Inflation and Macroeconomic Instability in Madagascar

by

Jean-Paul Azam

ARQADE and IDEI, University of Toulouse,
and Institut Universitaire de France.

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Abstract : The relationships between inflation and macro-economic instability are discussed analytically, using a simple monetary model with rational expectations, with an application to the case of Madagascar. The recent macroeconomic history of this country suggests that high inflation is correlated with high volatility of the inflation rate and the real effective exchange rate. The relevance of this observation is confirmed by an empirical analysis of the relationships between inflation, competitiveness and instability in Madagascar.

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Mailing address :

Prof. Jean-Paul Azam,
ARQADE, University of Toulouse 1,
21 Allée de Brienne,
31000 Toulouse, France.
E-mail : azam@univ-tlse1.fr

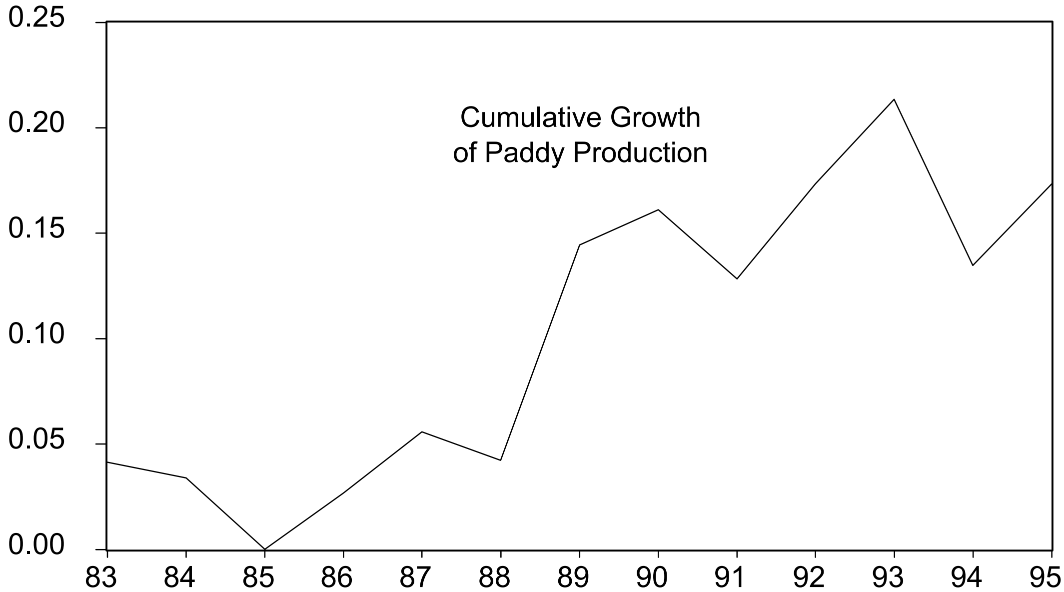
1. Introduction

The concept of macroeconomic instability is widely used in the policy-oriented literature. However, this concept is almost never really defined, and seems to refer in turn to high inflation, overvalued currency, unstable real exchange rate, balance of payment deficit, or fiscal deficit, etc. Roughly speaking, everything that is going wrong in a country's macroeconomic condition is often called macroeconomic instability. It is then implicitly entailed that what a country suffering from these ills ought to do is to implement a stabilization policy. Few authors have attempted to define precisely what is macroeconomic instability, but it is evident that this notion plays a useful role for indicating a situation of economic malaise, where the economy does not seem to have settled in a steady position, and where, eventually, something needs to be done for putting it back on track. An exception to this rule is provided by Elbadawi and Schmidt-Hebbel (1998), where an indicator of macroeconomic instability is produced for a large number of countries, with an interesting econometric application, showing how this instability is bad for long-term growth. However, this empirical construct does not have the required theoretical underpinnings for clarifying the analysis and leading to precise policy conclusions.

The present paper aims at providing more precision to this concept, both theoretically, using a simple monetary model with rational expectations, and empirically, with an application to the semi-open insular economy of Madagascar. The imperfect openness of this economy results from the high transport cost implied by insularity, making non tradable goods quite important. The theoretical model used is a drastically simplified variant of the model presented in Azam (1999.b), which emphasizes the fiscal role of the real exchange rate. The latter is crucial in most developing countries, and in Africa in particular, where a large share of fiscal revenues are levied on foreign trade, and where the so-called counterpart funds of foreign aid provide an important part of government revenues. For example, in Madagascar, foreign aid represented 10.2 % of GNP in 1994 (World Bank, 1997), most of it ending up in the government budget. Azam (1997 and 1999.a) and Yiheyis (2000) have shown the relevance of this fiscal role for the CFA zone countries and for various other African countries. The analysis of the rational expectations equilibria of this model brings out the links existing between high inflation and the joint volatility of the real exchange rate and the inflation rate, and some aspects of the government's fiscal and exchange rate policies. In line with the theory of sunspot equilibria, macroeconomic instability is related to a problem of multiple rational expectations equilibria, in application of the Woodford conjecture, which Shigoka (1994) and Drugeon and Wignolle (1996) have shown to apply to continuous-time models. The inflation rate and the real exchange rates are jointly determined by the equilibrium of the model, and the instability of one entails the instability of the other. This shows how illusory is the elegant distinction introduced by Corden (1993) between real targets and nominal anchor, as the alternative goals of exchange rate policy in developing country. A precise analysis is thus provided of how inflation affects some key relative prices, and their instability, and thus blurs the messages sent by the markets. The relevance of real exchange rate volatility for developing countries has been demonstrated in particular by Caballero and Corbo (1989), who show that it affects negatively their export performance.

Madagascar provides an interesting ground for applying these ideas, because its recent macroeconomic history displays alternating periods of relative stability and instability, against a background of poverty and underdevelopment. It is one of the poorest countries in the world, with an income per capita of 230 US$ in 1995, although its economic potential has always seemed quite promising. There is a relatively educated population, by African standards, with a female enrollment rate in secondary education of 14 % in 1993, and the country has a diversified resource base. However, misguided policies of the past have sent the economy astray. In the second half of the seventies, when the government had a clear socialist leaning, this country adopted a large public investment program, which eventually pushed the country into a crisis. The latter was so deep that shortages of consumer goods occurred in the countryside, leading to a fall in agricultural production, and in cash crops more particularly (Azam, Berthélemy and Morrisson, 1991). The Malagasy economy has never really recovered from this shock, and real GDP per capita has fallen by about 40 % between 1970 and 1994. Real GDP would have to grow for 15 years at the sustained rate of 6 % per annum if the economy was to recover its 1970 level of real GDP per capita, if population was to carry on growing at the current average rate of 2.6 % per annum (IMF, 1995). However, these past achievements are a proof of the potentials of this economy, which remain to be mobilized.

Figure 1 : Cumulative Growth of Paddy Production

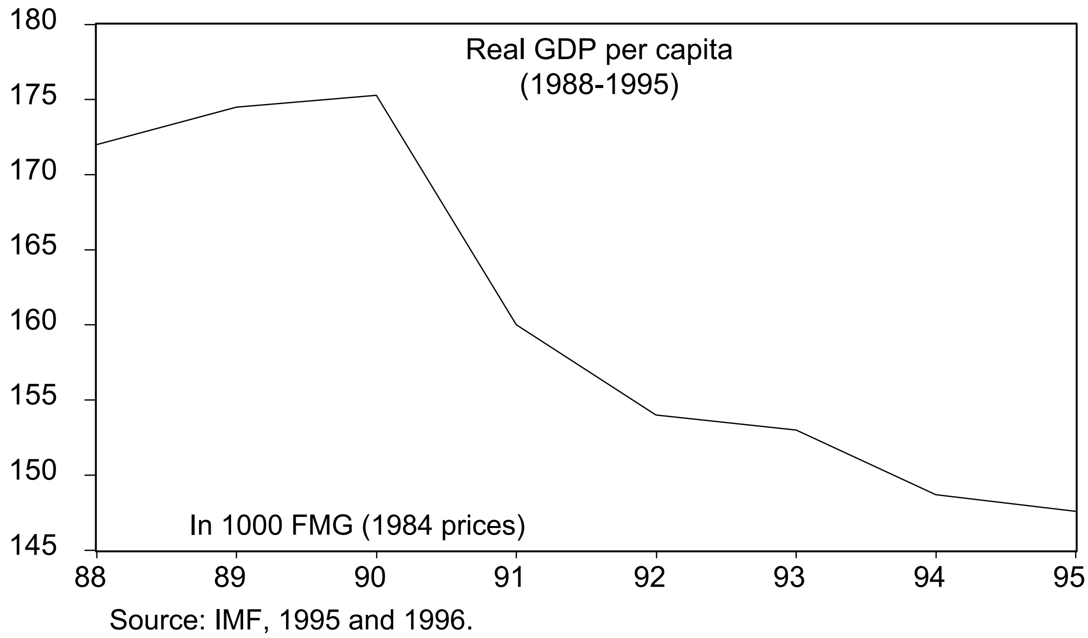


Source: IMF, 1996.

