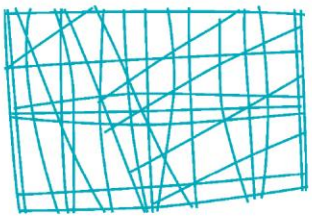

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ECONOMIC IMPACTS OF PRE-SALT ON A REGIONAL ECONOMY: THE CASE OF ESPÍRITO SANTO, BRAZIL

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Economic Impacts of Pre-Salt on a Regional Economy: The Case of Espírito Santo, Brazil

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Abstract. The Brazilian government has recently confirmed the discovery of a huge oil and natural gas field in the pre-salt layer of the country's southeastern coast. It has been said that the oil fields can boost Brazil's oil production, and turn the country into one of the largest oil producers in the world. The fields are spatially concentrated in the coast area of a few Brazilian states that may be directly benefited by oil production. This paper uses an interregional CGE model to assess the impacts of pre-salt on the economy of the State of Espírito Santo, a region already characterized by an economic base heavily reliant on natural resources. We focus our analysis on the structural economic impacts, considering two alternative closures.

1. Introduction

The State of Espírito Santo is best described as a small Brazilian state. It is responsible for only 2.3% of Brazilian gross domestic product (GDP) and is the home of 1.9% of the country's population.[1] Its economy relies heavily on the natural-resources-based industry, whose products are, in its majority, exported. As Caçador and Grassi (2009) show, in 2005, the commodity-based industry[2] was responsible for 76.6% of the State's manufacturing value added and for 92.5% of the State's total exports. The production of the commodity-based industry is concentrated in a few big companies (Vale, Samarco, ArcelorMittal Tubarão, Aracruz Celulose and Petrobras) that operate at international scale. It is noticeable that Vale, Samarco, ArcelorMittal Tubarão, Aracruz Celulose and ArcelorMittal Belgo together were responsible for 77.4% of the State's exports.

The traditional industry[3] is the second most important industry in the local economy, though it represented only 8.6% of the State's manufacturing value added in 2005 (Caçador and Grassi, 2009, p. 463). Its importance lies on its geographic location: many industries such as textile, clothing and furniture are located in the upstate and are

[1] Estimates for 2007. Source: IBGE. Available at www.ipeadata.gov.br.
[2] It is considered as being part of the commodity industry the following sectors: oil and gas extraction and related services; metal ore mining; pulp and paper manufacturing; basic metallurgy; manufacture of coke and petroleum refining; manufacture of nuclear fuel; ethanol production; and coal mining.
[3] By traditional industry we consider: food and beverage production; textile industry; clothing and accessories manufacturing; leather manufacturing; luggage and footwear manufacturing; wood products manufacturing; and furniture manufacturing.

responsible for the creation of jobs and income in small municipalities. Also the service sector related to foreign trade has an important role in the State economy. In addition to the exports of the commodities, the State can be considered the gateway for an important number of goods imported by trading firms. The establishment of these firms on the State of Espírito Santo was stimulated by the State Government through the Fundap[4] system, which gives financial incentives to firms that import from the state's ports. In 2006, these companies were responsible for 60.8% of the state's total imports and generated 30% of the ICMS[5] tax revenue, by far the most important state tax revenue (Caçador and Grassi, 2009, p. 458-459).

Although being a small economy inside the Brazilian federation, the State of Espírito Santo was recently projected to the national economic scenario after the discovery of a huge oil and natural gas field in the pre-salt layer of the country's southeastern coast. The first discoveries of oil and natural gas in the pre-salt layer were announced in 2006, but it was not until 2008 that the volume of barrels was confirmed. The new reserves amount to 14 billion barrels of oil and natural gas, and together with the 14 billion barrels of the post-salt layer already known, the Brazilian reserves were duplicated.[6] Of the 14 billion barrels, 3.5 billion barrels of oil of the light crude type is located on the coast of Espírito Santo. Besides that, the first oil well discovered is only 2.5 kilometers away of the FPSO JK (P-34) platform that, since 2006, extracts oil and natural gas of the post-salt layer of the state's coast.[7] This fact allowed to the anticipation of the oil extraction of the pre-salt layer. Currently, Petrobrás, the government-controlled national oil company, extracts around 15 thousand barrels a day from this well and 15 thousand more from the well located at the Rio de Janeiro's coast.[8] The company's goal to 2013 is to produce 100 thousand barrels daily in the pre-salt layer of the Espírito Santo's coast, with a predicted investment of R$ 10.3 billion (nearly US$ 5.7 billion)[9] between 2009 and 2013. This goal represents an expressive increasing in the output of the local

[4] Fund for the Development of Port Activities.
[5] Value added tax on goods and services.
[6] FOLHA ONLINE. Petrobras anuncia descoberta de reservas de petróleo em pré-sal do ES. 21 de novembro de 2008. Available at: <http://www1.folha.uol.com.br/folha/dinheiro/ult91u470121.shtml>. Accessed 12/02/2009.
[7] AGÊNCIA ESTADO. Lula e Petrobras inauguram exploração do pré-sal nesta terça. 2 de setembro de 2008. Available at:<http://www.estadao.com.br/economia/not_eco234746,0.htm> Accessed 12/02/2009.
[8] G1. Pré-sal vai produzir 1,8 milhão de barris por dia em 2020, diz Gabrielli. G1. Brasília, 08 de novembro de 2009. Available at:<http://g1.globo.com/Noticias/Economia_Negocios/0,,MUL1371103-9356,00.html> Accessed 12/02/2009.
[9] PETROBRAS (2009).

oil and natural gas extraction sector: compared to the actual production of 140 thousand barrels a day in the post-salt layer, the expected growth of the production is of 70%.

For the pre-salt layer as a whole, the goal of Petrobrás to 2013 is to extract 219 thousand barrels of oil and 7 million m^3 of natural gas daily, with predicted investments of R$ 28.9 billion (nearly US$ 16 billion) between 2009 and 2013. For 2020, the goal is 1.815 million barrels of oil and 40 million m^3 of natural gas daily. If one considers that in 2008 the Brazilian oil output was of 1.855 million barrels a day, one can see the magnitude of the pre-salt layer exploitation.[10]

The facts described above give rise to the question: will this natural resources discovery be a curse for the local economy? Although early economists stressed that natural resources would have a positive role in economic development, strong empirical evidence has shown a negative correlation between resource abundance and economic growth: resource-abundant countries tend to grow more slowly than resource-poor countries. And, as the availability of natural resource *per se* should not mitigate economic growth, the literature on "natural resource curse" has pointed out a number of explanations for these empirical results: the linkage theory, described in Gelb (1988); the "Dutch disease" effect, whose "core model" was presented by Corden and Neary (1982) and was also present in the model of Sachs and Warner (1999); the fluctuation of the terms of trade, with implication for the volatility of the revenue associated to the natural resources (Auty, 2001); the crowding-out effect (Buffie 1993, Sachs and Warner, 2001); and rent-seeking effects (Torvik, 2002).

The methodology used to describe and analyze the natural resource curse varies across studies, and a great number of them use cross-country regressions or panel data.[11] By far most studies concentrated on the country's economy as a whole, and only a few on regional economies. In fact, as far as we know only Papyrakis and Gerlagh (2007), Li and Polanski (2009) and Shao and Qi (2009) take on a regional approach, the former for the US States, and the latter two for Chinese provinces, although their focus was not exclusive on the Dutch disease mechanism neither in the computable general

[10] PETROBRAS (2009).

[11] The natural resource curse literature is quite extensive; we mentioned here a few examples of recent works in this line of investigation that also review previous studies: Sachs and Warner 1999, 2001; Papyrakis and Gerlagh 2004, 2007.

equilibrium (CGE) methodology, on which we focus here. Papyrakis and Gerlagh (2007) used cross-state regressions to verify the effect of resource abundance on the per capita economic growth rate of 49 US states for which they had data. Their findings show that resource abundance can have a negative impact on growth through indirect channels such as investment levels, schooling rates and openness. Li and Polanski (2009) study the natural resource curse through the linkage theory. For them, the main economical explanation for the curse resides on the low intraregional linkages, both backward and forward linkages, of the natural resource sector with the supply chain. Using regional input-output date for China for 1997 and 2002, the authors verified the low linkage of this sector and that Chinese regions that based their growth on natural resources grew less than the other regions. Shao and Qi (2009) used cross-province panel data regression for Western China provinces to analyze the effects of energy exploitation on growth. As a result, they find that energy exploitation has both direct and indirect negative effects on growth. The indirect effect hinders economic growth through S&T innovation, human capital investment and corruption.

The Dutch disease effect implies a structural change in the economy due to the boom in the natural resource sector. As the natural resource sector is a tradable sector, the inflow of revenue causes the real exchange rate to appreciate, what in turn dampen the exports and growth of the other tradable sectors, usually the more dynamic manufacture sector or the agricultural sector in poor developing countries. Some authors (e.g. David, 1995) argue this cannot be called a disease, and considered it an adjustment to the new long run equilibrium of the economy. However, it can be argued that this structural change is unwanted since it reduces the capacity of the economy to maintaining sustainable growth after the boom. Therefore, the Dutch disease mechanism implies general equilibrium effects in the economy, which makes CGE models appropriate tools to study these effects.

Thus, this paper brings a new contribution to the literature combining the regional analysis with the computable general equilibrium approach in evaluating the Dutch disease effect. It uses an interregional CGE model, called B-MARIA-ES (BMES), to assess the impacts of pre-salt on the economy of the State of Espírito Santo. We focus our analysis on the structural economic impacts, both in the short run and the medium run.

The remainder of this article is organized as follows. The next section introduces a brief review of the literature on the "Dutch disease" debate. Section 3 describes the interregional CGE model used in this study. Section 4 presents the features of the Espírito Santo's economy and of the oil and natural gas extraction sector. Section 5 discusses the results of the simulations, and the final section presents the conclusion of this study.

2. "Dutch Disease"

The fact that gave rise to the term "Dutch disease" was the economic effects of the discovery and exploitation of natural gas in the Netherlands in the 1960s. The inflow of revenue from the exports of natural gas led to the real appreciation of the Dutch real exchange rate, with adverse consequences for the country's manufacturing sector (Corden, 1984).

The theoretical core model was first presented in more detail by Corden and Neary (1982) and again in Corden (1984). The economy is modeled as a three-sector economy, including the Booming Sector (B), the Lagging Sector (L) and de Non-Tradable Sector (N). The first two sectors produces tradable goods facing world prices, the Booming Sector is associated to the natural resource sector and, usually, the Lagging Sector is associated to the manufacturing sector, although it can have alternative interpretations such as the agricultural sector, particularly in poor developing countries. Each sector uses specific factor and labor to produce its output, being labor mobile across all three sectors, assuring the wage equalization. All factor prices are flexible and all factors are internationally immobile.

As the authors highlight, the boom in sector B can be interpreted as a once-for-all exogenous technical improvement in B that elevates its productivity only in the analyzed country; as a windfall discovery of new resources or new resources reserves, when the resource is already explored; or as an exogenous rise in world's price of the country's product, which is only exported and not sold in the domestic market.

The initial effect of a boom in sector B is to raise the aggregate incomes of the factors employed in that sector. This leads to two other effects in the economy: the spending effect and the resource movement effect. The spending effect is related to the spent of the extra income of sector B into the non-tradable goods of sector N. Provided that the income elasticity of demand for N is positive, this spent raises the price of the non-tradable goods relative to the tradable ones, configuring the real appreciation and driving resources out of L into N.

The resource movement effect is associated to the movement of labor between the sectors. The boom in B raises the marginal productivity of labor in B and, at a constant wage in terms of tradable goods, it raises the demand for labor in B, which induces the movement of labor out of L and out of N. This effect is compounded by two parts: first, the movement of labor out of L into B, which lowers the output of the L sector and can be called direct de-industrialization effect; second, the indirect de-industrialization effect caused by the movement of labor out of N into B, which in turn shifts the supply curve of non-tradable goods creating excess demand for N and additional real appreciation, what brings additional movement of labor out of L into N.

Both effects combined lead to the decrease of real rents of the specific factor in L, "this being the essential problem of the Dutch Disease, at least as seen from the point of view of this factor." (Corden, 1984, p.362). The wage rises, but as the price of non-tradable goods also rises, the real wage defined in terms of a consumption basket of tradable and non-tradable goods may rise or fall.

The model described above also assumes that the Booming Sector output is wholly exported and that it is a final consumption good not an input. If these hypotheses are relaxed, the results of the core model are amplified (Corden 1984, pp. 368-369).

The Dutch disease effect is not an inevitable one. Depending on the assumptions, it is possible for the tradable sector to expand with the boom. As Corden and Neary (1982) show, if the capital is mobile between L and N and if L is the capital-intensive sector, the resource movement effect, under a constant real exchange rate, may lead to the expansion of the L sector. But the final effect depends on the sum of this resource movement effect with the negative effect on L of the spending effect. Also, even if the L

sector as a whole contracts it is possible that some industries inside the L sector expand, if there is capital mobility between these industries (Corden, 1984, p.363).

A special case of the core model appears when the Booming Sector is an "enclave", i.e., it does not employ a factor that is mobile to the other sectors of the economy. In this case there is no movement effect, only the spending one, and the key mechanism to the structural change in the economy is the real exchange appreciation. This hypothesis is usually made for developing countries, where the natural resource is exploited by foreign companies. Benjamin et al. (1989) assume this hypothesis in their study of the economy of Cameroon. Besides that, they also highlight that the effects of an oil boom on a developing country may be different due to two other characteristics of the economy: (i) in general, it is the agricultural sector that is the Lagging Sector and produces the tradable good, so it is most likely to be the hurt sector rather than the manufacturing sector, with implications for the rural-urban terms of trade and migration; and (ii) the manufacturing sector produces goods that normally are imperfect substitutes to the imported ones, so the consumer demand for the domestic manufactured product may not shift entirely to imported goods as the domestic prices rise with the spending effect. To evaluate the economic impacts of an increase in the oil revenues, Benjamin et al. (1989) used a CGE model for Cameroon that incorporated the characteristic mentioned above. The model included eleven sectors and three types of labor and was calibrated for 1979-1980, a period where the country's oil revenues were small. Their results showed that the tradable sector as a whole contracted, with the real exchange rate appreciation, but the impact was different depending on the sector: the agricultural sector suffer the most, but some tradable manufactures that were imperfect substitutes to the imported goods expanded their output. Also, there was an increasing in the rural-urban wage gap, although the wage rose across the board.

Another work that studied the Dutch disease under the CGE approach is Bandara (1991). The author constructed a miniature version of CGE models with three sectors to represent the Corden and Neary's core model. He then analyzed the effects of three shocks: an improvement in the technology of export industry; an increase in foreign capital inflows; and an increase in the price of the export commodity. The shocks were selected to result in a 10 percent rise in the wage rate economy-wide, so that the effects could be compared. The conclusion is that "a CGE model is well suited to analyzing

Dutch-disease-type effects" and "can be used to investigate the possible reasons for the Dutch disease effects as expected in the core model", although there are limitations regarding the assumptions made (Bandara, 1991, pp.91-92).

