

## A macroeconomic systemic model for the Brazilian economy

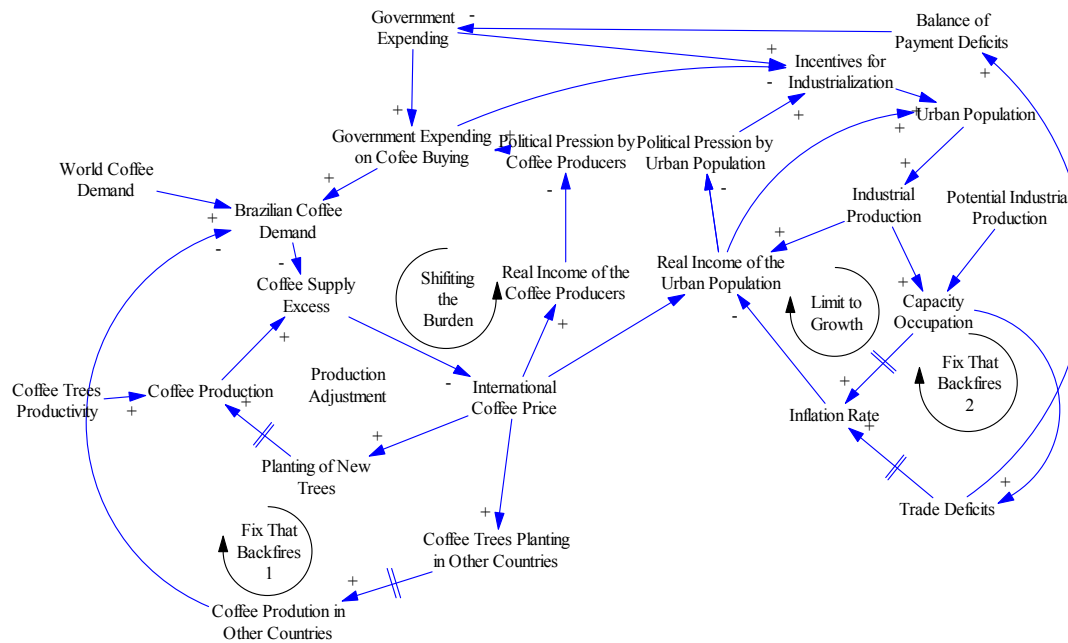
### 1 - Introduction

A systemic model is useful for mapping the future that can be expected to happen to a system based on its potentialities. Hence, the construction of sceneries as it is done in this work, is not just, and nor mainly, a process of elaboration of " menus " of probable exogenously determined states, but a simultaneous process of evaluation of potentialities and of systematic error correction, that determines in large part the destiny of the system being studied. In this work, sceneries for the Brazilian economy are built exactly in this spirit. In the first place, in section 2 of the paper, we try to identify the main long term restrictions to the growth, with base on system dynamics methodology. One of the main lessons of that theory is that the obstacles to the accomplishment of personal objectives are of endogenous nature; more specifically they occur because we insist on behaviors that aggravate the problems in the long period. In this section , it is shown that up to a certain measure that lesson can be also applied to countries. It will be suggested that the economic policies adopted to promote the industrialization in Brazil contributed to create important long term restrictions to growth, restrictions which, although still present, can probably be overcome by policies focused on leverage points. In order to identify those leverage points, a systemic macroeconomic model for Brazilian economy is built and simulated in the sections 3 and 4. In the section 5, the effects of the Lookup variables' forms on the system dynamics are analyzed. In the section 6, the effects of two competitive growth strategies are tested: in the first one, advocated by economists said to be " development oriented ", the government expenses have an important role in the stimulation of the effective demand and, in the other one , supported in general (but increasingly not only by them) by economists of more conservative tradition, the effects of an " export -led " growth strategy are simulated . The section 7 concludes the paper.

### 2 - A historical sketch

The diagram of influences below reproduces briefly the historical evolution of the Brazilian economy in the 20<sup>th</sup> century .

FIGURE 1: The Structural Restrictions for Growth in Brazilian Economy



The Brazilian economy can be characterized until 1930 as an export monoculture led economy. The last production/exports cycle - the one of the coffee - started in the beginning of the century XIX but became the dominant productive cycle of the economy only in the last 25 years of that century. In the beginning of the century XX, Brazil produced 75% of the coffee consumed in the world and the exports of this product accounted for about 2/3 of the total Brazilian exports. In a rough estimate, it is possible to say that coffee production for export accounted for direct employment of almost 15% of the economically active population. So it is understandable that the Brazilian government had adopted politics of protection of prices when growing stocks of the product began to accumulate in the beginning of the 20<sup>th</sup> century, in the period denominated by the historiography as The Old Republic. Three operations of this type were implemented from 1906 to 1930, and although they have differed in some important aspects, as the financing form and the intervention type, all of them sought to remove from the market coffee surplus that threatened to drastically drop the international prices. But, the problem of excess of supply was solved only in the short period; in the long term, the "valorization policy", as it was generically known, aggravated the conditions of dynamic realization of the production, because it prevented that the market signs that would suggest the need of diversification of the economic activity were transmitted to the producers. Instead, the maintenance of the international coffee price and consequently of the producer's income induced the subsequent growth of the production. A second effect contributed to make the problem progressively more serious: the fact that the valorization operations induced the increase of coffee production in competitive countries, which behaved as free-riders. It is evident that, although a commodity production as coffee is subject to endogenous oscillations due to existence of long production delays, such operations contributed to worsen the problem in the long period. The final crisis of that governance structure for the market of coffee happened when the international demand of the product dramatically decreased in consequence of the 1929' crisis.