This country entered into a wide ranging adjustment program in the mid-eighties, including in particular a gradual move to a more market-oriented economy. In particular, the rice market was liberalized, with a stabilizing impact on the real price of rice, the main staple in this country (Berg, 1989, Azam and Bonjean, 1995). Output responded to the reform by some growth, which is represented in figure 1. It shows that the output of paddy increased by about 20 % between its low point of 1985 and its peak of 1993. It fell back slightly after that, so that it is safe to say that the reforms of the rice market have led to a sustainable increase in paddy production about 15 %.

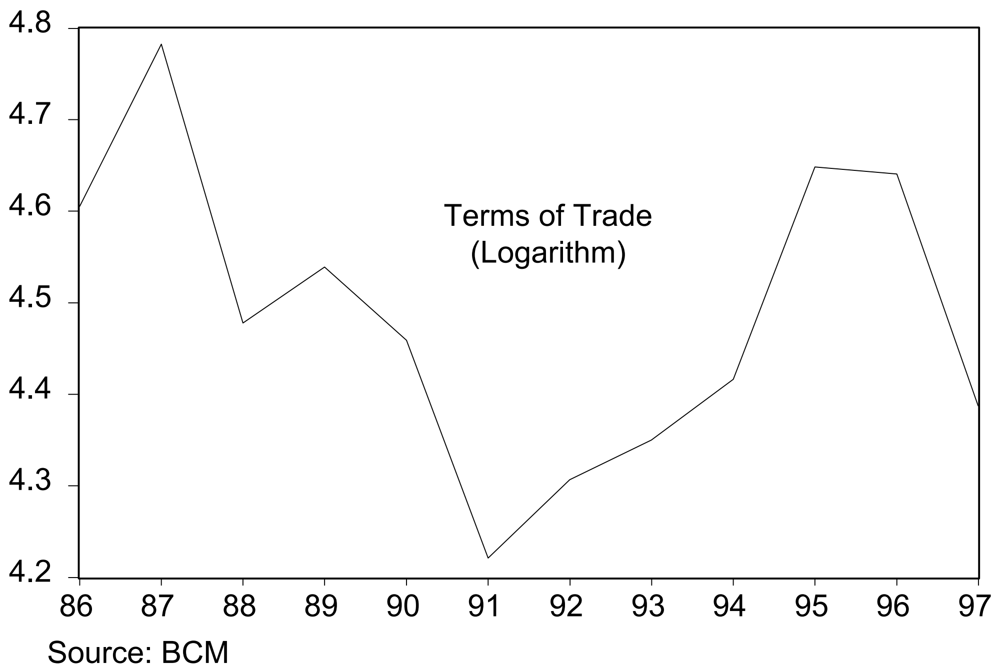
The reform process has been disturbed by political turmoil, in 1991, leading to a change in government, with free elections held in 1993. Reforms have been carried on since, and a sweeping reform of the exchange and trade system was implemented in May 1994. Despite these deep reforms, the Malagasy economy has resumed its downwards slide in the 1990s, as can be seen from figure 2, which depicts the fall in real output per capita since 1990.

Figure 2 : Real GDP per Capita



Like most low-income developing countries, Madagascar is subjected to large external shocks. Figure 3 shows the terms of trade, in logarithm. On average over this period, their value is 4.49. Therefore, this chart shows that the Malagasy terms of trade fluctuated roughly within a 30 %-wide band around its mean value. In other words, Malagasy exports lost about 60 % of their international purchasing power between 1987 and 1991, when the international prices of most commodities crashed on the world markets.

Figure 3 : Terms of Trade



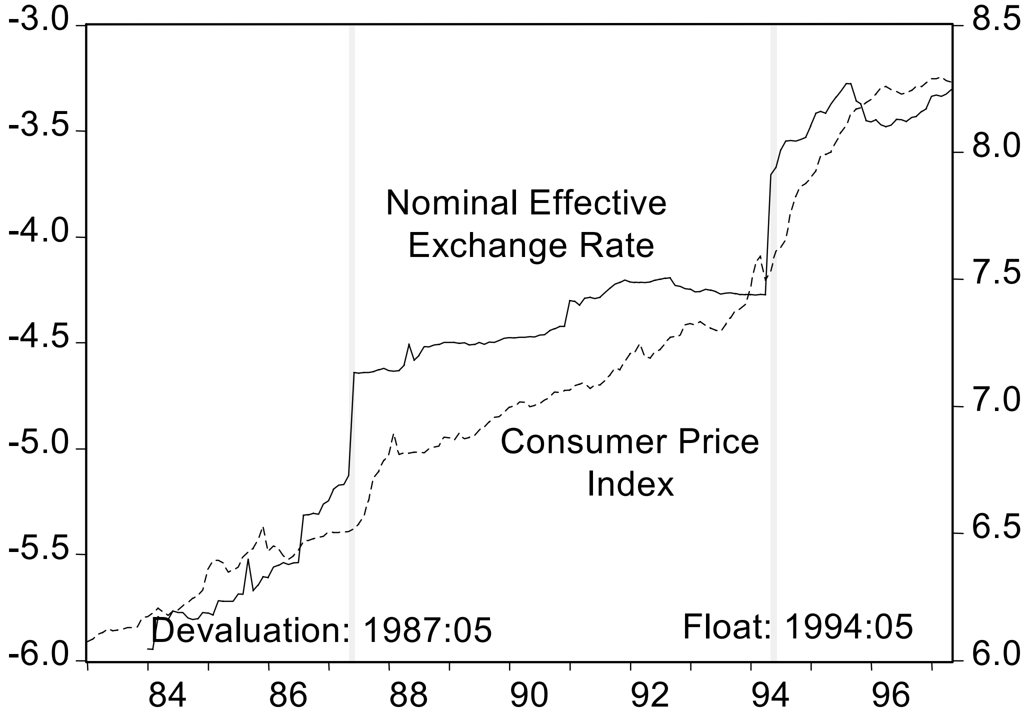
This economy has a very cyclical performance in terms of inflation, with a recurring inflation crisis every six or seven years, where the rate of inflation jumps over 20 or 30 % for a year or two (IMF, 1996). This occurred in 1974, 1981-83, 1988, and 1994-95. The latter inflationary episode saw the inflation rate stay above 45% for about a year. Otherwise, the rate of inflation fluctuates around 10%. The inflationary episodes affect the competitiveness of the economy, and entail some macro-economic instability, which is described in section 2 below. Section 3 looks in more detail at the role of the central bank in the determination of these results. Section 4 begins the more analytical part of the paper, and presents the simple theoretical model that explains the link between high inflation and macroeconomic instability. Section 5 presents some empirical results, showing the determinants of the real effective exchange rate and of its volatility, and the determinants of the inflation rate, estimated using monthly data. Section 6 concludes.

2. Inflation and Macro-economic Instability: A Narrative.

The surges in inflation that have been alluded to above are strongly correlated with major changes in the nominal and the real exchange rates. The latter is a key variable in the structural adjustment process, as it is the main determinant of competitiveness and current account performance. This close relationship between inflation and competitiveness shows that the monetary and exchange rate policies have a determinant impact on the performances of the real economy in this country. The present section is devoted to the joint analysis of the changes in the rate inflation and its relationship with the real effective exchange rate, which is a trade-weighted index of the price level of the main trading partners, relative to the domestic price level, all expressed in FMG (*Malagasy franc*) at the ruling exchange rate. This index is an imperfect indicator of the theoretical concept of real exchange rate, in that the possible over-valuation of the currency of any of the main trading partners of the country would entail an under-estimation of the over-valuation of the domestic currency. Nevertheless, this indicator is very convenient to use, because it is available at the monthly frequency, and it is the favorite indicator of competitiveness used by the IMF.

