The Impact of Crisis-related Changes in Trade Flows on Employment, Incomes, Regional and Sectoral Development in Brazil

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Scott McDonald[1]
Marion Jansen[2]
Erik von Uexkull[3]

DRAFT[4]

[1] Oxford Brookes University
[2] ILO
[3] ILO
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Abstract

The global financial crisis and the resulting drop in demand have caused unprecedented declines in world trade. This study uses the STAGE-LAB Computable General Equilibrium Model to analyse the potential impact of the trade shock associated with the global economic crisis on labour and household income in Brazil. To measure the trade shock, we use mirror data on trade with Brazil reported by the US and the European Union and define the shock as the percentage change in trade between January-April 2009 and the same period in the previous year. We consider this shock to be temporary and therefore assume that capital and land are fixed by activity.

Our model assumes that high skilled labour is fully employed, while there is oversupply of labour in the market for medium skill and low skilled labour. Labour market adjustment for high skilled labour thus takes the form of wage adjustments. For low and medium skilled workers, instead, labour market adjustments lead to changes in employment levels. The Social Accounting Matrix used in our study allows us to distinguish seven regions within Brazil and we allow for the possibility that high skilled labour migrates across regions in response to wage changes.

For our base case scenario we find a modest but appreciable GDP reduction of 2.1 per cent caused by reductions in trade flows during the crisis. Average returns to land and to capital increase during the period in some regions. All types of labour lose out in the crisis, with low and medium skilled labour losing more than high skilled labour.

1. Introduction

The global financial crisis and the resulting drop in demand have caused unprecedented declines in world trade. According to (Freund, 2009), world trade fell by 30% in value terms and 15% in volume terms in the first quarter of 2009 compared to the same quarter of the previous year. Trade has been one of the channels through which what began as a financial crisis in the developed world has quickly spread to developing countries, turning it into a global economic crisis that severely threatens progress in poverty reduction and employment creation around the world.

Brazil is often referred to as a country that has weathered the crisis fairly well. On a quarter-to-quarter basis, growth turned positive again in the second quarter of 2009 after two quarters of contraction. The IMF now predicts real GDP growth at -0.7% for 2009 and +3.5% for 2010.[5] The relative resilience of growth is often attributed to Brazil's large domestic market and strong macroeconomic fundamentals. While all this is good news, experience from past crisis shows that employment effects often materialize with a time-lag and recovery is much slower than for GDP growth. Furthermore, despite the moderate aggregate effect on growth, the trade shock is likely to lead to a re-allocation of resources both between sectors and within sectors with potentially substantial consequences for individual workers and households.

This study uses the STAGE_LAB Computable General Equilibrium Model (CGE) to examine the potential impact of the trade shock associated with the global economic crisis on labour and household incomes in Brazil. The purpose is to improve the understanding of the mechanisms through which the crisis was transmitted through international trade to the level of workers and their families in Brazil and to give some indicative figures of the magnitude this impact might take.

The model and its specifications are similar to those used in a previous study that analysed the gains from trade in Brazil and the potential impact of a number of future scenarios for trade policy (Polaski, et al., 2009). This study found relative small overall gains from trade, but significant re-allocation of resources as a result of trade liberalization. The model allows for

[5] IMF World Economic Outlook Database

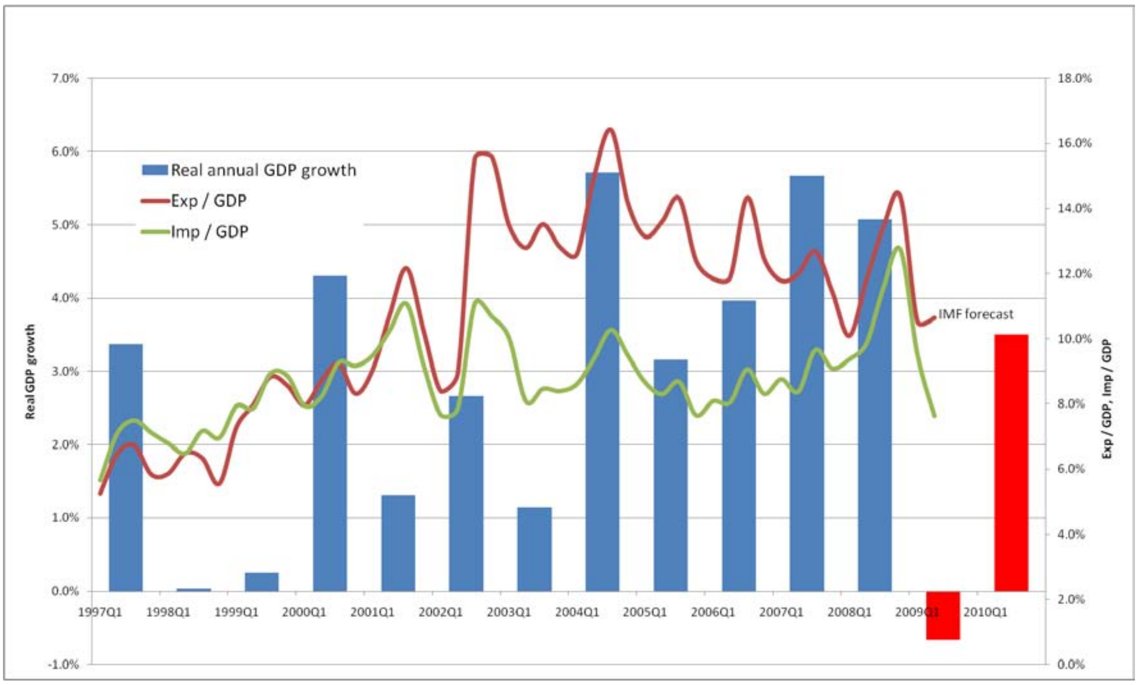
the analysis of labour market and income effects at great detail, including a breakdown of results by income level and region. The latter is particularly important given the large difference in income between the regions in Brazil. The model also prompts a number of methodological innovations, including labour migrations between regions and the ability to take into account unemployment in the unskilled segments of the labour market, which are explained in more detail in section 3.

The remainder of the report is organised as follows: Section 2 gives some background by discussing the structure of the Brazilian economy with a focus on the role of trade. It also presents the available information on the impact of the crisis on Brazil and the policy responses adopted by the government. Section 3 presents the model and its specifications as well as the trade data used to define the shock of the economic crisis. Section 4 discusses the specifications for the policy shocks and the model closure. Section 5 presents the results and analyses their implications for employment and income distribution in Brazil, and section 6 concludes.

2. Background

Structure and dynamics of the Brazilian Economy

Figure 1: GDP growth and trade openness

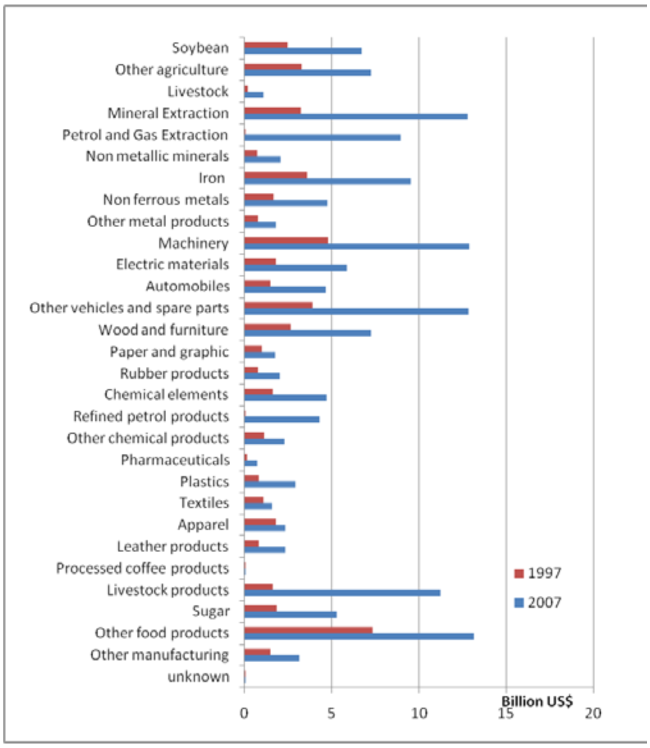


Source: Data from IMF

Since 2004, Brazil has shown solid annual real growth rates of GDP between 3% and 6%. Figure 1 also shows that exports have only played a rather limited role in GDP growth and in the overall structure of the economy. Since 2002, the exports to GDP ratio has been between 10% and 16% with a slight downward tendency. At the same time, imports / GDP have increased slightly, but remain below exports.[6] With the onset of the crisis, both imports and exports fell disproportionately and thus declined relative to GDP.

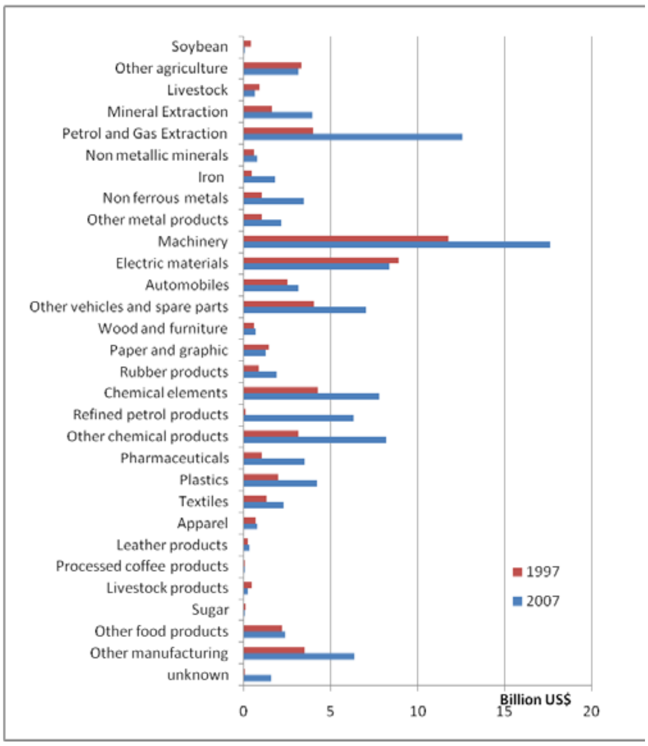
[6] Both imports and exports are reported excluding cost, freight and insurance cost.

Figure 2: Value of Merchandise Exports 1997 vs. 2007 by Sector



Source: Authors' calculation based on data from COMTRADE

Figure 3: Value of Merchandise Imports 1997 vs. 2007 by Sector

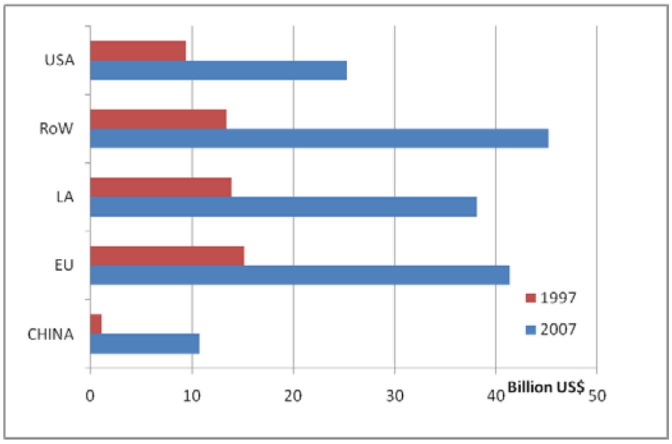


Source: Authors' calculation based on data from COMTRADE

According to the COMTRADE database, the value of exports has grown from $53 bln. to $160 bln. between 1997 and 2007 and imports increased from $65 to $120 bln.[7] Figure 2 and Figure 3 show a detailed breakdown by sector. The most important export sectors in 2007 were mineral extraction, machinery, vehicles other than automobiles and spare parts, and other food products. However, the export structure is rather diversified and a number of other sectors, both primary and higher value added products, play an important role in the export portfolio. The strongest growth was in petrol extraction and petrol products that were virtually nonexistent in 1997 while by 2007 they accounted for around $13 bln.– nearly 10% of exports. Imports of livestock products also increased very strongly. Export values in all categories increased between 1997 and 2007.

Machinery and petrol and gas extraction accounted for the largest import values in 2007. It can be noted that most imports are in investment goods or industrial inputs, while typical consumer goods such as food products or apparel only account for a very small share of the import bill. The strongest import growth was in refined petrol products that went from close to zero in 1997 to around $7 bln. in 2007.

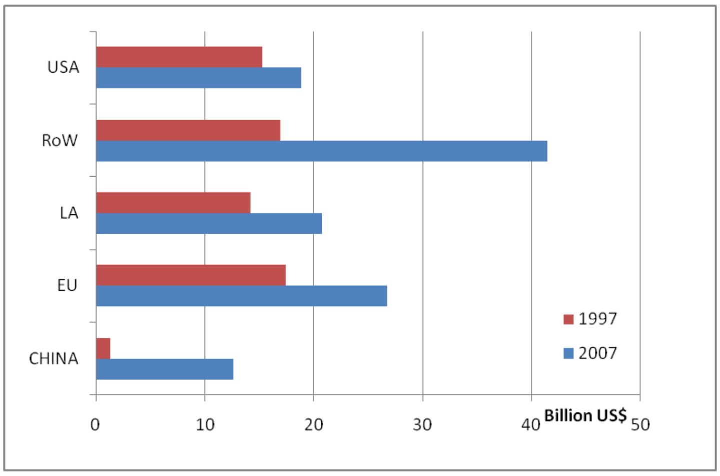
Figure 4: Exports by Destination, 1997 vs. 2007



Source: COMTRADE

[7] We use 2007 rather than 2008 as the last year for the discussion of long term growth trends in order to avoid the strong value changes associated with the commodity price hike in 2008.

Figure 5: Imports by Origin, 1997 vs. 2007



Source: COMTRADE

Brazil's export destinations are also rather diversified, with the EU and Latin America accounting for large shares (Figure 4). The US also remains an important export destination. Exports to China have grown very substantially from less than $1bln. in 1997 to over $10 bln. in 2007. For space reasons, a number of countries had to be aggregated into the group Rest of the World - the largest individual export destination within this group are Japan, Russia and Canada. As a source of imports, the group Rest of the World is largest, with the biggest imports in 2007 coming from Nigeria, Japan and Korea. The EU, Latin America, and the US are traditionally the largest individual sources of imports, and as with exports, imports from China have been the most dynamic (Figure 5).

Table 1 gives an overview of that share of output exported and the labour intensity measured as the wage share in total output by sector. These data are derived from the Social Accounting Matrix used to calibrate the CGE model (Polaski et at. 2009). The share of output exported should give a rough indication of the exposure of a sector to shocks in global demand. The wage share in a sector's output gives an indication of the extent to which workers are affected by any given shock to the sector. Mineral extraction (40%) and non-ferrous metals (40%) have the highest export share, followed by soybean (35%), leather products (29%), sugar (28%), vehicles other than automobiles and spare parts (26%). Iron (25%), wood and furniture (22%) and automobiles (20%) also have relatively high export exposure. In agriculture, soybeans (34.5%) have a high proportion of exports, but information on the wage bill is not available for agricultural sectors in the SAM. Even in sectors with high numbers of low-wage workers, the wage bill for low and very low wage labour typically only accounts for a very small fraction of output. The highest low wage labour bills are in the within the services sector and mainly in non-tradable services. In the merchandise sector, textile and apparel have the largest share of very low and low wage employment. In Brazil, these sectors are oriented mainly towards the domestic market. High and very high wage labour bills are also the highest in the services sector. The wood and furniture and leather industries have both high exposure to exports and a high share of labour in all but the very low wage segment.

