The parallel market as a policy instrument in collapsing exchange rate regimes

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Abstract

The objective of this paper is to bring evidence on the role of the parallel market as an additional temporary policy instrument in developing countries with balance of payments problems.

The extent of rationing of foreign currency at the official exchange rate is measured through a time-varying parameter.

The temporary nature of the parallel market is shown by calculating a one-step ahead probability of collapse as in Blanco and Garber (1986).

These issues are tested using data on Haiti, a country in the Caribbean which has been suffered balance of payments problems since the 1980s. © 2001 Elsevier Science Inc. All rights reserved.

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1. Introduction

At the breakdown of the Bretton Woods system in 1973, industrial economies moved to a regime of floating whereas most developing countries maintained a fixed exchange rate pegged to a single major currency. The choice of the major currency was usually motivated by the pattern of trade or by political ties.

Domestic stability was the goal behind such choice of a fixed exchange rate regime. It was
thought at that time that it was the best way to reduce risks inherent to external shocks from abroad and to increase credibility specially with regard to the level of development of the financial system of these developing countries.

One drawback from such choice was its interference with the pursuit of domestic objectives. Indeed such an exchange rate regime constrained these countries into fiscal and monetary discipline that most were unable to sustain and which culminated in the debt crisis of the early 80s. Sachs (1989) for instance has provided an analysis of the debt crisis with special emphasis on eight countries located in Latin America, the Middle East and East Asia. Overvalued exchange rate policy was one evidence mentioned for the origin of the crisis for all the countries surveyed.

Sachs’ study also revealed striking differences among countries along trade orientation of policy choice to alleviate the crisis. Inward-oriented countries, mostly from Latin America, allowed the exchange rate to remain overvalued for a significant period of time. Fear of the uncertainty associated with a flexible exchange regime, and of political instability that changes might bring, were the reasons put forward by Bird (1990) and Aldcroft and Olivier (1998) respectively to explain the choice to keep an overvalued exchange rate.

With no corrective measure in place, overvaluation would have brought these economies into crisis, an issue which is well established by the contribution of the “First-generation models” of currency crises developed by Salant and Henderson (1978), extended by Krugman (1979) and Flood and Garber (1984) notably. Exchange controls were put in place as a mean to delay the crisis, and a considerable parallel market for foreign exchange developed.

There were costs associated with the presence of exchange controls. Misallocation of resource, terms of trade deterioration, implicit tax on exports, and loss of seignorage revenue are some of the negative effects reported by Nowak (1984), Greenwood and Kimbrough (1987), and Pinto (1991) notably.

Wyplosz (1986), Gros (1987), Bacchetta (1990), and Dooley (1996) among others have pointed out the temporary nature of controls, a tool to keep the system viable a little longer.

Dorsainvil (2000a), however, made the observation that in developing countries where balance of payments crises are a recurrent problem, controls have been in place for several years and devaluation of the type predicted by this literature on currency crises has not been observed. Her explanation is that the parallel market which emerges as a result of exchange controls is an additional instrument used by policymakers to weather the crisis. A similar argument was made by Bahmani-Oskooee, and Shiva (1998) in their study of the Iranian economy from 1959 to 1990. In her study, Dorsainvil quantifies the use of this additional instrument by deriving a rationing parameter of foreign currency at the official exchange rate. This parameter expresses the extent of tolerance of the parallel market by policymakers of these countries. She makes, however, the restrictive assumption that rationing was constant over the period.

This paper expands this previous work by allowing the policymakers, at each point in time, to reevaluate their allocation of foreign currency to economic agents contingent on the new economic environment. That is, this paper allows for a time-varying rationing parameter. The parallel market is explicitly modeled by using the interaction between stock and flow equilibrium for exchange rate determination which has been developed by Dornbusch and Fischer (1980), Rodriguez (1980) and applied to the parallel market by de Macedo...
(1982) among others. The question of the parallel market as an engine for the sustainability of the system is also addressed by deriving the probability of collapse at each point in time, as in Blanco and Garber (1986).

These issues accord with events in Haiti, a country in the Caribbean which has been suffering balance of payments problems since the 1980s and where the parallel market played a crucial role from 1983 to 1991 when policymakers of that country moved the economy to floating.

The results show that rationing has been severe in the Haitian economy over the period studied. They also show the temporary nature of the parallel market as a policy instrument to avoid collapse.