This is also the historical bifurcation point where the country changed its previous development path based on the export agriculture in favor of the option for the industrialization. Several recent studies have suggested, however, that, more than a defined project, the industrialization impelled by the future dictator Getúlio Vargas for the next fifteen years was an unexpected consequence of the change of the incentives matrix of the economy. In short, the incentives to industry, as the offer of lines of subsidized credit and exemption of taxes, reflected more Vargas' intention of undermining his political opponents - the Old Republic elite - than a deliberate option for the industrialization of the country. The resulting industrial growth, however, stimulated the urbanization of the country and created the conditions for, as it was said by one of the most important Brazilian economists, Celso Furtado, the "displacement of the dynamic axis of the economy".

But already at the end of the "first Vargas" period, 1930-1945, a problem began to occur that would become recurrent in Brazil: the industrial growth, after a relatively easy first phase in which the "low-hanging fruits were picked", came down due long term restrictions to growth, such as low educational levels and several types of institutional restrictions. When these limits begin to appear, the imports starts to grow faster, generating deficits into the external accounts of the country, what forces the adoption of exchange-rate devaluations or of policies of reduction of domestic absorption of GDP, which are of recessive nature, in order to reduce the imports and to liberate a larger portion of the gross domestic product for exports.

In the first case, the inflation accelerates, reducing the real income of the urban sectors (which do not get, as the coffee planters do, the favorable effect of the exchange-rate devaluation on the internal price of the exported coffee). This induces those sectors to demand for nominal readjustments of the incentives, as reductions of the interest rate and increase of the credit, restarting the cycle marked as Limit to Growth in the diagram. In the second case, the dissatisfaction of the urban sectors with the reduction of the incentives for the industrialization forces the re-establishment of the level of government expenses. The consequences of both strategies is to accelerate inflation rate and/or to produce exchange-rate crises.

All the governments after 1945, including a second mandate of Vargas, have always been subject to the above two restrictions: to maintain the support of their political basis they had to maintain increasing government expenses. But in each presidential cycle the limits to the growth became progressively more restrictive. An especially instructive example was what happened during the Juscelino Kubitschek's government (1956-1961). Seeking to accelerate the rate of growth of the economy - his government slogan was "50 years in 5" - a series of ambitious goals were placed by the president, of the which most of them he indeed accomplished, as the construction of a new capital in the geographic center of the country. As he didn't have politic support to reduce the privileges that the traditional agents of the Brazilian politics historically enjoyed, he simply created a parallel structure to carry on the programs of industrialization and of investments in infrastructure. The final result, although his government is still reminded by the older Brazilians as an extremely favorable period in terms of economic growth, was an exchange rate crisis of great proportions in the final years, which eventually forced him to break up, with great popular support, with the International Monetary Fund and later to a further acceleration of the inflation rate. Three years after the Kubitschek government's end, and counting with high support of the urban middle classes, the military gave a coup d'état which removed the last populist president. This period of military dictatorship would last for 21 years and, during that period, the country's GDP increased at high rates, mainly in some periods as

between 1967 and 1973, denominated as "The Brazilian Miracle". The accelerated growth, however, was not accompanied by significant improvements for the poorer population income, what explains why the Brazilian national income has become one of the most concentrated of the world, a characteristic that is still present. The basic strategy adopted by the military to promote the growth, favored then by the high degree of international liquidity, was to increase the potential product of the economy through National Plans of Development, that sought to induce the domestic production of some vital imported inputs – such as petroleum, paper and cellulose and chemical products. The political repression to unions and progressively to other institutions of the civil society allowed to contain the urban workers' claims for nominal income adjustments and therefore "to buy" the necessary time to increase the potential product without accelerating the inflation rate.

But before that could fully happen, the developing countries' debt crisis, induced by the increase of the international interest rate at the beginning of the decade of 1980, interrupted the growth cycle that had begun at the end of the seventies. As the international loans to finance the development plans (and to pay the rising prices of petroleum imports during the period) had been contracted on variable interest rates basis, the explosive growth of the debt service led to a serious balance of payments crisis in 1982, what practically imposed, besides the recessive policies, maxi-devaluations of the exchange rate in order to reduce GDP's domestic absorption. The consequent elevation of the inflation rate led to the adoption of stabilization heterodox plans (named in this way because they involved prices and wages freezes to eliminate inflationary inertia transferred from the past for indexation mechanisms, then omnipresent in the Brazilian economy) that marked the second half of the eighties and the first years of the nineties.