Table 1: Export Orientation and Labour Intensity by Sector

		Output	of which exported	of which wage bill v low	of which wage bill low	of which wage bill medium	of which wage bill high	of which wage bill v high	of which total wage bill
cCana	Sugar Cane	12,586	0.6%						
cSoya	Soybean	42,821	34.5%						
cOagr	Other agriculture	128,691	8.0%						
cLstoc	Livestock	63,175	3.0%						
cMinex	Mineral Extraction	39,819	40.3%	0.02%	0.35%	1.36%	2.50%	3.26%	7.48%
CPGex	Petrol and Gas Extraction	79,293	9.4%	0.00%	0.00%	0.24%	1.01%	5.98%	7.23%
cNmetex	Non metallic minerals	44,255	9.8%	0.08%	0.89%	4.29%	3.89%	4.32%	13.47%
cIron	Iron	82,348	24.8%	0.02%	0.18%	1.62%	2.62%	2.48%	6.91%
cNfer	Non ferrous metals	24,221	40.0%	0.02%	0.18%	1.60%	2.58%	2.45%	6.83%
cOmet	Other metal products	57,354	5.9%	0.04%	0.41%	3.72%	5.99%	5.67%	15.83%
cMach	Machinery	97,015	15.7%	0.01%	0.13%	1.89%	4.24%	4.68%	10.95%
cEmat	Electric materials	59,816	9.2%	0.01%	0.15%	1.87%	2.99%	4.78%	9.80%
cEquip	Electronic Equipment	110,894	6.7%	0.01%	0.09%	1.10%	1.76%	2.81%	5.76%
cAuto	Automobiles	90,211	19.7%	0.00%	0.04%	0.70%	1.97%	2.99%	5.70%
cOveh	Other vehicles and spare parts	100,153	26.2%	0.00%	0.07%	1.43%	4.05%	6.13%	11.69%
cFurn	Wood and furniture	53,516	21.7%	0.09%	1.09%	6.17%	5.21%	2.81%	15.38%
cPap	Paper and graphic	83,150	10.3%	0.02%	0.30%	2.71%	3.89%	7.03%	13.95%
cRub	Rubber products	22,200	11.7%	0.01%	0.17%	1.42%	3.02%	6.47%	11.10%
cChem	Chemical elements	59,147	5.1%	0.00%	0.07%	1.46%	2.90%	1.29%	5.72%
cPetro	Refined petrol products	242,477	6.5%	0.00%	0.01%	0.10%	0.32%	1.93%	2.36%
cOchem	Other chemical products	52,916	6.7%	0.03%	0.25%	1.43%	2.11%	4.24%	8.06%
cPharm	Pharmaceuticals	84,971	2.9%	0.01%	0.14%	1.42%	2.02%	4.73%	8.31%
cPlas	Plastics	37,922	3.8%	0.01%	0.47%	4.14%	3.70%	4.24%	12.54%
cText	Textiles	44,375	10.0%	0.75%	1.21%	4.67%	3.88%	4.06%	14.55%
cApp	Apparel	38,359	2.6%	0.54%	3.16%	10.47%	5.50%	3.69%	23.35%
cLeath	Leather products	31,284	28.8%	0.08%	1.26%	8.42%	3.04%	3.82%	16.61%
cCoff	Processed coffee products	7,484	11.5%	0.07%	0.50%	2.17%	1.96%	1.50%	6.20%
cLprod	Livestock products	101,647	17.4%	0.08%	0.58%	2.55%	2.31%	1.76%	7.28%
cSug	Sugar	28,148	28.1%	0.11%	0.81%	3.57%	3.23%	2.47%	10.19%
cOfd	Other food products	210,474	11.7%	0.07%	0.53%	2.31%	2.09%	1.60%	6.60%
cOman	Other manufacturing	19,808	6.1%	0.17%	0.72%	3.07%	3.62%	4.53%	12.11%
cUtil	Public Utilities	147,386	0.0%	0.01%	0.36%	1.47%	2.57%	4.52%	8.92%
cCons	Civil construction	162,468	0.6%	0.24%	2.17%	11.28%	7.73%	5.41%	26.83%
cTrad	Trade	262,252	0.2%	0.47%	2.88%	11.74%	12.86%	15.69%	43.64%
cTran	Transport	170,049	8.0%	0.11%	0.70%	4.95%	10.80%	10.61%	27.18%
cComm	Communications	109,664	0.8%	0.01%	0.12%	1.57%	2.50%	4.60%	8.80%
cFser	Financial services	179,576	1.0%	0.01%	0.21%	1.86%	6.34%	17.59%	26.01%
cSfam	Services to families	249,713	5.2%	0.70%	3.77%	9.37%	9.92%	14.09%	37.84%
cSent	Services to enterprises	198,781	6.2%	0.07%	1.09%	6.34%	8.69%	20.67%	36.86%
cDwell	Dwellings	166,283	0.7%	0.01%	0.12%	1.05%	1.01%	1.40%	3.59%
cSpub	Public administration	379,020	0.2%	0.05%	1.90%	5.89%	15.13%	33.41%	56.37%
cSpriv	Non mercantile private services	59,529	1.6%	0.67%	3.92%	11.19%	14.71%	23.88%	54.38%

Source: SAM constructed by Joaquim Bento de Souza Ferreira Filho as described in (Polaski, et al., 2009)

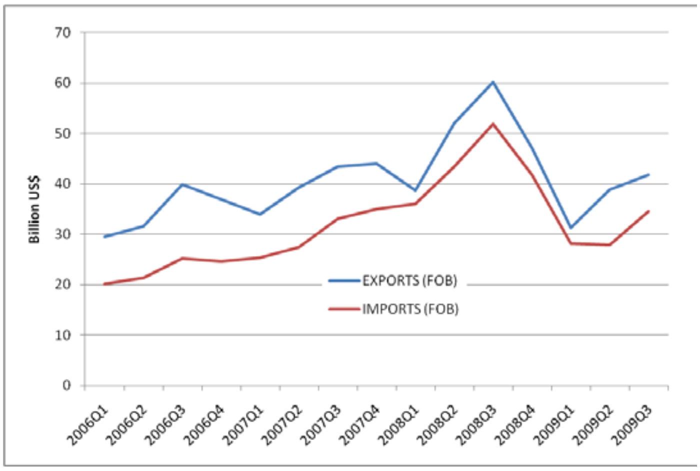
A number of previous studies have analyzed the impact of trade on Brazil before the global economic crisis. In terms of global studies, (OECD, 2005) in a global simulation of the impact of a universal 50% tariff cut and a 50% reduction agricultural subsidies predicts welfare gains of approximately 0.3% of GDP for Brazil, the main part of which would be caused by agricultural reform in OECD countries. (Anderson, Martin, & van der Mensbrugghe, 2006) in a long term simulation for an ambitious Doha agenda liberalization round predict welfare gains for Brazil of around 0.5% by 2015 and demonstrate that these results are extremely sensitive to any exceptions or remaining restrictions on agriculture. (Bouet, Mevel, & Orden, 2007) explore a liberalization scenario directed mainly towards high agricultural tariffs in industrialized countries and predict welfare gains between 0.1 to 0.3% of GDP for Brazil.

A number of studies have also focused specifically on Brazil. (Polaski, et al., 2009), using the same model applied by this study, analyze the impact of a conclusion of the Doha round and a number of south-south-trade arrangements. They also look at the impact of external factors, namely the growth of India and China and fluctuations in commodity prices. They predict welfare increases equivalent to 0.4% of GDP for both their Doha scenario and a comprehensive south-south-trade agreement. (Azzoni, Brooks, Guilhoto, & McDonald, 2007) predict that the gains of a Doha liberalization scenario would benefit most households, but mainly those involved in agriculture and especially commercial agriculture and large farms. (Bussolo, Lay, & van der Mensbrugghe, 2006) predict that under current conditions, the poverty headcount in Brazil would decline 5.6% by 2015, and that with Doha liberalization this would increase only marginally by 0.2 percent. Even if world trade was liberalized completely, they predict an increase in poverty reduction by no more than 0.5%. (Ferreira, Bento, & Horridge, 2010) predict that full global liberalization of agriculture would lead to an increase of 0.13% in Brazil's GDP and a 3% reduction in the number of poor households. In conclusion, previous studies have generally found small impacts of trade policy changes and other trade shocks on Brazil, but some of them point to the potential for substantial re-allocation among sectors producing both winners and losers.

Changes in trade flows during the crisis

The value of both Brazilian imports and exports declined substantially during the crisis, in particular in the last quarter of 2008 and the first quarter of 2009. In the first quarter of 2009, exports were 19% and imports 22% below their value in the same quarter of 2008. It is important to note that these are value changes which to some extent are driven by changes in world market prices.

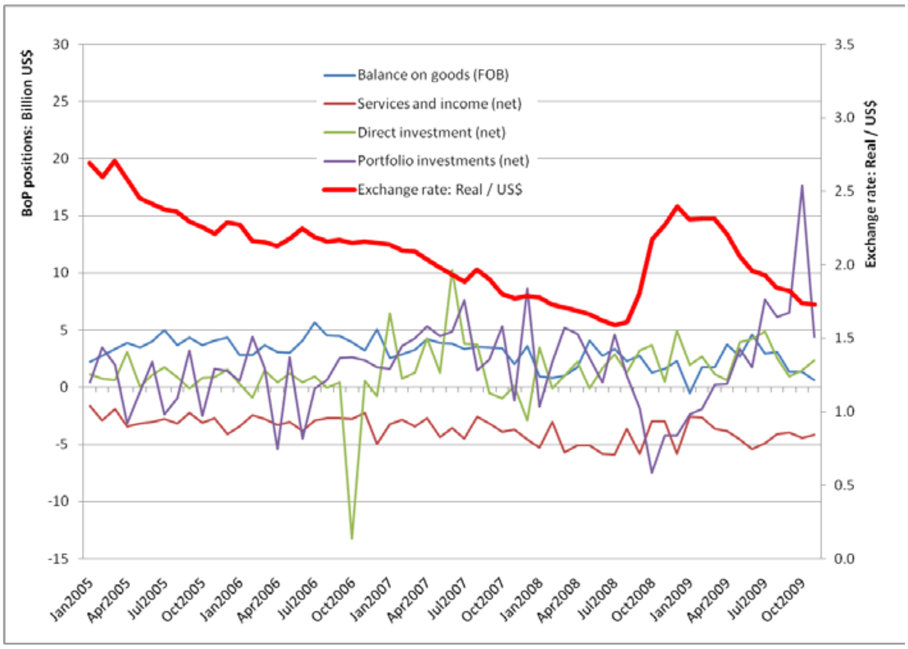
Figure 6: Imports and Exports, quarterly



Source: Banco Central do Brasil

The contraction in trade was not the only channel through which the global economic crisis affected Brazil. As shown in Figure 7, the Brazilian currency (Real) devalued steeply at the beginning of the economic crisis. Between August and December 2008, the exchange rate went from 1.6 to 2.4 Real / US$. Since then, it regained value and returned close to its pre-crisis level towards the end of 2009. Figure 7 also illustrates the balance of payment dynamics that caused this fluctuation. While the trade balance, both for goods and for services, and the balance for direct investment remained fairly stable throughout the crisis, the fluctuation in the exchange rate seems to have been driven by a rapid outflow of portfolio investment that was reversed with strong inflows since the second quarter of 2009.

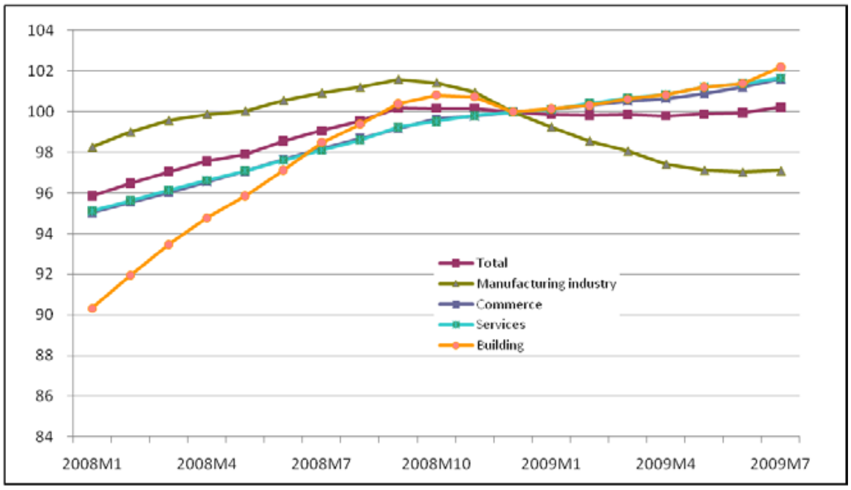
Figure 7: Selected Balance of Payment Positions and Exchange Rate



Source: Banco Central do Brasil

Figure 8 shows the impact of the crisis on employment by sector of the economy. Total employment dropped slightly in the first quarter of 2009. The data for the later months is showing a modest recovery. The decline in employment was caused mainly by a sharp drop in manufacturing employment. Construction employment also declined slightly in the beginning of the crisis but has already picked up again. Employment in services and commerce were not strongly affected and continued to grow.

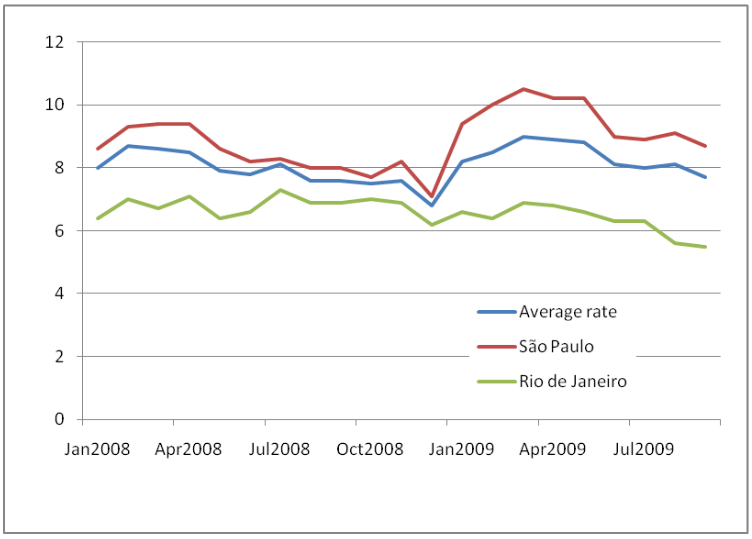
Figure 8: Unemployment Index by Activity



Source: Banco Central do Brasil

The average unemployment rate increased from 6.8% in December 2008 to 9.0% in March 2009 but then declined again to 7.7% in November 2009. It is interesting to note that the impact of the crisis on unemployment was considerably stronger in the industrial region of Sao Paulo, while unemployment in the region of Rio de Janeiro hardly increased at all during the crisis

Figure 9: Unemployment by Region



Source: Banco Central do Brasil

Policy Responses to the crisis[8]

In terms of monetary policy, Brazil responded to the crisis by cutting interest rates and reducing reserve requirements to increase liquidity in the banking system. The banking sector was stabilized through a capital injection, purchase of foul assets, and the provision of government guarantees. Fiscal stimulus measures included:

1. An extension of the *Bolsa Familia* conditional cash transfer program to cover an additional 1.3 mln. households over the previous 11.1 mln.
2. Extension of unemployment benefits by two months for workers in the most affected industries who lost their job after November 2008 and 12% increase in the minimum wage
3. Government vowed to maintain and expand a previously adopted 213 bln US$ investment program focused on social infrastructure, transport and energy.
4. US$ 6.5 bln for the agriculture sector to be spent through a number of different mechanisms
5. Tax breaks for car manufacturers under the condition that they do not lay off workers
6. A reduction in taxes on construction
7. A reduction on import tariffs for a number of capital goods

[8] Information on policy responses is based on (ILO, 2010)

3. Model and Data

The model used in this study is a development of the STAGE (STatic Applied General Equilibrium) model called STAGE_LAB. STAGE_LAB is a member of the STAGE suite of single country computable general equilibrium models. Conceptually, it falls into the class of models that follow the approach described by (Derivis, de Melo, & Robinson, 1982) and the models developed by (Robinson, Kilkenny, & Hanson, 1990) and (Kilkenny, 1991). At the core of the suite is the basic STAGE model, but the basic STAGE model is not often used in practical work rather it is customised to the setting/economic environment being explored. The guiding principle is that the basic STAGE model provides a template that can support multiple variants; indeed the expectation is that for most studies it will be necessary/desirable to make changes and/or additions to the basic STAGE model.

The basic STAGE model is characterised by several distinctive features. First, the model allows for a generalised treatment of trade relationships by incorporating provisions for non-traded exports and imports. Second, the model allows the relaxation of the small country assumption for exported commodities that do not face perfectly elastic demand on the world market. Third, the model allows for (simple) modelling of multiple product activities through an assumption of fixed proportions of commodity outputs by activities with commodities differentiated by the activities that produce them. Hence the numbers of commodity and activity accounts are not necessarily the same; this captures the empirical fact that real activities/industries typically produce multiple commodities/products and while for many manufacturing and services activities secondary products are relatively unimportant this is far from the case for agriculture.[9] Fourth, (value added) production technologies are specified as nested Constant Elasticity of Substitution (CES). And fifth, household consumption expenditure is modeled using Stone-Geary utility functions; these yield linear expenditure systems that allow for minimum levels of consumption of commodities, which is valuable when modelling consumption choices by households with very low incomes.

[9] An additional advantage is that the requisite databases can be compiled from the directly observed transactions data in Supply and Use tables rather than the transformed data in Input-Output tables. Thus output composition choices are modelled explicitly rather than being subsumed into data transformation processes.

The additional features added for the STAGE_LAB version are the inclusion of a generalised system of nested CES functions for the representation of production, the endogenous modelling of unemployment for all factors through a regime switching mechanism and the ability for factors to migrate between regions/areas and/or factor ‘classification’, e.g., between semi-skilled and unskilled labour. Except for a few minor changes – that imply no differences in behavioural relationship[10] –other features of the STAGE model are carried over directly to STAGE_LAB.

The model is designed for calibration using a reduced form of a Social Accounting Matrix (SAM) that broadly conforms to the UN System of National Accounts (SNA). This approach has been influenced by (Pyatt, 1987).

Model Overview

Behavioural Relationships

Households are assumed to choose the bundles of commodities they consume so as to maximise utility where the utility function is Stone-Geary. The households choose their consumption bundles from a set of ‘composite’ commodities that are aggregates of domestically produced and imported commodities. These ‘composite’ commodities are formed as Constant Elasticity of Substitution (CES) aggregates that embody the presumption that domestically produced and imported commodities are imperfect substitutes. The optimal ratios of imported and domestic commodities are determined by the relative prices of the imported and domestic commodities. This is the so-called Armington ‘insight’(Armington, 1969), which has the advantage of rendering the model practical by avoiding the extreme specialisation and price fluctuations associated with other trade assumptions. In this model the country is assumed to be a price taker for all imported commodities.