The remainder of the paper is divided into three sections. Section 2 presents the model. Empirical results and probability of collapse of the regime are discussed in Section 3. Concluding remarks are contained in Section 4.

2. The Model

The economy considered is a small, open economy with an official fixed exchange rate, denoted “e,” defined in units of domestic currency (gde) per unit of foreign currency ($). The official exchange rate is overvalued. However, policymakers of this economy do not want to resort to devaluation or pegging the exchange rate. Instead a policy of rationing the foreign currency at the official market is put in place which results in the emergence of a parallel market for foreign currency. $\theta$ is the rationing parameter. It expresses, at each point in time, the allocation of foreign currency at the official exchange rate. In such an environment, economic agents have strong incentive to diversify the composition of their currency holdings. They will hold foreign currency as well as maintain a certain amount of domestic money balance; i.e., currency substitution is assumed to hold in that economy. Domestic output is assumed to be a single, exportable good. It is taken as exogenous in this model. The following notations are used: $y_t$ is real GNP, $DC_t$ is domestic credit, $R_t$ are foreign reserves of the government expressed in domestic currency, $M^g_t$ is domestic money supply, $m^{fd}_t$ is real demand of foreign currency in the parallel market, $m^{fs}_t$ is real supply of foreign currency to the parallel market, $e_t$ is the parallel exchange rate, $Imp_t$ is official real imports, $W_t$ real wealth, $i^r_t$ is domestic nominal interest rate, $i^w_t$ is foreign nominal interest rate respectively. All equations are postulated in log form and parameters are assumed positive.

2.1. The parallel market for foreign currency

This is modeled in a partial-equilibrium setting and is characterized by the three equations below.

1) Stock Demand of Foreign Currency:
The stock demand of foreign currency in the parallel market is postulated as positively related to income ($y_t$) of economic agents. It is also positively related to the interest rate differential between the domestic economy and the rest of the world ($i^w_t - i^r_t$) adjusted for
the expected rate of depreciation of the parallel market exchange rate. Coefficient \( b_2 \) captures the extent of substitution between domestic and foreign currency based on Girton and Rooper (1981).

\[
m^s_{t} = \beta_0 + \beta_1 y_t + \beta_2 (i^w_t - i^r_t) - \beta_3 E_t e_{t+1} - e_t \]  

(1)

(2) Flow Demand for Foreign Currency:

This is postulated as positively related to wealth of economic agents \((W_t)\). Hence, the flow demand for foreign currency:

\[
\Delta m^s_d = \gamma_0 + \gamma_1 W_t
\]  

(2)

(3) Flow Supply of Foreign Money:

This equation follows from Blejer (1978). His rationale is that the main source of foreign exchange supply is overinvoicing of imports or underinvoicing of exports, a fact which is well warranted for the Haitian economy during that period. Therefore the flow supply of foreign currency is linked with foreign exchange differential.

\[
\Delta m^s_s = \alpha_0 + \alpha_1 (e_t - e) 
\]  

(3)

The net addition to the stock of foreign currency in the parallel market is:

\[
\Delta m^s_t = \Delta m^s_d - \Delta m^s_s = \alpha_0 + \alpha_1 (e_t - e) - \gamma_0 - \gamma_1 W_t
\]  

(4)

Market clearing conditions in the parallel market imply that stock demand equal stock supply. Equating Eqs. (1) and (4) yields:

\[
\alpha_0 + \alpha_1 (e_t - e) - \gamma_0 - \gamma_1 W_t = \beta_0 + \beta_1 y_t + \beta_2 (i^w_t - i^r_t) - \beta_3 E_t e_{t+1} - e_t
\]  

(5)

Note an expectation sign on the right-hand side of this equation. Assuming that expectations are formed rationally with the information set at time \( t \) to include all variables dated \( t \) and earlier, and using the method of undetermined coefficients, the final solution for \( e_t \) is obtained as:

\[
e_t = MU1 + \lambda_1 y_{t-1} + \lambda_2 (i^w_{t-1} - i^r_{t-1}) + \lambda_3 e_{t-1} + \lambda_4 W_{t-1}
\]  

where:

\[
MU1 = (\alpha_1 e + \beta_0 + \gamma_0 - \alpha_0) / \beta_3 \\
\lambda_1 = \beta_1 / \beta_3 \\
\lambda_2 = \beta_2 / \beta_3 \\
\lambda_3 = 1 - (\alpha_1 / \beta_3) \\
\lambda_4 = \gamma_1 / \beta_3
\]