The Dutch disease concept is applied not only to study the economic consequences of changes in the natural resource sector but also to others economical situations in which the inflow of external resources causes the real exchange rate to appreciate, with negative effects over the manufacturing or agricultural exported sectors. Nkusu (2004) analyzed the implications of foreign aid to the economy of low-income countries under the Dutch disease framework. In reviewing the literature, the author presents mix evidence, with some countries suffering from Dutch disease as a result of large official development assistance inflows and others not. He then presents a modified version of Corden and Neary (1982) core model in which the full employment and the small-country assumptions are relaxed. The result is that without the full employment hypothesis "the spending effect is not a sufficient condition for Dutch disease-type effects to occur." (Nkuru, 2004, p.12). When both assumptions are relaxed,

> "…there are indications that the RER [real exchange rate] may not appreciate at all as a result of a spending boom induced by ODA [official development assistance] flows, or, if it does, the appreciation will not necessarily give rise to a contraction of the tradable sector. An increased use of available resources allows both the tradables and non-tradables sectors to expand, and the trade balance would not necessarily deteriorate." (Nkuru, 2004, p.13).

Bresser-Pereira (2008) analyzed the Dutch disease as a market failure and as such he extends the Dutch disease concept to include not only countries that exploit natural resources but also countries that has an abundant cheap labor supply and a wage spread substantially larger than the one prevailing in rich countries. In this case, "the industries using mainly cheap labor have a lower marginal cost than the more technologically sophisticated industries. As a consequence, the exchange rate tends to converge on the level that makes it profitable to export goods that use cheap labor" (Bresser-Pereira, 2008, p. 67). The more sophisticated industries that use expensive labor become less competitive due to the appreciated exchange rate and, in turn, the extended Dutch disease becomes an obstacle to economic growth.

3. The BMES Model

In order to evaluate the effects of exploiting the pre-salt in Brazil, under different economic environments (closures), we departed from the B-MARIA-27 model, described in detail elsewhere (Haddad and Hewings, 2005). Its structure represents a further development of the **B**razilian **M**ultisectoral **A**nd **R**egional/**I**nterregional **A**nalysis Model (B-MARIA), the first fully operational interregional CGE model for Brazil.[12] Its theoretical structure departs from the MONASH-MRF Model (Peter *et al*., 1996), which represents one interregional framework in the ORANI suite of CGE models of the Australian economy. The interstate version of B-MARIA used in this research, the BMES model, contains over 480.000 equations[13], and it is designed for policy analysis in a comparative-static framework. Agents' behavior is modeled at the regional level, accommodating variations in the structure of regional economies. The model recognizes the economies of two Brazilian regions, the State of Espírito Santo and the rest of the country. Results are based on a bottom-up approach – national results are obtained from the aggregation of regional results. The model identifies 55 sectors (Table 1) in each region producing 110 commodities (Table 2) through a transformation process based on a constant elasticity of transformation (CET) specification.[14] The model also recognizes one representative household in each region, regional governments and one Federal government, and a single foreign consumer who trades with each region. Special groups of equations define government finances, accumulation relations, and regional labor markets. The mathematical structure of the suite of B-MARIA models is based on the MONASH-MRF Model for the Australian economy. It qualifies as a Johansen-type model in that the solutions are obtained by solving the system of linearized equations of the model. A typical result shows the percentage change in the set of endogenous variables, after an exogenous change is carried out, compared to their values in the absence of such change, in a given environment. The schematic presentation of Johansen solutions for such models is standard in the literature. More details can be found in Dixon *et al*. (1992).

[12] The complete specification of the model is available in Haddad (1999).
[13] There are 289 block equations and 346 block variables in the *condensed model*; the *entire model* contains 327 block equations and 397 block variables.
[14] The sectors/products are mapped into the three categories of Corden and Neary's core model: Booming sector – B (sector 3/product 19); Lagging sector – L (sectors 1-39, but 3/products 1-89, but 19); and Non-tradable sector (sectors 40-55/products 90-110).

Table 1. List of Sectors in the BMES Model

1	Agriculture, forestry, logging
2	Livestock and fishing
3	Oil and natural gas
4	Iron Ore
5	Other extractive industries
6	Food and Drink
7	Tobacco product
8	Textiles
9	Clothing and accessories
10	Leather goods and footwear
11	Wood products - exclusive mobile
12	Pulp and paper products
13	Newspapers, magazines, records
14	Petroleum refining and coking
15	Alcohol
16	Chemicals
17	Manufacture of resin and elastomers
18	Pharmaceutical products
19	Agrochemicals
20	Perfumery, hygiene and cleanliness
21	Paints, varnishes, enamels and lacquers
22	Various chemical products and preparations
23	Rubber and plastic
24	Cement
25	Other products of nonmetallic minerals
26	Manufacture of steel and steel products
27	Metallurgy of nonferrous metals
28	Metal products - except machinery and equipment
29	Machinery and equipment, including maintenance and repairs
30	Appliances
31	Office machines and computer equipment
32	Machinery, equipment and material
33	Electronic and communication equipment
34	Medical, hospital, measurement and optical apparatus / instruments
35	Cars, vans and utilities
36	Trucks and buses
37	Parts and accessories for motor vehicles
38	Other transportation equipment
39	Furniture and products of diverse industries
40	Electricity and gas, water, sewer and street cleaning
41	Construction
42	Commerce
43	Transport, storage and mailing
44	Information Services
45	Financial intermediation and insurance
46	Real estate services and rental
47	Maintenance and repair
48	Accommodation services and meals
49	Business services
50	Education mercantile
51	Health mercantile
52	Other services
53	Public education
54	Public health
55	Public administration and social security

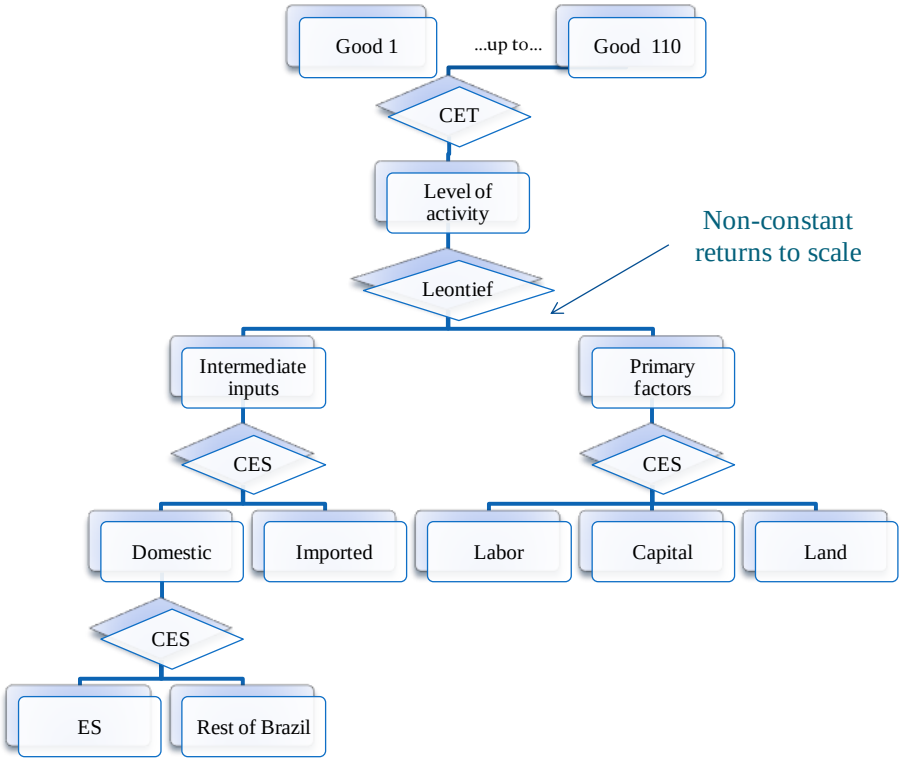
Table 2. List of Products in the BMES Model

1	Rough Rice	56	Ethanol
2	Grain maize	57	Fuel oil
3	Wheat grain and other cereals	58	Diesel oil
4	Cane sugar	59	Other products of petroleum refining and coking
5	Soybeans	60	Alcohol
6	Other products and services from farming	61	Inorganic chemicals
7	Cassava	62	Organic chemicals
8	Tobacco leaf	63	Manufacture of resin and elastomers
9	Upland cotton	64	Pharmaceutical products
10	Citrus fruits	65	Agrochemicals
11	Coffee bean	66	Perfumes, soaps and cleaning supplies
12	Forestry	67	Paints, varnishes, enamels and lacquers
13	Cattle and other livestock	68	Various chemical products and preparations
14	Cow's milk and of other animals	69	Rubber
15	Live pigs	70	Plastic
16	Live poultry	71	Cement
17	Chicken eggs and other poultry	72	Other products of nonmetallic minerals
18	Fishing and aquaculture	73	Pig iron and ferro-alloys
19	Oil and natural gas	74	Semi-finished, flat rolled and long steel tubes
20	Iron Ore	75	Metallurgy products of nonferrous metals
21	Mineral coal	76	Molten steel
22	Non-ferrous metal ores	77	Metal products - except machinery and equipment
23	Non-metallic minerals	78	Machinery and equipment, including maintenance and repairs
24	Slaughter and preparation of meat products	79	Appliances
25	Pig meat fresh, chilled or frozen meat	80	Office machines and computer equipment
26	Poultry meat fresh, chilled or frozen	81	Machinery, equipment and eletrical material
27	Industrialized fish	82	Electronic and communication equipment
28	Canned fruits, vegetables and other plants	83	Medical, hospital, measurement and optical apparatus / instruments
29	Soybean oil and raw pies, cakes and soybean meal	84	Cars, vans and utilities
30	Other vegetable oils and vegetable and animal fat, exclusive corn	85	Trucks and buses
31	Refined soybean oil	86	Parts and accessories for motor vehicles
32	Cold milk, sterilized and pasteurized	87	Other transportation equipment
33	Dairy products and ice cream	88	Furniture and products of diverse industries
34	Processed rice and related products	89	Recycled scrap
35	Wheat flour and related products	90	Electricity and gas, water, sewer and street cleaning
36	Cassava flour and other	91	Construction
37	Corn oils, starches and vegetable feed	92	Commerce
38	Products of the mills and refining of sugar	93	Freight
39	Roasted and ground coffee	94	Passenger Transport
40	Instant coffee	95	Mail
41	Other food products	96	Information Services
42	Drinks	97	Financial intermediation and insurance
43	Tobacco product	98	Real estate services and rental
44	Cotton processing and spinning of other textiles	99	Rent charged
45	Weaving	100	Maintenance and repair
46	Manufacture other textile products	101	Accommodation services and meals
47	Clothing and accessories	102	Business services
48	Preparation of leather and manufacture of artifacts - exclusive shoes	103	Education marcantile
49	Shoemaking	104	Health mercantile
50	Wood products - exclusive mobile	105	Household services
51	Pulp and other pulp for papermaking	106	Related Services
52	Paper and cardboard packaging and artifacts	107	Domestic Services
53	Newspapers, magazines, CDs and other products recorded	108	Public education
54	Liquefied petroleum gas	109	Public health
55	Automotive gasoline	110	Public service and social security

3.1. CGE Core Module

The basic structure of the CGE core module is very standard and comprises three main blocks of equations determining demand and supply relations, and market clearing conditions. In addition, various regional and national aggregates, such as aggregate employment, aggregate price level, and balance of trade, are defined here. Nested production functions and household demand functions are employed. For production, firms are assumed to use fixed proportion combinations of intermediate inputs and primary factors in the first level while, in the second level, substitution is possible between domestically produced and imported intermediate inputs, on the one hand, and between capital, labor and land, on the other. At the third level, bundles of domestically produced inputs are formed as combinations of inputs from different regional sources. The modeling procedure adopted in BMES uses a constant elasticity of substitution (CES) specification in the lower levels to combine goods from different sources. Given the property of standard CES functions, non-constant returns are ruled out. One can modify assumptions on the parameters values in order to introduce external scale economies of the Marshallian type. Changes in the production functions of the manufacturing sectors in each region were implemented in order to incorporate non-constant returns to scale, a fundamental assumption for the analysis of integrated interregional systems. We kept the hierarchy of the nested CES structure of production, which is very convenient for the purpose of calibration (Bröcker, 1998), but we modified the hypotheses on parameters values, leading to a more general form. Non-constant returns to scale were introduced in the group of equations associated with primary factor demands within the nested structure of production. The sectoral demand for the primary factor composite (in region *r*), *y*, relates to the total output, *z*, in the following way: $y = az^{\rho}$, with the technical coefficient a, and the parameter ρ specific to sector j in region r. This modeling procedure allows for the introduction of Marshallian agglomeration (external) economies, by exploring local properties of the CES function (Figure 1).

Figure 1. Nested Structure of Production in the BMES model



The treatment of the household demand structure is based on a nested CES/linear expenditure system (LES) preference function. Demand equations are derived from a utility maximization problem, whose solution follows hierarchical steps. The structure of household demand follows a nesting pattern that enables different elasticities of substitution to be used. At the bottom level, substitution occurs across different domestic sources of supply. Utility derived from the consumption of domestic composite goods is maximized. In the subsequent upper-level, substitution occurs between domestic composite and imported goods.

Equations for other final demand for commodities include the specification of export demand and government demand. Exports face downward sloping demand curves, indicating a negative relationship with their prices in the world market. One feature presented in BMES refers to the government demand for public goods. The nature of the input-output data enables the isolation of the consumption of public goods by both the federal and regional governments. However, productive activities carried out by the public sector cannot be isolated from those by the private sector. Thus, government

entrepreneurial behavior is dictated by the same cost minimization assumptions adopted by the private sector.

A unique feature embedded in the B-MARIA family of models is the explicit modeling of the transportation services and the costs of moving products based on origin-destination pairs. The model is calibrated taking into account the specific transportation structure cost of each commodity flow, providing spatial price differentiation, which indirectly addresses the issue related to regional transportation infrastructure efficiency. Such structure is physically constrained by the available transportation network, modeled in a geo-coded transportation module.[15] Other definitions in the CGE core module include: tax rates, basic and purchase prices of commodities, tax revenues, margins, components of real and nominal GRP/GDP, regional and national price indices, money wage settings, factor prices, and employment aggregates.

3.2. Structural Database

The CGE core database requires detailed sectoral and regional information about the Brazilian economy. National data (such as input-output tables, foreign trade, taxes, margins and tariffs) are available from the Brazilian Statistics Bureau (IBGE). At the regional level, a full set of state-level accounts were developed at FIPE-USP. These two sets of information were put together in a balanced interstate social accounting matrix, updated to 2004. Previous work in this task has been successfully implemented in interregional CGE models for Brazil (e.g. Haddad, 1999; Haddad and Hewings, 2005).

