Regime Switching and the Black Market for Foreign Currency

by

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Abstract

This paper demonstrates the importance of allowing for regime switching when investigating the behavior of the parallel market premium. Regime switching techniques are used to examine the credibility of a fixed exchange regime in economies with widespread parallel markets for foreign currency. Markov regime switching techniques used in this paper were developed in Hamilton (1989), Gray (1996) and, Diebold et al (1994). Application of this technique to the parallel market premium in Jamaica, Guyana and Trinidad for 1985-1993 suggests that exchange rate reforms Jamaica in the early 1990’s were credibility enhancing while those in Guyana and Trinidad did not enhance credibility.

Keywords Regime switching, credibility, parallel market, Guyana, Jamaica, Trinidad.

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1 Introduction

A number of papers have investigated the dynamic relationship between parallel mar-
ket and official exchange rates in developing countries incorporating many of the
econometric advances of recent years. However, these studies have typically not con-
sidered the possibility of regime switching in the time series. Also many papers
concentrate on Africa\(^1\), Asia\(^2\), Latin America\(^3\) and Mediterranean\(^4\) countries\(^5\).

The primary objective of this paper is to draw attention to the possible importance
of regime switching when analyzing the parallel market premium. The secondary aim
is to develop a criterion for assessing the credibility of a fixed exchange rate system
in economies with widespread parallel or black\(^6\) markets for foreign exchange.

This paper builds on Kaminsky’s (1995) application of Hamilton’s (1988) filter
to the study of the effectiveness of Mexico’s dual exchange rate system in limiting
speculative capital flows and insulating domestic prices from capital flows.

Parallel markets for foreign currency are of interest because they provide warning
signs of stress in foreign currency markets. For example, the British Broadcasting
Corporation (B.B.C.) Service Monitor\(^7\) reported that the parallel market premium

\(^1\) For example, Odedekun (1996).
\(^2\) For example, Phylaktis and Kassimatis (1997), and Chotigeat and Theerathorn (1996)
\(^3\) For example, Bessler and Hui (1994), Kharas and Pinto (1989).
\(^4\) See Kouretas (1991)
\(^5\) Studies using a broad sample of countries include, Montiel et al (1993).
\(^6\) The terms parallel market and black market will be used interchangeably.
\(^7\) BBC Service Monitor, September 1998.
for foreign exchange had risen sharply in Thailand, Malaysia, Korea and, Indonesia in the months preceding the currency crises of 1997. In this paper we argue that the credibility of a fixed exchange rate (the official exchange rate) can be assessed by the premium being charged in the freely determined parallel or black market for foreign exchange. The policy recommendation which emerges from our analysis is that, where parallel markets for foreign exchange are widespread, they should be monitored as they may provide early warning of impending currency or exchange rate crisis.

Section 2 discusses the evolution of the parallel market and the official exchange rates in Guyana, Jamaica and Trinidad during the sample period. Section 3 outlines the structure of the Markov regime switching models. Section 4 discusses the result of the estimation and Section 5 presents our conclusion.

2 The Evolution of the Parallel Market Exchange Rate in Guyana, Jamaica and Trinidad

This section discusses the evolution of the parallel market for foreign currency in Guyana, Jamaica and Trinidad during the period 1985 to 1993.

Guyana's decision to follow the cooperative socialist vision of development set the stage for the subsequent evolution of its foreign currency markets. Capital flight was widespread and exchange rate control led to the development of parallel markets for

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8 This section draws heavily from World Currency Yearbook, 1985 and 1995.
foreign exchange and goods and services. The nation’s chaotic economy along with exchange rate controls pushed the value of the Guyana dollar on the parallel market steadily downward, the unit reaching a low of G$50 per US$ at year end 1986. In January 1987 the government devalued the official exchange rate by 56% to G$78 =US$1 and created a Bank Market Rate which shifted parallel currency transactions off the streets and into the commercial banking sector. The Bank Market Rate was initially viewed as credible and the parallel rate appreciated to G$40 per US$. Further economic disruption resulted in increasingly diminishing international reserves, and in March of 1989 the government devalued the Guyana dollar by 96.7% and ended the operation of the Bank Market Rate. This pushed the parallel market premium to 480%. Guyana is an open economy, as has been the case with devaluations in extremely import dependent economies, inflation spiralled during this period.

In 1990, a Cambio Market Rate was established which effectively adopted the parallel market rate as the official rate. As Table1 indicates, since 1990 there has been a dramatic collapse in the premium in the parallel market. In September of 1991 the official rate was abolished; however, exchange rate controls are still enforced by the central bank via a requirement that earnings from sugar and bauxite exports must be surrendered at the average Cambio Rate. These controls have created conditions for continuation of parallel market transactions; at the end of 1993, the premium in

\[ \frac{\text{Parallel}}{\text{Official}} - 1 \times 100 \]
the parallel market was higher than 20%.