2.2. Change in reserves in this economy

Change in reserves in this economy comes from either the government allocation of foreign currency to economic agents \( (\theta_t EMC_t) \) or from the amount channeled to the parallel market through under/or overinvoicing \( (\alpha_0 + \alpha_1 (e_t - e)) \).
EMC_t is a constructed variable which expresses that this economy suffers from excess money creation. It has been derived by assuming that in equilibrium, domestic money supply is backed by domestic credit and by official foreign reserves:

\[ M_t^s = RDC_t + DC_t \quad (8) \]

where RDC_t is the ratio of reserves over domestic credit. Therefore, when there is excess money creation, EMC_t is defined as:

\[ EMC_t = M_t^s - RDC_t - DC_t \quad (9) \]

It is assumed that at each point in time a fraction of this excess money creation (\( \theta_t \)) is satisfied at the official exchange rate forcing economic agents to resort to the parallel market for the rest.

After substituting for Eqs. (6) and (9), the equation for the reserve ratio of this economy is:

\[ \Delta RDC_t = MU2 - \mu_1 M_t^r + \mu_1 DC_t + \mu_2 RDC_{t-1} - \mu_2 DC_{t-1} - \mu_4 W_{t-1} - \mu_5 Y_{t-1} \]

\[- \mu_6 (i_t^w - i_t^r) \quad (10)\]

where:

\[ MU2 = (\alpha_1 e - \alpha_0 - \alpha_1 MU1)/(1 - \theta_t) \]
\[ \mu_1 = \theta_t/(1 - \theta_t) \]
\[ \mu_2 = 1/(1 - \theta_t) \]
\[ \mu_3 = (\alpha_1/(1 - \theta_t))(1 - (\alpha_1/\beta_3)) \]
\[ \mu_4 = (\alpha_1 \gamma_1/(1 - \theta_t))(1/\beta_3) \]
\[ \mu_5 = (\alpha_1 \beta_1/(\beta_3(1 - \theta_t))) \]
\[ \mu_6 = (\alpha_1 \beta_2/(\beta_3(1 - \theta_t))) \]

2.3. The rationing parameter

The main assumption of this paper is the existence of an underlying policy instrument, \( \theta_t \), which helps sustain the system a little longer. It is known only to policymakers. However, we can infer its value from the observation of other economic variables of this economy. Official imports is such a one. I assume that economic agents use the official allocation of foreign currency to buy needed imports through the official channel. Hence, they set a fraction of their income for this purpose. This fraction has to be converted into foreign currency, and therefore reflects the availability of foreign currency at the official exchange rate or the extent of rationing at the official exchange. This suggests a state representation linking official imports and income of the following type:

\[ \text{Imp}_t = \theta_t Y_t \quad (11) \]
where $\theta_t$ is the fraction of income devoted to buying imports. It also translates the unobservable policymakers choice regarding the use of the parallel market. It changes over time depending on the economic environment. But at each point in time, its value summarizes the assessment of policymakers of the state of the economy. This assessment guides them for their choice for next period which suggests a Markov process representation for $\theta_t$.

3. **Empirical Analysis**

The overall model consists of Eqs. (7), (10), and (11). I have used a 2-step estimation procedure in this paper. That is, I have proceeded to estimate Eq. (11) first and then to estimate Eqs. (7) and (10) with $\theta_t$ replaced by its estimated value.

3.1. **Estimation method for the rationing parameter**

A Kalman Filter is applied to the state form of Eq. (11) to compute an optimal estimator of $\theta_t$ based on all information available at time $t$. Error terms added to the state form equation and to the Markov process are assumed normally distributed and uncorrelated with each other, and uncorrelated at lead or at lag. Estimation of $\theta_t$ from 1985:10 to 1991:08 appears in Fig. 1. It shows that rationing has been severe during the period with less than 25% of...
foreign allocation at the official exchange rate. For 1990:12, the Kalman Filter produces a negative rationing parameter. This result should be linked with the observed slowdown in the amount of foreign reserves available to the economy. This may have well forced policymakers to tighten their allocation of foreign reserves even further.

