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Is a more inclusive and sustainable development possible in Brazil?

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Title of Paper: **Labor productivity, and structural change in a three sector scge model: an application to Brazil**

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Abstract:

This paper presents a three sector (formal, informal, and energy) open-economy model that describes the schematic behavior of the Brazilian economy. The model distinguishes among three economic classes and assumes no financial sector. Formal and energy sectors are demand–constrained; the informal sector is supply– constrained. We intend to examine the linkages and bottlenecks among these sectors. Specifically, we compare the medium-run effects of three experiments: an investment shock, a rise in income transfers toward formal workers, and an exchange rate shock, and discuss them in the context of Brazil. Further, we assess the interrelations among the formal, the informal, and the energy–provider sectors along the cumulative process of growth.

Keywords: Structuralist CGE models; Labor surplus economies; Structural change.

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1 INTRODUCTION

One of the increasing concerns in economic development is the assessment of the interrelations among the formal, the informal and the energy–provider sectors along the cumulative process of growth. Economists agree that in many low- and middle-income countries, the informal sector is a key player as a provider of jobs and a source of labor surplus in periods of rapid output expansion. Moreover, in the 1990s, stylized facts highlight an increase in the share of the informal sector during economic expansion in many developing countries (Rada, 2010). This phenomenon, known as jobless growth, is present in some developing countries such as India, China and in parts of South America.

In this context, economic development results from structural transformation based on rising demand and productivity. The increase in the demand stimulates labor transfer from low productivity to high labor productivity sectors. Indeed, this labor transfer creates the condition for a rise in the labor productivity in the economy as a whole. In Kaldorian fashion, the boost in industrial demand is fundamental to drive domestic labor productivity and output expansion.

Alas, the robust increase in productivity may hurt job creation and stop the process of labor transfer to industry, setting the economy into a low equilibrium position. Insufficient rise in the demand and a rigid supply of agricultural goods can choke off an expansion. Further, energy supply bottlenecks can impose a barrier to development.

Because of the critical role of the informal and energy sectors in Brazil, evaluate their relationship with the formal sector becomes crucial to understand the complexities of the process of economic expansion and to support future economic policy in the Brazilian economy. Policies that attempt to reduce poverty and promote economic growth must be based on a profound understanding of the economic structure. In this context, the government should prevent situations of sectoral isolation, i.e, prevent a situation where sectors maintain loose forward and backward structural linkages.

The purpose of this paper is to present a structuralist model that attempts to describe the Brazilian economy. The model must be capable of shedding light on the interaction among the three sectors during economic expansion. Two key interrogations of this study are: (1) what the implications of the supply–constraint in the informal sector are for the macro-economy; and, (2) what macroeconomic relationship exists among income redistribution, labor productivity and economic activity. The time horizon of the model is the medium term. In this vein, the paper attempts to fill a gap in the literature on structural change and growth in the Brazilian economy.

The Structuralist CGE model presented in this paper comes from von Arnim and Rada (2011). Our paper is a reapplication of their model applied to the context of the Brazilian economy. The model describes an open, developing economy with three sectors, three commodities, and three classes. The formal sector includes high productivity activities in the industry, in the agriculture and in the services; the informal sector

contains low productivity activities: informal activities and family farming. Finally, the energy sector includes oil, electricity, coal and refinery activities. The formal and energy sectors are demand–constrained; hence, quantities adjust to achieve the equilibrium. The informal sector is supply–constrained, clearing by changes in prices. The model assumes no financial sector. We use the model in the medium run to compare the effects of three experiments: an investment shock, a rise in income transfer towards formal workers, and an exchange rate shock. Additionally, we applied sensitivity analysis experiments to test the sensitivity of model results with respect to different economic scenarios.

This paper is organized as follows. Following this introduction, we present a brief background on the Brazilian economy. In the following section, we present the simulation results. The remainder section presents the conclusions for the Brazilian economy. The description of the model appears in the appendix.

2 BACKGROUND

The Brazilian economy has performed rather poorly in the 1980s and 1990s. Starting in the 1980s, many economists and policy makers believed that South American countries had previously chosen the wrong development model. The well-known model of industrialization through substitution of imports was adopted by many South American countries during the 1930s. The strategy was to protect the domestic market against external competition. The main goal was to promote industrialization through exchange rate controls and subsidies for key economic sectors. This model worked relatively well until the 1970s; however, the oil shocks of 1973 and 1979, the debt crisis of the 1980s, and the lack of resources necessary to produce industrial goods were some factors responsible for the abandonment of this development model.

In the early 1980s, a heterogeneous model replaced the Industrialization for Substitution of Imports model (ISI), and, around the mid-80s, Brazil started its process of economic liberalization. Profound criticism followed the abandonment of the ISI model; the critics emphasized as the main shortcoming of the ISI model the proposition that industrialization would solve the historical problem of income inequality.

In 2003, following a change in government, Brazil adopted a new economic model with a focus on economic growth with inclusion. The policy shift toward job creation marked a new phase in the Brazilian economy.

Tables 1 to 4 document these changes. It shows some key economic indicators of the Brazilian economy. Comparing the statistics, one can argue that the economy presented some improvements in the economic indicators during the 2000s. Table 4 shows that there was a decline in the degree of informality in the Brazilian economy. It was 54.3 per cent in 2000 and dropped to 50.7 per cent in 2007 (IPEA, 2010), a modest but important recovery. One of the possible reasons for the equality improvement might be the conditional cash transfer program called Bolsa Familia that provides financial support for poor families. This program redistributes income for people situated in the informal sector may have contributed to the improvement in the Gini coefficient. In 2009, this program benefited 12,370,915 families, which compared to the 2004 numbers (6,571,839 families) represents an increase of 14.38 per cent (IPEA, 2010). Furthermore,

Table 2 shows better numbers for income inequality, as measured by the Gini index, after 2000. It seems that redistributive policy combined with economic expansion in the period may have positively impacted the economy.