3.3. Behavioral Parameters

The benchmark figures for the regional elasticities of substitution were 3.0 to tradable goods, and 2.0 for non-tradables. Parameter values for international trade elasticities were set at half the values of the corresponding regional trade elasticities. Substitution elasticity between primary factors was set to 0.5. Scale economies parameters were set to one in all sectors and regions, except for the core manufacturing sectors in the rest of the country, which were set to 0.8. Elasticities of transformation in the CET

[15] See Haddad and Hewing (2005), for more details.

specification were fixed at 0.05, for all sectors. The marginal budget shares in regional household consumption were calibrated from the SAM data, assuming the average budget shares to be equal to the marginal budget shares. We have set to -2.0 the export demand elasticities. Finally, we have assumed constant returns to bulk transportation, setting the parameter of scale economies in bulk transportation to one.

3.4. Model Closures

The full model contains 489.412 equations and 493.090 unknowns. Thus, to close the model, 3.678 variables have to be set exogenously. The nominal exchange rate was set as the *numéraire*. In order to capture the effects of increases in oil production associated with the pre-salt, the simulations were carried out under two alternative closures, referring to different hypotheses on regional labor markets. There is no dynamics in the model. The simulations with the BMES model capture the effects associated with the static impact-effect question, i.e., given the structure of the economy, what-if questions can be addressed in a comparative-static framework. The closures differ in the way the equilibrating mechanisms in the labor markets are set. Structural changes are captured *only* through the evaluation of a re-allocation of resources.

In both closures, capital stocks are held fixed. In addition to the assumption of interindustry and interregional immobility of capital, *closure 1* includes fixed regional population and labor supply, fixed regional wage differentials, and fixed national real wage. Regional employment is driven by the assumptions on wage rates, which indirectly determine regional unemployment rates. Labor is, thus, mobile only across sectors within the same region. On the demand side, investment expenditures are fixed exogenously – firms cannot reevaluate their investment decisions in the short run. Household consumption follows household disposable income, and real government consumption, at both regional and central levels, is fixed. Balance of payments has to adjust to changes in government deficit. Finally, preferences and technology variables are exogenous.

Closure 2 has the same set of assumptions as closure 1, except those for the labor markets. In closure 2, we also allow labor to move between regions. Aggregate employment is determined by population change, labor force participation rates, and the

natural rate of unemployment. The distribution of the labor force across regions and sectors is fully determined endogenously. Labor is attracted to more competitive industries in more favored geographical areas, keeping regional wage differentials constant. Such a closure tries to mimic the equilibrating mechanisms in the Corden and Neary's core model in a context of an integrated interregional system. By using two closures, with different degrees of interregional factor (labor) mobility, our goal is to assess the role of different hypotheses in driving Dutch disease type of results in a regional economy. While in closure 1 we have a more restricted set of hypotheses for labor mobility, in closure 2 the economic environment is closer to the more often discussed equilibrating mechanisms in Dutch disease models.

4. Structural Setting

The calibration of the model, i.e., the assignment of values to the relevant parameters and coefficients of the model which produce an initial solution, is based on the data files described above. By working with percentage changes rather than absolute changes, the coefficients of the model are often readily interpretable cost and sales shares, and they can be derived from input-output tables. Together with values of substitution elasticities, and some supplementary data on values of capital stocks, depreciation rates, demographic variables, and some other variables, the initial solution can be deduced.
In this section, the general structure of the absorption matrix is described in terms of summary indicators specifying agents' sales and purchases orientations, and output composition. An evaluation of the production linkages follows, based on the input-output flows, providing a comparative analysis of the economic structure of the two regions. Traditional input-output multipliers are used in an attempt to uncover similarities and differences in the structure of the regional economies. We highlight some features of the Espírito Santo's economy and of the state's oil and natural gas sector, based on the 2004 database used to calibrate the CGE model.

4.1. The Economy of Espírito Santo

The State of Espírito Santo is a small Brazilian state and, as argued in the introduction, its economy relies heavily on the natural resources based industry, whose products are, in its majority, exported. This reliance on natural resources can be traced back to the

1970s, when the Military Government implemented its Second National Development Plan and invested in industrial plants producing commodities in the State. Those investments encompassed the construction of major plants for pulp and cellulose (Aracruz Celulose), and steel and steel products (Samarco and CST, nowadays ArcelorMittal Tubarão), as well as the expansion of mining activities by Vale, at that time, a state-owned enterprise.

As already point out, in 2007, the State's gross regional product was equivalent to 2.3% of the Brazilian's GDP and the State's population represented 1.9% of the country's population. Considering the 2004 database used in the calibration of the CGE model, those numbers were 2.0% and 1.8%, respectively. However, it is important to notice that for some sectors the local output represented a larger share of the sectoral national output. For sectors such as manufacture of steel and steel products, iron ore pellets, others products of non-metallic minerals and oil and natural gas extraction the local output represented, respectively, 15.1%, 13.2%, 9.7% and 6.3% of the sector's national output.

The State's productive structure can be considered concentrated, with 12 out of the 55 sectors presented in the model being responsible for 71.2% of the State's output. The three largest sectors are: manufacture of steel and steel products, responsible 15.2% of the local output; transportation, whose output is equivalent to 7.9% of local output; and commerce, whose share are 7.1%. The other nine sectors are: food and beverages; public administration, construction, agriculture, oil and natural gas extraction, real estate services, other products of non-metallic minerals, iron ore pellets, pulp and paper manufacturing (see Table 4.A, in the Appendix A).

Regarding the State's sales structure, 46.4% of the State's output are destined to the intermediate consumption, 21.6% are sold to the households, 14.6% are exported, 9.9% are sold to regional and the Federal governments, and only 7.4% are destined to capital creation. From the output share that is destined to the intermediate consumption, only 18.1% are sold to local consumers, being the rest (28.3%) sold to the rest of the country. This indicates a relatively low degree of intraregional linkages (Table 1.A, in the Appendix A).

On the other hand, the data show a high degree of interregional dependence of the State. The State depends on the rest of the country to sell a considerable part of its output: if one adds the sales to the rest of the country of the intermediate consumption, capital creation and household consumption, the result is that 38% of the local output are sold to the rest of the country. But the country does not depend on the State: only 0.8% of its product is sold to Espírito Santo. This result is expected since the Espírito Santo's economy is very small compared to the country's economy.

The main sectors of the economy export a large share of their products: the pulp and paper sector exports 72.3% of its pulp output; the steel manufacturing and related products sector exports 70% of its pig iron and ferroalloys; and the iron ore pellets sector exports 65.5% of its output. Also, traditional sectors such as agriculture export most of its output. The main agricultural products exported are coffee, fish, poultry, and canned fruits and vegetables.

Regarding the cost and consumption structures of Espírito Santo, one can observe a certain balance in the aggregate. The cost structure is defined by (i) 40.0% of the intermediate consumption being supplied by the local production; (ii) 49.7% of the intermediate consumption being supplied by the rest of the country's production; and (iii) 10.3% being supplied by imports (Table 2.A, in the Appendix A). Household consumption structure is relatively similar, with a stronger presence of local output: (i) 47.9% of the household consumption is supplied by the local production; (ii) 46.9% is supplied by the rest of the country's production; and (ii) 5.2% is supplied by imports (Table 3.A, in the Appendix A).

4.2. The Oil and Natural Gas Extraction Sector

After almost shutting down in the first half of the 1990s, the oil and natural gas extraction sector in Espírito Santo experienced a rebirth following 1996 with the discovery of new reserves, most by Petrobras. As Caçador and Grassi (2009, p.461) show, between 1996 and 2006, the proved reserves of oil and natural gas grew 57.7% and 19%, respectively, while the national reserves as a whole grew 6.2% and 4.5%, respectively. Thereafter, the State's production also increased in the same period, with the local production of oil increasing 21.3% and the local production of natural gas

13.2%, both numbers superior to those of the national production (8.2% and 6.8%, respectively).

In 2004, the national production of oil and natural gas sector was R$ 51.68 billion (US$ 17.67 billion) and the Espírito Santo's production was R$ 3.26 billion (around US$ 1.1 billion), which was equivalent to 6.3% of the national output. Measuring in thousand barrels daily, the national production average was 1,539 and the local production average was 100.

The indicators described above are based on interdependence ratios of the absorption matrix, which only measure the direct linkages among agents in the economy. A comparative analysis of regional economic structures can be carried out by considering production linkages among sectors through the analysis of the intermediate inputs portion of the interregional input-output database. Both the direct and indirect production linkage effects of the economy are captured based on the evaluation of the Leontief inverse matrix. The purpose remains the comparison of economic structures.
To examine the linkage structure of the local oil and natural gas extraction sector to the others sectors of the Espírito Santo's economy and of the rest of the country's economy we rely on the analysis of its output multiplier (Table 3). The value of 1.894 is one of the highest for the State economy. However, the intraregional effect is only 1.352 (71.4% of the total), while the interregional effect is 0.542 (28.6%).

For the rest of the country, the output multiplier of the oil and natural gas extraction sector is 1.858, which can be divided between the intraregional effect of 1.829 and the interregional effect of 0.029. Differently from Espírito Santo, the expansion of the oil and natural gas extraction sector in the rest of the country has a very small interregional effect, while the expansion of this sector in Espírito Santo presents a considerable larger effect over the rest of the country's economy. This result originates from the linkages observed between this sector in ES and the others located in the rest of the country. A closer look at the Leontief inverse reveals that, in the State economy, higher linkages can be found between the local production of oil and natural gas and the metal sector and the machinery and equipments sector outside the State. Moreover, inside the local economy the oil and natural gas extraction sector has stronger linkages with service sectors, including transportation, services to companies, accommodation, real estate

services, and information services, and, to a lesser degree, to the construction sector and electricity sector.

Table 3. Input-output multipliers: Intraregional and interregional output effects, Espírito Santo and rest of the country

Sectors	Output Multipliers ES			Shares ES		Output Multipliers RBR			Shares RBR	
	Intra	Inter	Total	Intra	Inter	Intra	Inter	Total	Intra	Inter
1 Agriculture, forestry, logging	1,079	0,308	1,388	0,778	0,222	1,559	0,006	1,565	0,996	0,004
2 Livestock and fishing	1,155	0,424	1,579	0,732	0,268	1,758	0,007	1,765	0,996	0,004
3 Oil and natural gas	1,352	0,542	1,894	0,714	0,286	1,829	0,029	1,858	0,985	0,015
4 Iron Ore	1,273	0,533	1,806	0,705	0,295	1,675	0,015	1,690	0,991	0,009
5 Other extractive industries	1,223	0,566	1,789	0,684	0,316	1,730	0,012	1,742	0,993	0,007
6 Food and Drink	1,225	0,893	2,118	0,578	0,422	2,185	0,012	2,197	0,995	0,005
7 Tobacco product	1,115	0,923	2,038	0,547	0,453	2,114	0,006	2,120	0,997	0,003
8 Textiles	1,177	0,662	1,839	0,640	0,360	1,932	0,007	1,939	0,996	0,004
9 Clothing and accessories	1,188	0,541	1,729	0,687	0,313	1,836	0,005	1,842	0,997	0,003
10 Leather goods and footwear	1,183	0,845	2,027	0,583	0,417	2,111	0,008	2,119	0,996	0,004
11 Wood products - exclusive mobile	1,154	0,605	1,759	0,656	0,344	1,882	0,008	1,889	0,996	0,004
12 Pulp and paper products	1,197	0,621	1,818	0,658	0,342	1,881	0,029	1,910	0,985	0,015
13 Newspapers, magazines, records	1,123	0,524	1,647	0,682	0,318	1,739	0,007	1,746	0,996	0,004
14 Petroleum refining and coking	1,326	0,819	2,145	0,618	0,382	2,112	0,047	2,159	0,978	0,022
15 Alcohol	1,184	0,522	1,707	0,694	0,306	1,842	0,006	1,848	0,997	0,003
16 Chemicals	1,193	0,844	2,036	0,586	0,414	2,071	0,017	2,088	0,992	0,008
17 Manufacture of resin and elastomers	1,112	0,929	2,041	0,545	0,455	2,084	0,010	2,094	0,995	0,005
18 Pharmaceutical products	1,179	0,484	1,663	0,709	0,291	1,741	0,006	1,747	0,996	0,004
19 Agrochemicals	1,172	0,884	2,056	0,570	0,430	2,102	0,010	2,113	0,995	0,005
20 Perfumery, hygiene and cleanliness	1,175	0,666	1,841	0,638	0,362	1,916	0,008	1,924	0,996	0,004
21 Paints, varnishes, enamels and lacquers	1,225	0,851	2,076	0,590	0,410	2,122	0,012	2,134	0,995	0,005
22 Various chemical products and preparations	1,178	0,831	2,008	0,586	0,414	2,056	0,009	2,065	0,996	0,004
23 Rubber and plastic	1,139	0,864	2,003	0,569	0,431	2,058	0,010	2,069	0,995	0,005
24 Cement	1,209	0,407	1,616	0,748	0,252	1,707	0,018	1,725	0,990	0,010
25 Other products of nonmetallic minerals	1,240	0,509	1,750	0,709	0,291	1,816	0,016	1,832	0,991	0,009
26 Manufacture of steel and steel products	1,260	0,549	1,810	0,696	0,304	1,832	0,043	1,875	0,977	0,023
27 Metallurgy of nonferrous metals	1,219	0,589	1,807	0,674	0,326	1,856	0,020	1,876	0,989	0,011
28 Metal products - except machinery and equipment	1,225	0,510	1,734	0,706	0,294	1,792	0,050	1,843	0,973	0,027
29 Machinery and equipment, including maintenance and repairs	1,242	0,648	1,890	0,657	0,343	1,932	0,045	1,977	0,977	0,023
30 Appliances	1,254	0,661	1,915	0,655	0,345	1,948	0,046	1,994	0,977	0,023
31 Office machines and computer equipment	1,096	0,780	1,876	0,584	0,416	1,872	0,007	1,879	0,996	0,004
32 Machinery, equipment and material	1,190	0,637	1,827	0,651	0,349	1,886	0,023	1,908	0,988	0,012
33 Electronic and communication equipment	1,166	0,831	1,996	0,584	0,416	2,010	0,013	2,022	0,994	0,006
34 Medical, hospital, measurement and optical apparatus / instruments	1,119	0,397	1,515	0,738	0,262	1,604	0,012	1,616	0,993	0,007
35 Cars, vans and utilities	1,230	1,030	2,261	0,544	0,456	2,259	0,032	2,292	0,986	0,014
36 Trucks and buses	1,195	1,015	2,210	0,541	0,459	2,216	0,026	2,242	0,988	0,012
37 Parts and accessories for motor vehicles	1,206	0,786	1,992	0,605	0,395	2,029	0,039	2,067	0,981	0,019
38 Other transportation equipment	1,220	0,752	1,971	0,619	0,381	1,964	0,039	2,003	0,981	0,019
39 Furniture and products of diverse industries	1,148	0,605	1,753	0,655	0,345	1,851	0,018	1,869	0,990	0,010
40 Electricity and gas, water, sewer and street cleaning	1,246	0,548	1,793	0,695	0,305	1,616	0,007	1,623	0,996	0,004
41 Construction	1,207	0,357	1,564	0,772	0,228	1,608	0,023	1,631	0,986	0,014
42 Commerce	1,144	0,203	1,347	0,849	0,151	1,394	0,004	1,398	0,997	0,003
43 Transport, storage and mailing	1,179	0,475	1,654	0,713	0,287	1,681	0,010	1,692	0,994	0,006
44 Information Services	1,269	0,343	1,612	0,787	0,213	1,619	0,003	1,622	0,998	0,002
45 Financial intermediation and insurance	1,246	0,333	1,580	0,789	0,211	1,577	0,003	1,580	0,998	0,002
46 Real estate services and rental	1,037	0,041	1,077	0,962	0,038	1,079	0,001	1,080	0,999	0,001
47 Maintenance and repair	1,041	0,285	1,327	0,785	0,215	1,372	0,006	1,378	0,996	0,004
48 Accommodation services and meals	1,198	0,458	1,656	0,723	0,277	1,748	0,008	1,755	0,996	0,004
49 Business services	1,189	0,294	1,482	0,802	0,198	1,529	0,003	1,532	0,998	0,002
50 Education mercantile	1,238	0,305	1,543	0,802	0,198	1,550	0,005	1,555	0,997	0,003
51 Health mercantile	1,218	0,433	1,650	0,738	0,262	1,654	0,005	1,659	0,997	0,003
52 Other services	1,166	0,298	1,465	0,796	0,204	1,507	0,005	1,512	0,997	0,003
53 Public education	1,061	0,081	1,142	0,929	0,071	1,295	0,003	1,298	0,998	0,002
54 Public health	1,158	0,279	1,438	0,806	0,194	1,536	0,004	1,539	0,998	0,002
55 Public administration and social security	1,158	0,216	1,374	0,843	0,157	1,499	0,003	1,503	0,998	0,002

In the next section, BMES is used to evaluate the regional and sectoral impacts of recent pre-salt oil and natural gas discoveries in the Brazilian economy. The role played by the parameters of the model, which are directly or indirectly derived from the structural indicators described above, is crucial for the understanding of the model's results.