The nominal effective exchange rate series for 1983-97 is represented in figure 4, together with the consumer price index series. The exchange rate history of the Malagasy franc over these 15 years is that of a continuing depreciation, interrupted by two large step devaluations, one in 1987:06, and one in 1994:05, which was in fact the market response to a temporary shift to a regime of free floating. The former resulted in a depreciation of the nominal effective exchange rate of 48.5%, and the latter of 56.5%. Each of these devaluation episodes has been followed by a period of rather high inflation, against a background of low inflation, hovering most of the time about 10 % per annum. Several other more moderate step devaluation episodes occurred, in 1984:03 (15.2%), 1986:06 (22.4%), and 1991:01 (12.2%).

Figure 4: Nominal Effective Exchange Rate and Consumer Price Index



Notes: -Logarithmic scales
- An increase in the NEER is a depreciation of the local currency

This comes out clearly from figure 5, where the rate of change of the CPI over 12 months is represented, computed as the year-to-year difference in the logarithm of the CPI. It shows two high inflation episodes, one from mid-1987 to the end of 1988, and one from early 1994 to mid-1996. These inflationary episodes were clearly related to the two devaluations. Notice, however, that the 1994-96 inflationary episode started about six months before the currency attack, while inflation had also started to accelerate before the 1987 devaluation. It is not so clear whether the more drawn out inflation episode of 1985, which remained roughly about 20% per annum, was the consequence of the 1984:03 devaluation of the FMG, because it seems to have occurred with a longer lag than the other two. However, this more lagging response might result from the smaller rate of change of the parity, which might have dampened the speed of the inflation response.

Because of the large inflationary response of the consumer price index to the large step devaluation shocks, their degree of effectiveness vanished relatively quickly. This can be seen from figure 6, which shows the real effective exchange rate and the rate of change of the nominal effective exchange rate. Examination of the former series suggests that it returned to its trend value within less than a year after the 1987:06 devaluation, while the impact of the 1994:05 devaluation lasted about two years, before the real effective exchange rate returned to its pre-devaluation value

Figure 5: Inflation Rate (0.1=10%)

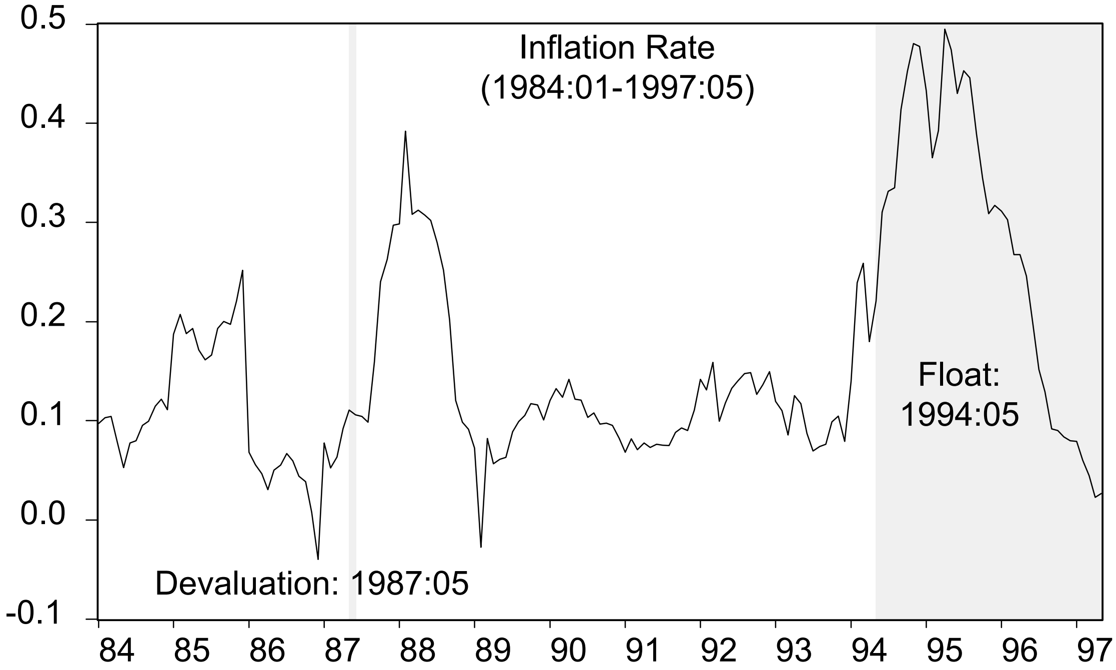


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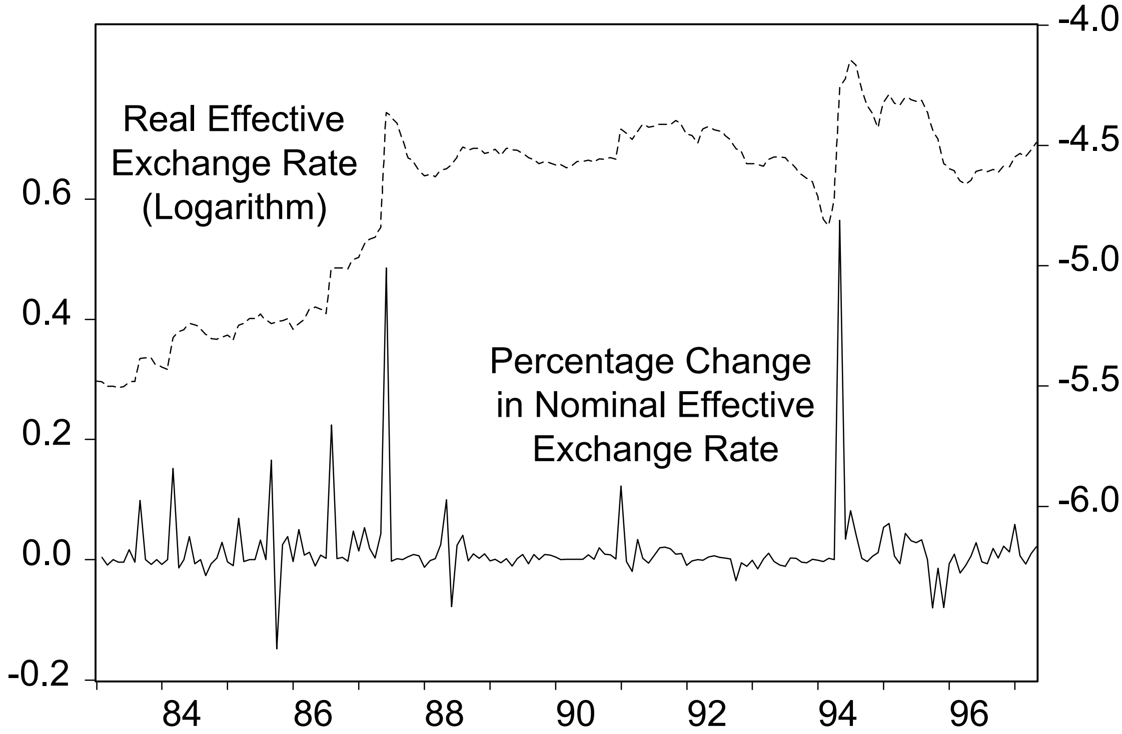
Figure 6: Real Effective Exchange Rate and Percentage Change in Nominal Effective Exchange Rate



Beside these two devaluation-*cum*-inflation episodes, figure 6 also shows that the time profile of the real effective exchange rate can be described as comprised of two periods.

