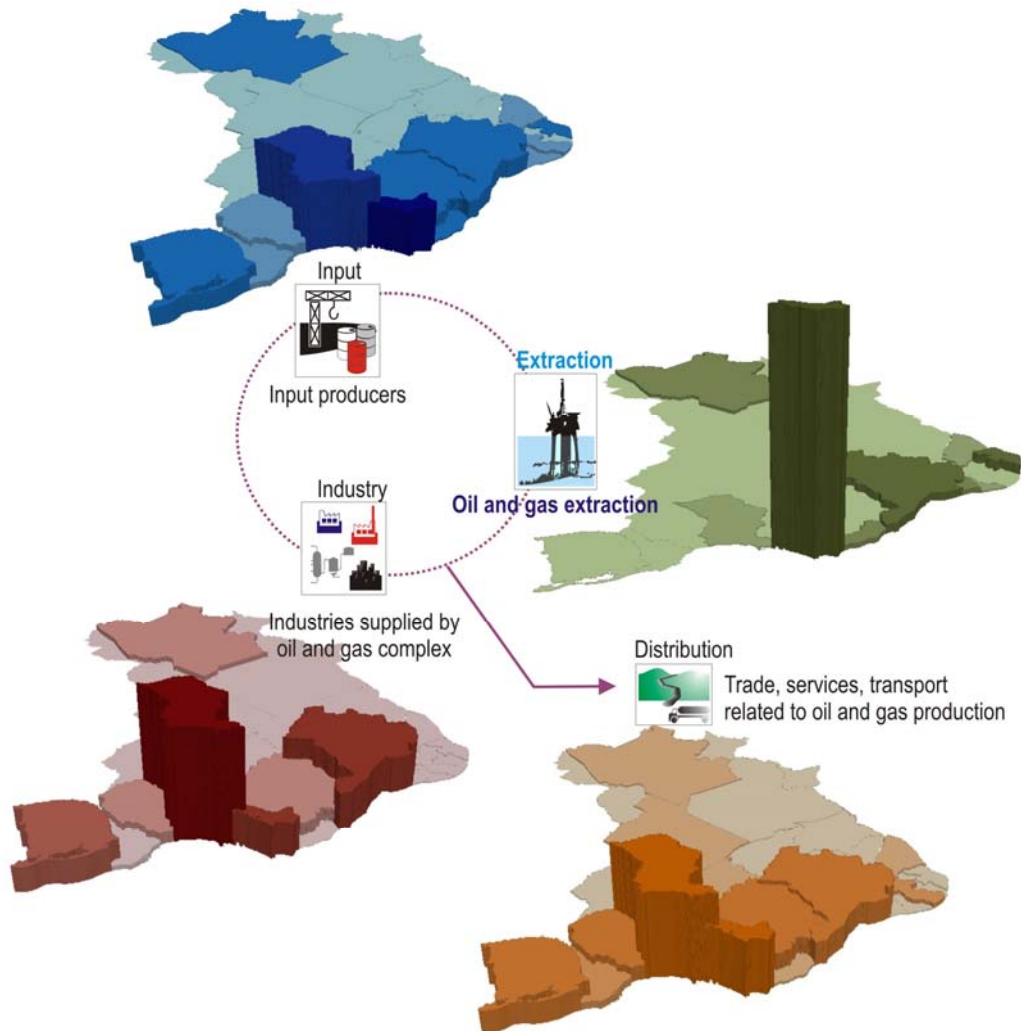
Observing the federation unities share on the O&G Complex GDP composition and each of its components (input, extraction, transformation and distribution), it was noted in Figure 4.1 that Sao Paulo state is more influent in three of the components (input, transformation and distribution). However, its difference compared to the other states is not as significant as the difference compared to Rio de Janeiro state due to extraction component. It was evident that the extraction sector GDP is predominant in Rio de Janeiro since the extraction is concentrated offshore this state, one single exception is demonstrated by the Amazonas state.

São Paulo state is noted by its set of industry of transformation, with four refineries and one petrochemical pole. This state also has industries directly associated to the petroleum derivatives, such as the chemical and rubber industries. Observing the map regarding to the industry component, in Bahia state, its importance is attributed to the Camaçari petrochemical pole. In other states such as Rio Grande do Sul and Minas Gerais, the refineries, petrochemical and resin industries are important to the GDP state composition.

It follows that the Oil & Gas Complex assumes great importance in the Brazilian economy, representing a tenth part of the national total GDP. Almost half of this percentage is attributed to the transformation sector, indicating that the industry sector associated to this complex is well developed. Thus, besides the ability of extracting petroleum and gas from its reserves, the country is also capable of effectuating the subsequent process of the productive chain, adding value to the derivative products which are, mostly, consumed inside the country. With new petroleum basin discoveries and the increase of the volume of petroleum extracted, Brazil has becoming independent in non-renewable energetic sources and its derivative products. Nevertheless, the

refining sector is still concentrated and unable to process all the crude oil extracted in Brazilian basins.

Obviously, it contributes to the country's economic development, but the spatial distribution of this complex is not homogeneous. The largest petroleum reserves are located offshore, leading the country as a reference in the technology of petroleum extraction in deep waters. It justifies the petrochemical industry installation in the coast neighborhood and the insignificant presence of the Oil & Gas Complex in states in the countryside, with one exception, the Amazonas state, where the petroleum-well and gas-well were found in the continental portion.



Source: Research data

**Figura 4.1. Magnitude of state components GDP from Oil & Gas Complex**

The petroleum extraction self-sufficiency is strategically important to the national development since it guarantees the energetic supply necessary to the industrial growth and provides raw-material to the production of a variety of refine derivatives. The presence of most of the technology used this production chain inside Brazil, contributes to the generation of value added inside the country. These funds are responsible for researches and new technologies creation related to the non-renewable and also renewable combustible production. The alcohol and bio-diesel are real promises that could replace part of the non-renewable combustible demand, supporting cultivation such as sugar-cane, soybean and castor bean placed in the countryside.

At last, the resources acquired in the Oil & Gas Complex finance the Oil & Gas technologies and, in the future, it might consolidate the use of renewable energetic combustibles, improving the wealth spatial distribution to the countryside of Brazil, through increase the agricultural products demand.

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