3.2. Estimation of the model

The endogenous variables of the system of Eqs. (7) and (10) are \( e_t \) and \( RDC_t \); error terms have been added to capture any randomness due to measurement error.

Data on the nominal interest rate from the Haitian economy were not available. Therefore as in Blejer (1978b) and Fasano-Filho (1986) the rate of domestic inflation\(^{10} \) has been used as a proxy.

A test of unit root was first performed on the variables of this model. It is reported in Table 1.

The last six variables of the table have unit roots and are cointegrated. One way to proceed with the estimation of this model is to impose the cointegrated relation through an Error-Correcting Representation (ECR). Doing so, the direct impact of the time-varying rationing parameter, one of the main points of this paper, will be diffused. Therefore I have chosen a procedure outlined by Stock and Watson (1988) where the equations are rewritten such that the coefficients of interest become coefficients of mean zero stationary process.\(^{11} \) The final model that I estimated using Full Information Maximum Likelihood (FIML) is the following:\(^{12} \)

\[
\Delta e_t = MU1 - \frac{\alpha_1}{\beta_3} \Delta e_{t-1} - \left( 1 - \frac{\alpha_1}{\beta_3} e_{t-2} \right) + \frac{\gamma_1}{\beta_3} \Delta W_{t-1} + \frac{\gamma_1}{\beta_3} W_{t-2} + \frac{\beta_1}{\beta_3} y_{t-1}
\]

\[
+ \frac{\beta_2}{\beta_3} \Delta i_{t-1}^{w} + \frac{\beta_2}{\beta_3} i_{t-2}^{w} - \frac{\beta_2}{\beta_3} i_{t-1}^{r}
\]

\[
\Delta RDC_t = MU2 + \frac{\theta_t}{(1 - \theta_t)} RDC_{t-1} - \frac{\theta_t}{(1 - \theta_t)} M_t^s + \frac{\theta_t}{(1 - \theta_t)} DC_t
\]

\[
- \left( 1 - \frac{\alpha_1}{\beta_3} \right) \Delta e_{t-1} - \left( 1 - \frac{\alpha_1}{\beta_3} \right) e_{t-2}
\]

Table 1:
Unit-Root Test

<table>
<thead>
<tr>
<th>Variable</th>
<th>Unit Root Test</th>
<th>P-Value</th>
<th>Number of Lags</th>
</tr>
</thead>
<tbody>
<tr>
<td>( y_t )</td>
<td>-3.70</td>
<td>.02</td>
<td>5</td>
</tr>
<tr>
<td>( r_t )</td>
<td>-3.43</td>
<td>.05</td>
<td>3</td>
</tr>
<tr>
<td>( i_t^{w} )</td>
<td>-1.75</td>
<td>.73</td>
<td>6</td>
</tr>
<tr>
<td>( W_t )</td>
<td>-2.11</td>
<td>.54</td>
<td>2</td>
</tr>
<tr>
<td>RDC(_t)</td>
<td>-1.99</td>
<td>.60</td>
<td>2</td>
</tr>
<tr>
<td>DC(_t)</td>
<td>-2.80</td>
<td>.20</td>
<td>2</td>
</tr>
<tr>
<td>( e_t )</td>
<td>-.88</td>
<td>.96</td>
<td>3</td>
</tr>
<tr>
<td>( M_t^s )</td>
<td>-2.40</td>
<td>.38</td>
<td>5</td>
</tr>
</tbody>
</table>
Results using monthly data from 1985:10 to 1991:08 with t-statistics in brackets are given below:

\[
\begin{align*}
\alpha_1 &= 1.42 \quad (1.90) \\
\beta_1 &= 0.50 \quad (3.21) \\
\beta_2 &= 0.44 \quad (4.15) \\
\beta_3 &= 2.05 \quad (2.61) \\
\gamma_1 &= 1.40 \quad (7.38)
\end{align*}
\]

The Durbin-Watson statistics for these equations are respectively DW1 = 0.33 and DW2 = 0.09. The R² for these equations are respectively R₁² = 0.09 and R₂² = 0.01. All parameters are significant at the 6% level and of the expected sign. There is empirical evidence of currency substitution in the Haitian economy.

