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Regional effects of economic integration: the case of Brazil

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Abstract

In this paper, alternative strategies of economic integration are evaluated from the Brazilian perspective. Traditional trade gains and losses are considered in a cost-competitiveness approach, based on relative changes in the industrial cost and demand structures. In the first part of the analysis, a national CGE model is used in order to assess the first-round impacts of three alternative trade liberalization scenarios. In the second part, a Machlup–Goodwin-type interregional model is integrated to the CGE model in order to generate a top-down disaggregation of the national results. Spatial implications of the trade policies are assessed, showing that the trade strategies examined are likely to increase regional inequality in the country.

JEL classification: C68; F17; R13

Keywords: Computable general equilibrium models; Commercial policy; Interregional trade; Regional analysis; FTAA

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1. Introduction

Recent years have witnessed a wave of neoliberal policies in Brazil. Regionalism, starting with the Mercosur Agreement in the early 1990s, and extended to broader regional trade agreements, still under negotiation, is a major element of the process of liberalization of the Brazilian economy. Motivated by both economic and political objectives, the country has been pursuing different strategies of regional integration in an attempt to reinforce strategic impulses for economic development.

Taking the lead in the negotiations concerning the future of Mercosur, Brazil foresees three main alternatives for the development of economic trading blocs. First, the country is involved in the creation of the Free Trade Area of the Americas (FTAA), keeping up with the process initiated in the 1994 Summit of the Americas to integrate the economies of the Western Hemisphere into a single free trade arrangement. Second, an agreement connecting the Mercosur countries and the European Union has already received the political compromise of the interested parts, but its implementation still faces localized disagreements. Finally, a broader negotiation under the WTO (Millennium Round) has also to be considered.

In the period 1997–1999, Brazilian main trade partners included countries in the FTAA, with imports from NAFTA and Mercosur reaching, respectively, 27 and 15% of the country's total imports, while exports to these areas altogether represented around 39% of Brazilian total exports. The European Union also accounted for a considerable share of Brazil's international trade, with around 28% of both exports and imports. This pattern, however, was very differentiated across the different Brazilian states (Table 1).

Table 2 reveals a spatially uneven regional distribution of international trade in the country. The Southeast and South regions were responsible for 84% of Brazil's total exports, and 85% of total imports in the 1997–1999 period. When one looks at bloc-specific trade flows, the Southeast region was responsible for more than half of total trade with the five groups considered. The state of São Paulo alone concentrated the country's exports, with a share of 57% in the total sales to the rest of the FTAA, and 54% in the sales to other Mercosur countries.

Recent research on trade and location has proposed different approaches to analyze the effects of globalization on industrial location.[2] Considering its two main driving forces — trade liberalization and technical progress — the globalization process is responsible for important shifts in the economic centers of gravity not only in the world economy but also within the national economies. In the latter case, the question one poses addresses equity concerns: are regional inequalities likely to widen or narrow? Although it is agreed that there is inherent unpredictability created by some of the forces involved, the research agenda seeks to use new techniques to illuminate at least some of the forces at work reshaping the economic

[2] For a survey, see Venables (1998).

Table 1
Direction of trade: exports and imports, by destination and origin in Brazilian states, 1997–1999 (in %)

Region/state	Mercosur		NAFTA		Rest of FTAA		EU		Rest of the world	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
North	5	1	17	26	5	5	36	14	36	54
AC	17	4	32	86	32	0	13	9	6	1
AP	4	0	9	18	6	6	34	45	48	31
AM	27	1	18	25	29	4	9	13	18	56
PA	2	10	17	41	1	10	40	24	39	15
RO	20	8	28	23	7	21	25	12	20	36
RR	0	0	0	2	50	74	22	20	29	4
TO	1	28	37	4	0	0	52	26	10	42
Northeast	14	17	29	22	4	14	25	17	29	29
AL	2	24	26	23	1	0	10	12	62	41
BA	18	13	28	23	5	18	25	12	24	34
CE	14	28	52	19	6	13	11	16	17	25
MA	7	4	21	23	0	29	43	29	29	16
PB	16	18	40	14	6	1	20	28	18	39
PE	15	22	22	22	8	11	2	18	54	27
PI	3	9	31	29	3	4	48	17	16	41
RN	10	8	29	27	6	2	36	23	19	40
SE	26	41	15	22	8	1	49	24	2	13

Table 1 (*Continued*)

Region/state	Mercosur		NAFTA		Rest of FTAA		EU		Rest of the world	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Southeast	19	13	24	30	10	4	25	32	22	22
ES	3	29	36	25	3	4	28	17	30	25
MG	10	22	20	19	4	4	38	44	28	12
RJ	18	10	26	32	15	2	17	27	24	28
SP	24	10	25	31	13	4	20	33	19	22
South	15	33	19	18	6	3	31	28	29	19
PR	11	29	8	17	5	3	42	34	34	17
SC	16	28	23	19	8	3	27	32	25	19
RS	18	38	26	18	7	3	24	20	26	21
Midwest	6	15	5	34	3	3	57	24	28	23
DF	1	2	4	46	1	1	1	38	93	13
GO	6	34	14	19	2	6	56	15	22	26
MT	2	11	1	43	4	1	61	14	33	31
MS	22	18	2	24	4	4	51	8	21	46
Brazil	17	15	22	27	8	4	28	29	25	24

Source: Ministry of Development, Industry and Trade (authors' elaboration).

Table 2
State share in total Brazilian exports and imports, by destination and origin, 1997–1999 (in %)

Region/state	Mercosur		NAFTA		Rest of FTAA		EU		Rest of the world		Total	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
North	2	1	4	6	3	7	7	3	8	15	5	7
AC	0	0	0	0	0	0	0	0	0	0	0	0
AP	0	0	0	0	0	0	0	0	0	0	0	0
AM	1	0	0	6	2	6	0	3	0	14	1	6
PA	1	0	4	1	1	1	7	0	7	0	5	0
RO	0	0	0	0	0	0	0	0	0	0	0	0
RR	0	0	0	0	0	0	0	0	0	0	0	0
TO	0	0	0	0	0	0	0	0	0	0	0	0
Northeast	6	8	10	6	4	23	7	4	9	8	8	7
AL	0	0	1	0	0	0	0	0	1	0	1	0
BA	4	2	5	2	2	11	3	1	3	4	4	3
CE	1	2	2	1	1	3	0	1	1	1	1	1
MA	1	0	1	1	0	4	2	1	2	0	1	1
PB	0	0	0	0	0	0	0	0	0	0	0	0
PE	1	2	1	1	1	4	0	1	1	2	1	2
PI	0	0	0	0	0	0	0	0	0	0	0	0
RN	0	0	0	0	0	0	0	0	0	0	0	0
SE	0	1	0	0	0	0	0	0	0	0	0	0

Table 2 (*Continued*)

Region/state	Mercosur		NAFTA		Rest of FTAA		EU		Rest of the world		Total	
	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports	Exports	Imports
Southeast	67	57	62	76	71	57	51	76	50	63	58	69
ES	0	12	3	6	1	5	2	4	2	6	2	6
MG	9	9	13	4	7	5	20	9	16	3	15	6
RJ	4	6	4	10	6	4	2	8	3	10	4	8
SP	54	31	42	56	57	42	27	55	28	44	37	48
South	24	33	23	10	20	12	29	15	30	12	26	16
PR	6	12	3	4	5	5	14	8	12	5	9	7
SC	5	4	6	1	5	1	6	2	6	2	6	2
RS	13	17	14	5	10	5	10	5	12	6	12	7
Midwest	1	2	1	2	1	1	6	1	3	2	3	2
DF	0	0	0	1	0	0	0	1	0	0	0	1
GO	0	1	1	0	0	1	2	0	1	1	1	1
MT	0	0	0	0	1	0	4	0	2	0	2	0
MS	1	0	0	0	0	0	1	0	0	0	1	0
Brazil	100	100	100	100	100	100	100	100	100	100	100	100

Source: Ministry of Development, Industry and Trade (authors' elaboration).

geography of the world and provide an empirical work to quantify these forces (Venables, 1998). In this paper we focus on the regional impacts of one of these driving forces in a national economy.