Before the first massive devaluation, one observes a steady real depreciation of the FMG, followed by a period of rough stability of the real effective exchange rate. In particular, between 1988 and 1990, the exchange rate was managed, under a system of crawling peg, with a view to stabilize the real effective exchange rate. During most of 1993, and the beginning of 1994 before the devaluation, the FMG shows a clear tendency to appreciate in real terms, which played a part in determining the choice of moving to the float in 1994:05. The latter was in fact the government response to a speculative attack. Although figure 6 clearly shows the occurrence of the massive devaluations, by presenting the month-to-month rate of change of the nominal effective exchange rate, it hides the fact that the inflationary episodes saw the rate of crawl rise to high levels for relatively long periods. Computed over 12 months, it rose over 20 % between 1986:08 and 1988:05, then for two months starting in 1991:10, and then again in a more sustained fashion in 1994:05-1995:09. Notice that the increase in the rate of crawl in 1986 predates the currency crisis.

The paddy market played an active role in the 1994 currency crisis, as it often does in many African countries. This is a highly speculative market, as inventories of paddy are the main inflation-proof asset held by a large number of people in Madagascar (Azam and Bonjean, 1995). The price of paddy has a clear seasonal pattern, with a low point usually in May, just before the beginning of the next harvesting season. During the year preceding the 1994 devaluation, paddy has been the star performing asset in this country : those who bought paddy in June 1993 and sold it in March 1994 made a record real return of 49.8 %. This suggests that the real price of paddy, deflated by the CPI, should be used by the central bank as part of a potential early warning device for speculative attacks against the FMG.

By comparing the two preceding charts, one can observe that the time profiles of the rate of inflation and the real effective exchange rate have some similarity. This is confirmed by analyzing their time-series relationships. First, these two series are borderline integrated of order 1 (~ $I(1)$). This is shown in table 1, which presents the values of the Augmented Dickey-Fuller unit root test for these two variables, both in level and in first difference.

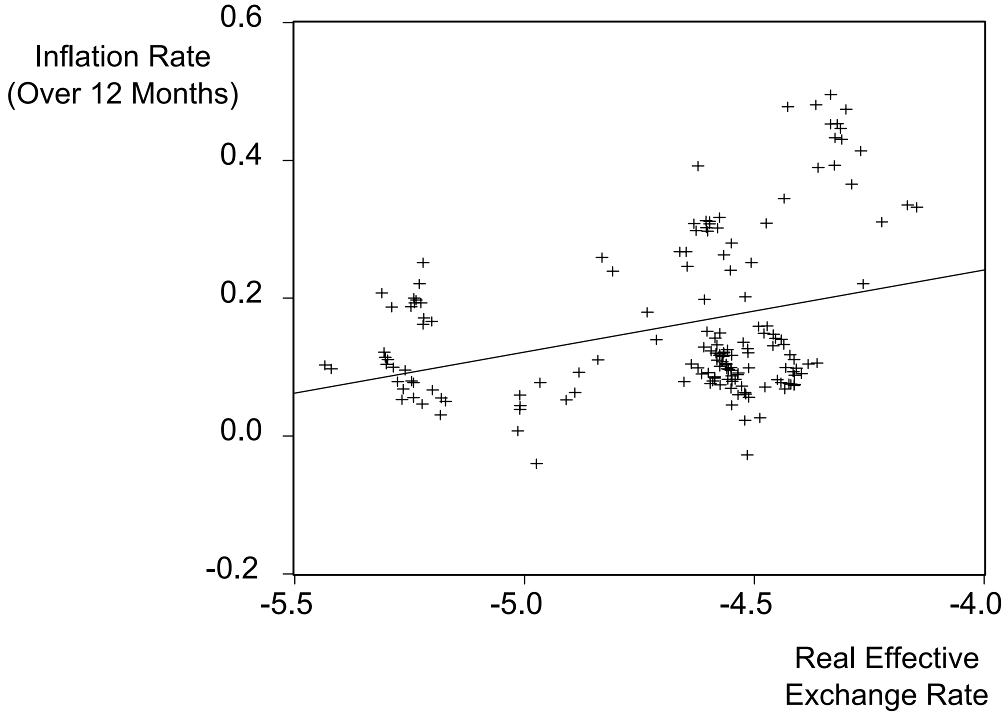
Table 1: Augmented Dickey-Fuller Unit Root Test (5% critical value = - 2.88)

	Level	*First Difference*
Inflation Rate	- 2.73	- 4.88
Real Effective Exchange Rate (log)	- 2.14	- 6.84

Second, these two variables are co-integrated, with a Johansen Likelihood Ratio test of 18.47, to be compared with the 5% critical value of 15.41. In the co-integrating equation, the growth rate of the nominal effective exchange rate, which is close to a dummy variable for the two massive devaluations, has been included as an exogenous forcing variable.

However, the co-integrating equation only provides some guidance regarding the long-run relationship between these two variables. It is far from a satisfactory econometric analysis of the determinants of the real effective exchange rate. Figure 7 represents the scatter diagram of the rate of inflation and the real effective exchange rate, together with the simple regression line that can be estimated by OLS between them. The simple regression line only provides a very crude description of their long-run joint behavior. It is quite evident that a deeper analysis of the relationship between the two series is required, for capturing the shorter-run dynamic relationship between them. This is done in section 4 and 5 below, where a more thorough analytical and econometric analysis of these two variables is performed.

Figure 7: Inflation and the Real Effective Exchange Rate (Scatter Diagram)



In the coming section, we carry on with the narrative, by describing the demand for reserves by the central bank, as well as some other variables under its control.

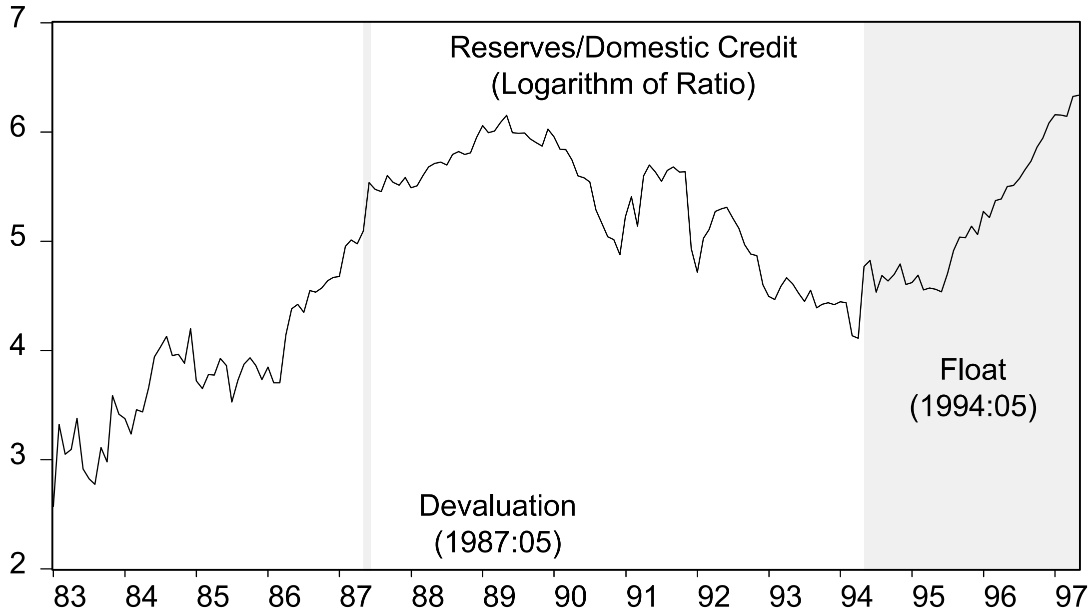
3. Aspects of the Central Bank Portfolio Behavior.

Inflation and competitiveness, which are jointly determined, as shown by the previous section, are affected by the behavior of the central bank.. This section presents some aspects of the central bank portfolio behavior, that will be shown below to affect these two variables.

Figure 8 represents the (log of) the ratio of reserves to domestic credit. This is a good indicator of the stance of the central bank policy towards foreign exchange. One can see three contrasted periods. Until the beginning of 1989, the amount of reserves held by the central bank is clearly rising, relative to domestic credit. Standard macro-economic theory suggests that this can be interpreted as a policy aiming at preventing any real appreciation of the exchange rate. In fact, as seen from figure 6, this period was mostly characterized by a continuing depreciation, except at the end of 1987, when some temporary real appreciation occurred, as inflation started to respond to the first massive devaluation. In other words, this period is one of fairly aggressive monetary policy in favor of external competitiveness, which achieved a sustained and substantial depreciation of the real effective exchange rate. However, it ended up in the strongly inflationary episode that was described above, after the massive devaluation of 1987.