5. Simulation Results

Petrobrás' production goal to 2013 of 100 thousand barrels daily in the pre-salt layer of the Espírito Santo's coast represents an increase of around 100% in the regional oil output (compared to 2004, the benchmark year). Following Corden and Neary (1982), we model that in terms of a once-for-all exogenous technical improvement in the oil and natural gas sector (the booming sector in the BMES model) that elevates its productivity proportionally to the expected increase in production.[16] Thus, we impose the shock in the variables measuring "technical change" in BMES. The value adopted is -50.0% for Espírito Santo. That would mean that 50% less of all inputs were needed to produce a given output of the oil and natural gas sector in Espírito Santo. The simulations were carried our using the software GEMPACK, using an Euler 2-4-6 procedure with 2 subintervals and extrapolation (Harrison and Pearson, 1996).

Results of the simulations are presented in Tables 4 and 5, and Figures 2-3[17]; they show the percentage deviation from the base case (which is the situation without policy changes). The analysis is concentrated on the effects on industrial activity and employment levels in the State of Espírito Santo, and on some general macro and regional variables. We look at the results in the two closures described in section 3. Overall, results are qualitatively similar in both closures.

To better understand the sector results of the model, an analysis of the structure of the economy is needed. A close inspection on the benchmark data base is necessary, conducted not only on the relationships in the input-output data base, but also on the other relevant parameters of the model. Some of the main structural features of the economy in the base-year were revealed in Section 4.

[16] The justification for the choice of such strategy for modeling the shock lies on the following bases: (i) as it follows traditional strategies used in the theoretical literature, it helps in providing the basis for an heuristic validation of the results of the model; (ii) one alternative strategy would have been to set an exogenous increase in the capital stock of the oil-producing sector in Espírito Santo which would provide the desirable increase in oil production in the State. There are two major drawbacks in pursuing this strategy in the context of this research: first, even though one can show it provides similar direct effects of an exogenous once-for-all exogenous technical improvement in the specific capital factor, it would have been difficult to isolate the impacts of the operations phase, simulating the impacts of the increase in the oil production inside the region; second, given the quality of the data on sectoral capital stocks, we have decided to focus on the primary-factors returns variables to make sure we had the appropriate metric; and (iii) the strategy allows us to focus on the operations phase, even though we do not consider neither oil production outside the region nor the royalties channels to government expenditures.

[17] Results for the oil and natural gas sector are not shown, for presentation purposes.

Industry activity results (Figure 2) show that, in general, non-tradable sectors benefit most from the increase in oil production in the pre-salt layer in Espírito Santo, while tradable (lagging) sectors are the main losers. Explanations for specific sector results should consider structural and parametric aspects of the data base. Sectors that present higher increases in their output tend to have higher share of imports in their cost structure, and greater penetration in the local market. On the other hand, sectors that face higher interregional and foreign competition and present bigger exposure to non-local markets in their sales structure are more likely to be harmed by the policy change.
According to the model, industry employment levels expand/contract in the same direction as activity levels, as the capital stocks are fixed. Figure 3 shows the percentage changes in employment, for each sector in Espírito Santo. Given the nature of the closure, which allows for producers to respond to exogenous shocks through changes in the employment level only, the figures reveal the supply responses from the model, for a stimulus of the oil and natural gas sector. Thus, the changes tend to be similar in sign and relative magnitude to those for activity level.

It is evident that there is a movement towards de-industrialization of the regional economy, suggesting the potential Dutch-disease effect that the State may face as production of oil in the pre-salt is fostered.

Figure 2. Sectoral activity effects in the State of Espírito Santo

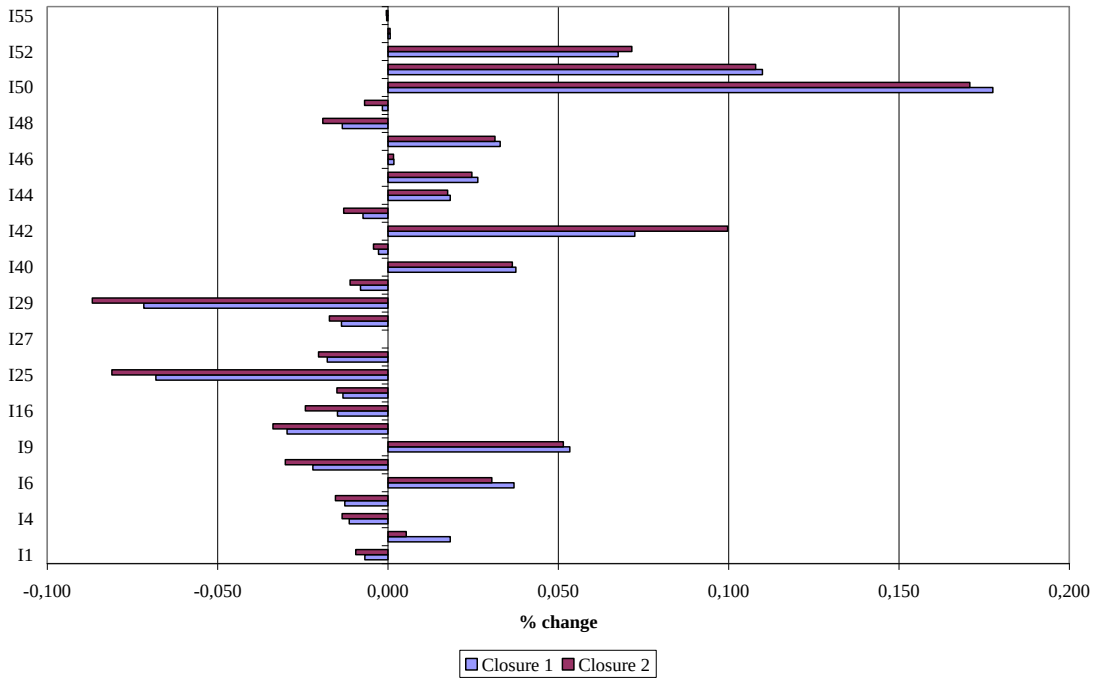


Figure 3. Sectoral employment effects in the State of Espírito Santo

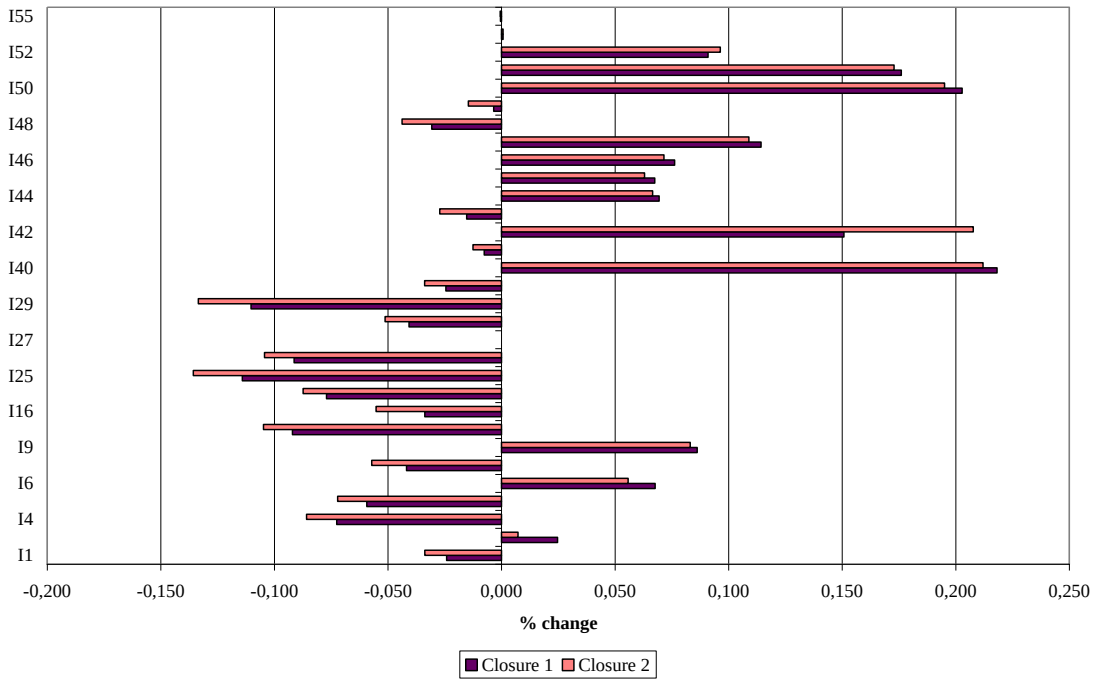


Table 4 summarizes the simulation results on some macro variables. The real GDP of Brazil is shown to increase by 0.145-0.147% with both regions positively affected. However, growth effects are highly concentrated in Espírito Santo, which experiences real GRP increases over 7.0%, while the rest of the country performance ranges from 0.001 to 0.003%. Thus, regarding the regional distribution of income, the pre-salt oil production in Espírito Santo improves the regional relative position in the country.

The results reveal that the projected growth of Espírito Santo is heavily pushed by its export performance, both in domestic and international markets. Such export-led growth of Espírito Santo – more concentrated on sales to the rest of the country – relies on the trade performance of the oil and natural gas sector. As an intermediate good not processed in the State of Espírito Santo (Brazilian oil refineries are located outside the State borders), the potentially most favored markets are other regions of the country. Thus, in the simulations, the share of oil and natural gas in the interregional exports from the State to the rest of the country goes from 10.7%, in the benchmark, to around 16% in both simulations. Moreover, the rest of the country tends to substitute away from imported oil as one of the domestic sources become more competitive.

The major difference noticed between the two closures is related to the spending effect, identified with the results for real household consumption. There appear significant spending effects, magnified in closure 2.

The main transmission mechanisms in the core theoretical model are also reflected in our results. In addition to the de-industrialization effect (reflecting both the spending and resource movement effects), described above and summarized in Table 4, which shows the decrease in the Lagging sectors (L) as opposed to an increase in the Non-tradable sectors (N), consistent relative price effects also show up. Comparing changes in the relative prices of L to N it is clear that prices of non-tradable goods raises relative to tradables. This acts in favor of an appreciation of real exchange rates, both domestic and foreign, as the results for terms of trade reveal: when the price of oil and natural gas is excluded from the calculations, prices of exports increase in relation to price of imports.

Finally, an increase in real rents of the Booming sector (B) at the expense of the specific factors in L (and also N) is also perceived, as factor shares in income in B rise from less than 3% in the benchmark to close 7.5% in both simulations. Noteworthy is that, given the nature of the closure, the gains in factor share of the Booming sector is concentrated in capital income (Table 5).

Table 4. Selected aggregate results

	Closure 1			*Closure 2*		
	ES	*RB*	*Brazil*	*ES*	*RB*	*Brazil*
GRP	7,1802	0,0031	0,1472	7,1819	0,0006	0,1448
Real household consumption	0,1928	0,1070	0,1086	0,2436	0,1068	0,1094
Interrregional exports	10,1973	0,0688	0,0000	10,1908	0,0849	-
Interregional imports	0,0688	10,1972	0,0000	0,0849	10,1908	-
International exports	3,3720	0,0250	0,1316	3,3445	0,0119	0,1180
International imports	-0,2587	-0,5332	-0,5279	-0,2413	-0,5287	-0,5232
Relative prices (L)	0,0780	-0,1030	-0,0992	0,0827	-0,0945	-0,0908
Relative prices (N)	0,5529	0,4561	0,4578	0,6218	0,4819	0,4843
Domestic terms of trade	-2,2464	0,5123	0,0000	-2,2559	0,5192	-
- without oil and gas in ES	0,6183	0,5123	0,0000	0,6099	0,5192	-
Foreign terms of trade	-1,4360	-0,0567	-0,1027	-1,4372	-0,0508	-0,0970
- without oil and gas in ES	0,0240	-0,0567	-0,0542	0,0227	-0,0508	-0,0485
Activity level (aggregate):						
Booming sector (B)	105,7860	0,0000	-	105,7832	0,0000	-
Lagging sectors (L)	-0,0063	-0,0200	-0,0197	-0,0113	-0,0243	-0,0241
Non-tradable sectors (N)	0,0221	0,0112	0,0114	0,0245	0,0093	0,0095
Real wage	-0,0738	0,0014	-	-0,0578	0,0438	0,0419
CPI	0,5126	0,4370	0,4384	0,5586	0,4562	0,4581
Unemployment rate	-0,2779	0,0008	-0,0045	-	-	-

Table 4. Sectoral shares in regional factor income

	Benchmark			*Closure 1*			*Closure 2*		
	ES	*RB*	*Brazil*	*ES*	*RB*	*Brazil*	*ES*	*RB*	*Brazil*
Wage income									
Lagging sectors (L)	0,2849	0,2395	0,2403	0,2839	0,2394	0,2403	0,2839	0,2394	0,2403
Booming sector (B)	0,0226	0,0064	0,0067	0,0254	0,0063	0,0067	0,0254	0,0063	0,0067
Nontradable sectors (N)	0,6925	0,7541	0,7529	0,6907	0,7543	0,7530	0,6907	0,7543	0,7531
Capital income									
Lagging sectors (L)	0,4293	0,2812	0,2846	0,3961	0,2814	0,2843	0,3957	0,2814	0,2842
Booming sector (B)	0,0335	0,0138	0,0143	0,1025	0,0114	0,0136	0,1025	0,0114	0,0136
Nontradable sectors (N)	0,5372	0,7050	0,7011	0,5014	0,7072	0,7021	0,5018	0,7073	0,7022
Factor income									
Lagging sectors (L)	0,3749	0,2638	0,2662	0,3558	0,2640	0,2660	0,3555	0,2639	0,2660
Booming sector (B)	0,0294	0,0107	0,0111	0,0748	0,0093	0,0107	0,0747	0,0092	0,0107
Nontradable sectors (N)	0,5957	0,7254	0,7226	0,5695	0,7268	0,7232	0,5698	0,7268	0,7233

6. Final Remarks

This paper has offered some pioneering efforts in looking at general equilibrium Dutch disease effects for a small regional economy in the context an integrated regional system. Modeling the regional economy of the State of Espírito Santo inserted in the national and international economies has proven relevant to address the potential impacts of oil production in the recently discovered pre-salt wells. The paper built on the BMES model, an interregional CGE model with non-constant returns and fully specified transportation costs.