Figures 1 and 2 exhibit the wage share and social spending as a percentage of GDP, respectively. Figure 1 shows a downward trend in the wage share [1] between 1995 and the mid-2000s. This persistent decline is interrupted in 2004, the turning point where the wage share starts to grow again. The intensification of distributive policies in an attempt to fight poverty and inequality, together with an economic model that has focused on job creation, are the defining features of the Brazilian economy during the 2000s.

Turning now to Figure 2, we detect that social spending increases during the 2000s. Social expenditures include government spending in social transfers, education, culture, health, social security, and housing. This positive trend on social spending with respect to GDP revels a possible positive effect on output expansion.

To summarize, the Brazilian economy's performance in the 1990s was a result of the adoption of a neoliberal economic model and negative external shocks. Redistribution of income may foster short-term economic expansion if the accelerator is the most important factor to explain the increase in the investment level. In other words, income redistribution is a sufficient condition for development if and only if the Brazilian economy is wage-led. The fact that some economies are wage-led and others are profit-led is entirely an empirical question. A progressive policy that combines exchange depreciation, and creation of jobs with social policies, through its impact in aggregate demand, may be an important source of economic growth. Indeed, the positive economic statistics in the 2000s are the result of an implemented policy with a focus on social policies and generation of formal jobs (International Labor Organization Report, 2011). Therefore, as the Great Recession (2007-2009) unfolded, the Brazilian economy was capable to present a fast recovery.

3 EMPIRICAL RESULTS

In this section, three simulation experiments are analyzed: a rise in investment demand, an increase in income transfer towards formal workers, and an exchange rate depreciation.

Before we explore the results, we highlight some assumptions of the model. First, it is assumed that only formal and energy sectors imports and exports exist. The fraction of income spent in the formal good from formal sector workers and the fraction of income spent in the formal good by workers in the subsistence sector depend on budget shares and Engel elasticities. Further, we assume a floor consumption of the informal good. Floor consumption of informal good depends on the same variables and marginal budget shares. Assuming the ratio of floor consumption with respect to total consumption of the formal households to be 0.2, while the ratio to the informal household is 0.5. It means that only a fraction of worker's demand is invariable to changes in their real income.

[1] The wage share was calculated as the wage bill over value added measured at factor costs. The estimation does not adjust for the informal sector.

In Table 6, three calibrations are considered: (1) a scenario where trade price elasticities are set to zero, (2) one where we turn on labor productivity in the formal sector, and, finally, (3) a situation where we turn on trade elasticities (χ_2, ϕ_2 =0.75; χ_3, ϕ_3 = 0.2) and labor productivity. For every shock, Table 6 shows three columns. Column (1) reveals the results for the first calibration, while Columns (2) and (3) show the results for the second and third calibrations, respectively. The top block of the table describes the macroeconomic indicators, such as inflation and real GDP growth. All the statistics are shown in percentage points. Lastly, the bottom block exhibits the labor productivity growth.

The remainder of this section is organized as follows. Below we explore the empirical results for the two demand shocks. Next, we analyze the model results for the exchange depreciation shock. Lastly, we discuss the sensitivity analysis experiments and summarizes the results.

3.1 Demand Shock: Investment and Income Transfer

In the first experiment, real investment rises 5.4 per cent (one percentage point of GDP). Columns 1 to 3 of Table 6 reveal the detailed numbers. Let us begin with the first calibration that turns off formal labor productivity and trade price elasticities.

At the macroeconomic level, real GDP grows at about 1.34 per cent; price grows at 0.7 percent. The private balance ($\frac{S-I}{GDP}$) deteriorates 0.6 percentage points of GDP. Output expansion rises government revenue, improving its balance. Because imports are proportional to output and exports respond to price changes, the external balance with respect to GDP, ($\frac{E-M}{GDP}$), deteriorates one fifth following the expansion.

The investment shock triggers structural change. Output share of formal activity and formal sector employment share peak. Assuming labor redundant in the informal sector– which behaves as a reservoir of labor– labor transfer to formal activities boost informal labor productivity. Informal labor productivity, ξ_1, grows at 8.2 per cent. Notice that since we have assumed a constant labor force, aggregate labor productivity grows at the rate of real GDP growth. Informal labor productivity drives the rise in aggregate labor productivity. This result follows from the labor transfer process.

Further, investment expansion, through the spending multiplier, leads to higher intermediate demand and higher incomes. Because of the presence of a steep supply for the informal sector good, inflationary pressures emerge. The price of the informal good increases 4 per cent. The inflationary process hurts further expansion, inflation is commodity-driven. In sum, a spike of investment leads to labor transfer, output expansion, and inflation.

Comparing the results of calibration (1) and (2), we detect a similar pattern. Both simulations have economic expansion as their outcome. GDP grows at 1.4 per cent; price (GDP-deflator) grows at 0.1 per cent. As expected, calibration (2) promotes a slightly stronger economic expansion with lower inflation since a pro-cyclical labor productivity

rule boost competitiveness (limiting inflation and exchange appreciation). The use of an augmented Kaldor-Verdoorn Law (hereafter KV Law) allows for positive impacts of demand expansion on productivity, stimulating exports and putting a counterbalance force against price increases.

How does the results change for the third calibration? With endogenous labor productivity in sector 2 (formal sector) and trade elasticities set to 0.75, the results become slightly stronger. Real GDP grows at about 1.5 per cent, and price grows at 0.1 percent. Real exchange rate appreciates 0.1 percentage points. As before, the external balance deteriorates one fifth.

