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Abstract: This paper uses a rational expectations macroeconomic model in which economic agents formulate the probability about the sustainability of the economic policy—that is, policy credibility—using current and lagged values of government expenditures and lagged values of the inflation rate. The estimation of the model is based on Hamilton's switching regime procedure. The contribution of this paper is the empirical estimation of the credibility of the stabilization program implemented in Peru in August 1990. The results of the estimation show that there are two different regimes in the government expenditure process. According to the economic agents' inferences, the stabilization program in Peru is not credible. This lack of credibility in the economic policy of the government authority explains the presence of hysteresis in currency substitution between August 1990 and June 1995. The estimation involves an expected inflation rate that includes the credibility of the economic policy in its formulation.

JEL classification: E52, E63, O54

Key words: credibility, stabilization policies, currency substitution, Markov switching model

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1. Introduction

A policy is credible when economic agents expect policymakers to be successful in implementing their announced economic program. Economic policies are more effective when they are credible to economic agents. In the context of stabilization policies, credibility will help to bring inflationary expectations down and to achieve the goal of disinflation. On the other hand, the lack of policy credibility brings an additional restriction to the economic programs implemented by policy authorities. If economic agents believe that the stabilization program will fail, and the inflation rate will not be reduced, they will allocate some of their monetary assets in foreign currency to offset the loss in their purchasing power. This behavior restricts the base of the inflation tax and imposes more uncertainty on the control of money supply.

The lack of policy credibility involves a learning process where the economic agents have observed a prior lack of commitment by the policy authority in continuing the announced policy. The level of credibility is related to the time-inconsistency problem in the implementation of economic policies. The policy authority will not fully commit to its economic program because, after its announcement, there will be short run incentives to repudiate the original plan. These incentives come from a lack of control of the policy instruments, inconsistency between economic policies, political and administrative constraints and uncertainty about the predictability of policy reforms due to exogenous shocks.

During the 1980s, several Latin American countries experienced failed stabilization programs. On several occasions, the failure of stabilization programs was due to the lack of commitment to reduce the fiscal deficit. This was due to the lack of control of policy instruments such as in the Austral Plan in Argentina, the Cruzado Plan in Brazil or the Inti Plan in Peru. On other occasions, the previous failure of these programs has contributed to the lack of credibility in economic policy even though the governments have shown greater commitment and consistency in their economic programs in the recent years.

In this study, I examine the credibility of stabilization policies and its effect on the hysteresis present in the process of currency substitution. Due to the lack of credibility in stabilization policies, economic agents may have maintained high expectations of both inflation and depreciation of the domestic currency. Even if inflation rates decrease and exchange rates become more stable, the lack of policy credibility may cause economic agents to continue holding their assets in foreign currency. They will continue to keep their deposits in foreign currency because they expect that the policy authority will abandon their policy. Therefore, this is the best way that the economic agents can protect their assets.

The contribution of this paper is the empirical estimation of the credibility of the stabilization program implemented in Peru in August 1990. Policy credibility is measured as the probability inferred by the economic agents about the sustainability of the economic policy using current and lagged values of government expenditures and lagged values of the inflation rate. The results of the estimation show that there are two different regimes in the government expenditure process. According to the economic agents' inferences, the stabilization program in Peru is not credible. This lack of credibility in the economic policy of the government authority

explains the presence of hysteresis in currency substitution between August 1990 and June 1995. The estimation involves an expected inflation rate that includes the credibility of the economic policy in its formulation.

The next section contains the literature review. Section 3 presents the theoretical model. Section 4 includes the estimation of this model using Hamilton's switching regime approach. The results of this estimation for the case of Peru are discussed in section 5. Finally, conclusions are drawn.

2. Literature review

There is no unified framework to study policy credibility despite its importance in the implementation and success of economic policy. The theoretical models of credibility have concentrated on the analysis of the strategic behavior of the economic agents and the policy authority, and on the interaction of policy instruments and its effects on policy credibility[2]. However, this wide theoretical study of policy credibility has not been followed by similar studies on empirical testing and estimation of policy credibility[3]. One of the problems of the empirical testing of policy credibility is that it is a difficult variable to measure. Also theoretical models have not contributed to the empirical work on this topic because they are static, deterministic and deal with few macro variables (Blackburn and Christensen 1989).

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[2] For a literature review of the theoretical work on credibility see Blackburn and Christensen (1989), Drazen and Masson (1994), and Obstfeld and Rogoff (1996).

[3] Blackburn and Christensen (1989), Agenor and Taylor (1992) and Quispe-Agnoli (1997) are some studies that review the empirical work on credibility.