Domestic production uses a multi-stage production process (see below). The vector of commodities demanded is determined by the domestic demand for domestically produced commodities and export demand for domestically produced commodities. Using the assumption of imperfect transformation between domestic demand and export demand, in the form of a Constant Elasticity of Transformation (CET) function, the optimal distribution of domestically produced commodities between the domestic and export markets is determined

[10] The main difference is through the addition of some extra sets to control the modelling of labour market transactions.

by the relative prices on the alternative markets. The model can be specified as a small country, i.e., price taker, on all export markets, or selected export commodities can be deemed to face downward sloping export demand functions, i.e., a large country assumption.

The other behavioural relationships in the model are generally linear. A few features do however justify mention. First, all the tax rates are declared as variables that can adjust endogenously to satisfy fiscal policy constraints. Similar adjustment mechanisms are available for a number of key parameters, e.g., savings rates for households and incorporated business enterprise and inter-institutional transfers. Second, technology changes can be introduced through changes in the activity specific efficiency variables – adjustment and/or scaling factors are also available for the efficiency parameters. Third, the proportions of current expenditure on commodities defined to constitute subsistence consumption can be varied. And fourth, the model is set up with a range of flexible macroeconomic closure rules and market clearing conditions. While the base model has a standard neoclassical model closure, e.g., full employment, savings driven investment and a floating exchange rate, these closure conditions can all be readily altered.

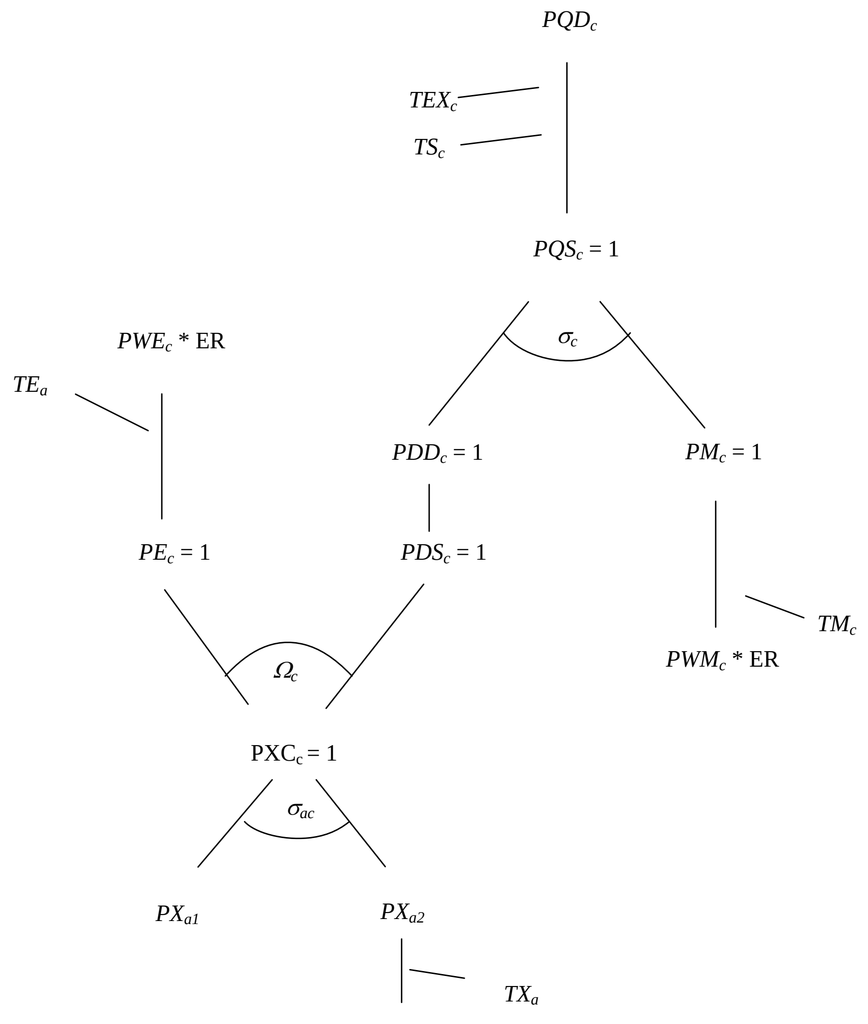
Price and Quantity Relationships

Figure 10 and Figure 11 provide detail on the interrelationships between the prices and quantities for commodities and activities. The supply prices of the composite commodities (PQS_c) are defined as the weighted averages of the domestically produced commodities that are consumed domestically (PD_c) and the domestic prices of imported commodities (PM_c), which are defined as the products of the world prices of commodities (PWM_c) and the exchange rate (ER) uplifted by *ad valorem* import duties (TM_c). These weights are updated in the model through first order conditions for optima. The average prices exclude sales taxes, and hence must be uplifted by (*ad valorem*) sales taxes (TS_c) to reflect the composite consumer price (PQD_c).[11] The producer prices of commodities (PXC_c) are similarly defined as the weighted averages of the prices received for domestically produced commodities sold on domestic and export (PE_c) markets. These weights are updated in the model through first order conditions for optima. The prices received on the export market are defined as the products of the world price of exports (PWE_c) and the exchange rate (ER) less any exports duties due, which are defined by *ad valorem* export duty rates (TE_c).

[11] For simplicity only one tax on domestic commodity sales is included in this figure.

The average price per unit of output received by an activity (PX_a) is defined as the weighted average of the domestic producer prices, where the weights are constant. After paying indirect/production/output taxes (TX_a), this is divided between payments to aggregate value added (PVA_a), i.e., the amount available to pay primary inputs, and aggregate intermediate inputs ($PINT_a$). Total payments for intermediate inputs per unit of aggregate intermediate input are defined as the weighted sums of the prices of the inputs (PQD_c).

Figure 10: Price Relationships in the STAGE Model



Total demands for the composite commodities, QQ_c, consist of demands for intermediate inputs, $QINTD_c$, consumption by households, QCD_c, incorporated business enterprises[12], QED_c, and government, QGD_c, gross fixed capital formation, $QINVD_c$, and stock changes, $dstocconst_c$. Supplies from domestic producers, QDD_c, plus imports, QM_c, meet these

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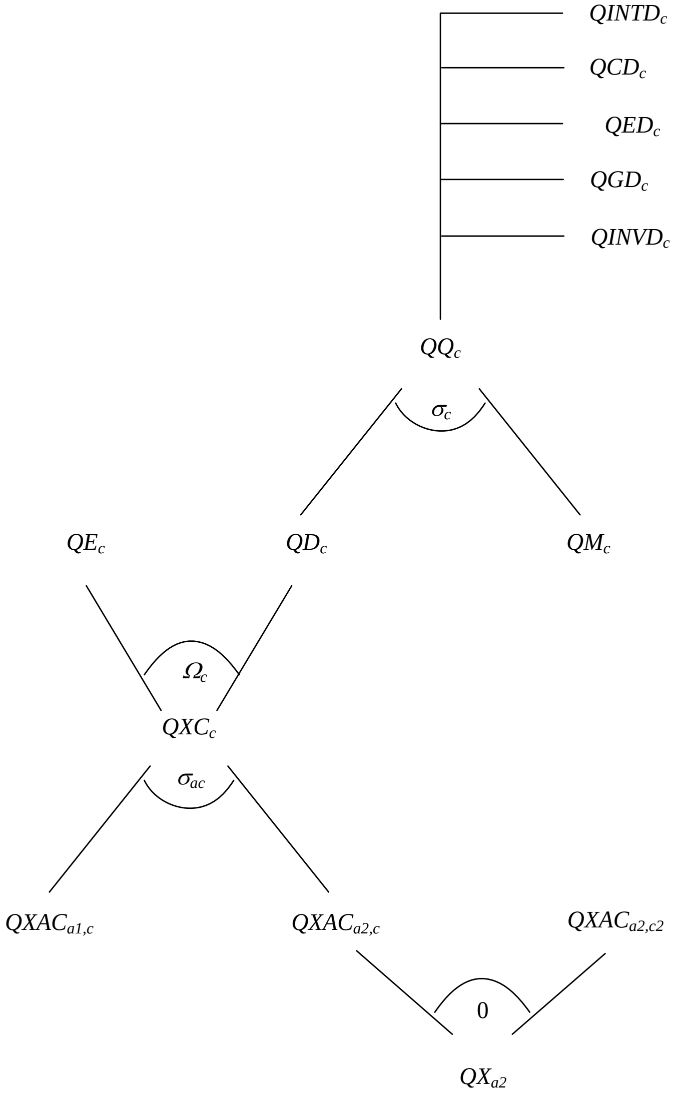
[12] Incorporated business enterprises are institutional accounts. An enterprise is defined as a legal or social entity that engages in economic activities and transactions in its own right.

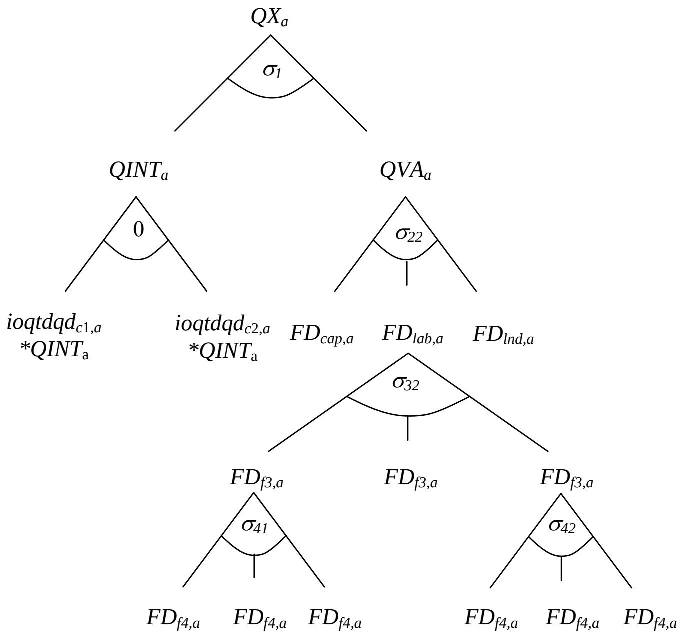
demands; equilibrium conditions ensure that the total supplies and demands for all composite commodities equate. Commodities are delivered to both the domestic and export, QE_c, markets subject to equilibrium conditions that require all domestic commodity production, QXC_c, to be either domestically consumed or exported.

Figure 11: Quantity Relationships in the STAGE Model



The presence of multi product activities means that domestically produced commodities can come from multiple activities, i.e., the total production of a commodity is defined as the sum of the amount of that commodity produced by each activity. Hence the domestic production of a commodity (*QXC*) is a CES aggregate of the quantities of that commodity produced by a number of different activities (*QXAC*), which are produced by each activity in activity specific fixed proportions, i.e., the output of *QXAC* is a Leontief (fixed proportions) aggregate of the output of each activity (*QX*).

Figure 12: Production Relationships for the STAGE_LAB Model: Quantities



Production relationships by activities are defined by a series of nested Constant Elasticity of Substitution (CES) production functions.[13] Mathematically the limit on the number of levels of nests is only constrained by the number of different factor types included in the database. However there are additional limits imposed by economic meaningfulness and the availability of empirical data that allow for the inclusion of information (elasticities of substitution) about the possibilities for substitution between and within sub groups of factors. The illustration in Figure 4 is for a four level production nest, in quantity terms; to simplify exposition two intermediate inputs, nine natural/actual primary inputs and three aggregate primary inputs are identified, and only the labour accounts are nested beyond the second level.

Activity output is a CES aggregate of the quantities of aggregate intermediate inputs (*QINT*) and value added (*QVA*), while aggregate intermediate inputs are a Leontief aggregate of the (individual) intermediate inputs and aggregate value added is a CES aggregate of the quantities of 'primary' inputs demanded by each activity (*FD*), where the primary inputs can be natural factors – types of labour, capital and land that exist – and aggregate factors that are aggregates of natural factors and/or other aggregate factors. Any factor at the end of any branch in Figure 4 is by definition a natural factor, i.e., it is not an aggregate. Thus all the factors $FD_{f4,a}$ are natural factors, as are $FD_{f3,a}$, $FD_{cap,a}$ and $FD_{lnd,a}$, whereas all $FD_{f3ag,a}$ and

[13] (Perroni & Rutherford, 1995) demonstrate that nested CES function can approximate any flexible functional form, e.g., translog.

$FD_{lab,a}$ are aggregates. In the model the set *ff* is defined as the set of all natural factors and aggregates while the set *f*, a sub set of *ff*, is defined as the set of all natural factors; other sub sets of *ff* define the level of each factor – natural or aggregate – in the nesting structure.

Starting from the bottom of the value added nests in Figure 4: the six types of natural labour (*f*4) form two groups of labour that can be substituted within the sub group to form two aggregates ($FD_{f3ag,a}$). These two aggregates, along with another natural factor ($FD_{f3,a}$), are also substitutes that form an aggregate labour factor ($FD_{lab,a}$), which combines with the natural factors capital ($FD_{cap,a}$) and land ($FD_{lnd,a}$) to generate aggregate value added (*QVA*). The optimal combinations of each natural and/or aggregate in each CES aggregate are determined by first order conditions based on relative prices.

The advantage of using such a nesting structure is that it avoids making the assumption that all natural factors are equally substitutable in the generation of value added. In the case illustrated by Figure 4 the implicit presumption is that different types of labour are not equally substitutable but that aggregate labour, capital and land are equally substitutable. For instance the level 3 labour aggregates, $FD_{f3ag,a}$, may be defined as the aggregate labour employed by an activity class in a specific region, which is made up of three types of labour that have different sets of skills – skilled, semi skilled and unskilled – but can only be employed in the specific region. However the activity class may choose to 'substitute' labour from different regions by altering the balance between production taking place in different regions.

This highlights an important consideration. The adoption of a nesting structure carries with it the presumption that factor markets are segmented, i.e., while unskilled labour from a region can be part of that region's aggregate labour factor, unskilled labour from another region cannot. Implicit to this structure therefore is the presumption that labour cannot migrate between regions, whereas in reality there is strong evidence that people are prepared to migrate in search of improved employment opportunities. To address this consideration STAGE_LAB includes a series of migration functions that allow net migration of factors of production between the sub nests of the production structure, e.g., unskilled labour can migrate between different regions in response to employment opportunities. The incentives to migrate are determined by the changes in the relative wages received by the factors in different sub nests.

The model includes a constant elasticity supply function for each factor type. If the relative wage of the factor in a sub nest increases or decreases, the supply of that factor to a sub nest can increase or decrease subject to the condition that the total supply of that factor type in the economy is fixed: the resultant migrations represent a partial adjustment in response to changes in relative wages and combined with the constraint ensure market clearing without any increase in labour supply. The degrees of mobility are controlled by the supply elasticities, which can vary for each and every factor, e.g., unskilled labour in one region may be more or less mobile than unskilled labour in other regions. In practice this version of the model operates a pooling system; the labour supply functions either as supply or demand to or from a series of pools rather than as bilateral migration between sub nests; thus only net migration is modelled. Full bilateral tracking of labour migration could be readily achieved, but would require the imposition of many more supply elasticities, for which there is limited information.[14] The choice of the pooling mechanism is accordingly driven by the decision to achieve a balance between detail and the imposition of exogenous information that has limited empirical basis.

The operation of the migration functions requires the specification of which types of labour can supply labour to a specific pool. This requires the association of factors with particular pools and it is important to ensure these associations are meaningful. In the regionalised examples given above it is clearly potentially valid to assume that labour of the same skill types employed in different regions might be able to move between regions. Furthermore it may be reasonable to argue that there may be some migration between skill types within a region, e.g., between semi skilled and unskilled labour although the ease of migration may depend upon the direction – semi skilled may be easily able to become unskilled, but unskilled may be much less easily transformed into semi skilled. But other migrations may not be appropriate.

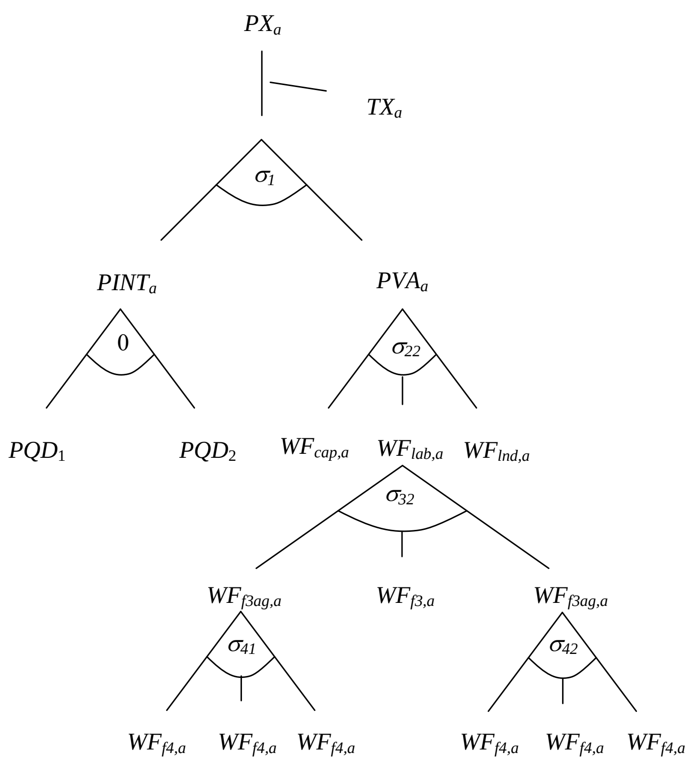
Consider a scenario where there is discrimination in labour markets on the basis of some readily observable characteristic – race, gender, religion, etc., - and labour in a skill class is sub divided according to the characteristic used in discrimination. In such a scenario migration between sub nests is clearly not straightforward since the characteristic used in

[14] It could be argued that migration between regions that are 'geographically' close would be greater than between regions that are far apart. However, it is also possible that there will be a series of migration decisions whereby labour simultaneously enters and leaves the same region.

discrimination cannot be transformed. Consequently care needs to be exercised when defining the possible channels for migration.

