

Haddad, Eduardo; Giuberti, Ana Carolina

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

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

Eduardo Haddad<sup>1</sup> and Ana Carolina Giuberti<sup>2</sup>

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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.<sup>3</sup> 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<sup>4</sup> 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

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<sup>1</sup> Fipe and Department of Economics, University of Sao Paulo, CNPq scholar, Av. Prof Luciano Gualberto, 908 – FEA 1, Cidade Universitária, 05508-900, São Paulo, SP, Brazil (e-mail: [ehaddad@usp.br](mailto:ehaddad@usp.br)).

<sup>2</sup> Department of Economics, Federal University of Espírito Santo and IPE, University of São Paulo (e-mail: [anagiuberti@yahoo.com.br](mailto:anagiuberti@yahoo.com.br)).

<sup>3</sup> Estimates for 2007. Source: IBGE. Available at [www.ipeadata.gov.br](http://www.ipeadata.gov.br).

<sup>4</sup> 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.

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<sup>5</sup> 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 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<sup>6</sup> 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<sup>7</sup> 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.<sup>8</sup> 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.<sup>9</sup> This fact allowed to the anticipation of the oil extraction of the pre-salt layer. Currently, Petrobrás, the government-controlled national

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<sup>5</sup> 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.

<sup>6</sup> Fund for the Development of Port Activities.

<sup>7</sup> Value added tax on goods and services.

<sup>8</sup> 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.

<sup>9</sup> 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](http://www.estadao.com.br/economia/not_eco234746,0.htm)> Accessed 12/02/2009.

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.<sup>10</sup> 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)<sup>11</sup> between 2009 and 2013. This goal represents an expressive increasing in the output of the local 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<sup>3</sup> 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<sup>3</sup> 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.<sup>12</sup>

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).

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<sup>10</sup> 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](http://g1.globo.com/Noticias/Economia_Negocios/0,,MUL1371103-9356,00.html)> Accessed 12/02/2009.

<sup>11</sup> PETROBRAS (2009).

<sup>12</sup> PETROBRAS (2009).

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.<sup>13</sup> 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 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 data 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

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<sup>13</sup> 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 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 the Non-Tradable Sector (N). The first two sectors produce 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 mixed 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 have 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 **Brazilian Multisectoral And Regional/Interregional Analysis Model (B-MARIA)**, the first fully operational interregional CGE model for Brazil.<sup>14</sup> 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<sup>15</sup>, 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 in each region producing 110 commodities through a transformation process based on a constant elasticity of transformation (CET) specification.<sup>16</sup> 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 a policy is carried out, compared to their values in the absence of such policy, in a given environment. The schematic presentation of Johansen solutions for

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<sup>14</sup> The complete specification of the model is available in Haddad (1999).

<sup>15</sup> There are 289 block equations and 346 block variables in the *condensed model*; the *entire model* contains 327 block equations and 397 block variables.

<sup>16</sup> 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).

such models is standard in the literature. More details can be found in Dixon *et al.* (1992).

### **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  $\rho$  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.

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.<sup>17</sup> 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,

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<sup>17</sup> See Haddad and Hewing (2005), for more details.

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 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.

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.

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. 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 (iii) 5.2% is supplied by imports.

#### ***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 1). 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 1. Input-output multipliers: Intraregional and interregional output effects, Espírito Santo and rest of the country**

| Sectors   | Output Multipliers |       |       | Shares |       | Output Multipliers |       |       | Shares |       |
|---|--------------------|-------|-------|--------|-------|--------------------|-------|-------|--------|-------|
|   | ES                 |       |       | ES     |       | RBR                |       |       | 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. 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 out 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 2 and 3, and Figures 1-2<sup>18</sup>; 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.

Industry activity results (Figure 1) 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

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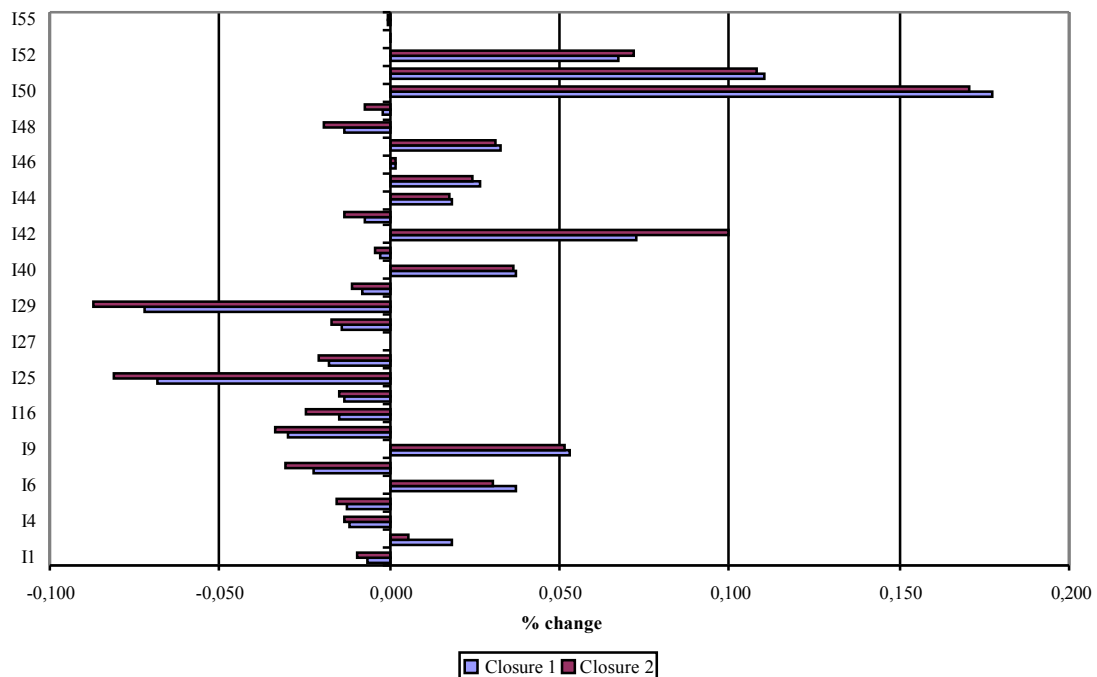
<sup>18</sup> Results for the oil and natural gas sector are not shown, for presentation purposes.