Next, the probability of collapse of the system is calculated. That is, the probability that the reserve ratio (RDCₜ) reaches a lower bound (Xₜ) at which policymakers will be forced to change their behavior completely. Using the sample regression function of Eq. (13) where the parameters have been replaced by their estimated value, I can rewrite Eq. (13) as:

\[
\Delta \text{RDC}_t = \Delta \text{RDC}_{\text{fitted}} + v_t. \quad (14)
\]

where \(\Delta \text{RDC}_{\text{fitted}}\) is the sample regression function and, \(v_t\) is the residual term of the regression. It is assumed to follow a normal distribution, i.e.,

\[
v_t \sim N(0, \sigma_v) \quad (15)
\]

The probability of collapse of the system is:

\[
P[\text{RDC}_t \leq X_t] \quad (16)
\]

Using Eq. (14) and rearranging terms, I get:\n
\[
P \left[ -\frac{v_t}{\sigma_v} \geq \frac{\Delta \text{RDC}_{\text{fitted}} + \text{RDC}_{t-1} - X_t}{\sigma_v} \right] \quad (17)
\]

Eq. (17) will be used to derive the probability of collapse at each point in time. Indeed, \(v_t/\sigma_v\) is a standard normal variable, and I can determine at each point in time the probability
that it is greater than the calculated value \((\Delta \text{RDC}_\text{fitted} + \text{RDC}_{t-1} - X_t)/\sigma_v\) by looking at the corresponding value in a normal table. \(\Delta \text{RDC}_\text{fitted}\) and \(\sigma_v\) come from the estimated Eq. (13).

To specify \(X_t\), I use two rules. The first rule is that \(X_t = 0\); i.e., policymakers will allow reserves to be completely depleted. The second rule is that \(X_t = \text{Min} [\text{RDC}_j, j \leq t]\); i.e., policymakers change the critical bound with the economic environment. The idea is that they are not willing to tolerate any bound lower than what has been observed previously.

As shown in Figs. 2 and 3, under both rules the probability of collapse increases over time. It appears closely linked to the rationing parameter derived earlier. The economy entered a critical phase in 1988 when a dramatic decrease in reserves started to take place evident in Fig. 4. The economy was very close to collapse in 1990 (probability around 90%), and was finally moved to floating in September 1991.

4. Concluding remarks

This paper brings empirical evidence for the role of the parallel market as an additional policy instrument to avoid collapse of economies with balance of payments problems. This additional instrument is of a temporary nature as the exchange controls from which it derives. This was shown by the calculation of the one-period ahead probability of collapse of the system. It was around 90% in the 1990s for the Haitian economy—used for the empirical

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Fig. 2. Probability of collapse with depleted reserves.
part of this paper. Another interesting result is the presence of currency substitution in that economy, a result which has not been empirically established yet for Haiti.

When all policy instruments are exhausted and the system becomes unsustainable, policymakers resort to a regime change. In the case of the Haitian economy, the economy was moved to floating.

Haitian policymakers could have chosen to devalue the official exchange rate, or move the economy to a crawling peg. Both options did not have much appeal because of their implications of fiscal, monetary and, trade discipline to which Haitian policymakers could not commit—not to mention they were suffering from a lack of credibility in the eyes of economic agents.

Higher inflation rates and loss of output growth have been observed since the implementation of this new exchange rate policy in Haiti. The outcome of these observations is the question of the benefits of this regime change compared to their costs. I plan to tackle that question in a subsequent paper.

Notes

1. Their approach is based on the Exchange Market Pressure (EMP) model of Girton and Rooper (1977).
2. The Haïtian currency, the gourde, was pegged to the US dollar at a rate of five gourdes for a dollar. Therefore $e$ is equal to 5. This is a result of the American occupation of that country which lasted from 1915 to 1945.

3. Rationing also results in rent-seeking activities, an issue which is addressed in another paper—Dorsainvil (2000b). See also Krueger (1974).

4. There is also the issue of the impact of a policy of overvaluation of the exchange rate on the real sector of the economy. This paper mainly concern is the link between policies of distortions, in this case a rationing scheme of foreign currency, and the prolonged sustainability of the system. Calvo and Rodriguez (1977), Edwards (1989), Pinto (1991) among others have studied the interaction between financial and real sectors in the case of an overvalued exchange rate. I also plan to look at such interaction in another paper for the case of the Haïtian economy.


6. For a detailed derivation of Eq. (6), see Appendix A.

7. When appeared in the ratio $RDC_t$, variables reserves and domestic credit are not in log form. For a detailed derivation of Eq. (8), see Appendix A.

