

# NEREUS

Núcleo de Economia Regional e Urbana  
da Universidade de São Paulo

The University of São Paulo  
Regional and Urban Economics Lab

## Lecture 10: Natural Resources

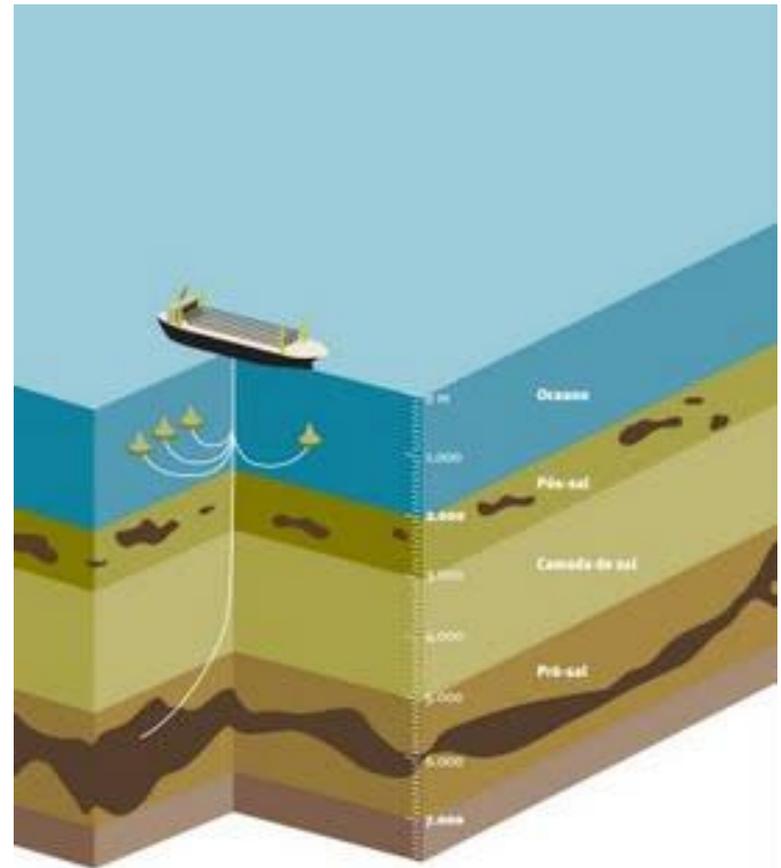
Prof. Eduardo A. Haddad

# Brazil has recently confirmed the discovery of a huge oil and natural gas field in the pre-salt layer...

2006 – first discoveries of oil and natural gas in the pre-salt layer in the Brazilian coast were announced by Petrobras

2008 – 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, **Brazilian reserves were duplicated**

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



... of the country's southeastern coast, where the State of Espírito Santo is located

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The **fields are spatially concentrated** in the coast area of a few Brazilian states that may be directly benefited by oil production

3.5 billion barrels of oil of the light crude type is located on the coast of Espírito Santo

The first oil well discovered is only 2.5 kilometers away from the FPSO JK (P-34) platform that, since 2006, extracts oil and natural gas of the post-salt layer of the state's coast

# Activities of Petrobras in the pre-salt layer

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Currently, Petrobras, the government-controlled national oil company, extracts around 15.000 barrels a day from the well located at the Espírito Santo's coast, and 15.000 more from the well located at the Rio de Janeiro's coast

Company's goal for 2013:

- ✓ 100.000 barrels daily in the pre-salt layer of the Espírito Santo's coast, which represents an increase of 70% in the local production. The predicted investment is of R\$ 10.3 billion (nearly US\$ 5.7 billion) between 2009 and 2013
- ✓ 219.000 barrels daily in the pre-salt layer of the Brazilian's coast

The goal for 2020: 1,815 million barrels daily of the pre-salt layer throughout the Brazilian coast

# Will this natural resources discovery be a curse for the local economy?

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Strong empirical evidence has shown a negative correlation between resource abundance and economic growth

