NEREUS

Núcleo de Economia Regional e Urbana
da Universidade de São Paulo
The University of São Paulo
Regional and Urban Economics Lab

Lecture 13: Port Infrastructure

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Outline

- ✓ Motivation
- Modeling issues
- Handling port costs
- Estimation of port efficiency in Brazil
- Overview of the B-MARIA-27 model
- Port efficiency scenarios

Port costs may be seen as an additional barrier to trade

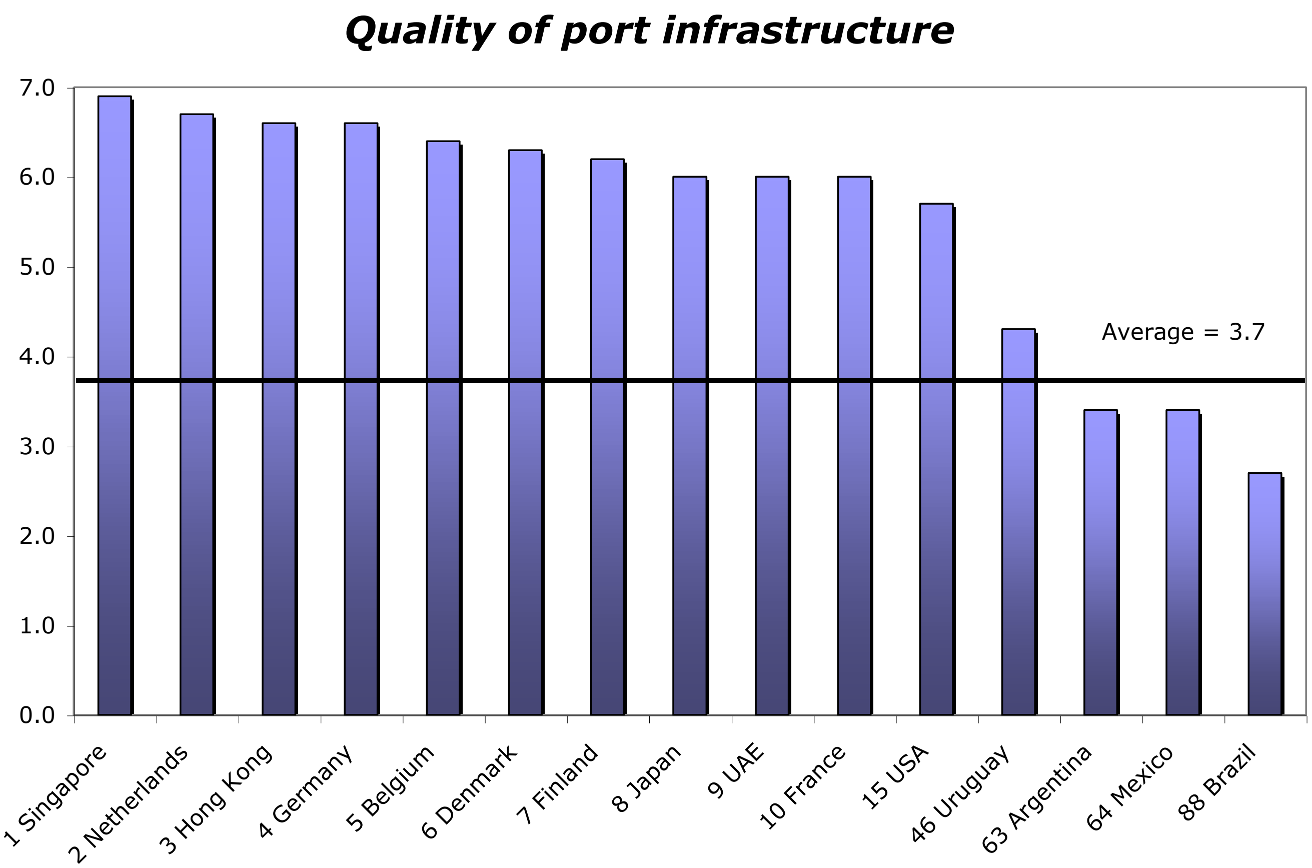
One of the main obstacles to economic development in Brazil is the so called *Custo Brasil*, the extra costs of doing business in the country.

Enterprises are faced with a heavy burden that competing firms in other countries do not confront, **hampering competitiveness**.

It includes different components that represent distortions in the relation between the public and the private sectors, reflecting inadequate legislation and deficient provision of public goods.

Ongoing debate centers on the contribution of different sectors to the *Custo Brasil*: labor costs; **transportation infrastructure**; the tax system; and the regulatory system.

Port efficiency varies widely from country to country…



Port facilities and inland waterways in your country are (1 = underdeveloped, 7 = as developed as the world's best) – Sample size = 125

Source: Global Competitiveness Report (2006)

... and Brazilian ports systematically rate poorly in different studies

In a survey-based study, by the *Confederação Nacional dos Transportes* – CNT (2006), the quality of port operators – which reflects not only operational efficiency, but also costs and provision of infrastructure and services – was poorly rated by roughly one-third of the respondents, major users of port services.

The empirical study by Blonigen and Wilson (2006) estimated a cost differential between Rotterdam and Santos of around 21.3%.

These stylized facts suggest that Brazilian port activity still can improve to achieve best practices, given international standards.

Maritime transport mode is very relevant for Brazilian international trade

Distribution of Brazilian Exports and Imports by Transport Modes, in 2002

	USD		Ton	
	Exports	Imports	Exports	Imports
Air	7.82	23.83	0.14	0.16
Road	12.29	7.16	3.77	10.54
Navigation	79.89	69.01	96.09	89.30
Total	100.00	100.00	100.00	100.00

The “Law of Modernization of Ports”

Problems associated with the port activity in Brazil have been tackled recently with a set of changes in the regulation of the sector.

In February 1993, the “Law of Modernization of Ports” (Law 8.630/93) was promulgated aiming at:

- decentralizing management,
- stimulating new investments (including from private investors),
- promoting competition, and
- adapting labor needs to new technological standards.

If it succeeds, *i.e.* if it helps to increase port efficiency in the country, it will be important to assess both its macro and regional impacts.

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Integration of CGE models and transportation networks

Modest but expanding literature.

Initial focus on spatial CGE models [e.g. Roson (1994), Bröcker (1998a), Bröcker and Schneider (2002)].

Kim *et al*. (2004) – Korea

- Multi-regional CGE model
- Examined optimal link construction strategies for major network expansion in highway network infrastructure
- Considered link and system-wide (synergetic) interactions

Kim *et al*. – US

- Integration of interregional commodity flow model and highway/rail transportation network to consider impacts of earthquake disruption

Haddad and Hewings – Brazil

- Explored role of market imperfections
- Focused on role of scale economies and transportation costs

Existing literature failed to look at network nodes

Integration focused on network structure

- Modal choice
- Congestion functions on links
- Route choice and path identification (e.g. Lee, 2005)

No consideration of nodal congestion

- e.g. US railroads and Chicago (48 hours LA-Chicago, 18 hours Chicago-NY but 36-130 hours within Chicago)
- Unlike highway link, congestion at port may have severe impacts spread over space and time whereas highway link congestion may be resolved within several hours

There are still unresolved issues!

How to include a nodal congestion function?

Consideration of regulation and spatial competition (competing destinations/origins/transfer).

Shipper/carrier/transfer agent issue

- Shipper – minimize O-D transportation costs
- Carrier – allocate shipper's goods to different modes or combination of modes
- Transfer agent (port) – attracting different modes to use specific ports

For ports:

- How much investment to reduce transfer costs?
- Specialize (e.g. in containers or handling particular cargoes)?
- Dependency on links with the hinterland

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First steps in modeling port costs

Assume transportation costs for export/import include two components

- Link costs (internally and externally);
- Transfer costs at the port (function of volume and capacity).

Assume standard network with nodes and links.