The adoption of those economic plans, although having success in containing the inflation during short periods (the longest period of price stability was produced by the first of them in 1986 and it lasted only one year), disorganized the economy, accelerating the future expectations of inflation, worsening the long period state of expectations, and therefore reducing drastically the growth rate of the productive investments. The result was that what is called in the literature "the lost decade", years in which the economic growth was not just extremely low by previous patterns, but the inflation accelerated, reaching the threshold of a real hiper-inflation. In 1994, the inflation was finally controlled, but the economic growth continued unsatisfactory, for a country that must generate a million and half of employments every year just to employ the youths that come to the job market for the first time. Some data help to understand why the decade of 1980 (and in many senses the decade of 1990 as well) can be considered as being lost in terms of growth.

	Per Capita Growth (Annual Average)	Inflation Rate	Total Factor Productivity (Annual Average Growth)	Productive Investments Index (Annual Average Growth)
1980s	-0.4	336.4	-2.62	-1.2
1990s	1.3	199.9	0.37	-1.3

Sources: columns 1,2: Fraga (2004); column 3: Pessoa (2003); column 4: IPEADATA

The unfavorable economic results in the second half of the decade of 1990 can be explained, at least partially, according to our second hypothesis mentioned above, by the maintenance of a over-valuated exchange rate in order to contain the inflation.

The low growth rate of the potential product and the resurgence of popular pressures for improvements in real income would have turned fruitless the attempts of controlling the inflation, without the growing resource to imports. The high degree of international liquidity was an incentive for the adoption of an over-valuated exchange rate as an "anchor" for the anti-inflationary program named "Plano Real" (The Real Plan) and made possible sustain the price stability in the second half of the decade de 1990. But the increasing trade deficits implicated in progressive elevations of the domestic interest rate in order to attract foreign capital what restricted the economic growth, as it had already happened in several other periods of the Brazilian economic history. .

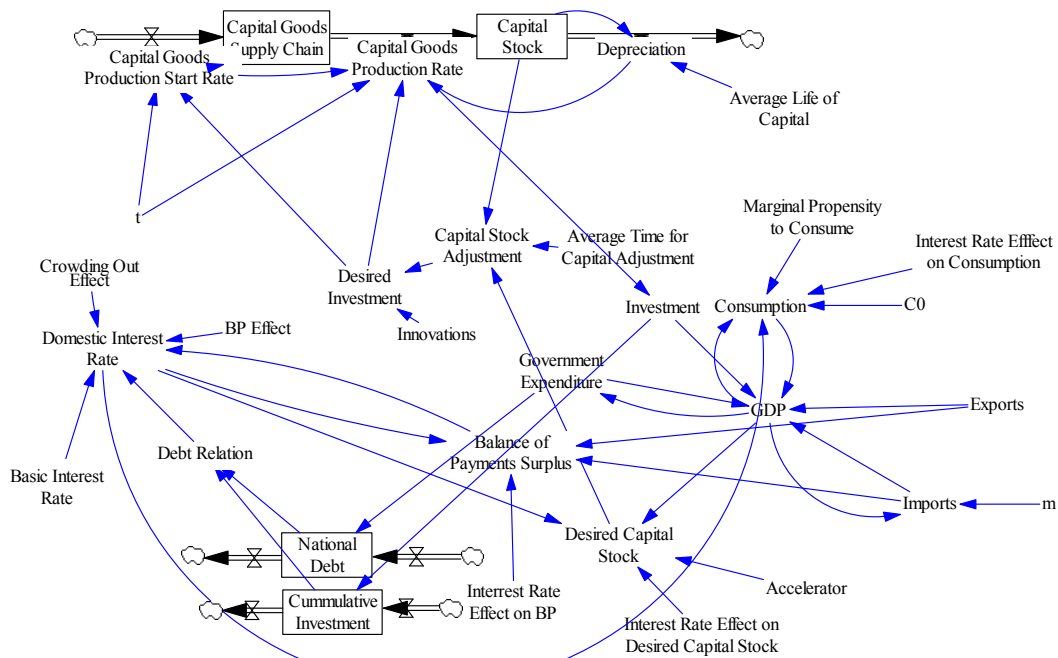
The evolution of the Brazilian economy in the present decade reinforced the previous tendencies, but with a further difficulty. The enlargement of minimum income programs for the present government (president Lula) became an important potential source of inflation and therefore an obstacle to the economic growth, because larger incentives to the industrialization (as more aggressive reductions of the interest rate) would implicate either in the resurge of the inflation or in a threat for the Balance of Payments equilibrium.

It seems therefore that the current situation of low economic growth cannot be reverted without the adoption of effective strategies for the relaxation of the Limit to the Growth restriction represented in the diagram. Several possibilities for that have been studied by Brazilian economists, as the intensification of the investments in human capital and physical infrastructure, institutional reforms in the bank system and social security institutions, which could reduce the long term interest rate, stimulating the productive investment, and labor and tributary reforms, that could contribute to reduce the costs of the work and so increase the employment level of the economy. However, a lot of doubts still remain on the leverage potential of those strategies; the preliminary model presented in the next section can contribute for that discussion.

### 3 - The simulation model

The model can be decomposed in three main blocks. In the first, in the lower left side of the Figure 2, it is specified that the National Income is determined by the sum of Consumption of the Families, Government Expenses, Investment and net Exports, such as in the simple Keynesian model.