One of the explanations is the “Dutch disease” effect – structural changes (shift away from tradable) 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 would cause the real exchange rate to appreciate, what in turn would dampen the exports and growth of the other tradable sectors, usually the more dynamic manufacture sector or the agricultural sector in poor developing countries

*How would it work at the sub-national level?*

# Booming sector and Dutch disease economics

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Corden and Neary (1982) and Corden (1984)

Three-sector economy: the Booming Sector (B), the Lagging Sector (L) and the Non-Tradable Sector (N)

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

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

## Booming sector and Dutch disease economics (cont.)

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**Initial effect:** rise in the aggregate incomes of the factors employed in sector B

This leads to two other effects: the spending effect and the resource movement effect

**Spending effect:** the extra income of sector B spent into the non-tradable goods of sector N

- ✓ Provided that the income elasticity of demand for N is positive, this extra expenditure 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)

## Booming sector and Dutch disease economics (cont.)

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**Resource movement:** movement of labor between the sectors (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

## Booming sector and Dutch disease economics (cont.)

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Both effects combined lead to the **decrease of real rents of the specific factor in L**

The wage rises, the price of non-tradable goods also rises, and the effect on the real wage is indefinite

# General features of the BMES model

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Large-scale interregional bottom-up CGE model for Brazil

- 2 domestic regions – Espírito Santo and Rest of Brazil
- 55 sectors and 110 goods in each region

Interregional flows of goods and services

Interregional factor mobility

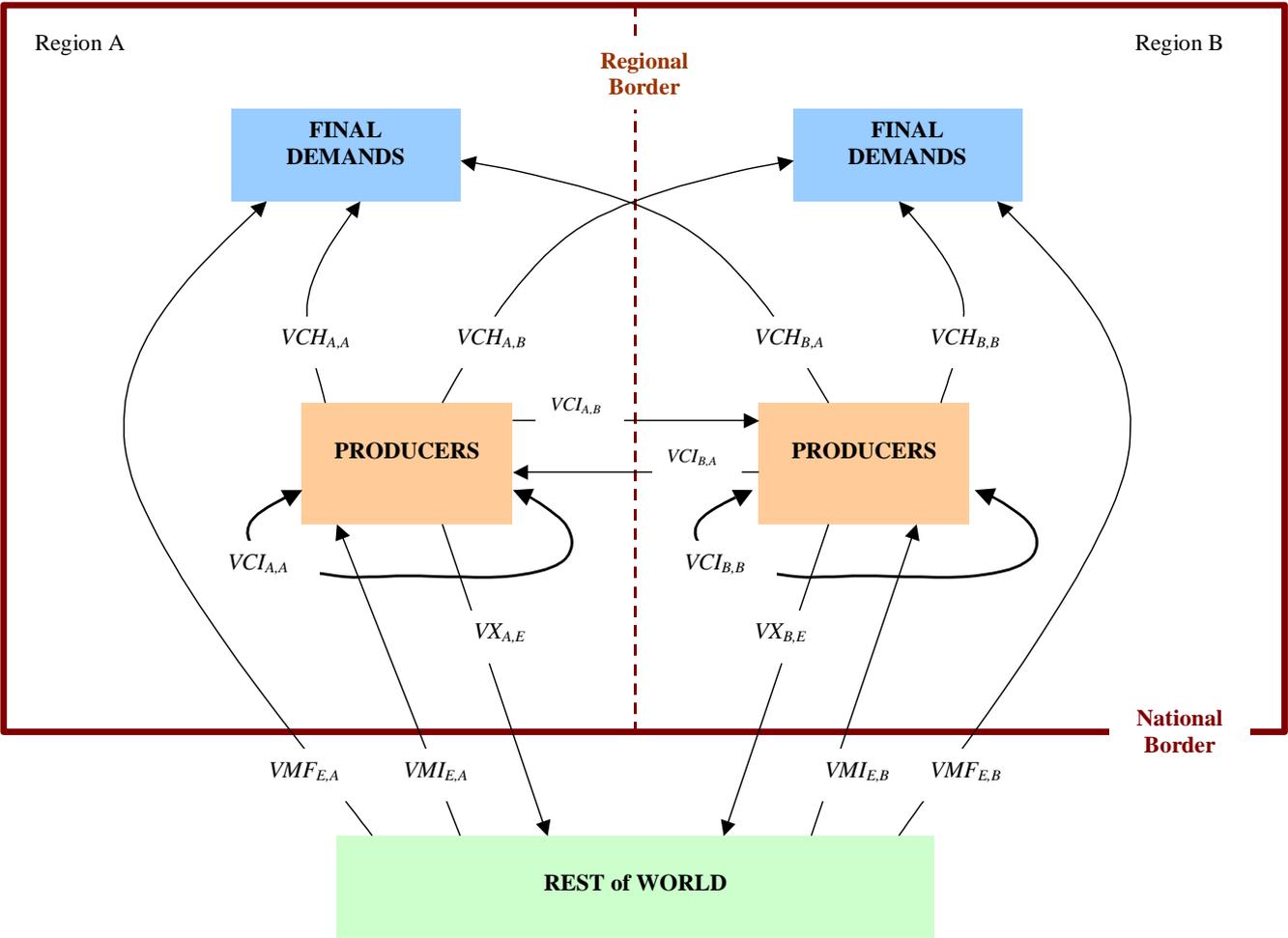
Explicit modeling of transportation costs based on origin-destination pairs, considering a stylized transportation network