In the estimation of credibility, it is important to remember that credibility is related to forward-looking expectations of the economic agents on the likelihood the announced economic policy will continue. One of the problems is to choose the appropriate variable or set of variables that will be the basis for the formation of these expectations. This variable should measure a learning process and the characteristics of policy credibility that varies over time. Policy credibility is endogenous, and unobserved process postulated to be responsive to economic policy. Regarding the estimation technique, credibility models do not present the linear characteristics necessary to applied traditional econometric techniques. Non-linear techniques are more adequate for its estimation that could include the updating nature of the credibility process.

3. Theoretical model

The objective of this theoretical model is to explain the role of credibility in the performance of economic policy. Credibility is defined as the probability that the announced economic policy will be continued. If disinflationary policy lacks credibility, economic agents will anticipate its breakdown, and will allocate their monetary holdings in foreign currency. If a process of currency substitution has already occurred and the economic policy lacks credibility, agents will remain in their current situation and will not be encouraged to switch back to domestic currency. In this case, hysteresis in the currency substitution process is explained by the lack of policy credibility.

This structural model of inflation was developed by Ruge-Murcia (1995). He applied it to testing the credibility of the stabilization policy implemented by Israel between 1982 and 1987.

In this macroeconomic model, the growth rate of real balances depends on inflationary expectations and the real interest rate differential. The money supply is one of the main sources to finance the fiscal deficit. Consequently, the growth rate of money supply is influenced by the behavior of government expenditures and revenues. The economic agents will allocate their real balances between different currencies based on their information about inflation and interest rates, and the level of government expenditures. The level of government expenditures is a signal of the commitment of the economic authority towards the announced economic program. Consequently, policy credibility is measured by the probability that changes in fiscal policy are consistent with the targets of the disinflationary program.

Assume that the demand for money can be expressed with unit income elasticity as follows

$$m_t^d - p_t = y_t - \alpha\, i_t + \varepsilon_t \quad \text{where} \quad \alpha > 0 \qquad 1$$

where m_t^d, p_t and y_t are the natural logarithms of money demand, the price level and real income. i_t is the nominal interest rate and ε_t is a disturbance term that follows a random walk, $\varepsilon_t = \varepsilon_{t-1} + e_t$ where e_t is i.i.d. $\sim N(0, \sigma_e^2)$.

In (1), the nominal interest rate (i_t) is defined as

$$i_t = r_t + E(\pi_{t+1}|I_t) \qquad 2$$

where r_t is the real interest rate and $E(\pi_{t+1}|I_t)$ is the forward inflationary expectation conditional to the information set at time t (I_t). This information set includes past information about inflation, nominal interest rates, and government expenditures.

Substituting (2) in (1) gives

$$m_t^d - p_t = y_t - \alpha\, r_t - \alpha E(\pi_{t+1}|I_t) + \varepsilon_t \qquad 3$$

and taking first differences

$$(m_t^d - m_{t-1}^d) - (p_t - p_{t-1}) = (y_t - y_{t-1}) - \alpha(r_t - r_{t-1}) - \alpha(E(\pi_{t+1}|I_t) - E(\pi_t|I_{t-1})) + \varepsilon_t - \varepsilon_{t-1}$$

Therefore, the expression for the change in real balances follows

$$\vartheta_t^d - \pi_t = y_t - y_{t-1} + \alpha[E(\pi_t|I_{t-1}) - E(\pi_{t+1}|I_t)] - \alpha(r_t - r_{t-1}) + \varepsilon_t - \varepsilon_{t-1} \qquad 4$$

where $m_t^d - m_{t-1}^d = \vartheta_t^d$ is the growth rate of nominal money demand, $p_t - p_{t-1} = \pi_t$ is the inflation rate, $y_t - y_{t-1} = n$, assuming a constant growth rate of income. Also the change in the real interest rate is $r_t - r_{t-1} = v_t$, where v_t is i.i.d.$\sim N(0,\sigma_\upsilon^2)$.

Therefore, the growth rate of demand for real balances can be rewritten as

$$\vartheta_t^d - \pi_t = n + \alpha[E(\pi_t|I_{t-1}) - E(\pi_{t+1}|I_t)] + e_t - \alpha v_t \qquad 5$$

The growth rate of money demand depends on the inflation rate, inflationary expectations and the change in the real interest rate. The coefficient α denotes the sensitivity of money demand to changes in inflationary expectations.