FIGURE 2: The Macroeconomic Systemic Model for the Brazilian Economy



The specifications of the functions are the usual ones, but it should be observed that the system dynamics notation is used in order to test the effect of different policy regimes on the paths of the simulated dependent variables. The function of Imports, for instance, is defined as:

$$\text{Imports}(t) = m * \text{National Income}(t) + \text{PULSE}(t_i, d_i) * i$$

This specification means that the Imports are proportional to the National Income, but they suffer an increment of  $i$  Billions of Real (the Brazilian currency), starting from the year  $t_i$  and lasting for  $d_i$  years.

The investment function modeling, done in the second block, is crucial for the model in several senses. In the first place, the investment decisions should contemplate in some measure the variations in the consumption in the recent past; in the second place, such decisions should be influenced by the capital cost and thus by the interest rate; in the third place, they become effective investments after a delay time. In the last place, the investment decisions should be influenced by the process of technological innovation, that makes old equipments obsolete.

To model the effect of the Consumption on the Investment, a simple version of the accelerator mechanism is used in which variations of the consumption induce variations in the stock of capital desired, and by this way in the requests of new capital goods.

The interest rate influences the investment decisions in a non linear way, so that small variations, that are irrelevant in the short period, can influence another variables which will affect investments in the future in a more important way. The methodology of system dynamics allows to model those relationships in a quite convenient way through variables Lookup.

The influence of the interest rate on the Desired Additional Capital Stock was modeled in the following way:

Desired Additional Capital Stock(t) = IF THEN ELSE [ C(t) - C(t-1) >=0 , (C(t) -C(t-1) ) \*Accelerator \* Interest Rate Effect on Desired Capital Stock (Domestic Interest Rate(t)) , (C(t) -C(t-1) )\* Acelerador \*1/ Interest Rate Effect on Desired Capital Stock (Domestic Interest Rate(t) )]

In which the specification IF THEN ELSE was used to avoid that the beneficial effect of low interest rates over the desired additional capital could amplify erroneously the negative variations on Consumption.

To model the function of capital goods supply it was supposed that the investment decisions, expressed by the variable Desired Investment, reflect the objective of adjusting the stock of existent capital to the desired capital stock through the following relation:

$$\text{Desired Investments}(t) = \text{Innovation}(t) + \text{Capital Stock Adjustment}(t)$$

and

$$\text{Capital Stock Adjustment}(t) = (\text{Desired Capital Stock}(t) - \text{Capital Stock}(t)) / \text{Capital Stock Adjustment Time}$$

The first equation means that the investment decisions contemplate, on one side, the technological opportunities (or any other type of supply shock), so that the innovations induce the substitution of equipments and affect in this way the requests of new capital goods. The process of innovation generation was modeled in the following way

$$\text{Innovation}(t) = \text{RANDOM NORMAL}(-1, 1, 0, dp, 1) * r + \text{RAMP}(\text{Drift}, 0, dd) + \text{RAMP}(\text{Drift2}, dd+1, \text{final time})$$

That means that the process of innovation generation is composed by a stochastic term, with maximum and minimum values of -1 and 1, mean zero and variance  $dp^2$ , multiplied by an intensity factor  $r$ , and two terms of deterministic trend. In the argument of the first trend term, it is specified that the rate of increment of the function is given by the parameter Drift, beginning in the period zero of the simulation to the period  $dd$ ; in the argument of the second one, it is specified that, starting from the period  $dd+1$ , until the end of the simulation, the increment rate will be Drift2. This specification, as it is easy to realize and it will be shown in detail ahead, is convenient to detect the possible occurrence of structural breaks in the innovation series.

The second equation simply means that variations in the desired capital stock becomes investment decisions after a period of expectation adjustment.

The requests of capital goods can only be partially attended by pre-existent stocks; the remaining of the requests should enter in the production chain according to the following relationships:

$$\text{Capital Goods Production}(t) = \text{Capital Goods Supply Chain Stock}(t) / \text{Average Supply Line Delay Time} + (1 / (1 + \text{supply elasticity})) * \text{Desired Investments}(t) + \text{Depreciation}(t)$$

and

$$\text{Capital Goods Supply Chain Stock}(t) = \text{Capital Goods Production Start Rate}(t) - \text{Capital Goods Production Rate}(t+d)$$

Capital Goods Start Rate(t)= (supply elasticity / (1+supply elasticity))\*Desired Investment (t)

The productive chain of the capital goods involves a 1,5 year time delay, but the capital production elasticity in the short period is not zero: part of the capital goods requests can be delivered in the short period by an intensification of the production. Then, for instance, if the supply elasticity is 2, 1/3 of the requests will be delivered immediately and 2/3 will have to enter at the beginning of the productive chain. This parameter, therefore, is an indicator of the short-term elasticity of the capital goods production.