The simulation strategy was to isolate the effects of the increase in the oil production in the State of Espírito Santo imposing a once-for-all exogenous technical improvement in the oil and natural gas sector in the State that elevates its productivity proportionally to the expected increase in production. By following traditional strategies used in the theoretical literature, it helped in providing the basis for a heuristic validation of the results of the model. Considering a similar setting of a national three-sector model, the results were in the expected direction as predicted by theoretical models. However, by incorporating more sectoral details and specific information on location for supply and demand, this exercise provided new insights for policy makers. As for magnitudes of the impacts, they can be perceived in the context of a comparative static exercise, enabling to draw a picture on potential gainers and losers from an increase in oil production in the State of Espírito Santo.

The results have shown that, from a regional perspective, not only the links with the international economy helps one better understanding potential de-industrialization and real exchange rate appreciation effects, but also (and more importantly) the links with other regions in the country, suggesting stronger dependence on national markets/suppliers.

As Haddad et al. (2002) have pointed out, the role of interregional trade to regional economies should not be relegated to a secondary place. One should consider interregional interactions for a better understanding of how the regional economies are affected, once for the smaller economies in Brazil, *as is the case of Espírito Santo*, the performance of the rest of the country plays a crucial role. Interstate trade might

generate the potential for the propagation of feedback effects that, in quantitative terms, could be larger than the effects generated by international trade.

Inspection of the estimates of the interstate and international export coefficients for Espírito Santo, in our database, show that interstate exports are 2.5 times higher than international exports. These estimates reveal, at first, the relevance of interstate trade for the regional economy.

One final aspect refers to the limitation of the results. Experience with the B-MARIA framework has suggested that interregional substitution is the key mechanism that drives model's spatial results. In general, interregional linkages play an important role in the functioning of interregional CGE models. These linkages are driven by trade relations (commodity flows), and factor mobility (capital and labor migration).

In the first case, interregional trade flows should be incorporated in the model. Interregional input-output databases are required to calibrate the model, and regional trade elasticities play a crucial role in the adjustment process. One data-related problem that modelers frequently face is the lack of such trade elasticities at the regional level. The pocket rule, used in this paper, is to use international trade elasticities as benchmarks for "best guess" procedures. However, a recent study by Bilgic *et al*. (2002) tends to refute the hypothesis that international trade elasticities are lower bound for regional trade elasticities for comparable goods, an assumption widely accepted by CGE modelers. Their estimates of regional trade elasticities for the U.S. economy challenged the prevailing view and called the attention of modelers for proper estimation of key parameters. In this sense, in the absence of such estimates, extra efforts should be undertaken in order to assess the robustness of the simulation results with relation to the set of elasticities used. This should be done in the sequence of this paper through proper estimation of regional trade elasticities and/or sensitivity analysis exercises.

In the second case, one should give one step further and look at different closure options. More specifically, it would be interesting to assess the impacts of pre-salt on the economy of the State of Espírito Santo in an economic environment in which capital flows are not restricted. As it has been suggested by Corden and Neary (1982), allowing for capital mobility among sectors may lead to a more complicated transmission

mechanism associated with the resource movement effect. The net effect may even be associated with an increase in the L. As one takes into account the further possibility of interregional capital movements, this issues becomes even more complex.

Finally, given the results of the paper, one could reach the conclusion that, for the State economy under consideration, understanding the future consequences associated with the booming of the oil sector should envisage not only traditional transmission mechanisms with the world economy, but also those related with its articulation with domestic markets. In this context, more room for regional development policies might be advocated, through actions towards competitive strategies for enhancing intraregional linkages in the economy of Espírito Santo.

References

AGÊNCIA ESTADO. Lula e Petrobras inauguram exploração do pré-sal nesta terça. 09/02/2008. Available at: http://www.estadao.com.br/economia/not_eco234746,0.htm. Accessed 12/02/2009.

AUTY, R.M. (2001). *Resource Abundance and Economic Development*. Oxford: Oxford University Press.

BANDARA, J. (1991) An Investigation of "Dutch Disease" Economics with a Miniature CGE Model. *Journal of Policy Modeling*, v.13, n.1, pp.67-92

BENJAMIN, N. et al. (1989). The Dutch disease in a developing country: oil reserves in Cameroon. *Journal of Development Economics*, v.30, pp.71-92.

BILGIC, A. et al (2002). Estimates of U.S. Regional Commodity Trade Elasticities. *Journal of Regional Analysis and Policy*, v.32, n.2.

BRESSER-PEREIRA, L.C. (2008). The Dutch disease and its neutralization: a Ricardian approach. Brazilian Journal of Polical Economy, v.28, n.1 (109), pp.47-71.

BRÖCKER, J. (1998). Operational Coputable General Equilibrium Modeling. *Annals of Regional Science*, v.32, p.p. 367-387.

BUFFIE, E.F. (1993). Direct Foreign Investment, Crowding Out, and Underemployment in the Dualistic Economy, *Oxford Economic Papers*, v. 45, pp. 639–667.

CAÇADOR, S.B.; GRASSI, R. A. (2009). Olha Crítico sobre o Desempenho recente da Economia capixaba: Uma Análise a partir da Literatura de Desenvolvimento Regional e de Indicadores de Inovação. *Revista Econômica do Nordeste*, v. 40, n. 3, PP. 453-480

CORDEN, W.M.; NEARY, J.P. (1982). Booming Sector and De-Industrialization in a Small Open Economy. *The Economic Journal*, v.92, n.368, pp.852-848.

CORDEN, W.M. (1984). Booming Sector and Dutch Disease Economics: Survey and Consolidation. *Oxford Economic Papers*, v.36, n.3, pp. 359-380.

DAVIS, G.(1995). Learning to Love the Dutch Disease: Evidence from the Mineral Economies. *World Development*, v.23, n.10, pp. 1765-1779.

DIXON, P. B., et al (1992). *Notes and Problems in Applied General Equilibrium Economics*. Advanced Textbooks in Economics 32, Eds. C. J. Bliss and M. D. Intriligator, North-Holland, Amsterdam.

FOLHA ONLINE. Petrobras anuncia descoberta de reservas de petróleo em pré-sal do ES. 11/21/2008. Available at: <http://www1.folha.uol.com.br/folha/dinheiro/ult91u470121.shtml>. Accessed 12/02/2009.

G1. Pré-sal vai produzir 1,8 milhão de barris por dia em 2020, diz Gabrielli. G1. Brasília, 11/08/2009. Available at: http://g1.globo.com/Noticias/Economia_Negocios/0,,MUL1371103-9356,00.html Accessed 12/02/2009.

GELB, A. H. (1988) *Oil windfalls: blessing or curse?* Published for The World Bank Oxford University Press.

HADDAD, E. A. (1999) *Regional inequality and structural changes: lessons from the Brazilian experience*. Aldershot: Ashgate.

HADDAD, E. A. (2002). Regional Effects of Economic Integration: The Case of Brazil. *Journal of Policy Modeling*, v.24, p.p. 453-482.

HADDAD, E. A. and HEWINGS, G. J. D. (2005). Market Imperfections in a Spatial Economy: some experimental results. *The Quarterly Review of Economics and Finance*, v. 45, pp. 476-496.

HARRISON, J.; PEARSON, K.(1996) An introduction to GEMPACK. *GEMPACK user documentation GPD-1*. Australia: IMPACT Project and KPSOFT Monash University.

LI, J.; POLENSKE, K. (2009) The Curse of Natural Resources: Coal and Regional Economic Development in China. *Mimeo*, 2009.

NKUSU, M. (2004) Aid and the Dutch Disease in Low-Income Countries: Informed Diagnoses for Prudent Prognoses. *IMF Working Paper*, n.49.

PAPYRAKIS, E.; GERLAGH, R. (2004).The resource curse hypothesis and its transmission channels. *Journal of Comparative Economics*, v.32, pp. 181-193.

PAPYRAKIS, E.; GERLAGH, R. (2007). Resource abundance and economic growth in the United States. *European Economic Review*, v. 51, pp. 1011-1039.

PETER, M. W., et. al. (1996). "The Theoretical Structure Of MONASH-MRF". *Preliminary Working Paper* no. OP-85, IMPACT Project, Monash University, Clayton, April.

PETROBRAS (2009). Plano de Negócios 2009-2013. 26 de janeiro de 2009. Available at: <www.petrobras.com.br>. Accessed 11/27/2009.

SACHS, J.; WARNER, A. (1999) The big push, natural resource booms and growth. *Journal of Development Economics*, v. 59, pp. 43-76.

SACHS, J.;WARNER, A. (2001). Natural resources and Economic Development: the curse of natural resources. *European Economic Review*, v. 45, pp. 827-838.

SHAO, S. QI, Z. (2009). Energy exploitation and economic growth in Western China: An empirical analysis based on the resource curse hypothesis. *Frontiers of Economics in China*, v. 4, n. 1, pp. 125-152.

TORVIK, R. (2002). Natural resource, rent seeking and welfare. *Journal of Development Economics*, v.67, n.2, pp. 455-470.