Until now it has been assumed that labour supplies are fixed. However STAGE_LAB allows for the possibility of unemployment for each and every natural factor. This is achieved by defining the supply of each factor by reference to current total demand PLUS the stock of the factor currently unemployed. In the case of labour, if there is current unemployment for a class of labour, e.g., unskilled, the real wage of that class is fixed until all the stock of unemployed unskilled workers have been absorbed by the labour market and thereafter the real wage of the factor is flexible.[15] This form of regime switching is attractive since it increases the realism with which the labour markets are modelled, but it does have some implications for the modelling of labour migration. Given that labour migration decisions depend on changes in relative wage rates there can only be **net** migration when a factor within a migration pool is fully employed, since only then can relative wages change.

Figure 13: Production Relationships for the STAFGE_LAB Model: Prices



[15] In terms of the model this requires that the model operates with one regime when there is unemployment and another regime when there is full employment. This regime switching is achieved by specifying the model as mixed complementarity problem (MCP). The variant used here generates a two segments labour supply function – horizontal until full employment and then vertical – but more complex options are possible, e.g., three segments – horizontal until unemployment rate fall below some level, upward sloping until full employment and thereafter vertical.

The price relations for the production system are illustrated in Figure 13. Note how the prices paid for intermediate inputs (*PQD*) are the same as paid for final demands, i.e., a ‘law’ of one price relationship holds across all domestic demand. Note also that factor prices are factor and activity specific ($WF_{ff,a}$), which means that the allocation of finite supplies of factors (*FS*) between competing activities depends upon relative factor prices via first order conditions for optima.

These extensions to the representation of the labour market increase the degree of realism achieved in the modeling of labour market transactions. One dimension of this increased realism is that the model reduces the degree of factor market response to changes in prices. This is achieved in several ways; first, the nested structure reduces the extent of substitution possibilities, second, the ease of substitution between factors is damped down by the nested structure and third the migration functions further reduce substitution possibilities through the partial adjustment to changes in wage rates.

Database: Social Accounting Matrix, Trade Shock Data and Elasticities

Social Accounting Matrix

A social accounting matrix (SAM) is an assemblage of data that reports all the economic transactions (flows of receipts and expenditures) incurred by all the agents in the economy for a particular year. These agents are the commodities, production sectors, domestic institutions - social groups (households), incorporated enterprises, government - and foreign agents. These flows take place due to commodity transactions (buying and selling) between the agents for purposes of consumption, intermediate use, investment, and the like, and by way of inter-agent transfers.

The SAM used in this study was constructed by Joaquim Bento de Souza Ferreira Filho. It is described in greater detail in (Polaski, et al., 2009). It improves upon earlier SAMs for the Brazilian economy by updating the economic data to the year 2004. Another characteristic of this SAM is the degree of regional detail, with information for the 27 regions inside Brazil (26 states plus the Federal District). It also provides a disaggregated representation of labour and households, with ten different labour types and ten different household groups. For the purposes of this study the SAM was reduced by aggregation to 7 regions with 42 commodity accounts, 45 activities, 7 (region specific) types of land, 7 (region specific types of capital, 35 types of labour (5 different skill types by 7 different regions) and 7 (region specific) households together with a series of other institutional accounts and multiple tax instruments.[16] Details of the accounts are reported in Appendix A.

Measuring the exogenous trade shock

Given that detailed monthly data on import and export values and quantities at the product level were not available, we reverted to mirror data on trade with Brazil reported by the US and the European Union. Together, they accounted for 41% of Brazil's total exports and 39% of total imports in 2007.[17] The data used come from the United States International Trade Commission (USITC) and EUROSTAT. It includes the value and quantity of monthly imports and exports at tariff line level and thus allows for the calculation of changes at constant prices in imports and exports at the product level as required to calculate the trade vector used in the model.[18] Imports and exports at constant prices were calculated at the tariff line level as the quantity of imports / exports multiplied by the average unit value (value / quantity) in the base year 2007 to be consistent with the other data in the SAM. For products where no sufficient information was available for 2007, the current value was used. Finally, the trade data were aggregated to the sectors used in the SAM. To isolate the impact of the crisis, the three months that arguably saw the peak impact of the trade shock in Brazil (Jan-Apr 2009) were compared with the same three months in 2008 to calculate percentage changes.

Table 2 shows the resulting data for the trade shock. The first column presents the percentage changes in export volumes with the EU and US calculated as described above. Simply applying these percentage changes to Brazil's total would likely lead to an overestimation of the trade shock as the contraction in demand in the EU and US was particularly strong during the crisis. Thus, the second column shows a hypothetical export shock with all trading partners if it is assumed that exports to the rest of the world remain unchanged (it is thus a function of the first column and the shares of EU, US and rest of the world in total exports for each sector). This leads to a much more conservative approximation of the total trade shock. With respect to imports, the percentage changes calculated based on the EU and US data is

[16] There are 4 taxes on commodities, 2 on activities, income taxes on household and enterprises and factor specific use taxes that vary by the employing activity. Not all the tax instruments are active in the base data.
[17] COMTRADE database
[18] The ability to augment the SAM by using directly observed data is one of the advantages of distinguishing between commodities and activities. If the SAM had been constructed around a 'standard' format input-output table these trade data would have required transformation to achieve definitional consistency.

used in all scenarios as there is no indication of a disproportional shock on imports from the EU and US.

The strongest export declines are for iron (-62%), mineral extraction (-58%) and non-ferrous metals (-57%). Vehicles other than automobiles (-48%), machinery (-45%) and other metal products (-39%) also declined very strongly. The total volume of exports to the EU and US declined by 23%. Assuming that exports to the rest of the world remained unchanged, this would translate into a 9% decline in total exports.

For imports, the strongest declines were in other agriculture (-66%), leather products (-58%), refined petrol products (-54%) and livestock products (-50%). The total volume of imports from the EU and US declined by 26%, which is a stronger decline than that experienced for exports.

Table 2: Trade Shock as used in the Model

		Exp volume change EU & US	Exp volume change world	Imp volume change EU & US
cCana	Sugar Cane	0.00%	0.00%	0.00%
cSoya	Soybean	31.20%	12.80%	0.00%
cOagr	Other agriculture	-21.50%	-14.20%	-66.40%
cLstoc	Livestock	-13.60%	-4.30%	-19.80%
cMinex	Mineral Extraction	-57.80%	-18.30%	19.90%
CPGex	Petrol and Gas Extraction	39.00%	21.90%	-10.40%
cNmetex	Non metallic minerals	-32.80%	-19.10%	-43.70%
cIron	Iron	-62.60%	-30.50%	-30.90%
cNfer	Non ferrous metals	-56.90%	-26.90%	-33.90%
cOmet	Other metal products	-39.00%	-13.10%	-18.90%
cMach	Machinery	-45.00%	-16.50%	-38.80%
cEmat	Electric materials	-22.50%	-6.90%	-22.00%
cEquip	Electronic Equipment	-22.50%	-6.90%	-22.00%
cAuto	Automobiles	-14.50%	-2.50%	-44.90%
cOveh	Other vehicles and spare parts	-48.00%	-17.80%	-14.30%
cFurn	Wood and furniture	-29.90%	-20.60%	-24.90%
cPap	Paper and graphic	20.20%	5.90%	-41.80%
cRub	Rubber products	-23.60%	-8.60%	-39.70%
cChem	Chemical elements	-12.20%	-5.00%	-25.20%
cPetro	Refined petrol products	-17.30%	-2.40%	-54.10%
cOchem	Other chemical products	6.80%	1.10%	-15.40%
cPharm	Pharmaceuticals	66.70%	15.70%	27.50%
cPlas	Plastics	-7.70%	-2.00%	-36.80%
cText	Textiles	-35.90%	-12.00%	-20.80%
cApp	Apparel	-26.90%	-17.20%	-6.60%
cLeath	Leather products	-26.90%	-13.10%	-57.90%
cCoff	Processed coffee products	-24.70%	-21.00%	-10.00%
cLprod	Livestock products	-8.20%	-2.40%	-50.40%
cSug	Sugar	-25.60%	-1.30%	-12.60%
cOfd	Other food products	-2.00%	-1.10%	-19.10%
cOman	Other manufacturing	-10.80%	-6.70%	-17.90%
	TOTAL	-23.00%	-9.40%	-25.80%

Source: Authors' calculation based on data from USITC and Eurostat

Elasticities

The elasticities selected for this study required substantial assumptions because of the lack of empirical evidence for Brazil or other similar economies. The base elasticities are reported in Annex 4 and Annex 5. A deliberate decision was taken to limit the number of different elasticity values and this is reflected in the chosen values.

4. Policy Shocks and Model Closure

The model is implemented using two different configurations of macroeconomic closure and market clearing conditions. In the main these configurations are identical. The common properties are

1. the exchange rate is flexible and the balance on the current account is fixed – this ensures no change in aggregate foreign debt is passed onto future generations and that the exchange rate adjusts to clear the foreign account;

2. the internal balance – government savings – is fixed, as are all tax rates except the income tax rates paid by households, which are free to adjust equiproportionately to clear the government account;

3. the volume of investment is fixed, i.e., the capital stock passed onto the next year is fixed, which with a fixed internal balance means that household savings rates adjust to clear the capital account;

4. the market clearing condition for the factor markets are for a short run adjustment, specifically

    a. capital is assumed to be fixed and immobile between activities;

    b. land is region specific, as are the agriculture accounts and is therefore fixed;

    c. skilled labour – the very high and high wage categories for each region – is assumed to be fully employed and mobile between activities;

    d. semi-skilled and unskilled labour is assumed to subject to the possibility of unemployment, therefore if activities choose to employ more of these types of labour they can do so at a fixed real wage rate until the labour type is fully employed when the wage rate becomes flexible and if activities choose to reduce employment of these labour types the wage rate reduces until it reaches the fixed minimum real wage rate after which unemployment increases; and

e. labour is mobile across regions in response to changes in the relative wages rates of each skill class of labour across regions, thus if relative wages for a labour type in a region rise and that labour type is fully employed then labour of that type will move into that region.

The differences relate to the treatment of import and export prices and quantities. In both configurations it is assumed that export quantities are fixed, i.e. made exogenous, and the world prices of exports, denominated in foreign currency units, are made flexible, i.e. endogenous. This allows us to "shock" the model with the export changes that have actually been observed. Implicitly, this approach reflects the assumption that Brazil would choose to export the exogenously determined quantities. The two configurations differ in the way they handle import prices and quantities:

1. In configuration 1 import quantities are deemed to be endogenously determined subject to the assumption that the world prices of imports, in foreign currency units, are fixed. We call this scenario X shock.

2. In configuration 2 import quantities are also fixed, i.e., made exogenous, and the world prices, denominated in foreign currency units, are made flexible, i.e., endogenous, so that Brazil would choose to export and import the exogenously determined quantities. We call this scenario X&M shock.

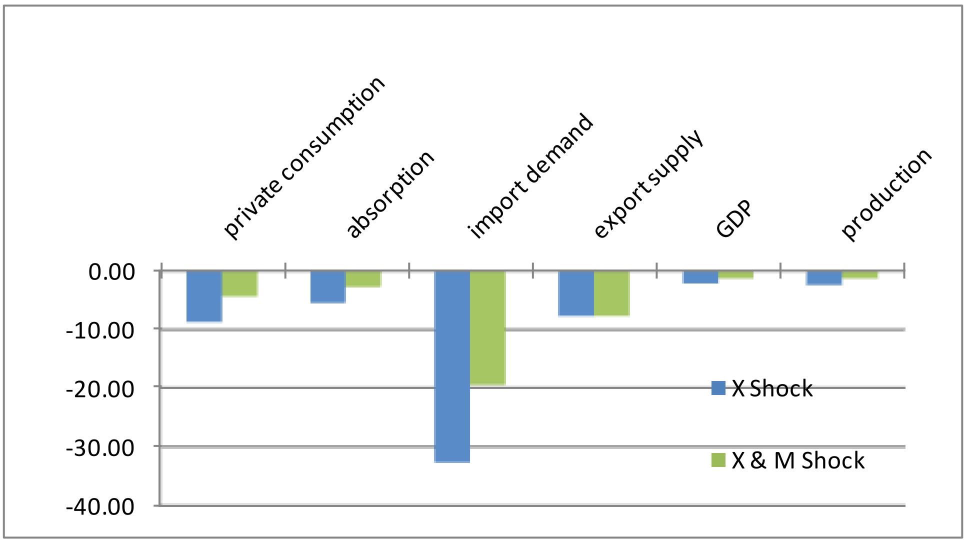
The first alternative contains the explicit presumption that it is the changes in export prices that induce Brazilian producers to alter export supply decisions but that events in the rest of the global economy do not result in changes in the prices of imports; it thus analyzes the export shock in a 'ceteris paribus' scenario. In contrast, the second alternative treats imports and exports symmetrically; the observed changes in export and import volumes are presumed to be a consequence of Brazilian agents responding to changes in relative price signals that induce the observed changes in exports and imports; this presumption is more consistent with the model specification which is built on the presumption that agents respond to price signals.

5. Results and Analysis

The discussion of the results will concentrate on the results for the simulations where only export volume changes are simulated ('X-shock'); this will be referred to as the base case. Where the results from other simulations provide useful insights, the discussion will reference those results. The real macroeconomic impacts of the shocks are summarised in Figure 14. These indicate that in all cases the export declines simulated amount to an approximately 9 percent reduction in real exports. In the base case ('X Shock'), where import prices in foreign currency unit are held constant, this generates small but appreciable reductions in GDP (-2.1%), domestic production, absorption and private consumption.[19]

If import volumes are also shocked ('X & M Shock') then the reductions in GDP, absorption and private consumption are ameliorated. This is because with world prices of imports fixed in scenario X shock, domestic responses to the export shocks are constrained and it is necessary for the economy to shrink by a greater amount than if the world prices of imports can adjust – in this case the adjustments are those generated in response to the imposed changes in import volumes. The additional contraction in domestic demand is manifest in terms of reduced volumes of domestic production and absorption, especially in private consumption that serves as a simple welfare metric.

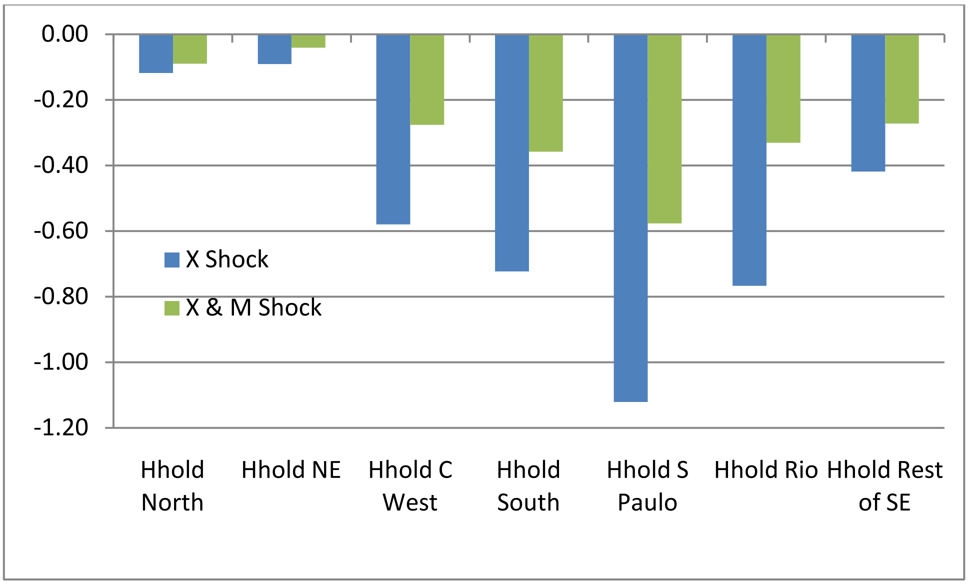
Figure 14: Simulation Results: Real Macroeconomic Aggregates (% change)



[19] Because of the assumption that intertemporal adjustments are not permitted, all costs of the shock are concentrated in one period. This is one of the reasons why the presented simulated reductions in GDP, absorption and private consumption are more severe than the ones observed in reality.

The main adjustment is through the value of final domestic demand. The price index for investment commodities increases, which means that the real value of investment expenditure must increase to maintain a constant volume of investment. On the other hand the price index for government consumption declines, which means that government consumption expenditures can decline while providing a constant volume of demand. The differences between investment and government absorption reflect the relative importance of traded and non-traded commodities in the compositions of their expenditures. Variations in the world prices of imports serve to ameliorate the adverse impacts on final domestic demand. These ameliorating effects are also evident in the welfare results below (Figure 15), where welfare losses are broken down by region.

