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The World Financial Crisis in Brazil: Industry and Regional Economic Impacts

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1. Introduction

The world experienced in 2008-2009 the most severe recession since 1930, affecting the real economy of most countries. As Stiglitz (2009) points out, the crisis that began in the U.S. in 2007 has affected all countries of the world through some channels. The most direct channel was the financial markets through reverse capital flows and deleveraging of the global banking system, which culminated in sharp devaluation of national currencies, mainly in emerging countries. Another channel was the unprecedented fall in exports. In addition, there are impacts on labor and capital flows. However, each developing region reacted differently to the crisis (International Monetary Fund [IMF], 2010; World Bank, 2011a). In particular, the impact of the crisis in so-called BRIC countries (Brazil, Russia, India and China) was not as intense as compared to other developed countries[6].

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[6] In 2009, China's GDP growth at market prices (2005 US$) was 9.1% and India, 6.8%. Brazil and Russia, however, were more strongly affected, although they recovered in 2010. Russia

The growth in pre-crisis years, the favorable situation in the external accounts coupled with the accumulation of international reserves and adjustment policies adopted in these countries face this crisis avoided the crisis affected them more deeply (Kregel, 2009; Stiglitz, 2009).

In Brazil, the financial crisis implied a downturn in the GDP growth performance, which grew by 5% per year between 2006 and 2008. In 2009, in turn, GDP growth was negative: -0.64%. Full knowledge of the real impacts of the crisis in terms of industrial sectors, for instance, is still not available, due to the delay in the production of some economic indicators. Using foreign trade data, which is promptly available, the impacts of the crisis on certain goods and markets may be inferred. For instance, the most penalized export group in 2009 was Vehicles and Transportation Equipment, with a decline of around -40% of the amount exported (FUNCEX).

The effects of the economic contraction on Brazil's industrial sectors are related not only to the decline in external demand, but also on the deceleration of the domestic market, as suggested by the strong drop in investments in 2009 (-17.51%). Data from Table 1 show that household and government consumption were the least affected by the crisis in 2009, with growth rates of 4.05% and 3.69%, respectively, although the base of comparison for these items is lower, given their low growth rates during the period 2006-2008.

For this reason, such indicators reflect only the aggregate impacts of the crisis, given that information on their sectoral components is unavailable. The study on how these macroeconomic impacts may have affected the industrial sectors is a relevant question for the design of policies aiming to mitigate the effects of the crisis such as, for instance, temporary tax cuts on specific sectors.

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experienced a recession of nearly 8% (7.8%) in 2009, while Brazil had a decline in GDP growth around 0.7% (World Bank, 2011b).

Table 1: Macroeconomic Indicators 2006-2009 (real % change)

Variables	2006	2007	2008	2009
GDP	3.96	6.09	5.16	-0.64
Household Consumption	5.20	6.30	5.38	4.05
Investment	10.41	13.96	16.96	-17.51
Government Consumption	2.58	4.73	5.64	3.69
Exports (quantum)	3.31	5.50	-2.46	-10.79
Imports (price index)	6.87	8.24	22.01	-10.54
Imports (quantum)	16.13	22.01	17.69	-17.38

Source: IBGE, IPEA and FUNCEX.

In addition, structural features of the economy may better explain the impacts of the crisis, especially if we take the industrial sectors. These elements may be divided into four indicators, for any economic sector in the economy:

1. Exports' share of sales;
2. Imports' share of production costs;
3. Imports' share of domestic consumption;
4. Sectoral domestic demand composition: intermediate consumption, household consumption, government consumption or investment.

All these elements are connected by production chains (input-output) which implies that the effect on a sector will spread to the other sectors of the economy, depending on the intensity of the links among them (interdependence of purchases and/or sales of inputs and outputs). Some cases of negative sectoral effects of the crisis may be typified: a) export sector affected by decline in foreign demand; b) important sector in the composition of gross fixed capital formation affected by the decline in investment; and c) sector competing with imports, affected by decline in international prices.On the other hand, some sectors may be less affected by the crisis, such as dependent on imported inputs decline in prices. Dependent sectors of government consumption (such as services), and dependent on household consumption and the availability of credit (such as cars) also be slightly affected.

The way in which these direct sectoral effects combine in the economy, through productive chains and input-output relations, suggest that an isolate sector analysis (partial equilibrium) is not sufficient. The partial equilibriumdoes not capture important causal elements of the economic effects. Thus, a general equilibrium analysis seems more appropriate since it considers the chain effects in the economy and its structural characteristics. Econometric models, in turn, usually in partial equilibrium, failure in predicting the events of impacts, such as the crisis of 2009. This is because the combination of elements of the crisis and structural data on the economy has not been observed in previous situations for Brazilian economy (problem domain of applicability of economic models).

The objective of this paper is to project consistently the impacts of the 2009 crisis, considering the sectoral interrelations (input-output) and the sectoral composition of final demand (exports, household consumption, investment, government consumption, and inventories).One way of consistently treating this information is by using computable general equilibrium models (CGE).In these models the empirical structure of the Brazilian economy is explicitly considered and also the economic principles and accounting identities are met. Simulations with CGE models allow for the projection of results of sectors and regions in 2009 using the macroeconomic components of the crisis and some sectoral indicators.

The simulation exercises comprise the use of a calibrated CGE model with the most recent available data (2005) on national accounts and input-output matrix for Brazil. From this starting point, the model is fed by economic information available on a yearly basis, between 2006 and 2009, forming a sequence of four chained simulations. For this reason, the results of 2009 represent a picture of the Brazilian economy that includes the effects of the economic events observed between 2006 and 2008. The model produces a broad set of results by sectors (55) and by goods (110), which allow for a detailed evaluation of the real impacts of the 2009 crisis. Thus, this paper also intends to contribute to a methodology for aid and inputs for the planning of public policies during periods of theeconomic downturn.

The remainder of this paper is organized in another three sections. Section 2 presents the GCE model, and the simulations performed. Section 3 discusses the results, and section 4 presents some final remarks.

1. Methodology and Simulations

The recent global financial crisis has raised a series of discussions on the neoclassical theory, especially in macroeconomics, trying to understand the process behind the financial collapse. The 2008-2009 recession has not been well-understood within current classes of economic models; including real business cycle models (see Caballero, 2010; Hall, 2010; Ohanian, 2010). In this paper, we use a dynamic general equilibrium model. The model is accurate and meaningful consistent to study the process of economic crisis in a 'real economy', as in the case of a country of great proportions like Brazil. The model is also specified to study the sectoral and regional impacts of the crisis in the country.

Some studies have analyzed the impacts of 2008-2009 recession on the economy using input-output and static CGE models. For China, Yuan, Liu, and Xie (2010) discusses the influence of the global financial crisis on energy consumption and economic growth and the stimulus plan against it by input-output analysis. Arnim (2009) assesses how the current housing and credit crisis will impact U.S. real activity, and how recession interacts with adjustment of global imbalances. Ahmed and O'Donoghue (2010)analyzed the impacts of the crisis on poverty in Pakistan while Meng, Siriwardana, Dollery, and Mounter (2010) examines the effects that began in 2008 on Singapore's tourism and economy[7].

Other three works have analyzed the impacts of the crisis, using dynamic CGE models, although on a global level. Lemelin, Robichaud, and Decaluwé (2010), for example, simulate some implications of the speculative bubble of 2007-2008 and the subsequent economic recovery plans. Strutt and Walmsley (2010) also examined the impacts of global financial crisis and fiscal stimulus packages in the global economy, exploring the sectoral impacts.McKibbin and Stoeckel (2009), in turn, explored implications of increase in fiscal deficits and of a global trade war in response to the financial crisis in 2009.

The computable general equilibrium (CGE) model used in this study is named BRIDGE (*Brazilian Recursive Dynamic General Equilibrium Model*).

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[7] Some other papers have used CGE models to analyze financial crisis over the last decades, as example, Adelman and Yeldan (2000).

It was developed from the theoretical structure of the ORANI (Dixon, Parmenter, Sutton, & Vicent, 1982) and MONASH (Dixon & Rimmer, 2002) models, including elements of recursive dynamics. The latter is important for implementing simulations in which the capital stock grows over time, and in which the labor market presents some sluggishness in the adjustments of wages and employment. Furthermore, the model is calibrated to the most recent data from national accounts and from the input-output matrix, which has not yet been used in the literature on these models for Brazil.

These features in CGE models are relatively new in the Brazilian literature. In general, the CGE models for the Brazilian economy are based on comparative static analysis. Among these models, one could mention: a) the PAPA model (Guilhoto, 1995), which was used for the analysis of agricultural policies; b) the TERM-BR model (Ferreira Filho, 1997), used for the analysis of agriculture development; c) the B-MARIA model (Haddad, 1999), calibrated for three regions of Brazil (North, Northeast, and Center-South), implemented for the discussion of regional inequality and structural change in the Brazilian economy; d) the SPARTA model (Domingues, 2002), applied to the analysis of the regional and sectoral dimensions of Brazilian integration into the American Free Trade Area; e) the MINAS-SPACE model (Almeida, 2003), a spatial CGE model, used for planning and analysis of transportation policies; f) the B-MARIA-IT model (Perobelli, 2004), which analyzes the interaction between Brazilian states and their trade relations with the rest of the world; and g) the IMAGEM-B model (Domingues, Magalhães, & Faria, 2009), a multi-regional model, applied to the evaluation of the effects of investments in infrastructure, transportation and inter-regional trade.

