Artigos

Business cycles in a small open Brazilian economy*

Fabio Kanczuk§

RESUMO

Desenvolve-se um modelo de equilíbrio geral dinâmico para uma economia pequena e aberta com o intuito de investigar quais as combinações de preferências e distorções que melhor mimetizam os ciclos reais brasileiros. Encontra-se que as preferências propostas por Greenwood, Hercowitz e Huffman (1988) em associação com custos de ajustamento de capital geram dados simulados consistentes com as volatilidades das contas nacionais e com o caráter contracíclico da balança comercial. As preferências padrão (Hansen, 1985) e custos de transação em mercados de capital são, em contraste, inconsistentes com várias propriedades dos dados.

Palavras-chave: custos de transação no mercados de capital externo, custos de ajustamento de capital.

ABSTRACT

We develop a dynamic general equilibrium model for a small open economy to investigate which combinations of preferences and distortions better replicate the Brazilian business cycles. We find that the preferences proposed by Greenwood, Hercowitz and Huffman (1988) in association with capital adjustment costs generate simulated data consistent with the cyclical volatilities of the national income accounts identity as well as with the countercyclical nature of the trade balance. The standard (Hansen, 1985) preferences and foreign capital markets transaction costs are, in contrast, largely inconsistent with many data properties.

Key words: transaction costs in foreign capital markets, capital adjustment costs.

JEL classification: E32, F32.

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* I acknowledge with pleasure, but without implication, discussions with Laura Alfaro, Celso Toledo, Chico Faria Jr. and Genilson Totó Santana, and the comments of an anonymous referee.

§ Dept. of Economics, University of São Paulo, Brazil.

Recebido em janeiro de 2001. Aceito em maio de 2001.

1 Introduction

To a large extent, the success of modeling the United States via Real Business Cycle (RBC) models has not been accompanied by models for other countries. In fact, there are serious doubts whether simple RBC models can be helpful explaining the behavior of less developed countries, since most of these economies have features that are very difficult to capture in simple dynamic setups (see Backus *et al.*, 1992). Together with a few notable exceptions,[1] this paper is an attempt to remedy this omission.

In particular, in this paper we summarize the main features of business cycles for Brazil, and discuss the extent to which these features can be rationalized on the basis of a simple stochastic general equilibrium model. We pay special attention to the trade balance properties to determine what type of preferences and distortions better emulate the data. The trade balance exhibits high cyclical volatility and is one of the few macroeconomic variables that are countercyclical. These features tend to be difficult to reproduce in simple RBC models, and therefore are good criteria to select the more promising models.

We consider two types of preferences. The first corresponds to Hansen's (1985) indivisible labor economy specification, and it's the most commonly used functional form in closed economy models of business cycles. The second was first proposed by Greenwood, Hercowitz and Huffman (1988), and recently became a natural functional form alternative (see, for example, Christiano, Eichenbaum and Evans, 1997).

At the same time, we consider two types of distortions. The first are the capital adjustment costs, commonly associated with Tobin's q. The second are the transaction costs due to foreign capital markets imperfections. Both types of costs are short cuts to microfounded formulations, and should be seen as a first research step. Again, the intention is to find the worthier modeling directions.

We see our results as an indication that the Brazilian economy can and should be modeled by RBC setups.[2] More generally, that the methodology of constructing stochastic dynamic general equilibrium models, and comparing the properties of their simulations with the data, allows us to identify which are the more important determinants of the Brazilian business cycles.

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1 RBC models for countries other than USA were analyzed by Mendoza (1991), Correa *et al.* (1995), Jonsson and Klein (1996), Kollintzas and Vassilatos (2000).

2 Cribari-Neto (1993) and Issler, Gonzaga and Marone (1996) had already provided evidence in favor of a real business cycle interpretation of the output dynamics in Brazil.

The paper is divided as follows: The next section presents the model. Section 3 describes the data and calibrates the model. Section 4 summarizes the empirical regularities of business cycles in Brazil and compares them with the implication of our model. A final section reviews the main findings and concludes the paper.

2 Model

Our artificial economy is populated by a continuum of infinitely lived identical households, with names in the interval *[0, 1]*. Each of these households has an endowment of time for each period, which it must divide between leisure (l_t) and work (h_t). We normalize the households' time endowment to unity, that is, $h_t + l_t = 1$. In addition, households own an initial stock of capital k_o which they rent to firms and may augment through investment, and an initial stock of government bonds b_o that yield stochastic interest rates r_t.