The abolition of the official rate was part of a broader set of stabilization measures which have restored some semblance of order to the Guyanese economy. Fiscal reforms resulted in the re-appearance of real economic growth in 1991. In 1993, the country ran a surplus on its recurrent budget, the last time this had been accomplished was in 1973. A program of debt reform as well as participation in the International Monetary Fund’s Debt Alleviation Program reduced debt service relative to recurrent revenue to 13.5% in 1992.

The behavior of the parallel exchange rate premium in the period under analysis is consistent with the patterns observed in other developing countries (see Montiel et al. (1993). During the crisis years of 1985-1988, the premium mushroomed averaging close to 700% during this period. With the implementation of partial reforms between 1989 and 1991, the premium shrunk to under 250%; and when systematic reforms were enacted in the early 1990’s, relative to the crisis years, the premium virtually disappeared.

The parallel market for foreign exchange in Jamaica developed to facilitate capital flight following the implementation of strict foreign exchange controls in 1974. In 1978, a dual exchange rate system was implemented with the official rate being applicable to essential imports and the earnings from bauxite. The dual rate was abolished in 1978 and replaced with a series of monthly mini-devaluations. In 1983, the dual exchange
rate system was re-established with commercial banks determining the ‘free-market rate’, while the official rate was made applicable to ‘essential imports’, government activities and the bauxite sector. An increase in parallel market activities led to the abolition of this system in November of 1983. A daily foreign exchange auction replaced the dual exchange rate system.

Cyclical downturns in the bauxite and tourism industries began to place pressure on satisfying exchange needs via the official channels which resulted in the Jamaican dollar depreciating against its US counterpart by 10%. Delays in adjusting the economy and half hearted policy reform resulted in a build up in inflation and debt between 1985 and 1987. By the end of 1987 Jamaica’s external debt was over US$4,000 million and debt service was consuming over 70% of current revenue. The parallel market responded in due fashion. Table 2 indicates that, by 1989, the premium had increased from 12.8% in 1985 to an average of 27.5% in 1989. The annual average premium in the parallel market was highest in the years 1989-1991.

In 1991, a process of exchange rate reform was initiated and most controls were removed. Rapid debt accumulation in the 1980’s forced the government to intervene in the foreign exchange market to secure funds for debt repayment. As a result there is still some parallel market activity but the annual average premium in the parallel market has not regained the levels seen in the period 1989-1991.

In 1982 the following scenario faced the Trinidadian economy: oil prices went into
decline after the buoyant 1970’s and the long neglected sugar industry went into its death throes. To dampen import demand, the government imposed a 6% stamp duty on imports and a 10% levy on all foreign exchange purchases. These stop gap measures had little effect on the decline in international reserves. The parallel foreign exchange market became the primary source for obtaining foreign currency to feed the demand for imports. In 1985, the premium in the parallel market averaged 58.4%. The official rate was devalued by 33.3% in the hope of stemming the imbalance between import demand and foreign exchange earning. This was not enough to turn the fortunes of the economy. To counter the economy’s slide, a cycle of borrowing against future earnings was begun which saw Trinidad’s external indebtedness almost tripling from US$ 838.4 million in 1984 to US$ 2402 million in 1988; the country’s net foreign asset position was also severely affected as is shown in the lower panel of Figure 4.2.

Other problems faced the government. The financial sector was hard hit by the downturn in the economy. The government was forced to take over a number of large financial houses which added to the growth in the fiscal deficit. In 1988, world oil prices declined further. As part of its response to this development, wide-ranging import restrictions were imposed and an unpopular Value Added Tax was introduced to shore up revenues. The official rate was also devalued in 1989 and an official rate for imports was introduced. The combination of the levy on foreign currency purchases and import restrictions fueled activity on the parallel market. In 1989 the average
premium was at its highest level for the period under analysis\textsuperscript{10}.

3 The Model

This section outlines the structure and estimation procedure used in Markov regime switching models.

Consider a univariate time series such as the parallel market premium \( f_{s,t|g} \): Let \( f_{s,t|g} \) be generated by the following stochastic process

\[
[s_{t|i} \ A(\cdot; t)] = [s_{t|i} \ A(\cdot; t_i; t_i)] + \varepsilon_t \]

where \( j' j < 1; f \varepsilon_t \) is a sequence of i.i.d \( N(0; 1) \) random variables, \( A(\cdot) \) is an intercept shift term and \( \cdot \) is an unobserved discrete-time, discrete-state Markov process governing the shift in the intercept. Notice that if \( A(\cdot) \) is assumed to be time invariant, then (1) is a standard linear stationary AR \( (i) \) model.