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 2 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 1. Sectoral activity effects in the State of Espírito Santo**



**Figure 2. Sectoral employment effects in the State of Espírito Santo**

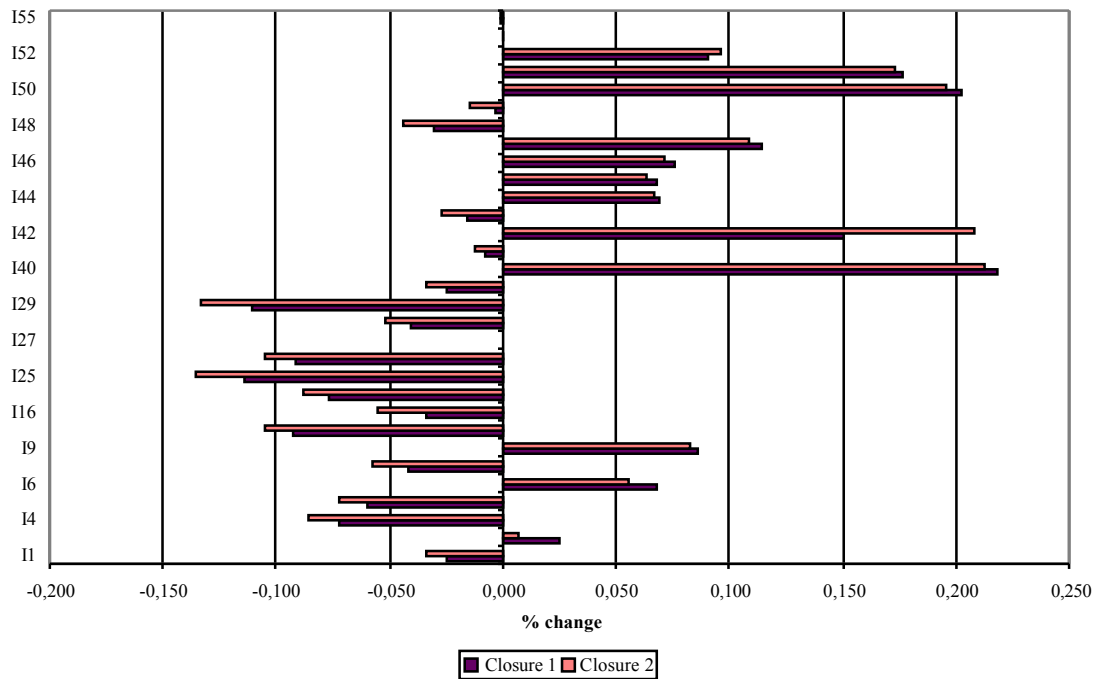


Table 2 summarizes the simulation results on some macro variables. The real GDP of Brazil is shown to increase by 0.145-0.147% with both regions positively affected. However, growth effects are highly concentrated in Espírito Santo, which experiences real GRP increases over 7.0%, while the rest of the 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 2, 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 3).

**Table 2. Selected aggregate results**

|                                    | <i>Closure 1</i> |           |               | <i>Closure 2</i> |           |               |
|------------------------------------|------------------|-----------|---------------|------------------|-----------|---------------|
|                                    | <i>ES</i>        | <i>RB</i> | <i>Brazil</i> | <i>ES</i>        | <i>RB</i> | <i>Brazil</i> |
| 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       |
| <i>Activity level (aggregate):</i> |                  |           |               |                  |           |               |
| 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 3. Sectoral shares in regional factor income**

|                         | <i>Benchmark</i> |           |               | <i>Closure 1</i> |           |               | <i>Closure 2</i> |           |               |
|-------------------------|------------------|-----------|---------------|------------------|-----------|---------------|------------------|-----------|---------------|
|                         | <i>ES</i>        | <i>RB</i> | <i>Brazil</i> | <i>ES</i>        | <i>RB</i> | <i>Brazil</i> | <i>ES</i>        | <i>RB</i> | <i>Brazil</i> |
| <i>Wage income</i>      |                  |           |               |                  |           |               |                  |           |               |
| 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        |
| <i>Capital income</i>   |                  |           |               |                  |           |               |                  |           |               |
| 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        |
| <i>Factor income</i>    |                  |           |               |                  |           |               |                  |           |               |
| 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 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.

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