Figure 15: Simulation Results: Welfare per capita (equivalent variation in '00 Real)

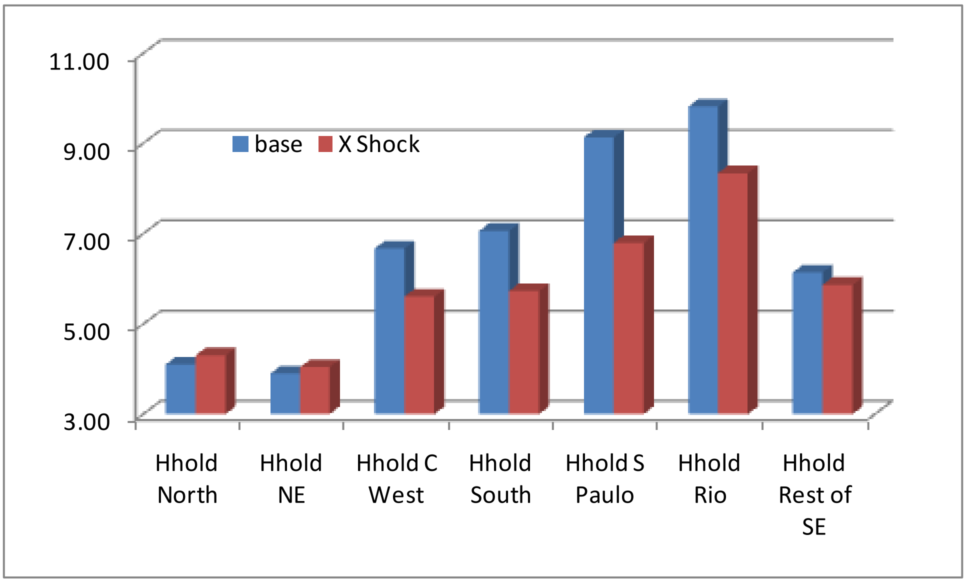


There is a notable tendency for the reductions in welfare, based on equivalent variations[20], to be greater in the relatively richer – more developed – regions of Brazil (Figure 2). As with the macroeconomic indicators the impact of holding world prices constant is an appreciably greater reduction in welfare in all regions. The magnitudes of the differences in base period welfare are illustrated in Figure 3, where the first column for each household

[20] Equivalent variation is the change in income required to maintain the same level of welfare as in the base period when evaluated at base period prices.

records the value of base period consumption/welfare. These expenditures serve to indicate several important considerations. First the very large differences between consumption expenditures across regions – those in the Rio Janeiro and Sao Paulo regions being more than twice those in the North and North East. Second the muted impacts of the shock for households in the North, North East and South East. And third, the small increases in real consumption expenditures in the North and North-East regions even though the regions experience small welfare losses.

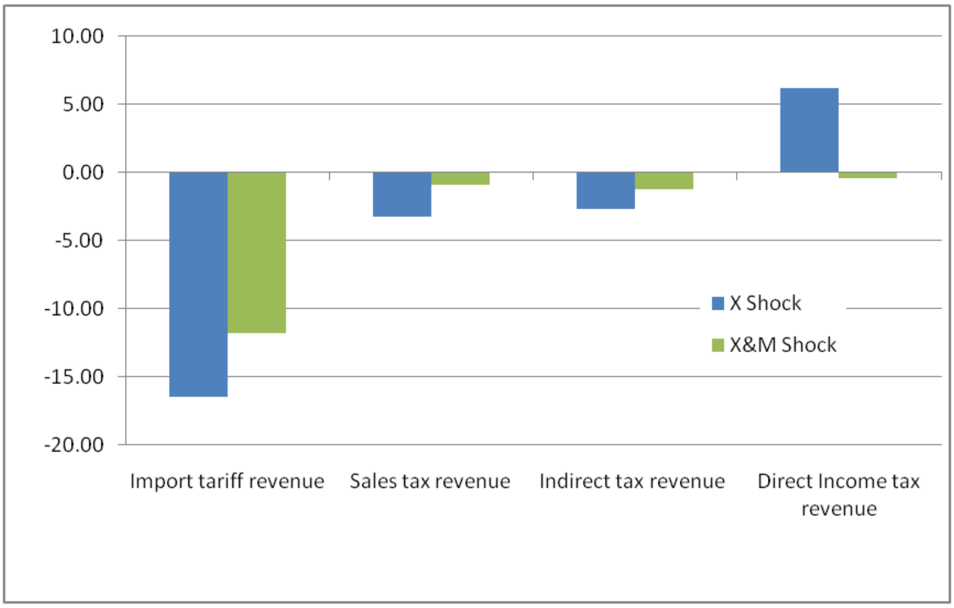
Figure 16 Real Household Consumption Expenditures ('00 real)



Source: simulation results.

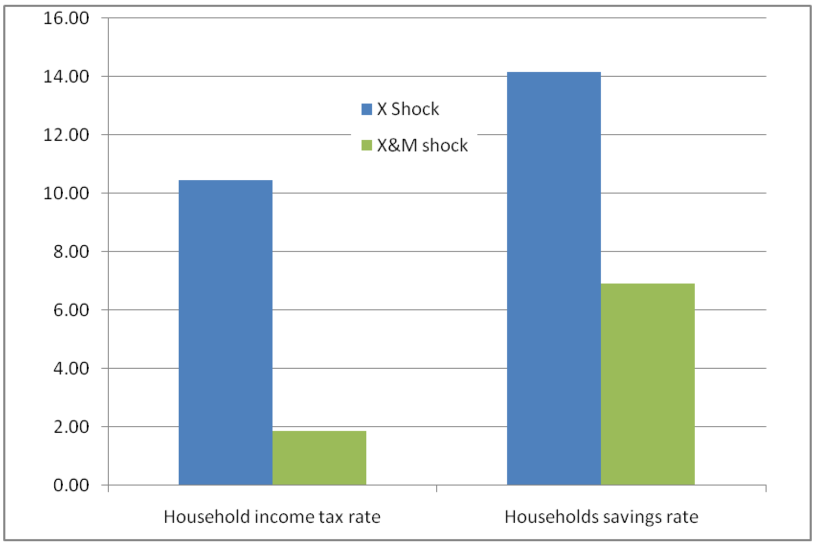
The STAGE_LAB model also allows for an evaluation of the crisis impact on government revenues from taxes, which is interesting in the context of the ongoing debate on government deficits triggered by the crisis. The model assumes that the government collects revenue through import tariffs, sales taxes, indirect taxes and direct income taxes. The model is set up in such a way that revenue from import tariffs, sales taxes and indirect taxes automatically adjusts with changes in the aggregates that are taxed. The direct income tax rates, instead, will be changed by the government in order to achieve a balanced budget. Figure 17 shows that under scenario X shock, the government would need to raise an additional 5 per cent of revenue in direct income taxes in order to balance for the losses from the other revenue sources that are triggered by the trade shock. Under scenario X&M shock, the two effects roughly offset each other and direct income tax revenue can remain largely unchanged.

Figure 17: Simulation Results: Changes in Tax Revenues (% change)



It is important to note that the required increase in direct tax revenues is less than the required increase in income tax rates. This is because the fall in tax revenue requirements is less than the fall in household incomes and therefore income tax rates need to increase in both scenarios (Figure 18). Furthermore, the increased cost of investment requires an increase in the savings rates of households, which indicates the relative importance of imports in investment in Brazil.

Figure 18: Simulation Results: Household Income Taxes and Savings (% change in rates)



The driving forces behind the changes in household consumption and welfare are the induced changes in the factor markets and their implications for factor incomes that are passed down to households to generate household incomes and, to a lesser extent, the changes in household tax and savings rates required to maintain the government's budgetary position and real investment volumes. The incomes of different types of labour decline, and particularly so for the very low and low wage labour types: see Table 3. Similar patterns emerge for capital with declines in all regions. However, the declines in factor income for capital are smaller than those for low and very low wage labour in all regions. The declines in factor incomes are stronger in the X shock scenario than in the X&M shock scenario. It is notable that returns to land increase in one region – Centre West; this is because of increases in demand for the agricultural products predominantly produce in the Centre West.

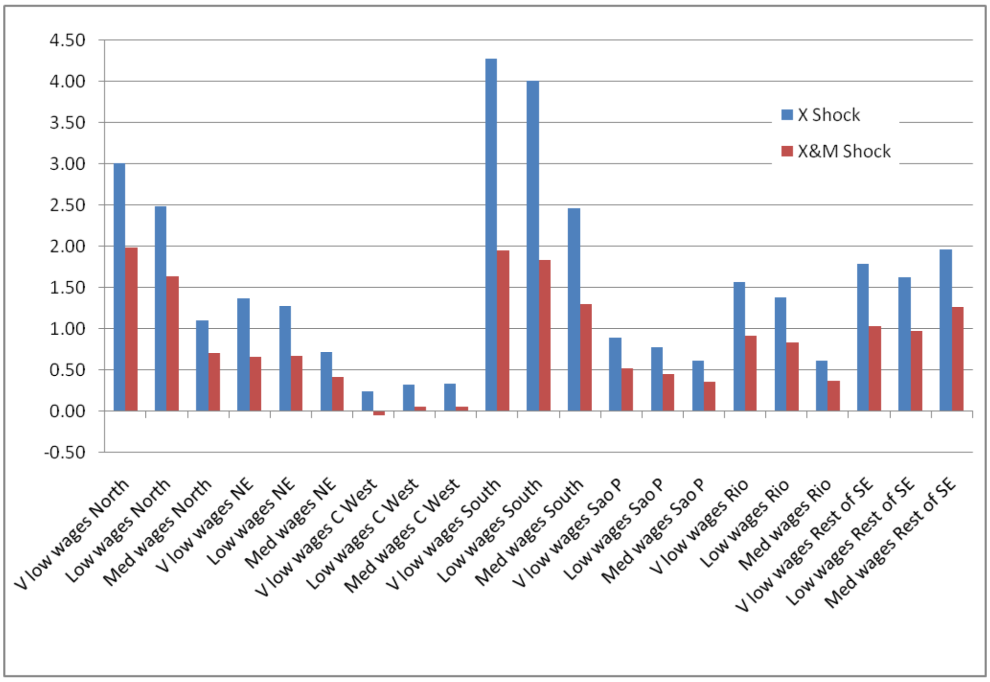
Table 3: Simulation Results: Factor Incomes (% changes)

	X Shock	X&M Shock
V low wages North	-11.15	-7.34
Low wages North	-9.24	-6.07
Med wages North	-7.37	-4.75
High wages North	-2.85	-1.91
V high wages North	-2.83	-1.89
V low wages NE	-7.27	-3.53
Low wages NE	-6.78	-3.57
Med wages NE	-6.09	-3.51
High wages NE	-2.48	-1.46
V high wages NE	-2.19	-1.20
V low wages C West	-1.60	0.29
Low wages C West	-2.13	-0.36
Med wages C West	-2.06	-0.38
High wages C West	-0.95	-0.31
V high wages C West	-1.08	-0.45
V low wages South	-6.00	-2.73
Low wages South	-5.64	-2.57
Med wages South	-5.94	-3.13
High wages South	-2.44	-1.24
V high wages South	-2.36	-1.18
V low wages Sao P	-7.43	-4.37
Low wages Sao P	-6.48	-3.78
Med wages Sao P	-5.68	-3.30
High wages Sao P	-2.56	-1.50
V high wages Sao P	-2.77	-1.76
V low wages Rio	-7.71	-4.51
Low wages Rio	-6.80	-4.07
Med wages Rio	-5.96	-3.60
High wages Rio	-2.44	-1.46
V high wages Rio	-1.41	-0.49
V low wages Rest of SE	-8.80	-5.07
Low wages Rest of SE	-7.99	-4.78
Med wages Rest of SE	-6.71	-4.30
High wages Rest of SE	-2.86	-2.08
V high wages Rest of SE	-2.94	-2.08
Capital North	-4.64	-3.36
Capital NE	-3.73	-1.83
Capital C West	-5.26	-3.32
Capital South	-4.75	-2.68
Capital Sao P	-5.10	-3.04
Capital Rio	-2.39	-0.69
Capital Rest of SE	-5.16	-4.63
Land North	-9.51	-6.45
Land NE	-5.48	-2.45
Land C West	6.37	5.88
Land South	-1.01	1.04
Land Sao P	-3.37	-1.12
Land Rio	-8.69	-5.66
Land Rest of SE	-6.97	-3.70

The model assumes that land and capital are fixed and sector specific. High skilled labour is fully employed, but there is an oversupply of low and medium skilled labour that leads to unemployment. In this set-up, a trade shock will generate changes in unemployment among low and medium skilled workers and wage changes for the high skilled. Because the model allows for high skilled labour to migrate across regions in response to wage difference, simulations allow for conclusions on migration pressures triggered by the simulated trade shock. Therefore, it is useful to subdivide factor incomes between those referring to the labour types that have the potential for unemployment, the labour types that are fully employed, and the fixed and sector specific factors land and capital. It is also useful to keep in mind that in our set-up the main endogenous adjustment mechanism available to sectors/activities is the adjustment of the volumes of lesser skilled employees; therefore unemployment rates are more volatile than they would be otherwise.

The patterns of the effects on labour types that can be unemployed are illustrated in Figure 19. Very low wage earners suffer – often significantly - stronger increases in unemployment than low and medium wage workers in five out of seven regions in Brazil. The relatively small negative (or even slightly positive in scenario X&M shock) impact on very low skilled workers in Central West is again driven by the increase in demand for agricultural products.

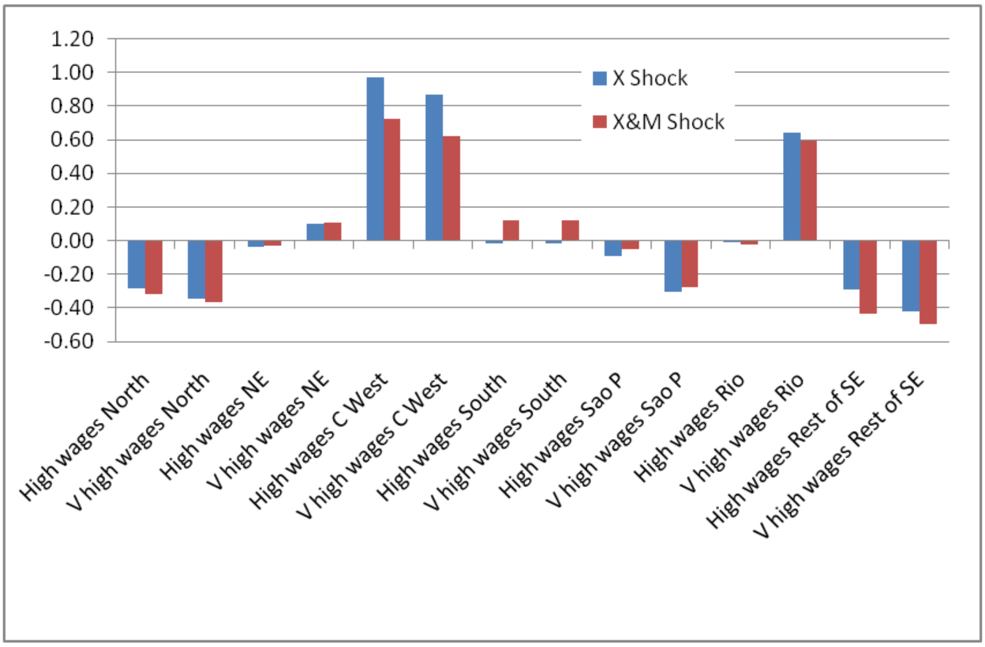
Figure 19: Simulation Results: Unemployment (% changes)



The results on changes in employment of highly skilled labour due to migration (

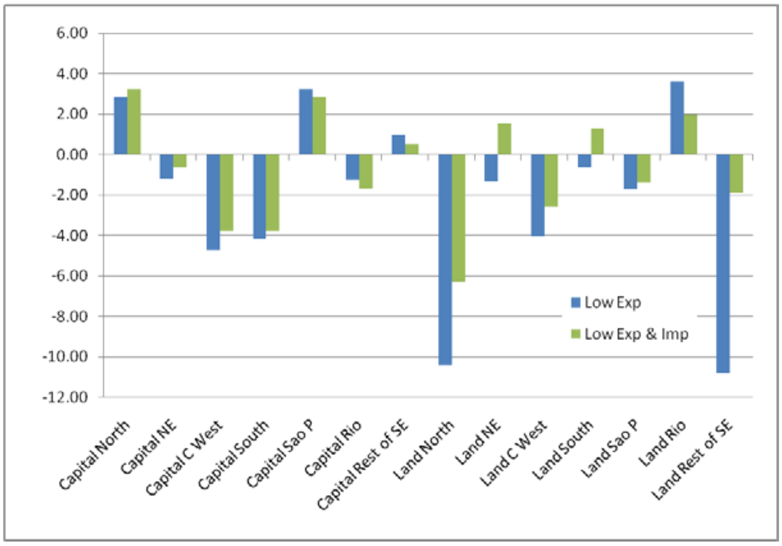
Figure 20) reflect the incentives for these types of labour to exit from the North, Sao Paulo and Rest of SE regions and migrate towards other regions, especially the Centre West and Rio Janeiro. This is broadly consistent with the pattern of impacts on unemployment for lesser skilled labour with the notable exception of Rio Janeiro, which experiences appreciable increases in unemployment among lesser skilled workers while also experiencing a strong increase in the wages of higher skilled workers; this reflect the patterns of production and sectoral employment in the Rio Janeiro region.