On the other hand, it is worth mentioning some models with recursive features that have been applied to the Brazilian economy. The model by Fochezato and Souza (2000), calibrated for 1994, is one of the few models in Brazil which uses recursive dynamics. Developed to analyze the Brazilian economy, the model projects the impacts of stabilization policies and structural reforms in the economy. The model MIBRA (Hasegawa, 2003), in turn, investigated the effective proposals of the federal government given by a combination of investment increases, public expenditures, and the productivity of production factors, including the investments endogenously in a recursive structure.Moreover, finally, the EFES model (Haddad & Domingues, 2001) projects macroeconomic scenarios through projection analysis.

This model is also an important reference given the projection analysis developed, which deals explicitly with recursive dynamics in capital accumulation.

The Brazilian Recursive Dynamic General Equilibrium (BRIDGE) model, used in this paper, is set up for the year 2005, according to the sectoral and products classification of Brazil's input-output matrix[8]: 55 sectors, 110 products, five final demand components (household consumption, government consumption, investment, exports and inventories), two primary factors elements (capital and labor), two margin sectors (commerce and transportation), imports by product for each of the 55 sectors and five final demand components, one aggregate of indirect taxes and one aggregate of taxes on production.

The model comes from the theoretical structure of the MONASH model (Dixon & Rimmer, 2002) with some of its elements of recursive dynamics. The model's theoretical structure is standard in computable general equilibrium (CGE) models: all markets clear in equilibrium (Walras' Law is satisfied); demand and supply equations for private-sector agents are derived from the solutions to the optimization problems (producers minimize cost and household maximize utility); firm's production function presents a technology with constant returns to scale; producers prevent the earning of pure profits; and all agents are price-takers.

The main difference between BRIDGE and other CGE models is in the dynamic mechanisms. While most CGE models are used in comparative statics simulations, the BRIDGE model has the advantage of including recursive dynamic mechanisms. Recursive dynamic models produce sequences of annual solutions connected by dynamic relationships such as physical capital accumulation and labor market adjustments. Policy analysis involves the comparison of two alternative sequences of solutions, one generated without the policy change, the other with the policy change in place. The first sequence called the baseline projection serves as a control path from which deviations are measured in assessing the effects of the policy shock (Dixon & Rimmer, 2002). BRIDGE is a CGE model of the Johansen type (Johansen, 1960), in which the mathematical structure is represented by a set of linearized equations. Thesolutions of the underlying levels equations are obtained in percentage change form and in deviations from an initial solution. The model is implemented using Gempack and RunDynam softwares.

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8 Developed by the Intituto Brasileiro de Geografia e Estatística (IBGE).

The theoretical specification of the model follows some of the standard specification of CGE models. The productive sectors minimize production costs subject to a constant returns to scale technology, in which the combination of intermediate inputs and (aggregate) primary factor is given by fixed coefficients (Leontief). In the composition of inputs, there is thesubstitution at prices between domestic and imported goods, by means of constant elasticity of substitution (CES) functions. In the composition of the primary factor, there is also asubstitution through prices between capital and labor via CES functions. Even though, all the sectors present the same theoretical specification, the substitution effects through prices differ according to the sectoral composition of domestic/imported inputs (present in the database).

The household demand is specified according to a Stone-Geary non-homothetic utility function (Peter, Horridge, Meguer, Navqui, & Parmenter, 1996). The composition of consumption by product between domestic and imported is controlled by means of a constant elasticity of substitution (CES) function. The sectoral exports respond to demand curves thatare negatively related to domestic production costs and positively affected by the exogenous growth of international income, using a small country hypothesis in international trade. Government consumption is typically endogenous, associated or not with household consumption or tax revenues. Inventories accumulate according to changes in production.

Investment and capital stock follow mechanisms of accumulation and sectoral mobility from predetermined rules, associated with return and depreciation rates. The labor market also presents an intertemporal adjustment feature, involving variables such as the real wage, current employment, and trend employment. Appendix 1 presents in greater detail the mathematical formalization of the model and database.

a) Simulations

The theoretical and empirical specification of the BRIDGE model allows for a consistent projection of the sectoral impacts of the 2009 crisis, using macroeconomic information about the crisis and some available indicators of sectoral exports and imports.

Thus, for the simulations with the CGE model two sets of aggregate shocks have been built, for the period from 2006 to 2008.

The first set includes the percentage changes in household consumption, in government consumption, investment and the Gross Domestic Product (GDP) – measured from the income side. The calculation of these changes was based on data from the National Accounts, by the IBGE (2007) (Table 1). The second set includes the export quantities (*quantum* indexes from FUNCEX) and import prices (FUNCEX)[9]. Since the data is unavailable for all the 110 products of the CGE model, the indicators were associated with groups of similar sectors.. Table 2 presents the percentage variations in export quantities and import prices for each year, by sector. The model closure in presented in Appendix 1.

Table 2 indicates which the sectors with highest decline in exports in 2009 were *Other transportation equipment*, *Automobile vehicles*, *Machinery and equipment*, and *Wood products*: -46.3%, -40.9%, -38.8% e -32.8%, respectively. It may be noted, however, that some of these sectors – such as *Wood products* and *Automobile vehicles* – presented declining exports during the entire period under analysis, which suggest an even stronger deceleration.

For some activities, the 2009 crisis did not mean falling exports. On the contrary, these activities presented some dynamism since in general they had significant export growth in the period prior to the crisis (2006-2008). These sectors are, among others, *Oil extraction* (21.2%), *Pulp and paper* (13.1%), *Agriculture and livestock* (10.5%), and *Chemical products* (4.2%).

9 In a CGE model, there cannot be exogenous prices and quantities at the same time. Thus we opted for export quantities (endogenous prices) and import prices (endogenous quantities). Here we assume the hypothesis of a small country in relation to international trade, so that both export and import quantities do not affect international prices.

Table 2: Percentage Changes in Export Quantities and Import Prices – Simulations Shocks

Sectors	% change in export quantity				% change in import prices			
	2006	2007	2008	2009	2006	2007	2008	2009
Agriculture and Livestock	10.0	10.9	-1.9	10.5	10.5	31.9	40.9	-19.8
Plastic and rubber products	7.7	8.4	-4.0	-17.1	11.7	10.0	12.6	-6.1
Pulp, paper and paper products	6.3	4.3	6.7	13.1	7.2	4.2	10.7	-9.1
Manufacture of wearing apparel	-24.2	-15.3	-27.5	-24.7	10.4	18.5	10.9	1.9
Coke, refined petroleum and fuel	14.2	5.7	-4.9	-13.3	15.4	15.4	44.7	-38.6
Medical and surgical equipment	17.8	8.1	-2.8	-17.3	-14.7	-8.2	7.6	-10.4
Mining of metal ores	3.7	13.4	5.1	-11.7	59.8	17.0	-2.8	-27.3
Mining of non-metal ores	10.6	3.0	-2.3	-16.6	4.0	11.3	52.1	-28.2
Extraction of crude petroleum	34.1	14.5	2.8	21.2	26.6	9.0	49.1	-39.3
Machinery and equipment	-1.2	6.7	-2.1	-38.8	0.7	3.5	9.7	2.5
Office machinery and computers	0.1	-19.5	-13.7	-5.2	-1.3	2.8	3.6	-0.6
Electrical machinery and apparatus	16.9	5.8	-0.2	-24.4	0.3	12.4	9.6	-1.4
Eletronic and communication equipment	5.9	-21.8	-4.2	-29.3	-5.2	-1.5	9.8	0.9
Manufacture of basic metals	5.4	-4.8	-6.2	-11.3	25.7	16.7	10.1	-20.5
Furniture and manufacturing n.e.c	-6.9	7.1	-6.2	-21.2	10.4	16.4	14.1	3.2
Other transportation equipment	-4.3	47.2	12.8	-46.3	-7.0	5.5	9.0	1.0
Other sectors	3.3	5.5	-2.5	-10.8	6.9	8.2	22.0	-10.5
Manufacture of leather and leather products	4.1	-5.9	-16.9	-16.4	12.5	3.6	7.8	6.1
Food products and beverages	-3.1	7.3	-1.6	-1.0	10.6	19.7	26.0	-10.6
Wood Products	-7.1	-2.0	-27.8	-32.8	12.9	13.5	15.6	-11.5
Metal products	-3.9	10.6	6.8	-24.3	4.1	10.1	10.6	0.4
Non-metalic mineral products	8.3	-1.7	-20.2	-24.9	-5.0	5.7	13.3	0.9
Chemical products	5.3	8.4	-7.8	4.2	4.7	13.5	35.0	-8.5
Textile products	-7.8	9.4	-4.8	-19.2	7.6	8.3	8.3	-3.6
Motor vehicles, trailers and semi-trailers	-2.1	-4.3	-4.6	-40.9	4.9	4.3	10.1	1.8

Source: FUNCEX.

Regarding the behavior of imported goods prices, the largest decline occurred in *Coke, refined petroleum and fuel* (-38.6%), *Mining of non-metal ores* (-28.2%) and *Agriculture and livestock* (-19.8%), which may bring about declining production costs in related sectors within the production chain. The few sectors with increasing import prices were *Manufacture of leather and leather products* (6.1%), *Furniture and manufacturing n.e.c.* (3.2%), *Machinery and equipment* (2.5%) and *Motor vehicles* (1.8%).