8. For a detailed derivation of Eq. (10), see Appendix A.
9. Pagan (1984) have shown that estimators from a 2-step estimation procedure are efficient.

10. The rate of domestic inflation is measured as $\log(P_t/P_{t-1})$. Therefore for consistency, the foreign interest rate variable will be taken in log form. US interest rate is used as a proxy for foreign interest rate because of strong ties between the two countries.

11. They also appear as coefficients of lag cointegrated variables.

12. For a detailed derivation of Eqs. (12) and (13), see Appendix A. Using the Akaike Information Criterion (AIC) estimation results are presented with one lag dependent variable.

13. For details about data source, see appendix B.

14. The Haitian economy was moved to floating on September 1991.

15. For a detailed derivation of Eq. (17), see Appendix A.

16. In 1988, Haiti entered a period of great political instability. Capital flight is a reasonable explanation behind the observed loss of foreign reserves.

Acknowledgments

I would like to thank two anonymous referees of this journal for helpful comments and suggestions. All remaining errors are my responsibility.

Appendix A

A.1. Detailed derivation of Eq. (6)

Market clearing conditions in the parallel market implies the following equation noted Eq. (5):

$$\alpha_0 + \alpha_1(e_t - e) - \gamma_0 - \gamma_1 W_t = \beta_0 + \beta_1 y_t + \beta_2 (i^w_t - i^r_t) - \beta_3 (E_t e_{t+1} - e_t)$$

(1-1)

or equivalently:

$$E_t e_{t+1} = \gamma_0 + \beta_0 e + \alpha_1 e - \alpha_0 + \frac{\beta_3 - \alpha_1}{\beta_3} e_t + \frac{\beta_1}{\beta_3} y_t + \frac{\beta_2}{\beta_3} (i^w_t - i^r_t) + \frac{\gamma_1}{\beta_3} W_t$$

(1-2)

There is an expectation sign on the left hand side of (1-2). I assumed that expectations are formed rationally and specifying the information set at time $t$ as including all variables dated $t$ and earlier, I conjecture the solution for $e_t$ as:

$$e_t = A_0 + A_1 e_{t-1} + A_2 y_{t-1} + A_3 (i^w_{t-1} - i^r_{t-1}) + A_4 W_{t-1}$$

(1-3)

Eq. (1-3) is updated. Then, taking expectations of Eq. (1-3) and equating coefficients of Eqs. (1-3) and (1-2) implies the solution for $e_t$: 
\[
e_t = \frac{\gamma_0 + \beta_0 + e \alpha_1 - \alpha_0}{\beta_3} + \frac{\beta_1 - \alpha_1}{\beta_3} e_{t-1} + \frac{\beta_1}{\beta_3} y_{t-1} + \frac{\beta_2}{\beta_3} (i_{t-1}^{w} - i_{t-1}^{r}) + \frac{\gamma_1}{\beta_3} W_{t-1}
\]

(1-4)

A.2. Detailed derivation of Eq. (8)

In equilibrium, domestic money supply is backed by domestic credit and by official foreign reserves. In log form, I can write

\[
\log M_t = \log (R_t + DC_t)
\]

(2-1)

where \( R_t, DC_t \) are the amount of foreign reserves and domestic credit respectively.

Eq. (2-1) can also be rewritten as:

\[
\log M_t = \log (R_t(1 + R_t/DC_t))
\]

(2-2)

Using the formula \( \log ab = \log a + \log b \) and the approximation \( \log(1 + x) \approx x \), Eq. (2-2) becomes:

\[
\log M_t \approx R_t/DC_t + \log DC_t
\]

(2-3)

\( R_t/DC_t \) is noted \( RDC_t \) which implies for Eq. (2-3)

\[
\log M_t \approx RDC_t + \log DC_t
\]

(2-4)

A.3. Detailed derivation of Eq. (10)

Change in reserves of this economy is postulated as coming either from excess money creation of an amount \( u^tEMC_t \) or from the amount channeled to the parallel market by under/over invoicing, \( \alpha_0 + \alpha_1(e_t - e) \). This implies the following equation noted Eq. (7)

\[
\Delta RDC_t = -[\alpha_0 + \alpha_1(e_t - e)] - \theta_t [EMC_t]
\]