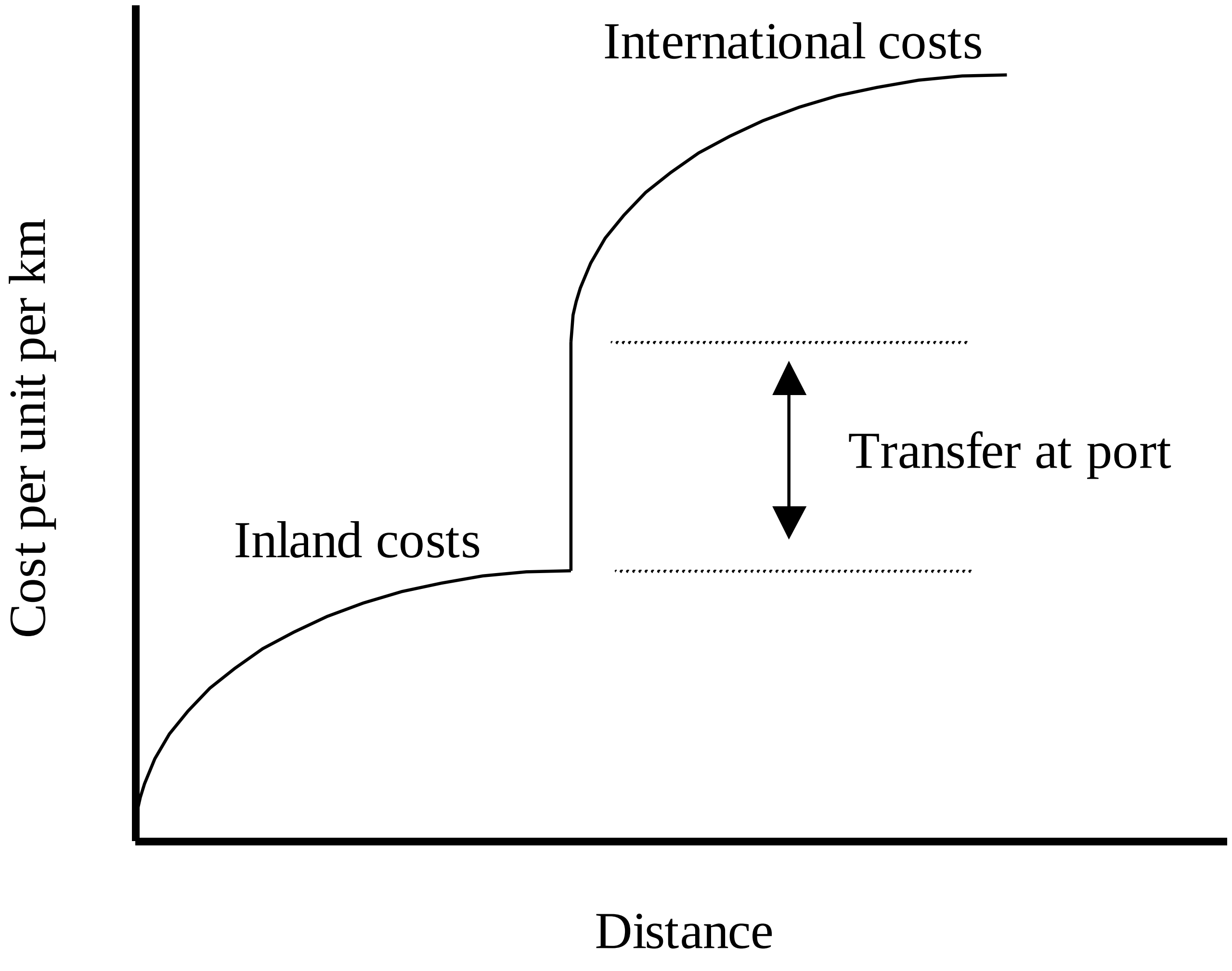
At port, introduce a self-link to capture the transfer costs.

Need to formulate a model of imperfect competition among the ports

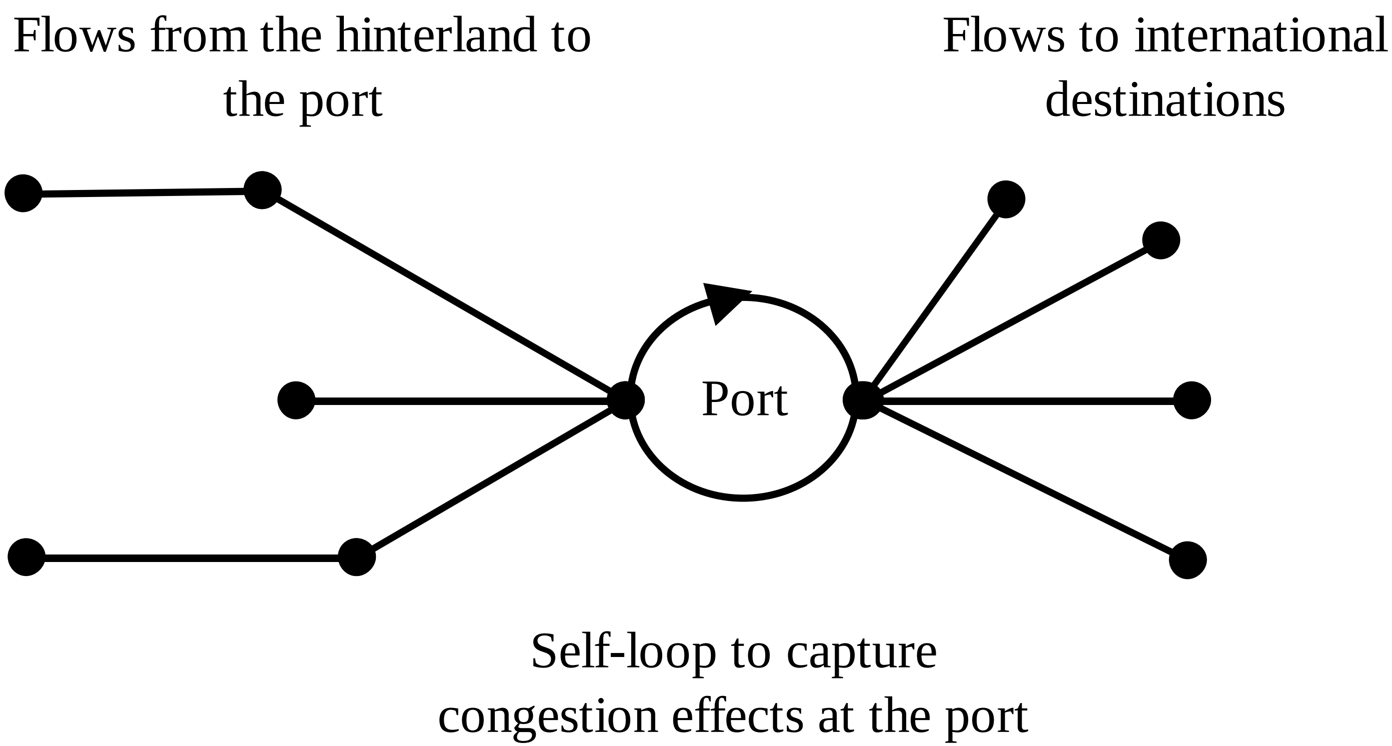
- Different capacities,
- Different hinterland connectivities restrict the degree to which one port can serve as substitute for another – i.e., “trade areas” imperfectly overlap.

Since port is part of the transportation network, any congestion/disruption is likely to ripple throughout the hinterland.

Cost function for export of a domestically produced good



Stylized representation of link and nodal costs



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Port efficiency varies across ports within Brazil

In order to calibrate the CGE model, we need estimates of cost differentials among Brazilian ports.

As this information is not readily available, we provide estimates of port efficiency measures using international trade data, adapting the methodology developed in Blonigen and Wilson (2006).

The results offer a new perspective on regional differentials of port efficiency in Brazil, as they provide **estimates of relative efficiency among Brazilian ports**.

Results from Santos (2007).

The model

$$lnic_{rijk} = \alpha + \beta_1 lnkg_{rijk} + \beta_2 lnvolume_{ij} + \beta_3 sqlnvolume_{ij} + \beta_4 lnunitval_{rijk} + \beta_5 lndist\_uf_{ri} + \beta_6 sqlndist\_uf_{ri} + \beta_7 lndist\_part_{ij} + \beta_8 sqlndist\_part_{ij} + \beta_9 dumport_i + \beta_{10} dumprod_k + \varepsilon_{ijk}$$

$lnic_{rijk}$ is the natural logarithm of import charges on the import flow of product k shipped from country j to Brazilian port i to be consumed in state r;

α is the constant term;

$lnkg_{rijk}$ is the natural logarithm of the weight of the import flow of product k shipped from country j to Brazilian port i to be consumed in state r;

$lnvolume_{ij}$ is the natural logarithm of the total volume of shipments from country j to Brazilian port i;

$sqlnvolume_{ij}$ is the square of the natural logarithm of the total volume of shipments from country j to Brazilian port i;

$lnunitval_{rijk}$ is the natural logarithm of the U.S. dollar value of the specific shipment of product k shipped from country j to Brazilian port i to be consumed in state r divided by its weight in kilos;

The model

$lnic_{rijk} = \alpha + \beta_1 lnkg_{rijk} + \beta_2 lnvolume_{ij} + \beta_3 sqlnvolume_{ij} + \beta_4 lnunitval_{rijk} + \beta_5 lndist\_uf_{ri} + \beta_6 sqlndist\_uf_{ri} + \beta_7 lndist\_part_{ij} + \beta_8 sqlndist\_part_{ij} + \beta_9 dumport_i + \beta_{10} dumprod_k + \varepsilon_{ijk}$

$lndist\_uf_{ri}$ is the natural logarithm of the distance between port *i* and destination state *r*;

$sqlndist\_uf_{ri}$ is the square of the natural logarithm of the distance between port *i* and destination state *r*;

$lndist\_part_{ij}$ is the natural logarithm of the distance between port *i* and origin country *j*;

$sqlndist\_part_{ij}$ is the square of the natural logarithm of the distance between port *i* and origin country *j*;

$dumport_i$ is the set dummy variables for each Brazilian port;

ε_{ijk} is the error term.