Then starts a period of declining reserves, relative to domestic credit, which does not entail any real appreciation of the FMG until, say, 1993. On the contrary, one observes a slight real depreciation, during a period marked by a remarkable stability of the real effective exchange rate, partly due to the crawling peg policy, and of the inflation rate. Then starts a period of real appreciation, in 1993 and 1994, which ends up in the speculative attack described in the previous section, inducing the government to adopt a regime of free floating in May 1994.

Figure 8 : Reserves of the Central Bank and Domestic Credit



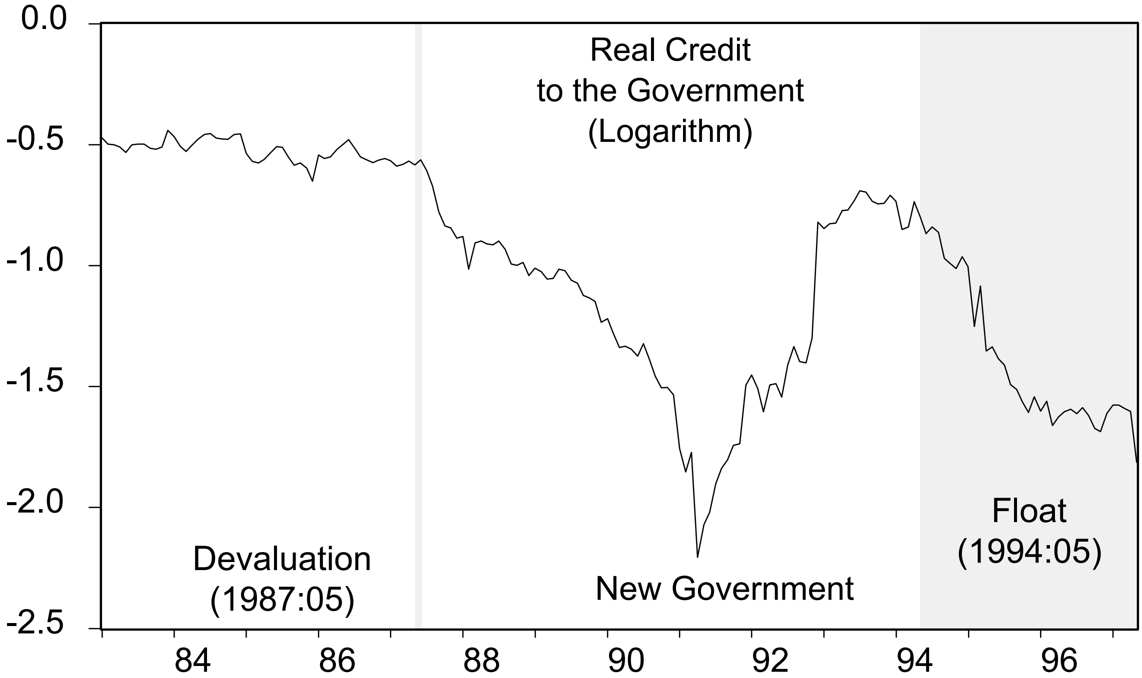
However, after about a year of floating, reserves start piling up again, showing that the central bank adopted an active foreign exchange market policy, accumulating reserves. This was probably aimed at preventing the real exchange rate from appreciating again, relative to some implicit target. It can be seen at figures 4 and 6 that both the nominal effective exchange rate and the real effective exchange rate had a slight tendency to depreciate during this period. This policy was adopted after the episode of sharp real appreciation that marks the end of the post-float inflationary episode, as can be seen in figures 5 and 6. However, the determination of the exchange rate remained market-based, without administrative fixing.

The other crucial element of the central bank portfolio behavior is its credit to the treasury. This is the channel by which the government extracts some seignorage from the private sector, via the inflation tax. This is often regarded as the main cause of inflation in developing countries.

Figure 9 shows the real value of the stock of credit to the treasury. Four different phases can be distinguished. Before the 1987 devaluation, this stock is high and steady, and this is probably the root of the problem that led to this devaluation. Then, the government pursues a drastic policy of reducing its indebtedness to the central bank, which lasts until the political turmoil of 1991. The new government abandons this austerity policy, and the stock of real credit to the government starts rising at a brisk pace. This leads to the switch to the floating exchange rate regime that was adopted in 1994, after the real appreciation period and the speculative attack described above. On the face of it, then, these two speculative attacks bear some resemblance to the theoretical framework introduced by Krugman (1979), where the accumulation of central bank credit to the treasury leads eventually to the currency attack (see as well Dornbusch, 1987). Then, the government starts reducing its indebtedness towards the central bank again, in real terms. This means that the surge in inflation that followed the 1994 devaluation played probably a part in reducing the real value of the central bank credit to the government. The accumulation of reserves seen above played also a part in bringing about this result.

The econometric analyses that follow show that this portfolio behavior of the central bank had a significant impact on inflation and the real effective exchange rate. This underlines the intimate links that exist between the real and the monetary sides of the economy. This suggests that monetary policy, and more generally the portfolio behavior of the central bank, should be regarded as an integral part of the government's policy towards the real economy, and in particular of the structural adjustment program, and, more generally, of the development strategy of the country.

Figure 9 : Central Bank Credit to the Treasury



To sum up, the foregoing brief quantitative analysis of the macroeconomic history of Madagascar can be described by the following stylized facts. We observe two periods of macroeconomic instability, before 1989, and between 1994 and mid-1996, and a period of relative stability in the interim period, in 1989-93. The two instability spells are characterized by high and volatile inflation, together with an unstable real effective exchange rate. The level of reserves, relative to domestic credit, is low and rising, as if the government was trying to prevent the currency from appreciating in real terms, relative to some implicit target, while the terms of trade are relatively high. In both cases, the stock of central bank credit to the government is high, in real terms, and a currency attack takes place in the course of each period of instability, in May 1987 and May 1994, resulting in a massive nominal depreciation of about 50 %. During the interim stability episode, the rate of inflation is low and stable, the real effective exchange rate has a regular time profile without major swings, while the terms of trade are low, the reserves are declining, as is the stock of central bank credit to the government.

The following two sections provide the simple theoretical framework that helps linking up these events, as well as the empirical analysis that confirms its relevance.

4 : A Simple Model of Inflation and Macroeconomic Instability

Denote M the quantity of money and p the price level. Real money balances are then defined as $m = M/p$. Let e be the exchange rate. For the sake of simplicity, units are selected such that the international price of tradable goods in terms of foreign currency is equal to 1, so that their nominal price in domestic currency is e. Then, the price level is an increasing (and linearly homogenous) function of e and of the price of non-tradable goods, which is kept implicit in what follows. Define $q = e/p$ as the real exchange rate. This is in fact an increasing function of the real exchange rate as defined usually as the ratio of the price of tradable goods to the price of non tradable goods. There is a one-to-one correspondence between these two definitions.

In order to model the fiscal role of the real exchange rate, we split government expenditures and revenues into two different budgets, depending on whether they are directly affected by the exchange rate or not. Assume that the government has, on the one hand, more expenditures than revenues that are indexed on the price level p, and, on the other hand, more revenues (foreign aid included) than expenditures indexed on the exchange rate. Let D and F be the excess of expenditures over revenues indexed on p and the excess of revenues over expenditures indexed on e, respectively. Regarding D and F as constant is a simple way of capturing the idea that the government is assumed not to subordinate its budgetary policy to the goal of monetary stability. Hence, the monetary financing of the overall deficit implies:

$$d M/d t = p D - e F. \qquad (1)$$

Denote $\pi = d \log p/d t$ the rate of inflation and $\delta = d \log e/d t$ the rate of crawl of the national currency chosen by the government. As seen in the previous section, the exchange rate regime in Madagascar can be described as a managed float, or a crawling peg, during most of the period under study, as testified by the behavior of the reserves. This is captured simply here by assuming that the government controls δ. Moreover, this rate of crawl is assumed to be credible and known to the private agents. Then, the real depreciation of the domestic currency is governed by the following differential equation :

$$d q/d t = (\delta - \pi) q. \qquad (2)$$

Using the notation m for real money balances presented earlier, (1) may be rewritten as:

$$d m/d t = D - q F - \pi m. \qquad (3)$$

Assume that the demand for real money balances is determined à la Cagan (1956) as a function of the expected rate of inflation π^e by the following function:

$$m = \lambda (\pi^e), \ \lambda' < 0. \qquad (4)$$

The analysis is restricted to the case of rational expectations equilibria, where (4) holds with $\pi^e = \pi$ and $|\pi^e| << \infty$, $\forall t > 0$, where 0 is the present date.