Hamilton's version of the regime switching model works as follows: the regime indicator variable \( \cdot \) evolves as a Markov process with \textit{fixed} transition or switching probabilities

\[
P^H = \begin{pmatrix}
\frac{1}{4_{11}} & \frac{1}{4_{12}} & \cdots & \frac{1}{4_{1K}} \\
\frac{1}{4_{21}} & \cdots & \cdots & \frac{1}{4_{2K}} \\
\vdots & \ddots & \ddots & \vdots \\
\frac{1}{4_{K1}} & \cdots & \cdots & \frac{1}{4_{KK}}
\end{pmatrix}
\]

\textsuperscript{10}See Table 3.
where \( 0 \cdot \frac{1}{4_j} \cdot 1; \sum_{j=1}^{M} \frac{1}{4_j} = 18_j \) and \( \frac{1}{4_j} = P(\cdot_{t+1} = j; \cdot_t = i) \) i.e. element \( \frac{1}{4_j} \) is the probability of the system being in state \( j \) in period \( t + 1 \) given that the system is in state \( i \) at period \( t \). Each \( \frac{1}{4_j} \) is assumed to be fixed in Hamilton’s version of the regime switching model but this is a rather restrictive assumption as it can be easily argued that ‘fundamentals’ would play some role in determining the transition probabilities. Diebold et al (1994) developed and estimated a model in which they dropped the requirement of fixed transition probabilities built into the Hamilton (1989, 1996, 1994) model. In Diebold et al.’s. (1994) model the Markov process governing regime switching varies over time according to logistic functions conditioned on information believed to be of relevance in determining the transition probabilities. The transition or switching probabilities in the Diebold et al (1994) framework is

\[
P^D = \begin{pmatrix}
P^{0}_{0; \bar{K}} e^{s^0_{t;0} - i - 00} & P^{0}_{1; \bar{K}} e^{s^0_{t;0} - i - 01} & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \[2pt]P^{0}_{0; \bar{K}} e^{s^0_{t;0} - i - 10} & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \[2pt]P^{0}_{0; \bar{K}} e^{s^0_{t;0} - i - K0} & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \end{pmatrix}
\]

where \( s^0_{t;0} \) is a \((K \times M)\) conditioning vector which includes variables affecting the switching probabilities. Gray (1996) developed a model which nests both the Hamilton and Diebold et al. models. Gray’s (1996) approach differs from Hamilton and Diebold et al. in that it is cast in terms of the probability of a regime probabilities...
rather than the probability of a regime switch, i.e.,

$$Pr(\cdot_t = i|\mathcal{G}_{t-1})$$

(4)

where the vector $\mathcal{G}_{t-1}$ represents the available information at time $t-1$.

To situate Gray’s framework in the Markov regime switching framework define where $\cdot_t$ as the $N$ vector regime indicator random variable whose $i$th element is unity for $\cdot_t = i$ and whose other elements are zero otherwise, that is,

$$\cdot_t =
\begin{cases}
(1; 0; 0 \ldots 0) & \text{if } \cdot_t = 1 \\
(0; 1; 0 \ldots 0) & \text{if } \cdot_t = 2 \\
\vdots & \\
(0; 0 \ldots 0; 1) & \text{if } \cdot_t = K
\end{cases}$$

The conditional expectation of the regime that will hold at $t+1$ is

$$E(\cdot_{t+1} | \cdot_t = i) =
\begin{bmatrix}
p_{i1} \\
p_{i2} \\
\vdots \\
p_{iK}
\end{bmatrix}$$

(5)

where the second term in (6) is the $i$th column of (5), it follows from the Markov property of the transition matrix that

$$E(\cdot_{t+1} | \cdot_t; \cdot_{t-1}; \ldots) = P^{\otimes}_{-t}$$

(6)

It is possible to express (7) as a vector autoregression of the form

$$\cdot_{t+1} = P^{\otimes}_{-t} + \nu_{t+1}$$
where $v_{t+1} \sim t_{1} \cdot E(- t_{1} \cdot t_{1} \cdot t_{1} \cdot t_{1} \cdot t_{1})$: Gray's model can be written recursively by defining

$$1 p_{t; t - 1} = \begin{bmatrix}
2 \\
3 \\
p_{1; t - 1} \\
p_{2; t - 1} \\
\vdots \\
p_{k; t - 1}
\end{bmatrix}$$

where $p_{t; t - 1} = \text{Pr}(\cdot = i | t; t - 1)$: It follows from the Markov property that

$$P_{G t; t - 1} = P_{H} P_{G t - 1; t - 1}$$

(7)

Gray (op. cit.) shows that $P_{G t; t - 1}$ can be written as

$$P_{G t; t - 1} = P^{H} p_{t; t - 1} \cdot \#$$

(8)

where $f_{t; 1}$ is a $K \times 1$ vector of conditional densities, $\cdot$ represents element by element vector multiplication and 1 is $K \times 1$ vector of 1s. Equation (8) is a first order non-linear recursive scheme which nests both the Hamilton and Diebold et al. models.