As mentioned before, some sectoral indicators may help in understanding the direct impacts of the crisis. Tables 3a and 3b present a number of such indicators for 2005 (base year of the model), specified by product or sector. The first column of Table 3a shows the share of imports in the production costs of the respective sectors. The products are easily associated with the sectors in the model.

In general, it is expected that the sectors with a higher share of imports in production costs are going to benefit from the decline in international prices. In this case, the sectors with higher shares are *Office machinery and computers*, *Electronic and communication equipment*, and *Chemical products*.

The second column of 3a, in turn, presents the share of exports in the sales of each product. This component is crucial for the results since sectors with higher export share are expected to be the most affected by the generalized decline in exports caused by the crisis. Then, sectors with a higher share of exports in total sales are the most vulnerable to the decline in the external market. Among the products with a higher share of exports in total sales, we mention *Pulp and paper*, *Manufacture of basic metals*, *Coffee in grain*, and *Iron ore*.

Table 3.a: Structural Indicators of Costs and Sectoral Demand – Brazil 2005

Imports in production costs	%	Exports in sectoral sales	%	Imports in total product supply	%
Office machinery and computers	38.1	Pulp, paper and paper products	71.0	Mineral coal	86.1
Electronic and communications equipment	28.1	Pig iron and ferro-alloys	67.2	Wheat in grain and other cereal	53.0
Chemical products	22.0	Coffee in grain	65.8	Medical and surgical equipment	48.8
Trucks and buses	21.4	Iron ores	63.7	Ellectronic and communication equipment	40.2
Motor vehicles, trailers and semi-trailers	17.8	Soluble coffee	49.2	Non-ferrous metal ores	39.6
Coke and refined petroleum	17.3	Meat of poultry, fresh, chilled or frozen	43.4	Prepared/preserved fish	39.4
Paint, varnish, enamel, and lac	17.1	Fuel oils	42.7	Office machinery and computers	37.4
Miscelaneous chemical products	17.1	Soya beans in grain	40.5	Pulp, paper and paper products	33.2
Manufacture of non-metal ores	16.3	Gross soya oil and soya bran	38.8	Non-ferrous metal products	31.8
Other transportation equipment	16.0	Non-ferrous metal products	36.5	Other transportation equipment	31.2
Agricultural pesticides	15.6	Product of Mills and of refined sugar	33.4	Machinery and equip., repairs and maint	30.5
Medical and surgical equipment	14.8	Other transportation equipment	33.3	Organic chemical products	27.8
Pharmaceutical products	12.4	Preserves of fruits and vegetables	30.7	Non-metal ores	26.5
Manufacture of steel and steel products	11.5	Wood products – except furniture	30.6	Other products from petroleum and coke	26.5
Electrical machinery and apparatus	10.3	Trucks and buses	29.3	Tobacco products	26.2
Rubber and plastic products	9.7	Meat of swine, fresh, chilled or frozen	27.8	Petroleum and natural gas	25.6
Machinery and equip., repairs and maint.	8.9	Leather products – except footwear	27.7	Manufacture of resin and elastomers	24.9
Petroleum and natural gas	7.9	Prepared/preserved fish	26.1	Pharmaceutical products	24.2
Perfumes, cosmetics, toileteries	7.9	Non-ferrous metal ores	24.3	Electrical machinery and apparatus	21.8
Appliances	7.3	Manufacturing of footwear	22.6	Chemical products n.e.s.	21.8
		Semi-finished, flat-rolled and steel tubes	0.21		
		Tobacco products	0.2		

Fonte: IBGE.

The third column of 3.a shows the share of imports in total product supply, reflecting the competition with domestic production. In this case, we may infer that the decline in import prices for products with a high import share tends to increase the participation of the imported component in the domestic market, since imports would become more competitive in comparison with domestic production. Among these products, we have *Mineral coal, Wheat in grain, Medical and surgical equipment,* and *Electronic and communications equipment*.

The first column of Table 3.b shows the share of investment in sales by product. It is expected that products with higher shares of this component would be the most affected by the crisis since investment presented a considerable reduction in 2009, about 17% (see Table 1). Some of the sectors with the highest investment shares in sales are *Construction* (84%), *Office equipment and computers* (73%), *Trucks and buses* (57%), *Machinery and equipment* (51%).

Table 3.b: Sectoral Participation Indicators in the Components of Final Demand – 2005

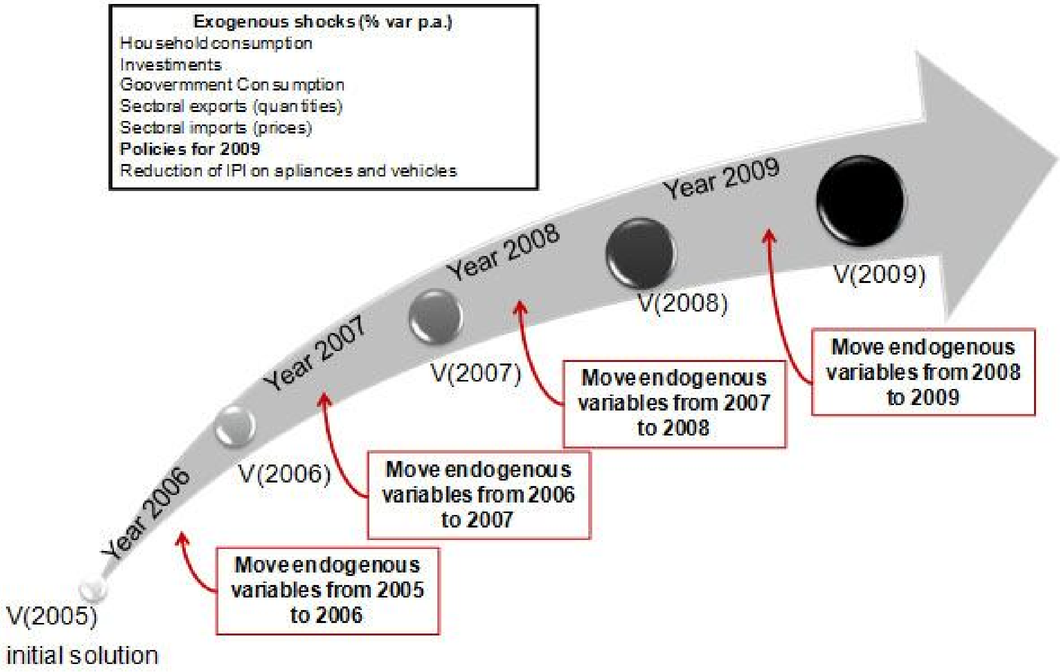
Sectoral sales for Investment	%	Sectoral sales for households	%	Sectoral sales for the government	%
Construction	84.0	Imputed rent	100.0	Public education	100.0
Office machinery and equipment	73.2	Household services	100.0	Public health	100.0
Trucks and buses	56.6	Private education	96.5	Private health	14.9
Machinery and equip., repairs and maint	51.0	Processed rice and related products	95.4	Financial intermediation and insurance	0.7
Electronic and communication equipment	44.2	Associated services	93.7		
Bovines and other live animals	26.5	Liquefied petroleum gas	92.5		
Motor vehicles, traillers and semi-trailers	21.0	Articles of apparel and accessories	89.6		
Metal Products	19.8	Household services	86.9		
Medical and surgical equipment	19.8	Appliances	85.7		
Furniture and parts thereof	19.1	Chilled, sterilized and pasteurized milk	85.1		
Other transportation equipment	11.5	Dairy products and ice cream	81.1		
Live swine	10.9	Perfumes, cosmetics, toileteries	75.2		
Other products and services of agriculture	8.6	Refined soy oil	74.6		
Electrical machinery and apparatus	8.5	Other edible products	74.6		
Renting and real estate services	5.5	Fishing	71.7		
Products from forestry	3.9	Tobacco products	70.6		
Appliances	2.0	Manioc flour and others	70.5		
Wood products – except furniture	0.9	Passengers transportation	70.3		
Services to companies	0.7	Gasoline	69.4		
		Lodging and food services	68.3		
		Footwear	67.4		
		Pharmaceutical products	66.2		

Source: IBGE.

The second column of 3.b indicates that the products with highest participation of household in sales were Imputed rents (100%), Household services (100%), Private education (96.5%), Processed rice and related products (95.4%), Associated services (93.7%). Here, these products are unexpected to be highly affected by the crisis since household and government consumption kept growing in 2009, at rates around 4% and 3.7%, respectively (see Table 1). In the case of government participation in sales by product (third column), the product with highest shares are Public education (100%), public health (100%), and private health (15%).

The simulation methods used in this paper are described below, taking into account the determinants of the direct impacts of the crisis, which explain the main results. Figure 1 illustrates the dynamics of the simulations, and how the model is fed with information since 2006.

Figure 1: Recursive Dynamic Simulations with the CGE model



The first simulation applies the 2006 scenario as a shock and generates sectoral results and a new baseyear of the model. After that, the 2007 scenario is applied, generating a new set of results and a new database. In the end, we have the last simulation of results, for 2009. It is worth noting that in this year there were two additional shocks besides the regular set of shocks of 2009: (i) reduction in the average tax on household appliances – from 10% to 5% for fridges and freezers, and from 20% to 10% for washing machines; and (ii) reduction to zero of the tax on the production of vehicles (known as zero IPI[10]).

2. Results and Discussion

The following sections present the projections of the simulations based on external and domestic demand shocks due to 2009 global crisis on the Brazilian economy. Two general aspects related to the results are worth noting.