Port Efficiency Index (PEI)

The set of dummy variables for Brazilian ports are expected to capture the cost differential specific to each port, in other words, differences in port efficiency.

Given that our dependent variable is in logarithm form, the coefficients β_9 approximately equal to the percentage difference (in decimal form) in the port's effect on import charges relative to the Port of Santos effect, after controlling for all other factors.

More precisely, we can calculate a Port Efficiency Index (PEIi) based on such coefficients with the formula:

$$PEI_i = \exp(\beta_9^i)$$

The *PEI* for the Port of Santos will be equal to one, by construction. Such index for the remaining ports will give the extent to which port costs differ from those in Santos, in percentage change. **Ports that present an index smaller than one are considered to be more efficient than Santos, while those that present values greater than one are less efficient.**

The data

Sources: Brazilian Ministry of Development (ALICEWEB) and the United Nations (COMTRADE)

Matching procedure reduced the sample from around 100,000 records to 71,223 observations

Information on Brazilian imports, in 2002

	ALICEWEB	COMTRADE
Six-digit HS code	yes	yes
Country of origin	yes	yes
Port of entry	yes	no
State destination	yes	no
Weight	yes	no
USD value	FOB	CIF

Distance measures were obtained through geo-processing with the software TransCAD.

Port sample

After an evaluation of the available database, we had to limit our sample to 13 major ports, which covered, in 2002, 56,5% of all Brazilian import activity, in US dollars, or 67,3%, in tons. Given the role of the maritime mode in Brazilian import activity, in the same year (69,1%), these ports cover over 80% of imports by such mode.

Estimation procedure

We estimated the model using the method of instrumental variables to correct for **endogeneity**.

The endogenous variables are $lnkg_{rijk}$, $lnvolume_{ij}$, $sqlnvolume_{ij}$ and $lnunitval_{rijk}$.

We used as instruments (all in logarithms) the GDP of the destination state in Brazil, both in level and squared; GDP of the foreign country, also in level and squared; population and its squared size.

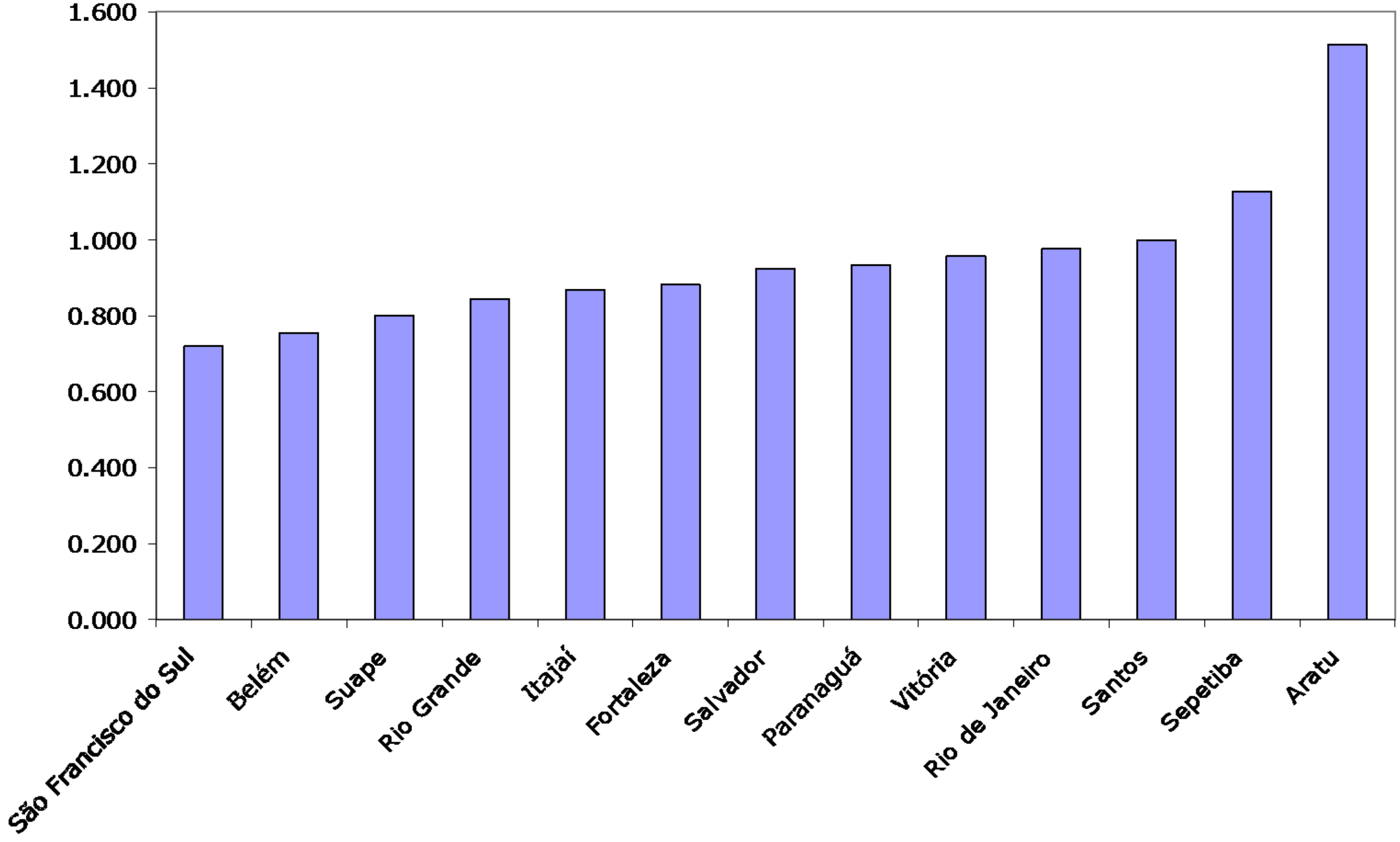
Another problem is that we only have data concerning the efficiency of port *i* when *i* is actually used to import a product *k* from country *j* to state *r*. To correct the **problem of sample selection** derived from this, we used Heckman's (1979) two stage estimation procedure: first, probit models for the probability of a port to be used to import a product *k* from country *j* to state *r* were estimated for each port; second, the estimated probabilities were included in the model.

Due to the use of estimated regressors, the standard errors were incorrect; so we used bootstrapping techniques to obtain the correct ones.

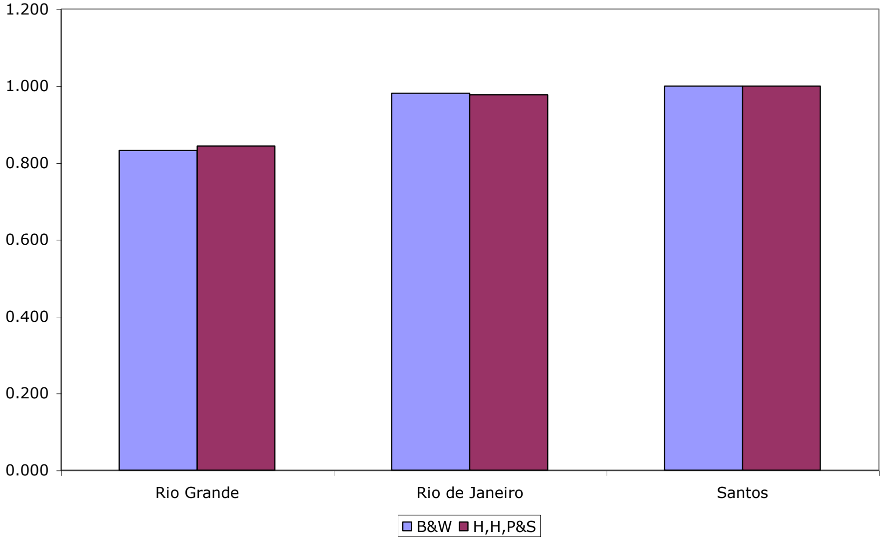
Results

Variable	*Coefficient*	*Standard error*	*t-stastistics*	*p-value*
lnkg	0.8195	0.0297	27.5693	0.0000
lnvolume	-0.1417	0.0340	-4.1689	0.0000
sqlnvolume	0.0055	0.0011	5.1909	0.0000
lnvalor/peso	0.5241	0.0327	16.0344	0.0000
lndist_uf	0.1027	0.0201	5.1063	0.0000
sqlndist_uf	-0.0140	0.0028	-4.9635	0.0000
lndist_parceiro	2.1650	0.1772	12.2155	0.0000
sqlndist_parceiro	-0.1032	0.0100	-10.3115	0.0000
ditajai	-0.1402	0.0322	-4.3534	0.0000
dparanagua	-0.0676	0.0227	-2.9810	0.0029
drio_de_janeiro	-0.0235	0.0223	-1.0535	0.2921
dsepetiba	0.1184	0.1497	0.7909	0.4290
drio_grande	-0.1699	0.0271	-6.2710	0.0000
dsalvador	-0.0795	0.0463	-1.7178	0.0858
dsao_fco_sul	-0.3279	0.0585	-5.6083	0.0000
dvitoria	-0.0430	0.0264	-1.6290	0.1033
daratu	0.4133	0.1861	2.2202	0.0264
dsuape	-0.2232	0.0486	-4.5975	0.0000
dfortaleza	-0.1243	0.0589	-2.1090	0.0349
dbelem	-0.2818	0.1743	-1.6170	0.1059

