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Abstract:

This paper analyzes the relation between international liquidity and growth for Brazil in 1966-2000. Defining the former as the ratio of foreign reserves to foreign (interest-bearing) debt, the objective is to build a model connecting growth with international liquidity, and then check whether the results from such a model hold up in practice. The model builds upon Thirlwall's (1979) law and uses some basic accounting identities to specify a liquidity constraint on small open economies. The main implication of such a model is that, similar to what happens with liquidity constrained agents in closed economies, small open economies tend to adjust their current account, especially their trade balance, to the availability of external finance. Thus, in face of fluctuations in international liquidity, one should expect fluctuations in growth after a time lag. This is exactly what the paper verifies for Brazil in 1966-2000, that is, changes in Brazil's international liquidity tends to lead changes in its growth rate. Overall, inertia and international liquidity explains approximately 40% of the variation in Brazil's growth rate in 1966-2000.

Key words: International Liquidity, Liquidity Constraint, Growth, and Brazil.

JEL classification: F410, F430, O200, and O540.

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Introduction

Changes in international financial conditions have been one of the major determinants of Brazil's growth rate since the late 1960s. For instance, during the 1970s, Brazil received a huge amount of foreign capital and was able to maintain an average annual GDP growth rate of 8.7%, [note 1] that is, a cumulative expansion of 131% between 1969 and 1979. In contrast, during the 1980s, Brazil was hit hard by the increase in international interest rates and the reduction in foreign lending that followed the debt crisis of Latin American countries. The average annual growth rate fell to 3.0%, that is, a cumulative expansion of 35% between 1979 and 1989.

More recently, the increase in capital flows from advanced economies to “emerging markets” allowed Brazil once again to increase its growth rate. After a recession in 1990-92, when its GDP decreased 1.2% per year, Brazil grew at an annual average of 4.0% in 1993-97. However, as international financial conditions worsened in the wake of the East Asian and Russian crises, Brazil experienced yet another recession. In 1998-99 the average annual growth rate fell to 0.5% and, between 1989 and 1999, the cumulative GDP expansion was only 19%.

Given such an apparent connection between international financial conditions and Brazil's growth rate, this paper analyzes the link between GDP growth and an index of international liquidity, namely: the ratio of foreign reserves to foreign debt. The objectives are, first, to build a stock-flow model connecting growth with international liquidity and, second, to test whether or not changes in international liquidity have a significant impact on Brazil's growth rate.

The period under study is 1966-2000 and the analysis is organized in three sections. Section one presents the stock-flow model of international liquidity. Section two investigates whether international liquidity had a significant impact (mathematically and statistically) on Brazil's growth rate during the period under study. Section three concludes the analysis with a summary of the results and their implications for economic policy.

1 Unless stated otherwise, all growth averages are geometric averages.

1 - International liquidity and growth: the stock-flow model

This section models the liquidity constraint on a small open economy using Brazil's experience as a guide. The analysis follows the top-down approach of structuralist macroeconomics, that is, starting with some aggregate accounting identities, we will investigate how some stylized assumptions impact on the macroeconomic dynamics of a small open economy. To keep the analysis as simple as possible, assume that:

- (i) the world economy consists of a large foreign country and a small home country;
- (ii) the home country is a net debtor to the foreign country;
- (iii) both countries are one-sector economies;
- (iv) there is imperfect substitution between the home and foreign goods; and
- (v) the foreign currency is also the international currency.

Since the home country cannot issue the international currency, it has to export goods, borrow funds or sell assets in the foreign financial market to obtain the foreign currency. So, in the same way that households and firms may be liquidity constrained in a closed economy, the home country may be liquidity constrained in the world economy.

The basic idea is that, when financial markets are incomplete, the home country may not be able to borrow as much as it wants and, therefore, causality may run from capital flows to current-account flows in its balance of payments.[note 2] For instance, given an exogenous and unexpected suspension in foreign lending, the home country may face a shortage of foreign exchange and suffer a substantial depreciation of its currency. Through its effects on relative prices and income levels, such an exchange-rate “correction” may lead to an increase in net exports and, in this way, complete the causal chain from capital flows to current-account flows.[note 3]

2 According to the intertemporal approach of Obstfeld and Rogoff (1996, ch.2), the current-account balance of a small open economy is determined by the intertemporal utility maximization of its representative agent. When financial markets are incomplete such consumption smoothing may not be possible and, therefore, the availability of foreign finance becomes the critical constraint on a small open economy whose rate of discount exceeds the world interest rate. For an analysis of how asymmetric information may lead to imperfect financial markets internationally, see Obstfeld and Rogoff (1996, ch.6).

3 Note that, if there is a high pass-through effect to home prices, the depreciation may result in an exchange rate and price spiral, of the sort that happened with Germany in the early 1920s. For an analysis of the latter, see Bresciani-Turroni (1937).

Now, to transform the above qualitative analysis into a mathematical model, we have to measure the scarcity of foreign exchange. In models of currency-crisis this is usually done by normalizing foreign reserves by some aggregate stock or flow, that is, by defining a liquidity ratio for the country in question.

1.1 - The liquidity ratio

By analogy with the situation of firms in a closed economy, the home country issues bonds in a currency that it cannot create. Thus, using the fact that liquidity is usually measured by some cash to debt ratio at the firm level, let us define the liquidity of the home country simply as

$$(1) \quad l = R/D,$$

where R and D are respectively its net foreign reserves and net foreign interest-bearing debt.

Now, to introduce the liquidity constraint into the analysis, assume that

- (vi) the home government has to keep l above some non-negative critical level l_c to avoid discontinuous and unexpected changes in the home-foreign exchange rate.