Households' utility for each period is defined over stochastic sequences of consumption and leisure:

$$U_s = E_s \sum_{t=s}^{\infty} [(1+\eta)\beta]^{t-s} u(c'_t, 1-h'_t)$$

where c'_t and h'_t represent the sequences of Arrow-Debreu event-contingent consumption and labor supplies in per capita terms, η represents the population growth rate, and $\beta \in [0, 1]$ a discount parameter. We consider two different momentary utility functions. Hansen's (1985) indivisible labor specification (to which we will refer by Hansen) are consistent with steady state growth when utility depends on raw leisure hours, and are given by,

$$u(c, 1-h) = \log(c) - ah$$

The second class of momentary utility function was proposed by Greenwood, Hercowitz and Huffman (1988) and has the special property that the elasticity of intertemporal substitution associated with leisure is zero (we will refer to these as GHH preferences):

$$u(c, 1-h) = (c - ah^{\nu})^{1-\sigma} / (1-\sigma)$$

In order for economies with GHH preferences to be consistent with steady state growth, the disutility of work in the market has to increase with the level of technical progress. This effect can be interpreted as representing technological progress associated with home production activities (see footnote 11 on Christiano, Eichenbaum and Evans, 1997).

The households supply capital and labor to firms, which have access to a technology described by a Cobb-Douglas production function:

$$Y'_t = F(z_t, K'_t, H'_t) = exp(z_t)(1+\gamma)^{(1-\theta)t} K'^{\theta}_t ((1+\eta)^t H'_t)^{1-\theta}$$

where, with some abuse of notation, labor (H'_t) and accumulated capital (K'_t) are inputs, γ represents the technology growth rate, and z_t is a random productivity parameter.

The steady state in this economy is a balanced growth path. To work with detrended variables, we normalize the previous equation by the economy growth factor, $(1 + \eta)(1 + \gamma)$, and denote $K_t = K'_t/[(1 + \eta)(1 + \gamma)]^t$, with analogous expressions for the other variables. Similarly, for already in per capita terms variables, we use $c_t = c'_t/(1 + \gamma)^t$

The technology shock is assumed to follow a first order Markov process. In particular, z_t obeys the following law of motion:

$$z_{t+1} = \rho_z z_t + \varepsilon_{zt}$$

where ε_z are distributed normally, with zero mean, and standard deviations σ_z.

Capital depreciates exponentially at the rate δ and consumers add to the stock of capital by investing some amount of real output each period. Investment in period t produces productive capital in period $t + 1$, so that the law of motion for the aggregate capital stock is

$$(1+\eta)(1+\gamma)K_{t+1} = (1-\delta)K_t + I_t$$

Firms rent capital and hire labor in each period. The firm's problem can be treated as a period-by-period maximization problem that can be written as

$$Max\{Y_t - w_t H_t - u_t K_t\}$$

This optimization problem yields factor prices

$$w_t = exp(z_t)(1-\theta)(K_t / H_t)^{\theta}$$

and

$$v_t = exp(z_t)\theta(H_t / K_t)^{1-\theta}$$

Because returns to scale are constant, equilibrium profits will be equal to zero.

Households, in contrast, face an intertemporal problem and have to form expectations over future prices. Households will choose consumption, investment, net exports and hours of work at each date to maximize the expected discounted value of utility subject to sequences of budget constraints and laws of motion for households capital stock and bond stocks:

$$c_t + i_t[1+\phi_1(i_t / k_t)] + nx_t[1+\phi_2(nx_t / b_t)] \leq w_t h_t + v_t k_t$$

$$(1+\eta)(1+\gamma)k_{t+1} = (1-\delta)k_t + i_t$$

$$(1+\eta)(1+\gamma)b_{t+1} = (1+r_t(1-\tau))b_t - nx_t$$

The sequences i_t and nx_t represent, respectively, investment and net exports. The functions $\phi_1(i_t/k_t)$ and $\phi_2(nx_t/b_t)$ are convex, and represent, respectively, the costs associated with installing capital, and the transaction costs in the foreign sector. Very similar formulations were proposed by Kollintzas and Vassilatos (2000) for the foreign capital markets imperfections, and Chari, Kehoe and McGrattan (2000) for the capital adjustment costs. We assume they have functional forms $\phi_1(i_t/k_t) = \phi_1(i_t/k_t - \delta - \eta - \gamma - \eta\gamma)^2$ and $\phi_2(nx_t/b_t) = \phi_2(nx_t/b_t - r(1 - \tau) + \eta + \gamma + \eta\gamma)^2$, where, with slight abuse of notation, ϕ_1 and ϕ_2 are constants (on the RHS of the equations). This formulation drives costs to zero in the steady state.