The effects of trade reforms have been extensively studied in the international trade literature. Trade liberalization processes are said to have long-run economic benefits derived from gains in the production side and the consumption side, as well as non-economic benefits (Devlin & French-Davis, 1997; Whalley, 1997). However, the trade liberalization process also involves two kinds of short-run costs to the economy: distributional costs (protected sectors tend to lose), and balance of payments pressures due to the rapid increase in imports (Bruno, 1987). These costs, which can be considered the “first-round” impacts of a trade liberalization process, can be perceived in a time span long enough for local prices of imports to fully adjust to tariff changes, for major import users to decide whether or not to switch to domestic suppliers, for domestic suppliers to hire labor and to expand output with their existing plant, for new investment plans to be made but not completed, and for price increases to be passed onto wages and wage increases passed back to prices (Dixon, Parmenter, Sutton, & Vincent, 1982).

In the Brazilian case, the impacts of trade liberalization, in general, and regional integration, in particular, have been assessed in different contexts.[3] Partial equilibrium studies have focused on the impacts of regional integration on trade flows related to Brazil’s international trade (Carvalho & Parente, 1999; Maciente, 2000). Although data requirements are relatively low, these studies generate detailed information on product-specific trade flows. However, they fail to recognize that regional integration is a complex general equilibrium phenomenon, producing biased estimates.

Other attempts to assess the impacts of trade liberalization policies in Brazil have considered the general equilibrium approach. Most of them addressed issues related to Mercosur policies with gentle methodological twists (Campos-Filho, 1998; Flores, 1997); others also looked at unilateral liberalization issues and their implications for resource allocation (Haddad, 1999; Haddad & Azzoni, 2001; Campos-Filho, 1998). The common feature of these studies refers to the timing of the analysis: they all consider benchmarks at the early stages of the liberalization process, precluding the further analysis of the process of regional integration. In order to fill this gap, taking as the benchmark a more recent year, a cost-competitiveness approach methodology is developed in this paper in order to evaluate new initiatives of trade arrangements.[4] We examine three alternative strategies of regional integration for Brazil reflecting its basic degree of intensity (Bowen, Hollander, & Viaene, 1998). Potential free trade areas are explored, in which member countries eliminate tariffs among themselves but maintain

[3] For a survey, see Bonelli and Hahn (2000).

[4] Two recent studies have used a global model (GTAP) for comparing new initiatives of regional integration from the Brazilian perspective. However, they have relied on outdated benchmark data, weakening the accuracy of their conclusions.

individual tariff schedules on imports for non-member countries. Moreover, we also consider their spatial implications for the national economy.

The discussion of regional impacts of trade arrangements on the Brazilian economy has often lacked a formal analytical framework. The debate has often focused on sectoral implications considering economy-wide effects (Flores Jr., 1997; Campos-Filho, 1998; Gonzaga, Terra, & Cavalcante, 1999). The few incursions on sub-national issues have not gone further than exercises of well-educated speculation, nor presented an integrated interregional framework, treating the regions as isolated entities in aspatial dimensions. To close this gap, this study also includes a Machlup–Goodwin-type interregional model to analyze the short-run regional effects of specific trade policies. The model produces estimates for the 27 Brazilian states, using a top-down disaggregation of the national results. By using the results to evaluate changes in the economic gravity center, it is shown that the integration strategies examined are likely to generate geographical shifts towards the Center-South, increasing regional inequality in the country.

1.1. Modeling issue

The specification of linkages between the national and regional economy represents an interesting theoretical issue in regional modeling. Two basic approaches are prevalent — top-down and bottom-up — and the choice between them usually reflects a trade-off between theoretical sophistication and data requirements.

The top-down approach consists of the disaggregation of national results to regional levels, on an ad hoc basis. The disaggregation can proceed in different steps (e.g., country–state $\rightarrow$ state–municipality), enhancing a very fine level of regional divisions.[5] The desired adding-up property in a multi-step procedure is that, at each stage, the disaggregated projections have to be consistent with the results at the immediately higher level. The starting point of top-down models is economy-wide projections. The mapping to regional dimensions occurs without feedback from the region; in this sense, effects of policies originating in the regions are precluded. In accordance with the lack of theoretical refinement in terms of modeling the behavior of regional agents, most top-down models are not as data demanding as bottom-up models.

In the bottom-up approach, agents' behavior is explicitly modeled at the regional level. A fully interdependent system is specified in which national–regional feedback may occur in both directions. Thus, analysis of policies originating at the regional level is facilitated. The adding-up property is fully recognized, since national results are obtained from the aggregation of regional results. In order to make such highly sophisticated theoretical models operational, data requirements are very demanding. To start with, an interregional input–output database is usually required, with full specification of interregional flows. Data also include

[5] Adams, Dixon, and Parmenter (1994) report regionally disaggregated projections for 56 statistical divisions in Australia derived from national forecasts of the MONASH Model.

interregional trade elasticities and other regional parameters, for which econometric estimates are rarely available in the literature.

The strategy adopted in this paper utilizes a national computable general equilibrium model integrated to an interstate model to evaluate geographical shifts in the economic structure and regional specialization in the Brazilian economy due to different strategies of economic integration. The remainder of the paper is organized in four sections and one Appendix. First, after this introduction, an overview of the CGE model to be used in the simulations (EFES-IT) is presented, focusing on its general features. Second, a Machlup–Goodwin-type interstate model, which will be integrated to the CGE model to generate the state projections, is introduced. After that, the simulation experiment is designed and implemented, and the main results are discussed. Final remarks follow in an attempt to evaluate our findings and put them into perspective, considering their extension and limitations. Appendix A containing the full specification of the CGE model is also presented.

2. The EFES-IT model

In order to evaluate the short-run ("first-round") effects of alternative trade agreements involving Brazil, a national computable general equilibrium model was developed and implemented (EFES-IT). The structure of the model represents an extension of the EFES model (Haddad & Domingues, 2001), which focuses on the disaggregation of its external sector. EFES is a forward-looking CGE model for the Brazilian economy, specified to run both comparative-static and forecast simulations. Its theoretical structure departs from the prototype CGE model presented in Dixon and Parmenter (1996).

The model identifies 42 sectors and 80 commodities, two margin commodities (trade and transportation services), three types of indirect taxes, and five different groups of users (producers, investors, households, foreigners, and "other demands," which includes government). In its extension, the EFES-IT model, special attention was given to the specification of international flows. The external sector was disaggregated into five different components related to different trade blocs, namely, Mercosur, NAFTA, rest of FTAA, EU, and rest of the world. It enabled the capability of assessing policy effects related to changes in the structure and determinants of bilateral trade flows referring to the Brazilian economy.