An in-depth sectoral analysis allows us to verify that the expansion promotes structural change with lower labor transfer — e.g., the formal sector employment share improves only 0.8 percentage points and the output share of formal activity rises 0.2 percentage points. The limited labor transfer occurs because labor productivity in sector 2 now grows at positive rates. Energy intensity drives the rise in formal labor productivity. Differently from the previous calibrations, labor transfer and energy use explain the spike of aggregate labor productivity. The former creates higher aggregate labor productivity because of the presence of a higher capital-labor ratio and an easier access to capital in formal activities. On the other hand, labor productivity in the informal sector grows at 5.1 per cent since we assume that labor is redundant in this sector. Lastly, energy intensity grow explains the remaining boost in productivity. Comparing to calibration (2), note that informal productivity rises stronger with energy intensity, due to labor transfer.

To summarize, we detect that the three experiments present similar results, only magnitudes differ. Despite the modest output expansion results, endogenous productivity in sectors 1 and 2 reinforce the expansion, limiting inflation and real exchange appreciation. In addition, it reduces labor transfer. The strongest expansion (with lower inflation) in calibration (3) is due to the combined effects of higher trade price elasticities and KV Law. Endogenous productivity leads to lower formal prices, improving competitiveness and boosting exports. Further, scenario 3 provides the stronger rise in real wages. In short, the three calibrations suggest that a progressive policy that promotes investment, such as industrial policy, currently and back in 2006, leads to modest expansion.

The next experiment includes an income transfer— of 1 per cent of GDP— from government to formal workers. We found that the spike of income transfer towards formal workers produces positive effects in the economy. Scenario 1 shows that real GDP increases 1.1 per cent, and GDP-deflator grows at 0.8 per cent. Following the boost in disposable income and its positive effects on consumption, an inflationary process emerges. The output expansion and the forced savings process improve the private balance ($\frac{S-I}{GDP}$) by 0.4 percentage points. Public balance deteriorates since government income transfer finances the boost in private consumption. As a result of the simulation, energy and formal imports increase following the modest output expansion.

The basic storyline can be summarized as follows. First, a rise in formal workers' disposable income triggers consumption. Because of a steep supply for the informal good, inflationary pressures emerge. In this vein, prices peak containing further increases in

consumption. The rise in demand feeds into the economic system, leading to output expansion and labor transfer toward formal activities. This labor transfer leads to an improvement in informal productivity (6.5 per cent), and higher income. In conclusion, the rise in labor productivity and the surge of disposable income explain the expansion. The rise in consumption triggers output expansion through the spending multiplier.

Comparing the results of calibration (1) and (2), we observe a similar pattern. Both simulations have expansion as outcome, but now the results are slightly better because of the pro-cyclical productivity rule (KV Law). GDP grows at 1.18 per cent; price (GDP-deflator) increases a bit. Calibration (2) promotes a slightly stronger economic expansion with lower inflation.

Lastly, calibration 3 delivers similar results. High trade elasticities are unable to change the sign pattern of the results. In this case, expansion is roughly the same (1.19 per cent). Because of the presence of a large domestic market, domestic consumption is more important to explain economic expansion than foreign trade. Public and external balances deteriorate because of the output expansion combined with exchange rate appreciation. As before, labor transfer to formal activities improves the informal labor productivity.

The experiments, therefore, suggest that investment and redistribution of income promote structural change and economic expansion. The supply–constraint for the informal good explains the modest inflationary process. Inflation is unable to abort the expansion. Overall, the positive relationship among redistribution, labor productivity and output explain the rise in economic activity. In spite of the modest results, investment and redistributive policies trigger output expansion. They can contribute to economic development in Brazil.

3.2 Exchange Rate Shock

Now lets turn to the final experiment: an exchange rate depreciation of 10 per cent. According to calibration (1), an exchange depreciation triggers output contraction. A contractionary depreciation might be caused by many factors; for instance, capital goods imports might be price inelastic in developing countries. This can create a tight constraint for many low and mid-income countries. Further, depreciation may reduce real wages, consequently, reducing consumption. Krugman and Taylor (1978) present a detailed discussion of these factors. For a recent discussion, see Razmi (2007).

Table 6 shows that post-shock the economy goes into a situation characterized by output contraction, deflation, and real depreciation. GDP grows at a negative rate of 2.1 per cent. At the same time, prices present a negative growth rate of 0.5 per cent. Private, public, and external balances deteriorate as a result. Following the exchange depreciation, real income and overall savings fall, which leads to labor transfer to informal activities. It causes a reduction in aggregate labor productivity. In this context, labor productivity in the informal sector drops sharply. Since wages in the subsistence sector, w_1, depend on

labor productivity, real wage fall. This wage reduction has a negative impact on consumption, leading to further decreases in output.

The basic storyline follows. The exchange rate depreciation leads to a trade-induced contraction. This negative demand shock propagates throughout the economy, triggering structural change. The lack of external demand leads to a drop in employment, further reducing wages, consumption, and productivity in general. In formal terms, the share of value added in total supply, ν, is a negative function of exchange rate. In this vein, depreciation raises the import bill and reduces ν.

At the sectoral level, output contraction leads to reverse labor transfer towards informal (low productivity) activities, which reduces informal labor productivity. Real wages of informal households drop sharply. Informal labor productivity drives the decline in aggregate labor productivity. On the other hand, output share of formal activity and formal sector employment share plunged.

Since informal prices are pro-cyclical, the lower real wages lead to a consumption fall and deflation. In short, the reduction in demand and prices promotes continuous recessionary pressures.

Notice the incapacity of scenario 2 — turning on labor productivity in sector 2—to deliver a different picture. Endogenous productivity (and pro-cyclical) acts only as a counterbalance force against the recession, limiting deflation and real exchange depreciation. Insufficient, however, to overcome the recessionary tendency.