Why should the home authorities care about the exchange rate? The recent history of developing countries, and especially Latin American countries, indicates that a sudden and substantial depreciation of the home currency usually has major disruptive effects on inflation and growth. [note 4] Moreover, inflation targeting is now one of the main objectives of demand management in advanced and developing countries and, since foreign exchange is usually a basic good in small open economies, inflation targeting implies exchange-rate targeting.[note 5]

4 The impact on inflation depends crucially on the degree of price and wage indexation. The impact on growth depends mainly on the response of the real wage and balance sheets of home agents. For a structuralist model where an increase in the nominal exchange rate reduces income, see Taylor (1991, ch.7). The basic idea is that, with a stable markup and a Kaleckian savings function, the fall in consumption induced by the reduction in the real wage may offset the increase in net exports brought by depreciation.

5 In the jargon of Sraffian models a good is basic when it is used directly or indirectly in the production of all other goods in the economy. For an outline of the Sraffian theory of production, see Kurz and Salvadori (1995).

The next natural question is: what is the value of the critical liquidity ratio? The answer may involve some formal or informal agreement between the home government and foreign financial institutions but, in practice, l_c can be tautologically defined as the liquidity ratio below which the home country suffers a speculative attack. In short, the critical liquidity ratio depends on the expectations of foreign and domestic investors, who can initiate a “bank run” on the home country whenever an exogenous shock or the natural evolution of l indicates that a “maxi-depreciation” of the home currency is imminent.

The size, form, and timing of speculative attacks have been the objective of an extensive investigation since Krugman's (1979) model but, for the purposes of this paper, we “just” have to assume that l_c exists.[note 6] On the theoretical side, the existence of a critical liquidity ratio is based on the fact that a low l means a high leverage ratio in foreign currency and, therefore, a high probability of currency crises in the event of small adverse shocks to the home country. On the empirical side, the currency crises of the 1990s lend some support to the existence of a critical liquidity ratio since “Almost all of the countries affected by the financial turmoil of the last few years had one thing in common: large ratios of short-term foreign debt, whether public or private, to international reserves. In Mexico 1995, Russian 1998, and Brazil 1999, the debt was the government's; in Indonesia, Korea, and Thailand in 1997, the debt was primarily owed by private banks and firms. But in each case a combination of large short-term liabilities and relatively scarce internationally liquid assets resulted in extreme vulnerability to a confidence crisis and a reversal of capital flows.” (Rodrik and Velasco 1999, p.1).

So, a low ratio of net foreign reserves to net short-term debt in foreign currency was one of the main leading indicators of the recent currency crises in “emerging markets.”⁷ Now, although Rodrik and Velasco (1999) normalize foreign reserves by short-term foreign debt, (1) does not make any distinction between short and long-term debt in to simplify the analysis in just two dimensions. A more detailed investigation

6 For a survey of mainstream models of currency crises, see Flood and Marion (1998) and the references therein. For a mainstream approach that emphasizes the central role of liquidity indexes in currency crises, see Chang and Velasco (1999).

7 For a survey of other leading indicators, see Kaminsky, Lizondo, and Reinhart (1997).

would require breaking l between short and long-term bonds but this would not change the interpretation substantially.[note 8]

1.2 - The stock-flow model

To construct the stock-flow model, let r and d be respectively R and D normalized by nominal home income in foreign currency, that is:

$$(2) \quad r = \frac{ER}{P_h Q_h} \text{ and}$$

$$(3) \quad d = \frac{ED}{P_h Q_h},$$

where E is the home-foreign nominal exchange rate, P_h the home price, and Q_h the home real income. Since $l=r/d$, we can use the joint dynamics of r and d to analyze the evolution of l . Totally differentiating (2) and (3) in relation to time,

$$(4) \quad \frac{dr}{dt} = \frac{E}{P_h Q_h} \frac{dR}{dt} + (e - p_h - q_h)r$$

$$(5) \quad \frac{dd}{dt} = \frac{E}{P_h Q_h} \frac{dD}{dt} + (e - p_h - q_h)d$$

where e , p_h , and q_h are the exponential growth rates of E , P_h , and Q_h , respectively.

From social accounting we know that dR/dt is the home balance-of-payments surplus,[note 9] as well as that dD/dt is the net inflow of foreign capital to the home country through interest-bearing bonds. Formally

$$(6) \quad \frac{dR}{dt} = \frac{P_h}{E} Q_x - P_f Q_m - (i_f + s)D - N + U + F_D + F_I \text{ and}$$

8 More formally let $D=DS+DL$ and $ls=R/DS$, where DS and DL are respectively the short and long-term foreign debt of the home country and ls is its "short" liquidity ratio. By definition, $l = ls(DS/D)$ and, since the composition of foreign debt usually changes towards short-term bonds when ls falls, ls and DS/D are positively correlated. The result is that changes in l are a good proxy to changes in ls , and, in the specific case of Brazil, such a proxy is extremely useful because the total-debt series starts in 1950, whereas the break between short and long-term debt starts only in 1982. Appendix A describes the series used in the analysis.

$$(7) \quad \frac{dD}{dt} = F_D,$$

where Q_x and Q_m are respectively the real exports and imports of the home country, P_f the foreign price, i_f the nominal interest rate in the foreign country, s the spread paid by home borrowers in the foreign financial market, N the net profits and dividends paid by the home country to the foreign country, U the net unilateral transfers received by the home country, F_D the net inflow of foreign capital to the home country through interest-bearing bonds, and F_I the net foreign direct investment in the home country.

Normalizing (6) and (7) by the home income in foreign currency and substituting the results in (4) and (5), we have

$$(8) \quad \frac{dr}{dt} = x - m - (i_f + s)d - n + u + f_D + f_I - (p_f + q_h - z)r \text{ and}$$

$$(9) \quad \frac{dd}{dt} = f_D - (p_f + q_h - z)d,$$

where naturally x , m , n , u , f_D , and f_I are the ratios of exports, imports, net unilateral transfers, and investment and non-investment capital inflows to income. p_f is the exponential growth rate of P_f and, to simplify the notation, z is the exponential growth rate of the home-foreign real exchange rate $Z = EP_f / P_h$. [note 10]

Taken together, (8) and (9) form a 2x2 dynamic system that describes the evolution of the home liquidity ratio ex-post. To transform these equations into a theoretical model, we have to add some assumptions about their right-hand-side variables.