The last block of equations models the determination of the domestic interest rate under a specification of Mundell-Fleming type. The basic equations are the following ones:

Domestic Interest Rate(t)= Selic(t\* BP Effect (BP Surplus(t))/Reference Surplus) \*Crowding Out Effect(Debt Relation)

and

BP Surplus(t)= (Exports(t)-Imports(t))\*Interest Rate Effect on BP(Delayed Interest rate(t) )

The variable Selic is the Brazilian prime rate and represents the discretionary power of the monetary authority in calibrating the basic interest rate of the economy for, for instance, keeping the inflation rate under control. The second component specifies that a surplus in the balance of payments below a certain reference level (or a deficit), elevates the interest rate to attract foreign capital. The Crowding Out Effect captures the impact of the excessive amplification of demand generated by the public expense relatively to the investments. The second equation finally specifies that the elevation of interest rate increases the deficit in balance of payments after a time delay

## 4 - Results

### 4.1 - Calibration of the model

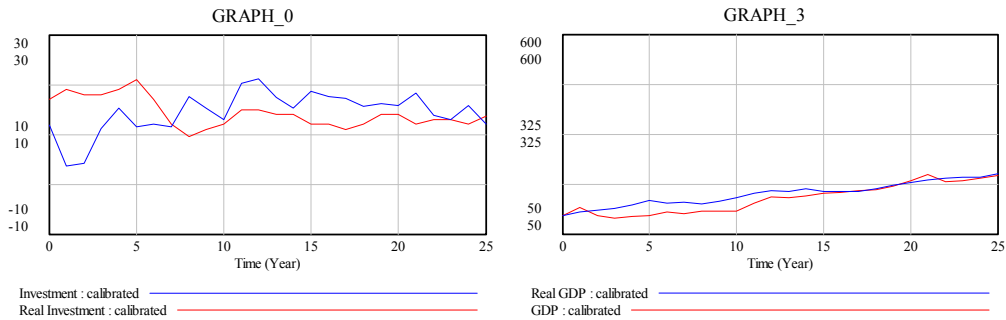
The model was calibrated for the variables Investment and National Income in the calibration period: 1975 to 2000, using the software VENSIM, whose optimization tool includes this procedure, which minimizes the quadratic total error of the estimates in relation to the real values of the variables above defined. Data were extracted from other studies for the Brazilian economy and from databases as IPEADATA. To initialize the model, the variable National Income was normalized at the value 100 and the expenditure items, in proportional values to the National Income; therefore to obtain the value in dollars of the national income, for instance for 2005, one only has to multiply the value in dollars of the national income in 1975 by the ratio Estimated National Income 2005/100. The values for the other variables in the period t can be gotten similarly using as multiplicative factor the ratio Variable Estimated Value in t/ Initial Variable Value. The following, non-directly observable, parameters were estimated for calibrating the model: accelerator; adjustment time of the capital stock; short-term elasticity of capital goods production; supply shock's intensity, standard deviation and drift; reference trade balance surplus; reference interest rate and



autonomous consumption (the model presented below and enclosed in a separated file attached include those parameters with calibrated values)

The graphs on the Figure 3 show the investment and the national income dynamics of the calibrated model during the calibration period.

FIGURE 3: CALIBRATED MODEL'S DYNAMICS

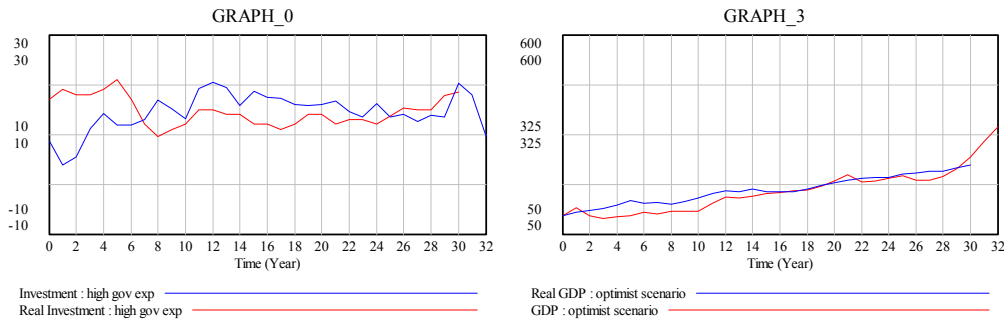


#### 4.2 - Estimation

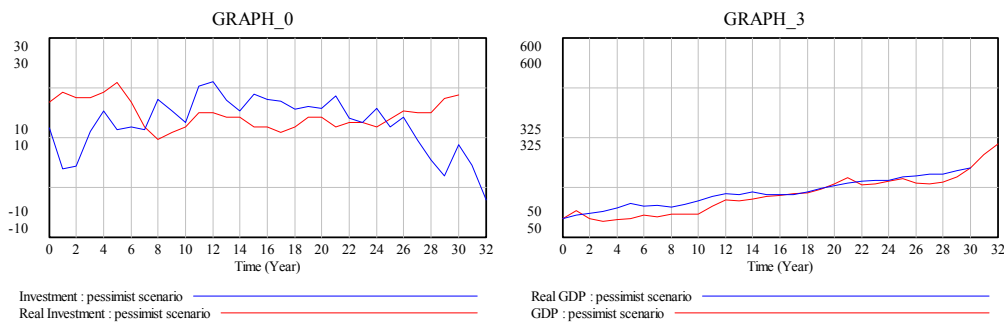
Two sceneries for the subsequent years from 2000 were built: in the first one (optimistic scenery) it is assumed that: a) the innovation process returns back to the previous drift it followed before 1994, in which a path change happened in its dynamics (this year -1994 - was obtained through the calibration procedure) and b) that the country sustains the export rate growth reached in the last years, that is significantly larger than the historical growth rate of exports. In the second scenery, it is supposed that are maintained: a) the estimated innovation drift observed in the period 1995-2000, that was considerably lower than the real one, and b) the historical rate of growth of the Brazilian exports of about 7% a.a.