(3-1)

After substituting for Eq. (9), Eq. (3-1) becomes

\[
\Delta RDC_t = -[\alpha_0 + \alpha_1(e_t - e)] - \theta_t [M_t - RDC_t - DC_t]
\]

(3-2)

\( e_t \) appears on the right hand side of Eq. (3-2). Substituting for Eq. (1-4) implies the following solution for \( \Delta RDC_t \):

\[
\Delta RDC_t = M2 - \mu_1 M_t + \mu_1 DC_t + \mu_1 RDC_t - \mu_2 e_{t-1} - \mu_3 W_{t-1} - \mu_4 y_{t-1}
\]

\[
- \mu_5 (i_{t-1}^{w} - i_{t-1}^{r})
\]

(3-3)

where:

\[
M2 = \gamma_t \epsilon - \alpha_0 - \alpha_1 MU1
\]

\[
\mu_1 = \theta_t
\]

\[
\mu_2 = \alpha_t (1 - \gamma_t / \beta_3)
\]

\[
\mu_3 = \alpha_t \gamma_t / \beta_3
\]
\[ \mu_4 = \frac{\alpha_1 \beta_1}{\beta_3} \]
\[ \mu_5 = \alpha_1 \beta_2 / \beta_3 \]

RDC\(_t\) appears on the right hand side of Eq. (3-3) with coefficient \(\mu_1\). It is moved to the left-hand side of that equation. RDC\(_{t-1}\) is moved to the right-hand side and dividing both sides by \((1 - \mu_1)\) yields:

\[
\begin{align*}
\text{RDC}_t &= \frac{M2}{(1 - \mu_1)} + \frac{1}{(1 - \mu_1)} \text{RDC}_{t-1} - \frac{\mu_1}{(1 - \mu_1)} M_1 + \frac{\mu_1}{(1 - \mu_1)} \text{DC}_t \\
&\quad - \frac{\mu_2}{(1 - \mu_1)} e_{t-1} - \frac{\mu_3}{(1 - \mu_1)} W_{t-1} - \frac{\mu_4}{(1 - \mu_1)} y_{t-1} - \frac{\mu_5}{(1 - \mu_1)} (i^w_{t-1} - i_{t-1})
\end{align*}
\]

(3-4)

Subtracting RDC\(_{t-1}\) from both sides of Eq. (3-4) yields:

\[
\begin{align*}
\Delta \text{RDC}_t &= \text{MU}_2 + \frac{\theta_t}{(1 - \theta_t)} \text{RDC}_{t-1} - \frac{\theta_t}{(1 - \theta_t)} M_1 + \frac{\theta_t}{(1 - \theta_t)} \text{DC}_t \\
&\quad - \frac{\alpha_1}{(1 - \theta_t)} \left(1 - \frac{\alpha_1}{\beta_3}\right) e_{t-1} - \left(\frac{\alpha_1 \gamma_1}{\beta_3 (1 - \theta_t)}\right) W_{t-1} - \frac{\alpha_1 \beta_1}{\beta_3 (1 - \theta_t)} y_{t-1} \\
&\quad - \frac{\alpha_1 \beta_2}{\beta_3 (1 - \theta_t)} (i^w_{t-1} - i_{t-1})
\end{align*}
\]

(3-5)

with \(\text{MU}_2 = M2/(1 - \theta_t)\) and \(\mu_1\) replaced by its value \(\theta_t\).

**A.4. Detailed derivation of Eq. (12)**

\[
\begin{align*}
\epsilon_t = \gamma_0 + \beta_0 + \epsilon \frac{\alpha_1 - \alpha_0}{\beta_3} + \left(1 - \frac{\alpha_1}{\beta_3}\right) \epsilon_{t-1} + \frac{\beta_1}{\beta_3} y_{t-1} + \frac{\beta_2}{\beta_3} (i^w_{t-1} - i^w_{t-2}) \\
&\quad + \frac{\gamma_1}{\beta_3} W_{t-1}
\end{align*}
\]

(1-7)

In Eq. (1-4) coefficients \(\alpha_1, \beta_2, \beta_3, \gamma_1\) appear as coefficients of integrated processes \(\epsilon_t, i^w_t, W_t\). They will be rewritten to appear as coefficients of stationary variables by the following algebraic manipulations:

\[
\left(1 - \frac{\alpha_1}{\beta_3}\right) \epsilon_{t-1} = \left(1 - \frac{\alpha_1}{\beta_3}\right) \Delta \epsilon_{t-1} + \left(1 - \frac{\alpha_1}{\beta_3}\right) e_{t-2}
\]