The methodology for estimating Markov regime switching models is presented here. It is also shown that the output of Markov regime switching models is an estimate of the mean and variance of the dependent variable in each of the unobservable states and an estimate of the probability of being in each state. Markov regime switching models are typically estimated by maximum likelihood. To motivate the discussion assume that when the system is in state $i$ the parallel market premium $s_t$
is drawn from $N(\mu_i; \sigma_i^2)$ and in state $j$ from $N(\mu_j; \sigma_j^2)$ where $N(\cdot)$ is the density of the normal distribution. The conditional density is

$$f(s|\cdot_t = j : -t) = \frac{1}{2\pi \sigma_j} e^{-\frac{(s_t - \mu_j)^2}{2\sigma_j^2}}$$

(9)

where $\cdot$ is a vector of parameters $\mu_1, \mu_2, \ldots, \mu_K; \sigma_1, \sigma_2, \ldots, \sigma_K; \phi_1, \phi_2, \ldots, \phi_K$ where the mean, variance, autoregressive term and transition probability in state $i$ are $\mu_i, \sigma_i^2; \phi_i$ and $\phi_i$ respectively. Recall from the transition matrix that we are assuming that the unobserved regime is drawn from some arbitrary probability distribution such that the unconditional probability is

$$\Pr(\cdot = j : -t) = \frac{1}{K}$$

(10)

To obtain the joint density distribution of $s_t$ and $\cdot_t$ note that the probability of any event $A$ conditioned on event $B$ is $\frac{\Pr(A \mid B)}{\Pr(B)}$ which implies that

$$\Pr(A \mid B) = \Pr(A \mid B) \cdot \Pr(B)$$

(11)

The first term on the right hand side of equation (12) is equivalent to (10) and the second term is equivalent to (11). The joint density of $s_t$ and $\cdot_t$ can then be written as

$$\Pr(s_t; \cdot_t = j : -t) = \frac{1}{2\pi \sigma_j} e^{-\frac{(s_t - \mu_j)^2}{2\sigma_j^2}}$$

(12)

The marginal or unconditional density of $s_t$ can then be obtained by summing over
the \( K \) possible values for \( j \)

\[
f(s:\cdot) = \frac{1}{P} \prod_{i=1}^{K} \frac{1}{2^j} e^{-\frac{(s_{t+1} - s_i)^2}{2^j}}.
\]

(13)

The density can be calculated from the observed data using a log likelihood function of the form

\[
\ell(\cdot) = \sum_{t=1}^{N} \log f(s:\cdot):
\]

(14)

The estimate of \( \cdot \) is obtained by maximizing (14) subject to the constraint that \( P_{i=1}^{K} \frac{1}{2^j} = 1 \) and \( \frac{1}{2^j} \geq 0 \). The procedure outlined in this section is, strictly speaking, germane only to the Hamilton framework. To fit the Gray (1996) and Diebold (1994) models, \( \cdot \) must be augmented to include conditioning variables and changes in the structure and interpretation of the elements of the transition matrices associated with each of these models.

The E.M.\(^{11}\) algorithm has been used to obtain estimates in all of the models discussed in this section. The underlying methodology at work in the E.M. algorithm is this: (1) obtain estimates of the unconditional probability of a particular state using the observed data and some initial ‘guess’ of the parameters in the model by maximizing an incomplete log likelihood, (2) use the estimated state and transition probabilities obtained in (1) to estimate the complete data log likelihood, and (3) substitute the updated estimates into the expected log likelihood and repeat until convergence is obtained.

\(^{11}\)Detailed discussion of the EM algorithm is contained in Diebold et al.
4 Results

The estimates of parameters from two states Markov regime switching models using monthly data for the period 1985:01 to 1993:12 are presented in Table 4 and Table 5. The fixed transition probabilities estimates were made using the GAUSS v.3.2.22 software from Aptech Systems Inc. Algorithms used in the estimates were provided by James Hamilton of University of California San Diego and Stephen Gray of Duke University. The time varying transition probabilities estimates were made using Matlab v.5 using algorithms developed by Frank Diebold and Gretchen Weinbach of University of Pennsylvania. The two possible regimes are labeled the ‘credible’ and ‘not credible’ states. The former corresponds to $\cdot_t = 0$ and represents conditions in which there are no large depreciations and the variance of the parallel market premium is stable. The latter corresponds to $\cdot_t = 1$ and is characterized by excessive volatility in the parallel market premium. The parameters $\lambda_0; \lambda_1$ are the probabilities that similar states follow each other, i.e. a credible state will follow a ‘credible state’ and a ‘not credible’ state will follow a ‘not credible state’ respectively. Correspondingly, $\lambda_0; \lambda_1$ are the mean and standard deviation in the credible state and $\lambda_1; \lambda_2$ are those in the state without credibility. $\lambda_1; \lambda_2$ are autoregressive terms. The estimates were made using the log difference of the parallel market premium. The terminating condition
used in estimating the parameters is
\[ j - j - j - 1 - 1 - < 10^{-8} \]