Regional and Central government

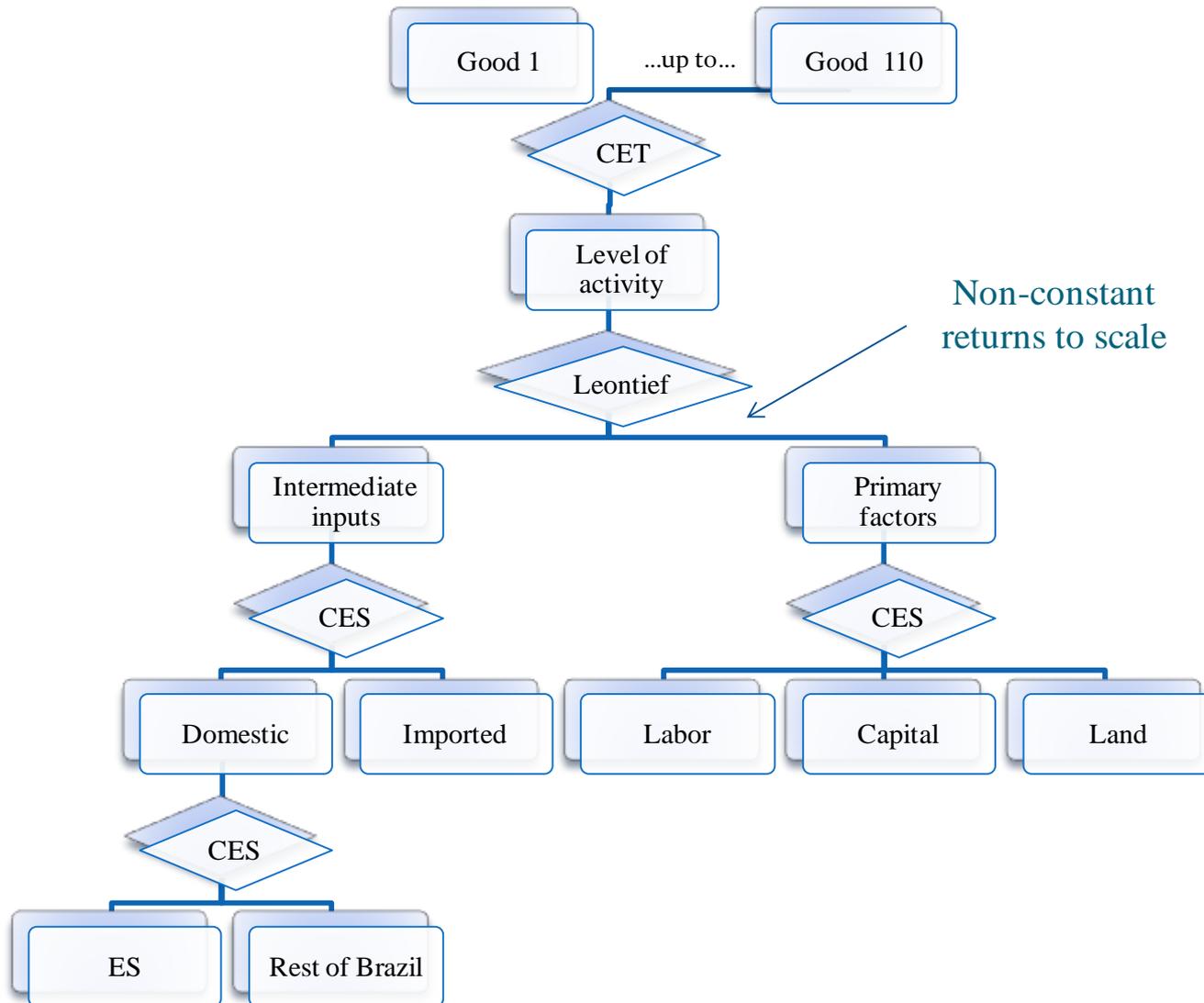
Regional labor markets

Non-constant returns to scale (agglomeration economies)

# Stylized flows



# Nested structure of production



# Closure 1

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Capital stocks are held fixed

*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

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*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.

# We highlight some features of the economy of Espírito Santo,...

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The State of Espírito Santo is a small Brazilian state

- ✓ 2.3% of Brazilian GDP
- ✓ 1.9% of the country's population

The economy relies heavily on the natural resources based industry, whose products are, in its majority, exported.

For some sectors the local output represents a larger share of the sectoral national output (2007 figures)

- ✓ steel and steel products (15,1%), iron ore pellets (13,2%), others products of non-metallic minerals (9,7%) and oil and natural gas extraction (6,3%)

Strong dependence upon the rest of the country (over 50% of supply in the region)

## ... and of the oil and natural gas sector

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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.

### Linkage analysis

Output multiplier (ES) = 1.894

- ✓ intraregional effect is 1.352 (71.4% of the total)
- ✓ interregional effect is 0.542 (28.6% of the total)

Output multiplier (Rest of Brazil) = 1.858

- ✓ intraregional effect is 1.829 (98.5% of the total)
- ✓ interregional effect is 0.029 (1.5% of the total)

# Simulation strategy

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Petrobras' 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)