On the other hand, changes in the money supply will be determined mainly by the financing of the fiscal deficit with high-powered money. The growth rate of money supply can be written as

$$\vartheta_t^s = a + \gamma D_t + \varsigma_t \text{ where } \gamma > 0 \text{ and } \varsigma_t \text{ i.i.d.} \sim N(0,\sigma_{\varsigma_t}^2) \qquad 6$$

where ϑ_t^s is the growth rate of money supply and the fiscal deficit (D_t) is the difference between government expenditures (G_t) and revenues (T_t),

$$D_t = G_t - T_t \qquad 7$$

The fiscal deficit, government expenditures and revenues are measured as percentage of Gross Domestic Product (GDP). Tax revenues depend on the lagged values of the inflation rate. When the inflation rate increases, the real value of tax revenues declines. Tax revenues are expressed as

$$T_t = h(\pi_{t-1}, \pi_{t-2}, \pi_{t-3}, \ldots\ldots, \pi_{t-k}) \qquad 8$$

Assuming that the lagged value of the inflation rate is the relevant variable, the tax function becomes

$$T_t = \tau - \varphi\pi_{t-1} + \eta_t \quad \text{where} \quad \tau, \varphi > 0 \quad \text{and} \quad \eta_t \text{ i.i.d.} \sim N(0, \sigma_\eta^2) \qquad 9$$

Using the definitions of the fiscal deficit and tax revenues in equations (7) and (9), the growth rate of money supply is

$$\vartheta_t^s = a + \gamma\,(G_t - (\tau - \varphi\pi_{t-1} + \eta_t)) + \varsigma_t \qquad 10$$

rearranging

$$\vartheta_t^s = a + \gamma\, G_t - \gamma\,\tau + \gamma\,\varphi\pi_{t-1} - \gamma\,\eta_t + \varsigma_t \qquad 11$$

The final expression for the change in money supply is

$$\vartheta_t^s = c + \gamma\, G_t + \psi\pi_{t-1} + \varsigma_t \qquad 12$$

where $c = a-\gamma\tau$, $\psi = \gamma\varphi > 0$ and the error term ς_t includes the term $-\gamma\eta_t$. The money supply is determined by government expenditures and the inflation rate that decreases the real value of tax revenues. This decline in real tax revenues also increases the fiscal deficit. In equation (12), the money supply is endogenous and influenced by government expenditures and the previous inflation rate.

The solution of the model is found by assuming equilibrium in the money market and therefore $\vartheta_t^d = \vartheta_t^s$,

$$\pi_t + n + \alpha E(\pi_t|I_{t-1}) - \alpha E(\pi_{t+1}|I_t) + e_t - \alpha v_t = c + \gamma G_t + \psi\pi_{t-1} + \varsigma_t \qquad 13$$

rearranging the terms, the following expression will be useful in the derivation of the equation for the inflation rate and the change in interest rate,

$$\alpha E(\pi_{t+1}|I_t) - \alpha E(\pi_t|I_{t-1}) + \psi\pi_{t-1} - \pi_t = n - c - \gamma G_t - \mu_t - \alpha v_t \qquad 14$$

where $\mu_t = \varsigma_t - e_t$ and μ_t is i.i.d. $\sim N(0,\sigma^2_\mu)$

Taking expectations at time t-1, (14) becomes a second-order difference equation with roots denoted $0< \lambda_1 <1$ and $\lambda_2 >1$. As the solution shows, the necessary conditions for saddle-path stability are $\lambda_1 + \lambda_2 = \frac{(1+\alpha)}{\alpha} >1$ and $\lambda_1 * \lambda_2 = \frac{\psi}{\alpha} >0$[4].

The solution for inflationary expectations is

$$\begin{aligned} E(\pi_t|I_{t-1}) = \kappa + \lambda_1\pi_{t-1} + \frac{\gamma}{\alpha}\sum_{j=0}^{\infty}\lambda^{-(j+1)}E(G_{t+j}|I_{t-1}) \\ - \lambda_1\gamma[G_{t-1} - E(G_{t-1}|I_{t-1})] - \lambda_1\mu_{t-1} - \lambda_1\alpha v_{t-1} \end{aligned} \qquad 15$$

where $\kappa=(n-c)/\alpha(1-\lambda)$ and $\gamma/\alpha>0$. According to (15), the inflationary expectations are positively related to the lagged values of the inflation rate and to the weighted sum of expected future government expenditures. The expression for inflationary expectations also includes a term that shows that economic agents compare the expected and the realized levels of government expenditures. If the government decreases their expenditures more than the announced level, it will decrease inflationary expectations.

The solution for the inflation rate comes from substituting (15), and (15) one period forward into (14),

[4] A detailed solution of the model is available from the author.

$$\pi_t = k + \lambda_1 \pi_{t-1} + \gamma(G_t - E(G_t|I_t)) + \gamma\beta(G_{t-1} - E(G_{t-1}|I_{t-1})) + \mu_t + \alpha v_t + \beta\mu_{t-1}$$
$$+ \alpha\beta v_{t-1} + \gamma\lambda_2(\beta+1)\sum_{i=0}^{\infty}\lambda_2^{-(i+1)}[E(G_{t+i}|I_t) - E(G_{t+i}|I_{t-1})] \qquad 16$$

where $\beta = \dfrac{\alpha\lambda_1}{1-\alpha\lambda_1} = \dfrac{\psi}{\lambda_2 - \psi}$.