b_t denotes holdings of international bonds, which bear interests r_t. The tax rate t reflects any premium over the financial remuneration of international bonds. International interest rates are assumed to follow a first order Markov process:

$$r_{t+1} = \rho_r r_t + \varepsilon_{rt}$$

where ε_{rt} are distributed normally, with zero mean, and standard deviations σ_r.

We assume that the amounts that are "taxed" through τ, ϕ_1 and ϕ_2 are simply wasted. The constant t is determined in the calibration section, to match first moments. In contrast, the functions $\phi_1(i_t/k_t)$ and $\phi_2(nx_t/b_t)$ are not calibrated. We simulate the model for various $\phi_1(i_t/k_t)$ and $\phi_2(nx_t/b_t)$, searching for parameters that could reproduce the second moments of actual Brazilian fluctuations.

We use the "Recursive Competitive Equilibrium" concept. The state variables for each household in this economy, at time t, are $(z_t, r_t, K_t, k_t, B_t, b_t)$. The optimality equation for the household's problem can then be written as

$$V(z,r,K,k,B,b) = Max\{u(c,1-h) + \beta(1+\eta)E[V(z',r',K',k',B',b') \mid z,r]\}$$

such that

$$c + i[1+\phi_1(i/k)] + nx[1+\phi_2(nx/b)] \leq wh + vk$$

$$(1+\eta)(1+\gamma)k = (1-\delta)k + i$$

$$(1+\eta)(1+\gamma)K = (1-\delta)K + I$$

$$(1+\eta)(1+\gamma)b = (1+r(1-\tau))b - nx$$

$$(1+\eta)(1+\gamma)B = (1+r(1-\tau))B - NX$$

$$z' = \rho_z z + \varepsilon_z$$

$$r' = \rho_r r + \rho_y y + \varepsilon_t$$

A **recursive competitive equilibrium** for this economy consists of a value function $V(z, r, K, k, B, b)$; a set of decision rules for the households, $c(z, r, K, k, B, b)$, $i(z, r, K, k, B, b)$, $nx(z, r, K, k, B, b)$, and $h(z, r, K, k, B, b)$; a corresponding set of aggregate per capita decision rules, $C(z, r, K, B)$, $I(z, r, K, B)$, $NX(z, r, K, B)$, and $H(z, r, K, B)$; and factor price functions, $w(z, r, K)$ and $v(z, r, K)$, such that these functions satisfy·

i) the households' problem

ii) the firms' problem

iii) the market clearing condition, that is, $c(z, r, K, K, B, B) = C(z, r, K, B)$, $i(z, r, K, K, B, B) = I(z, r, K, B)$, $nx(z, r, K, K, B, B) = NX(z, r, K, B)$, and $h(z, r, K, K, B, B) = H(z, r, K, B)$.

3 Data and calibration

Following Pastore and Pinotti (2000), we use quarterly data from 1980:1 to 2000:1, excluding observations for the turbulent year of 1990.[3] All data was obtained from IPEA DATA, and more information about them can be obtained at www.ipea.gov.br.

Output is the seasonally adjusted GDP, and investment comes from the fraction of GDP allocated to gross capital formation. Net exports are the quantum series from FUNCEX. The series of consumption was obtained from the residual, subtracting investment from output. Rigorously, net exports also should have been subtracted, but we have chosen to disregard them, because of two reasons. First, there are major inconsistencies in the trade balance series obtained from FUNCEX and the annual series obtained from IBGE. For example, in the time horizon considered, exports from IBGE grow 4,4%, whereas exports from FUNCEX grew 111%. Second, in Brazil, net exports are a very small fraction of GDP (typically under 2%, while consumption amounts to 80%). By disregarding net exports one does not affect the basic properties of the consumption series, and does not risk polluting it. Because we do not have a separate series for consumption of durable good, they are also included in the consumption series, instead of being added to investments, the usual practice in RBC modeling. As it is usual in models where government is not explicitly taken, the consumption series includes both private and government consumption.