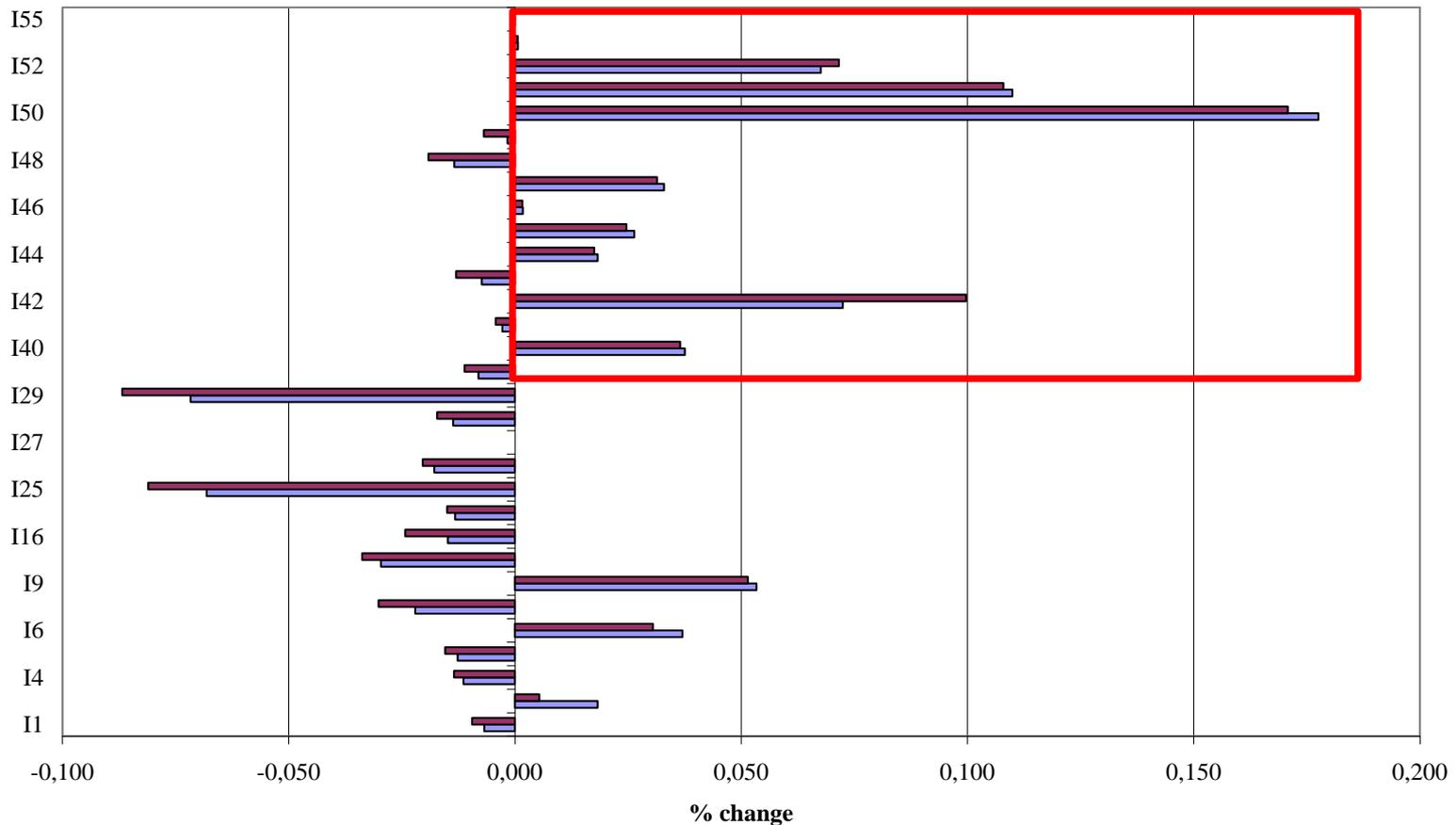
We model that in terms of a **once-for-all exogenous technical improvement in the oil and natural gas sector** (the booming sector in the BMES model) that elevates its productivity proportionally to the expected