[10] N.T. IPI stands for tax on manufatured goods.

First, it can be seen in Table 4 that the projected results suggest a good macroeconomic adjustment of the simulations since the endogenous results for aggregate exports and imports are close the values observed. The difference in the results of imports is due to the definition of aggregation, which follows the share in total imports in monetary terms in the model, whereas it is based on real weights in the Funcex indicator.

Table 4: Simulation´s Results and Observed Figures (Real % Change)

Variables	Source	2006	2007	2008	2009
Exports	Observed	3.31	5.50	-2.46	-10.79
	Simulation results	3.38	5.68	-2.42	-11.14
Imports	Observed	6.87	8.24	22.01	-10.54
	Simulation results	17.23	16.69	18.42	-13.41

Source: FUNCEX and projected results of the CGE model.

Another aspect to be considered in the analysis of the results is that the sectoral impacts reflect the behavior of the sectors given the simulated external shock (export quantities and import prices) as well as the behavior facing changes in domestic demand (household consumption, government and investment) and the dynamics of previous years. The following subsection describes in greater detail the simulation results.

a) Industry Impacts and Causing Factors

This subsection shows the projected sectoral impacts of the crisis, which depend on the external and internal scenarios, and on the effects of previous years. In the simulations, according to data from FUNCEX, not all the sectors faced negative export shocks. On the other hand, in the domestic front, results show that the investment was the most affected component of demand (-17.4%). This implies stronger negative impacts in sectors related to investment such as Construction and its inputs (see Table 3.b). Household and government consumption, in turn, increased in 2009 and some cases were responsible for keeping the strong demand for sectors dependent on these components, such as the majority of sectors related to Services.

Table 5 reports the projections of the impacts on the sectors most affected by the 2009 crisis, according with the results of the model.

The columns show the projected sectoral growth for 2009, given the simulation shocks and the recursive dynamics in the model. The table also showthe average growth of the pre-crisis years (2006-2008) and the difference in growth rates between the periods (2009 and 2006-2008), which reflects the idea of deceleration. The most affected sector was *Other transportation equipment* (-28.9%), which comprises the building of ships, trains, airplanes, motorcycles and bicycles. The sector presented an average projected growth of 13.1% per year (2006-2008) and had a decline of -42% in the year of the crisis. Other sectors related to transportation also had negative impacts in 2009, such as *Trucks and buses* (-14.3%) and *Parts for motor vehicles.* (-7.7%).

The explanation for these results can be evaluated by the analysis of Table 5. Itpresents the decomposition of the impact on the variation of production of goods in three factors: external market, domestic market, and domestic share (composition domestic/imported). The decomposition of the impact by product allows pointing out the most important factor for the sectoral results in the simulations[11].. In addition, the analysis of the results can be associated with the examination of the sectoral indicators presented in Tables 3.a and 3.b. Thus, according to Table 6, the poor performance of the transportation sectors mentioned above (*Other transportation equipment, Trucks and buses, and Parts for motor vehicles*) can be explained mostly by the decline in the exports of products related to these sectors, and by a reduction of domestic demand. These sectors, as shown in Tables 3.a and 3.b, present high shares of exports in sales and significant participation in sales due to investment. Exports and investment, as seen before, are the components that have been most affected by the crisis. Thus, these negative results impacted upon the mentioned sectors.

[11] Appendix 2 shows this decomposition in greater details.

Table 5: Projected Impacts on the 20 Most Affected Sectors (2009 Crisis)

Sectors	Growth 2009 (% var GDP)	Growth 2006-08 (% var GDP p.a.)	Deceleration 2009 (2006/08 - 2009)
Other transportation equipment	-28.9	13.1	-40.6
Trucks and buses	-14.3	0.5	-12.1
Construction	-14.2	12.1	-29.4
Wood products – except furniture	-13.0	-0.5	-8.0
Office machinery and computers	-12.8	10.2	-25.5
Electronic and communication equipment	-11.8	7.1	-21.7
Other non-metallic mineral products	-9.4	5.6	-14.4
Cement	-9.4	9.0	-20.1
Machinery and equip., repairs and maint	-9.3	0.6	-10.0
Parts and accessories for motor vehicles	-7.7	-0.5	-6.2
Manufacture of steel and related products	-7.1	1.2	-7.0
Metallurgy of non-ferrous metals	-6.8	0.7	-5.6
Other products from extractive industries	-6.1	3.6	-8.8
Electrical machinery and apparatus	-5.6	5.1	-10.2
Paint, varnish, enamel, and lac	-3.9	6.3	-11.5
Metal products – except machinery and equipment	-3.3	4.0	-7.6
Medical and surgical equipment	-2.2	6.2	-8.1
Iron ore	-1.5	5.4	-5.4
Furniture and parts thereof	-1.0	5.4	-6.5
Rubber and plastic products	-0.7	2.7	-2.0

Source: Authors' calculation from the model results.

Table 6: Decomposition of the Effect on Production (% change in 2009)

Product	Production (% var.)	Decomposition of effect (% var)		
		Local market	Domestic share	Exports
Other transportation equipment	-29.0	-7.1	1.9	-23.8
Construction	-15.0	-15.1	0.1	0.0
Trucks and buses	-14.6	-12.1	10.2	-12.7
Office machinery and computers	-13.5	-13.3	0.1	-0.3
Wood products – except furniture	-13.5	-6.4	0.2	-7.4
Electronic and communication equipment	-12.4	-9.1	0.6	-3.8
Cement	-10.6	-10.8	0.4	-0.3
Other non-metallic mineral products	-10.1	-8.5	1.3	-2.9
Pig iron and ferro-alloys	-9.9	-2.1	0.3	-8.0
Machinery and equip., repairs and maint	-9.9	-9,2	9.2	-9.9
Parts and accessories for motor vehicles	-8.3	-1.4	0.5	-7.4
Non-ferrous metal products	-8.2	-3.9	0.6	-5.0
Semi finished steel products	-7.8	-5.5	0.2	-2.4
Fuel oil	-7.4	-0.1	0.0	-7.3
Non-ferrous metal ores	-7.4	-3.2	0.7	-4.9
Electrical machinery and apparatus	-7.0	-4.4	1.0	-3.7
Non-metal ores	-5.9	-1.5	-2.2	-2.2
Cast steel	-5.4	-5.3	0.0	-0.1
Paint, varnish, enamel, and lac	-4.6	-5.6	0.9	0.2
Recycled waste	-4.5	-4.8	0.3	0.0

Source: Authors' calculation from the model results.

Still regarding the decomposition of the impact on the variation in production, it should be noted that the sector *Trucks and Buses* presented a significant increase of domestic share in the product, i.e. an increase of domestic participation in the product supply due to a change in relative prices between domestic and imported goods. This gain, however, was not enough to reverse the negative overall result of the sector.

Other sectors show strong projected contractions. Among them, we have the ones related to *Construction* and *Steel and Iron*, directly influenced by the retraction of investment in 2009, and which presented significant growth in previous years, intensifying the deceleration even further. *Construction* (-14.2%), *Cement* (-9.4), *Other non-metallic mineral products* (-9.4%) and *Paint* (-3.9%), for instance, presented significant decline in economic activity in 2009. The high share of sales in the *Construction* sector linked to investment (as shown in Table 3a) corroborate this result, in addition to the fact that the performance of this sector also impacts upon the economic activity of the remainder of its production chain.Thus, we have the negative effects for*Cement*, *Other non-metallic mineral products,* and *Paint.* The decomposition analysis of the impact of changes in the production of related sectors suggests, as expected, that the contraction in such sectors can be explained by the effects in the domestic market, since those sectors are typically non-tradables, and the decline in exports does not affect them directly.

Regarding the sectors related to *Iron and Steel* (*Manufacture of steel*, -7.1%; *Non-ferrous metals*, -6.8%; *Metal products*, -3.3%; and *Iron ores*, -1.5%), the explanation for their performance lays on a combination of two factors, namely: (i) the decline in domestic demand for some products which are inputs for other sectors, such as *Semi-finished products of iron and nonalloy steel*; and (ii) a strong decline in exports, as in the case of *Pig iron* and *Ferro-alloys*, which present high export shares in sales (see Table 3.a).

Machinery, equipment and maintenance, in turn, presented negative variations due to the domestic market (particularly because of the sector's dependence on credit and investments) and to exports, since both components had a significant decline in 2009.

This result occurred despite the positive effect of the change in relative prices between domestic and imported goods (raise in the domestic share due to an increase in the price of imports).

On the other hand, Table 7 presents the projected impacts on the 20 sectors with the potentially smallest effects from the 2009 crisis.

Table 7: Projected Impacts on the 20 Least Affected Sectors (2009 crisis)

Sectors	Growth 2009 (% var GDP)	Growth 2006-08 (% var GDP p.a.)	Acceleration 2009 (2006/08 - 2009)
Appliances	7.6	5.1	2.6
Chemical Products	7.6	0.9	7.6
Agricultural pesticide	7.2	2.0	5.7
Pulp and paper products	6.8	3.8	2.9
Motor vehicles, trailers and semi-trailers	6.6	-1.9	11.0
Agriculture and forestry	5.6	4.1	3.2
Tobacco products	5.4	1.9	5.1
Pharmaceutical products	5.1	4.2	1.1
Articles of apparel and accessories	5.1	4.2	1.2
Private education	4.9	4.7	0.9
Maintenance and repair services	4.8	4.5	0.4
Perfumes, cosmetics, toileteries	4.8	4.5	0.8
Renting and real estate services	4.7	3.4	0.8
Public health	4.6	4.1	-0.9
Public education	4.6	4.1	-0.9
Public administration and social security	4.6	4.1	-0.9
Textiles	4.4	1.2	4.9
Newspapers, magazines, discs	4.4	3.3	1.2
Information services	4.4	2.9	1.6
Manufacture of resin and elastomer	4.3	0.8	4.5

Source: Authors' calculation from the model results.