Using the results of calibrations (3)— where we turn on trade— we found that exchange depreciation leads to modest economic expansion. The statistics improve across the board. Real GDP grows at 1 per cent and inflation grows at 0.1 per cent; the modern sector employment share improves by 0.5 percentage points. The surge of aggregate labor productivity follows from the expansion. As expected, labor transfer, energy productivity and energy use explain the spike of aggregate labor productivity.

Comparing the two calibrations, we detect a clear change in pattern. It seems that there is a threshold, in terms of trade price elasticities, beyond which further depreciations become expansionary. Von Arnim and Rada (2011) and Cuesta (1990) found a similar sign change to Egypt and Colombia, respectively.

In conclusion, exchange rate policies should be implemented in a cautious way. The fact that exist a modest economic expansion suggests that exchange rate policies have a limited potential to boost the economy. It seems that the large domestic market is more important than foreign trade to explain economic expansion in Brazil.

3.3 Sensitivity Analysis and Summary

Figure 3 presents the results. The figure contains three panels. Panels (a) and (b) in Figure 3 show, respectively, the results for an exchange rate depreciation of 10 per cent, and a rise in investment (1 per cent of GDP). On the bottom, panel (c) show the results for an income transfer towards formal workers. The vertical axis reveals the real GDP growth, the horizontal axis shows the trade price elasticity range ($0 \leq \phi$, $\chi \geq 1$) .

The results for panels (a), (b) and (c) suggest that the higher the trade price elasticities, the stronger is the growth rate of output. As expected, the results for panel (a), show that, after the shock, there is a clear sign pattern change. There is a clear threshold, $\chi, \phi \approx 0.5$ per cent, beyond which depreciation becomes expansionary.

In summary, the combined effects of the labor transfer, the informal supply constraint, and the labor productivity growth explain the model's behavior. The positive relationship between redistribution and labor productivity indicates that redistributive policies are worth to implement. The positive effect of investment on output suggest that industrial policy has the potential to stimulate the economy. Moreover, exchange rate policy should be applied in a cautious way because it may lead to economic contraction. Overall, the effect of the experiments on economic activity are modest but important. They can be combined to boost stronger economic expansion. Policy makers in Brazil should apply redistributive and investment policies (e.g., industrial policy) to trigger economic growth.

4 CONCLUSIONS

This paper has introduced a three sector model to assess the interrelations among the formal, the informal and the energy–provider sectors along the cumulative process of growth. According to the model results, we suggest that an income transfer toward formal labor has the potential to generate economic expansion in the medium run. The rise in consumption is responsible for the boost in economic activity. In the long run, redistribution might improve health and education of workers, improving their labor productivity.

The results for a rise in real investment demand indicates a modest output expansion and structural change. The fact that the Brazilian government has policy space to implement different policies, suggest that the economy could grow faster if industrial policies are applied.

Last but not least, an exchange rate shock might lead to expansion or contraction, depending the scenario adopted. In the context of an open economy, an exchange depreciation promotes modest output expansion. The impact of the exchange rate shock in the economy is limited.

The empirical results, therefore, suggest that redistributive and investment policies affect positively the Brazilian economy. The results for the three experiments indicate that these policies should be implemented. However, they are no panacea. Their impact in the economy is important but modest. Many economists overestimate the impact of these policies in the Brazilian economy.

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APPENDIX A: SAM

This paper borrows notation and methodology heavily from von Arnim and Rada (2011). The data to built the SAM comes from the System of National Accounts (SNA-IBGE, 2011) and Morrone (2012). In addition, Hallak et al. (2009) provided the estimation for the sectoral share of the informal sector in the economic activity.

In this study, the informal sector is defined as a subdivision of the household sector in the System of National Accounts - SNA, characterized by a particular way of organizing the production and an unclear division between labor and capital. This sector includes businesses that are not officially registered. Hallak et al. (2009) estimated the size of the informal sector for the aggregate economy and for ten sectors from 2000 to 2007. Informal labor has two main component parts: autonomous labor and employees without

legal contract.

In addition, the informal sector includes low productivity activities: informal activities and family farming. We assume that the informal sector uses only informal labor. These estimations for the 10 sectors were disaggregated into 12 sectors following the procedures suggested by the Brazilian Institute of Geography and Statistics.

The statistics of value added for informal activities for the 12 major sectors in 2007 are used to estimate the shares of the informal and formal sectors in 2006. It is assumed that there is no significant structural change, in terms of the change in the size of the informal sector, between 2006 and 2007.

Lastly, the SAM includes two additional sectors and two households. The formal sector incorporates high productivity agriculture, industry and services. The energy-provider sector includes the production of electricity, coal, oil, and refineries. Wage shares for formal and informal workers were used to separate consumption between the households.

In summary, the Brazilian SAM for 2006 is a first attempt to measure informality and its relation to the remaining sectors. It is a relatively new SAM that incorporates three key sectors of the Brazilian economy. Despite its relative high aggregation, the SAM can shed some light on the interrelations among sectors and institutions.

THE MODEL

This section introduces the mathematical model. We borrow the model from von Arnin and Rada (2011). This is a reapplication of a model applied to Egypt by von Arnim and Rada (2011). The following two subsections present output and price equations.

The model presented in this section represents a surplus labor open economy with three sectors, three commodities, and three economic classes - a capitalist, a formal, and an informal (subsistence) household, respectively. The model can be considered structuralist because it takes into account the structural features of the economy as important determinants of its evolution. The antecedents of the model are the Taylor (1983) and Rada (2007) two-sector models.