Figure 20: Simulation Results: Changes in Employment due to Labour Migration (% changes)



The factor payment rates for capital and land are also mixed. For five regions land and capital payments move in opposite directions and only for the Centre West and the North do they move in the same directions (Figure 21). To some extent the emergence of mixed results is not surprising – these factors are fixed by activity and therefore cannot respond to price signals. But they are hard to comprehend intuitively because they depend on the complex interaction of positive and negative effects on overall factor payments by activity, the ability of higher skilled labour to migrate into employment – thereby cushioning the impact on wage rates for this type of labour while restricting options for the activities – and the option for the activities to shed or hire lesser skilled workers[21]. A major consequence of this is that the main endogenous adjustment mechanism available to the activities is the adjustment of the volumes of lesser skilled employees; consequently unemployment rates are more volatile than they would be otherwise.

Figure 21: Factor Payment Rates for Capital and Land (% changes)



Source: simulation results

More insight into the impacts upon factor incomes can be gained by examining the impacts upon payment rates to the aggregate factors by each activity[22]. For labour it is only aggregate labour employed by agriculture in the Centre West that experiences an average increase and then only for one simulations ('Shock X); elsewhere the impacts on labour are consistently negative. They are also relatively uniform, which is not surprising since it has been assumed that activities can adjust employment levels and that labour allocations will adjust. On the other hand for (aggregate) capital the impacts are mixed; again this is not surprising since export demand for some commodities increase while for others it decreases, which means that the prices received by activities for their outputs will increase or decrease

[21] Note that lesser skilled workers can migrate but when they do so they enter a pool of lesser skilled workers where they is already and excess supply, i.e., they do not migrate into employment.

[22] NOTE: the payment rates have no real world counterparts, rather they are the implied rates of payment for the aggregates and can therefore be interpreted as summary measures (indices) that indicate the *average* changes across the broad categories.

respectively, but capital cannot reallocate to equalise returns. For activities outside of agriculture the processes are relatively simple since each activity produces a single commodity, but the agriculture activities are multi-product activities and therefore the driving force behind changes in land and capital returns depends upon both the mix of increasing and decreasing export demand and the mix of outputs in each agricultural activity (region). The Centre West and South agricultural activities/regions experience increases in overall export demand given their output mixes.

Table 4: Factor Payment Rates by Aggregate Factors (% change)

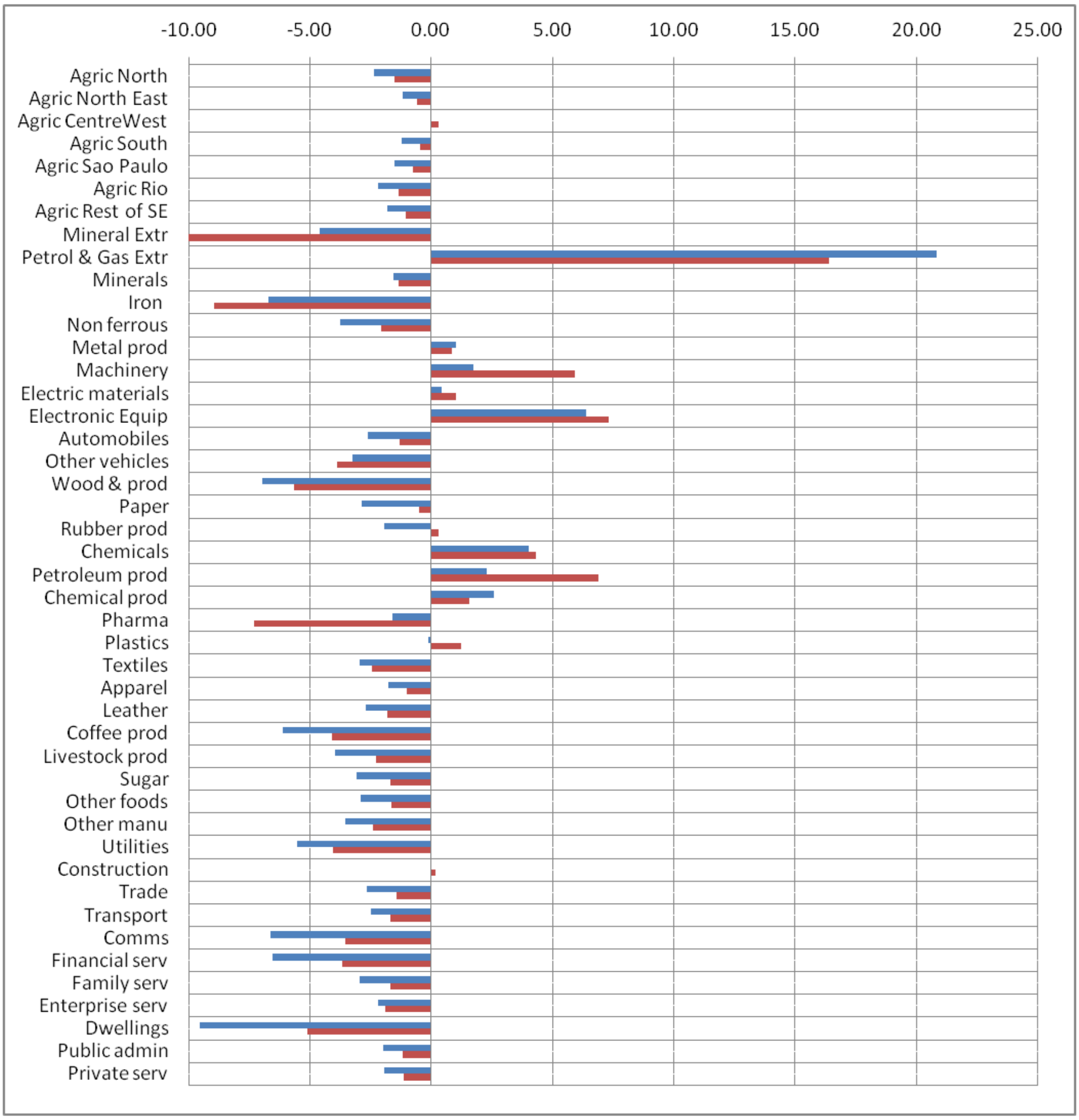
		LABOUR		CAPITAL		LAND	
		X Shock	X&M Shock	X Shock	X&M Shock	X Shock	X&M Shock
Agg capital	Agric North	-1.05	-0.64	-9.51	-6.45	-9.51	-6.45
Agg capital	Agric North East	-0.42	-0.24	-5.48	-2.45	-5.48	-2.45
Agg capital	Agric CentreWest	-1.10	-0.60	6.37	5.88	6.37	5.88
Agg capital	Agric South	-1.25	-0.69	-1.01	1.04	-1.01	1.04
Agg capital	Agric Sao Paulo	-1.19	-0.70	-3.37	-1.12	-3.37	-1.12
Agg capital	Agric Rio	-1.01	-0.55	-8.69	-5.66	-8.69	-5.66
Agg capital	Agric Rest of SE	-0.88	-0.55	-6.97	-3.70	-6.97	-3.70
Agg capital	Mineral Extr	-1.88	-1.13	-5.38	-19.72		
Agg capital	Petrol & Gas Extr	-2.13	-1.18	32.76	25.24		
Agg capital	Minerals	-1.46	-0.86	-1.60	-1.78		
Agg capital	Iron	-1.82	-1.09	-8.25	-11.41		
Agg capital	Non ferrous	-1.82	-1.08	-4.47	-2.40		
Agg capital	Metal prod	-1.81	-1.06	3.84	2.77		
Agg capital	Machinery	-1.99	-1.16	8.82	19.74		
Agg capital	Electric materials	-1.94	-1.14	3.47	3.85		
Agg capital	Electronic Equip	-1.95	-1.15	19.70	20.93		
Agg capital	Automobiles	-2.15	-1.27	-5.19	-1.37		
Agg capital	Other vehicles	-2.13	-1.25	-5.98	-10.19		
Agg capital	Wood & prod	-1.28	-0.74	-12.61	-10.58		
Agg capital	Paper	-1.89	-1.11	-3.66	0.00		
Agg capital	Rubber prod	-2.07	-1.21	-1.75	2.28		
Agg capital	Chemicals	-1.78	-1.04	6.24	6.37		
Agg capital	Petroleum prod	-2.10	-1.17	4.10	10.26		
Agg capital	Chemical prod	-1.92	-1.13	7.33	4.42		
Agg capital	Pharma	-1.96	-1.15	-1.32	-12.15		
Agg capital	Plastics	-1.55	-0.91	2.79	5.53		
Agg capital	Textiles	-1.35	-0.78	-4.77	-4.28		
Agg capital	Apparel	-0.97	-0.56	-7.15	-4.23		
Agg capital	Leather	-1.00	-0.57	-11.09	-8.07		
Agg capital	Coffee prod	-1.36	-0.80	-12.77	-8.81		
Agg capital	Livestock prod	-1.35	-0.78	-7.77	-4.46		
Agg capital	Sugar	-1.36	-0.79	-3.89	-2.09		
Agg capital	Other foods	-1.34	-0.76	-4.57	-2.53		
Agg capital	Other manu	-1.64	-0.96	-5.69	-4.04		
Agg capital	Utilities	-1.90	-1.11	-6.45	-4.79		
Agg capital	Construction	-1.19	-0.70	1.22	1.16		
Agg capital	Trade	-1.58	-0.92	-4.42	-2.26		
Agg capital	Transport	-1.90	-1.11	-3.50	-2.72		
Agg capital	Comms	-1.90	-1.10	-8.05	-4.32		
Agg capital	Financial serv	-2.18	-1.27	-10.68	-5.97		
Agg capital	Family serv	-1.52	-0.88	-8.31	-4.69		
Agg capital	Enterprise serv	-1.89	-1.10	-2.89	-3.67		
Agg capital	Dwellings	-1.61	-0.93	-9.86	-5.28		
Agg capital	Public admin	-2.03	-1.18	-1.68	-1.23		
Agg capital	Private serv	-1.69	-0.98	-8.68	-4.82		

The divergence of the results for capital initially seems counter intuitive since overall rates of return to capital decline (see Table 4). There are multiple forces at play. First changes in commodity prices cause changes in the price indices of intermediate inputs and therefore, *ceteris paribus*, on the resources available to pay primary factors; these impacts differ across activities according to their mixes of intermediates. Second, the declines in wage rates, which are overwhelmingly negative, imply the potential for increased returns to capital since capital is the fixed factor in this case. Third, quantities of capital employed vary across activities and the overall average rates of return depend on both the changes in rates of return and the volumes of capital. Fourth, the shocks generate relative changes in the prices of the outputs of activities (see Table 5.6) and these changes induce changes in the prices of values added and hence factor returns. And finally, the shocks generate differential changes in the scales of production by activities, which given that capital cannot be reallocated means that there are further changes in the prices of the outputs of activities that impact on factor returns. Inevitably, since capital cannot be reallocated to even out the rates of return by sector, the changes in returns to capital vary across sector with some being positive and others negative even though the **weighted** averages are negative. A dominated determinant is the changes in the prices of value added.

The extent to which activities seek to increase or decrease the employment of primary inputs in aggregate depends upon the interaction of the average prices received for outputs and paid for (aggregate) intermediate inputs after paying any taxes on production and/or factors used in production. In terms of the model used these interactions determine the 'price of value added', which simply defines the amount available to pay primary inputs after meeting all other costs. The impacts on the price of value added by sector are illustrated in Figure 22.

What emerges is a pattern of incentives to restructure the mix of activities in the economy following the changes in export and import volumes. Overwhelmingly the expanding activities are manufacturing activities and among the manufacturing activities those seeking to expand are those that are typically more natural resource intensive.

Figure 22 **Price of Value Added (% Change)**



Critical to the diversity of the impacts from the different simulations are the patters of export and import volumes and world prices, Table 5 and Table 6. In all simulations the volumes of exports are exogenously fixed – the first column of Table 5 reports these changes – and the world prices (denominated in foreign currency units) are flexible. Since each of the reported simulations involves different response mechanisms so are the vectors of world prices consistent with the export volume changes – the first three columns of Table 6. If the world prices of imports – in foreign currency units – are fixed then the world prices of all imported commodities decline relative to domestic prices, while if import volumes are fixed the world prices of all imports rise. The decline in world prices is generated by the depreciation of the (nominal) exchange rate by 25.2% (see Table 5.5), whereas the increase in relative import prices derives from an appreciation of the exchange rate (45%). These are large and somewhat implausible movements in exchange rates.

Table 5 Export and Import Volumes (% changes)

	EXPORTS	IMPORTS	
	All scenarios	X Shock	X&M Shock
Soybean	12.76	-36.39	0.00
Other agric	-14.15	-59.84	-66.35
Livestock	-4.31	-66.61	-19.78
Mineral Extr	-18.34	-45.75	19.90
Petrol & Gas Extr	21.87	-31.88	-10.40
Minerals	-19.08	-53.48	-43.68
Iron	-30.54	-47.68	-30.94
Non ferrous	-26.87	-29.56	-33.88
Metal prod	-13.11	-32.91	-18.94
Machinery	-16.49	-24.81	-38.81
Electric materials	-6.94	-33.36	-21.96
Electronic Equip	-6.94	-24.00	-21.96
Automobiles	-2.50	-37.25	-44.94
Other vehicles	-17.82	-28.53	-14.28
Wood & prod	-20.55	-42.46	-24.94
Paper	5.93	-42.10	-41.83
Rubber prod	-8.60	-36.04	-39.70
Chemicals	-4.96	-31.34	-25.23
Petroleum prod	-2.42	-31.06	-54.10
Chemical prod	1.13	-31.59	-15.41
Pharma	15.68	-40.29	27.47
Plastics	-2.04	-42.09	-36.85
Textiles	-11.97	-49.88	-20.78
Apparel	-17.23	-52.94	-6.62
Leather	-13.13	-51.31	-57.88
Coffee prod	-20.99	-52.91	-10.04
Livestock prod	-2.42	-56.14	-50.43
Sugar	-1.32	-51.30	-12.56
Other foods	-1.06	-50.85	-19.14
Other manu	-6.67	-50.30	-17.88
Construction	0.00	na	0.00
Comms	0.00	na	0.00
Financial serv	0.00	na	0.00
Family serv	0.00	na	0.00

Source: Simulations and simulation results

Unsurprisingly if import volumes are fixed the implied changes in the world prices are large since the ability of domestic producers to adjust behaviour in response to the changes in export volumes are tightly constrained and therefore a greater proportion of the adjustment has to be borne by price changes than by changes in import volumes and production structures – through output changes and changes in the use of variable inputs.

However when there are exogenous changes in both export and import volumes the price changes are far less uniform – see the third and sixth columns in Table 6. The world prices of imports do generally increase but this is much less a consequence of an exchange rate movement – in this instance it now only depreciates by 1.6% - than a consequence of adjustment by domestic producers. In part these responses are driven by the changes in export volumes, that in themselves require changes in domestic production structures, but also in part shifting demand from imported to domestically produced commodities, which stimulates further changes in domestic production structures.

Table 6 World Prices of Exports and Imports in World Currency Units (% Changes)

	EXPORTS		IMPORTS	
	X Shock	X&M Shock	X Shock	X&M Shock
Soybean	-3.26	18.69	0.00	10.13
Other agric	-24.69	-3.71	0.00	36.55
Livestock	-25.00	-5.26	0.00	1.56
Mineral Extr	-24.46	-5.82	0.00	-10.26
Petrol & Gas Extr	-11.42	12.35	0.00	14.87
Minerals	-25.16	-5.37	0.00	20.31
Iron	-28.04	-10.76	0.00	14.54
Non ferrous	-26.13	-8.08	0.00	30.47
Metal prod	-23.26	-2.95	0.00	15.85
Machinery	-25.24	-6.74	0.00	44.41
Electric materials	-20.65	0.99	0.00	18.78
Electronic Equip	-21.51	-0.18	0.00	26.24
Automobiles	-15.37	5.35	0.00	36.20
Other vehicles	-22.77	-2.14	0.00	13.86
Wood & prod	-26.21	-6.06	0.00	14.83
Paper	-17.09	5.98	0.00	29.47
Rubber prod	-21.03	0.57	0.00	33.08
Chemicals	-18.85	0.25	0.00	20.78
Petroleum prod	-14.76	4.62	0.00	56.52
Chemical prod	-17.58	5.49	0.00	14.13
Pharma	-13.19	11.19	0.00	-13.19
Plastics	-17.39	5.74	0.00	25.34
Textiles	-22.56	-0.98	0.00	9.79
Apparel	-24.40	-4.97	0.00	2.77
Leather	-21.25	-0.36	0.00	36.61
Coffee prod	-25.51	-5.17	0.00	5.09
Livestock prod	-22.04	-1.53	0.00	24.36
Sugar	-17.10	4.02	0.00	5.88
Other foods	-16.82	4.96	0.00	9.00
Other manu	-20.39	1.46	0.00	8.67

Source: simulation results

Table 7 **Exchange Rates and Producer Price Indices (% change)**

	X Shock	X&M Shock
Producer price index	0.49	0.73
Exchange rate	25.19	-1.62

Source: Simulation results

An interesting indicator is the producer price index (Table 5.5). The values for the PPIs indicate that producer incentives are, on average, positive in two simulations and only negative when import volumes are fixed. The reasons behind this are illustrated by the movements of import, export and domestic producer prices expressed in domestic currency units (Table 5.6).

The key prices are the domestic producer prices. Typically for two of the simulations ('Low Exp B' and 'Low Exp & Imp') they show increases while for the third they show decreases. Comparing these prices changes with those for imports and exports indicates that typically there is an incentive to replace imports by domestic production AND to direct a greater share of domestic production towards the domestic market and away from the export market. It is these changes in relative price received by activities that are driving the changes.