where - \( j \) is a parameter vector at iteration \( j \), i.e. if the maximum absolute difference between like parameters is less than \( 10^{-8} \); the iteration terminates. The estimated parameters for the fixed transition probabilities model are summarized in Table 4.

The credible regime exhibits less persistence than the regime without credibility in all three countries. The average duration of the credible period can be calculated from
\[ \frac{1}{1 - \frac{\lambda}{100}} \].

The implied duration of the credible period is 3.87 months in Guyana and 5.34 months in Trinidad while in Jamaica the duration is 11.36 months. The duration of the regime without credibility, calculated from \[ \frac{1}{\lambda} \frac{\lambda}{100} \], is 26 months in the case of Guyana, 12 months in Jamaica and 10 months in Trinidad. The unconditional probability of the system being in either regime can be calculated from the eigenvectors of the transition matrix. The eigenvector associated with the credible regime is
\[ \frac{1}{\lambda} \frac{\lambda}{100} \frac{\lambda}{100} \],

which implies that the likelihood of being in the credible regime in Guyana is 0.13 and 0.35 and 0.34 in Jamaica and Trinidad respectively.

What explains the fact that the ‘credible’ regime is of such short duration while the ‘not credible’ regime is relatively long? The explanation is that our estimates of the duration of each regime are based on \( \frac{\lambda}{100} ; \frac{\lambda}{100} \) which indicate the probabilities of being in the same regime in consecutive periods. The average period of duration reported here should then be interpreted as a measure of the frequency with which
the same regime is observed consequentially. In the broader context, it is possible that the regime durations observed in the data gives support to the argument that countries operating fixed exchange rate systems (the official exchange rate is fixed) tend not to adjust the exchange rate with the frequency required to avoid excessive misalignment of the official exchange rate. In effect, the 26\textsuperscript{12} months duration of the ‘not credible’ regime in Guyana indicates that someone, figuratively, ‘fell asleep at the controls’ of the official exchange rate or ignored the high premia existing in parallel market for foreign currency.

The conditional mean parameters $\hat{\eta}_0$, $\hat{\eta}_1$ are statistically not significantly different from zero in the case of Guyana and Trinidad but generally speaking the parameters provide a useful way of describing the characteristics of each regime. The credible regime is found to be characterized by low premia and low variance in all countries; however, the credible regime had different characteristics across countries. In Jamaica, the conditional means are statistically significantly different from zero. In the credible regime in Jamaica, the conditional mean of the parallel market premium is -2.3% implying that credibility in Jamaica is marked by a 2.3% appreciation of the parallel market premium whereas in Guyana and Trinidad the premium depreciated by 55% and 7% respectively.

What explains the difference between the results for Jamaica versus the results $^{12\text{12}}$ and 10 months in Jamaica and Trinidad respectively.
for Trinidad and Guyana? One possible explanation can be had by recalling our earlier discussion of the macro-economic backgrounds of each of these countries. The post-unification exchange rate regime in Jamaica was closer to a floating exchange rate when compared to the inter-bank system adopted by Trinidad and Guyana. This analysis establishes that the post-unification regime is a sensitive determinant of the credibility gains associated with the unification of exchange rate regimes.

Figures 4-6 plot the filtered probability of a credible state given the available data. When close to 1 the inferred probability provides strong evidence from the data that the exchange rate is viewed as credible. Conversely, when close to 0, there is evidence that the exchange rate is not credible. The plot of the filtered probability from Guyanese data presented in Figure 4 indicates that exchange rate reform has not had much effect on credibility with the exception being the devaluation of the Guyanese dollar for US$1 = G$10 to US$1 = G$33 in 1989. The filtered probabilities for the Jamaican data are plotted in Figure 5. The exchange rate reforms undertaken by Jamaica in 1989 brought credibility gains which lasted until the latter part of 1993. Trinidad, in contrast, as can be inferred from the filtered probabilities plotted in Figure 6, has had mixed experiences, credibility gains having been intermittent.