9 In general, dR/dt is the balance-of-payments surplus plus the net capital gains from changes in the foreign price of reserve assets. Since we assumed that the foreign currency is the unique reserve asset of the home country, the net capital gain is zero.

10 Z is the amount of home good exchanged for one unit of foreign good and, since we assumed that each country produces just one good, it also measures the terms of trade.

1.3 - The export and import ratios

Since the home country is small in relation to the foreign country, i_f and p_f are exogenous variables in (8) and (9). The assumptions about the remaining nine variables vary according to the objective of the analysis and the case under consideration. To simplify the exposition and with the Brazilian experience in mind let us assume that:

- (vii) f_D and s are exogenous because these variables are determined mainly by fluctuations in foreign financial conditions;
- (viii) f_I and n are exogenous because these variables tend to be determined by long-run considerations and, therefore, they are not subject to wide unexpected short-run fluctuations; and
- (ix) u is exogenous because unilateral transfer were not an important source of foreign finance to Brazil during the period under analysis.

From the above assumptions and the liquidity constraint on the home country, the remaining four variables (x , m , q_h , and z) follow residually from the foreign conditions and the institutional and technological structure of the home country. To see how, let us follow the post-Keynesian approach of Thirlwall (1979) and assume that:

- (x) the supply curves of the home and foreign goods are horizontal,[note 11] meaning that we can model x and m from the demand side; and
- (xi) the demand for the home exports and imports can be described by the following functions:

$$(10) \quad Q_m = AZ^{-\alpha} Q_h^\beta \text{ and}$$

$$(11) \quad Q_x = BZ^\gamma Q_f^\delta,$$

respectively, where Q_f is the real foreign income, α the price elasticity of home imports, β the income elasticity of home imports, γ the price elasticity of home exports, and δ the

11 In other words, the home and foreign goods are produced at constant unit variable costs and priced through a stable mark-up rule.

income elasticity of home exports. The positive parameters A and B are included in the functions to control for other effects than price and income.

From the (10) and (11) it is straightforward that

$$(12) \quad \frac{dm}{dt} = m[(1-\alpha)z + (\beta-1)q_h] \text{ and}$$

$$(13) \quad \frac{dx}{dt} = x(\gamma z + \delta q_f - q_h),$$

where naturally q_f is the exponential growth rate of Q_f .

Given all the previous assumptions, the home government should use its macroeconomic policy to keep x and m at levels consistent with $l \geq l_c$. How can it do this? From to (12) and (13) the obvious control variables are q_h and z , that is, adjusting net exports to the availability of foreign finance implies adjusting income and relative prices to the availability of foreign finance. Formally, for x and m to be stable,[note 12] we should have

$$(14) \quad q_h = \left[\frac{(1-\alpha)\delta}{1-\alpha-\gamma+\beta\gamma} \right] q_f \text{ and}$$

$$(15) \quad z = \left[\frac{(1-\beta)\delta}{1-\alpha-\gamma+\beta\gamma} \right] q_f,$$

In the literature on the balance-of-payments constraint on open economies, (14) and (15) represent an extension of Thirlwall's (1979) model to incorporate the real exchange and allow for unbalanced but stable trade.¹³ In fact, if the income-elasticity of imports equals one, the real exchange rate is stable and the home growth rate satisfies Thirlwall's law, that is, the home growth rate equals the foreign growth rate multiplied by the ratio of the income elasticity of exports to the income elasticity of imports.[note 14]

12 Note that by setting the target as $dx/dt = dm/dt = 0$ instead of just $dx/dt = dm/dt$ we rule out the extreme case of a stable net-export ratio $x-m$ with x and m tending to zero or infinite.

13 In its turn, Thirlwall's law (1979) represents an extension of the dual-gap approach of Chennery and Bruno (1962) to the case where the income elasticity of imports and exports is different than one.

14 For a survey of the theory and empirical evidence on Thirlwall's law, see McCombie and Thirlwall (1994). For a recent methodological critique of the empirical results see Alexander and King (1998).

Now the crucial question, can the home country really control its income and real exchange rate? Theoretically, this can only happen if there exists a core and stable “institutional-technological” system connecting income, prices, and exchange rates in the home country, and where macroeconomic policy enters as an exogenous variable. In the usual terms of Keynesian theory, if there exists a “Philips curve” connecting growth and inflation and the home government is capable of controlling at least one of these variables, then it may be possible for macroeconomic policy to achieve (14) and (15) temporarily.[note 15]

In practice, a stable institutional-technological structure is obviously a very strong long-run assumption but, on the other hand, it is a reasonable approximation to the short-run reality of capitalist economies. In fact, the experience of Brazil since the late 1960s indicates that a very interventionist economic policy may be able to control income and real exchange rates in the short run, at the cost of periodic currency crises.[note 16]

Overall, (14) and (15) should be interpreted as short-run targets for income growth and real-exchange-rate growth of a country that is constrained to adjust its net exports to the availability of foreign finance. The advantages of cheap foreign credit and the inability to issue international money during periods of crisis are usually more convincing than the Lucas critique in the determination of macroeconomic policy in small open economies.

1.4 - The liquidity constraint

The targets for income and the real exchange rate tell us how to keep x and m stable but they do not tell us at what level these ratios should be stable. This is exactly where the

15 For instance, if home growth is a function of the home real interest rate and there exists a risk-adjusted parity between the home and foreign nominal interest rates, then we have two extra functions that can be added to (14) and (15) and solved for q_h , p_h , e , and the home nominal interest rate.

16 During the period of military government (1964-84), the Brazilian government complemented its stop-and-go policy with a myriad of other instruments like income policy, selective credit policy, and industrial policy. The return to a civilian government in the mid-1980s did not change the economic situation very much because Brazil's tendency to hyperinflation then could only be stopped by major policy shocks. From 1986 to 1994 the Brazilian economy experienced a series of stabilization plans and, since the Real Plan of 1994, stable inflation rates have been maintained through a very interventionist macro policy. For an overview of Brazil's economic policy in 1966-89, see Abreu (1990, ch. 9 through 13). For an overview of the 1990s, see Mercadante (1998).

liquidity constraint closes the analysis and, to see this, we have to return to the 2x2 dynamical system.