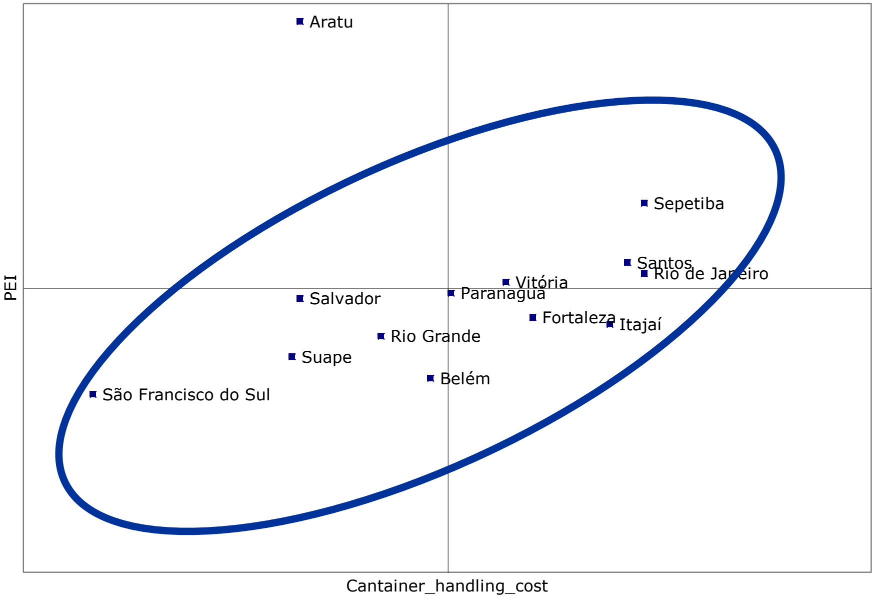
Port Efficiency Index (PEI) – Santos = 1



Comparing the PEI to other measures



Comparison of efficiency indices based on B&W and H,H,P&S



Correlation between the PEI estimates and container handling charges

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The B-MARIA-27 model has been widely used for assessing regional impacts of policies in Brazil

Starting point: B-MARIA (Haddad, 1999) and its extensions

- Well documented
- Critical reviews
- Various applications

Need to undertake structural modifications to achieve the goal of this paper

- Haddad and Hewings (QREF, 2005)

General features of the model

Interstate bottom-up CGE model for Brazil

- 27 regions
- 8 sectors/goods

Integrated with a geo-coded transportation model

Interregional flows of goods and services

Interregional factor mobility

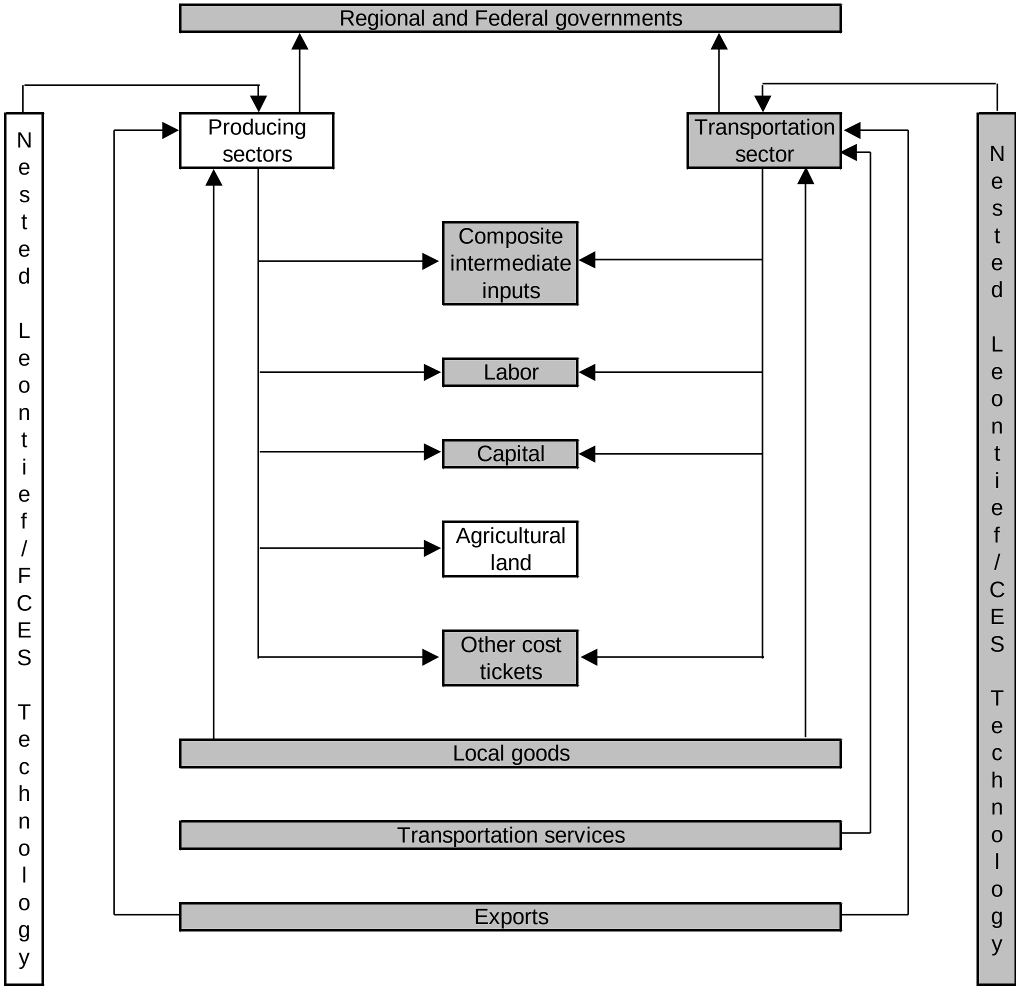
Explicit modeling of transportation costs based on origin-destination pairs

Regional and Federal government

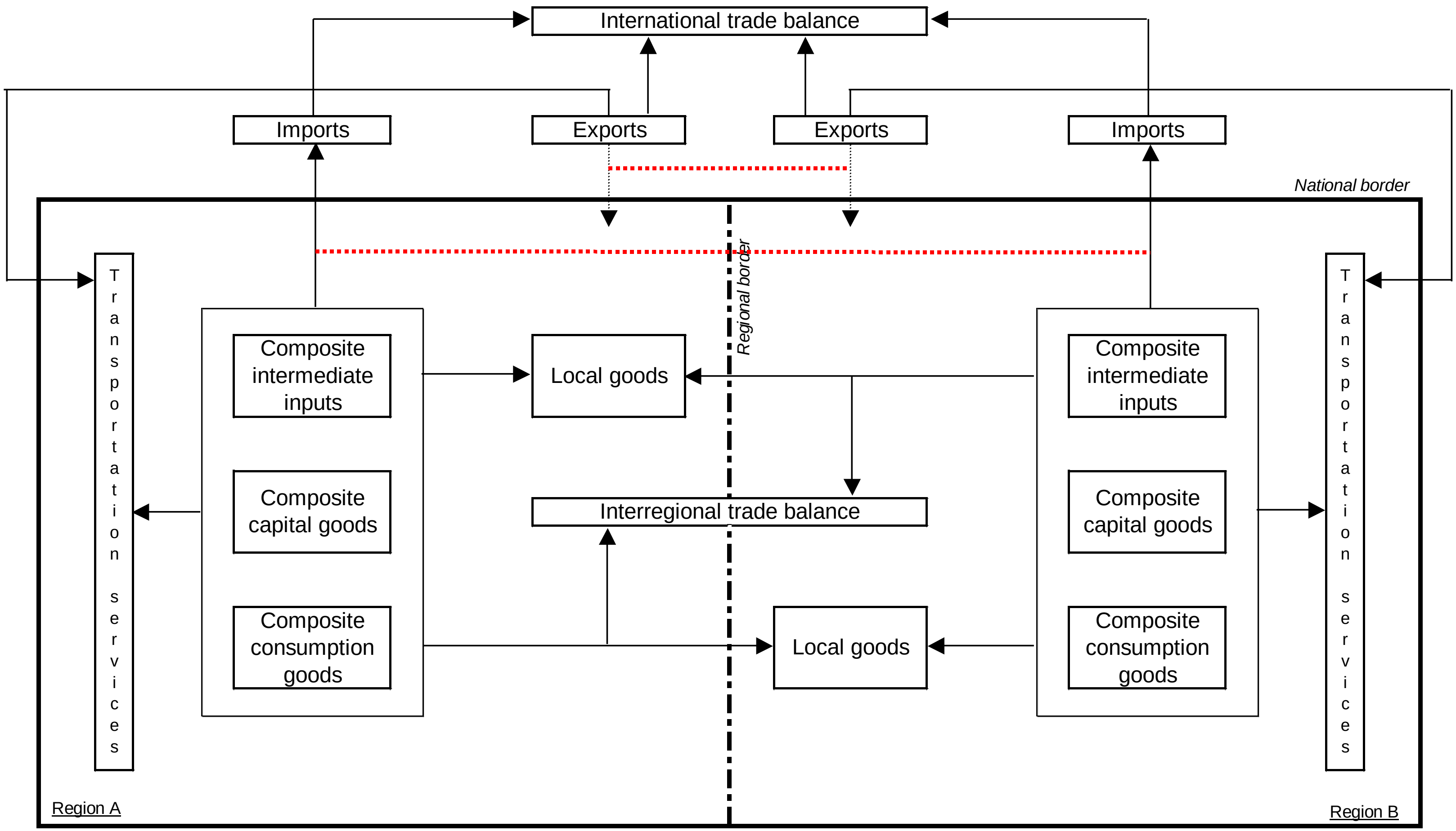
Regional labor markets

Non-constant returns to scale (agglomeration economies)

Regional production technology in B-MARIA-27: highlighting the transportation sector



The Role of transportation services in B-MARIA-27: illustrative flowchart in a two-region framework



Innovation: modeling of port costs

Prices paid for commodity *i* from region *s* in region *q* by each user equate to the sum of its basic value and the costs of the relevant taxes and margin-commodities.