Table 7 shows that among those sectors are the ones that benefit from tax cuts associated with the temporary reduction of theIPI (tax on manufactured goods). In this case, some of the sectors are *Appliances*, which presented the highest growth rate in 2009 (7.6%) and *Motor Vehicles, trailers and semi-trailers*, with a projected growth rate of 6.6%. If one compares these rates and the average growth rates before the crisis (2006 to 2008), one may conclude that the sectors' activity increased 2.6% and 8.5%, respectively.

The shares shown in Tables 3.a and 3.b, along with the decomposition of the sectoral effect, as presented in Table 8, explain some of the reasons for the projected sectoral behavior.

Appliances, for instance, has a significant share of household consumption in sectoral sales. This helps to explain the positive result of the sector since the component of household consumption presented a positive growth rate in 2009.

Thus, the decomposition analysis shows that the positive effect of the domestic market overcame the negative impact of exports in this sector. In the case of *Motor Vehicles, trailers and semi-trailers*, the positive growth rate derives from the increase in the domestic share in sales given changes in relative prices of domestic and imported goods (the tax cuts change the relative price of the domestic good in comparison with the imported good). Also here, this increase overcame the negative effect of exports in this sector.

Table 8: Decomposition of the Effect on Production (% variation in 2009)

Product	Production (% var)	Decomposition of effect (% var)		
		Local market	Domestic share	Exports
Cellulose and other pulps for paper manuf.	11.9	1.0	0.0	11.0
Coffee in grain	8.3	1.0	0.0	7.3
Soya in grain	7.1	2.4	-0.1	4.8
Organic chemical produts	6.8	2.1	4.0	0.7
Appliances	6.7	10.7	0.3	-4.4
Agricultural pesticide	6.5	4.4	1.8	0.2
Inorganic Chemical	6.2	3.4	2.5	0.2
Tobacco	5.5	5.4	0.0	0.1
Automobiles, trailers and semi-trailers	5.1	-0.5	16.3	-10.7
Processed fish	5.0	1.6	3.8	-0.4
Textiles	4.8	3.8	2.8	-1.8
Liquefied petroleum gas	4.5	4.7	0.1	-0.2
Tobacco products	4.5	1.6	3.3	-0.4
Manioc	4.5	4.5	0.0	0.0
Paper, paperboard, and packing products	4.4	3.0	0.2	1.3
Coated rice	4.4	4.4	0.0	0.0
Herbaceous cotton	4.4	4.4	0.0	0.0
Citrus fruits	4.4	4.1	0.0	0.2
Pharmaceutical products	4.2	3.4	0.7	0.2
Wheat in grain and other cereals	4.2	4.2	-0.3	0.3

Source: Authors' calculation from the model results

Other important results can be seen in *Chemical Products* (7.6%), *Agricultural pesticides* (7.2%), and *Pulp and paper* (6.8%). The latter has an interesting aspect, since in this case exports (11.0%) was the main explanation for the sectoral performance, in contrast to the other sectors impacted by the crisis.

In general, the sectors that are more dependent on household consumption – and to a certain extent on government consumption – show a positive performance during the 2009 crisis. Here, for instance, we could mention *Tobacco products*, *Pharmaceutical products*, and *Articles of apparel and accessories*, and also Services sectors such as *Private education*, *Maintenance and repair services*, and *Renting and real estate services*.

The model also measures the impacts of the crisis on the sectors *Appliances* and *Motor vehicles, trailers and semi-trailers* had the tax cuts on IPI not been put in place. Thus, in a specific scenario simulation, the sectoral impacts can be estimated isolating the effect of the IPI reduction from the other shocks in 2009. Table 9 presents the accumulated variation in sectoral activity considering the policy of IPI reduction. The tax cut was 50% for *Appliances*, whereas, for *Motor Vehicles, trailers and semi-trailers* there was full tax exemption (100%).

Table 9: Projected Impacts of the Crisis and the taxCuts in Brazil (% Variation in 2009)

Sectors	Impact **without** IPI reduction (A)	Impact **with** IPI reduction (B)	IPI effect: (B)/(A)-1
	% Variation in the level of sectoral activity		
Appliances	4.04	6.57	61%
Motor vehicles, trailers and semi-trailers	3.96	7.62	52%

Source: Authors' calculation. IPI: tax on industrialized products.

The results suggest that the sectors *Appliances* and *Motor Vehicles, trailers and semi-trailers* grew between 40% and 50% more in 2009 than they would have grown without the IPI reduction policy. Therefore, the projections indicate that the IPI tax cuts are responsible for 61% of the effect on economic activity in *Motor Vehicles, trailers and semi-trailers*, and 52% of the effect on *Appliances* in the 2009 projections. The remainder of the effects on these sectors is explained by other components of the macroeconomic scenario (mainly household consumption).

An interesting question refers to the comparison of the projected results with sectoral indicators observed in 2009. A useful indicator for this comparison is the change in industrial production, from the Monthly Industrial Survey, by IBGE (Brazilian Institute of Geography and Statistics).

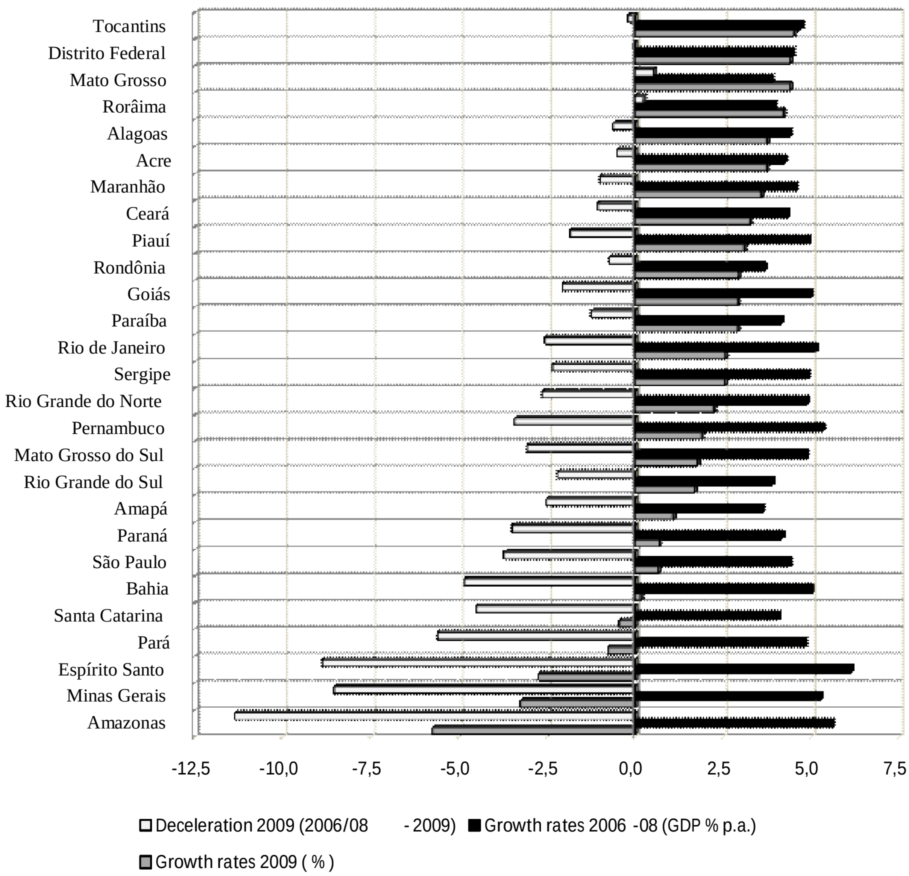
Other transportation equipment, for instance, corroborates the projection results (-28.9% contraction in 2009) since the actual decline in production according to the Monthly Industrial Survey was -25%.

b) Regional impacts at state level

The regional results follow a decomposition procedure (see Annex 1), taking a set of indicators of state's shares on final demand components and production. Based on the projected behavior of the variables in the simulations, the model estimates an average growth of 5% for the Brazilian states between 2006 and 2008, with emphasis on the performance of commodities exporters (Minas Gerais, Espírito Santo) and of exploitation of natural resources such as oil (Rio de Janeiro, Bahia, Pernambuco). The year 2009 implies a reversion of the trends in regional growth for most of the states, despite the increase in government expenses and tax reductions (graph 1).

In comparison with the average growth of previous years, aggregate GDP of Brazilian states declined -0.64%. The projections indicate that the state of Amazonas was the most impacted by the crisis since it grew at an average rate of 5.6% per yearbetween 2006 and 2008 and it declined -5.7% in 2009. This result is explained by the fact that Amazonas has an industrial sector with products highly impacted by the crisis, despite the benefits that part of the state's industrial sector had with the decline of the IPI for *Appliances* (graph 1).

Graph 1: Performance of State GDP in the Projected Scenario (% change)



Source: model simulations.