The mathematical structure of EFES-IT is based on the MONASH 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 such models is standard in the literature. More details can be found in Dixon, Parmenter, Powell, and Wilcoxen (1992), Harrison and Pearson (1994, 1996), and Dixon and Parmenter (1996).

2.1. Closure

EFES-IT contains 81,048 equations and 87,841 variables. Thus, to close the model, 6,793 variables have to be set exogenously.[6] In order to capture the first-round effects of each integration agreement, the simulations were carried out under a standard short-run closure, which considers, from the supply side, fixed capital stocks and given technology, and, from the demand side, exogenously defined domestic absorption.

3. The model of interstate flows

The development of the Model of Interstate Trade Flows (MIST) follows Haddad (1999). However, while the latter paper deals with countries in a global economy, in the present context, attention is directed to interactions between states within a national economy. Consider the following balance identity, which is applicable for each state i ($i = 1, \ldots, n$) in the national economy:

$$\mathrm{EXP}_i + \mathrm{HHC}_i + \mathrm{INV}_i + \mathrm{GOV}_i \equiv \mathrm{IMP}_i + \mathrm{GRP}_i \tag{1}$$

where

$$\mathrm{EXP}_i + \mathrm{HHC}_i + \mathrm{INV}_i + \mathrm{GOV}_i = \text{total production of state } i \tag{2}$$

$$\mathrm{IMP}_i + \mathrm{GRP}_i = \text{total expenditures of state } i \tag{3}$$

and HHC, INV, GOV, EXP and IMP are private consumption, investment, government expenditures, exports and imports in state i, respectively. EXP and IMP are composed by both domestic and external flows, that is, they incorporate interregional flows and foreign trade.

The trade flows EXP and IMP for each state can be decomposed into two parts, domestic and foreign:

$$\mathrm{EXP}_i = \sum_{j=1}^{n} \mathrm{rexp}_{ij} + \overline{\mathrm{WEXP}_i} \tag{4}$$

$$\mathrm{IMP}_i = \sum_{j=1}^{n} \mathrm{rimp}_{ij} + \overline{\mathrm{WIMP}_i} \tag{5}$$

The rexp_{ij}s are the sales of state i to state j and $\overline{\mathrm{WEXP}_i}$s are the foreign exports of state i. In a similar way, the rimp_{ij}s are purchases (imports) of state i from state j and $\overline{\mathrm{WIMP}_i}$ are foreign imports by state i. The interregional flows matrices $[\mathrm{rexp}_{ij}]$ and $[\mathrm{rimp}_{ij}]$ are the same.

[6] The list of the exogenous variables is presented in Appendix A.

Substituting (4) and (5) into (1):

$$\sum_{j=1}^{n}\text{rexp}_{ij} + \overline{\text{WEXP}_i} + \text{HHC}_i + \text{INV}_i + \text{GOV}_i$$
$$= \sum_{j=1}^{n}\text{rimp}_{ij} + \overline{\text{WIMP}_i} + \text{GRP}_i = E_j, \quad \text{for } i = 1, \ldots, n \tag{6}$$

where E_j is the total expenditure of state i.

Given these definitions, we can propose the design of matrices of interstate trade, that present structural similarities to the closed-economy input–output tables.[7] The result will be an input–output-type table in which the rows describe the distribution of a state's domestic production throughout the national economy plus foreign exports ($\sum_{j=1}^{n}\text{rexp}_{ij} + \overline{\text{WEXP}_i} + \text{HHC}_i + \text{INV}_i + \text{GOV}_i$), while the columns reveal the composition of a state domestic expenditure plus foreign imports ($\sum_{j=1}^{n}\text{rimp}_{ij} + \overline{\text{WIMP}_i} + \text{GRP}$). The mathematical structure of the system consists of a set of n linear equations with n unknowns. In similar fashion to input–output systems, the solutions are straightforward mathematically.

The system of n equations can be written in matrix notation as:

$$\boldsymbol{TZ} + \mathbf{FD} = Z \tag{7}$$

where $\boldsymbol{T}$ is the interstate import coefficients matrix ($n \times n$), $\boldsymbol{Z}$ is the total production vector ($n \times 1$) and **FD** is the final demand vector ($n \times 1$).

Solving (7) yields:

$$\boldsymbol{Z} = (I - \boldsymbol{T})^{-1}\mathbf{FD} \tag{8}$$

which is the relevant equation for the forthcoming analysis.

4. Simulations results[8]

In this section, the main results from the simulations are presented. The basic experiment consisted of the evaluation of three alternative scenarios: (a) implementation of the FTAA; (b) implementation of a free trade area including Mercosur and European Union countries; and (c) generalized bilateral agreements involving Brazil and its trade partners.[9] Only tariff barriers were considered. Calibrated estimates of bloc-product-specific tariff rates for the benchmark year relied on data compiled by the IADB and Castilho (2000). In each simulation, tariffs related to each individual bilateral flow were abolished. As the economies of the Brazilian

[7] The basic data used to construct the matrix include estimates of interstate flows, gross regional product (GRP) and total production, by state.

[8] Simulations results were computed using GEMPACK (Harrison & Pearson, 1994, 1996).

[9] Hereafter, the scenarios will be referred to as FTAA, EU, and All.

Table 3
Impact on selected macro variables (in %)

	FTAA	EU	All
Real GDP	0.14	0.24	0.61
Aggregate employment	0.26	0.47	1.19
GDP deflator	−0.57	−1.64	−3.73
Real wage	−0.10	−0.93	−1.84
Rate of return on capital	0.54	0.88	2.28
Volume of exports	4.13	4.64	13.35
Volume of imports	1.72	0.82	3.47

trade partners are not explicitly modeled in a general equilibrium context,[10] a vector of subsidies to Brazilian exports was estimated so that a zero-tariff-equivalent reduction in their prices could be implemented. In terms of the model variables, listed in Appendix A, shocks were given in both the appropriate $t^{(0)}_{(i(2b))}$'s and $f^{(4b)}_{(i)}$'s.

4.1. The big picture: macro results

Table 3 summarizes the results of the three simulations for some macro variables. Although real GDP effects are rather small (<1%), they do present a well-defined hierarchy: regarding GDP growth, a general trade agreement under WTO negotiations is preferable to a regional agreement involving Mercosur and the European Union, which is preferable to the implementation of a free trade area in the Americas. The same hierarchy is verified when one looks at employment effects. However, a clear trade-off between employment level and national real wage is apparent.

The labor market results, combined with the ones for the rate of return on capital, reflect two characteristics of the experiment. First, as either one of the integration strategies is shown to have a positive impact in the Brazilian economy, under a short-run closure, the capital/labor ratio of the economy decreases making labor (capital) relatively less (more) productive. Second, there appears a Stolper–Samuelson-type effect. A closer look at the benchmark tariff schedule reveals a relative concentration of high-tariff products related to labor-intensive sectors. As tariffs vanish, with fixed capital stocks, capital becomes better off.

4.1.1. Direction of trade

Aggregate effects on import and export volumes point to a favorable movement towards trade surplus, as exports grow at a faster pace. Part of the reduced effects on imports can be explained by trade diversion. From Table 4, it is noticeable the change in the composition of the Brazilian imports in the three scenarios. In the FTAA case, imports from NAFTA and rest of FTAA countries grow at a rate above

[10] There are no feedbacks from the trade partners' economies.