3 The results of the paper do not change if the 1990 year were included. All series become more volatile, but their relative volatility remain the same. The performance of the proposed models, therefore, are unaffected.

We also do not have a series of hours worked for Brazil. In its place we use employment in metropolitan areas (PME), and compare it with a measure of hours worked in the industrial sector (PIM).

The real interest rate is the quarterly (accumulated) SELIC (government primary rate) discounted by the exchange rate devaluation. Using its mean over the period, we calibrate $r^m = 3.3\%$. With the average population growth rate and average per capita output growth rate we set, respectively, $\eta = 0.36\%$, and $\gamma = 0.11\%$.

Dividing the government budget constraint by output we get,

$$(1+\eta)(1+\gamma)B_{t+1}/Y_{t+1} = (1+r_t(1-\tau))B_t/Y_t - NX_t/Y_t$$

The average net exports over the period were 1.4% of GNP, and the average external liabilities, 73% of GNP. Using these values and the previous equation in the steady state, we get $\tau = 29\%$. Notice here that t does not necessarily mean explicit taxes on international bonds, but may reflect any difference between the devaluation discounted SELIC and the average yield on international bonds. The debt over GDP ratio is also a calibrated parameter, in the sense that the steady state depends on its value.

The parameter θ corresponds to the capital remuneration share. Brazilian national accounts (IBGE) suggest a capital share of 50%, but that unfortunately includes some of the labor remuneration of self-employed. We opt to set $\theta = 0.40$, following the calibrations for the U.S. economy. This choice of parameter value implies a capital-output ratio according with other Brazilian studies (Boneli and Fonseca, 1999), whereas $\theta = 0.50$ would imply unreasonably high levels of capital.

The first order condition for investment and the capital law of motion in the steady state are, respectively,

$$r^m(1-\tau) = (\theta y/k - \delta)$$

$$(1+\eta)(1+\gamma)k/y = (1-\delta)k/y + i/y$$

Solving this system and using $i/y=0.17$ (average in the period), one gets $\delta = 0.95\%$ and $k/y = 12$ (quarterly). We use these values and the series of investment to construct our capital series by the inventory method. The first value of capital is chosen so that the average of our constructed series matches this capital-output ratio.

Following Araujo and Ferreira (1999), we use the Euler equation for labor, and that hours worked in the steady state are $H = 1/3$ to calibrate a. For the Hansen preference, $(1 - \theta)y / (Hc) = a = 2.2$. For the GHH preference, $a = (1 - \theta)y / (\nu H^{\nu}) = [(1 - \theta) / (\nu H^{\nu - 1})](k/y)^{(\theta/(1-\theta))}$ Following Greenwood, Hercowitz and Huffman, we set n $= 1.7$ and $\sigma = 2.0$, what implies $a = 4.0$. From the Euler equation for international bonds in the steady state, we have $\beta = (1 + \gamma)^{\sigma} / [1 + r(1 - \tau)]$, which implies $\beta = 0.98$ both for the Hansen and GHH preferences.

The parameters for the r_t stochastic process are obtained by OLS regressions. We obtain that the coefficient for the lagged interest rate (ρ_y) is statistically irrelevant (its p-value is over 76%), and the standard deviation of the residual is $\sigma_r = 11\%$.

Because there are no series on hours worked for Brazil we cannot follow the strategy of computing the Solow residual and use it to estimate the stochastic process associated with technology shocks. For this reason, we resorted to the alternative strategy of choosing the parameters to reproduce the serial correlation and volatility of output. Following the literature for the U.S. we choose $\rho_z = 0.95$. The parameter σ_z, is chosen jointly with the parameters ϕ in order to match the volatilities of output and investment

We summarize our calibrated parameters in the accompanying table.

θ	δ	R^m	σ_z	ρ_z	τ	$Debt/y$	γ
0.40	0.0095	0.033	0.11	0.95	0.29	0.73	0.0011

σ	ν	β^{Hansen}	β^{GHH}	a^{Hansen}	a^{GHH}	η
2.0	1.7	0.98	0.98	2.2	4.0	0.0036

4 Findings

We next compute the equilibrium using computational techniques to approximate the problem to a linear-quadratic one (see Cooley, 1995). Then we simulate the artificial economy to compare the second moments of its series with those of Brazilian data.