Table 10 shows the decomposition of state GDP into its sectoral components, in order to unfold the negative and positive effects on the results for 2009. It should be noted that the anti-cyclical policy adopted by the government (increase in government consumption in 2009) had stronger effects on small state economies (in the states of Roraima and Mato Grosso, for instance, economic growth rates in 2009 were actually higher than the average growth of the previous period, 2006-2008). These positive effects are explained by the weight of public administration and services in such states, sectors that could most benefit from public expenses and the small impact of the crisis on service sectors.

The potentially most impacted states would be the ones with economies dependent on sectors most affected by the crisis, and mainly where investment plays a crucial role, related to *Construction* and *Extractive industries*. In turn, states that tended to present positive growth rates in 2009 are the ones focused on *agriculture*, *services* and *public administration*. As mentioned before, such activities benefited from the dynamics of government expenses and household consumption.

Table 10: Sectoral Contribution to State GDP Growth in 2009 (% of State GDP)

	Agriculture	Industry	Construction	Services	Public admin.	Total
Rondônia	0. 4	-0.8	0.0	0.9	2.4	2.9
Acre	0.4	-0.1	-0.1	0.6	2.8	3.7
Amazonas	0.1	-6.2	-0.5	-0.4	1.3	-5.8
Rorâima	0.3	-0.1	0.0	1.0	2.9	4.2
Pará	0.2	-1.8	-0.9	0.1	1.6	-0.7
Amapá	0.1	-2.5	-0.1	0.5	3.2	1.1
Tocantins	0.8	0.0	-0.1	1.4	2.3	4.4
Maranhão	0.6	-0.3	-0.3	1.2	2.3	3.5
Piauí	0.3	-0.1	-0.7	1.4	2.3	3.1
Ceará	0.2	-0.1	-0.5	2.0	1.7	3.2
Rio Grande do Norte	0.2	0.0	-0.9	1.2	1.8	2.2
Paraíba	0.1	-0.7	-0.2	1.2	2.5	2.9
Pernambuco	0.2	-0.1	-1.3	1.6	1.6	1.9
Alagoas	0.1	1.8	-0.3	0.8	1.3	3.7
Sergipe	0.1	0.1	-0.8	1.2	1.9	2.5
Bahia	0.4	-0.4	-1.8	0.8	1.2	0.2
Minas Gerais	0.2	-0.8	-2.9	-0.4	0.7	-3.3
Espírito Santo	0.2	-0.8	-2.5	-0.5	0.8	-2.7
Rio de Janeiro	0.0	0.2	-0.5	2.2	0.6	2.5
São Paulo	0.0	-0.3	-0.8	1.3	0.4	0.7
Paraná	0.4	-0.9	-0.5	1.0	0.7	0.7
Santa Catarina	0.2	-0.9	-0.8	0.6	0.5	-0.4
Rio Grande do Sul	0.2	-0.3	-0.6	1.5	0.8	1.7
Mato Grosso do Sul	-0.1	0.1	-0.3	0.9	1.2	1.8
Mato Grosso	3.2	-0.4	-0.1	1.2	0.5	4.4
Goiás	0.5	0.2	-0.8	1.9	1.1	2.9
Distrito Federal	0.0	0.0	-0.2	1.9	2.6	4.3

Source: Results of model simulations

Maps in Figure 2 illustrate the regional results of simulations. Map 3a shows the dynamics of regional growth between 2006 and 2008. Map 3b represents growth projections in 2009. Map 3c indicates the deceleration effect in 2009 vis-à-vis the projected trend between 2006 and 2008.

The maps show that the most dynamic states during 2006-2008 (Minas Gerais, Espírito Santo, Amazonas and Pernambuco) were also the most impacted by the crisis in 2009, whereas states with lower growth rates before the crisis (Maranhão and Piaui) were not as affected, due to the positive effect of the expansion of government consumption. The negative GDP effects in states such as Espírito Santo, Minas Gerais and Bahia were mostly fueled by the *Construction* sector (intermediate goods and capital goods), which followed the decline in investments during this period.

The sectoral decomposition of GDP growth for the states of Amazonas, Pará and Paraná showed a decline caused mainly by the industrial sector. The contraction in this sector in 2009 was due to the adverse scenario in the foreign and domestic market (investment), which contributed heavily to the negative variation in GDP, despite the adoption of anti-cyclical policies. On the other hand, the decomposition of GDP for Mato Grosso shows that the agricultural sector played a significant role in the positive result, which reflects the smaller contraction observed for this sector, both domestically and internationally (see Table 2).By the way, for most of the states we found the result that an increase in government expenses would generate positive effects in small states, such as Acre, Amapá, Roraima, Tocantins and Distrito Federal. In these states public sector has an important participation in the productive structure, contrarily to the case of exports and investment.Therefore, the increase in government consumption tends to expand economic activity significantly in these states and positively impact their levels of employment and GDP.

Figure 2: Performance of Gross Regional Product (GRP) in Selected Years (% Change)

FIGURE 2a: GRP % var p.a. (2006-2008)

FIGURE 2b: GRP % var p.a. (2009)

Figure 2c: GRP deceleration (growth in 2009 – growth in 2006/08)

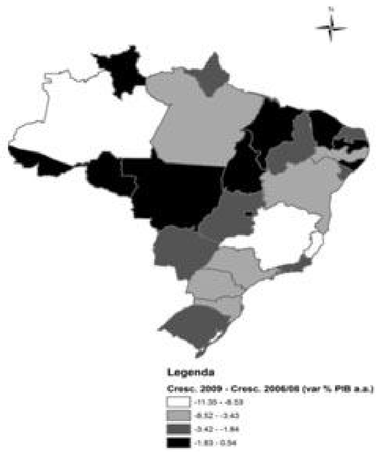
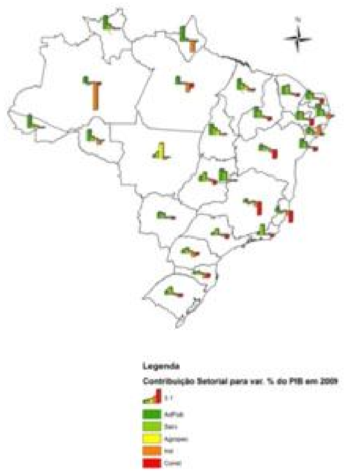


Figure 2d: Sectoral contribution for state GRP (2009)



Source: Results of model simulations

4. Final Remarks

The objective of this paper was to project the likely effects of the economic slowdown of 2008-2009 in the sectors and regions of the Brazilian economy. The financial crisis was reflected in a set of macroeconomic indicators (household consumption, government consumption, investment) and foreign trade indicators (exports and imports). However, regional and industry impacts were not yet observed. This paper aims to estimate those impacts, taking into account the input-output structure of the Brazilian economy.

We used a national computable general equilibrium (CGE) model with recursive dynamic and specific designed simulation exercises to take into account various shocks related to the financial crisis. Simulation exercises for 4 years with the CGE model (2006 to 2009) allowed to build and analyze various industry results (production, consumption, employment, and relative prices) that were consistent with indicators observed during the period. The configuration and implementation of CGE models in this fashion are new in the Brazilian and Latin America literature, and few examples can be found in the international literature.

The results allow identifying the most significant components both in the propagation and in the limitation of the 2009 crisis on the real economy. The results indicated, for instance, the role of government and tax reductions in the mitigation of the financial crisis impacts.

Our results quantified the role of household consumption and government expenses for the mitigation of the impacts of the crisis on particular sectors, such as services, and on some Brazilian states. The projections pointed that anti-cyclical policies may compensate, or minimize, the likely negative effects of the economic crisis on states with low share in national GDP (e.g. Roraima and Mato Grosso). On the other hand, in larger and more diversified state economies (São Paulo, Minas Gerais, and Bahia) such policies did not overcome the negative effects brought about by the adverse external and domestic scenario caused by the crisis in 2009.

This paper also aims to contribute to a methodology for helping the planning of public policies during economic downturns. The method presented here may have future applications.

Among them, the calibration of parameters of CGE models (elasticities of substitution, for instance), in order to find the observed sectoral results in a given period of analysis. This validation exercise will allow higher credibility in its use in future studies of policies and economic events.

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Appendix 1 - Model and Database

The BRIDGE database and equations require the calibration of the parameters and coefficients.The structure of the BRIDGE input-output database was calibrated for Brazilian economy's data from 2005. Figure 3 provides the BRIDGE database in three parts: an absorption matrix, a joint-production matrix, and a vector of import duty. In the first row is the absorption matrix (V1,…,V6) and it presents basic flows in year *t* of commodities to producers, investors, households, exports, government and inventory variation.

Each basic flows matrix contains C x S rows. *C* is number of commodities in the model (i.e. 110 for the year 2005 database) and *S* is absorption's source (domestic and imported). Thus, the basic flows show demand at basic prices[12] (production cost) for goods (c) of domestic or imported origin (s) by firms (i) or final consumers (final demand). The V2BAS coefficient, for example, is the value of (c,s) used to create capital for industry *i*. This coefficient was distributed according to the V1CAP (remuneration of capital), because Brazilian investment data is not disaggregated by firms. V3BAS to V6BAS each, in turn, have one column. Worth mentioning that no imported good is exported directly (V4BAS (c,"imported") is zero).