Table 4
Impact on Brazilian imports by origin (in %)

Origin	Scenario		
	FTAA	EU	All
Mercosur	−0.29	−0.21	−1.10
NAFTA	6.21	−1.21	4.05
Rest of FTAA	6.69	−0.44	5.38
EU	−0.68	5.76	4.15
Rest of the world	−0.79	−1.24	4.16

6%. However, imports originated in Mercosur countries, EU, and the rest of the world decrease. The estimated trade diversion is close to US$340 million, from which 45.3% refer to reductions in imports of European products, and 9.5% refer to imports of Mercosur products.

In the European Union scenario, it is apparent trade diversion towards European products, as these products become less expensive than similar goods from outside the free trade area. In this case, the estimated trade diversion is higher, accounting for US$612 million. Noteworthy is the share of NAFTA products in this total, which reaches 49.5%.

These results suggest that European Union and NAFTA countries (read USA) play major roles in the first two strategies examined. If, on one hand, the implementation of a free trade area in the Americas benefits American exports to Brazil against European exports, on the other hand, an agreement with the European Union would revert this situation in favor of European products, causing a reduction in the market share of American products in the Brazilian domestic market. As it is evident, this result carries political implications that might not be neglected. It has been pointed out elsewhere that one of the objectives of trade arrangements is to increase multilateral bargaining power (Whalley, 1997). Thinking prospectively, Mercosur seems to have been serving this purpose.

4.1.2. Exports

Under different trade arrangements, specific changes in the direction of Brazilian exports are likely to emerge. Table 5 reveals some of these changes, showing that, in the FTAA scenario, exports to NAFTA and rest of FTAA countries grow at the expense of exports to other world markets; in the EU scenario, exports to Europe grow faster than those directed to FTAA countries; and, in the All scenario, exports growth tends to be more evenly distributed, with better performances in the rest of FTAA markets, followed by EU and rest of the world.

This brings about important structural changes in the national economy, as different patterns of direction of trade imply different compositions of trade flows. The inspection of more detailed information — not shown here — on the impact on trade flows from Brazil to five different trade blocs, under the three scenarios, suggests the following.

Table 5
Impact on Brazilian exports by destination (in %)

Destination	Scenario		
	FTAA	EU	All
Mercosur	−0.04	1.15	1.92
NAFTA	8.80	0.63	9.83
Rest of FTAA	26.24	1.34	28.57
EU	−0.15	16.68	16.03
Rest of the world	−0.18	−0.56	15.33

(a) In the case of the implementation of the FTAA, two distinct effects appear: first, the positive results for the exports to NAFTA are concentrated in traditional products, such as products in the textile and food sectors; second, the good performance of Brazilian exports to rest of FTAA countries shows a more diversified pattern, presenting significant results not only for traditional products, but also to more elaborated manufacturing products.
(b) The trade arrangement with the European Union would have a positive impact on the Brazilian exports, concentrated in agriculture products and textile and food industry products.
(c) The effects of a generalized bilateral agreement involving Brazil and its trade partners on Brazilian exports would be more balanced in relation to the composition of the export list. The destination of the products with the better performance reveals the existing protection schedule: the European market tends to absorb agriculture and food industry products to a greater extent, while FTAA countries receives more manufactures.

As will be seen, these results heavily influence sectoral activity outcomes. When one looks at results for the main products in the Brazilian export list, concentrated in primary and intermediate goods, the FTAA strategy appears to be more favorable to higher value-added products, directed mostly to the less developed countries of the region. A similar movement is apparent from the general trade arrangement. The positive FTAA effects over Brazilian exports to NAFTA, however, concentrate in lower value-added products. In the case of an arrangement with Europe, there would also be relative gains in the performance of exports of traditional products with localized impulses to products with higher technological content (e.g., auto parts).

4.1.3. Sectoral activity

Finally, one has to put the trade flow results into perspective. Given the closure adopted in our simulations, in which the components of the domestic absorption are set exogenously, the trade balance results will be important to generate the activity level results. The aforementioned results will depend not only on the performance of product-specific exports and imports, but also on each industry's external

Table 6
Impact on sectoral GDP components (in %)

	FTAA	EU	All
Agriculture	0.08	0.47	0.97
Industry	0.34	0.37	1.14
Extractive	0	0.69	1.07
Manufacturing	0.44	0.46	1.44
Nonmetallic minerals	0.32	0.17	0.72
Metallurgy	0.82	0.43	2.04
Machinery	0.16	0.16	0.54
Transportation equipment	1.07	0.59	2.42
Chemicals	0.14	0.28	0.74
Textile, clothing and shoes	1.37	0.70	2.53
Food	0.10	0.56	1.35
Other manufacturing	0.46	0.70	1.79
Services	0.07	0.19	0.44
Construction	0	0.01	0.02
Electric, gas and sanitary services	0.16	0.29	0.73
Trade	0.12	0.22	0.53
Transportation	0.41	1.14	2.59
Communication	0.10	0.24	0.58
Financial institutions	0.05	0.10	0.26
Other services	0.05	0.24	0.52
Real estate	0	0.02	0.04
Public administration	0	0	0

dependency. Table 6 summarizes the impacts on the activity level of different sectoral components of GDP. Noteworthy is the fact that, under the FTAA scenario, the industrial sector would be the main "winner," while, under the EU scenario, agriculture would be the most benefited sector. In the All scenario, however, gains from integration would be more evenly distributed across sectors.

4.2. Kaleidoscope analysis: state-level disaggregation

The Brazilian economy is highly concentrated in geographical terms. The state of São Paulo, with only 2.9% of territory, hosts 35.3% of national GDP and 21.7% of population; the Northeast region, with 28.5% of national population and 18.3% of national territory, produces only 13.5% of national GDP (1996 figures). Starting in 1939, when state GDP statistics started being calculated, there was a clear trend towards regional concentration in the Southeast until the mid-1970s. From then on, some signs of polarization reversal were present, leading some analysts to predict the future deconcentration of the national production (Diniz, 1994; Azzoni, 2001). Since financial problems affecting the data collection agencies precluded the production of updated regional GDP figures, this belief remained in all analysis of regional concentration in Brazil until recently. However, new data released indicate that reconcentration took place after the mid-1980s, relating to production restructuring, the liberalization of the national economy, the weakening of the public sector (downgrading all kinds of regional policies), the creation of a free trade area with Argentina, Uruguay and Paraguay, etc.

Although some sectors presented higher than average growth in the Northeast, mainly non-durable consumption goods, the traditional industrial area was able to keep and even increase its share in national GDP. The expected deconcentration is taking place mainly among the neighboring states of São Paulo, the richest state in the country, despite the development of resource-oriented activities (agriculture, agribusiness, mining) in the Midwest and North regions of the country. The neighboring states of São Paulo, Paraná and Minas Gerais, in the South and Southeast, together sum up to over 50% of total GDP; in manufacturing, their share sums up to over 67%, and it does not seem to be falling (data for 1997).

Although explicit regional policies were almost absent in the last two decades, macroeconomic (five stabilization plans after 1986; undervalued exchange rate between 1994 and 1998) and sectoral policies (a large scale incentive program for the production of alcohol as fuel, for example) were very active, producing regional consequences. It is of interest of this section to focus on the spatial implications of special trade arrangements.

The results described in the previous section are very relevant for the understanding of an integrated economic system. The CGE model produces results only at the national level, fully recognizing the general equilibrium nature of economic interdependence and the fact that the policy impacts in various commodity markets differ. However, in the Brazilian federalism, states play an important role, and, thus, for many policy purposes state disaggregation may be required. In order to meet such needs, under conditions of limited information at the state level, a top-down disaggregation scheme is suggested and implemented. It takes EFES-IT national results as an input and produces results for each of the 27 Brazilian states.