As mentioned before, we used Brazilian data from 1980 to 2000, excluding observations for 1990. To characterize the cyclical behavior of the different variables we performed two transformations. First, we computed the logarithm of all variables with the exception of the net exports, and then removed a smooth trend using the Hodrick-Prescott filter with a smoothing parameter of 1600.[4]

Since the net exports takes on negative values we expressed it as a percentage deviations from the mean using the following local approximation to $log(nx_t)$: $nx_t / mean(nx_t) -1$ We then proceeded to detrend the variable with the Hodrick-Prescott filter.

Table 1 shows how the Brazilian cyclical fluctuations conform to the stylized facts of business cycles described in Cooley (1995). Consumption, investment, output and employment are positively correlated. All variables are procyclical (with the exception of net exports) and show high degree of persistence. Investment is about three times more volatile than output, while consumption is slightly less volatile than output. The movements in the net exports, which are countercyclical and exhibit high volatility, also conform to the patterns of behavior found in other countries.

Table 1
Cyclical Behavior of Brazilian Economy: 1980:1 – 2000:1, year 1991 excluded

VARIABLE X	S.D.[X] (%)	CORR[X(-1), Y]	CORR[X, Y]	CORR[X(+1), Y]
Output - y	2.7	.75	1.0	.73
Consumption	2.0	.68	.93	.61
Investment	7.7	.66	.88	.73
Labor (PME)	1.6	.37	.49	.49
Labor (PIM)	3.6	.42	.70	.74
Net Exports	68.6	-.28	42	-.46

The two reported series of labor do not correspond exactly to hours worked in Brazil. The PME labor indicates volatility lower than output, whereas the PIM shows much higher volatility. That is exactly what we should have expected, since PME refers to adjustments only in the number of employees, and PIM refers to labor adjustments in the industry sector, which tends to be more volatile than the rest of the economy. Both PIM and PME show modest correla-

4 This is a common practice, but see Harvey and Jaeger's (1993) critique.

tion with output, but we know from Kanczuk and Faria's (2000) study of Brazilian Industry that hours worked tend to be extremely correlated to output. Our understanding is that PME and PIM should therefore only be taken as indicatives of labor behavior. Additionally, because $mean(nx_t)$ is close to zero, and the local approximation of the logarithmic function becomes very sensitive in this point, we should also look at net exports standard deviation as a rough indicative of its volatility.

Tables 2 to 6 summarize the second moment properties of five simulations. These five economies are representative of our attempt to find a combination of preferences and costs parameters that could mimic the Brazilian economy. With this objective in mind, we tried, for each preference, various values for ϕ_1 while ϕ_2 was set equal to zero, and vice-versa. Then we tried many combinations with both parameters different from zero. In all these cases, the volatility of the Solow Residual σ_z, was set in order to match output volatility, and the costs parameters ϕ_i were set in order to match all the other volatilities and correlations. Because there are many more criteria to meet than parameters to set, the results are imperfect, but informative. To analyze the performance of the specifications, we pay special attention to (i) the relation of investment volatility to output volatility, (ii) the correlation of net exports to output, and (iii) the relation of net exports volatility to output volatility.

Table 2 shows an economy with Hansen preferences with international financial costs (ϕ_2) set equal to zero and capital adjustment costs set to match investment to output volatility ($\phi_1 = 470$). Notice that σ_z, was set equal to 0.006 in order to match output volatility, a value lower than the one for the US economy (0.007), and for this reason, questionable. Notice also that the correlation of net exports and output is clearly positive, contrary to Brazilian data. We tried other values for ϕ_1, and obtained very similar results.

Table 2
Hansen Preferences, $s_z = .006$, $\phi_1 = 470$, $\phi_2 = 0$

VARIABLE - X	S.D.[X] (%)	CORR[X(-1), Y]	CORR[X, Y]	CORR[X(+1), Y]
Output - y	2.7	.68	1.0	.68
Consumption	2.3	.29	.49	.35
Investment	7.7	.60	.84	.53
Labor	3.1	.67	.98	.65
Net Exports	118.7	.13	.19	.14

We then set $\phi_1 = 0$ and searched for ϕ_2 that could mimic at least the output volatility, but that implied unreasonably low values for σ_z. Table 3 indicates the results when both costs are different from zero. The existence of small foreign markets costs imply unreasonably high consumption volatilities, negative consumption and investment correlations with output, whereas the net exports–output correlation is still positive.