The margin matrices, V1MAR,…, V6MAR, have CxSxN rows and represent the values of *M* margin commodities used in facilitating the flow of goods between origin and destination. In the model, there are two margin types demanded by sectors and final users: trade and transportation services. Thus, for example, V1MAR and V2MAR are the values of margin commodity *m* required in facilitating the flow of (c,s) to industry *i* for current production and capital creation. The Brazilian margins data are not distributed by users (industries and final users), and the solution was to use a rate (trade and transportation margin / total basic value) weighted V1BAS to V6BAS each. This procedure was not applied for Government and changes in Inventories, since both users are not, in practice, margin demanders.

[12]It should be noted that basic prices plus margins and net taxes correspond to the flows at market prices.

Figure 3: Bridge Model: Core Database Structure

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	**Investors**	**Household**	**Export**	**Government**	**Inventories**
	Size	*I*	*I*	1	1	1	1
Basic Flows	*CxS*	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	CxSxM	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	V6MAR
Taxes	*CxS*	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	V6TAX
Labor	*O*	V1LAB_O					
Capital	1	V1CAP					
Land	1	V1LND					
Production Tax	1	V1PTX					
Other Costs	1	V1OCT					

C = Number of Commodities
I = Number of Industries
S = 2: Domestic,Imported,
O = Number of Occupation Types
M = Number of Commodities used as Margins

	Joint Production Matrix
Size	*I*
c	MAKE

	Import Duty
Size	1
C	V0TAR

The sales taxes matrices, V1TAX, …, V6TAX, in turn, are aggregated values (IPI, ICMS and Other taxes minus subsidies) for all users (except inventories) and have C x S rows. For example, V1TAX is the sales tax on the flow of commodities (c,s) to industry *i*. The Brazilian sales taxes data also are not distributed by users (industries and final users), and we used a same solution of the margins. We also calculated a rate (sales taxes / total basic value) weighted V1BAS to V6BAS. Although the model allows dealing with tax incidence on export flows, these flows are tax exempt by law in the Brazilian case (V4TAX = 0).

The value added matrices show payments by industries for their use of labor, capital and land, as well as their payments of taxes on production and other costs.

V1LAB_O was calibrated with Brazilian wages and payroll taxes. In this model, there is only one labor type. Using the same database, we also calibrated the V1CAP with gross operating surplus information and the V1PTX with "other taxes on production" values. V1OCT denotes other costs, and it was calculated as residuals. It is worth noting that the elements of the coefficient V1LND (land rents) had zero value, due to the absence of information in the tables used.

The other two data sets in Figure 2 are MAKE and V0TAR. V0TAR is a C x 1 vector and it represents tariff revenue by imported goods (import duty). The multiproduction matrix MAKE, in turn, is the output (valued at basic prices) of commodity (c) by industry (i) (joint production matrix). Both coefficients also were calibrated with the Brazilian input-output matrix's data. In the BRIDGE database the absorption and joint-production matrices satisfy the balance conditions, so that the test of homogeneity is verified.

Table 11 provides a stylized version of BRIDGE equations. The first group (1) represents the composition of industry outputs and inputs. Each industry (i) might produce several goods (c), using locally as inputs domestic and imported commodities, as well as primary-factor composite [labor (L) and capital (K)]. In (1), the output of each firm (i) is a function of prices (P_1) of domestic commodities and activity level [X1TOT(i)], The sum over industries of output represents total output (see 2, X0COM(c)). Assuming constant returns to scale in function production, an increase in X1TOT(i) permits industry (i) to produce proportionally more of all commodities. As the level of manufacturing activity rises, primary-factors and intermediate inputs demands in the sector increase too. Consequently, inputs and primary-factors demands depend on X1TOT (i). The demands for inputs [X1(c,s,i)] and primary-factors (L(i) and K(i)) also is function on technology variables (A_{PFi}) on their prices. The industry (i) might demands for two varieties inputs (domestic and imported) which each has a price [P_s(c), s=1,2]. The primary-factors' prices, in turn, is the wage rate (W) and the capital's rental price [Q(i)]]. Changes in the relative prices of theeprimary-factors and inputs induce substitution in favor of relatively cheapening factors (cost-minimizing assumptions).

The second group (2) shows the capital-creation functions. The inputs used (in 8) to capital creation also subject to the investor's cost-minimization problem. Therefore, the demands for inputs of commodity c from source s for capital creation is function on the quantity of capital creation (X2TOT(j)) in industry j, on the prices of domestic and imported input i, and on technology variables (A_{2j}).These last two factors also determine the cost of a unit of capital (PI(j)), whose value is treated as the price that a unit can be sold (the asset price).

The third group (3) describes household demands for commodities that a single representative household maximize a Stone-Geary utility function (Stone, 1954) subject to a budget constraint. The demand equations that arise from this utility function are a linear function of prices (P3) and household budget (C), known as *Linear Expenditure System* (LES). X3SUB are "subsistence" commodities, and they are purchasedregardless at price. The total subsistence demand for each good c is proportional to the number of households, q_H, and to the individual household subsistence demands, $A3_{SUB}(c)$. $X3_{LUX}(c)$, call this "luxury" expenditure, are remnant allocated of the consumer budget. Thus, $X3_{LUX}$ are luxury usages or the difference between the subsistence quantities and total demands (in 12).

The fourth group treats the exports. In the stylized version, the foreign demand for domestic commodity c (X4) depends on the foreign-currency price [PE(c)] to a shift variable (A_4). Usually, the shift variable is exogenous and represents the movements in the foreign demand curve for good c. Thus, as export demand is a decreasing function of the foreign-currency price. Devaluation in the exchange rate causes increases the exports. The fifth group presents the government's demands for commodities. The level and composition of government consumption are exogenously determined by $A_5(c,s)$ and A_{5TOT} variables (shift variables). $A_5(c,s)$ allows changes on thecomposition of government consumption, while A_{5TOT} might adjust government spending subject a budget constraint. In the absence of shocks to the shift variables, the aggregate government consumption (A_{5TOT2}) changes with real household consumption (C) [i.e. we are endogenizing (A_{5TOT}) as afunction to C].

In the six group, the demands for margins are proportional to the commodity flow with which the margins are associated when A3MAR variable is exogenous. A3MAR variables allow for technical change in margins usage (for example, household). The seventh group includes market-clearing equations for locallyconsumed commodities, both domestic and imported. The output (supply) of commodity (c,s) is equal the sum of demands for same commodity (c,s). Imported commodities are not directly exported. As balance conditions, zero-pure-profits conditions for production also are satisfied. Equation 19 shows that the revenue in theindustry*i* is equal to the cost.

The eighth group contains default rules for setting sales-tax for producers, investors, households and government. Sales-tax variables in the linearized model are treated as powers of the taxes. Equation 20 shows the power of indirect taxes as the product of various shift variables. These shift variables allow applying a reduction in the power of tax for a commodity to all users.

In group, 9 are macroeconomic variables. The first equation (21) shows the consumer price index (CPI) being defined by consumer prices for domestic and imported goods ($P3_1$ and $P3_2$). The real wage rate (WR) is determinedby the nominal wage rate (W) deflated by the CPI. There is an overall wage shifter for money wages (A_{WR}). LTOT and KTOT are, respectively, total employment and total capital stock as sums across industries. $GDP_{expenditure}$, in turn, denotes Gross Domestic Product from theexpenditure side in nominal terms (equation 25). As balance condition, this variable is equal to GDP_{income} (equation 27).

The tenth group contains equations about the intertemporal adjustment in the capital stocks[13], investment and rates of return. At end of period *t*, the amount of new capital stock created for each industry *j* [K_t(j)] is function to depreciated capital stock [(1-D)(j)*K(j)] and investment [X2TOT(j)] during the year *t*. Defining the gross rate of investment as the ratio of investment to capital in industry *j* [IKRATIO(j) = X2TOT(j)/K(j)], then, by algebraic manipulation, we might achieve the capital growth [(K_t(j)/ K(j))-1= IKRATIO(j) - D(j)]. If this rate is 3% and IKRATIO(j) is 6.42%, so the calibrated rate of depreciation [D(j)] in the model results to be 3.42%. The BRIDGE model was calibrated with a steady state growth rate of 3%, with a capital depreciation rate of 3.42%. This percentage is very close to the rate of 3.5% used by Oreiro, Lemos, Missio, and Padilha(2005) and Haddad and Domingues (2001). We are assuming that economic growth in the steady state of the Brazilian economy is around 3%.

Changes in the capital growth [(K_t(j)/ K(j))-1] are determined by industry (j) 's expected rate of return [EROR(j)] when shift variable [A_{KG}(j)] is exogenous. The expected rate of return in industry *j* depends on the current rental rate [Q(j)] and asset price [PI(j)] of *j*'s capital, as well as Normal gross rate of return [ROR(j)]. In the case, expectations are static and adaptive. According to Dixon and Rimmer (1998), it is assumed that the capital growth in industry *j* (and therefore the levels of investment) are given by the willingness of investors to supply funds to industry *j* facing limited increases in the expected rate of return in *j*.In short-term, the growth rate of capital in industry *j* in year *t* will only be higher than its normal rate (steady state of capital growth) when the expected rate of return by the investors is greater than the normal rate of return (Dixon & Rimmer, 1998).Similarly to the ORANIG-RD model, we calibrated the normal rate of return [ROR(j)] is based on the relation between capital profitability (V1CAP) and capital stock at current prices [K(j)], whose value was 14.3%.

[13]The Institute for Applied Economic Research (IPEA) supplies the data on net capital stock at 2000 prices, estimated by Moranti and Reis (2004). These values are used to the sectoral capital stock [K(j)] adjusted for 2005 prices with base on the implicit deflator of fixed capital.