The role of margin-commodities is to facilitate flows of commodities from points of production or points of entry to either domestic users or ports of exit.

Margin-commodities, or, simply, margins, include transportation and trade services, which take account of transfer costs in a broad sense.

The margin demand equations show that the demands for margins are proportional to the commodity flows with which the margins are associated; moreover, a technical change component is also included in the specification in order to allow for changes in the implicit transportation rate.

In the case of imported goods, the implicit transportation margin refers to the costs at the port of entry, while for exports it refers to costs at the port of exit.

Demand for port services related to **import** activity

The general functional form used for the equations of margin demand on imported goods, for different users, is presented below.

It can be interpreted as the demand for port services related to import activity.

$$XMARG(i,"foreign",q) =$$
$$AMARG(i,"foreign",q) * [\eta(i,"foreign",q) * X(i,"foreign",q)^{\theta(i,"foreign",q)}]$$

where *XMARG(i,"foreign",q)* is the transportation margin on the flow of commodity *i*, produced abroad ("foreign") and consumed in region *q*; *AMARG(i,"foreign",q)* is a technology variable related to commodity-specific flows, **which also enters the relevant purchasers' prices equations**; $\eta(i,"foreign",q)$ is the margin rate on specific basic import flows; *X(i,"foreign",q)* is the flow of imported commodity *i* consumed in region *q*; and $\theta(i,"foreign",q)$ is a parameter reflecting scale economies to port activity related to imports.

Demand for port services related to **export** activity

In a similar fashion, the general functional form used for the equations of margin demand on exported goods is presented below.

It can be interpreted as the demand for port services related to export activity.

$$X4MARG(i,s) = A4MARG(i,s) * [\eta 4(i,s) * X4(i,s)^{\theta 4(i,s)}]$$

where *X4MARG(i,s)* is the transportation margin on the flow of commodity *i*, produced in region *s* and consumed abroad; *A4MARG(i,s)* is a technology variable related to commodity-specific flows, **which also enters the relevant purchasers' prices equations**; $\eta 4(i,s)$ is the margin rate on specific basic export flows; *X4(i,s)* is the flow of exported commodity *i* produced in region *s*; and $\theta 4(i,s)$ is a parameter reflecting scale economies to port activity related to exports.

Calibration of demand for port services equations – data needs

Calibration of demand for port services equations requires information on the transport margins related to each commodity flow.

Aggregated information for margins on imported flows associated with intersectoral transactions, capital creation, household consumption, and exports are available at the national level.

The problem remains to disaggregate such information considering previous spatial disaggregation of commodity flows in the generation of the interstate social accounting matrix.

Available information – international trade commodity flows by states, port efficiency indices by ports, mapping of international transactions for each state by port of entry (imports) and port of exit (exports), and national aggregates for specific margins

Calibration of demand for port services equations – strategy

In the calibration, *AMARG(i,"foreign",q)* was set equal to port efficiency indices calculated for each state q, PEI_q, invariable across commodities.

To do that, we first mapped state imports by port of entry.

With the estimates of PEI_i, for every port i, we built the PEI_q as weighted averages of the PEI_is considering the share of each port in the imports of a given state, as the weights.

Similar assumptions were used for equations related to export activity.

Port and mode distribution of state imports and exports, Brazil, 2002 (weights matrix)

(A) Imports

State Destination

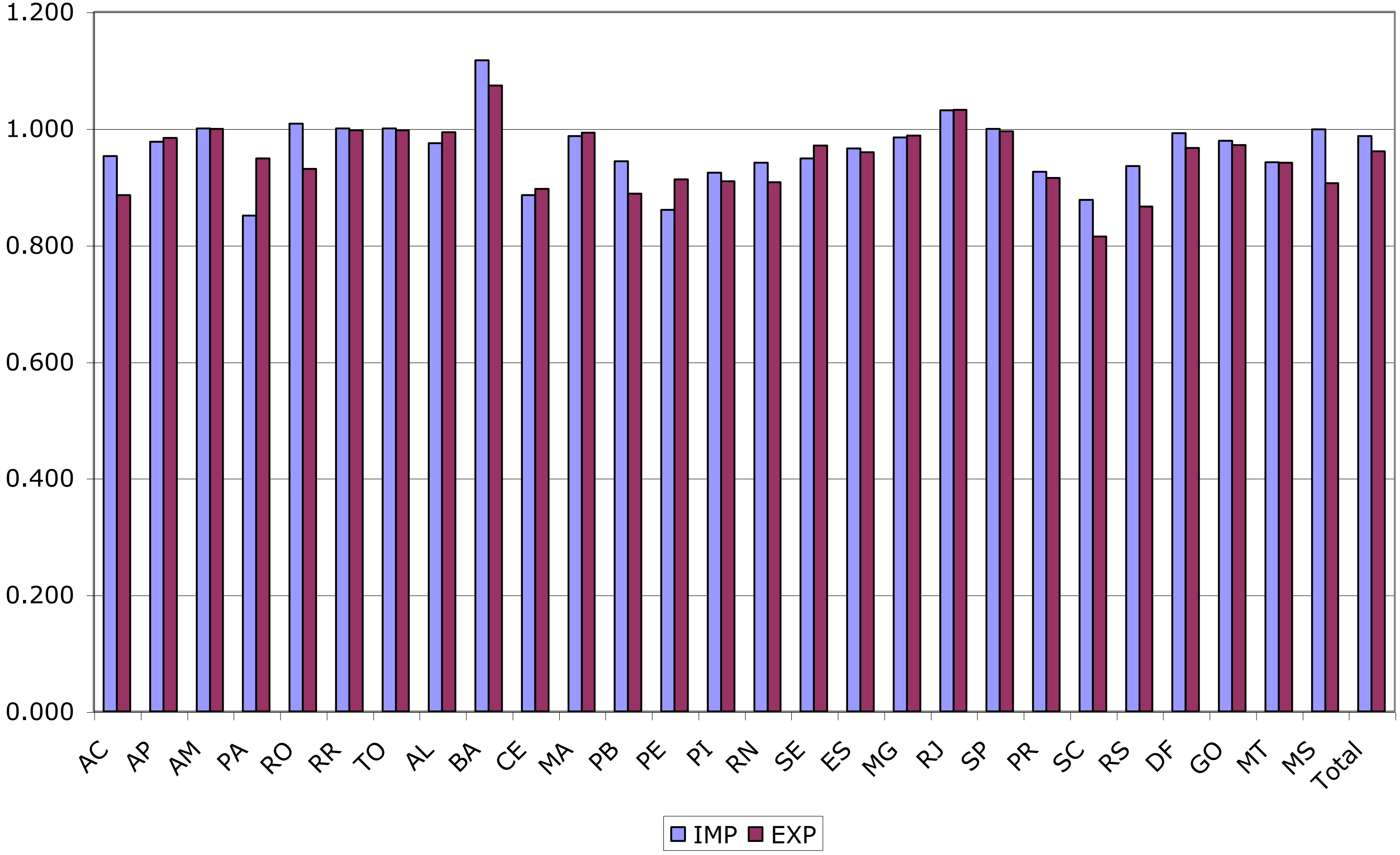
		AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	RN	SE	ES	MG	RJ	SP	PR	SC	RS	DF	GO	MT
	Maritime	0.8117	0.8745	0.5260	0.9427	0.9160	0.2144	0.8307	0.5855	0.9035	0.9458	0.9882	0.9051	0.9197	0.8151	0.8948	0.7972	0.8296	0.8100	0.7543	0.6047	0.7644	0.6755	0.7559	0.2754	0.7987	0.7180
Port of Entry	Itajai	-	-	0.0000	-	-	-	-	-	0.0001	0.0001	-	-	0.0001	-	-	-	0.0021	0.0058	0.0007	0.0026	0.0108	0.3877	0.0048	0.0013	0.0049	0.0014
	Paranaguá	0.6991	-	0.0012	-	0.0032	-	0.0000	0.0020	0.0002	0.0000	-	-	0.0024	-	-	-	0.0007	0.0050	0.0026	0.0050	0.5903	0.0358	0.0028	0.0168	0.1384	0.4126
	Rio de Janeiro	-	0.0020	0.0012	0.0081	-	-	0.0194	0.0051	0.0036	0.0002	0.0005	-	0.0025	0.0039	0.0024	0.0244	0.0391	0.2781	0.3259	0.0085	0.0020	0.0055	0.0039	0.0516	0.0199	0.0030
	Sepetiba	-	-	0.0003	0.0009	0.0713	-	-	-	0.0002	-	-	-	-	-	0.0002	0.0053	0.0008	0.0401	0.3277	0.0011	0.0002	-	-	0.0067	0.0002	-
	Rio Grande	-	-	-	0.0013	-	-	-	-	0.0004	0.0012	-	0.0059	0.0001	-	-	-	-	0.0004	0.0005	0.0005	0.0050	0.0103	0.3709	0.0025	0.0003	0.0760
	Salvador	-	-	-	0.0019	-	-	-	0.0190	0.4468	0.0001	-	0.0030	0.0022	0.2999	0.0299	0.2286	0.0016	0.0021	0.0000	0.0002	0.0000	0.0004	-	0.0014	0.0003	-
	São Francisco do Sul	-	-	0.0002	0.0001	0.0011	-	-	-	0.0001	-	-	-	-	-	-	-	0.0005	0.0001	0.0000	0.0012	0.0970	0.1942	0.0024	0.0140	0.0064	0.0515
	Vitória	-	-	-	0.0005	-	-	-	0.4864	0.0120	0.0388	0.0007	0.0238	0.0014	-	0.2615	0.2268	0.7689	0.2854	0.0045	0.0022	0.0010	0.0033	0.0001	0.0063	0.2042	0.0084
	Aratu	-	-	-	-	-	-	-	-	0.3694	-	-	-	0.0337	-	-	-	0.0001	-	-	0.0008	-	-	-	-	-	-
	Suape	-	-	-	0.0001	-	-	-	0.0117	0.0003	0.0105	0.0011	0.2415	0.6878	0.0031	0.1709	0.1070	-	0.0000	0.0001	0.0001	0.0000	-	0.0000	0.0003	0.0001	-
	Fortaleza	-	-	-	0.0013	-	-	-	0.0007	0.0000	0.8898	0.0085	0.0021	0.0008	0.4169	0.0566	-	-	0.0002	0.0000	0.0000	0.0000	-	0.0000	0.0001	-	-
	Belém	-	0.0824	-	0.5271	-	-	-	-	-	-	0.0413	-	0.0000	-	0.0000	-	-	0.0000	0.0000	0.0001	-	-	-	0.0025	-	-
	Santos	0.0496	0.0609	0.0003	0.0079	0.0022	-	0.8112	0.0606	0.0179	0.0052	0.0001	0.0114	0.0187	-	-	0.0510	0.0157	0.1894	0.0268	0.5174	0.0510	-	0.0449	0.1720	0.4232	0.0951
	Other ports	0.0631	0.7292	0.5228	0.3934	0.8382	0.2144	-	-	0.0526	0.0001	0.9360	0.6174	0.1697	0.0913	0.3733	0.1540	0.0002	0.0033	0.0653	0.0647	0.0072	0.0383	0.3260	-	0.0007	0.0700
	Other modes	0.1883	0.1255	0.4740	0.0573	0.0840	0.7856	0.1693	0.4145	0.0965	0.0542	0.0118	0.0949	0.0803	0.1849	0.1052	0.2028	0.1704	0.1900	0.2457	0.3953	0.2356	0.3245	0.2441	0.7246	0.2013	0.2820
	Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