From (8) and (9) it is straightforward that the stability condition for r and d is

$$(16) \quad p_f + q_h - z > 0,$$

which from (14) and (15) can be rewritten as

$$(17) \quad p_f + \left(\frac{\beta - \alpha}{1 - \alpha - \gamma + \beta\gamma} \right) \delta q_f > 0.$$

Given the postwar growth and inflation in capitalist economies, it is reasonable to assume that

$$(xii) \quad q_f \text{ and } p_f \text{ are positive variables.}$$

so that the stability of r and d depends on the trade elasticities in (17).

There are many possible mathematical combinations consistent with (17) but, with the Brazilian case in mind, let us assume that

$$(xiv) \quad \text{the home imports are income-elastic } (\beta > 1) \text{ and price-inelastic } (\alpha < 1). [\text{note 17}]$$

Altogether, (xii) and (xiv) imply that (17) holds and, therefore, that we can concentrate our analysis on the stationary value of l . From the non-trivial stationary solution of (8) and (9), this is

$$(18) \quad l = \frac{x - m - n + u + f_I}{f_D} - \left(\frac{i_f + s + z - p_f - q_h}{p_f + q_h - z} \right)$$

and, since the liquidity constraint implies $l \geq l_c$, we have

$$(19) \quad x - m \geq n - u - f_I + f_D \left(\frac{i_f + s + z - p_f - q_h}{p_f + q_h - z} + l_c \right)$$

17 Alternatively, it would also be reasonable to assume that imports are income elastic ($\beta > 1$), but that their income elasticity exceeds their price elasticity ($\beta > \alpha$), and that exports are price elastic ($\gamma > 1$). The reason is that commodities responded for a major part of Brazil's exports during the period under analysis, whereas capital goods and oil responded for a major part of its imports.

In words, the right-hand-side of (19) is the minimum net-export ratio consistent with the liquidity constraint on the home country. With (19) the home control problem is complete that is, in the terms of Tinbergen's (1955) classic analysis of economic policy, the home government has three instruments (q_h , z , and $x-m$) to achieve three targets (stable x , stable m , and $l \geq l_c$).

Given the foreign financial conditions, the adjustment of net exports to the liquidity constraint involves two analytically distinct phases. First, an once-for-all change in the real exchange rate to put the home net-export ratio at a level consistent with the liquidity constraint and, second, a continuous control of income and real-exchange-rate growth to keep the home net-export ratio at such level. In practice these two phases overlap and (19) allows us to identify the five types of shocks that can tighten the liquidity constraint on the home country.

First, assuming that the home country receives a net inflow of foreign capital through interest-bearing bonds ($f_D > 0$), an increase in its critical liquidity ratio (l_c) increases its minimum net-export ratio. The economic intuition is that an increase in the perceived risk of a currency crisis forces the home country to increase its net exports.

Second, also assuming that the home country receives a net inflow of foreign capital through interest bearing bonds, an increase in the real cost of foreign debt in home currency ($i_f + s + z - p_f$) increases its minimum net-export ratio.[note 18] The economic intuition is that an increase in the interest payments to foreigners forces the home country to increase its net exports.

Third, assuming that the real cost of foreign debt in home currency is greater than the home growth rate ($i_f + s + z - p_f > q_h$), an increase in the capital inflows through interest-bearing bonds increases the minimum net export ratio. The economic intuition is that foreign loans force the home country to increase its net exports when the corresponding real interest rate is “high.” In contrast, if the real cost of foreign debt in

18 To see that $i_f + s + z - p_f$ is the real cost of foreign borrowing in home currency, just substitute $e - p_h$ for $z - p_f$ in (19).

home currency is smaller than the home growth rate ($i_f + s + z - p_f < q_h$), a reduction in the capital inflows through interest-bearing bonds increases the minimum net export ratio. By analogy with the previous case, the economic intuition is that foreign loans allows the home country to reduce its net exports when the corresponding real interest rate is “low.”

Fourth, a reduction in the net foreign direct investment in the home country (f_I) or an increase in the net dividends and profits paid to the foreign country (n) leads to an increase in the minimum net-export ratio. The economic intuition is that, once foreign direct investment falls below its corresponding capital income, the home country has to increase its net exports.

Fifth, a reduction in the net unilateral transfers from the foreign country (u) forces the home country to increase its net exports. The economic intuition is that the home country has to compensate for less unilateral transfers with higher net exports.

Since the adjustment of net exports usually takes time, the probable result of each of the above shocks is a temporary recession while net exports do not reach their new target. In short, the immediate impact of an adverse foreign shock tends to be a fall in the home liquidity ratio, and then a temporary decrease in the home growth rate. This is exactly the sequence that we shall seek in the Brazilian data.

2 - Empirical evidence from Brazil

According to the previous section changes in international liquidity should precede and cause changes in the real growth rate of a small open economy. To test this for Brazil, we will estimate a univariate econometric model for GDP growth where lagged changes in the liquidity ratio enter as explaining variables.[note 19]

2.1 - The estimable model

Since GDP series usually follow a non-stationary process integrated of order one, let our estimable model be

19 Appendix B presents the bivariate model for growth and liquidity and, since we cannot reject the null that past growth rates have no impact on the current change in the liquidity ratio at 10% of statistical significance, this section presents just the growth equation.

$$(20) \quad Q_{h,t} = \eta_t + \omega_t,$$

where $Q_{h,t}$ is the log of the home GDP at period t , η_t a random variable integrated of order one, and ω_t a deterministic variable integrated of order zero.[note 20] More formally,

$$(21) \quad \eta_t = \eta_{t-1} + \zeta_t$$

where ζ_t is integrated of order zero. The intuition is that the non-stationary term η_t represents the stochastic trend of $Q_{h,t}$, whereas the stationary term ω_t represents deviations from such trend.