Table 3

Hansen Preferences, $\sigma_z = .006$, $\phi_1 = 470$, $\phi_2 = 10$

VARIABLE - X	S.D.[X] (%)	CORR[X(-1), Y]	CORR[X, Y]	CORR[X(+1), Y]
Output - y	2.2	.15	1.0	.15
Consumption	21.6	.10	-.46	.10
Investment	6.1	.23	-.49	.24
Labor	3.1	.03	.94	.04
Net Exports	576.6	-.01	.47	-.03

In table 4 we use GHH preferences with only capital adjustment costs. The Solow volatility that matches output volatility (with the correct investment volatility ratio) is now $\sigma_z = 0{,}0145$, about twice the its US correspondent. The economy with $\phi_1 = 290$ does an excellent job in matching consumption, investment and labor volatilities and correlation with output, but net exports correlation with output is practically zero.

Table 4

GHH Preferences, $\sigma_z = .0145$, $\phi_1 = 290$, $\phi_2 = 0$

VARIABLE X	S.D.[X] (%)	CORR[X(-1), Y]	CORR[X, Y]	CORR[X(+1), Y]
Output - y	2.7	.67	1.0	.67
Consumption	2.0	.62	.93	.64
Investment	7.6	.69	.98	.62
Labor	1.6	.67	1.0	.67
Net Exports	70.4	.00	.05	.07

Differently from economies with Hansen preferences, the economies with GHH preferences are fairly sensitive to changes in ϕ_1. In table 5 we reduced capital adjustment costs to $\phi_1 = 220$, what increases investment volatility, but makes net exports to output correlation negative. **In our opinion this is the economy that better resembles Brazil**. Lower values for ϕ_1 imply in unreasonably high investment volatility without raising (in absolute value) the net exports–output correlation.

Table 5

GHH Preferences, $\sigma_z = .0145$, $\phi_1 = 220$, $\phi_2 = 0$

VARIABLE X	S.D.[X] (%)	CORR[X(-1), Y]	CORR[X, Y]	CORR[X(+1), Y]
Output y	2.7	.68	1.0	.68
Consumption	2.0	.62	.94	.64
Investment	9.7	.69	.98	.60
Labor	1.6	.68	1.0	.67
Net Exports	114.3	.18	.21	-.09

When we set $\phi_1 = 0$ and search for a ϕ_2 that could mimic the output volatility, we again have that it implied unreasonably low values for σ_z. Table 6 shows an attempt of setting both costs different from zero. With GHH preferences, as with Hansen preferences, even small amounts of foreign capital markets costs imply unreasonably high consumption volatilities, without improving consumption investment and net exports correlations with output. That foreign capital markets imperfections, as defined in this paper, are inconsistent with the Brazilian business cycles seems to be a robust finding. This does not mean that these imperfections may be important to explain secular movements (low frequency) in the data.

Table 6

GHH Preferences, $\sigma_z = .0145$, $\phi_1 = 290$, $\phi_2 = 10$

VARIABLE X	S.D.[X] (%)	CORR[X(-1), Y]	CORR[X, Y]	CORR[X(+1), Y]
Output - y	2.7	.67	1.0	.67
Consumption	14.0	.38	.56	.39
Investment	16.1	.34	.44	.29
Labor	1.6	.67	1.0	.67
Net Exports	797.3	-.01	.03	.02

5 Conclusion

In this paper we searched for combinations of preferences and distortions that better reproduce the properties of some Brazilian macroeconomic series fluctuations, including the trade balance. In special, we considered two types of preferences - Hansen and GHH -, and two types of distortions - foreign capital markets imperfections and capital adjustment costs.

We see our results as indicating that:

(i) foreign capital markets imperfections are not an important determinant of Brazilian fluctuations; on the contrary, their presence generate simulated data inconsistent with several key features of Brazilian data.

(ii) GHH preferences are more promising than Hansen preferences as a specification for Brazil, since they may generate simulations in which net exports are countercyclical.

(iii) Capital adjustment costs are an important feature to reduce investment and output volatilities.

More generally, our results suggest that the Brazilian economy can and should be modeled using RBC setups. The methodology of constructing stochastic dynamic general equilibrium models, and comparing the properties of their simulations with actual data, allowed us to identify which factors, out of the ones we tried, seem to be important determinants of the Brazilian business cycles. Moreover, Table 5 is a promising start in the direction of modeling the Brazil as a small open economy.