Table 5 reports the parameter estimates from the time varying transition probabilities Markov regime switching model. In each of the estimates presented here the starting values used are the estimates from the fixed parameter model. The coe-
The coefficients for the condition variable used in the estimates are $\beta_{00}$ and $\beta_{01}$ which enter into the formulation of $\beta_{00}$ and its complement $\beta_{01}$. Similarly, $\beta_{10}$ and $\beta_{11}$ enter into the calculation of $\beta_{11}$ and $\beta_{10}$. The variable used to condition the estimates are the changes in base money. A relative increase in base money is expected to cause a depreciation of the parallel market exchange rate. The expected sign on the coefficients can be explained as follows. If the regime in place at time $t-1$ is not credible, then for the system to remain in this state at time $t$, base money must continue to push the system in that direction. Accordingly, $\beta_{11}$ is expected to be positive while $\beta_{01}$ is expected to be negative. Similarly, if at time $t-1$ the exchange rate regime is credible, for this regime to continue at time $t$ the base money must support the continuation of this regime, the expected sign on coefficient $\beta_{00}$ is negative. All of the conditioning coefficients are correctly signed. The $\beta_{11}$ and $\beta_{10}$ for Guyana and $\beta_{01}$ for Trinidad are statistically insignificant.

The filtered probabilities from the time varying model are presented in Figures 7-9. These probabilities are computed using parameter values reported in Table 5 as the starting values. There are some differences between the probabilities reported for the constant transition probabilities and those reported for the time varying model. Diebold et al demonstrated that the mean squared extraction error for the time varying transition probabilities model is lower than the model with constant transition probabilities using simulated data. Our findings corroborates Diebold et al.
results are based on comparing the information extracted by the filtered probabilities in both models while Diebold et al are able to compare the extraction rate of the two models vis a vis the true parameters embedded in simulated data, however, it is possible to compare the two models estimated here.

To compare the time varying and constant transition probabilities presented here recall the following: the Granger causality analysis presented in Table 6 indicated that the official exchange rate Granger caused the parallel market exchange rate (in Guyana and Trinidad). Movements in the official exchange rate should therefore register through movements in the parallel market premium which should then be reflected in the filtered probabilities. We then compare this criterion to the historical records to evaluate the extraction rate of both estimates. The comparison of the probabilities for Guyana presented in Figures 4 and 7 against the historical records reveal that whereas the time varying model is able to extract information regarding the devaluations of January 1987, April 1989, June 1990, and February 1991, the constant transition probability model is only able to extract information regarding the devaluation of April 1989. In the case of Jamaica, both estimates do fairly well, both extracted information regarding the large devaluations 1989, 1991 and 1992. Both estimates fail to capture any effects from the multitude of mini-devaluations carried out in Jamaica in between 1989 and the end of the sample period. The historical records show that Trinidad had major devaluations in November 1985, June 1988
and February 1993. The constant transitions probabilities estimates presented in Figure 6 do not extract this information whereas the estimates from the time varying model presented in Figure 9 are able to do so. Both set of estimates fare well with respect to the other devaluations.

Gains in credibility from unification of the parallel and official exchange rates maybe dependent on the type of exchange rate regime put in place after unification. Future research could focus on how the post unification exchange rate regime influences the credibility gains coming from unification.

5 Conclusions

We find that the parallel market premium is appropriately modelled as a Markov process with two states, each with a separate mean and variance. Our findings suggest that the credibility gains coming from unification is sensitive to the post unification regime. In Trinidad and Guyana, which adopted semi-fixed Inter Bank exchange rates following unification the credibility gains were not sustained especially in the case of Guyana. Jamaica, on the other hand, enjoyed sustained credibility gains via a adoption of a post unification exchange regime that was closer to a floating exchange rate.

Comparison of the Markov regime switching model with time-varying transition probabilities to the Markov regime switching with fixed transition probabilities re-
vealed that the model with time varying transition probabilities was able to extract more information from the data. In particular, the model with time varying transition probabilities was able to extract information regarding changes in the premium resulting from small devaluations of the official exchange rate.

There are a number of possible extension to the work presented in this paper. One relevant exercise would be to conduct forecasting exercise to see how accurately Markov regime switching models can forecast currency crises. Another would be to extend the theoretical model to examine cross-country linkages in exchange rate uni-cation exercises.
References