To represent the hypothesis that international liquidity explains part of home GDP, let $\omega_t = \rho(l_{t-1} - l_c)$ be a linear function of international liquidity at the end of period $t-1$. Substituting this in (20) we have

$$(22) \quad Q_{h,t} = \eta_t + \rho(l_{t-1} - l_c).$$

In economic terms, whenever l falls below l_c , the home GDP falls below its trend in the following year. The first difference of (22) is

$$(23) \quad \Delta Q_{h,t} = \zeta_t + \rho \Delta l_{t-1},$$

where $\Delta Q_{h,t}$ is a proxy of the home GDP growth rate. Since ζ_t is stationary, $\Delta Q_{h,t}$ is also stationary.

Given the inertia displayed by GDP series, the final step is to assume that ζ_t can be approximated by a linear function of the past values of $\Delta Q_{h,t}$, that is

$$(24) \quad \zeta_t = \varphi + \sum_{i=1}^L \phi_i \Delta Q_{h,t-i} + \varepsilon_t,$$

where φ is a constant term and, provided that enough lags are included, ε_t is a white noise. Substituting (24) into (23) we obtain the estimable model, that is

20 This will be tested below.

$$(25) \quad \Delta Q_{h,t} = \varphi + \sum_{i=1}^L \phi_i \Delta Q_{h,t-i} + \rho \Delta I_{t-1} + \varepsilon_t,$$

The economic intuition is that inertia and international liquidity explain variations of the growth rate.

2.3 - The statistical model

To obtain the variables of the estimable model we need only three time series from the Brazilian economy, namely: real GDP, foreign reserves, and foreign debt. Using an annual frequency, the common sample of these series contains 38 observations, that is, from 1963 to 2000.[note 21]

Figures 1 and 2 show Brazil's real GDP growth and international liquidity during the period under analysis. Exactly like we assumed in the estimable model, the observations on reserves and debt are the values at the end of the year (the liquidity ratio of 1963 measures Brazil's international liquidity at the beginning of 1964 and so on and so forth).

[FIGURES 1 AND 2 HERE]

Table 1 shows the results of the Augmented-Dickey-and-Fueller (ADF) tests on Brazil's GDP and liquidity ratio. Given the limited number of observations, the maximum lag length is two years and, therefore, all tests were estimated for the 1966-2000 sample. Using the Akaike information criterion to select between one or two lags, the results indicate that:

- (a) we cannot reject the unit-root null for the log of Brazil's GDP at 10% of significance;[note 22]
- (b) we can reject the unit-root null for Brazil's GDP growth at 5% of significance
- (c) we can reject the unit-root null for Brazil's liquidity ratio at 10% of significance; and
- (d) we can reject the unit-root null for the change in Brazil's liquidity ratio at 1% of significance.

21 The series were obtained from the *Instituto de Pesquisa Economica Aplicada* (IPEA), at www.ipeadata.gov.br.

22 Unless stated otherwise, significance means statistical significance.

[TABLE 1 HERE]

So, setting the level of significance at 10%, Brazil's GDP seems to be integrated of order one whereas its liquidity ratios seems to be stationary. Moreover, since the estimable model includes the change in the liquidity ratio, the high level of significance associated with the latter does not pose problem.

2.3 - The econometric model

Table 2 shows the econometric results for Brazil. The maximum lag length is two and, to have the same observations in all models, the results were obtained from the 1966-2000 sample.

[TABLE 2 HERE]

Comparing the four alternative econometric models, model 3 is the best one because it has the higher adjusted R-squared and the lower Akaike information criterion, while its Durbin-Watson statistic is slightly smaller than the ones of models 2 and 4.[note 23]

Comparing models 2 and 3, we can see that adding the past change in the liquidity ratio to the regression increases the R-squared from 0.30 to 0.39 and the adjusted R-squared from 0.26 to 0.33. Moreover, if we ignore the constant coefficient, adding the past change in the liquidity ratio also makes all remaining coefficients different than zero at 5% of statistical significance.

According to model 3 Brazil's GDP growth rate follows a stationary autoregressive process with two lags. Assuming that there is no change in international liquidity, its expected stationary solution is 4.62, that is, in the absence of random shocks and given a constant liquidity ratio, Brazil's GDP growth rate would have been 4.62% per year during the period under analysis.[note 24]

23 Using the Durbin-Watson tables of Greene (1997) and given the 35 observations and the number of regressors, the upper and lower limits of the Durbin-Watson statistics of model 3 are 1.439 and 1.085 respectively.

24 The long-run dynamic multiplier is $[1/(1-0.314-0.283)]=2.481$ so that, given the constant coefficient, the expected growth rate is $1.862 \times 2.481 = 4.619$. The arithmetic average for 1966-2000 is 4.71.

Focusing on the impact of international liquidity on the expected stationary solution of model 3, the estimated coefficients indicate that, if Brazil's liquidity ratio falls one percentage point (say, foreign reserves fall from 10% to 9% of foreign debt) in t , its growth rate tends to fall 0.21 percentage point in $t+1$, increase 0.15 in $t+2$, fall 0.04 in $t+3$, and then increase gradually to its expected long-run value. As shown in figure 3, the impact of such a shock tends to disappear after 11 years.

[FIGURE 3 HERE]

Considering the wide variations in Brazil's liquidity ratio during the period under analysis, the estimated coefficients of model 3 confirm our initial hypothesis, namely: changes in international financial conditions have been one of the major determinants of Brazil's growth rate since the mid-1960s. To illustrate this point, figure 4 shows the actual and fitted time paths of Brazil's growth rate in 1966-2000.

[FIGURE 4]

3 - Conclusion

The results of model 3 indicate that inertia and international liquidity explains almost 40% of the variation of Brazil's growth rate in 1966-2000. Comparing models 2 and 3, changes in the liquidity ratio alone seem to explain 9% of the variation in Brazil's growth rate. These results are consistent with the hypothesis that Brazil is liquidity constrained internationally and, as such, it was bound to suffer booms and busts in face of the wide variations in international financial conditions since the late 1960s.