The method proposed here can be summarized in six different steps: (1) use EFES-IT to project economy-wide and sectoral effects of the exogenous shock; (2) decompose $\overline{\mathrm{EXP}}_i$ (foreign exports of state *i*) into 80 products and five destinations; (3) allocate the national results obtained for each commodity-destination export flow without respect to its geographical origin; (4) generate $\Delta\overline{\mathrm{EXP}}_i$, for every state *i*; (5) determine *gross* activity effects for each state; (6) scale gross projections to ensure that the adding-up restrictions hold.

Data requirements for the implementation of this top-down methodology include a minimal amount of data. Estimates of the interstate trade matrix for the benchmark year and the disaggregation of state foreign trade flows by product and origin/destination are the main piece of information needed.

National results are regionalized through the use of the MIST. Given the economic structure in 1997, we should estimate a vector of changes $\Delta\mathbf{FD}$, related to Eq. (8), in percentage change form:

$$\Delta \boldsymbol{Z} = (I - \boldsymbol{T})^{-1} \Delta\mathbf{FD} \tag{9}$$

Table 7
Estimated impact on export volumes — Δ**FD**: Brazilian states (in %)

	FTAA	EU	All
AC	6.07	0.90	10.06
AL	1.99	2.56	12.13
AP	1.86	4.11	11.82
AM	5.91	3.53	12.50
BA	4.75	4.15	12.50
CE	9.93	1.83	12.83
DF	0.63	0.87	12.85
ES	2.51	1.81	6.58
GO	1.58	13.92	17.80
MA	0.37	0.79	7.65
MT	0.40	14.83	18.16
MS	0.31	10.71	13.66
MG	2.48	3.39	8.84
PA	1.17	3.12	8.15
PB	9.08	5.0	19.61
PR	1.93	10.21	17.0
PE	5.55	4.23	15.38
PI	2.87	6.68	11.88
RN	4.22	11.97	18.94
RS	7.42	4.80	18.73
RJ	6.23	2.49	12.59
RO	3.30	3.79	12.07
RR	9.08	1.81	23.28
SC	4.26	7.87	22.22
SP	6.20	4.38	14.51
SE	9.38	9.82	20.75
TO	6.21	12.46	18.06

where Δ**FD** is the vector of changes in the final demand, and in our simulations, it represents the state impacts on exports from the different trade strategies.[11] These impacts are calculated from the prevailing export structure in each state in the benchmark year and the percentage change in the export of each product to each of the five destinations estimated by the national CGE model. Table 7 presents the results for Δ**FD**, used in each of the three simulations. A communication channel between the national model and the interstate model is built through the use of adding-up restrictions of the top-down disaggregation results, requiring consistency of injections and leakages.

Exports of peripheral states, in general, tend to gain relative position in the national export list. Among the states with better results in each of the trade strategies, it is noteworthy the performance of states playing a secondary role in Brazil's international trade: (a) *FTAA* — Ceará, Sergipe, Paraíba and Roraima; (b) *EU* — Mato

[11] Recall that the components of the domestic absorption are set exogenously.

Grosso, Goiás, Tocantins, Rio Grande do Norte and Mato Grosso; (c) *All* — Roraima, Sergipe, Paraíba and Rio Grande do Norte. However, the exports from these states rely heavily on primary products, or manufactures with low technological content. It should also be mentioned that the states located in the more dynamic regions of the Southeast and South, with greater penetration in international markets, present satisfactory performance occupying intermediate positions.

The results in Table 8 show that, from the spatial point of view, the three strategies generate concentration of the economic activity. Although the export effects of the less developed states are relatively higher, three factors contribute to a better overall performance of the economies of the Southeast and South: (a) higher value-added content in the exports by the states in the region; (b) higher degree of trade openness of the state economies of the South and Southeast regions, which gives exports a relatively more prominent role in the growth process; and (c) the pattern of interregional integration at the sub-national level and the operation of feedback effects, as the state interdependence generates leakages from the less developed to the more developed regions.

Table 8
Impact on activity level: Brazilian states (in %)

	FTAA	EU	All
AC	0.04	0.05	0.14
AL	0.09	0.11	0.45
AP	0.06	0.12	0.35
AM	0.20	0.17	0.52
BA	0.19	0.17	0.51
CE	0.17	0.06	0.28
DF	0.01	0.02	0.05
ES	0.19	0.17	0.52
GO	0.07	0.24	0.40
MA	0.04	0.07	0.49
MS	0.09	0.78	1.09
MT	0.07	0.26	0.44
MG	0.20	0.25	0.66
PA	0.14	0.34	0.88
PB	0.08	0.06	0.19
PR	0.18	0.58	1.08
PE	0.07	0.06	0.20
PI	0.04	0.07	0.15
RN	0.07	0.14	0.26
RS	0.45	0.33	1.19
RJ	0.12	0.08	0.30
RO	0.05	0.08	0.19
RR	0.04	0.03	0.12
SC	0.29	0.47	1.31
SP	0.30	0.26	0.78
SE	0.08	0.10	0.24
TO	0.04	0.07	0.14

5. Final remarks: the moving picture

The previous analysis provides important insights into the debate on regional inequality in a developing country. The simulations have supported the argument that the strategies for economic integration pursued by the Brazilian government are very likely to increase regional inequality in the country. Moreover, they call the attention to a phenomenon that permeates this debate: the role of trade as an engine to growth. The relationship between trade and growth has been a familiar topic of discussion in the development literature. More often, the question posed concerns the effects of international trade on economic growth, and thus focuses on trade as an active "agent" of growth. This active role played by international trade can be found in many different models. Todaro (1994) concludes that trade can be an important stimulus to rapid economic growth, although it might not be a desirable strategy for economic and social development. The contribution to development depends on the nature of the export sector, the distribution of its benefits, and the sector's linkages with the rest of the economy. It seems that, to the extent we are only interested in the effects of international trade on pure economic growth, there is a consensus that trade can provide an important stimulus to growth. At the sub-national level, the export base theory provides the foundations to different models of regional development.

Recently, however, given the focus on globalization issues and the implicit assumption that a region's economic future is inextricably tied with its ability to compete in the international export market, international trade has attracted the attention of regional analysts as well. As it has been shown, in the Brazilian case, its relevance is noticeable in only a few states. Would the other states be fated to an archaic structure of trade, based on the export of less elaborated products directed to specific markets? Would the likely regional concentration pattern of international trade flows be irreversible, once liberalization points to the strengthening of this phenomenon?

To our understanding, the answers to both questions are negative. Firstly, one should consider the contemporary trend towards the broadening of trade agreements involving Brazil — in which the gradual reduction in trade restrictions with more extensive geographical areas is seek — as a complex dynamic general equilibrium process, whose effects expand in the long run. The process of regional integration includes issues that relate growth to technology, learning, externalities, political economy and political agreements (Devlin & French-Davis, 1997). In this sense, its repercussion in the sub-national space can be redirected by public policies. At today's stage of development of the Brazilian economy, the interplay of market forces is likely to concentrate economic activity in the Center-South,[12] but there is still room for government intervention in order to attenuate the effects of this market failure. It is necessary, however, that guidelines

[12] See Haddad (1999).

to regional planning be established aiming at the efficient use of the potentiality of the peripheral regions and the creation and consolidation of dynamic comparative advantages in the regions.