Table 8 Import, Export and Domestic Producer Prices (% Change domestic currency units)

	X Shock			X&M Shock		
	Imports	Domestic	Exports	Imports	Domestic	Exports
Cane	25.19	8.37	10.79	4.38	4.91	5.87
Soybean	25.19	12.73	21.11	8.35	9.52	16.77
Other agric	25.19	-1.03	-5.72	34.34	0.56	-5.27
Livestock	25.19	-5.72	-6.11	-0.09	-5.53	-6.8
Mineral Extr	25.19	4.82	-5.43	-11.71	-4.29	-7.35
Petrol & Gas Extr	25.19	8.66	10.89	13.01	6.63	10.53
Minerals	25.19	2.04	-6.31	18.36	1.47	-6.9
Iron	25.19	4.88	-9.91	12.68	1.88	-12.21
Non ferrous	25.19	10.25	-7.52	28.35	9.79	-9.57
Metal prod	25.19	4	-3.92	13.97	3.16	-4.52
Machinery	25.19	6.51	-6.41	42.07	7.49	-8.25
Electric materials	25.19	3.79	-0.66	16.85	3.87	-0.65
Electronic Equip	25.19	6.51	-1.74	24.2	6.69	-1.8
Automobiles	25.19	4.34	5.95	33.99	3.8	3.64
Other vehicles	25.19	7.28	-3.31	12.02	5.35	-3.72
Wood & prod	25.19	0.58	-7.62	12.96	1.42	-7.58
Paper	25.19	-0.57	3.79	27.37	0.67	4.26
Rubber prod	25.19	3	-1.13	30.92	4.06	-1.06
Chemicals	25.19	5.11	1.59	18.82	2.87	-1.37
Petroleum prod	25.19	7.01	6.71	53.98	6.68	
						2.93
Chemical prod	25.19	4.26	3.18	12.28	3.74	3.78
Pharma	25.19	0.25	8.68	-14.6	-1.83	9.38
Plastics	25.19	4.41	3.42	23.31	5.52	4.03
Textiles	25.19	0.98	-3.05	8.01	1.48	-2.58
Apparel	25.19	-0.02	-5.36	1.1	0.38	-6.51
Leather	25.19	1.34	-1.42	34.4	2.49	-1.98
Coffee prod	25.19	0.34	-6.74	3.39	1.84	-6.7
Livestock prod	25.19	-3.42	-2.4	22.34	-2.68	-3.13
Sugar	25.19	0.84	3.78	4.17	0.96	2.34
Other foods	25.19	1.11	4.13	7.23	1.45	3.26
Other manu	25.19	0.74	-0.34	6.91	1.38	-0.18
Utilities	25.19	-2.39	-0.36	-2.8	-1.82	-0.33
Construction	25.19	1.84	2.04	1.51	1.58	1.68
Trade	25.19	-1.51	2.13	-2.1	-0.77	1.05
Transport	25.19	0.84	5.24	-1.67	1.28	5.35
Comms	25.19	-3.67	1.56	-3.98	-2.01	0.68
Financial serv	25.19	-4.45	-0.36	-4.27	-2.72	-0.61
Family serv	25.19	-1.36	6.59	-3.89	-0.76	3.57
Enterprise serv	25.19	-1.02	0.81	-3.14	-1.1	1.68
Dwellings	25.19	-8.92	-8.5	-4.92	-4.75	-4.53
Public admin	25.19	-1.33	-1.14	-1.16	-1.06	-0.92
Private serv	25.19	-1.12	7.11	-3.78	-0.6	3.8

6. Concluding Comments

The implications of export and import volume shocks on the Brazilian economy are complex and depend critically upon assumptions about how trade commodity prices change and how much flexibility domestic agents are assumed to possess in response to relative price changes. For these simulations the responses available to domestic activities were limited; the assumption of a short run adjustment period meant that capital and land use were fixed by activity and hence the majority of activity level response would be through the labour market. The responses available to labour types were also constrained; for higher skilled labour the choices were limited to reductions in wage rates that could to a limited extent be mitigated by migrating to regions wherein the corresponding wage rates were falling by (relatively) less, but for lower skilled labour types there was not offsetting options since they were price takes at fixed real wage rates.

Average returns to land and capital could increase in some regions despite a shrinking level of income; overwhelmingly this was a consequence of the expansion of export demand for the characteristic commodities of certain activities. Since the patterns of ownership of capital and land will vary across the economy this indicates that there will be gainers and losers amongst the households that own land and capital, even if the average income from land and capital increase.

The results suggest that a large proportion of the adjustment costs have to be borne by labour, with all labour types typically losing out. The more highly skilled labour types can ameliorate the losses but the lesser skilled labour types cannot and hence bear a disproportionate amount of the adjustment costs. As such the results are consistent with expectations. However a qualification is in order. The simulations assume full adjustment to a new equilibrium and therefore do not include restrictions upon how activities may respond; rather they indicate how activities might respond in the short run IF they believe the changes are permanent. If activities believe the changes are temporary they may be inclined to retain critical types of labour and maintain at least nominal wage rates.

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Appendices

Annex 1: Database Accounts

Commodities		Activities		Factors		
cCana	Sugar Cane	aAgnorth	Agriculture North	fvlownorth	Very low wages North	fvlowrs
cSoya	Soybean	aAgneast	Agriculture North East	flownorth	Low wages North	flowrsea
cOagr	Other agriculture	aAgcwest	Agriculture CentreWest	fmednorth	Medium wages North	fmedrse
cLstoc	Livestock	aAgsouth	Agriculture South	fhighnorth	High wages North	fhighrse
cMinex	Mineral Extraction	aAgspaulo	Agriculture Sao Paulo	fvhighnorth	Very high wages North	fvhighrs
CPGex	Petrol and Gas Extraction	aAgriojan	Agriculture Rio Janeiro	fcapnorth	Capital North	fcaprsea
cNmetex	Non metallic minerals	aAgrseast	Agriculture Rest of South East	flandnorth	Land North	flandrse
cIron	Iron	aMinex	Mineral Extraction	fvlowneast	Very low wages North East	
cNfer	Non ferrous metals	aPGex	Petrol and Gas Extraction	flowneast	Low wages North East	
cOmet	Other metal products	aNmetex	Non Metallic Minerals	fmedneast	Medium wages North East	
cMach	Machinery	aIron	Iron	fhighneast	High wages North East	hnorth
cEmat	Electric materials	aNfer	Non ferrous metals	fvhighneast	Very high wages North East	hneast
cEquip	Electronic Equipment	aOmet	Other metal products	fcapneast	Capital North East	hcwest
cAuto	Automobiles	aMach	Machinery	flandneast	Land North East	hsouth
cOveh	Other vehicles and spare parts	aEmat	Electric materials	fvlowcwest	Very low wages CentreWest	hspaulo
cFurn	Wood and furniture	aEquip	Electronic equipments	flowcwest	Low wages CentreWest	hriojan
cPap	Paper and graphic	aAuto	Automobiles	fmedcwest	Medium wages CentreWest	hrseast
cRub	Rubber products	aOveh	Other vehicles and spare parts	fhighcwest	High wages CentreWest	
cChem	Chemical elements	aFurn	Wood and furniture	fvhighcwest	Very high wages CentreWest	
cPetro	Refined petrol products	aPap	Paper and graphic	fcapcwest	Capital CentreWest	
cOchem	Other chemical products	aRub	Rubber products	flandcwest	Land CentreWest	imptax
cPharm	Pharmaceuticals	aChem	Chemical elements	fvlowsouth	Very low wages South	exptax
cPlas	Plastics	aPetro	Refined petrol products	flowsouth	Low wages South	saltax
cText	Textiles	aOchem	Other chemical products	fmedsouth	Medium wages South	ectax
cApp	Apparel	aPharm	Pharmaceuticals	fhighsouth	High wages South	indtax
cLeath	Leather products	aPlas	Plastics	fvhighsouth	Very high wages South	indsub
cCoff	Processed coffee products	aText	Textiles	fcapsouth	Capital South	dirtax
cLprod	Livestock products	aApp	Apparel	flandsouth	Land South	facttax
cSug	Sugar	aLeath	Leather products	fvlowspaulo	Very low wages Sao Paulo	Othtax
cOfd	Other food products	aCoff	Processed coffee products	flowspaulo	Low wages Sao Paulo	Govt
cOman	Other manufacturing	aLprod	Livestock products	fmedspaulo	Medium wages Sao Paulo	i_s
cUtil	Public Utilities	aSug	Sugar	fhighspaulo	High wages Sao Paulo	dstoc
cCons	Civil construction	aOfd	Other food products	fvhighspaulo	Very high wages Sao Paulo	row
cTrad	Trade	aOman	Other manufacturing	fcapspaulo	Capital Sao Paulo	total
cTran	Transport	aUtil	Public Utilities	flandspaulo	Land Sao Paulo	
cComm	Communications	aCons	Civil construction	fvlowriojan	Very low wages Rio Janeiro	
cFser	Financial services	aTrad	Trade	flowriojan	Low wages Rio Janeiro	
cSfam	Services to families	aTran	Transport	fmedriojan	Medium wages Rio Janeiro	
cSent	Services to enterprises	aComm	Communications	fhighriojan	High wages Rio Janeiro	
cDwell	Dwellings	aFser	Financial services	fvhighriojan	Very high wages Rio Janeiro	
cSpub	Public administration	aSfam	Services to families	fcapriojan	Capital Rio Janeiro	
cSpriv	Non mercantile private services	aSent	Services to enterprises	flandriojan	Land Rio Janeiro	
		aDwell	Dwellings			
		aSpub	Public administration			

Annex 2: Production Nesting Structure and Labour Types

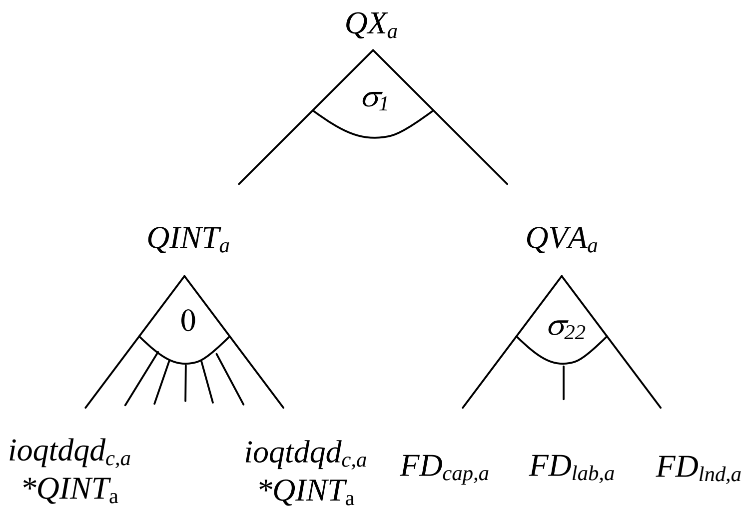
Production relationships by activities are defined by a series of nested Constant Elasticity of Substitution (CES) production functions.[23] Mathematically the limit on the number of levels of nests is only constrained by the number of different factor types included in the database. However there are additional limits imposed by economic meaningfulness and the availability of empirical data that allow for the inclusion of information (elasticities of substitution) about the possibilities for substitution between and within sub groups of factors. The illustrations below are for the four level production nest, in quantity terms, used for this study. To facilitate understanding there are four figures for quantities and four for prices.

Figure 23 illustrates the top two levels of the production nest. At the top level activity output (*QX*) is a CES aggregate of the quantities of aggregate intermediate inputs (*QINT*) and value added (*QVA*). Aggregate intermediate inputs are a Leontief aggregate of the (individual) intermediate inputs. Aggregate value added is more complex: it is a CES aggregate of the quantities of 'primary' inputs demanded by each activity (*FD*), where the primary inputs can be natural factors – types of labour, capital and land that exist – and aggregate factors that are aggregates of natural factors and/or other aggregate factors. Any factor at the end of any branch in

Figure 25,

Figure 27, and Figure 29 is by definition a natural factor, i.e., it is not an aggregate, whereas all the intermediate 'factors' are CES aggregates. Thus the terms *FD* can refer to both 'natural' factors and aggregates. In the model the set *ff* is defined as the set of all natural and aggregated factors while the set *f*, a sub set of *ff*, is defined as the set of all natural factors; other sub sets of *ff* define the level of each factor – natural or aggregate – in the nesting structure. The members of the sets *ff* and *f* are detailed in Table 9.

Figure 23: Production Relationships: Top Two Levels (Quantities)



Starting from the top of the value added nests in Figure 23, aggregate value added is an aggregate of three aggregate factors – land (*lnd*), capital (*cap*) and labour (*lab*). This reflects the fact that the database records transactions for 7

[23] (Perroni & Rutherford, 1995) demonstrate that nested CES function can approximate any flexible functional form, e.g., translog.

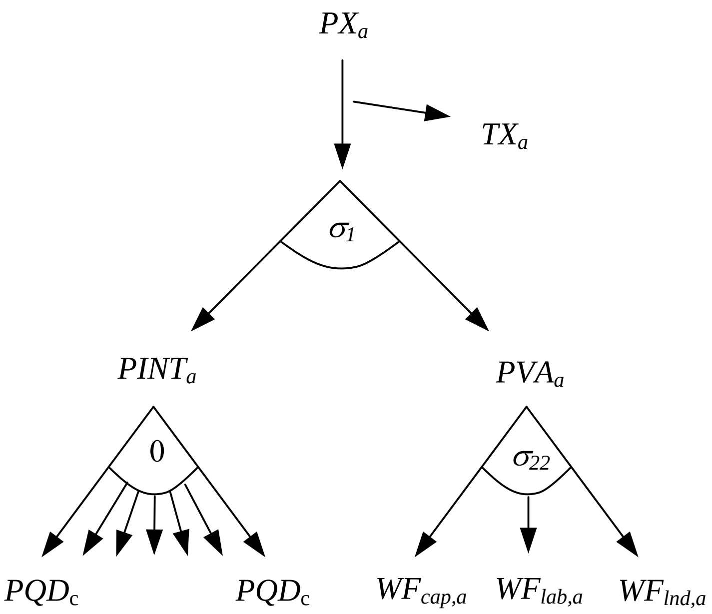
types of land and capital and 35 types of labour. The aggregates for land and capital are both formed in one extra nest – see

Figure 25 and

Figure 28– where land and capital differentiated by the regions of Brazil in which they are employed are aggregated using CES technology.

The corresponding levels of the price system are illustrated in Figure 24. Several points justify emphasis. First, the output price (*PX*) is expressed inclusive of production taxes (*TX*) but the relevant price for the determination of the optimum quantities of aggregate intermediates and value added is net of production taxes. Second, the prices for individual intermediate inputs are the purchaser prices for commodities in the economy. And third, the prices for aggregate intermediates (*PINT*) and value added (*PVA*) are constructs; they have no existence in reality rather they are simple intermediate steps used by the model to determine the optimum quantities of natural inputs used in the production processes of activities. An important point to note about these prices, as with all the price constructs, is that they cannot be subject to price wedges that are due to tax, or similar, instruments.

Figure 24: Production Relationships: Top two Levels (Prices)



Since land cannot be moved it is reasonable to assume that the quantities of land in each region are fixed, at least over a substantial period of time, although of course more land may be brought within the production boundary in a relative short time, e.g., through land clearance, or existing land may be made more productive, e.g., through drainage. Even if, for simplicity, it is assumed that the supplies of productive services flowing from the stocks of land in each region are fixed this does not preclude substitution of land in one region for another by any activity except in so far as the land using activities are region specific. In this database (SAM) the agricultural activities are specified as region specific activities that produce multiple outputs (commodities) and are the only users of land as a productive input in their regions. Therefore there are no substitution possibilities between the different types of land: the effective elasticities of substitution for the aggregate land factors for each activity (σ_{33}) are all therefore equal to zero. Strictly therefore this nest for land, see

Figure 25 and

Figure 26, could be avoided by entering each of land types as a separate factor in the aggregate value added function with a common elasticity of substitution across all land types and aggregate capital and labour; the choice to include a land nest has no impact on the performance of the model.

In the case where the nest has zero substitutability the aggregate price ($WF_{lnd,a}$) is a simple constant weighted sum of the component prices, e.g., $WF_{n4,a}$.