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 increase in production

# Non-tradable sectors tend to benefit most from the increase in oil production in the pre-salt layer in ES

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



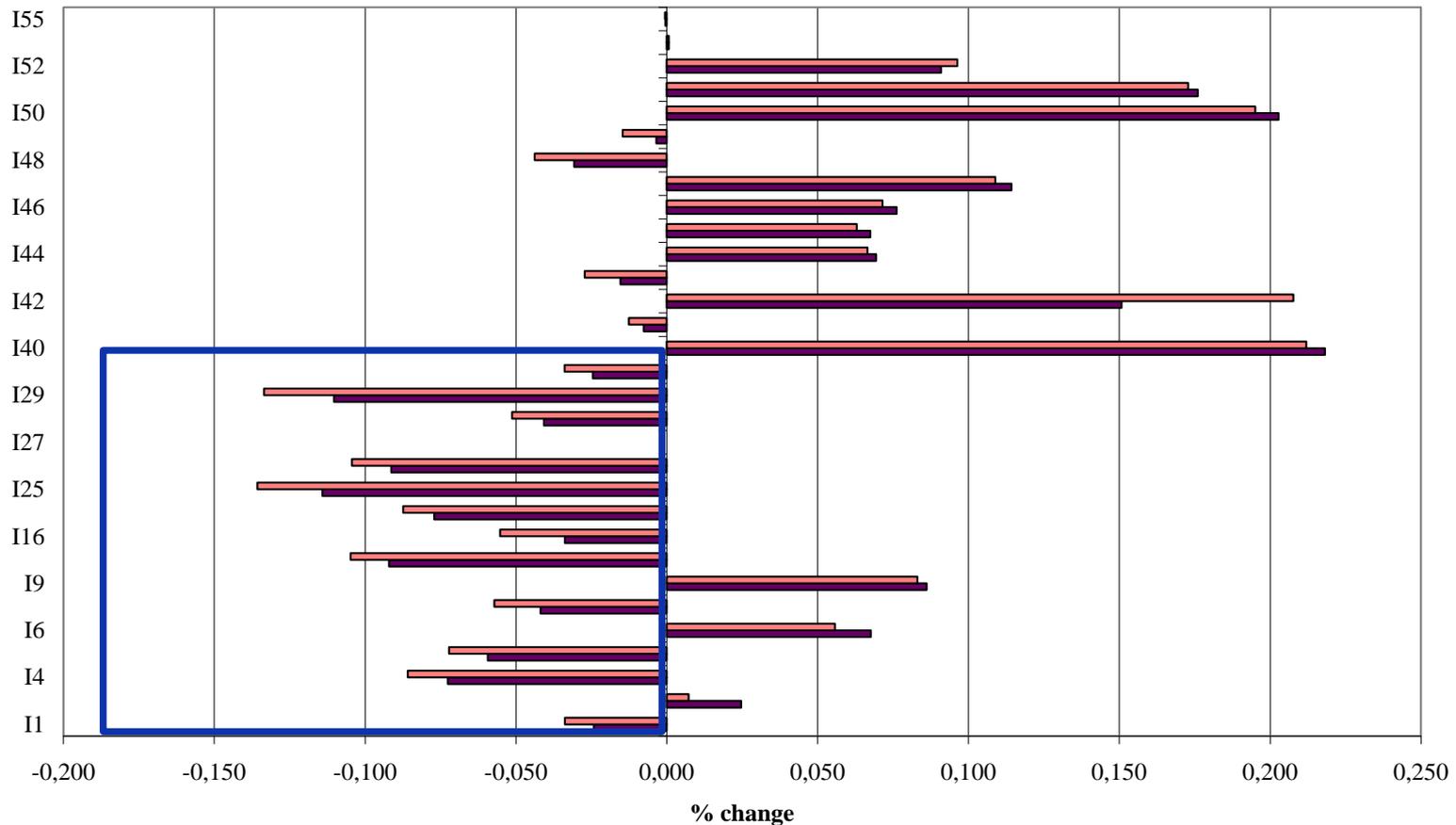
I1-I39 – tradables

I40-I55 – non-tradables

■ Closure 1 ■ Closure 2

# Potential Dutch-disease effect that the State may face as production of oil in the pre-salt is fostered

**Figure 1. Sectoral employment effects in the State of Espírito Santo**



I1-I39 – tradables

I40-I55 – non-tradables

■ Closure 1 ■ Closure 2

# Potential Dutch-disease effect that the State may face as production of oil in the pre-salt is fostered

**Table 1. 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	-	-	-

# Potential Dutch-disease effect that the State may face as production of oil in the pre-salt is fostered

**Table 2. 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

## Efforts in looking at general equilibrium Dutch disease effects for a small regional economy

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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

For a regional economy, 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