Appendix A. Structural Indicators

Table 1.A. Sales Structure, by user and destination – Espírito Santo

Products	Sales								
	Intermediate Consumption		Capital Creation		Household Consumption		Exports	Government Consumption	
	ES	RBR	ES	RBR	ES	RBR		Regional	Federal
1 Rough Rice	0,543	0,450	0,000	0,000	0,003	0,004	0,000	0,000	0,000
2 Grain maize	0,549	0,233	0,000	0,000	0,047	0,033	0,139	0,000	0,000
3 Wheat grain and other cereals	0,667	0,333	0,000	0,000	0,000	0,000	0,000	0,000	0,000
4 Cane sugar	0,610	0,390	0,000	0,000	0,000	0,000	0,000	0,000	0,000
5 Soybeans	1,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
6 Other products and services from farming	0,049	0,135	0,036	0,074	0,183	0,475	0,048	0,000	0,000
7 Cassava	0,404	0,366	0,000	0,000	0,100	0,130	0,000	0,000	0,000
8 Tobacco leaf	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
9 Upland cotton	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
10 Citrus fruits	0,528	0,202	0,000	0,000	0,169	0,075	0,026	0,000	0,000
11 Coffee bean	0,031	0,394	0,000	0,000	0,000	0,000	0,576	0,000	0,000
12 Forestry	0,409	0,308	0,070	0,113	0,026	0,053	0,019	0,000	0,000
13 Cattle and other livestock	0,317	0,242	0,239	0,171	0,013	0,012	0,008	0,000	0,000
14 Cow's milk and of other animals	0,384	0,308	0,000	0,000	0,162	0,146	0,000	0,000	0,000
15 Live pigs	0,524	0,215	0,135	0,061	0,042	0,023	0,000	0,000	0,000
16 Live poultry	0,579	0,339	0,000	0,000	0,045	0,035	0,003	0,000	0,000
17 Chicken eggs and other poultry	0,216	0,208	0,000	0,000	0,298	0,275	0,004	0,000	0,000
18 Fishing and aquaculture	0,124	0,068	0,000	0,000	0,495	0,268	0,045	0,000	0,000
19 Oil and natural gas	0,036	0,812	0,000	0,000	0,000	0,000	0,152	0,000	0,000
20 Iron Ore	0,198	0,148	0,000	0,000	0,000	0,000	0,655	0,000	0,000
21 Mineral coal	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
22 Non-ferrous metal ores	0,337	0,406	0,000	0,000	0,000	0,000	0,257	0,000	0,000
23 Non-metallic minerals	0,527	0,323	0,000	0,000	0,009	0,006	0,135	0,000	0,000
24 Slaughter and preparation of meat products	0,055	0,096	0,000	0,000	0,290	0,369	0,190	0,000	0,000
25 Pig meat fresh, chilled or frozen meat	0,133	0,138	0,000	0,000	0,216	0,231	0,282	0,000	0,000
26 Poultry meat fresh, chilled or frozen	0,037	0,061	0,000	0,000	0,198	0,289	0,415	0,000	0,000
27 Industrialized fish	0,076	0,040	0,000	0,000	0,257	0,120	0,508	0,000	0,000
28 Canned fruits, vegetables and other plants	0,099	0,018	0,000	0,000	0,405	0,073	0,404	0,000	0,000
29 Soybean oil and raw pies, cakes and soybean meal	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
30 Other vegetable oils and vegetable and animal fat, exclusive corn	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
31 Refined soybean oil	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
32 Cold milk, sterilized and pasteurized	0,086	0,189	0,000	0,000	0,227	0,498	0,000	0,000	0,000
33 Dairy products and ice cream	0,079	0,059	0,000	0,000	0,508	0,335	0,019	0,000	0,000
34 Processed rice and related products	0,018	0,034	0,000	0,000	0,421	0,527	0,000	0,000	0,000
35 Wheat flour and related products	0,160	0,296	0,000	0,000	0,193	0,350	0,001	0,000	0,000
36 Cassava flour and other	0,095	0,214	0,000	0,000	0,226	0,459	0,006	0,000	0,000
37 Corn oils, starches and vegetable feed	0,321	0,331	0,000	0,000	0,177	0,151	0,020	0,000	0,000
38 Products of the mills and refining of sugar	0,184	0,128	0,000	0,000	0,204	0,159	0,325	0,000	0,000
39 Roasted and ground coffee	0,207	0,117	0,000	0,000	0,447	0,224	0,004	0,000	0,000
40 Instant coffee	0,018	0,037	0,000	0,000	0,132	0,265	0,548	0,000	0,000
41 Other food products	0,033	0,129	0,000	0,000	0,196	0,593	0,050	0,000	0,000
42 Drinks	0,310	0,207	0,000	0,000	0,317	0,154	0,013	0,000	0,000
43 Tobacco product	0,000	0,003	0,000	0,000	0,413	0,369	0,216	0,000	0,000
44 Cotton processing and spinning of other textiles	0,414	0,405	0,000	0,000	0,001	0,001	0,178	0,000	0,000
45 Weaving	0,662	0,241	0,000	0,000	0,000	0,000	0,098	0,000	0,000
46 Manufacture other textile products	0,374	0,134	0,000	0,000	0,252	0,149	0,091	0,000	0,000
47 Clothing and accessories	0,032	0,040	0,000	0,000	0,395	0,506	0,027	0,000	0,000
48 Preparation of leather and manufacture of artifacts - exclusive shoes	0,229	0,105	0,000	0,000	0,202	0,095	0,369	0,000	0,000
49 Shoemaking	0,016	0,017	0,000	0,000	0,343	0,344	0,280	0,000	0,000
50 Wood products - exclusive mobile	0,395	0,190	0,009	0,005	0,014	0,010	0,376	0,000	0,000
51 Pulp and other pulp for papermaking	0,023	0,254	0,000	0,000	0,000	0,000	0,723	0,000	0,000
52 Paper and cardboard packaging and artifacts	0,491	0,223	0,000	0,000	0,107	0,082	0,096	0,000	0,000
53 Newspapers, magazines, CDs and other products recorded	0,387	0,274	0,000	0,000	0,203	0,127	0,009	0,000	0,000
54 Liquefied petroleum gas	0,000	0,000	0,000	0,000	0,684	0,316	0,000	0,000	0,000
55 Automotive gasoline	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
56 Ethanol	0,178	0,108	0,000	0,000	0,467	0,247	0,000	0,000	0,000
57 Fuel oil	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
58 Diesel oil	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
59 Other products of petroleum refining and coking	0,514	0,453	0,000	0,000	0,015	0,018	0,000	0,000	0,000
60 Alcohol	0,104	0,430	0,000	0,000	0,144	0,233	0,089	0,000	0,000
61 Inorganic chemicals	0,495	0,446	0,000	0,000	0,001	0,001	0,057	0,000	0,000
62 Organic chemicals	0,430	0,416	0,000	0,000	0,006	0,006	0,142	0,000	0,000
63 Manufacture of resin and elastomers	0,309	0,546	0,000	0,000	0,000	0,000	0,145	0,000	0,000
64 Pharmaceutical products	0,130	0,130	0,000	0,000	0,445	0,261	0,036	0,000	0,000
65 Agrochemicals	0,662	0,260	0,000	0,000	0,010	0,003	0,066	0,000	0,000
66 Perfumes, soaps and cleaning supplies	0,069	0,048	0,000	0,000	0,551	0,296	0,036	0,000	0,000
67 Paints, varnishes, enamels and lacquers	0,532	0,315	0,000	0,000	0,068	0,048	0,037	0,000	0,000
68 Various chemical products and preparations	0,452	0,351	0,000	0,000	0,020	0,014	0,163	0,000	0,000
69 Rubber	0,429	0,280	0,000	0,000	0,088	0,059	0,144	0,000	0,000
70 Plastic	0,536	0,372	0,000	0,000	0,027	0,020	0,044	0,000	0,000
71 Cement	0,372	0,580	0,000	0,000	0,010	0,030	0,007	0,000	0,000
72 Other products of nonmetallic minerals	0,204	0,637	0,000	0,000	0,004	0,016	0,140	0,000	0,000
73 Pig iron and ferro-alloys	0,169	0,131	0,000	0,000	0,000	0,000	0,700	0,000	0,000
74 Semi-finished, flat rolled and long steel tubes	0,082	0,675	0,000	0,000	0,000	0,000	0,243	0,000	0,000
75 Metallurgy products of nonferrous metals	0,234	0,244	0,000	0,000	0,000	0,000	0,522	0,000	0,000
76 Molten steel	0,603	0,385	0,000	0,000	0,000	0,000	0,012	0,000	0,000
77 Metal products - except machinery and equipment	0,477	0,197	0,160	0,078	0,020	0,012	0,057	0,000	0,000
78 Machinery and equipment, including maintenance and repairs	0,158	0,102	0,271	0,242	0,008	0,009	0,209	0,000	0,000
79 Appliances	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
80 Office machines and computer equipment	0,046	0,045	0,439	0,282	0,064	0,053	0,071	0,000	0,000
81 Machinery, equipment and eletrical material	0,372	0,247	0,127	0,056	0,044	0,024	0,130	0,000	0,000
82 Electronic and communication equipment	0,062	0,089	0,302	0,220	0,106	0,096	0,125	0,000	0,000
83 Medical, hospital, measurement and optical apparatus / instruments	0,048	0,048	0,354	0,201	0,144	0,107	0,099	0,000	0,000
84 Cars, vans and utilities	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
85 Trucks and buses	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000
86 Parts and accessories for motor vehicles	0,465	0,326	0,000	0,000	0,000	0,000	0,209	0,000	0,000
87 Other transportation equipment	0,067	0,053	0,127	0,053	0,084	0,048	0,568	0,000	0,000
88 Furniture and products of diverse industries	0,056	0,110	0,101	0,123	0,206	0,316	0,088	0,000	0,000
89 Recycled scrap	0,564	0,436	0,000	0,000	0,000	0,000	0,000	0,000	0,000
90 Electricity and gas, water, sewer and street cleaning	0,501	0,231	0,000	0,000	0,172	0,096	0,000	0,000	0,000
91 Construction	0,077	0,025	0,745	0,147	0,000	0,000	0,006	0,000	0,000
92 Commerce	0,689	0,175	0,000	0,000	0,000	0,000	0,136	0,000	0,000
93 Freight	0,509	0,386	0,000	0,000	0,029	0,031	0,046	0,000	0,000
94 Passenger Transport	0,186	0,046	0,000	0,000	0,609	0,152	0,007	0,000	0,000
95 Mail	0,782	0,115	0,000	0,000	0,090	0,013	0,000	0,000	0,000
96 Information Services	0,579	0,068	0,000	0,000	0,311	0,035	0,007	0,000	0,000
97 Financial intermediation and insurance	0,426	0,080	0,000	0,000	0,400	0,077	0,009	0,006	0,001
98 Real estate services and rental	0,491	0,044	0,066	0,005	0,329	0,034	0,031	0,000	0,000
99 Rent charged	0,000	0,000	0,000	0,000	0,769	0,231	0,000	0,000	0,000
100 Maintenance and repair	0,325	0,102	0,000	0,000	0,403	0,170	0,000	0,000	0,000
101 Accommodation services and meals	0,155	0,027	0,000	0,000	0,540	0,103	0,174	0,000	0,000
102 Business services	0,714	0,096	0,011	0,001	0,069	0,009	0,100	0,000	0,000
103 Education marcantile	0,014	0,004	0,000	0,000	0,832	0,149	0,001	0,000	0,000
104 Health mercantile	0,000	0,000	0,000	0,000	0,635	0,179	0,000	0,149	0,036
105 Household services	0,071	0,013	0,000	0,000	0,751	0,112	0,010	0,036	0,007
106 Related Services	0,049	0,013	0,000	0,000	0,046	0,015	0,002	0,698	0,177
107 Domestic Services	0,000	0,000	0,000	0,000	0,819	0,181	0,000	0,000	0,000
108 Public education	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,814	0,186
109 Public health	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,827	0,173
110 Public service and social security	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,817	0,183
Total	0,181	0,283	0,057	0,017	0,137	0,080	0,146	0,081	0,018

Table 2.A. Cost Structure, by user and origin – Espírito Santo

Sectors	Consumption					
	Intermediate Consumption			Capital Creation		
	ES	RBR	RW	ES	RBR	RW
1 Agriculture, forestry, logging	0,279	0,589	0,132	0,469	0,411	0,120
2 Livestock and fishing	0,395	0,544	0,061	0,469	0,411	0,120
3 Oil and natural gas	0,483	0,411	0,105	0,469	0,411	0,120
4 Iron Ore	0,430	0,466	0,105	0,469	0,411	0,120
5 Other extractive industries	0,360	0,497	0,144	0,469	0,411	0,120
6 Food and Drink	0,288	0,671	0,041	0,469	0,411	0,120
7 Tobacco product	0,143	0,824	0,030	0,469	0,411	0,121
8 Textiles	0,288	0,615	0,096	0,469	0,411	0,120
9 Clothing and accessories	0,371	0,550	0,079	0,469	0,411	0,120
10 Leather goods and footwear	0,265	0,648	0,087	0,469	0,411	0,121
11 Wood products - exclusive mobile	0,289	0,649	0,061	0,469	0,411	0,120
12 Pulp and paper products	0,317	0,568	0,116	0,469	0,411	0,120
13 Newspapers, magazines, records	0,253	0,656	0,091	0,469	0,411	0,120
14 Petroleum refining and coking	0,297	0,450	0,254	0,469	0,411	0,120
15 Alcohol	0,363	0,617	0,020	0,469	0,411	0,120
16 Chemicals	0,229	0,578	0,193	0,469	0,411	0,120
17 Manufacture of resin and elastomers	0,131	0,651	0,218	0,469	0,411	0,120
18 Pharmaceutical products	0,343	0,530	0,129	0,469	0,411	0,120
19 Agrochemicals	0,216	0,630	0,154	0,469	0,411	0,121
20 Perfumery, hygiene and cleanliness	0,283	0,579	0,138	0,469	0,411	0,121
21 Paints, varnishes, enamels and lacquers	0,275	0,563	0,163	0,469	0,411	0,120
22 Various chemical products and preparations	0,229	0,606	0,164	0,469	0,411	0,120
23 Rubber and plastic	0,182	0,645	0,172	0,469	0,411	0,120
24 Cement	0,442	0,460	0,098	0,469	0,411	0,120
25 Other products of nonmetallic minerals	0,410	0,473	0,117	0,469	0,411	0,120
26 Manufacture of steel and steel products	0,384	0,457	0,159	0,469	0,411	0,120
27 Metallurgy of nonferrous metals	0,328	0,509	0,163	0,469	0,411	0,120
28 Metal products - except machinery and equipment	0,391	0,493	0,116	0,469	0,411	0,120
29 Machinery and equipment, including maintenance and repairs	0,337	0,527	0,136	0,469	0,411	0,120
30 Appliances	0,347	0,514	0,125	0,473	0,405	0,122
31 Office machines and computer equipment	0,115	0,575	0,310	0,468	0,411	0,121
32 Machinery, equipment and material	0,280	0,555	0,166	0,469	0,411	0,120
33 Electronic and communication equipment	0,189	0,579	0,233	0,471	0,414	0,126
34 Medical, hospital, measurement and optical apparatus / instruments	0,264	0,526	0,210	0,469	0,411	0,120
35 Cars, vans and utilities	0,245	0,633	0,122	0,500	0,500	0,167
36 Trucks and buses	0,200	0,640	0,120	0,500	0,333	0,167
37 Parts and accessories for motor vehicles	0,266	0,605	0,129	0,469	0,411	0,120
38 Other transportation equipment	0,245	0,505	0,250	0,469	0,411	0,120
39 Furniture and products of diverse industries	0,268	0,634	0,099	0,469	0,411	0,120
40 Electricity and gas, water, sewer and street cleaning	0,390	0,529	0,081	0,469	0,411	0,120
41 Construction	0,486	0,431	0,083	0,469	0,411	0,120
42 Commerce	0,533	0,409	0,058	0,469	0,411	0,120
43 Transport, storage and mailing	0,374	0,539	0,086	0,469	0,411	0,120
44 Information Services	0,536	0,394	0,070	0,469	0,411	0,120
45 Financial intermediation and insurance	0,529	0,432	0,039	0,469	0,411	0,120
46 Real estate services and rental	0,608	0,349	0,043	0,469	0,411	0,120
47 Maintenance and repair	0,151	0,664	0,184	0,469	0,411	0,120
48 Accommodation services and meals	0,476	0,480	0,044	0,469	0,411	0,120
49 Business services	0,497	0,448	0,055	0,469	0,411	0,120
50 Education mercantile	0,550	0,385	0,065	0,469	0,411	0,120
51 Health mercantile	0,426	0,478	0,097	0,469	0,411	0,120
52 Other services	0,475	0,465	0,060	0,469	0,411	0,120
53 Public education	0,554	0,399	0,047	0,469	0,411	0,120
54 Public health	0,428	0,450	0,122	0,469	0,411	0,120
55 Public administration and social security	0,530	0,422	0,048	0,469	0,411	0,120
Total	0,400	0,497	0,103	0,469	0,411	0,120

Table 3.A. Household Consumption and Total Consumption, by origin – Espírito Santo