Figure 25: Production Relationships: Aggregate Land (Quantities)

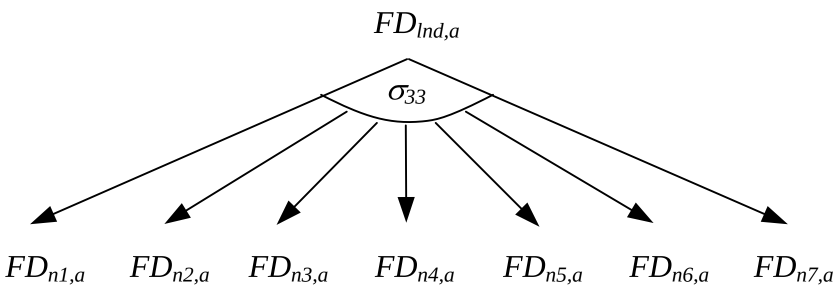
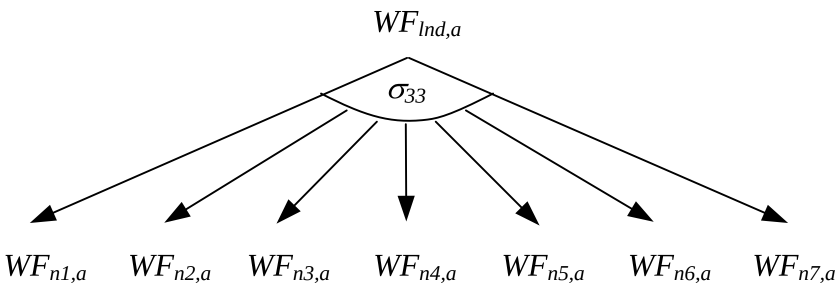
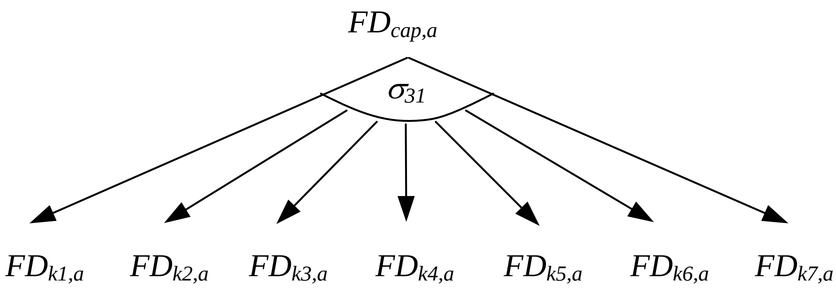


Figure 26: Production Relationships: Aggregate Land (Prices)



Unlike land, capital is not region specific since capital for all regions is potentially used by all activities. Thus there are substitution possibilities between types of capital and therefore the elasticities of substitution ($\square_{31}$) are all positive and are activity specific, and the aggregate is a construct formed as an index of the natural types of capital.

Figure 27: Production Relationships: Aggregate Capital (Quantities)



In the case where the nest has imperfect substitutability the aggregate price ($WF_{cap,a}$) is a weighted sum of the component prices, e.g., $WF_{k4,a}$, where the weights vary with the optimal mix of capital across the different types of capital. Consequently changes in the demand for different (natural) types of capital will causes changes in the prices of those types of capital and in the price of the aggregate; these will be passed up to the next level of the nest as changes in the price of the capital aggregate.

Figure 28: Production Relationship: Aggregate Capital (Prices)

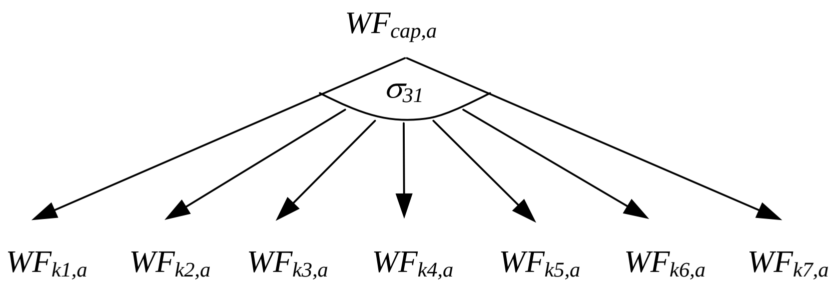


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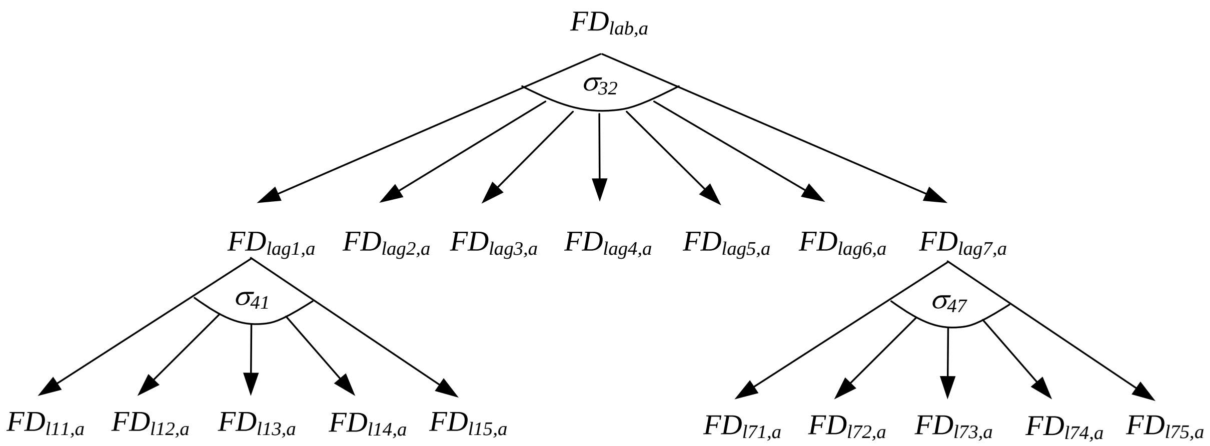
Table 9: Natural and Aggregate Factors

	Aggregates	Natural Factors	Aggregates	Natural Factors
Aggregate labour	Aggregate labour North	Labour V low wages North	Aggregate land	Land North
		Labour Low wages North		Land North East
		Labour Med wages North		Land CentreWest
		Labour High wages North		Land South
		Labour V high wages North		Land Sao Paulo
	Aggregate labour North East	Labour V low wages North East		Land Rio Janeiro
		Labour Low wages North East		Land Rest of South East
		Labour Med wages North East	Aggregate capital	
		Labour High wages North East		Capital North
		Labour V high wages North East		Capital North East
	Aggregate labour CentreWest	Labour V low wages CentreWest		Capital CentreWest
		Labour Low wages CentreWest		Capital South
		Labour Med wages CentreWest		Capital Sao Paulo
		Labour High wages CentreWest		Capital Rio Janeiro
		Labour V high wages CentreWest		Capital Rest of South East
	Aggregate labour South	Labour V low wages South		
		Labour Low wages South		
		Labour Med wages South		
		Labour High wages South		
		Labour V high wages South		
	Aggregate labour Sao Paulo	Labour V low wages Sao Paulo		
		Labour Low wages Sao Paulo		
		Labour Med wages Sao Paulo		
		Labour High wages Sao Paulo		
		Labour V high wages Sao Paulo		
	Aggregate labour Rio Janeiro	Labour V low wages Rio Janeiro		
		Labour Low wages Rio Janeiro		
		Labour Med wages Rio Janeiro		
		Labour High wages Rio Janeiro		
		Labour V high wages Rio Janeiro		
	Aggregate labour Rest of S East	Labour V low wages Rest of South East		
		Labour Low wages Rest of South East		
		Labour Med wages Rest of South East		
		Labour High wages Rest of South East		
		Labour V high wages Rest of South East		

The labour nesting is more complex because it involves two levels of nesting. At the bottom of the nesting structure are 35 different types of natural labour ($FD_{lij,a}$); each type of labour is distinguished by which of seven the regions (i) within which it is currently employed and five levels of wages rates (j), where wage rates are taken as proxies for levels of skill. The implicit behavioural assumption is that employers choose from the pool of differently skilled workers within a region according to the relative prices of the different types of labour within the region, which process identifies the aggregate quantities of labour employed within each region by each activity. If the average price of labour in a region rises – relative to the price in other regions – then it is assumed that activities will substitute between labour from the different regions according to relative prices. There is again an implicit presumption; as activities change the mix of aggregate labour types so implicitly they are reallocating productivity activities across regions.

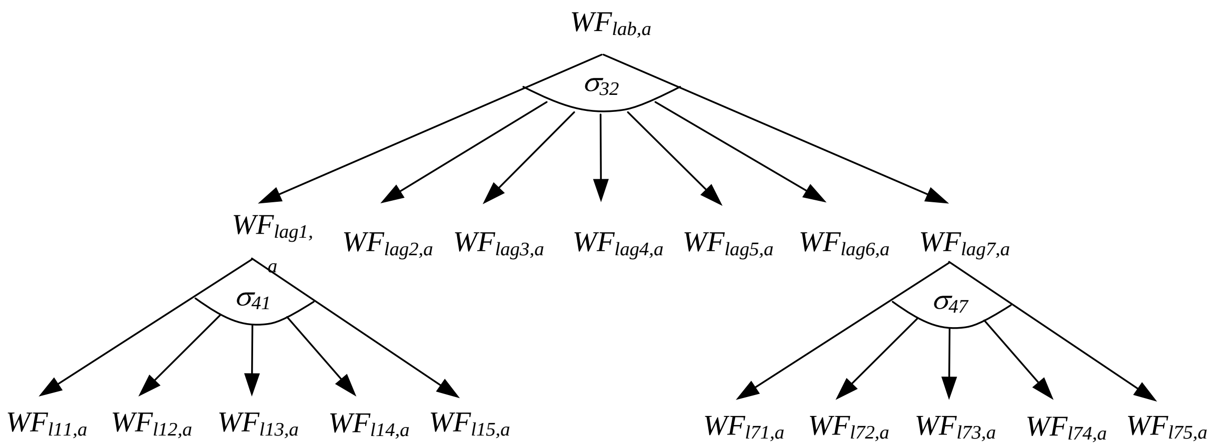
Figure B4a Production Relationships: Labour (Quantities)

Figure 29: Production Relationships: Labour (Quantities)



The nesting structure in quantity terms for labour is illustrated in Figure 4a and for prices in Figure 4b, where the bottom level of the nesting is only fully articulated for two regions. The construct prices, $WF_{lag*,a}$ have no real world counterpart and therefore cannot be subjected to changes in tax instrument. But the bottom level prices can be subjected to tax and the model allows for all natural factors to be subjected to factor use taxes that are activity and factor specific; these taxes obviously enter into the first order conditions for optimal input mixes.

Figure B4b Production Relationships: Labour (Prices)



The advantage of using such a nesting structure is that it avoids making the assumption that all natural factors are equally substitutable in the generation of value added. In the case illustrated by Figures 1 to 4 the implicit presumption is that different types of labour are not equally substitutable but that aggregate labour, capital and land are equally substitutable. For instance the level 3 labour aggregates, $FD_{lag,a}$, may be defined as the aggregate labour employed by an activity class in a specific region, which is made up of seven types of labour that have different sets of skills but can only be employed in the specific region. However the activity class may choose to 'substitute' labour from different regions by altering the balance between production taking place in different regions.

This highlights an important consideration. The adoption of a nesting structure carries with it the presumption that factor markets are segmented, i.e., while unskilled labour from a region can be part of that region's aggregate labour factor, unskilled labour from another region cannot. Implicit to this structure therefore is the presumption that labour cannot migrate between regions, whereas in reality there are large amounts of evidence that people are prepared to migrate in search of improved employment opportunities. To address this consideration STAGE_LAB includes a series of migration functions that allow net migration of factors of production between the sub nests of the production structure, e.g., unskilled labour can migrate between different regions in response to employment opportunities. The incentives to migrate are determined by the changes in the relative wages received by the factors in different sub nests.

Annex 3: Migration Relationships

One problem the presumption that factor markets are segmented is that it prohibits movement of factors between the sub nests. This restriction makes economic and logical sense when it imposes the condition that inherently different factors cannot be transformed from one format to another, e.g., labour cannot be transformed capital (except through production processes and investment). On the other hand there is no binding reason to suppose that skilled labour cannot provide unskilled labour services relatively easily, although the opposite transformation is likely to be time and resource consuming. Even more compelling is the argument that labour of the same skill type located in different regions can substitute for the same labour type in another regions, albeit migration is not costless and there are limitations on the extent of relocations that are likely to take place for a range of reasons, e.g., personal preferences and family commitments. When migration is from one physical location to another it accords with normal usage of the terminology, but in this instance the term migration is adopted to embrace all economically induced transitions form one labour market segment to another.

In order to allow for these migration possibilities the model includes a supply function with constant elasticity for each factor type. If the relative wage of the factor in a sub nest increases/decreases the supply of that factor to a sub nest increases/decreases subject to the condition that the total supply of that factor type in the economy is fixed: the resultant migrations represent a partial adjustment in response to changes in relative wages and combined with the constraint ensure market clearing without any increase in labour supply. The degrees of mobility are controlled by the supply elasticities, which can vary for each and every factor, e.g., unskilled labour in one region may be more or less mobile that unskilled labour in other regions. In practice this version of the model operates a pooling system; the labour supply functions either supply or demand labour to/from a series of pools rather than engage in bilateral migration between sub nests; thus only net migration is modeled. Full bi lateral tracking of labour migration could be readily achieved, but would require the imposition of many more supply elasticities for which there is limited information.[24] The choice of the pooling mechanism is accordingly driven by the decision to achieve a balance between detail and the imposition of exogenous information that has limited empirical basis.

[24] It could be argued that migration between regions that ‘geographically’ close would be greater than between regions that are far apart. However, it is also possible that there will be a series of migration decisions whereby labour simultaneously enter and leave the same region.

Migration Block Equations

$$WFMIG_{f,mig} = \left(\frac{\sum_a WF_f * WFDIST_{f,a} * FD_{f,a}}{\sum_a FD_{f,a}} \right) \Big/ AVGWF_{mig} . \tag{MG1}$$

$$FS_f = FS0_f * \left(\sum_{mig} \frac{WFMIG_{f,mig}}{WFMIG_{f,mig}} \right)^{etamig_f} . \tag{MG2}$$

$$\sum_{f\$map\_mig\_f_{mig,f}} FS_f = \sum_{f\$map\_mig\_f_{mig,f}} FS0_f . \tag{MG3}$$

Migration Possibilities and Elasticities

The implementation of these migration functions requires the specification of first the migration possibilities, i.e., the factors that can migrate and other factor categories to which they can migrate, and supply elasticities for the factors that can migrate.

The migration possibilities are defined by the mapping set, *map_mig_f*(*mig,f*), that defines the factors, *f*, that can migrate to each pool, *mig*. In this configuration it is assumed that labour factors can change the region within which they are employed, i.e., they can relocate/migrate to another region, but they cannot change their skill category. Thus high skilled labour can relocate from one region to another but only as high skilled labour. But note the model does not track bilateral migration flows; rather labour that chooses to exit a region if that regions relative wage falls and enters a 'pool' from which regions whose relative wage has risen draws labour. The current migration possibility mapping is recorded in the workbook as 'migrat!N4:O39'.

The migration elasticities are recorded in the worksheet 'migelast' (see Table 5 for the default values).

Annex 4: Commodity Elasticities

	sigma	omega	sigmaxc
Sugar Cane	3.75	2	2.5
Soybean	3.75	2.5	2.5
Other agriculture	3.75	2.5	2.5
Livestock	3.75	2.5	2.5
Mineral Extraction	3.75	2.5	1.5
Petrol and Gas Extraction	3.75	2.5	1.5
Non Metallic Metals	3.75	2.5	1.5
Iron	3.75	2.5	1.5
Non ferrous metals	3.75	2.5	1.5
Other metals	2.25	2	1.5
Machinery	2.25	2	1.5
Electric materials	2.25	2	1.5
Electronic equipments	2.25	2	1.5
Automobiles	2.25	2	1.5
Other vehicles and spare parts	2.25	2	1.5
Wood and furniture	2.25	2	1.5
Paper and graphic	2.25	2	1.5
Rubber products	2.25	2	1.5
Chemical elements	2.25	2	1.5
Refined petrol products	2.25	2	1.5
Other chemical products	2.25	2	1.5
Pharmaceuticals	2.25	2	1.5
Plastics	3	2	1.5
Textiles	3	2	1.5
Apparel	3	2	1.5
Leather products	3	2	1.5
Processed coffee products	3	2	1.5
Livestock products	3	2	1.5
Sugar	3	2	1.5
Other food products	3	2	1.5
Other manufacturing	3	2	1.5
Public Utilities	3	2	1.5
Civil construction	1.2	0.9	1.5
Trade	1.2	0.9	1.5
Transport	1.2	0.9	1.5
Communications	1.2	0.9	1.5
Financial services	1.2	0.9	1.5
Services to families	1.2	0.9	1.5
Services to enterprises	1.2	0.9	1.5
Dwellings	1.2	0.9	1.5
Public administration	1.2	0.9	1.5
Non mercantile private services	1.2	0.9	1.5

Annex 5: Activity Elasticities

	sigmax	sigmava	flnd	fcap	flab	flnorth	flneast	flcwest	flsouth	flspaulo	flriojan	flrseast
Agriculture North	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Agriculture North East	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Agriculture CentreWest	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Agriculture South	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Agriculture Sao Paulo	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Agriculture Rio Janeiro	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Agriculture Rest of South East	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Mineral Extraction	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Petrol and Gas Extraction	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Non Metallic Metals	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Iron	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Non ferrous metals	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Other metals	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Machinery	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Electric materials	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Electronic equipments	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Automobiles	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Other vehicles and spare parts	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Wood and furniture	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Paper and graphic	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Rubber products	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Chemical elements	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Refined petrol products	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Other chemical products	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Pharmaceuticals	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Plastics	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Textiles	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Apparel	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Leather products	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Processed coffee products	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Livestock products	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Sugar	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Other food products	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Other manufacturing	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Public Utilities	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Civil construction	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Trade	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Transport	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Communications	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Financial services	0.45	0.6	1.5	1.5	0.9	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Services to families	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Services to enterprises	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Dwellings	0.9	1.2	1.5	1.5	2	3	3	3	3	3	3	3
Public administration	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2
Non mercantile private services	0.675	0.9	1.5	1.5	1.6	2	2	2	2	2	2	2