FIGURE 4: SCENERIES FOR THE EVOLUTION OF THE INVESTMENT AND OF THE NATIONAL INCOME IN THE PERIOD 2005-2012

### Optimistic Scenery



### Pessimistic Scenery



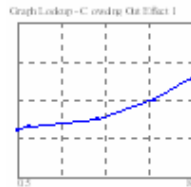
Considering the dynamics of the series of investments during the verification period, 2000-2005, the optimistic scenery seems more plausible, although the fit of the estimated GDP series to the actual GDP series is slightly better in the pessimistic scenery.

## 5 – Sensitivity Analyses on the form of the Lookup functions

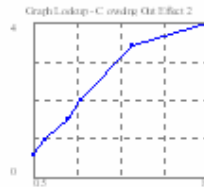
It is obvious that the right specification of the Lookup functions is important for the dynamics of the models, so it is necessary to proceed the sensibility analysis of the results to variations in the form of those functions. To evaluate the sensibility of the simulations to the form of the Lookup functions used a small change in the model is made, re-defining the function Desired Capital Stock in the following way:

Desired Capital Stock<sub>(t)</sub> = IF THEN ELSE( $C_{(t)} - C_{(t-1)} \geq 0$ ,  $(C_{(t)} - C_{(t-1)}) * p * \text{Accelerator} * \text{Crowding Out Effect 1 (Debt relation}_{(t)}) + (C_{(t)} - C_{(t-1)}) * (1-p) * \text{Crowding Out Effect 2 (Debt Relation}_{(t)})$ ,  $(C_{(t)} - C_{(t-1)}) * (p) * \text{Accelerator} * 1 / \text{Crowding Out Effect 1 (Debt Relation}_{(t)}) + (C_{(t)} - C_{(t-1)}) * (1-p) * 1 / \text{Crowding Out Effect 2 (Debt Relation}_{(t)})$  )

That means that the interest rate effect on the Desired Capital Stock is given by the weighted mean of the two Lookup functions bellow (the weights in the formula were obtained in the procedure of calibration of the model).



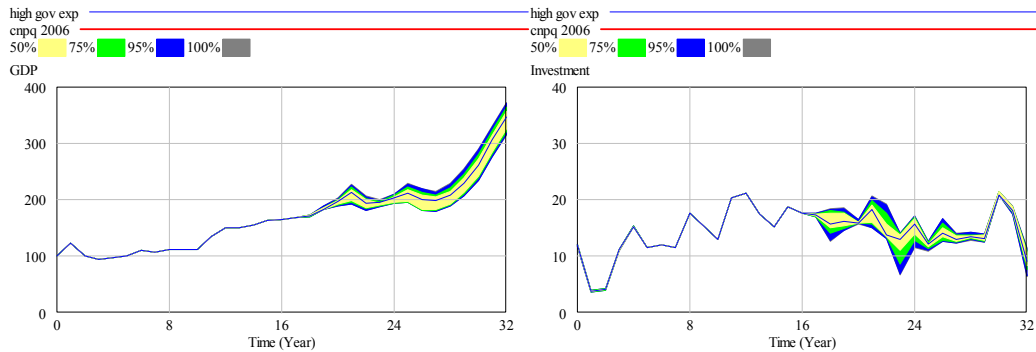
Indifferent to Risk Agents



Averse to Risk Agents

This is equivalent to presuppose the existence of two classes of agents in the economy: averse and indifferent to the risk, that respond to the variations on interest rates as specified above by the Lookup functions. Those classes comprehend, respectively,  $p$  and  $(1-p)$  of the total agents. That formulation allows to proceed to sensibility analyses as in the Figure 5.