The results of model 3 also indicate that changes in liquidity ratio lead and are negatively related with Brazil's growth rate. Assuming that one of the objectives of macroeconomic policy is to create a stable macroeconomic environment, some action should thus be taken to reduce the volatility of Brazil's liquidity ratio. Given Brazil's structural trade deficits, the question does not seem to be a choice between domestic and foreign finance, but actually a way to smooth fluctuations in foreign finance. In the absence of an international lender of last resort or a world financial authority, capital controls are a foregone conclusion. Whether the same applies to other small open

economies is point to be investigated empirically but the recent currency crises in emerging markets indicate that Brazil's situation may be the rule rather an exception.

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Appendix A: Time series

1. Q: annual real GDP of Brazil in thousands of Brazilian reals of 2000; source: Instituto de Pesquisa Economica Aplicada (IPEA); start date: 1947.
2. R: foreign reserves of Brazil in millions of US dollars and according to the IMF liquidity concept; value at the end of the year; source: IPEA; start date: 1963.
3. D: total foreign debt of Brazil in millions of US dollars; value at the end of the year; source: IPEA; start date: 1950.
4. $q=100x(\Delta\log Q)$: annual growth rate of the Brazilian real GDP in \% terms; source: IPEA; start date: 1948.
5. $l=R/D$: annual liquidity ratio of the Brazilian economy in \% terms; source: IPEA; start date: 1963.

Appendix B: VAR model

This appendix presents a vector auto regressive (VAR) for Brazil's growth rate and change in international liquidity. Following the same procedure of section 2, the lag length is two and table B.1 shows the estimated model. To test whether growth has a statistically significant impact on changes in the liquidity ratio, table B.2 shows the results of the Wald test on the nulls that:

- (i) the coefficients for growth in $t-1$ and $t-2$ of the liquidity equation are zero; and
- (ii) the coefficients for $\Delta\text{liquidity}$ in $t-1$ and $t-2$ are zero of the growth equation are zero.

At 10% of statistical significance, we cannot reject the null past changes in liquidity have an impact on growth but, on the other hand, we can reject the null that past growth rates have an impact on $\Delta\text{liquidity}$.

[TABLES B1 AND B2 HERE]

Figure 1: annual growth rate of Brazil's real GDP, 1966-2000

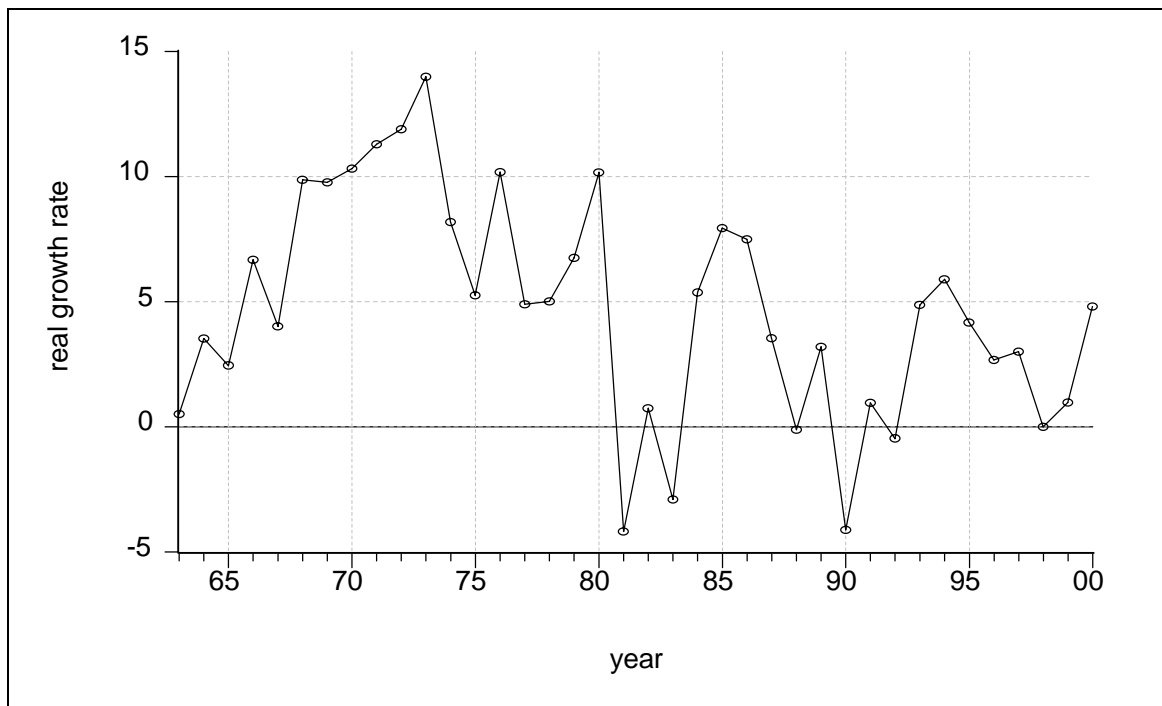


Figure 2: Brazil's liquidity ratio, 1966-2000.