Then, using (3) and (4), yields:

$$d \pi /d t = (1/\lambda') \, d m/d t = (1/\lambda') (D - q F - \pi \lambda (\pi)). \qquad (5)$$

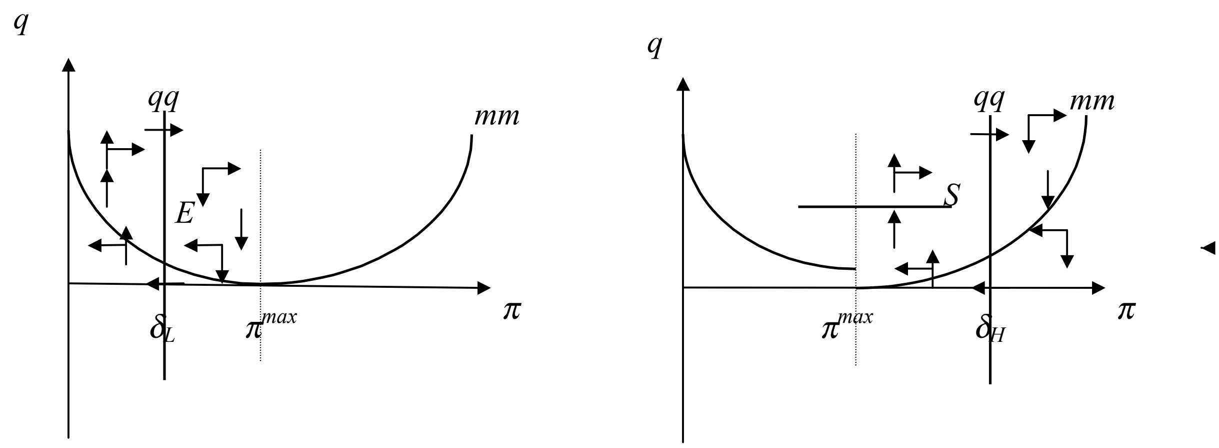
Therefore, inflation is stabilized ($d\,\pi / d\,t = 0$) for all pairs $\{ q\ ,\ \pi \}$ such that:

$$D - q\,F = \pi\,\lambda\,(\pi). \qquad (6)$$

Real seignorage, represented by the left-hand side of equation (6), is a linear decreasing function of *q*. Notice that this negative slope would be reinforced if we assumed *D* and *F* to be functions of *q*, as the natural assumptions to make would be $D' < 0$ and $F' > 0$, as a real depreciation would increase the real value of foreign trade, on which a lot of taxes are based, thus increasing *F*, while it would reduce the real value of public expenditures on non traded goods, which can be safely assumed to be dominant in *D*. May be also, a real appreciation (a fall in *q*) would trigger some increases in wages and salaries, as the cost of living would go up, entailing an increase in the real value of *D*. Hence, our simplifying assumption ($D' = F' = 0$) does not entail any loss of generality. The proceeds of the inflation tax, represented by the right-hand side of this equation, form a non monotonic concave function of π , according to the inflation-tax Laffer-curve mechanism (Bruno and Fischer, 1990, Dornbusch et Fischer, 1993). Define the inflation-tax maximizing rate of inflation as :

$$\pi^{max} = argmax\ \ \pi\ \ \lambda(\ \pi\ ). \qquad (7)$$

Therefore, (6) can be represented as a non monotonic convex curve, labeled *mm* in figures 10.a and 10.b. This implies that any level of the real exchange rate that is consistent with the existence of a stationary equilibrium, i.e. located on *mm*, could correspond equally to a low or a high rate of inflation, depending on the side of the curve on which the equilibrium is located. Hence, knowledge of the equilibrium real exchange rate provides very little information on the macroeconomic situation. Off the *mm* locus, the inflation rate increases over time for the $\{ q\ ,\ \pi \}$ pairs located above it, according to (5), and it decreases over time below this locus. This captures the fact that, if the real exchange rate *q* depreciates, the fiscal deficit decreases, as the real value of aid and trade-related taxes increases. Then, private agents must be reducing their real money balances. This is only consistent with the rational expectations equilibrium if inflation is accelerating.



10.a : Zero-Dimensional Saddle-Path **10.b : Stable Steady State**

Figure 10 : Dynamic Analysis of the System

Combined with the real exchange rate dynamics embodied in (2), the dynamics of this system can be analyzed with the help of the phase diagrams 10.a and 10.b. The locus of points such that $d\,q/d\,t = 0$ is denoted qq . Case 10.a, where the chosen rate of crawl lies below the inflation-tax maximizing inflation rate, represents a saddle point with a zero-dimensional convergent sub-space. Then, as there is no pre-determined variable in the system, the economy jumps instantly at point E, and stays there as long as the chosen rate of crawl δ_L is credible. Hence, the choice of the rate of crawl determines uniquely the real exchange rate and the inflation rate in this case. In case 10.b, we have a different outcome, as the chosen rate of crawl δ_H is larger than π^{max}. Now, the steady-state point S is stable, with a two-dimensional convergent sub-space. Moreover, a close examination of the phase diagram shows that the stationary point can only be reached from either the north-east, or the south-west, i.e. along a trajectory with a positive slope in this space.

We can confirm analytically the diagnosis derived above from the phase diagrams as follows. Linearizing the system around the stationary point $\{\pi^*, q^*\}$, where $\pi^* = \delta$, we obtain :

$$\begin{bmatrix} d\pi/dt \\ dq/dt \end{bmatrix} = \begin{bmatrix} (-1/\lambda')(\lambda+\pi\lambda') & (-1/\lambda')F \\ -q & 0 \end{bmatrix} \begin{bmatrix} \pi-\pi^* \\ q-q^* \end{bmatrix}. \qquad (8)$$

The determinant of the Jacobian matrix in (8) is always positive, while its trace has the same sign as $\lambda+\pi\lambda'$, which in turn is the same as the sign of $\pi^{max} - \delta$, because of the assumed inflation-tax Laffer curve. Therefore, the eigenvalues of this matrix are both positive, if the chosen rate of crawl is smaller than the inflation-tax maximizing rate of inflation, or they are both negative in the opposite case. This confirms the results derived above from the phase diagrams.

The economic predictions derived from this model are entirely different in these two cases. When the chosen rate of crawl is below the inflation-tax maximizing rate of inflation, we have a unique rational expectations equilibrium, which determines simultaneously the rate of inflation and the real exchange rate. Any point other than the stationary point E would belong to an explosive trajectory, and would thus violate the convergence condition for a rational expectations equilibrium. Thus, in this case, the government controls the inflation rate and the real exchange rate through the rate of crawl, for given values of the parameters of the system. In the opposite case, where the stationary point S is stable, any point inside the phase space belongs to a trajectory that converges eventually to S, and thus qualifies as a rational expectations equilibrium. Therefore, we have now a *continuum* of rational expectations equilibria.

The economic intuition behind this result is as follows : in both cases, whether the rate of crawl is chosen high or low, the agents know rationally that any deviation of the rate of inflation above the rate of crawl, for example, would entail gradually a real appreciation of the currency, and an increase in the rate of money creation entailed by the resulting increase in the fiscal deficit, unless the rise in the inflation tax compensates it. Sooner or later, the former effect will come to dominate the latter, because of the concavity of the inflation-tax Laffer curve. Then, real cash balances will start to grow, as the real deficit widens, and this can only happen if agents are prepared to absorb higher real money balances, i.e. if they expect the rate of inflation to come down. Under rational expectations, this means that the actual rate of inflation will respond to a deviation above the rate of crawl by going down, after a while, as the real exchange rate appreciates. Hence, some oscillations in the rate of inflation and in the real exchange rate would follow from this mechanism.