There are many extensions to this paper that could be undertaken in order to improve our understanding of Brazilian fluctuations. Because our costs of capital adjustments formulation is not microfounded, one should redo our exercise with a "time to build" formulation (Kydland and Prescott, 1982), to check if this type of distortion is quantitatively important. Because our simulations indicate that foreign capital markets distortions generate inconsistent results even in small amounts, a similar effort does not seem promising in that direction.

In our economy all goods are tradeable. It should be interesting to construct an economy with non tradeable goods, and see how technological shocks in different sectors can modify the results. Finally, in our economy, prices are flexible. There is a booming new literature on New Open Macroeconomics (Obstfeld and Rogoff, 2000) that explicitly considers sticky prices and monopolistic firms. That seems to be, even more for a country like Brazil, a path with high potential rewards.

References

Araújo, C. H. V., Ferreira, P. C. G. Reforma tributária, efeitos alocativos e impactos de bem-estar. *Revista Brasileira de Economia,* v. 53, n. 2, p. 133-166, 1999.

Backus, K., Kehoe, P.; Kydland, F International real business cycles. *Journal of Political Economy*, 101, p. 745-755, 1992.

Boneli, R., Fonseca R. Ganhos de produtividade e competitividade da produção manufatureira no Brasil. *Pesquisa e Planejamento Econômico,* v. 28, n. 2, p. 273-314, 1998.

Chari, V. V., Kehoe, P.; McGrattan, E. Sticky prices of the business cycle: can the contract multiplier solve the persistence problem? *Econometrica*, v. 68, n. 5, p. 1151-1179, 2000.

Christiano, L. J., Eichenbaum, M., Evans, C. L. Sticky price and limited participation models of money: a comparison. *European Economic Review,* 41, p. 1201-1249, 1997.

Cooley, T. F. *Frontiers of business cycle research*. Princeton Univ. Press, 1995.

Correia, I., Neves, J.; Rebelo, S. Business cycles in a small open economy. *European Economic Review,* 39, p. 1089-1113, 1995.

Cribari-Neto, F The cyclical components in Brazilian GDP. *Revista de Econometria*, 13, p. 1-22, 1993.

Ellery, R. Jr., Gomes, V., Sachsida, A. Business cycle fluctuations in Brazil. *UnB working paper*, 2000.

Greenwood, J., Hercowitz, Z., Huffman, G. Investment, capacity utilization and the business cycle. *American Economic Review,* 78, p. 402-417, 1988.

Hansen, G. D. Indivisible labor and the business cycle. *Journal of Monetary Economics*, 16, p. 309-327, 1985.

Harvey, A. C., Jaeger, A. Detrending, stylized facts and the business cycle. *Journal of Applied Econometrics*, 8, p. 231-247, 1993.

Issler, J. V., Gonzaga, G. M., Marone, G. C. Educação, investimentos externos e crescimento econômico: evidências empíricas. *Revista de Econometria*, 16, p. 101-127, 1996.

Jonsson, G.; Klein, P. Stochastic fiscal policy and the Swedish business cycle. *Journal of Monetary Economics*, v. 38, n. 2, p. 245-268, 1996.

Kanczuk, F. Real interest rates and Brazilian business cycles. *IPE/USP working paper*, 2001.

_______. Usando ciclos para projetar a tendência. *IPE/USP working paper*, 2001.

Kanczuk, F., Faria, F Jr. Ciclos reais para a indústria brasileira. *Estudos Econômicos*, v. 30, n. 3, p. 335-350, jul./set. 2000.

Kollintzas, T.; Vassilatos, V. A small open economy model with transaction costs in foreign capital. *European Economic Review*, 44, p. 1515-1541, 2000.

Kydland, F., Prescott, E. C. Time to build and aggregate fluctuations. *Econometrica*, 50, p. 1345-70, 1982.

Mendoza, E. Real business cycles in a small open economy. *American Economic Review*, September, v. 81, n. 4, p. 797-818, 1991.

Obsfeld, M., Rogoff, K. New directions for stochastic open economy models. *Journal of International Economics*, v. 50, n. 1, p. 117-153, 2000.

Pastore, A. C., Pinotti, M. C. One year of inflation targeting in Brazil: what have we learned about the channels of monetary transmission. *Working paper* 2000.