Table 1: Guyana-The Parallel and Official Rates and Premium

<table>
<thead>
<tr>
<th>Year</th>
<th>Parallel Rate</th>
<th>Parallel Exchange</th>
<th>Official Rate</th>
<th>Official Exchange</th>
<th>Maximum Premium</th>
<th>Premium (%)</th>
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<tbody>
<tr>
<td>1985</td>
<td>28.92</td>
<td>4.24</td>
<td>684.04</td>
<td>843.37</td>
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<td>1986</td>
<td>43.75</td>
<td>4.28</td>
<td>1019.87</td>
<td>1209.30</td>
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<td>1987</td>
<td>51.33</td>
<td>10.00</td>
<td>513.33</td>
<td>540.00</td>
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<td>1988</td>
<td>50.75</td>
<td>10.00</td>
<td>507.50</td>
<td>530.00</td>
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<td>1989</td>
<td>55.75</td>
<td>27.25</td>
<td>263.03</td>
<td>550.00</td>
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<td>1990</td>
<td>85.08</td>
<td>40.00</td>
<td>213.52</td>
<td>233.33</td>
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<td>1991</td>
<td>161.42</td>
<td>114.15</td>
<td>47.17</td>
<td>244.44</td>
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<td>1992</td>
<td>167.92</td>
<td>125.13</td>
<td>34.22</td>
<td>141.13</td>
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<td>1993</td>
<td>157.58</td>
<td>126.96</td>
<td>24.17</td>
<td>134.92</td>
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Table 2: Jamaica-The Parallel and Official Rates and Premium

<table>
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<th>Year</th>
<th>Official Exchange Rate</th>
<th>Parallel Exchange Rate</th>
<th>Maximum Premium(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>5.56</td>
<td>6.27</td>
<td>12.77</td>
</tr>
<tr>
<td>1986</td>
<td>5.48</td>
<td>6.52</td>
<td>18.99</td>
</tr>
<tr>
<td>1987</td>
<td>5.49</td>
<td>6.34</td>
<td>15.48</td>
</tr>
<tr>
<td>1988</td>
<td>5.49</td>
<td>6.57</td>
<td>19.67</td>
</tr>
<tr>
<td>1989</td>
<td>5.74</td>
<td>7.32</td>
<td>27.53</td>
</tr>
<tr>
<td>1990</td>
<td>7.18</td>
<td>9.48</td>
<td>32.03</td>
</tr>
<tr>
<td>1991</td>
<td>12.12</td>
<td>16.33</td>
<td>34.74</td>
</tr>
<tr>
<td>1992</td>
<td>22.96</td>
<td>25.28</td>
<td>10.11</td>
</tr>
<tr>
<td>1993</td>
<td>24.95</td>
<td>28.85</td>
<td>15.63</td>
</tr>
</tbody>
</table>
Table 3: Trinidad and Tobago-The Parallel, Official Rates and Premium

<table>
<thead>
<tr>
<th>Year</th>
<th>Official Rate (Year)</th>
<th>Parallel Rate</th>
<th>Premium (%)</th>
<th>Maximum Premium (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>2.50</td>
<td>3.96</td>
<td>58.4</td>
<td>66.67</td>
</tr>
<tr>
<td>1986</td>
<td>3.60</td>
<td>4.76</td>
<td>32.0</td>
<td>46.39</td>
</tr>
<tr>
<td>1987</td>
<td>3.60</td>
<td>4.71</td>
<td>31.0</td>
<td>40.28</td>
</tr>
<tr>
<td>1988</td>
<td>3.90</td>
<td>5.88</td>
<td>52.0</td>
<td>58.33</td>
</tr>
<tr>
<td>1989</td>
<td>4.25</td>
<td>6.62</td>
<td>56.0</td>
<td>62.35</td>
</tr>
<tr>
<td>1990</td>
<td>4.25</td>
<td>6.07</td>
<td>43.0</td>
<td>57.65</td>
</tr>
<tr>
<td>1991</td>
<td>4.25</td>
<td>5.64</td>
<td>33.0</td>
<td>40.47</td>
</tr>
<tr>
<td>1992</td>
<td>4.25</td>
<td>4.95</td>
<td>17.0</td>
<td>23.53</td>
</tr>
<tr>
<td>1993</td>
<td>5.36</td>
<td>5.87</td>
<td>9.5</td>
<td>15.56</td>
</tr>
</tbody>
</table>
Figure 1: Guyana: Exchange Rates
Figure 2: Trinidad: Exchange Rates
Figure 3: Jamaica: Exchange Rates
Table 4: The Constant Transition Probabilities Markov Regime Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Guyana</th>
<th>Jamaica</th>
<th>Trinidad</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi_{00} = \Pr(\cdot, t_1 = 0</td>
<td>t_{t-1} = 0)$</td>
<td>0.742 (0.035)</td>
<td>0.912 (0.01)</td>
</tr>
<tr>
<td>$\pi_{11} = \Pr(\cdot, t_1 = 1</td>
<td>t_{t-1} = 1)$</td>
<td>0.962 (0.028)</td>
<td>0.954 (0.03)</td>
</tr>
<tr>
<td>$\pi_{0}</td>
<td>t_1 = 0$</td>
<td>0.547 (0.61)</td>
<td>-0.234 (0.021)</td>
</tr>
<tr>
<td>$\pi_{1}</td>
<td>t_1 = 1$</td>
<td>8.63 (0.61)</td>
<td>1.15 (0.51)</td>
</tr>
<tr>
<td>$\pi_{2}</td>
<td>t_1 = 2$</td>
<td>1.44 (0.11)</td>
<td>0.76 (0.2)</td>
</tr>
<tr>
<td>$\pi_{3}</td>
<td>t_1 = 3$</td>
<td>4.89 (1.14)</td>
<td>0.82 (0.32)</td>
</tr>
<tr>
<td>$\hat{\lambda}_1$</td>
<td>0.05 (0.09)</td>
<td>0.06 (0.09)</td>
<td>0.123 (0.09)</td>
</tr>
<tr>
<td>$\hat{\lambda}_2$</td>
<td>0.123 (0.09)</td>
<td>-0.16 (0.06)</td>
<td>0.123 (0.08)</td>
</tr>
<tr>
<td>Log-L</td>
<td>-160.97</td>
<td>-323.97</td>
<td>-160.97</td>
</tr>
<tr>
<td># of Iter.</td>
<td>49</td>
<td>84</td>
<td>53</td>
</tr>
</tbody>
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Table 5: The Time Varying Transition Probabilities Markov Regime Estimates