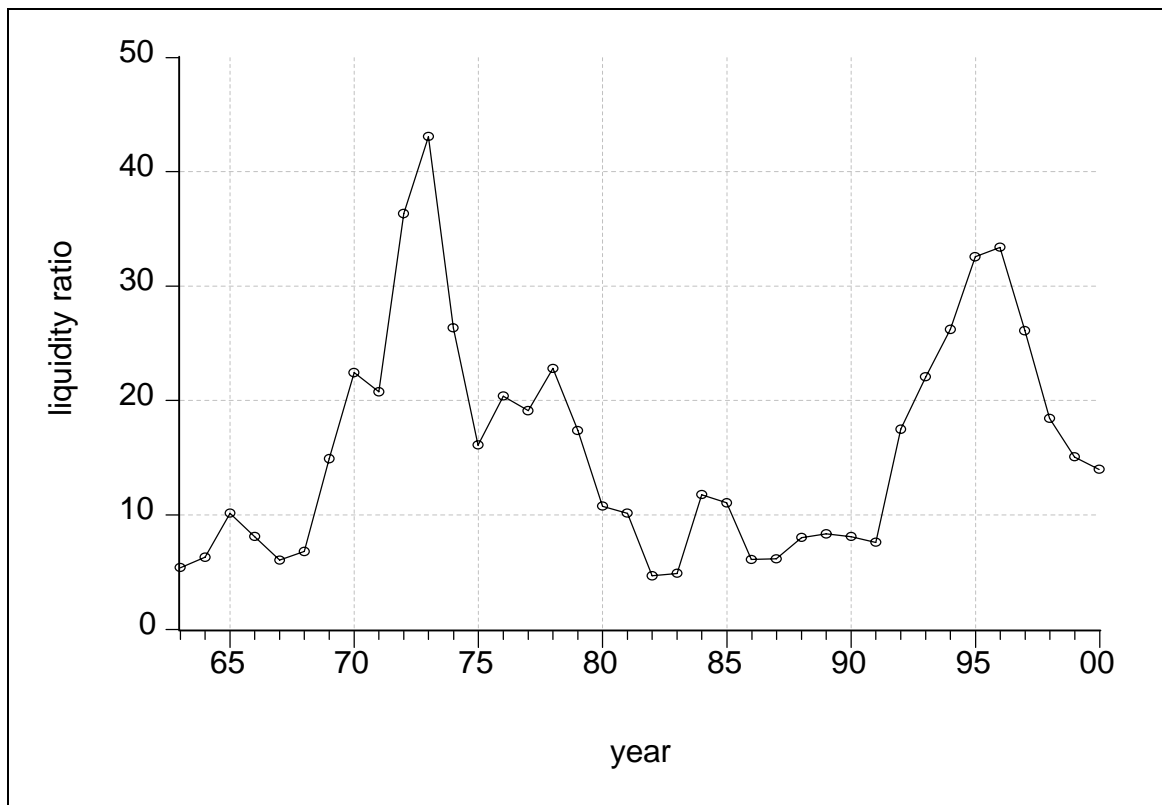


Figure 3: impact of a one-percentage point reduction of the liquidity ratio on the annual growth rate (in %), Brazil 1966-2000.

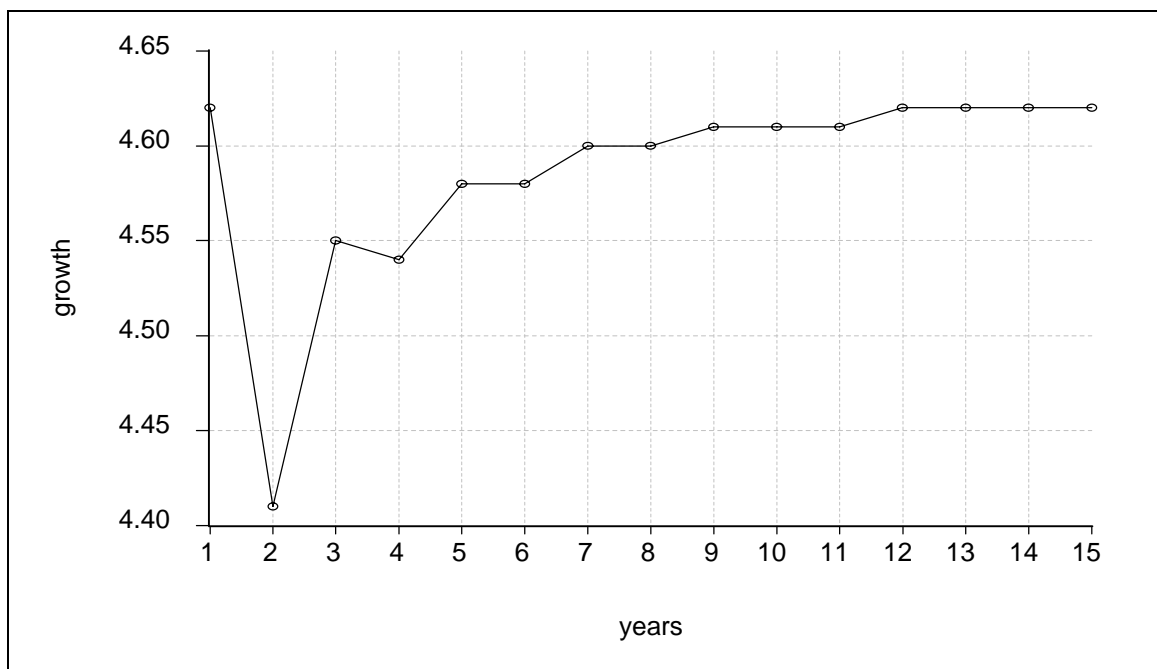


Figure 4: actual and fitted annual growth rate of Brazil's real GDP, 1966-2000.