(4-1)

\[
\frac{\gamma_1}{\beta_3} W_{t-1} = \frac{\gamma_1}{\beta_3} \Delta W_{t-1} + \frac{\gamma_1}{\beta_3} W_{t-2}
\]

(4-2)

\[
\frac{\beta_2}{\beta_3} i^w_{t-1} = \frac{\beta_2}{\beta_3} \Delta i^w_{t-1} + \frac{\beta_2}{\beta_3} i^w_{t-2}
\]

(4-3)
Substituting (4-1), (4-2), (4-3) in Eq. (1-4), yields the following solution for $\Delta c_t$:

$$
\Delta c_t = MU1 - \frac{\alpha_1}{\beta_3} \Delta e_{t-1} - \left(1 - \frac{\alpha_1}{\beta_3} e_{t-2}\right) + \frac{\gamma_1}{\beta_3} \Delta W_{t-1} + \frac{\gamma_1}{\beta_3} W_{t-2} + \frac{\beta_1}{\beta_3} \gamma_{t-1}
$$

$$
+ \frac{\beta_2}{\beta_3} \Delta i_{r-1}^w + \frac{\beta_2}{\beta_3} i_{r-2}^w - \frac{\beta_2}{\beta_3} i_{r-1}^r
$$

(4-4)

A.5. Detailed derivation of Eq. (13)

$$
\Delta RDC_t = MU2 - \mu_3 M^t_r + \mu_2 DC_t + \mu_3 RDC_{t-1} - \mu_4 e_{t-1} + \mu_5 W_{t-1} + \mu_6 \gamma_{t-1}
$$

$$
+ \mu_7 i_{r-1}^w
$$

(3-5)

In Eq. (3-5), coefficients $\alpha_3, \beta_2, \beta_3, \gamma_1$ appear as coefficients of integrated processes $e_t, W_t, i_t^w$. Therefore I have proceeded as in the previous section using similar algebraic manipulations.

A.6. Detailed derivation of Eq. (17)

The probability that the reserve ratio reaches a lower bound $X_t$ is:

$$
P[RDC_t \leq X_t] \tag{6-1}
$$

Using the sample regression function, noted $\Delta RDC_{fitted}$, Eq. (13) can be rewritten as:

$$
\Delta RDC_t = \Delta RDC_{fitted} + \nu_t \tag{6-2}
$$

where

$$
\nu_t \sim N(0, \sigma_\nu) \tag{6-3}
$$

Adding $-RDC_{t-1}$ to both sides of the inequality, Eq. (6-1) can be rewritten as:

$$
P[\Delta RDC_t \leq X_t - RDC_{t-1}] \tag{6-4}
$$

Substituting Eq. (6-2) in Eq. (6-4), yields:

$$
P[\Delta RDC_{fitted} + \nu_t \leq X_t - RDC_{t-1}] \tag{6-5}
$$

Rearranging terms, I obtain:

$$
P[-\nu_t \geq \Delta RDC_{fitted} + RDC_{t-1} - X_t] \tag{6-6}
$$

Dividing both sides by $\sigma_\nu$, yields:

$$
P[-\nu_t/\sigma_\nu \geq (\Delta RDC_{fitted} + RDC_{t-1} - X_t)/\sigma_\nu] \tag{6-7}
$$
Appendix B

Data Source

The sample period under consideration is from 1985:10 to 1991:08 and I use monthly data. Data from domestic credit (DC$_t$), foreign reserves (R$_t$), imports (Imp$_t$), assets of domestic residents, (W$_t$, i.e., savings + terms deposits accounts in commercial banks), and money supply (M$_t^s$) are taken form the Bulletin de la Banque de la République d’Haití, the Central Bank of Haiti monthly publication.

Data for the parallel exchange rate are taken from Pick’s The World Currency Yearbook. Data on industrial production, (y$_t$), used as a proxy for GNP, come from the Haitian Institute of Statistics.

Data on US interest rate (i$_t^w$) come from the Federal Reserve Bulletin of the Board of Governors of the Federal Reserve System, Washington DC, USA.

References