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Guyana</th>
<th>Jamaica</th>
<th>Trinidad</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\theta_{00}$</td>
<td>-0.239</td>
<td>-0.558</td>
<td>-1.19</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.074)</td>
<td>(0.27)</td>
</tr>
<tr>
<td>$\theta_{01}$</td>
<td>0.17</td>
<td>0.290</td>
<td>0.1</td>
</tr>
<tr>
<td></td>
<td>(0.1)</td>
<td>(0.042)</td>
<td>(0.072)</td>
</tr>
<tr>
<td>$\theta_{10}$</td>
<td>-0.35</td>
<td>-0.668</td>
<td>-0.053</td>
</tr>
<tr>
<td></td>
<td>(0.3)</td>
<td>(0.065)</td>
<td>(0.03)</td>
</tr>
<tr>
<td>$\theta_{11}$</td>
<td>0.66</td>
<td>0.265</td>
<td>0.756</td>
</tr>
<tr>
<td></td>
<td>(0.143)</td>
<td>(0.021)</td>
<td>(0.29)</td>
</tr>
<tr>
<td>$\lambda_{0}$</td>
<td>0.49</td>
<td>-0.275</td>
<td>0.882</td>
</tr>
<tr>
<td></td>
<td>(0.51)</td>
<td>(0.13)</td>
<td>(0.23)</td>
</tr>
<tr>
<td>$\lambda_{1}$</td>
<td>8.77</td>
<td>1.13</td>
<td>1.27</td>
</tr>
<tr>
<td></td>
<td>(1.76)</td>
<td>(0.64)</td>
<td>(0.83)</td>
</tr>
<tr>
<td>$\eta_{0}$</td>
<td>1.37</td>
<td>0.82</td>
<td>0.27</td>
</tr>
<tr>
<td></td>
<td>(0.12)</td>
<td>(0.21)</td>
<td>(0.18)</td>
</tr>
<tr>
<td>$\eta_{2}$</td>
<td>6.49</td>
<td>1.18</td>
<td>2.23</td>
</tr>
<tr>
<td></td>
<td>(2.14)</td>
<td>(0.34)</td>
<td>(1.2)</td>
</tr>
<tr>
<td>Log-L</td>
<td>-118.21</td>
<td>-259.18</td>
<td>129.3</td>
</tr>
<tr>
<td># of Iter.</td>
<td>49</td>
<td>163</td>
<td>88</td>
</tr>
</tbody>
</table>

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Figure 4: Guyana: Filter Probabilities

Table 6: Granger Causality Tests

<table>
<thead>
<tr>
<th>Country</th>
<th>$c$</th>
<th>$e$</th>
<th>$F$-value</th>
<th>$c$</th>
<th>$s$</th>
<th>$F$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guyana</td>
<td>yes</td>
<td>no</td>
<td>2.08</td>
<td>no</td>
<td>no</td>
<td>0.32</td>
</tr>
<tr>
<td>Jamaica</td>
<td>yes</td>
<td>yes</td>
<td>5.48</td>
<td>yes</td>
<td></td>
<td>4.61</td>
</tr>
<tr>
<td>Trinidad</td>
<td>yes</td>
<td>no</td>
<td>4.44</td>
<td>no</td>
<td>no</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Figure 5: Jamaica-Filter Probability
Figure 6: Trinidad-Filter Probabilities
Figure 7: Guyana: Filter Probabilities (Time Varying)
Figure 8: Jamaica: Filter Probabilities (Time Varying)
Figure 9: Trinidad: Filter Probabilities (Time Varying)