FIGURE 5: SENSIBILITY ANALYSES FOR THE FORM OF LOOKUPS FUNCTIONS

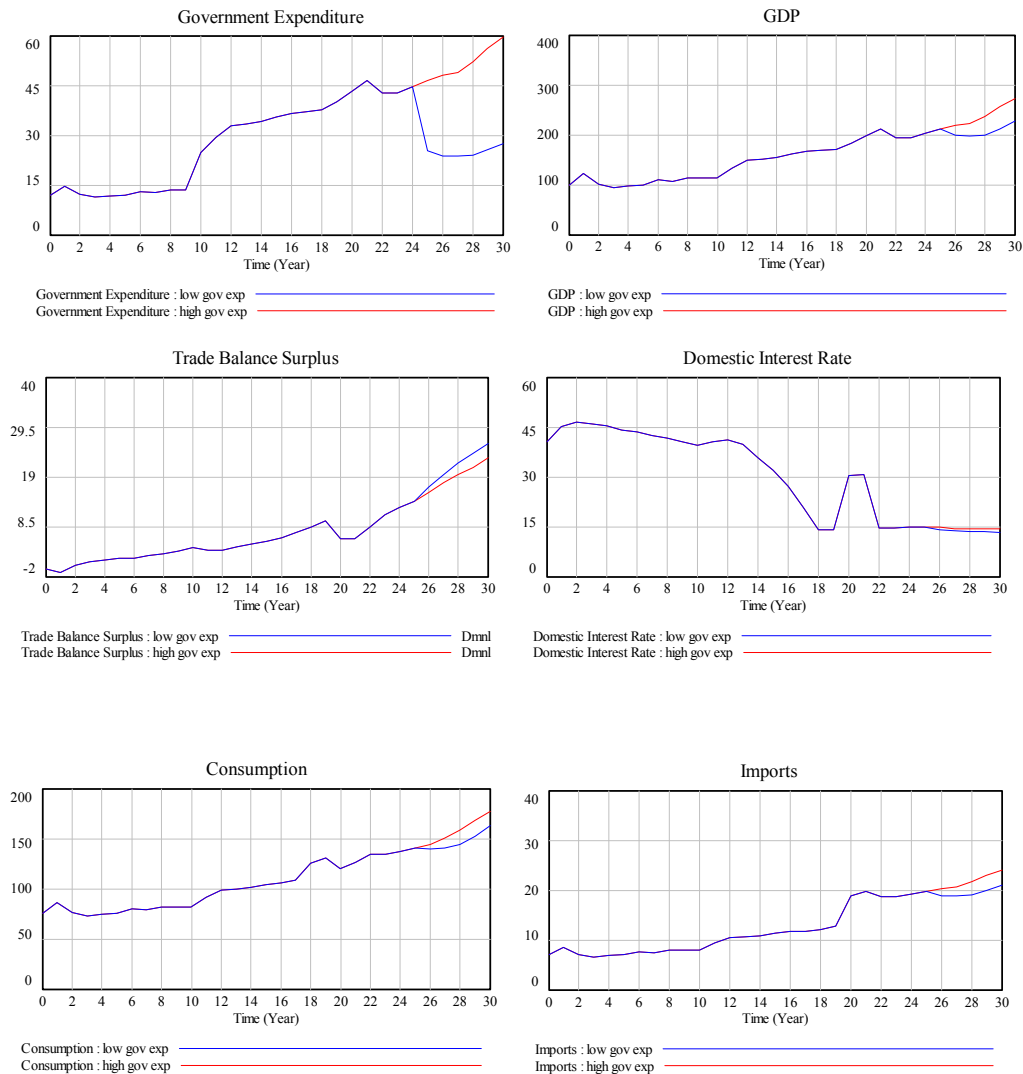


The sensibility analysis indicates that the dynamics of the series is not significantly affected by variations in the parameter  $p$ , that results in the final form of the lookup function employed

## 6 – Economic Policy's Effects Simulations

From 2000 on, the governments Fernando Henrique Cardoso (1994-2002) and Luís Inácio Lula da Silva (2003 -) began to adopt restrictive fiscal policies with the objective of reverting the explosive growth of the public debt. The main element of those policies was the generation of primary superavits of about 4,5% of GDP. As in several moments that strategy was criticized with the argument that it was responsible for the low GDP's growth rates in the period, it is of interest to analyze if it would have been really as important as those critics believed. In the Figure 6, simulations for the two following sceneries are presented: a) high government expenditures: in which it is simulated the effects of a less restrictive monetary policies, in which the government expenses would have maintained, in the period 2000-2005, the same 2000 participation in GDP and b) low government expenditures, in that the model is simulated for the lower levels of government expenses really practiced in that period.