Secondly, the role of interregional trade to the state economies should not be relegated to a secondary place. One should consider interstate interactions for a better understanding of how the state economies are affected, both in the international and in the domestic markets, once for the smaller economies, the performance of the more developed regions plays a crucial role. As Anderson and Hewings (1999) observe, the usual region versus the rest of the world characterization of spatial interaction provides a convenient mechanism to generate demand-driven models, but it provides little insights into two properties associated with spatial interaction that have not featured prominently in regional models, namely, feedbacks and hierarchy. On one hand, 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. On the other hand, the impact of feedback effects will be determined, partly, by the hierarchical structure of the interregional system under consideration. Thus, in the Brazilian case, it is expected that the impacts of interstate trade related to the São Paulo economy will differ from those from the other state economies.

Inspection of Table 9 reveals some important characteristics of the Brazilian interregional system. It presents estimates of the interstate and international export coefficients for the 27 Brazilian states. It is noteworthy that, for every state, interstate exports are higher than international exports. In general, interstate flows have higher relative importance to the less developed economies.[13] These estimates reveal, at first, the relevance of interstate trade for the regional economies. A further analysis of the trade among the Brazilian states, including the way of generalizations about the type of trade involved, its changing composition over time as an economy evolves and the implications for these structural differences in the articulation and implementation of development policies, would enhance the understanding of the economic system.

Finally, one could reach the conclusion that, for some of the state economies under consideration, the future is not only tied with its ability to compete in the international export market, but also with its articulation with other domestic markets. Again, more room for public policy might be advocated, through actions towards the modernization of the transportation infrastructure of the country to generate a more efficient integration of producers and consumers, and, thus, maximize the effects of the different strategies of trade policy: not only the mechanisms of propagation of feedback effects would be enhanced, but also the competitiveness of Brazilian products in international markets would increase.

[13] Exceptions include the states of Amapá, Maranhão and Pará, whose transportation and communication infrastructure systems were projected to facilitate exports of mineral products.

Table 9
Interstate and international export coefficients: Brazilian states, 1997 (in %)

	Interstate exports/GRP (A)	International exports/GRP (B)	A/B
AC	25.7	0.1	460.8
AL	30.8	4.6	6.6
AP	5.3	3.4	1.5
AM	87.7	1.9	45.8
BA	30.5	4.4	6.9
CE	28.9	2.1	13.7
DF	10.4	0	301.6
ES	90.2	5.6	16.0
GO	52.6	2.3	22.9
MA	13.1	8.7	1.5
MT	76.5	7.9	9.7
MS	41.6	2.6	16.0
MG	57.5	7.6	7.6
PA	14.5	14.0	1.0
PB	27.5	0.9	30.2
PR	59.1	7.7	7.7
PE	31.2	1.1	27.9
PI	13.5	1.2	10.9
RN	23.8	1.4	16.5
RS	36.1	7.6	4.7
RJ	32.3	1.6	19.7
RO	17.6	1.0	18.0
RR	13.8	0.3	39.7
SC	61.7	7.9	7.8
SP	49.0	5.4	9.0
SE	39.1	0.6	65.9
TO	20.5	0.6	36.7

Source: (A) Confaz and IBGE; (B) MDIC and IBGE (authors' elaboration).

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Appendix A

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

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

A.1. Equations

Substitution between imported products from different sources:

$$x_{(i(2b))}^{(u)} = x_{(i(2\cdot))}^{(u)} - \sigma_{(i)}^{(u)} \left(p_{(i(2b))}^{(u)} - \sum_{l \in S*} \left(\frac{V(i, 2l, (u))}{V(i, 2\cdot, (u))} \right) p_{(i(2l))}^{(u)} \right), \quad i = 1, \ldots, g; \quad b = 1, \ldots, r; \quad (u) = 3 \quad \text{and} \quad (kj), \quad \text{for } k = 1,2; \quad j = 1, \ldots, h \tag{A.1}$$

Substitution between domestic and imported products:

$$x_{(is)}^{(u)} = x_{(i\cdot)}^{(u)} - \sigma_{(i)}^{(u)} \left(p_{(is)}^{(u)} - \sum_{l=1,2\cdot} \left(\frac{V(i, l, (u))}{V(i, \cdot, (u))} \right) p_{(il)}^{(u)} \right), \quad i = 1, \ldots, g; \quad s = 1, 2\cdot; \quad (u) = 3 \quad \text{and} \quad (kj), \quad \text{for } k = 1, 2; \quad j = 1, \ldots, h \tag{A.2}$$

Substitution between labor and capital:

$$x_{(g+1,s)}^{(1j)} - a_{(g+1,s)}^{(1j)} = x_{(g+1\cdot)}^{(1j)} - \sigma_{(g+1)}^{(1j)} \left\{ p_{(g+1,s)}^{(1j)} + a_{(g+1,s)}^{(1j)} - \sum_{l=1,2} \left(\frac{V(g+1, l, (1j))}{V(g+1, \cdot, (1j))} \right) (p_{(g+1,l)}^{(1j)} + a_{(g+1,l)}^{(1j)}) \right\}, \quad j = 1, \ldots, h; \quad s = 1, 2 \tag{A.3}$$

Household demands for composite commodities:

$$V(i, \cdot, (3))(p_{(i\cdot)}^{(3)} + x_{(i\cdot)}^{(3)}) = \gamma_{(i)} P_{(i\cdot)}^{(3)} Q(p_{(i\cdot)}^{(3)} + x_{(i\cdot)}^{(3)}) + \beta_{(i)} \times \left(C - \sum_{j \in G} \gamma_{(j)} P_{(i\cdot)}^{(3)} Q(p_{(i\cdot)}^{(3)} + x_{(i\cdot)}^{(3)}) \right), \quad i = 1, \ldots, g \tag{A.4}$$

Prices of composite commodities to households:

$$p_{(i\cdot)}^{(3)} = \sum_{l=1,2\cdot} \left(\frac{V(i, l, (3))}{V(i, \cdot, (3))} \right) p_{(il)}^{(3)}, \quad i = 1, \ldots, g \tag{A.5}$$

Intermediate and investment demands for composites, commodities and primary factors:

$$x_{(i\cdot)}^{(u)} = z^{(u)} + a_{(i)}^{(u)}, \quad \begin{cases} u = (kj) & \text{for } k = 1, 2; \quad j = 1, \ldots, h \\ \text{if } u = (1j) & \text{then } i = 1, \ldots, g+2 \\ \text{if } u = (2j) & \text{then } i = 1, \ldots, g \end{cases} \tag{A.6}$$

Foreign demands (exports) for domestic goods:

$$(x_{(is)}^{(4b)} - f_{(is)}^{4qb}) = \eta_{(is)}(p_{(is)}^{(4b)} - e - f_{(is)}^{4pb}),$$
$$i = 1, \ldots, g; \quad s = 1, 2b, \quad \text{for } b = 1, \ldots, r \tag{A.7}$$

Other demands:

$$x_{(is)}^{(5)} = f_{(is)}^{(5)} + f^{(5)}, \quad i = 1, \ldots, g; \quad s = 1, 2b, \quad \text{for } b = 1, \ldots, r \tag{A.8}$$

Margins demands for domestic goods:

$$x_{(m1)}^{(is)(u)} = x_{(is)}^{(u)}, \quad \begin{cases} m, \quad i = 1, \ldots, g \\ (u) = (3), (4b), \quad \text{for } b = 1, \ldots, r \\ (u) = (5), (kj), \quad \text{for } k = 1, 2; \\ j = 1, \ldots, h; \quad s = 1, 2b, \quad \text{for } b = 1, \ldots, r \end{cases} \tag{A.9}$$