The eleventh group provides the intertemporal adjustment in the labor market, considering variables such as real wage (WR), current (LTOT) and trend employment ($LTOT_T$). In its adjustment mechanism, when the level of employment in $t+1$ exceeds $x\%$ in relation to the economy's trend employment, the real wage grows $\gamma x\%$. Since there is a negative relation between employment and real wage in the labor market, the increase in $\gamma x\%$ will adjust the level of employment in future periods until it converges to its trend level. For example, while employment is above its forecast level, the real wage deviation (WR/WR_0) will be increasing.

The final group (12) describes the decomposition on variations in production of a commodity. There are three reasons for these variations. First, the variation might be caused by an effect of the local market; that captures the variations in local use (domestic and imported goods). The equation (33) defines the percentage change in local sales for both origins (domestic and imported) represented by x0loc(c), weighted by the amount of local domestic sales [DOMSALES(c)]. INITSALES(c) corresponds to the initial value of total sales, adjusted for price changes in the model. Second, the variation in production might be explained by an effect of domestic participation, which refers to the change in thecomposition of local demand between domestic and imported commodities. In this effect, the x0loc(c) variable is divided by sdom(c). Finally, the variation in production might be an export effect's result. The exports component [V4BAS(c)] represents the flow of exports weighted by the demand for exports x4(c).

Table 11 - BRIDGE model: Core Equations

Number	Group	Dimension	Identifier
1	**Composition of outputs and inputs**		
	$X0(c,1,i) = X1TOT(i)*\Psi_{0c1i}(P_1)$	N_cN_i	(1)
	$X0COM(c) = \sum_i X0(c,1,i) + A(c)_{PF}$	N_c	(2)
	$X1(c,s,i) = X1TOT(i)*\Psi_{1csi}[P_1(c), P_2(c), A_{1i}, A_{TWIST}]$	$N_cN_SN_i$	(3)
	$L(i)= X1TOT(i)*\Psi_{Li}[W, Q(i),A(i)_{PF}]$	N_i	(4)
	$K(i)= X1TOT(i)*\Psi_{Ki}[W, Q(i),A(i)_{PF}]$	N_i	(5)
	$TOT_{PFc}=\sum_c A(c)_{PF}$	1	(6)
	$TOT_{PFi}=\sum_j A(i)_{PF}$	1	(7)
2	**Inputs to capital creation and asset prices**		
	$X2(c,s,j) = X2TOT(j)*\Psi_{2csj}[P_1(c), P_2(c), A_{2j}, A_{TWIST}]$	$N_cN_SN_i$	(8)
	$PI(j) = \Psi_{PIj}(P_1,P_2,A_{2j})$	N_j	(9)
3	**Household demands for commodities**		
	$X3(c,s)= \Psi_{3cs}[C, P3_1,P3_2, A_3,A_{C/GDP}]$	N_cN_S	(10)
	$X3_{SUB}(c) =q_H*A3_{SUB}(c)$	N_c	(11)

	$X3_{LUX}(c) = X3\_S(c) - X3_{SUB}(c)$	N_c	(12)
4	**Exports**		
	$X4(c) = \Psi_{4i}[PE(c)] + A_4(c)$	N_c	(13)
5	**Government demands**		
	$X5(c,s) = A_5(c,s)*A5_{TOT}$	N_cN_S	(14)
	$A5_{TOT} = C*A5_{TOT2}$	1	(15)
6	**Demands for margin services (example: households)**		
	$X3MAR(c,s,m) = A3MAR(c,s,m)*X3(c,s)$	$N_cN_SN_m$	(16)
7	**Imports and zero-pure-profits conditions**		
	$X0COM(c) = \sum_i X1(c,1,i) + \sum_i X2(c,1,i) + X3(c,1) + X4(c) + X5(c,1) + \sum_c \sum_s \sum_m X3MAR(c,s,m)$	N_c	(17)
	$X0IMP(c) = \sum_i X1(c,2,i) + \sum_i X2(c,2,i) + {}_iX3(c,2) + X5(c,2)$	N_c	(18)
	$\sum_c P_1(c)X0(c,1,j) = \sum_c \sum_S P_S(i)X1(c,s,j) + W*L(j) + Q(j)*K(j)$	N_i	(19)
8	**Indirect taxes (for example: exports)**		
	$T4(c) = A_{OT}(c)*A_{4T}(c)$	N_c	(20)
9	**Macroeconomic variables**		
	$CPI = \Psi_{CPI}(P3_1,P3_2)$	1	(21)
	$WR = (W / CPI)*A_{WR}$	1	(22)
	$LTOT = \sum_j L(j)$	1	(23)
	$KTOT = \sum_j K(j)$	1	(24)
	$GDP_{expenditure} = C + X2TOT\_i *\sum_j PI(j) + X5TOT*\sum_i P_S(i) + \sum_i [PE/\Phi]*X4(i) - \sum_i [PM/\Phi]*X0IMP(i)$	1	(25)
	$GDP_{income} = W*L(j) + Q(j)*K(j) + A(i)_{PF}$	1	(26)
	$GDP_{income} = GDP_{expenditure}$	1	(27)
10	**Capital stocks, investment and rates of return**		
	$K_t(j) = [(1-D)(j)*K(j)] + X2TOT(j)$	N_i	(28)
	$IKRATIO(j) = X2TOT(j)/K(j)$	N_i	(29)
	$[K_t(j)/ K(j)] - 1 = \Psi_{KG}[EROR(j)] + A_{KG}(j) + A_{KGT}$	N_i	(30)
	$EROR(j) = \Psi_{EROR}[Q(j), PI(j), ROR(j)] + A_{EROR}(j)$	N_i	(31)
11	**Adjustment in the labor market**		
	$\Delta WR/WR_0 = \Psi_{WR} [(LTOT_0/LTOT_{T0})-1] + \Psi_{WR} \Delta(LTOT/LTOT_T) + A_{WRT}$	1	(32)
12	**Decomposition on variations in production**		
	INITSALES(c)*DECOMP(c,"*localMarket*") = DOMSALES(c)*x0loc(c)	N_c	(33)
	INITSALES(c)*DECOMP(c,"*DomShare*") = DOMSALES(c)*x0loc(c) / sdom(c)	N_c	(34)
	INITSALES(c)*DECOMP(c,"*Export*") = V4BAS(c)*X4(c)	N_c	(35)

Table 12 depicts the closure used in the simulations. The first part are the usually endogenous variables in a CGE simulation. The second part we show the variables chosen to simulate the macroeconomic scenario and its endogenous counterpart. The third part are the usual exogenous variables, including the numerary.

Table 12 - Model Closure and Variables

i. Endogenous variables			
X0(c,1,i)	Output of domestic commodity by industry	A3SUB	Taste change, subsistence demands
X0COM(c)	Output of commodities	PE(c)	Basic price of exportables
X1(c,s,i)	Intermediate basic demands	X3MAR(c,s,m)	Household margin demands
X1TOT (i)	Activity level or value-added in industry	X5(c,s)	Government basic demands
L(i)	Employment by industry	X0IMP(c)	Total supplies of imported goods
K(j)	Start-of-year capital stock for each industry j	T4(c)	Power of tax on export
P1(c)	Basic prices for domestic commodity	CPI	Consumer price index
P2(c)	Basic prices for imported commodity	LTOT	Total employment
W	Average wage rate	KTOT	Total start-of-year capital stock
Q(j)	Rental price of capital	IKRATIO(j)	End-of-year ratio of investment to capital in industry j
X2(c,s,j)	Investment basic demands	EROR(j)	Expected rate of return in industry j
X2TOT(j)	Investment by using industry	INITSALES(c)	Initial volume of SALES at current prices
PI(j)	Cost of unit of capital	DECOMP(c,"localMarket")	Fan decomposition of the local market
X3(c,s)	Household basic demands	DECOMP(c,"DomShare")	Fan decomposition of the domestic good market' share
X3SUB(c)	Household - subsistence demands	DECOMP(c,"Export")	Fan decomposition of the exports
X3LUX(c)	Household - luxury	DOMSALES(c)	Total sales to local market

	demands		for commodities
$P3_1$	Household purchases price for domestic commodity	x0loc(c)	Real percent change in total local sales
P32	Household purchases price for imported	A_{WR}	Overall wage shifter
Sdom(c)	Sales' share for domestic commodities	A_{KG}(j)	Switch on capital accumulation
WR_0	Real wage rate in theprevious year	K_t(j)	End-of-year capital stock for each industry j
$LTOT_0$ / $LTOT_{T0}$	(Actual / Trend) employment in theprevious year		
ii. Variables to accommodate scenario simulations			
Exogenous		**Endogenous counterpart**	
GDP_{income}	Real GDP (income side)	$A(i)_{PF}$	All Sectors technical change
C	Real household consumption	$A_{C/GDP}$	Ratio, consumption / GDP
X2TOT_i	Aggregate real investment expenditure	A_{2j}	Investment slack variable for exogenizing aggregate investment
X5TOT	Aggregate real government demands	A_{5TOT2}	Overall government demands shift
X4(c)	Export basic demands	A4(c)	Quantity (right) shift in export demands
PM (c)	C.I.F. foreign currency import prices	X0IMP(c)	Imported goods
iii. Exogenous variables			
Φ	Exchange rate		
q_H	Number of households		
$LTOT_T$	Trend employment		
ROR(j)	Normal gross rate of return		
All other A's	Potential slack variables and variables used to represent shifts in technology and preferences		