The Social Accounting Matrix (SAM) in Table 5 shows the circular flow of income for the economy. The data comes from the System of National Accounts (SNA-IBGE, 2011) and Morrone (2012). It presents the SAM for Brazil for 2006. The Social Accounting Matrix consists of a union of both the input-output (I-O) table, which describes the inter-industry transactions in the economy, and a flow of funds table, which shows the income transfers between institutions. The columns of the matrix represent purchases and the rows represent sales. The sum of each row must be equal to the sum of each column to guarantee the national accounting condition that income is equal to expenditure.

The three sectors that are important in the analysis are the informal sector (1), the formal sector (2), and the energy sector (3). The former produces a nontradable good while the remaining two sectors produce a tradable good. They are imperfect substitutes. Private income is distributed among three classes: capitalists, workers in the formal sector, and workers in the informal sector. Capitalists save a fix proportion of their income. Workers spend almost all of their income on the consumption of both tradable

and nontradable goods, which is in agreement with the classical approach. The formal sector produces its own tradable commodity that can be exported, consumed, or invested. In this way, the foreign sector supplies intermediate inputs to the formal and energy sectors. Note that the subsistence sector[2] presents a low labor productivity level, whereas the other two sectors do not. Lastly, investment and government expenditures are treated as exogenous variables.

Two central assumptions of the model relate with the process of price formation and labor markets. The formal and energy sectors are demand–constrained; the informal sector is supply–constrained. The informal sector operates close to full productive capacity. Its price level adjusts to achieve the new equilibrium in the short. In contrast to the informal sector, the modern (formal) sector operates with excess capacity; hence, a quantity-clearing sector. Output in the modern sector changes to accommodate disturbances in other variables. Unemployment and excess of productive capacity –in the energy and formal activities– are common features of the economy.

We begin the exposition with an accounting identity. Let Y be real GDP, L an index of total employment, and J an index of aggregate energy use. Further, define labor productivity as $\xi = \frac{Y}{L}$, energy productivity as $\xi_J = \frac{Y}{J}$, and energy intensity as $\varepsilon = \frac{J}{L}$. Obviously, $\xi_L = \xi_J \varepsilon$, and log-differentiation gives

$$\hat{\xi}_L = \hat{\xi}_J + \hat{\varepsilon}, \tag{1}$$

where a "hat" over a variable indicates its growth rate. Growth of labor productivity is equal to the sum of the growth rates of energy productivity and energy intensity. In this vein, a rise in energy productivity means that the same amount of energy produces now a larger quantity of output. A decline in energy intensity implies that the average worker produces the same amount of output but uses less energy than before.

With a given technology, as defined by fixed input-output coefficients, the model is best interpreted to describe the short/medium run (between two and six years). The standard Kaldor-Verdoorn Law determines labor productivity as a function of demand. Labor productivity for the formal sector follows an extended version of the Kaldor-Verdoorn (KV) Law. It can be written as

$$\xi_2 = \delta_0 Y_2^{\delta^1} \varepsilon^{\delta^2}, \tag{2}$$

where the sub-index 2 denotes the sector, δ^0 is a parameter and δ^1 and δ^2 are the elasticities for demand and energy intensity, respectively.

Output and Employment

This subsection reveals the details of the model regarding the process of output

[2] There is no division between labor and capital income in the informal sector.

adjustment and employment. Lets begin with a closer look at the process of quantity adjustment.

Informal activity is supply-constrained; hence, the adjustment in this sector takes place through price changes. Informal real output depends on the level of capital stock. However, we abstract away from the problems on measuring capital, assuming real output, X_1, constant in the short term.

$$X_1 = \gamma K_1 = \overline{X}_1 \tag{3}$$

In contrast to informal activities, the formal and energy-provider sectors operate with excess capacity; hence, demand-constrained, functioning as quantity-clearing sectors. In the formal sector, the sum of intermediate demands, consumption (C_2), investment (I_2), government expenditures (G_2) and exports (E_2) determines real output (X_2).

$$X_2 = \sum_j^3 a_{2j} X_j + C_2 + G_2 + E_2 + I_2 \tag{4}$$

Where total consumption of the formal good, C_2, results from adding the consumption by formal and informal households. The notations (subscript and superscript) in this section are based on (are similar to) von Arnim and Rada (2011). The element a_{ij} (i,j= 1,2,3) represents a technical coefficient; the term input-output coefficient is also used. For instance, the element a_{22} measures a fixed relationships between the formal sector's output and its own produced inputs. In this sense, $a_{22}X_2$ represents intermediate sales of the formal sector to itself.

Analogous to the formal sector, the energy's real output, X_3, can be formalized as follows:

$$X_3 = \sum_j^3 a_{3j} X_j + C_3 + G_3 + E_3 + I_3 \tag{5}$$

Value added is proportional to supply. The share of value-added in real output are presented below:

$$\nu_j = \frac{Y_j}{X_j} = 1 - (\sum_i^3 a_{ij} + t_j^X + f_j e) \tag{6}$$

where f_j, $f_j = \frac{M_j}{X_j}$, and e, stand, respectively, for the share of imports in supply and nominal exchange rate. Notice that for the informal sector the last term, $f_j e$,

should be dropped since the informal good is nontradable.

An alternative to express, formally, the value added of the informal sector can be found below. The value added in this specific sector is a function of the interaction between labor employed and productivity. Considering labor productivity equals to its value-added divided by labor, or $\xi_1 = Y_1/L_1$, we can rewrite the equation as:

$$Y_1 = \xi_1 L_1 \tag{7}$$

Additionaly, the model has exports and imports as endogenous variables that respond to price and output changes. The two equations are presented below:

$$E_j = \chi_j^0 (\rho_j)^{\chi_j} X_j^f \tag{8}$$

$$M_j = \phi_j^0 (\rho_j)^{-\phi_j} X_j \tag{9}$$

where ρ_j, $\rho_j = \frac{eP^*}{P_j}$, is the real exchange rate and X_j^f is the foreign demand for the modern sector goods. The parameters ϕ_j and χ_j stand, respectively, for exports and imports' trade elasticities.