(B) Exports

State Origin

		AC	AP	AM	PA	RO	RR	TO	AL	BA	CE	MA	PB	PE	PI	RN	SE	ES	MG	RJ	SP	PR	SC	RS	DF	GO	MT
	Maritime	0.9039	0.8289	0.3586	0.7292	0.9406	0.0529	0.9985	0.9983	0.9390	0.8959	0.9968	0.8653	0.8254	0.9171	0.9189	0.9514	0.9608	0.9180	0.8913	0.6711	0.9267	0.9022	0.8351	0.8101	0.8443	0.9553
Port of Exit	Itajai	0.5736	-	0.0004	0.0001	0.0916	-	-	-	0.0001	-	-	0.0000	0.0000	-	-	-	0.0000	0.0054	0.0003	0.0063	0.0892	0.4371	0.0505	0.0020	0.0533	0.0130
	Paranaguá	0.2431	-	0.0005	0.0016	0.6575	0.0472	0.0450	-	0.0002	-	0.0000	-	0.0000	-	-	-	0.0001	0.0073	0.0013	0.0223	0.7017	0.0740	0.0104	-	0.0706	0.1973
	Rio de Janeiro	-	0.0155	0.0060	0.0001	0.0182	-	-	-	0.0073	0.0004	0.0002	0.0001	0.0010	0.0004	0.0001	-	0.0107	0.2033	0.2716	0.0160	0.0024	0.0002	0.0010	0.0015	0.0013	0.0001
	Sepetiba	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1007	0.3302	0.0004	0.0001	0.0000	0.0001	-	0.0000	-
	Rio Grande	0.0635	-	-	0.0001	0.0004	-	0.0003	-	0.0025	0.0068	0.0029	0.0034	0.0038	-	-	0.0043	0.0000	0.0002	0.0026	0.0018	0.0050	0.0030	0.7128	-	0.0004	0.0023
	Salvador	-	-	0.0012	0.0000	-	-	0.0004	0.0171	0.4749	0.0002	-	0.0093	0.1096	0.0230	0.0013	0.3174	0.0009	0.0006	0.0001	0.0003	0.0000	0.0000	0.0001	-	-	-
	São Francisco do Sul	0.0199	-	-	0.0001	0.0281	-	-	-	0.0002	-	-	0.0001	-	-	-	-	0.0000	0.0025	0.0004	0.0048	0.0743	0.3614	0.0158	-	0.0115	0.1216
	Vitória	-	-	-	0.0006	0.0146	0.0045	-	0.0001	0.0885	0.0008	-	0.0016	0.0001	-	0.0003	-	0.9466	0.4129	0.0039	0.0010	0.0002	0.0001	0.0000	0.7709	0.2946	0.0866
	Aratu	-	-	-	-	-	-	-	-	0.2838	-	-	-	-	-	-	-	-	-	0.0000	0.0000	-	-	-	-	-	-
	Suape	-	-	0.0002	0.0002	-	-	-	0.0229	0.0043	0.0057	0.0013	0.3517	0.3204	0.0001	0.2051	0.0143	0.0000	0.0000	0.0002	0.0001	-	-	0.0000	-	0.0000	-
	Fortaleza	-	0.0042	-	0.0012	-	-	-	0.0030	0.0027	0.8167	0.0020	0.2609	0.0537	0.7172	0.3776	0.0017	-	0.0000	0.0000	0.0001	-	-	0.0025	-	-	0.0000
	Belém	-	0.0558	0.0009	0.1819	0.0078	-	-	-	0.0001	0.0004	0.0222	-	0.0006	-	0.0000	-	0.0000	0.0000	0.0004	0.0002	0.0000	0.0000	0.0001	-	0.0000	0.0001
	Santos	-	0.0004	0.0065	0.0026	0.0996	-	0.0604	0.0019	0.0141	0.0376	0.0008	0.0352	0.0169	0.0003	0.0019	-	0.0015	0.1841	0.0083	0.6158	0.0410	0.0058	0.0182	0.0358	0.4043	0.4429
	Other ports	0.0039	0.7530	0.3430	0.5407	0.0227	0.0012	0.8924	0.9533	0.0603	0.0274	0.9675	0.2028	0.3193	0.1761	0.3326	0.6137	0.0009	0.0010	0.2720	0.0020	0.0127	0.0205	0.0237	-	0.0082	0.0914
	Other modes	0.0961	0.1711	0.6414	0.2708	0.0594	0.9471	0.0015	0.0017	0.0610	0.1041	0.0032	0.1347	0.1746	0.0829	0.0811	0.0486	0.0392	0.0820	0.1087	0.3289	0.0733	0.0978	0.1649	0.1899	0.1557	0.0447
	Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

Port Efficiency Index (PEI), by State



Simulation strategy

Changes in port efficiency can be calculated either through changes in the weights matrix or in the PEIs' estimates for a given (set of) port(s).

Then, it can be incorporated in the interstate CGE model, as follows.

$$\frac{XMARG(i,"foreign",q)}{X(i,"foreign",q)^{\theta(i,"foreign",q)}} = AMARG(i,"foreign",q) * \eta(i,"foreign",q)$$

$$\frac{X4MARG(i,s)}{X4(is)^{\theta(is)}} = A4MARG(i,s) * \eta 4(i,s)$$

With both θs equal to one implying that the left-hand-side is equivalent to the specific margin rate multiplied by the efficiency index. A percentage change in the margin rate, or the use of port services by trade flow, can then be mapped into the technology variable, or the state port efficiency index. Thus, in percentage-change form, amarg(i,"foreign",q) and a4marg(i,s) become the relevant linkage variables!