Composition of output by industries:

$$x_{(i1)}^{(0j)} = z^{(1j)} + \sigma^{(0j)} \left(p_{(i1)}^{(0)} - \sum_{t \in G} \left(\frac{Y(t, j)}{Y(\cdot, j)} \right) p_{(t1)}^{(0)} \right),$$
$$j = 1, \ldots, h; \quad i = 1, \ldots, g \tag{A.10}$$

Demand equals supply for domestic commodities:

$$\sum_{j \in H} Y(l, j) x_{(l1)}^{(0j)} = \sum_{u \in U} B(l, 1, (u)) x_{(l1)}^{(u)} + \sum_{i \in G} \sum_{s \in S} \sum_{u \in U} M(l, i, s, (u)) x_{(l1)}^{(is)(u)},$$
$$l = 1, \ldots, g \tag{A.11}$$

Industry revenue equals industry costs:

$$\sum_{l \in G} Y(l, j)(p_{(l1)}^{(0)} + a_{(l1)}^{(0)}) = \sum_{l \in G^*} \sum_{s \in S} V(l, s, (1j))(p_{(ls)}^{(1j)}), \quad j = 1, \ldots, h \tag{A.12}$$

Basic price of imported commodities:

$$p^{(0)}_{(i(2b))} = p^{(w)}_{(i(2b))} - e + t^{(0)}_{(i(2b))}, \quad i = 1, \ldots, g; \quad b = 1, \ldots, r \tag{A.13}$$

Purchasers' prices related to basic prices, margins and taxes:

$$\begin{aligned} V(i, s, (u))p^{(u)}_{(is)} &= \left(B(i, s, (u) + \sum_{\tau \in T} T(\tau, i, s, (u)) \right) (p^{(0)}_{(is)} + t(\tau, i, s, u)) \\ &\quad + \sum_{m \in G} M(m, i, s, (u)) p^{(0)}_{(m1)}, \\ &\quad \begin{cases} i = 1, \ldots, g \\ (u) = (3), (4b), \quad \text{for } b = 1, \ldots, r \\ (u) = (5), (kj), \quad \text{for } k = 1, 2 \quad \text{and} \\ j = 1, \ldots, h; \quad s = 1, 2b, \quad \text{for } b = 1, \ldots, r \end{cases} \end{aligned} \tag{A.14}$$

Investment behavior:

$$\begin{aligned} & x^{(1j)}_{(g+1,2)}(1) - x^{(1j)}_{(g+1,2)} \\ &\quad = f_{(k)} + f^{(j)}_{(k)} + \alpha_{(j)} \left(\frac{P^{(1j)}_{(g+1,2)}}{P^{(1j)}_{(g+1,2)} + (1 - \delta_{(j)}) P^{(1j)}_{(k)}} \right) (p^{(1j)}_{(g+1,2)} - p^{(1j)}_{(k)}), \\ &\qquad j = 1, \ldots, h \end{aligned} \tag{A.15}$$

Capital accumulation:

$$\begin{aligned} & X^{(1j)}_{(g+1,2)}(1) x^{(1j)}_{(g+1,2)}(1) \\ &\quad = X^{(1j)}_{(g+1,2)}(1 - \delta_j) x^{(1j)}_{(g+1,2)} + Z^{(2j)}_{(k)} z^{(2j)}_{(k)}, \quad j = 1, \ldots, h \end{aligned} \tag{A.16}$$

Cost of constructing units of capital for industries:

$$\begin{aligned} & V(\cdot, \cdot, (2j))(p^{(1j)}_{(k)} - a^{(1j)}_{(k)}) \\ &\quad = \sum_{i \in G} \sum_{s \in S} V(i, s, (2j))(p^{(2j)}_{(is)} + a^{(2j)}_{(is)}), \quad j = 1, \ldots, h \end{aligned} \tag{A.17}$$

Wage determination:

$$p^{(1j)}_{(g+1,1)} = \text{ipc} + f^{(1j)}_{(g+1,1)} + f_{(g+1,1)}, \quad j = 1, \ldots, h \tag{A.18}$$

Consumer price index:

$$\text{ipc} = \sum_{i \in G} \sum_{s = 1,2\cdot} \left(\frac{\bar{V}(i, s, (3))}{\bar{V}(\cdot, \cdot, (3))} \right) p^{(3)}_{(is)} \tag{A.19}$$

Tax rates:

$$t(\tau, i, s, (u)) = f_{(\tau)} + f_{(i\tau)} + f_{(i)}^{(u)},$$

$$\begin{cases} i = 1, \ldots, g; \quad s = 1, 2b, \\ \text{for } b = 1, \ldots, r; \quad \tau = 1, 2, 3 \\ (u) = (3), (4b), \quad \text{for } b = 1, \ldots, r \\ (u) = (5), (kj), \quad \text{for } k = 1, 2; \quad j = 1, \ldots, h \end{cases} \tag{A.20}$$

Ratio of real investment to real consumption:

$$i_R = c_R + \text{fic} \tag{A.21}$$

Relation between capital growth and rates of return in the short-run:

$$-\alpha_{(j)}^{SR}(x_{(g+1,2)}^{(1j)}(1) - x_{(g+1,2)}^{(1j)}) + r_{(j)} = \omega + f_{(2j)}, \quad j = 1, \ldots, h \tag{A.22}$$

A.2. Other definitions

Other definitions include aggregate employment, real and nominal macroeconomic aggregates, price indices, trade balance, other market-clearing conditions, special aggregations.

A.3. Variables

Variable	Index ranges	Description
$x_{(is)}^{(u)}$	$(u) = (3), (4b)$ for $b = 1, \ldots, r$, (5) and (kj) for $k = 1, 2$ and $j = 1, \ldots, h$; $s = 1, 2b$ for $b = 1, \ldots, r$; if $(u) = (1j)$ then $i = 1, \ldots, g + 1$; if $(u) \neq (1j)$ then $i = 1, \ldots, g$	Demand by user (u) for good or primary factor (is)
$p_{(is)}^{(u)}$	$(u) = (3), (4b)$ for $b = 1, \ldots, r$, (5) and (kj) for $k = 1, 2$ and $j = 1, \ldots, h$; $s = 1, 2b$ for $b = 1, \ldots, r$; if $(u) = (1j)$ then $i = 1, \ldots, g + 1$; if $(u) \neq (1j)$ then $i = 1, \ldots, g$	Price paid by user (u) for good or primary factor (is)
$x_{(i(2\cdot))}^{(u)}$	$(u) = (3)$ and (kj) for $k = 1, 2$ and $j = 1, \ldots, h$; if $(u) = (1j)$ then $i = 1, \ldots, g + 1$; if $(u) \neq (1j)$ then $i = 1, \ldots, g$	Demand for composite good or primary factor i by user (u)
$a_{(g+1,s)}^{(1j)}$	$j = 1, \ldots, h$ and $s = 1, 2$	Primary factor saving technological change

Appendix A.3. (*Continued*)