Investment and government expenditure are exogenous variables. Consumption follows from standard Linear Expenditure System (LES). The fraction of income spent in the three goods (informal, formal, and energy) from modern sector workers and the fraction of income spent in the modern good by workers in the subsistence sector depend on budget shares and Engel elasticities. Capitalist profit—profits from activities 2 and 3 plus savings— is taxed at the rate t^C.

The labor market captures the features of a surplus labor economy. Unemployed labor can find work in the informality. Informal sector serve as a reservoir of labor, expanding and contracting according to the phase of the business cycle. The transfer of workers from informal to formal sectors leads to a rise in average labor productivity in the whole economy. With a higher capital-labor ratio and access to capital, formal activities can make any transferred worker more productive. Formally, the level of informal employment follows below:

$$L_1 = L - L_2 + L_3 \tag{10}$$

where L stands for the exogenous labor force.

In contrast to informal sector, the remaining two sectors present a pro-cyclical labor demand. In other words, employment in these sectors rise with demand. The relationship is defined as

$$L_j = \frac{Y_j}{\xi_j} \tag{11}$$

for j=2,3. ξ_j represents the labor productivity.

To recap, formal and energy activities are demand constrained while the informal behaves as a supply-constrained sector. Labor can find work (jobs) in the informal sector, so only underemployment is a feature of the model. Additionally, exist a pro-cyclical labor demand in modern and energy activities.

Prices and Distribution

The model contains three output prices (P_1, P_2, P_3), three value added prices (Z_1 , Z_2, Z_3), two profit rates (r_2, r_3) and three wages (w_1, w_2, w_3). Let us begin with the analysis of sectoral prices for sector 1.

Informal sector's output price responds to demand. Output prices in this sector, P_1, clears excess demand because X_1 is exogenous.

$$P_1 \propto \sum_j^3 a_{1j} X_j + C_1 - X_1 \tag{12}$$

Further, value added price (Z_1) for the informal sector can be described as:

$$Z_1 = \frac{(1-a_{11})P_1 - a_{21}P_2 - a_{31}P_3}{\nu_3}, \tag{13}$$

the equation is an accounting relationship to clear the cost decomposition.

The labor remuneration in the subsistence sector is $w_1 = \xi_1 Z_1$; hence, lacks a clear distinction between capital and labor income in this sector. The transfer of workers from the informal sector, a low labor productivity sector, to the formal sector, a high labor productivity sector, leads to a rise in average labor productivity in the economy. Wages for the remaining sectors are exogenous.

In contrast to informal activity, the formal sector price, P_2 , is established by an accounting relationship. Different from the informal sector, this price is cost-determined, mathematically expressed as a weighted average of cost components (von Arnim and Rada, 2011). Using the variables introduced previously, the function is presented below.

$$P_2 = \frac{a_{12}P_1 + a_{32}P_3 + \nu_2 Z_2 + f_2 e}{1 - a_{22} - t_2 X} \tag{14}$$

Where $t_2 X$ stands for government tax on the production of the formal good.

In the same fashion, the energy sector price is given by the equation that follows.

$$P_3 = \frac{a_{13}P_1 + a_{23}P_2 + \nu_3 Z_3 + f_3 e}{1 - a_{33} - t_3 X} \tag{15}$$

To include intermediates into the model, we need to incorporate value-added prices of the two remaining sectors. In this sense, Z_2 represents the value added price for the formal sector, and Z_3 stands for the energy value added price. Since we consider the formal and energy sectors labor-output ratio, b_2 and b_3, fix, their net price Z_j responds to changes in wage and profit share. They are two behavior functions. The respective equations for $j = 2,3$ are presented below:

$$Z_j = \frac{1}{(1-\pi_j)} \frac{w_j}{\xi_j}. \tag{16}$$

In conclusion, P_2 and P_3 respond to costs, Z_1 reacts to changes in the excess of P_1 over sectoral costs, and Z_2 and Z_3 react on changes in the functional distribution of income.

Finally, the aggregate price for the economy, the GDP-deflator, is calculated as a Fisher index[3] of the three sectoral prices. It is estimated as the square root of the multiplication of Laspeyres and Paashe indexes, considering sectoral value added prices and quantities pre- and post-shocks.

Consumer Demand Equations

As we indicated before, we have in our model three classes. Workers save a small fraction of income while capitalists do not consume. Capitalists face no trade-off between consumption and savings. Their income is $Y_\pi = \pi_1 Z_1 Y_1 + \pi_3 Z_3 Y_3$. In this case, they save a constant fraction of their income. The equations below show that workers' disposable incomes are a positive function of wages and transfers.

$$Y_d^F = (1 - t_w - s_w^F)((1-\pi_2) Z_2 Y_2 + (1-\pi_3) Z_3 Y_3 + TRF) \tag{17}$$

$$Y_d^I = (1 - s_w^I) Z_1 Y_1 + TRI \tag{18}$$

Where TRF and TRI stand for income transfer to formal and informal workers, respectively.