FIGURE 6: Two Sceneries for the Fiscal Policy

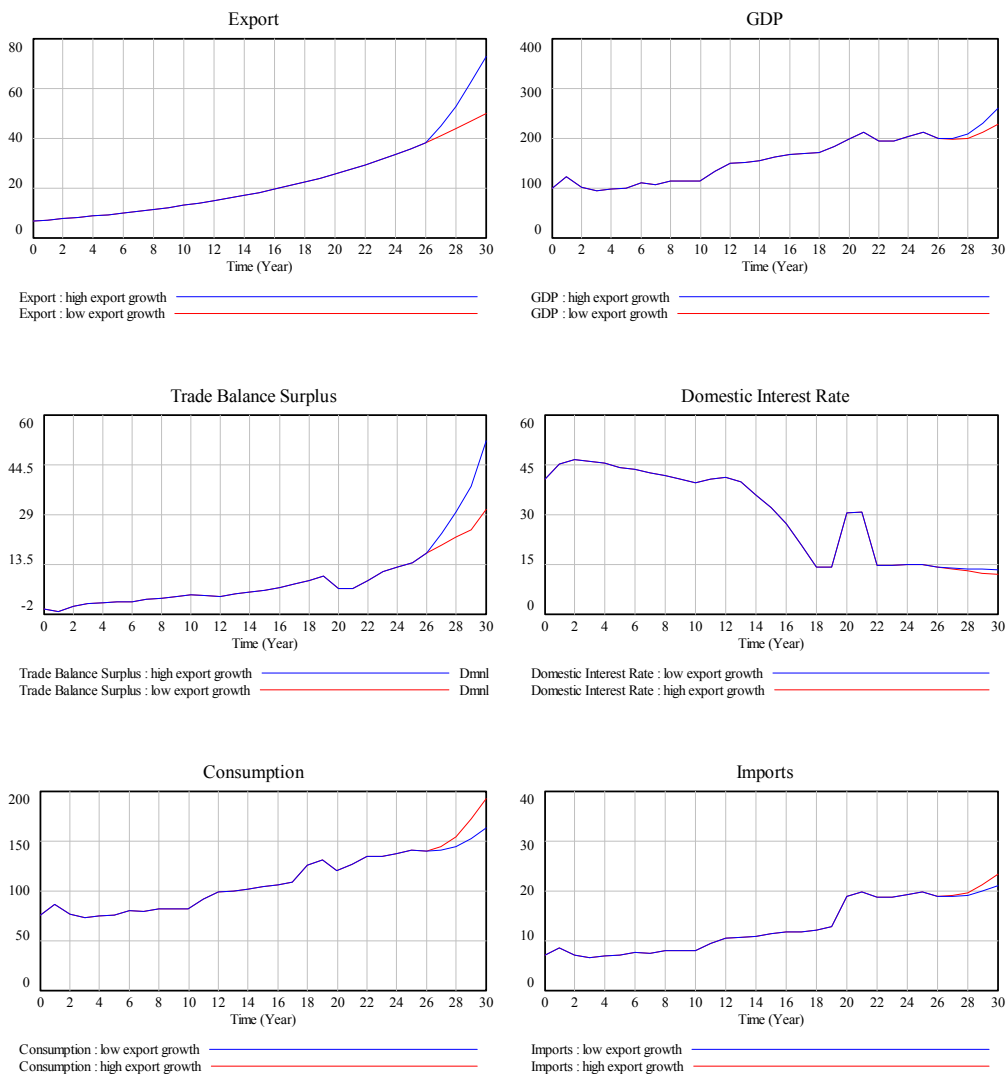


The conclusion is that the effects of a less restrictive monetary policies would have been probably important - the national income would be 16% larger in 2005 in this case, but that would be true only if all the other exogenous variables were kept constant. Note, however, that this policy would have led to less favorable results into the external accounts, what could have generated instability in the external flow of capitals and, consequently, significant reduction in the National Income growth rate above mentioned. The low relative leverage power of a less restrictive fiscal policy becomes clearer when its results are compared with those of a more aggressive export

strategy. In the Figure 7, two sceneries are compared. In the first - high export growth - the effects of the elevation of the rate of growth of the exports for 16,5% per year in the period 2000-2005 (almost nine percentile points above the historical rate of growth of this rate) are reproduced. In the second - low export growth - it is simulated what would have happened with some variables of interest without that increase in export growth rate - something that certainly would have happened if the government had practiced a less restrictive monetary policy.

The main difference in relation to the previous sceneries is that, with the increase in the exports, the economic growth becomes compatible with the generation of a rising superavit in the trade balance, what is a sine qua non condition for a sustained growth in countries like Brazil.

FIGURE 7: Two Sceneries for the Trade Policy



## 7 - Summary and Conclusion

It was shown that a simple systemic model is able to “imitate” the behavior of a complex economy, a result that has been surprising for an increasing number of

economists that use simulation techniques to study economic dynamics . But the fact of being capable to do this should not be considered as an evidence of its validation in any absolute sense. More important than that, however, is to verify if it captures important characteristics of less developed economies as the Brazilian one. The main ones are:

1) the short term growth rate is influenced in an important way by the effective demand; in the medium term, however, the growth is restricted by real factors such as the capital stock and the capacity to import ;

2) attempts of growing above the rate allowed by those restrictions accelerate the inflation rate or provoke unbalance in the balance of payments;

3) in both cases, the government is forced, earlier or later, to adopt restrictive monetary policies to reduce the final demand growth rate, reducing the domestic absorption of resources

4) an important leverage point to reach a sustainable growth path is to create conditions for a consistent increase of the exports. The reason is that, differently of the growth induced by public expenses, the increase of exports generates international currency that can be used to finance the indispensable imports to sustain the growth process in the long period. That is, the growth of the exports allows increasing the employment level internally without pressing the inflation rate (because the imports can grow along the process) and without generating external unbalance;

5) the growth of exports in the medium term, however, requires significant investments in competitiveness acquisition, without which the country will be limited to sell products in international markets already saturated such as the one of commodities and, therefore, with limited growth potential.

The model presented, although it still needs to be largely improved, seems to be consistent with those general characteristics of the Brazilian economy and it seems to be capable, above all, of throwing some light in the current discussion, in large part inconclusive, on how to rediscover the road of economic growth, which for a long time seemed to be the natural state of our economy but was lost since the decade of 1980.

#### References

PESSOA, S.A (2003) A experiência de crescimento das Economias de mercado nos últimos 40 anos. Graduate School of Economics, Getúlio Vargas Foundation: Rio de Janeiro.

FRAGA, A. (2004) Latin America since the 1990s: rising from the sickbed? *Journal of Economic Perspectives*, vol. 18 (2), Spring.

IPEADATA Instituto de Pesquisa Econômica Aplicada. [www.ipeadata.gov.br](http://www.ipeadata.gov.br)