Variable	Index ranges	Description
$a_{(i)}^{(u)}$	$i = 1, \ldots, g$, $(u) = (3)$ and (kj) for $k = 1, 2$ and $j = 1, \ldots, h$	Technical change related to the use of good i by user (u)
c		Total expenditure by household
q		Number of households
$p_{(i\cdot)}^{(3)}$	$i = 1, \ldots, g$	Price to households of composite goods
$z^{(u)}$	$(u) = (kj)$ for $k = 1, 2$ and $j = 1, \ldots, h$	Activity levels: current production and investment by industry
$f_{(is)}^{4qb}$	$i = 1, \ldots, g$; $s = 1, 2b$ for $b = 1, \ldots, r$	Shift (quantity) in foreign demand curves
$f_{(is)}^{4pb}$	$i = 1, \ldots, g$; $s = 1, 2b$ for $b =1, \ldots, r$	Shift (price) in foreign demand curves
e		Exchange rate
$x_{(m1)}^{(is)(u)}$	$m, i = 1, \ldots, g$; $s = 1, 2b$ for $b = 1, \ldots, r$; $(u) = (3)$, $(4b)$ for $b = 1, \ldots, r$, (5) and (kj) for $k = 1, 2$ and $j = 1, \ldots, h$	Demand for commodity $(m1)$ to be used as a margin to facilitate the flow of (is) to (u)
$x_{(i1)}^{(0j)}$	$i = 1, \ldots, g$; $j = 1, \ldots, h$	Output of domestic good i by industry j
$p_{(is)}^{(0)}$	$i = 1, \ldots, g$; $s = 1, 2b$ for $b = 1, \ldots, r$	Basic price of good i from source s
$p_{(i(2b))}^{(w)}$	$I = 1, \ldots, g$, $b = 1, \ldots, r$	US\$ *cif* price of imported commodity i
$t_{(i(2b))}^{(0)}$	$i = 1, \ldots, g$, $b = 1, \ldots, r$	Power of the tariff on imports of i
$t(\tau, i, s, (u))$	$i = 1, \ldots, g$; $\tau = 1, 2, 3$; $s = 1, 2b$ for $b = 1, \ldots, r$, $(u) = (3)$, $(4b)$ for $b = 1, \ldots, r$, (5) and (kj) for $k = 1, 2$ and $j = 1, \ldots, h$	Power of the tax τ on sales of commodity (is) to user (u)
$f_{(k)}^{(j)}$	$j = 1, \ldots, h$	Industry-specific capital shift terms
$f_{(k)}$		Capital shift term
$x_{(g+1,2)}^{(1j)}(1)$	$j = 1, \ldots, h$	Capital stock in industry j at the end of the year, i.e., capital stock available for use in the next year

Appendix A.3. (*Continued*)

Variable	Index ranges	Description
$p_{(k)}^{(1j)}$	$j = 1, \ldots, h$	Cost of constructing a unit of capital for industry j
$f_{(g+1,1)}^{(1j)}$	$j = 1, \ldots, h$	Industry-specific wage shift term
$f_{(g+1,1)}$		Wage shift term
ipc		Consumer price index
$f_{(\tau)}$	$\tau = 1, 2, 3$	Shift term allowing uniform percentage changes in the power of tax τ
$f_{(i\tau)}$	$i = 1, \ldots, g$; $\tau = 1, 2, 3$	Shift term allowing uniform percentage changes in the power of tax τ on commodity I
$f_{(i)}^{(u)}$	$(u) = (3), (4b)$ for $b = 1, \ldots, r$, (5) and (kj) for $k = 1, 2$ and $j = 1, \ldots, h$	Shift term allowing uniform percentage changes in the power of tax of commodity i on user (u)
i_R		Real aggregate investment
c_R		Real aggregate consumption
fic		Ratio of real investment to real consumption
$f_{(is)}^{(5)}$	$i = 1, \ldots, g$; $s = 1, 2b$ for $b = 1, \ldots, r$	Commodity and source-specific shift term for "other demands" expenditures
$f^{(5)}$		Shift term for "other demands" expenditures
ω		Overall rate of return on capital (short-run)
$r_{(j)}$	$j = 1, \ldots, h$	Industry-specific rate of return
$z_{(k)}^{(2j)}$	$j = 1, \ldots, h$	Investment by industry
$f_{(2j)}$	$j = 1, \ldots, h$	Shift term for investment by industry
trend$_{(j)}$	$j = 1, \ldots, h$	Long-run sectoral rate of return on capital
Others		Related to other definitions

Exogenous variables: q, $a_{(i)}^{(u)}$, $f_{(\tau)}$, $f_{(i\tau)}$, $f_{(i)}^{(u)}$, $f_{(is)}^{4pb}$, $f_{(is)}^{(5)}$, $x_{(\cdot,\cdot)}^{(5)}$, $t_{(i(2b))}^{(0)}$, c_R, $a_{(g+1,s)}^{(1j)}$, e, $x_{(g+1,2)}^{(1,j)}$, fic, $f_{(k)}$, $f_{(2j)}$, $f_{(is)}^{(4qb)}$

A.4. Parameters, coefficients and sets

Symbol	Description
$\sigma_{(i)}^{(u)}$	Parameter: elasticity of substitution for user (u) between alternative sources of commodity or factor i
$\sigma^{(0j)}$	Parameter: elasticity of transformation in industry j between outputs of different commodities
$V(i, l, (u))$	Input–output flow: purchasers' value of good or factor i from source l used by user (u)
$V(i, \cdot, (u))$	Input–output flow: $V(i, s, (u))$ summed over s
$V(\cdot, \cdot, (u))$	Input–output flow: $V(i, s, (u))$ summed over s and i
$V(i, 2l, (u))$	Input–output flow: purchasers' value of good or factor i from imported source $2l$ used by user (u)
$V(i, 2\cdot, (u))$	Input–output flow: $V(i, 2l, (u))$ summed over imported sources
$\gamma_{(i)}$	Parameter: subsistence parameter in linear expenditure system
$\beta_{(i)}$	Parameter: marginal budget shares in linear expenditure system
$\eta_{(is)}$	Parameter: foreign elasticity of demand
$Y(l, j)$	Input–output flow: basic value of output of domestic good l by industry j
$Y(\cdot, j)$	Input–output flow: sum of $Y(l, j)$ over l, i.e., basic value of output by industry j
$B(l, s, (u))$	Input–output flow: basic value of (is) used by (u)
$M(l, i, s, (u))$	Input–output flow: basic value of domestic good l used as a margin to facilitate the flow of (is) to (u)
$T(\tau, i, s, (u))$	Input–output flow: collection of tax τ on the sale of (is) to (u)
$\delta_{(j)}$	Parameter: rate of depreciation of industry j's capital
$\alpha_{(j)}$	Parameter: sensitivity of capital growth to rates of return
$\bar{V}(i, s, (3))$	Parameter: initial values of $V(i, s, (3))$
$\bar{V}(\cdot, \cdot, (3))$	Parameter: initial values of $V(\cdot, \cdot, (3))$
G	Set: $\{1, \ldots, g\}$, g is the number of composite goods
G^*	Set: $\{1, \ldots, g + 1\}$, $g + 1$ is the number of composite goods and primary factors
H	Set: $\{1, \ldots, h\}$, h is the number of industries
U	Set: $\{(3), (4), (5), (kj)$ for $k = 1, 2$ and $j = 1, \ldots, h\}$
U^*	Set: $\{(3), (kj)$ for $k = 1, 2$ and $j = 1, \ldots, h\}$
S	Set: $\{1, \ldots, r + 1\}$, $r + 1$ is the number of regions (including domestic)
S^*	Set: $\{1, \ldots, r\}$, r is the number of foreign regions

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