Consumer demand functions for three goods are derived from the utility maximization process at the individual level. Workers consume a minimum floor-level, θ, which is insensitive to income and prices. The lower the floor-level consumption of the

[3] The procedure to estimate the GDP-deflator is based on von Arnim and Rada (2011).

subsistence (informal) good, the higher the demand level for the formal and energy good. For the formal household (F), the demand equations appear bellow:

$$C_2^F = \frac{c_2^F (DY_F - P_1\theta)}{P_2} \tag{19}$$

$$C_3^F = \frac{c_3^F (Y_d^F - P_1\theta)}{P_3} \tag{20}$$

$$C_1^F = (c_2^F + c_3^F)\theta + (1 - c_2^F - c_3^F)\frac{Y_{dF}}{P_1} \tag{21}$$

TABLES

Table 1

Average GDP growth rate for Brazil during 1970-2009.

	1970-79	1980-89	1990-99	2000-09
Brazil	8.789	3.022	1.645	3.33

Source: Instituto de Pesquisa Econômica Aplicada (IPEA).

Table 2

Inequality in Brazil (Gini index), 1985-2009.

	1990	1995	2001	2005	2009
Brazil	0.614	0.601	0.596	0.569	0.543

Source: Instituto de Pesquisa Econômica Aplicada (IPEA).

Table 3

Land distribution in Brazil, 1967-2000.

	1967	1972	1978	1992	1998	2000
Brazil	0.836	0.837	0.854	0.831	0.843	0.802

Source: Instituto Nacional de Colonização e Reforma Agraria (INCRA).

Table 4

Informality in Brazil (percentages), 2003-2007.

	2003	2004	2005	2006	2007
Brazil	54.3	53.7	52.9	52	50.7

Source: Instituto de Pesquisa Econômica Aplicada (IPEA).

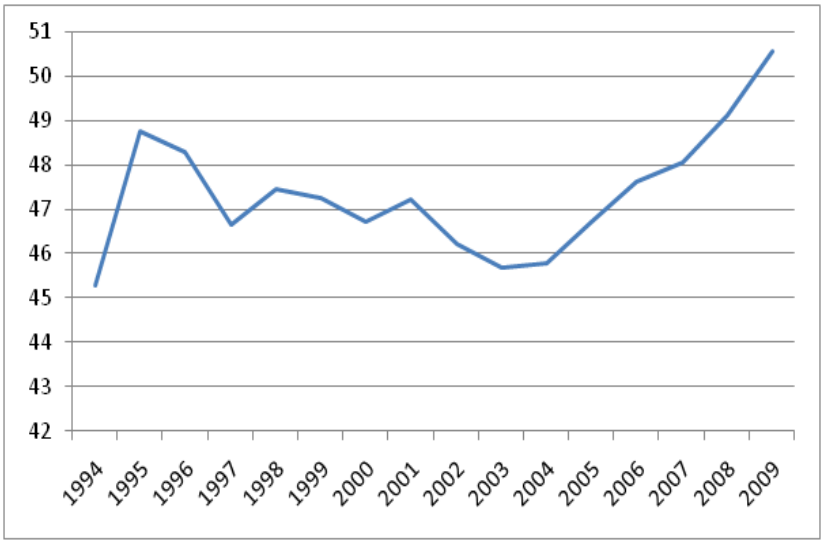

Figure 1: Wage share (% of GDP).
Source: Instituto Brasileiro de Geografia e Estatística (IBGE).

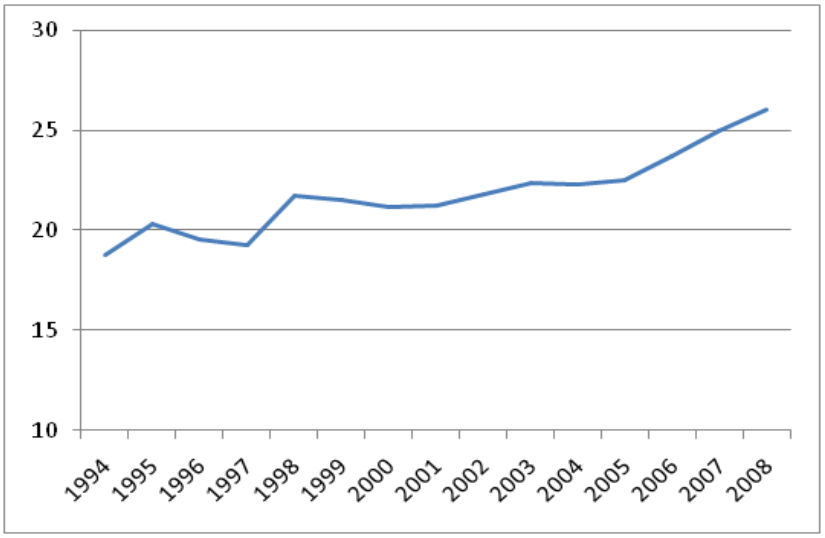

Figure 2: Social spending (% of GDP).
Source: Economic Commission for Latin America & the Caribbean (ECLAC).

Table 5: Social Accounting Matrix (SAM) for Brazil 2006.

SAM	Interm. Consumption			Demand						
				HH		HH				
	F	I	Energy	Formal	Business	Informal	GOV.	Exports	Inv.	Total
Formal	989274.4	133632.0	51022.1	854477.5		233628.4	473588.2	291909.8	371568.0	3399100.4
Informal	179803.3	25998.5	10264.9	123390.8		34083.1				373540.6
Energy	120235.5	18443.5	105236.1	61815.0		17074.6	3.0	22119.6	545.6	345473.0
Labor (F)	959345.5		27498.0		209031.5		118896.2			1314771.2
Business (F)	728797.0		96201.0							824998.0
Labor (Inf.)		195466.5			73443.5		41774.4			310684.4
Government	188522.8		16693.9	186563.6	138740.0			26427.5	24913.4	581861.2
Imports	233121.9		38557.1							2716.8
Savings				88524.3	403783.0	25898.3	-52400.6	-68778.0	-397027.0	0.0
Totals	3399100.4	373540.6	345473.0	1314771.2	824998.0	310684.4	581861.2	271679.0	0.0	

Table 6: Simulation Results.