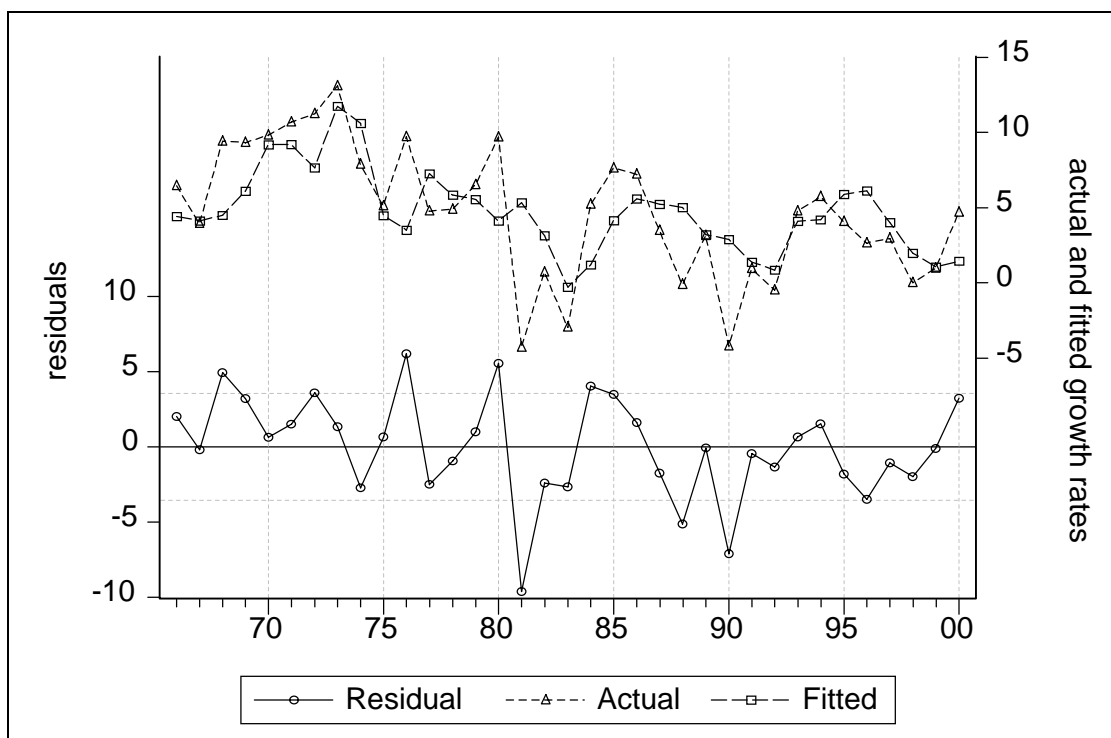


TABLE 1: ADF tests on Brazil's GDP and international liquidity, 1966-2000.

Number of lagged differences in the estimated equation	Variable: log of real GDP			Critical values of the ADF statistic*	
	ADF statistic	Akaike inf. Criterion	DW statistic		
0	-1.4772	-3.7296	1.4116	1%	-4.2412
1	-1.7626	-3.7987	2.1976	5%	-3.5426
				10%	-3.2032
Number of lagged differences in the estimated equation	Variable: 1st log differ. of real GDP			Critical values of the ADF statistic**	
	ADF statistic	Akaike inf. Criterion	DW statistic		
0	-3.2843	-3.6454	2.1899	1%	-3.6289
1	-2.2132	-3.6438	1.8676	5%	-2.9472
				10%	-2.6118
Number of lagged differences in the estimated equation	Variable: liquidity ratio			Critical values of the ADF statistic**	
	ADF statistic	Akaike inf. Criterion	DW statistic		
0	-1.9726	6.4728	1.3719	1%	-3.6289
1	-2.6781	6.3776	1.8353	5%	-2.9472
				10%	-2.6118
Number of lagged differences in the estimated equation	Variable: 1st differ. of the liquidity ratio			Critical values of the ADF statistic**	
	ADF statistic	Akaike inf. Criterion	DW statistic		
0	-4.5026	6.5227	1.8213	1%	-3.6289
1	-4.8393	6.4745	1.8424	5%	-2.9472
				10%	-2.6118
* critical values for an equation with an intercept and time trend.					
** critical values for an equation with an intercept.					

TABLE 2: Economic growth in Brazil, 1966-2000

Variable	Model 1	Model 2	Model 3	Model 4
Constant	2.333	1.788	1.862	1.789
Standard error	0.640	0.809	0.807	0.807
t-statistic	3.643	2.211	2.308	2.216
Probability of t-statistic	0.001	0.034	0.028	0.034
Growth is t-1	0.511	0.390	0.314	0.333
Standard error	0.146	0.124	0.102	0.124
t-statistic	3.498	3.138	3.061	2.686
Probability of t-statistic	0.001	0.004	0.005	0.012
Growth in t-2		0.235	0.283	0.283
Standard error		0.127	0.114	0.117
t-statistic		1.851	2.487	2.411
Probability of t-statistic		0.074	0.019	0.022
Change the liquidity ratio in t-1			0.214	0.222
Standard error			0.090	0.078
t-statistic			2.371	2.841
Probability of t-statistic			0.024	0.008
Change the liquidity ratio in t-2				-0.042
Standard error				0.116
t-statistic				-0.358
Probability of t-statistic				0.723
R-squared	0.263	0.303	0.393	0.396
Adjusted R-squared	0.241	0.260	0.334	0.315
Sum of the squared errors	477.306	451.492	393.341	391.413
Durbin-Watson	2.190	1.868	1.846	1.878
Akaike information criterion	5.565	5.567	5.486	5.538
F-statistic	11.804	6.965	6.691	4.917
Probability of F-statistic	0.002	0.003	0.001	0.004

Obs: standard error obtained from the Newey-West heteroskedasticity and autocorrelation consistent covariance matrix estimator, with a lag truncation of 3.

TABLE B1: VAR model for growth and changes in Brazil's liquidity ratio.

Variable	Growth in t	Change in the liq. Ratio
Growth in t-1	0.345	0.201
Standard error	0.177	0.284
t-statistic	1.946	0.709
Growth in t-2	0.277	-0.259
Standard error	0.169	0.272
t-statistic	1.639	-0.953
Change the liquidity ratio in t-1	0.231	0.292
Standard error	0.107	0.172
t-statistic	2.154	1.698
Change the liquidity ratio in t-2	-0.049	-0.331
Standard error	0.112	0.180
t-statistic	-0.435	-1.837
Constant	1.840	0.456
Standard error	1.030	1.654
t-statistic	1.786	0.276
R-squared	0.404	0.180
Adj. R-squared	0.324	0.071
Sum sq. resids	421.004	1084.472
F-statistic	5.080	1.648
Log likelihood	-93.190	-109.749
Akaike AIC	5.611	6.557
Determinant Residual Covariance		356.5342
Log Likelihood		-202.1632
Akaike Information Criteria		12.12361

TABLE B.2: Wald test on the VAR model

Null hypothesis: coefficients for growth in t-1 and t-2 equal zero in the equation for the change in the liquidity ratio in t			
Chi-square	0.9675	Probability	0.6165
Null hypothesis: coefficients for changes in the liquidity ratio in t-1 and t-2 equal zero in the equation for growth in t			
Chi-square	4.638237	Probability	0.09836