The difference between the two cases comes from the elasticity of the demand for money with respect to the expected rate of inflation. If the economy is on the increasing side of the inflation-tax Laffer curve, then the gradual fall in inflation will entail a destabilizing fall in the inflation tax, resulting in a further fall in expected inflation leading the agents to absorb a further increase in the fiscal deficit. This deviation-amplifying force works as a disciplining device, as agents are not prepared to embark on such an explosive path, by the convergent expectations assumption. On the contrary, when the economy is on the other side of the inflation-tax Laffer curve, the gradual fall in expected inflation increases the proceeds of the inflation tax, thus providing a stabilizing influence. Then there is no threat of embarking on an explosive trajectory, and agents will rationally predict convergence to a finite equilibrium, whatever the initial deviation of expected inflation from the rate of crawl. Hence, expected deviations will be self-fulfilling in this case.

The real-world translation of a continuum of rational expectations equilibria is the prediction of a high volatility of the variables involved. The system has no anchor, so that the variables can jump from one trajectory to the other, as a response to any information whose only relevance is to affect the agents' expectations. In the theoretical literature, models of sunspot equilibria have been devised to capture this idea (see Blanchard and Fischer, 1989, for an introduction). There is no point in going into the mathematical developments of this theory here, as the main component of these equilibria is a continuum of rational expectations equilibria, like the one that has been shown to exist in the neighborhood of point S above. Then, Shigoka (1994) and Drugeon and Wignolle (1996) have shown that Woodford's conjecture applies even in continuous-time models. This conjecture states that there exist stationary sunspot equilibria in the neighborhood of any stationary point of a deterministic model where there exists a continuum of perfect foresight equilibria converging to this stationary point. In this case, any information that affects the agents' expectations will be self-fulfilling, even if it has no other intrinsic relevance for the economy than that of affecting expectations. As the economy is not anchored to a unique equilibrium trajectory by the fundamentals, it can be buffeted away by any random shocks affecting the agents' expectations. Consequently, this model leads to the prediction that the volatility of the inflation rate and of the real exchange rate will be higher when the chosen rate of crawl is above some inflation threshold than when it is below it. Conversely, it suggests that an excessive volatility of the rate of inflation and of the real exchange rate could be corrected by lowering sufficiently the rate of crawl.

This threshold is determined by the parameters of the demand for money function, which determine the inflation-tax maximizing rate of inflation. Adam, Ndulu and Sowa (1996) have offered a set of estimates for Kenya, Ghana, and Tanzania that suggests that this rate is much lower in Africa than in other parts of the world. Their estimates suggest that the typical inflation-tax maximizing inflation rate for African economies, as judged from the three case studies presented, would be about 15 or 20 %. This is very low by European standards. More recent work on the Tanzanian economy by Randa (1999) yields a figure about 44 %. No estimate of this kind is available for Madagascar, but it seems safe to conjecture that the corresponding figure would be of the same order of magnitude as the estimates in Adam, Ndulu and Sowa (1996). As we have seen above, the rate of crawl rose above 20 % for several months during the episodes of macroeconomic instability in this country.

5 : Empirical Analysis of the Real Effective Exchange Rate, the Inflation Rate, and their Volatility.

The simplified model analyzed above is certainly too simple and too abstract for being applied directly to the complexities of the real world. However, it yields a basic insight that is probably worth investigating further, as it is reminiscent of some themes that have been present in the macroeconomic literature for a long time. It predicts (1) that inflation and the real exchange rate are jointly determined, and (2) that their joint volatility increases when the rate of crawl, and hence the underlying trend rate of inflation, rises above some threshold level. This is reminiscent of Friedman's classic idea that when inflation is high, it is also highly variable. In this section, we test a simplified version of these predictions, looking at the stochastic processes generating the inflation rate and the real exchange rate, as measured by the real effective exchange rate, as well as their volatility, testing in particular the hypothesis that the inflation rate is a significant determinant of the latter. We have already seen in section 2 that the two variables under study are integrated of order 1 (see table 1), and are co-integrated. We go now deeper into the dynamic analysis of these series.

After an intensive search procedure, going from the general to the simple, à la Hendry, the following equation has been selected for the real effective exchange rate:

$$
\begin{aligned}
\Delta log(REER) = & - 0.219 + 0.827\ \Delta log(NEER) + 0.011\ log(RATIO) \qquad (9)\\
& \quad (3.49) \quad (12.38) \qquad\qquad\qquad (2.57)\\
& - 0.034\ log(REER(-1)) - 0.214\ \Delta INFL\\
& \quad (3.24) \qquad\qquad\qquad (2.14)\\
& \qquad\qquad\qquad\qquad\quad [0.32]^{N}
\end{aligned}
$$

N = 160, R^2 = 0.80, F = 158.91, $D.W.$ = 2.09, $LM(2)$-F = 0.22, *White-F* = 2.00, $ARCH(1)$ = 22,55.

In equation (1) *REER* and *NEER* are the real effective exchange rate and the nominal effective exchange rate, respectively. Notice that the former, lagged once, has a significant negative impact on its own growth rate, suggesting that this variable is stationary after all, once all the other effects are taken into account. This is an example of conditional stationarity. The ratio of reserves of the central bank to domestic credit is noted *RATIO*, and is meant to capture the stance of the exchange rate policy pursued by the government. As seen in section 3, an increase in reserves indicates the willingness of the government to depreciate the domestic currency faster, *ceteris paribus*, in real terms. Lastly, *INFL* is the rate of inflation, computed over 12 months, so that no seasonality effect is expected. The number of lags is noted (-1), and Δ is the first difference operator. The sample used covers 1984 :02-1997 :05, and N is the number of observations. The numbers in parentheses below the estimated coefficients are White's Heteroscedasticity-Consistent t ratios, because of the heteroscedasticty problem detected by the relevant tests. There are two serial correlation tests, the *DW*, which is biased here because of the inclusion of the lagged endogenous variable, and the *LM* test, which tests serial correlation up to the second order. They signal no autocorrelation problem. Then come two heteroscedasticity tests, White's F test detects some slight heteroscedasticity, while the *ARCH* test spots some massive auto-regressive conditional heteroscedasticy. These two problems do not create biases for the estimation of the coefficients of the equation, but raise problems for the usual t ratios. This explains why the heteroscedasticity-consistent ones have been used instead.

The number in the square brackets with a superscript N is the Nakamura and Nakamura (1981) exogeneity test. It aims at testing whether the estimate of the coefficient of $\Delta INFL$, which is theoretically endogenous, would have been different, had two-stage least squares been used instead of OLS. It is done by estimating an auxiliary equation including the residuals of equation (11) below, which explains $\Delta INFL$, as an additional variable beside the latter in equation (9). The t ratio corresponding to this variable in this auxiliary equation, and reported here, tests precisely whether the difference between the estimates obtained under the two estimation method is significant. The low number found here shows that using TSLS instead of OLS would have made no significant difference.

However, it would be disappointing just to be content with correcting the tests for the heteroscedasticity and *ARCH* problems detected above. It is in fact worthwhile to investigate the process generating this changing residuals variance, in relation to the theoretical model described above. We are thus interested in analyzing whether the rate of inflation is a forcing variable that affects the stochastic process generating the volatility of the two series of interest. Using the *GARCH* framework (see e.g. Enders, 1995), we can estimate the residuals-variance-generating process in the following way :

$$RES^2 = \underset{(2.54)}{0.003}\, INFL + \underset{(1.61)}{0.338}\, RES^2(-1). \qquad (10)$$

N = 159, R^2 = 0.14, F = 24.40, $LM\text{-}F$= 4.34, $White\text{-}F$ = 1.38.

In this equation RES^2 is the square of the residuals from equation (9). Although it suffers from a little residuals serial correlation, this equation shows that inflation is the main driving force behind the changing variability of the real effective exchange rate, which raises the problem described above. The higher is the inflation rate, the more volatile is the real exchange rate. Caballero and Corbo (1989) have shown empirically that the variability of the real exchange rate is negatively related to export performance in LDCs. Then our result creates a link between inflation and export performance.