	Demand			Transfers			Exchange rate		
	A rise in real investment (1% of GDP)			A rise in transfers to formal workers (1% of GDP)			10% nominal exchange depreciation (rise)		
	1	2	3	1	2	3	1	2	3
Macroeconomic statistics									
Real GDP growth	1.3	1.4	1.5	1.10	1.18	1.19	-2.1	-2.2	1.0
Inflation	0.7	0.1	0.1	0.8	0.3	0.3	-0.5	0.0	0.1
Real exchange rate	-0.7	-0.1	-0.1	-0.8	-0.3	-0.3	10.6	10.0	9.9
Private balance (Δ in % pts of GDP)	-0.6	-0.7	-0.6	0.4	0.3	0.3	-0.7	-0.7	0.2
Public balance (Δ in % pts of GDP)	0.4	0.4	0.4	-0.5	-0.5	-0.5	-0.5	-0.5	0.3
External balance (Δ in % pts of GDP)	-0.2	-0.3	-0.2	-0.1	-0.2	-0.2	-1.2	-1.2	0.4
Employment share of formal sector (Δ in % pts)	1.2	0.7	0.8	1.0	0.6	0.6	-1.8	-1.3	0.5
Output share of formal sector (Δ in % pts)	0.1	0.1	0.2	0.1	0.1	0.1	-0.1	-0.1	0.2
Productivity									
Formal sector (excludes energy-provider sector)									
Labor productivity growth	0.0	0.7	0.7	0.0	0.6	0.6	0.0	-0.7	0.6
Informal sector									
Labor productivity growth	8.2	4.8	5.1	6.5	3.9	3.9	-10.1	-7.8	2.8
Key parameters									
Trade price elasticities (formal activity)	0	0	0.75						
Kaldor-Verdoorn elasticity	0	0.35	0.35						
Energy intensity elasticity	0	0.20	0.20						

This table shows results for three shocks: an investment, An income transfer towards formal workers in the formal sector (excludes energy sector), and an exchange rate shock. The bottom of the table shows key parameters for the formal sector. Calibration (1) "turns off" labor productivity and set trade price elasticity to zero. Calibration (2) turns on only labor productivity, and Calibration (3) turns on both trade and labor productivity.

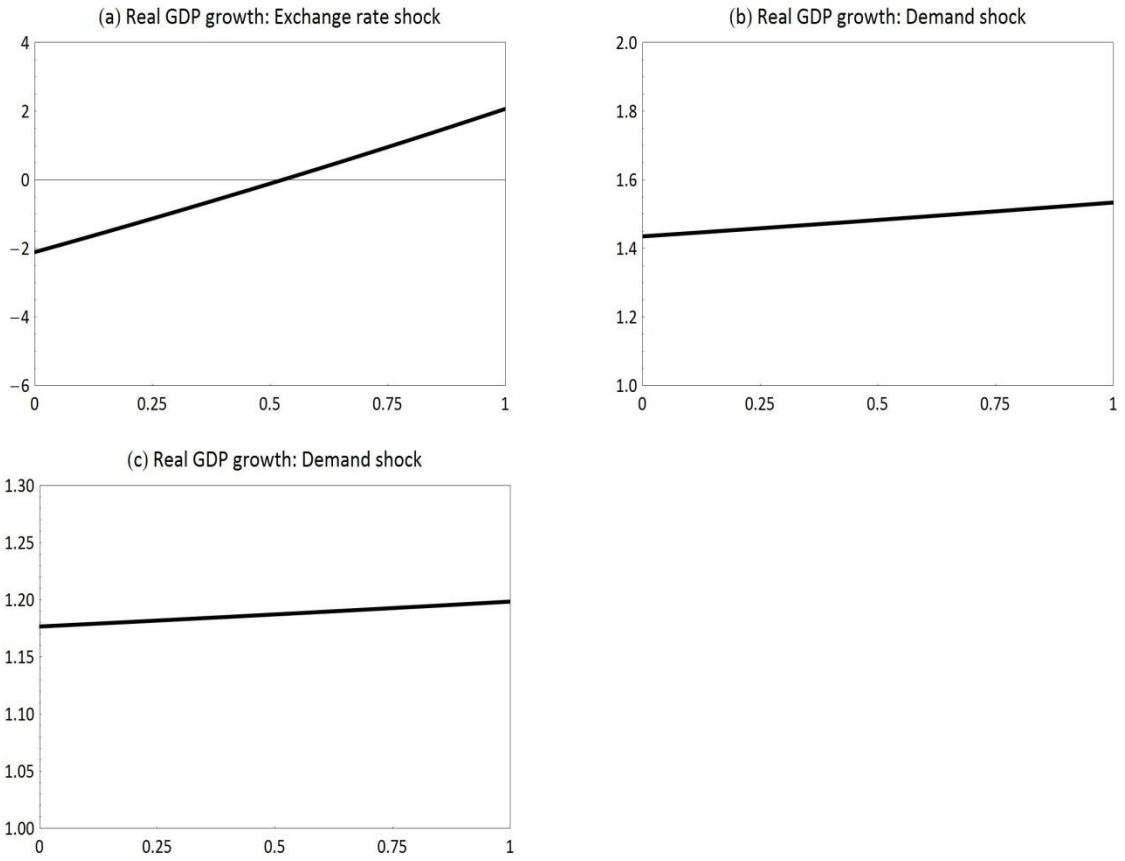

Figure 3: Sensitivity of model results to varying trade price elasticity in the formal sector. Horizontal axes present trade price elasticity for the interval [0,1]. Vertical axes GDP growth rates in percentage points.