Outline

Motivation

Modeling issues

Handling port costs

Estimation of port efficiency in Brazil

Overview of the B-MARIA-27 model

✓ Port efficiency scenarios

We analyze three different scenarios related to port efficiency changes in Brazil...

Scenario 1. Brazilian port activity still can improve to achieve best practices, given international standards. In this sense, we simulate in this first scenario an overall increase in port efficiency of 20%.

Scenario 2. Even though the "Law of Modernization of Ports" (Law 8.630/93) was promulgated in 1993, port reforms are taking a very slow pace. One of its pillars, namely that of **port management decentralization**, has not been properly implemented. Most of Brazilian ports are still under Federal control. The few ports under regional control (either state of municipality administrations) seem to perform better, as our estimates of port efficiency suggest. Simple average of the PEI for the sets of federal- and regional-managed ports reveal that regional-managed ports are, on average, approximately 18% less costly than those ports controlled by the Union. Thus, in our second scenario, we assume that this gap is eliminated (possibly through management decentralization).

... in which we consider (i) best international practices; (ii) management decentralization,...

Port Efficiency of Federal and Regional Ports (Santos = 1)

Port	*PEI*	*Management*
Belém	0.754	Federal
Fortaleza	0.883	Federal
Salvador	0.924	Federal
Vitória	0.958	Federal
Rio de Janeiro	0.977	Federal
Santos	1.000	Federal
Sepetiba	1.126	Federal
Aratu	1.512	Federal
Average	*1.017*	*Federal*
São Francisco do Sul	0.720	Regional
Suape	0.800	Regional
Rio Grande	0.844	Regional
Itajaí	0.869	Regional
Paranaguá	0.935	Regional
Average	*0.834*	*Regional*

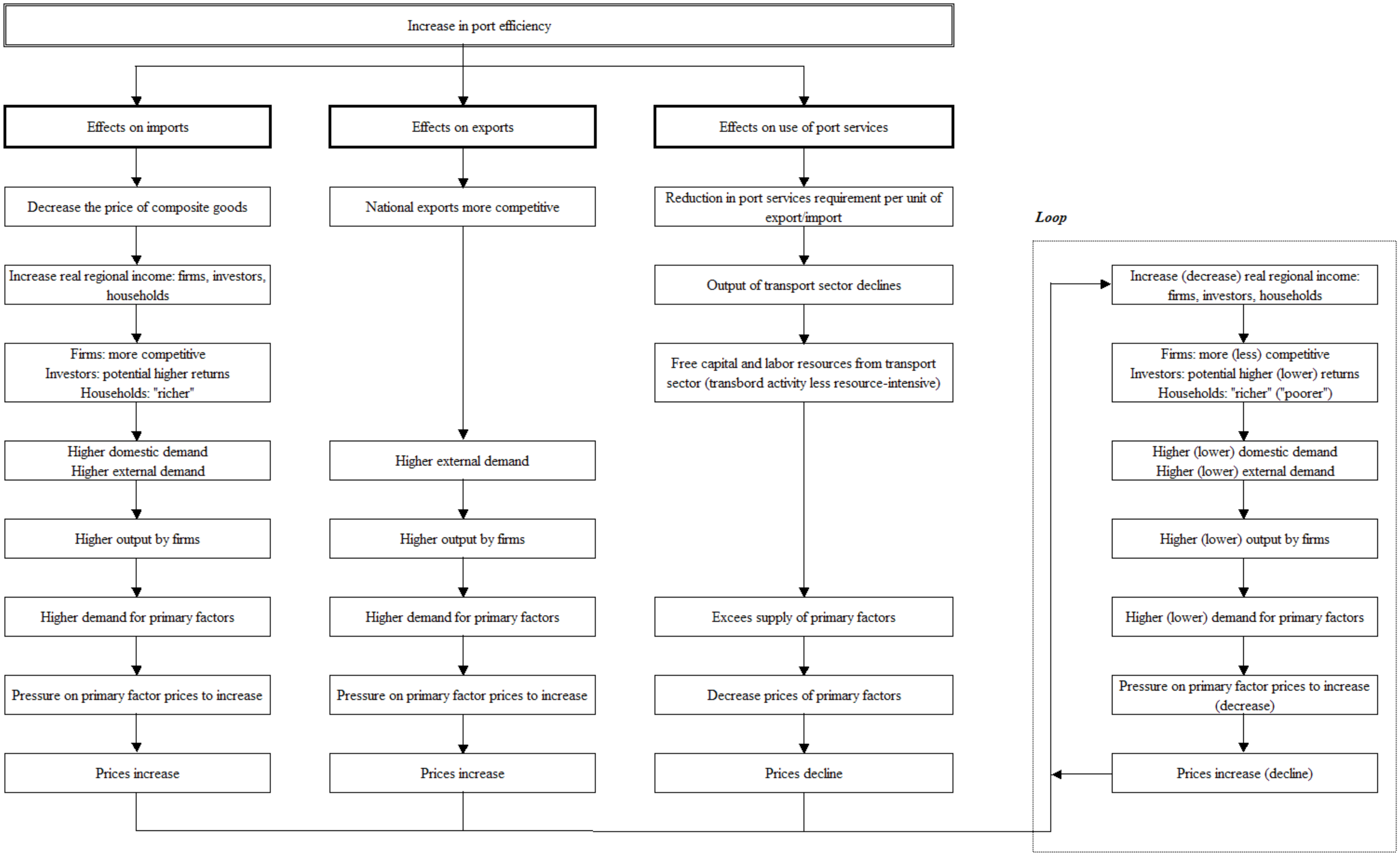
... and (iii) best national practices

Scenario 3. The Port of São Francisco do Sul was the most efficient port, and, therefore, can be considered lying on the efficiency frontier of our sample. In this third scenario, we simulate regionally differentiated increases in port efficiency in order to reach such boundary of the national efficiency frontier. All other 12 ports are assumed to achieve the same port efficiency index as the one estimated for São Francisco do Sul.

Calculated state PEI values, under the three scenarios

State	Benchmark		Scenario 1		Scenario 2		Scenario 3	
	IMP	EXP	IMP	EXP	IMP	EXP	IMP	EXP
AC	0.953	0.886	0.800	0.728	0.932	0.885	0.734	0.704
AP	0.977	0.983	0.806	0.821	0.816	0.832	0.713	0.728
AM	1.000	0.999	0.895	0.928	0.904	0.934	0.828	0.882
PA	0.851	0.948	0.692	0.813	0.678	0.815	0.691	0.761
RO	1.008	0.930	0.823	0.756	0.841	0.900	0.700	0.692
RR	1.000	0.997	0.957	0.987	0.961	0.996	0.930	0.983
TO	1.000	0.997	0.834	0.798	0.847	0.822	0.728	0.673
AL	0.975	0.993	0.863	0.795	0.870	0.814	0.808	0.673
BA	1.116	1.074	0.912	0.871	0.951	0.903	0.704	0.692
CE	0.885	0.896	0.719	0.738	0.714	0.734	0.690	0.706
MA	0.987	0.993	0.792	0.795	0.806	0.811	0.676	0.673
PB	0.944	0.888	0.774	0.737	0.823	0.794	0.703	0.716
PE	0.860	0.912	0.704	0.765	0.818	0.820	0.698	0.729
PI	0.924	0.909	0.776	0.744	0.775	0.741	0.733	0.699
RN	0.941	0.907	0.774	0.742	0.809	0.776	0.707	0.699
SE	0.948	0.971	0.799	0.786	0.822	0.800	0.739	0.688
ES	0.966	0.959	0.807	0.775	0.814	0.783	0.728	0.685
MG	0.984	0.987	0.826	0.806	0.838	0.822	0.734	0.699
RJ	1.031	1.032	0.874	0.847	0.893	0.869	0.753	0.708
SP	0.999	0.995	0.878	0.862	0.890	0.879	0.802	0.780
PR	0.926	0.915	0.788	0.747	0.915	0.904	0.749	0.696
SC	0.877	0.815	0.767	0.671	0.869	0.810	0.779	0.704
RS	0.935	0.866	0.797	0.725	0.867	0.857	0.752	0.726
DF	0.992	0.967	0.939	0.811	0.948	0.818	0.910	0.734
GO	0.979	0.971	0.823	0.808	0.860	0.841	0.738	0.723
MT	0.942	0.941	0.810	0.762	0.909	0.827	0.765	0.687
MS	0.998	0.906	0.939	0.756	0.949	0.859	0.903	0.723
Total	0.987	0.960	0.852	0.807	0.881	0.858	0.774	0.735