Products	Consumption					
	Household Consumption			Total Consumption		
	ES	RBR	RW	ES	RBR	RW
1 Rough Rice	0,144	0,842	0,014	0,143	0,842	0,015
2 Grain maize	0,231	0,760	0,010	0,231	0,760	0,010
3 Wheat grain and other cereals	0,000	0,400	0,600	0,000	0,400	0,600
4 Cane sugar	0,000	0,000	0,000	0,000	0,000	0,000
5 Soybeans	0,000	0,991	0,009	0,000	0,991	0,009
6 Other products and services from farming	0,721	0,230	0,049	0,721	0,230	0,049
7 Cassava	0,333	0,667	0,000	0,333	0,667	0,000
8 Tobacco leaf	0,000	0,000	0,000	0,000	0,000	0,000
9 Upland cotton	0,000	0,000	0,000	0,000	0,000	0,000
10 Citrus fruits	0,252	0,748	0,000	0,252	0,748	0,000
11 Coffee bean	0,000	0,000	0,000	0,000	0,000	0,000
12 Forestry	0,580	0,329	0,091	0,580	0,329	0,091
13 Cattle and other livestock	0,242	0,757	0,001	0,242	0,757	0,001
14 Cow's milk and of other animals	0,403	0,597	0,000	0,403	0,597	0,000
15 Live pigs	0,054	0,946	0,000	0,054	0,946	0,000
16 Live poultry	0,715	0,283	0,001	0,715	0,283	0,001
17 Chicken eggs and other poultry	0,714	0,279	0,007	0,714	0,279	0,007
18 Fishing and aquaculture	0,175	0,780	0,046	0,175	0,780	0,046
19 Oil and natural gas	0,000	0,000	0,000	0,000	0,000	0,000
20 Iron Ore	0,000	0,000	0,000	0,000	0,000	0,000
21 Mineral coal	0,000	0,000	0,000	0,000	0,000	0,000
22 Non-ferrous metal ores	0,000	0,000	0,000	0,000	0,000	0,000
23 Non-metallic minerals	0,266	0,442	0,292	0,266	0,442	0,292
24 Slaughter and preparation of meat products	0,500	0,480	0,020	0,500	0,480	0,020
25 Pig meat fresh, chilled or frozen meat	0,256	0,744	0,000	0,256	0,744	0,000
26 Poultry meat fresh, chilled or frozen	0,125	0,875	0,000	0,125	0,875	0,000
27 Industrialized fish	0,033	0,514	0,454	0,033	0,514	0,454
28 Canned fruits, vegetables and other plants	0,143	0,748	0,109	0,143	0,748	0,109
29 Soybean oil and raw pies, cakes and soybean meal	0,000	0,991	0,009	0,000	1,000	0,000
30 Other vegetable oils and vegetable and animal fat, exclusive corn	0,000	0,901	0,099	0,000	0,901	0,099
31 Refined soybean oil	0,000	1,000	0,000	0,000	1,000	0,000
32 Cold milk, sterilized and pasteurized	0,527	0,473	0,000	0,527	0,473	0,000
33 Dairy products and ice cream	0,063	0,912	0,024	0,063	0,912	0,024
34 Processed rice and related products	0,124	0,830	0,046	0,124	0,830	0,046
35 Wheat flour and related products	0,570	0,405	0,025	0,570	0,405	0,025
36 Cassava flour and other	0,730	0,268	0,001	0,730	0,268	0,001
37 Corn oils, starches and vegetable feed	0,506	0,475	0,020	0,506	0,475	0,020
38 Products of the mills and refining of sugar	0,101	0,898	0,000	0,101	0,898	0,000
39 Roasted and ground coffee	0,318	0,682	0,001	0,318	0,682	0,001
40 Instant coffee	0,510	0,487	0,003	0,510	0,487	0,003
41 Other food products	0,729	0,248	0,023	0,729	0,248	0,023
42 Drinks	0,540	0,417	0,043	0,540	0,417	0,043
43 Tobacco product	0,017	0,778	0,205	0,017	0,778	0,205
44 Cotton processing and spinning of other textiles	0,363	0,540	0,097	0,362	0,540	0,098
45 Weaving	0,000	0,000	0,000	0,000	0,000	0,000
46 Manufacture other textile products	0,424	0,529	0,047	0,424	0,529	0,047
47 Clothing and accessories	0,691	0,291	0,018	0,691	0,291	0,018
48 Preparation of leather and manufacture of artifacts - exclusive shoes	0,151	0,772	0,077	0,151	0,772	0,077
49 Shoemaking	0,247	0,733	0,020	0,247	0,733	0,020
50 Wood products - exclusive mobile	0,136	0,844	0,021	0,136	0,844	0,021
51 Pulp and other pulp for papermaking	0,000	0,000	0,000	0,000	0,000	0,000
52 Paper and cardboard packaging and artifacts	0,053	0,886	0,061	0,053	0,886	0,061
53 Newspapers, magazines, CDs and other products recorded	0,277	0,711	0,011	0,277	0,711	0,011
54 Liquefied petroleum gas	0,000	0,813	0,187	0,000	0,813	0,187
55 Automotive gasoline	0,000	0,000	0,000	0,000	0,000	0,000
56 Ethanol	0,373	0,627	0,000	0,373	0,627	0,000
57 Fuel oil	0,000	0,000	0,000	0,000	0,000	0,000
58 Diesel oil	0,000	0,918	0,082	0,000	0,918	0,082
59 Other products of petroleum refining and coking	0,000	0,782	0,218	0,000	0,782	0,218
60 Alcohol	0,590	0,410	0,000	0,590	0,410	0,000
61 Inorganic chemicals	0,322	0,473	0,205	0,323	0,472	0,205
62 Organic chemicals	0,023	0,712	0,265	0,023	0,712	0,265
63 Manufacture of resin and elastomers	0,000	0,000	0,000	0,000	0,000	0,000
64 Pharmaceutical products	0,017	0,703	0,279	0,017	0,703	0,279
65 Agrochemicals	0,015	0,784	0,201	0,015	0,785	0,201
66 Perfumes, soaps and cleaning supplies	0,021	0,790	0,189	0,021	0,790	0,189
67 Paints, varnishes, enamels and lacquers	0,112	0,808	0,079	0,112	0,808	0,079
68 Various chemical products and preparations	0,292	0,491	0,217	0,292	0,491	0,217
69 Rubber	0,074	0,773	0,153	0,074	0,773	0,153
70 Plastic	0,017	0,899	0,085	0,017	0,899	0,085
71 Cement	0,769	0,219	0,012	0,769	0,219	0,012
72 Other products of nonmetallic minerals	0,834	0,095	0,071	0,834	0,095	0,071
73 Pig iron and ferro-alloys	0,000	0,000	0,000	0,000	0,000	0,000
74 Semi-finished, flat rolled and long steel tubes	0,000	0,000	0,000	0,000	0,000	0,000
75 Metallurgy products of nonferrous metals	0,000	0,000	0,000	0,000	0,000	0,000
76 Molten steel	0,000	0,000	0,000	0,000	0,000	0,000
77 Metal products - except machinery and equipment	0,201	0,724	0,075	0,201	0,724	0,075
78 Machinery and equipment, including maintenance and repairs	0,145	0,566	0,289	0,145	0,566	0,289
79 Appliances	0,000	0,957	0,043	0,000	0,957	0,043
80 Office machines and computer equipment	0,184	0,406	0,410	0,184	0,406	0,410
81 Machinery, equipment and eletrical material	0,174	0,572	0,254	0,174	0,572	0,254
82 Electronic and communication equipment	0,001	0,622	0,377	0,001	0,622	0,377
83 Medical, hospital, measurement and optical apparatus / instruments	0,052	0,451	0,497	0,052	0,451	0,497
84 Cars, vans and utilities	0,000	0,921	0,079	0,000	0,921	0,079
85 Trucks and buses	0,000	0,000	0,000	0,000	0,968	0,032
86 Parts and accessories for motor vehicles	0,000	0,000	0,000	0,000	0,000	0,000
87 Other transportation equipment	0,071	0,511	0,418	0,071	0,511	0,418
88 Furniture and products of diverse industries	0,474	0,482	0,043	0,474	0,482	0,043
89 Recycled scrap	0,000	0,000	0,000	0,000	0,000	0,000
90 Electricity and gas, water, sewer and street cleaning	0,380	0,598	0,022	0,380	0,598	0,022
91 Construction	0,000	0,000	0,000	0,801	0,198	0,001
92 Commerce	0,000	0,000	0,000	0,000	0,000	0,000
93 Freight	0,925	0,075	0,000	0,925	0,075	0,000
94 Passenger Transport	0,662	0,297	0,040	0,662	0,297	0,040
95 Mail	0,522	0,478	0,000	0,522	0,478	0,000
96 Information Services	0,698	0,263	0,039	0,698	0,263	0,039
97 Financial intermediation and insurance	0,500	0,482	0,019	0,500	0,482	0,019
98 Real estate services and rental	0,564	0,321	0,115	0,564	0,321	0,115
99 Rent charged	0,676	0,324	0,000	0,676	0,324	0,000
100 Maintenance and repair	0,817	0,183	0,000	0,817	0,183	0,000
101 Accommodation services and meals	0,589	0,270	0,141	0,589	0,270	0,141
102 Business services	0,531	0,388	0,081	0,531	0,388	0,081
103 Education marcantile	0,564	0,430	0,006	0,565	0,430	0,006
104 Health mercantile	0,614	0,386	0,000	0,614	0,386	0,000
105 Household services	0,495	0,496	0,009	0,495	0,496	0,009
106 Related Services	0,600	0,399	0,000	0,600	0,399	0,000
107 Domestic Services	0,612	0,388	0,000	0,612	0,388	0,000
108 Public education	0,000	0,000	0,000	0,613	0,387	0,000
109 Public health	0,000	0,000	0,000	0,563	0,437	0,000
110 Public service and social security	0,000	0,000	0,000	0,640	0,360	0,000
Total	0,479	0,469	0,052	0,508	0,435	0,057

Table 4.A. Selected Structural Indicators – Espírito Santo

Sectors	Structural Indicators				
	Capital + Labor / Total Cost	Capital-Labor Ratio	Production Share		
			Regional	National	Sector
1 Agriculture, forestry, logging	0,726	2,574	0,050	0,001	0,025
2 Livestock and fishing	0,600	0,349	0,012	0,000	0,012
3 Oil and natural gas	0,323	1,847	0,048	0,001	0,063
4 Iron Ore	0,402	5,398	0,034	0,001	0,132
5 Other extractive industries	0,398	3,692	0,007	0,000	0,036
6 Food and Drink	0,232	0,825	0,056	0,001	0,016
7 Tobacco product	0,254	3,577	0,000	0,000	0,001
8 Textiles	0,414	0,898	0,006	0,000	0,012
9 Clothing and accessories	0,478	0,611	0,011	0,000	0,030
10 Leather goods and footwear	0,317	0,084	0,002	0,000	0,007
11 Wood products - exclusive mobile	0,469	0,736	0,001	0,000	0,004
12 Pulp and paper products	0,403	2,116	0,031	0,001	0,057
13 Newspapers, magazines, records	0,539	0,906	0,003	0,000	0,007
14 Petroleum refining and coking	0,112	2,368	0,003	0,000	0,002
15 Alcohol	0,512	3,461	0,004	0,000	0,026
16 Chemicals	0,237	1,282	0,008	0,000	0,009
17 Manufacture of resin and elastomers	0,260	2,181	0,001	0,000	0,002
18 Pharmaceutical products	0,482	0,781	0,000	0,000	0,001
19 Agrochemicals	0,259	1,461	0,000	0,000	0,002
20 Perfumery, hygiene and cleanliness	0,398	2,163	0,001	0,000	0,003
21 Paints, varnishes, enamels and lacquers	0,245	0,728	0,000	0,000	0,004
22 Various chemical products and preparations	0,284	0,354	0,002	0,000	0,009
23 Rubber and plastic	0,305	0,594	0,001	0,000	0,001
24 Cement	0,540	4,851	0,008	0,000	0,079
25 Other products of nonmetallic minerals	0,419	0,679	0,035	0,001	0,097
26 Manufacture of steel and steel products	0,389	4,140	0,152	0,003	0,151
27 Metallurgy of nonferrous metals	0,392	2,012	0,003	0,000	0,010
28 Metal products - except machinery and equipment	0,487	1,988	0,005	0,000	0,008
29 Machinery and equipment, including maintenance and repairs	0,345	0,542	0,008	0,000	0,010
30 Appliances	0,313	1,047	0,000	0,000	0,000
31 Office machines and computer equipment	0,165	0,600	0,002	0,000	0,012
32 Machinery, equipment and material	0,375	0,466	0,002	0,000	0,005
33 Electronic and communication equipment	0,148	0,540	0,000	0,000	0,000
34 Medical, hospital, measurement and optical apparatus / instruments	0,573	2,279	0,001	0,000	0,004
35 Cars, vans and utilities	0,095	-0,215	0,000	0,000	0,000
36 Trucks and buses	0,148	0,405	0,000	0,000	0,000
37 Parts and accessories for motor vehicles	0,304	0,991	0,001	0,000	0,001
38 Other transportation equipment	0,210	0,589	0,001	0,000	0,003
39 Furniture and products of diverse industries	0,474	2,043	0,011	0,000	0,025
40 Electricity and gas, water, sewer and street cleaning	0,410	4,757	0,023	0,000	0,013
41 Construction	0,576	1,959	0,055	0,001	0,024
42 Commerce	0,743	1,073	0,074	0,001	0,020
43 Transport, storage and mailing	0,520	1,093	0,079	0,002	0,034
44 Information Services	0,526	2,784	0,025	0,001	0,014
45 Financial intermediation and insurance	0,573	1,552	0,027	0,001	0,011
46 Real estate services and rental	0,945	42,256	0,037	0,001	0,016
47 Maintenance and repair	0,747	2,454	0,008	0,000	0,023
48 Accommodation services and meals	0,491	1,294	0,014	0,000	0,016
49 Business services	0,630	1,129	0,021	0,000	0,011
50 Education mercantile	0,582	0,141	0,007	0,000	0,013
51 Health mercantile	0,491	0,596	0,014	0,000	0,015
52 Other services	0,649	0,344	0,019	0,000	0,014
53 Public education	0,894	0,071	0,015	0,000	0,015
54 Public health	0,634	0,041	0,010	0,000	0,012
55 Public administration and social security	0,724	0,180	0,061	0,001	0,016
Total	0,523	1,348	1,000	0,020	0,020

Appendix B. The CGE Core Equations

The functional forms of the main groups of equations of the spatial CGE core are presented in this Appendix together with the definition of the main groups of variables, parameters and coefficients.

The notational convention uses uppercase letters to represent the levels of the variables and lowercase for their percentage-change representation. Superscripts *(u), u = 0, 1j, 2j, 3, 4, 5, 6*, refer, respectively, to output *(0)* and to the six different regional-specific users of the products identified in the model: producers in sector *j (1j)*, investors in sector *j (2j)*, households *(3)*, purchasers of exports *(4)*, regional governments *(5)* and the Central government *(6)*; the second superscript identifies the domestic region where the user is located. Inputs are identified by two subscripts: the first takes the values *1, ..., g*, for commodities, *g + 1*, for primary factors, and *g + 2*, for "other costs" (basically, taxes and subsidies on production); the second subscript identifies the source of the input, being it from domestic region *b (1b)* or imported *(2)*, or coming from labor *(1)*, capital *(2)* or land *(3)*. The symbol (•) is employed to indicate a sum over an index.