Therefore, the two econometric exercises performed above show a crucial link between real and monetary factors in the Malagasy economy : the rate of inflation affects both the rate of real depreciation, and its volatility. Notice that in equation (9), an increase in the rate of inflation entails a negative effect on the real exchange rate, i.e. an appreciation. This is the short run effect, to be distinguished from the positive long-run effect found in the co-integration equation and in figure 7. The latter suggests that a lot of the observations might be located on some trajectories heading to the ‘wrong side’ of the *mm* curve. The other interesting point worth mentioning about this equation is that an increase in the ratio of reserves to domestic credit has an impact going in the direction of a real depreciation, as expected from standard macro-economic theory.

Using a similar approach, we have estimated an equation for explaining the rate of inflation. This is the equation yielding the residuals used at equation (9) for performing the Nakamura and Nakamura (1981) exogeneity test. After an intensive search *à la* Hendry, the following specification has been selected.

$$\Delta INFL = \underset{(2.66)}{0.219} - \underset{(2.45)}{0.079}\, INFL(-1) + \underset{(2.38)}{0.081}\, \Delta log(NEER(-5)) \qquad (11)$$
$$+ \underset{(2.48)}{0.038}\, log(REER(-1)) + \underset{(2.14)}{0.027}\, log(REAV(-1))$$

N = 160, R^2 = 0.12, F = 5.18, $D.W.$ = 1.97, $LM(2)\text{-}F$ = 0.41,
$White\text{-}F$ = 1.25, $ARCH(1)$ = 2.35.

This equation relates the change in the rate of inflation to its lagged value, with a negative sign, suggesting also that inflation might be stationary after all, once the impacts of all the exogenous variables have been taken into account. The impact of the devaluations is significant, with a 5-months lag. This confirms the visual impression gathered from examining figures 5 and 6. The impact of the *REER* lagged once is significantly positive, confirming the effect found in the long-run (co-integrating) equation. This may be interpreted as a feed back effect from the real economy, and in particular from its external competitiveness, on the monetary side. Lastly, *REAV* is the real value of the central bank credit to the treasury. Its positive impact shows the standard inflationary impact of government budget deficits, when they are financed through the « printing press ». As it is lagged once, it should not raise any problem of strict exogeneity. This equation is affected by no heteroscedasticity, probably because of the de-seasonalization implied by the use of the inflation rate computed over 12 months. However, the following exercise recovers the expected effect of inflation on volatility.

In order to test for the impact of the rate of inflation on its own volatility, we now compute the rate of change of the consumer price index on a month-to-month basis *Δlog(CPI)*. This is a stationary variable, with an augmented Dickey-Fuller statistics equal to - 5.24, to be compared with a critical value at the 5 % threshold equal to - 2,87. The preferred equation reads :

$$\Delta log(CPI) = \underset{(4.40)}{0.356} + \underset{(4.27)}{0.060}\, log(REER(-1)) + \underset{(2.45)}{0.038}\, \Delta log(NEER(-5)) \quad (12)$$
$$- \underset{(2.96)}{0.014}\, log(RATIO(-1)) - \underset{(2.05)}{0.072}\, log(CPI(-1)) + \underset{(2.00)}{0.079}\, log(CPI(-12))$$
$$+ \underset{(3.59)}{0.031}\, log(REAV(-1))$$

$N = 161$, $R^2 = 0.18$, $F = 5.80$, $D.W. = 1.94$, $LM(2)\text{-}F = 0.65$,
$White\text{-}F = 3.01$, $ARCH(1) = 2.79$.

All the tests used here have been explained before. Only White's heteroscedasticity test signals a problem. The *t* ratios used here for testing the significance of the individual coefficients are again the heteroscedasticity consistent ones. As done above, the heteroscedasticity problem is not just corrected, but it is analyzed instead, with a view to understand its cause. Using again the *GARCH* framework applied at equation (11), the squared residuals from equation (12) are regressed on the assumed explanatory variables. This yields :

$$RES^2 = \underset{(1.80)}{0.003} + \underset{(3.90)}{0.018}\, \Delta log(CPI(-1)) + \underset{(2.33)}{0.178}\, RES^2(-1). \quad (13)$$

N = 160, $R^2 = 0,11$, $F = 9,12$, $LM(2)\text{-}F = 2,35$.

Here again, the positive effect of inflation on the variability of the residuals can be observed. The quality of the fit is not good, but the *F* statistics confirms the significance of this regression at the conventional level.

Hence, we have observed not only some long-run (co-integration) and shorter-run relationships between inflation and the real effective exchange rate, but also a positive relationship between inflation and the volatility of the former two variables. These results provide some support for the basic insight derived from the analysis of the theoretical model of the previous section.

Given the insights provided by the theoretical and empirical analyses performed in the last two sections, we can now return to the issues raised by the currency crises that occurred during the two phases of macroeconomic instability that we have identified. When discussing figure 9 above, the remark was made that the behavior of the reserves-to-domestic credit ratio, compared with the time profile of the real and nominal exchange rates, seemed to square relatively well with the predictions resulting from a model of a currency crisis *à la* Krugman (1979). However, the analysis performed in this section and the preceding one are pointing in the opposite direction, suggesting that a self-fulfilling element should be at work in this case. We know in particular from Obstfeld (e.g. Obstfeld, 1996) that self-fulfilling speculative attacks are closely related to the problem of multiple rational expectations equilibria, and recent empirical results (Berg and Pattillo, 1999) lean in this direction, by suggesting that their predictability is very limited. Hence, this type of currency crises can be expected to be an ever-present possibility when the rate of crawl moves above the inflation-tax maximizing rate of inflation, i.e. when it pushes the economy in the macroeconomic instability zone.

6. Conclusion

This paper has argued, both theoretically and empirically, that the rate of inflation is the crucial (proximate) determinant of macroeconomic instability in Madagascar. After presenting a statistical description of the recent macroeconomic history of this country, bringing out the relationships between the rate of inflation and the real exchange rate, in section 2, this paper has offered a description of the central bank's behavior with respect to foreign exchange reserves and credit to the government. Then, a simple monetary model with rational expectations has been used to explain the simultaneous determination of the rate of inflation, the real exchange rate, and their joint volatility. It suggests that the level of the inflation rate is the fundamental component of macroeconomic instability : when it rises above some threshold, the rational expectations equilibrium is not locally unique, and the model predicts that a strong volatility of the two endogenous variables sets in.

Although the empirical analysis presented next did not test precisely the theoretical model presented, which is probably too simple and too abstract for that, it has tested the main insight that derives from its analysis. Paying special attention to the heteroscedasticity problems arising from the equations estimated using Malagasy monthly data on inflation, the real effective exchange rate, and the policy tools used by the central bank, the econometric analysis presented has confirmed that the rate of inflation has a significant positive impact on its own volatility, and on the real exchange rate and its volatility.

These results have clear implications for the conduct of macroeconomic policy in this country. The central bank plays a crucial role in affecting both the rate of inflation and the real effective exchange rate in Madagascar, as well as their volatility. Its policy should thus be geared on a monetary target, like the trend rate of inflation, and real targets like the degree of competitiveness of the economy would be automatically taken care of by the same token, given the other determinants of the fiscal deficit. The central bank of Madagascar has several tools in its tool kit that have significant impact on the behavior of this variable. First, the level of the nominal effective exchange rate has been shown to affect both the rate of inflation, which responds with a short lag to any change in the former, and the real effective exchange rate, on which it has a temporary impact. Second, the portfolio behavior of the central bank also affects these two variables, with the ratio of foreign exchange reserves affecting significantly the real effective exchange rate, while the real value of the stock of credit to the treasury seems to affect predominantly the rate of inflation. Hence, the central bank is equipped to be a major actor in the structural adjustment program of the Malagasy economy, and in its longer-run strategy. In particular, the exchange rate turns out to be the main instrument to be used for maintaining macroeconomic stability. Keeping the rate of crawl low enough is the main proximate objective to be pursued in this policy framework.

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