Functioning mechanisms of the simulations



Aggregate results

	Scenario 1		Scenario 2		Scenario 3	
	SR	*LR*	*SR*	*LR*	*SR*	*LR*
Aggregates						
Real GDP	0.036	0.092	0.026	0.061	0.053	0.130
Aggregate employment, wage bill weights	(0.016)	0.033	(0.011)	0.026	(0.024)	0.047
Equivalent variation – total (change in $ 1,000,000)	693.9	623.5	460.9	428.6	1,010.2	1,005.4
Economy-wide terms of trade	(0.266)	(0.304)	(0.193)	(0.216)	(0.399)	(0.447)
GDP price index, expenditure side	0.012	0.017	(0.016)	0.006	0.001	0.003
GDP components						
Real household consumption	0.025	0.056	0.017	0.039	0.036	0.082
Real aggregate investment	-	0.119	-	0.066	-	0.152
Real aggregate regional government demand	-	0.075	-	0.051	-	0.103
Real aggregate federal government demand	-	0.056	-	0.039	-	0.082
International export volume	0.550	0.672	0.396	0.458	0.825	0.981
International import volume	0.229	0.309	0.159	0.201	0.339	0.445
Activity level						
Agriculture	0.022	0.098	0.015	0.056	0.033	0.133
Manufacturing	0.034	0.125	0.025	0.086	0.052	0.179
Utilities	0.009	0.051	0.006	0.036	0.013	0.073
Construction	(0.001)	0.064	(0.001)	0.045	(0.002)	0.089
Trade	0.011	0.059	0.007	0.036	0.016	0.081
Financial institutions	0.041	0.098	0.029	0.059	0.061	0.136
Public administration	0.005	0.062	0.004	0.043	0.008	0.089
Transportation and other services	(0.077)	(0.064)	(0.053)	(0.047)	(0.114)	(0.099)

What do the aggregate results tell us?

Gains in efficiency (real GDP growth) and welfare (equivalent variation) are positive.

In all scenarios positive impacts on real GDP growth are verified (biggest impacts occur in scenario 3).

In the long run the effects on GDP are magnified.

In terms of employment, in the short run we verify negative results (reduction in employment), led by the weak performance of the transportation and construction sectors; the latter, specifically, has a strong employment coefficient.

Changes in terms of trade tend to benefit Brazilian exports in the three scenarios, as the results point to increasing competitiveness of Brazilian products.

International trade appears to increase its share in national GDP, revealing a more open Brazilian economy after port efficiency increases.

In the long run, real investments also grow faster than real GDP.

What do the aggregate results tell us?

At the sectoral level, there is a shift against the production of transportation services, as expected. As resources are scarce, the reduction in the production of port services (transborder activities become less resource-intensive) is achieved at the gains of other sectoral output, especially from sectors producing tradable goods, which face stronger competition from foreign products.

In summary: in aggregate terms simulation results suggest that increases in port efficiency lead to a faster-growing, more competitive, and more open Brazilian economy.

Spatial effects

In the three scenarios, the real GDP is shown to increase in all the macro-regions, except for the Center-West – a landlocked region – in the long run.

In the short run, there appear clearly three spatial regimes in the Brazilian economy (scenario 1).

First, a space associated with “primary exporters”, in which the transportation infrastructure is sparse and the main links and nodes are easily associated with specific and scattered export activities. This area – which encompasses the states of Amazonas, Pará and Mato Grosso – benefits from lower costs associated with its export activities. In the case of Amazonas, a relevant indirect effect also occurs through the improvement of efficiency in imports transshipments, as the interstate exports from the “Zona Franca de Manaus” become more competitive.

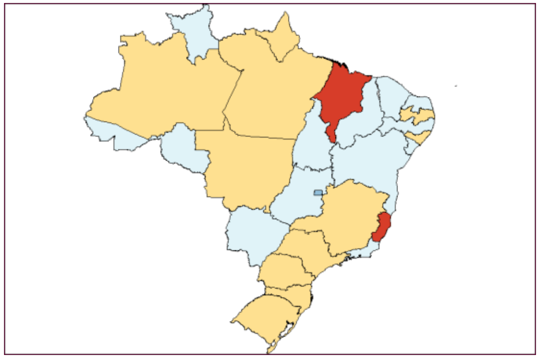
Spatial results (continued)

Second, there appears an “intermediate space”, which assumes a role of transition in the context of the interface of the Brazilian interregional system with the world economy, and is more articulated with the domestic markets.

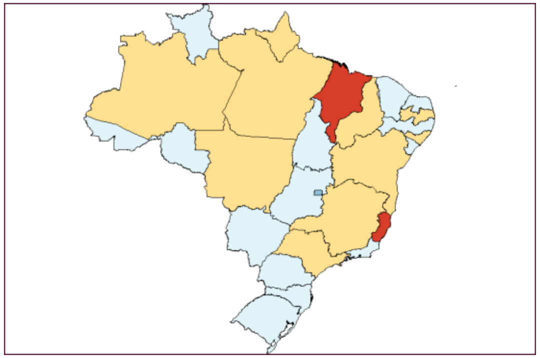
Third, there appears a denser economic space, more integrated with the world economy, where port efficiency plays a crucial role in affecting its overall competitiveness; this third group includes Brazilian “global traders” located in the more developed regions of the Southeast and South.

Short run results for scenario 3 also reveal similar spatial regimes.

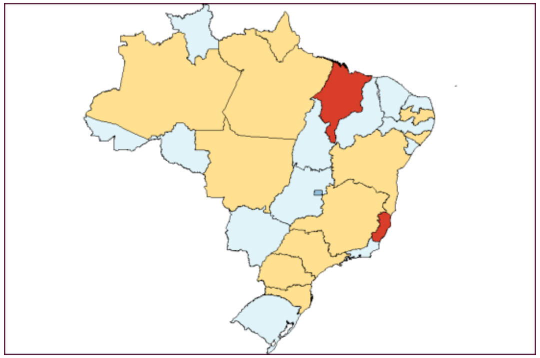
Short-run spatial results



Scenario 1



Scenario 2



Scenario 3

Fiscal effects

	Scenario 1				*Scenario 2*				*Scenario 3*			
	Short run		*Long run*		*Short run*		*Long run*		*Short run*		*Long run*	
	Federal	*Regional*	*Federal*	*Regional*	*Federal*	*Regional*	*Federal*	*Regional*	*Federal*	*Regional*	*Federal*	*Regional*
I. TOTAL REVENUE	0.053	0.065	0.236	0.119	0.013	0.021	0.207	0.070	0.061	0.079	0.329	0.139
I.1. Tax Revenue	0.058	0.087	0.315	0.114	0.017	0.036	0.293	0.059	0.069	0.111	0.452	0.131
I.1.1. Indirect taxes and contributions	0.083	0.094	0.124	0.119	0.036	0.041	0.073	0.061	0.107	0.122	0.148	0.137
I.1.2. Direct taxes	0.036	0.046	0.486	0.086	(0.000)	0.008	0.491	0.047	0.034	0.051	0.725	0.097
I.2. Payroll Taxes	0.045	0.021	0.093	0.091	0.006	(0.010)	0.049	0.108	0.048	0.013	0.102	0.108
I.3. Federal Transfers to Regions	-	0.030	-	0.157	-	(0.004)	-	0.092	-	0.026	-	0.187
I.4. Other Revenue	0.045	0.048	0.093	0.091	0.006	0.009	0.049	0.067	0.048	0.054	0.102	0.107
II. TOTAL OUTLAYS	0.053	0.065	0.236	0.119	0.013	0.021	0.207	0.070	0.061	0.079	0.329	0.139
II.1. Government Consumption (Personnel)	0.012	0.013	0.088	0.094	(0.015)	(0.015)	0.063	0.065	0.002	0.001	0.109	0.115
II.2. Federal Transfers to Regions	0.030	-	0.157	-	(0.004)	-	0.092	-	0.026	-	0.187	-
II.3. Personal Benefit Payments	0.105	0.023	0.032	0.053	0.045	(0.009)	0.020	0.031	0.137	0.017	0.023	0.050
II.4. Subsidies	0.117	0.091	0.126	0.131	0.056	0.044	0.072	0.050	0.154	0.122	0.152	0.140
II.5. Other Outlays	0.045	0.139	0.715	0.155	0.013	0.072	0.687	0.077	0.052	0.188	1.060	0.173
III. Government Balance	0.053	0.065	0.236	0.119	0.013	0.021	0.207	0.070	0.061	0.079	0.329	0.139
Real budget surplus	0.041	0.053	0.219	0.102	0.029	0.037	0.200	0.063	0.060	0.078	0.326	0.136

Increases in port efficiency do have non-negligible fiscal impacts, enhancing the performance of government accounts, mainly through economy-wide effects on economic activity.

Final remarks

The results of this analysis suggest that formal consideration of nodes in a transportation network is required if the full implications of transportation costs are to be considered in CGE models.

While the insights gained from integrating a transport network with the multi-region CGE model are substantial, in cases where nodal inefficiencies play a key role as is in the case in Brazil and much of Latin America, it becomes important to separate out link and node costs.

From a policy perspective this separation is even more important. Brazil faces daunting challenges to identify the necessary resources to upgrade its infrastructure; the choice of ports for such investment will have significant implications on the hinterlands serving those ports (and other areas that may be able to access them once the investments have been completed).