Equations

(A1) Substitution between products from different regional domestic sources

$$x_{(i(1b))}^{(u)r} = x_{(i(1\bullet))}^{(u)r} - \sigma_{(i)}^{(u)r}\left(p_{(i(1b))}^{(u)r} - \sum_{l\in S^*}\left(V(i,1l,(u),r)/V(i,1\bullet,(u),r)\left(p_{(i(1l))}^{(u)r}\right)\right)\right)$$

$$i = 1,...,g;\ b = 1,...,q;\ (u) = 3 \text{ and } (kj) \text{ for } k = 1 \text{ and } 2 \text{ and } j = 1,...,h; r = 1,...,R$$

(A2) Substitution between domestic and imported products

$$x_{(is)}^{(u)r} = x_{(i\bullet)}^{(u)r} - \sigma_{(i)}^{(u)r}\left(p_{(is)}^{(u)r} - \sum_{l=1\bullet,2}\left(V(i,l,(u),r)/V(i,\bullet,(u),r)\left(p_{(il)}^{(u)r}\right)\right)\right)$$

$$i = 1,...,g;\ s = 1\bullet \text{ and } 2;\ (u) = 3 \text{ and } (kj) \text{ for } k = 1 \text{ e } 2 \text{ and } j = 1,...,h; r = 1,...,R$$

(A3) Substitution between labor, capital and land

$$x^{(1j)r}_{(g+1,s)} - a^{(1j)r}_{(g+1,s)} = \alpha^{(1j)r}_{(g+1,s)} x^{(1j)r}_{(g+1\bullet)} - \sigma^{(1j)r}_{(g+1)} \{ p^{(1j)r}_{(g+1,s)} + a^{(1j)r}_{(g+1,s)} - \sum_{l=1,2,3} (V(g+1,l,(1j),r)/V(g+1,\bullet,(1j),r))(p^{(1j)r}_{(g+1,l)} + a^{(1j)r}_{(g+1,l)}) \}$$

$j = 1,...,h; \quad s = 1, 2 \text{ and } 3; r = 1,...,R$

(A4) Intermediate and investment demands for composites commodities and primary factors

$$x^{(u)r}_{(i\bullet)} = \mu^{(u)r}_{(i\bullet)} z^{(u)r} + a^{(u)r}_{(i)}$$

$u = (kj)$ for $k = 1, 2$ and $j = 1,...,h$

if $u = (1j)$ then $i = 1,...,g+2$

if $u = (2j)$ then $i = 1,...,g;$

$r = 1,...,R$

(A5) Household demands for composite commodities

$$V(i,\bullet,(3),r)(p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}) = \gamma^{r}_{(i)} P^{(3)r}_{(i\bullet)} Q^{r} (p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}) + \beta^{r}_{(i)} (C^{r} - \sum_{j \in G} \gamma^{r}_{(j)} P^{(3)r}_{(i\bullet)} Q^{r} (p^{(3)r}_{(i\bullet)} + x^{(3)r}_{(i\bullet)}))$$

$i = 1,\ldots, g; r = 1,...,R$

(A6) Composition of output by industries

$$x^{(0j)r}_{(i1)} = z^{(1j)r} + \sigma^{(0j)r} (p^{(0)r}_{(i1)} - \sum_{t \in G} (Y(t,j,r)/Y(\bullet,j,r)) p^{(0)r}_{(t1)})$$

$j = 1,...,h; \quad \text{i} = 1,...,\text{g}; r = 1,...,R$

(A7) Indirect tax rates

$$t(\tau,i,s,(u)r) = f_{(\tau)} + f_{(\pi)} + f^{(u)}_{(\pi)} + f^{(u)r}_{(\pi)}, \quad i = 1,...,g; \quad s = 1b,2 \text{ for } b = 1,...,q; \ \tau = 1,...,t$$

$(u) = (3), (4), (5), (6) \text{ and } (kj) \text{ for } k = 1, 2; \ j = 1,...,h$

$r = 1,...,R$

(A8) Purchasers' prices related to basic prices, margins (transportation costs) and taxes

$$V(i,s,(u),r)\,p_{(is)}^{(u)r} = (B(i,s,(u),r) + \sum_{\tau\in T} T(\tau,i,s,(u),r))(p_{(is)}^{(0)} + t(\tau,i,s,u,r)) + \sum_{m\in G} M(m,i,s,(u),r)p_{(m1)}^{(0)r},$$

$i = 1,\ldots,g;\ (u) = (3),(4),(5),(6)$

and (kj) for $k = 1, 2$ and $j = 1,\ldots,h;\ s = 1b, 2$ for $b = 1,\ldots,q$

$r = 1,\ldots,R$

(A9) Foreign demands (exports) for domestic goods

$$(x_{(is)}^{(4)r} - fq_{(is)}^{(4)r}) = \eta_{(is)}^{r}(p_{(is)}^{(4)r} - e - fp_{(is)}^{(4)r}) \ , \qquad i = 1,\ldots,g\ ;\ s = 1b, 2 \text{ for } b = 1,\ldots,q; r = 1,\ldots,R$$

(A10) Regional government demands

$$x_{(is)}^{(5)r} = x_{(\bullet\bullet)}^{(3)r} + f_{(is)}^{(5)r} + f^{(5)r} + f^{(5)} \qquad i = 1,\ldots,g;\ s = 1b,2 \text{ for } b = 1,\ldots,q; \text{r} = 1,\ldots,\text{R}$$

(A11) Regional government demands

$$x_{(is)}^{(6)r} = x_{(\bullet\bullet)}^{(3)\bullet} + f_{(is)}^{(6)r} + f^{(6)r} + f^{(6)} \qquad i = 1,\ldots,g;\ s = 1b,2 \text{ for } b = 1,\ldots,q; \text{r} = 1,\ldots,\text{R}$$

(A12) Margins demands for domestic goods

$$x_{(m1)}^{(is)(u)r} = \theta_{(is)}^{(u)r} x_{(is)}^{(u)r} + a_{(m1)}^{(is)(u)r}$$

$m, i = 1,\ldots,g;$

$(u) = (3),(4b) \text{ for } b = 1,\ldots,r, (5) \text{ and } (kj) \text{ for } k = 1, 2;$

$j = 1,\ldots,h;\ s = 1b, 2 \text{ for } b = 1,\ldots,r;$

$r = 1,\ldots,R$

(A13) Demand equals supply for regional domestic commodities

$$\sum_{j\in H} Y(l,\ j,r)x_{(l1)}^{(0\,j)r} = \sum_{u\in U} B(l,1,(u),r)x_{(l1)}^{(u)r} + \sum_{i\in G}\sum_{s\in S}\sum_{u\in U} M(l,i,s,(u),r)x_{(l1)}^{(is)(u)r} \qquad l = 1,\ldots,g; r = 1,\ldots,R$$

(A14) Regional industry revenue equals industry costs

$$\sum_{l\in G} Y(l,\ j,r)(p_{(l1)}^{(0)r} + a_{(l1)}^{(0)r}) = \sum_{l\in G^*}\sum_{s\in S} V(l,s,(1j),r)(p_{(ls)}^{(1j)r}), \quad j = 1,\ldots,h; r = 1,\ldots,R$$

(A15) Basic price of imported commodities

$$p_{(i(2))}^{(0)} = p_{(i(2))}^{(w)} - e + t_{(i(2))}^{(0)}, \qquad i = 1,\ldots,g$$

(A16) Cost of constructing units of capital for regional industries

$$V(\bullet,\bullet,(2j),r)(p_{(k)}^{(1j)r} - a_{(k)}^{(1j)r}) = \sum_{i\in G}\sum_{s\in S} V(i,s,(2j),r)(p_{(is)}^{(2j)r} + a_{(is)}^{(2j)r}), \qquad j = 1,...,h; r = 1,...,R$$

(A17) Investment behavior

$$z^{(2j)r} = x_{(g+1,2)}^{(1j)r} + 100\, f_{(k)}^{(2j)r}, \qquad j = 1,...,h; r = 1,...,R$$

(A18) Capital stock in period T+1 – comparative statics

$$x_{(g+1,2)}^{(1j)r}(1) = x_{(g+1,2)}^{(1j)r} \qquad j = 1,...,h; r = 1,...,R$$

(A19) Definition of rates of return to capital

$$r_{(j)}^{r} = Q_{(j)}^{r}(p_{(g+1,2)}^{(1j)r} - p_{(k)}^{(1j)r}), \qquad j = 1,...,h; r = 1,...,R$$

(A20) Relation between capital growth and rates of return

$$r_{(j)}^{r} - \omega = \varepsilon_{(j)}^{r}(x_{(g+1,2)}^{(1j)r} - x_{(g+1,2)}^{(\bullet)r}) + f_{(k)}^{r}, \qquad j = 1,...,h; r = 1,...,R$$

Other definitions in the CGE core include: revenue from indirect taxes, import volume of commodities, components of regional/national GDP, regional/national price indices, wage settings, definitions of factor prices, and employment aggregates.

Variables

Variable	Index ranges	Description

$x_{(is)}^{(u)r}$	(u) = (3), (4), (5), (6) and
	(kj) for k = 1, 2 and j = 1,…,h;
	if (u) = (1j) then i = 1,…,g + 2;
	if (u) ≠ (1j) then i = 1,…,g;
	s = 1b, 2 for b = 1,…,q; and i = 1,…,g and
	s = 1, 2, 3 for i = g+1
	r = 1,…,R
		Demand by user (u) in region r for good or primary factor (is)

$p_{(is)}^{(u)r}$	(u) = (3), (4), (5), (6) and
	(kj) for k = 1, 2 and j = 1,…,h;
	if (u) = (1j) then i = 1,…,g + 2;
	if (u) ≠ (1j) then i = 1,…,g;
	s = 1b, 2 for b = 1,…,q; and i = 1,…,g and
	s = 1, 2, 3 for i = g+1
	r = 1,…,R
		Price paid by user (u) in region r for good or primary factor (is)

$x_{(i\bullet)}^{(u)r}$	(u) = (3) and (kj) for k = 1, 2 and
	j = 1, …,h.
	if (u) = (1j) then i = 1, …,g + 1;
	if (u) ≠ (1j) then i = 1, …,g
	r = 1,…,R
		Demand for composite good or primary factor i by user (u) in region r

$a_{(g+1,s)}^{(1j)r}$	j = 1, …,h and s = 1, 2, 3 r = 1,…,R	Primary factor saving technological change in region r
$a_{(i)}^{(u)r}$	i = 1,...,g, (u) = (3) and (kj) for k = 1, 2 and j = 1,..., h r = 1,…,R	Technical change related to the use of good i by user (u) in region r
C^r		Total expenditure by regional household in region r
Q^r		Number of households
$z^{(u)r}$	(u) = (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Activity levels: current production and investment by industry in region r
$fq_{(is)}^{(4)r}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (quantity) in foreign demand curves for regional exports
$fp_{(is)}^{(4)r}$	i = 1, …,g; s = 1b, 2 for b = 1, …,q r = 1,…,R	Shift (price) in foreign demand curves for regional exports
e		Exchange rate
$x_{(m1)}^{(is)(u)r}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and	Demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in

Variable	Index ranges	Description
	(kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	region r
$a_{(m1)}^{(is)(u)r}$	m, i = 1,…,g; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …,h r = 1,…,R	Technical change related to the demand for commodity (m1) to be used as a margin to facilitate the flow of (is) to (u) in region r
$x_{(i1)}^{(0\,j)r}$	i = 1,…,g; j = 1,…,h r = 1,...,R	Output of domestic good i by industry j
$p_{(is)}^{(0)r}$	i = 1,…,g; s = 1b, 2 for b = 1,…,q r = 1,...,R	Basic price of good i in region r from source s
$p_{(i(2))}^{(w)}$	i = 1,…,g	USD c.i.f. price of imported commodity i
$t_{(i(2))}^{(0)}$	i = 1,…,g	Power of the tariff on imports of i
$t(\tau,i,s,(u)r)$	i = 1,…,g; τ = 1,…,t; s = 1b, 2 for b = 1,…,q (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1,…,h r = 1,...,R	Power of the tax τ on sales of commodity (is) to user (u) in region r
$f_{(k)}^{(2\,j)r}$	j = 1,…,h r = 1,...,R	Regional-industry-specific capital shift terms
$f_{(k)}^{r}$	r = 1,...,R	Capital shift term in region r
$x_{(g+1,2)}^{(1\,j)r}(1)$	j = 1,…, h r = 1,...,R	Capital stock in industry j in region r at the end of the year, i.e., capital stock available for use in the next year
$p_{(k)}^{(1\,j)r}$	j = 1,…, h r = 1,...,R	Cost of constructing a unit of capital for industry j in region r
$f_{(\tau)}$	τ = 1,…,t	Shift term allowing uniform percentage changes in the power of tax τ
$f_{(\tau i)}$	τ = 1,…,t; i = 1, …,g	Shift term allowing uniform percentage changes in the power of tax τ on commodity i
$f_{(\tau i)}^{(u)}$	τ = 1,…,t; (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …, h	Shift term allowing uniform percentage changes in the power of tax τ of commodity i on user (u)
$f_{(\tau i)}^{(u)r}$	τ = 1,…,t; (u) = (3), (4), (5), (6) and (kj) for k = 1, 2 and j = 1, …, h r = 1,…,R	Shift term allowing uniform percentage changes in the power of tax τ of commodity i on user (u) in region r

Variable	Index ranges	Description
$f_{(is)}^{(5)r}$	i = 1, …,g; s = 1b, 2 for b = 1,…,q r = 1,…,R	Commodity and source-specific shift term for regional government expenditures in region r
$f^{(5)r}$	r = 1,…,R	Shift term for regional government expenditures in region r
$f^{(5)}$		Shift term for regional government expenditures
$f_{(is)}^{(6)r}$	i = 1, …,g; s = 1b, 2 for b = 1,…,q r = 1,…,R	Commodity and source-specific shift term for Central government expenditures in region r
$f^{(6)r}$	r = 1,…,R	Shift term for Central government expenditures in region r
$f^{(6)}$		Shift term for Central government expenditures
ω		Overall rate of return on capital (short-run)
$r_{(j)}^{r}$	j = 1,...,h r = 1,…,R	Regional-industry-specific rate of return

Parameters, Coefficients and Sets

Symbol	Description
$\sigma_{(i)}^{(u)r}$	Parameter: elasticity of substitution between alternative sources of commodity or factor i for user (u) in region r
$\sigma^{(0\,j)r}$	Parameter: elasticity of transformation between outputs of different commodities in industry j in region r
$\alpha_{(g+1,s)}^{(1\,j)r}$	Parameter: returns to scale to individual primary factors in industry j in region r
$\beta_{(i)}^{r}$	Parameter: marginal budget shares in linear expenditure system for commodity i in region r
$\gamma_{(i)}^{r}$	Parameter: subsistence parameter in linear expenditure system for commodity i in region r
$\varepsilon_{(j)}^{r}$	Parameter: sensitivity of capital growth to rates of return of industry j in region r
$\eta_{(is)}^{r}$	Parameter: foreign elasticity of demand for commodity i from region r
$\theta_{(is)}^{(u)r}$	Parameter: scale economies to transportation of commodity (i) produced in region r shipped to user (u) in region r
$\mu_{(i\bullet)}^{(u)r}$	Parameter: returns to scale to primary factors (i = g+1 and u = 1j); otherwise, $\mu_{(i\bullet)}^{(u)r}=1$
$B(i,s,(u),r)$	Input-output flow: basic value of (is) used by (u) in region r
$M(m,i,s,(u),r$	Input-output flow: basic value of domestic good m used as a margin to facilitate the flow of (is) to (u) in region r
$T(\tau,i,s,(u),r)$	Input-output flow: collection of tax τ on the sale of (is) to (u) in region r
$V(i,s,(u),r)$	Input-output flow: purchasers' value of good or factor i from source s used by user (u) in region r
$Y(i,j,r)$	Input-output flow: basic value of output of domestic good i by industry j from region r
$Q_{(j)}^{r}$	Coefficient: ratio, gross to net rate of return
G	Set: {1,2, …, g}, g is the number of composite goods
G*	Set: {1,2, …, g+1}, g+1 is the number of composite goods and primary factors
H	Set: {1,2, …, h}, h is the number of industries
U	Set: {(3), (4), (5), (6), (k j) for k = 1, 2 and j = 1, …, h}
U*	Set: {(3), (k j) for k = 1, 2 and j = 1, …, h}
S	Set: {1, 2, …, r+1}, r+1 is the number of regions (including foreign)
S*	Set: {1, 2, …,r}, r is the number of domestic regions
T	Set: {1, …, t}, t is the number of indirect taxes