According to (16), the inflation rate is a function of its lagged value, the difference between the actual and the agents' expectations of the behavior of the government conditional on the information at time t and t-1, the error made by the economic agents at time t and t-1, and the difference in the expectations of the future behavior of the government conditional to the current and past information.

The inflation rate increases if the economic agents see a high government expenditure regime in the past or if they expect one in the future. The structure of the error terms is explained by the assumption that the information set does not include the current values of the economic variables or the lagged value of the inflation rate (Ruge-Murcia 1995).

The rational expectation solution for the change in the nominal interest rate follows from equation (2)

$$i_t - i_{t-1} = (r_t - r_{t-1}) + E(\pi_{t+1}|I_t) - E(\pi_t|I_{t-1})$$

using $r_t - r_{t-1} = v_t$ where v_t i.i.d.$\sim N(0,\sigma_\upsilon^2)$ then this expression is

$$\Delta i_t = E(\pi_{t+1}|I_t) - E(\pi_t|I_{t-1}) + v_t \qquad 17$$

The solution for the change of the interest rate is obtained by substituting (16), (15), and (15) forwarded one period into (17),

$$\Delta i_t = \lambda_1 k - \lambda_1(\lambda_1 - 1)\pi_{t-1} + \frac{\gamma}{\alpha}\sum_{i=0}^{\infty}\lambda_2^{-(i+1)}[E(G_{t+i+1}|I_t) - E(G_{t+i}|I_{t-1})]$$
$$+ \frac{\gamma\beta}{\alpha}(G_{t-1} - E(G_{t-1}|I_{t-1})) + v_t + \frac{\beta}{\alpha}\mu_{t-1} + \beta v_{t-1} \qquad 18$$
$$+ \frac{\gamma\lambda_2\beta}{\alpha}\sum_{i=0}^{\infty}\lambda_2^{-(i+1)}[E(G_{t+i}|I_t) - E(G_{t+i}|I_{t-1})]$$

The change of the interest rate is influenced directly by previous values of the inflation rate and government expenditures.

The theoretical framework presented in this section is a rational expectations model of inflation where the money supply is influenced by the financing of the government deficit. In this model, the economic agents will make their decisions about the allocation of their assets by reviewing the previous and current level of government expenditures. Credibility is measured by the probability the economic policy will be continued given the information from previous periods. This probability is built by the joint observation of inflation and interest rates and government expenditures.

Previous studies of policy credibility used univariate models where the variable of interest is in function of its lagged values. For example, the expectations of economic agents were modeled by changes in the inflation rate or in the exchange rate premium depending on their lagged values. Other studies analyze policy credibility by concentrating on the changes in policy tools, i.e. reduction of government expenditures or discipline in the expansion of the money supply, estimating its consistency with the targets of the economic policy. This model incorporates both approaches. The economic agents take into account not only previous values of inflation rates but they consider the market fundamentals for their behavior. They use both types of information to build their inferences of whether or not the economic policy is credible.

4. Empirical model

For the derivation of the empirical model, the process of government expenditures follows an autoregressive process subject to discrete regime switches. Government expenditures can be expressed as

$$G_t = \beta_{s_t} + \phi G_{t-1} + \sigma_{s_t} \varepsilon_t$$

where s_t characterizes the state or regime of the government expenditure process at time t. Assuming that there are two regimes, one of high government expenditures($s_t = 1$) and a second one of low government expenditures ($s_t = 2$), then the process of government expenditures will be characterized by two different stochastic segmented trends[5]. Therefore, depending on the regime, government expenditures are distributed $N(\beta_{st}/(1-\phi), \sigma^2_{st}/(1-\phi))$. The error term, ε_t, is an i.i.d. N(0,1).

It is assumed that the state variable follows a Markov chain, where the current state of government expenditures will depend on its previous value. Consequently the transition probabilities can be derived

$P(s_t = 1| s_{t-1} = 1) = p_{11}$ $\quad$ $P(s_t = 2| s_{t-1} = 1) = p_{12} = 1 - p_{11}$

$P(s_t = 1| s_{t-1} = 2) = p_{21} = 1 - p_{22}$ $\quad$ $P(s_t = 2| s_{t-1} = 2) = p_{22}$

These probabilities do not vary over time. The matrix of transition probabilities will be

$$P = \begin{pmatrix} p_{11} & p_{12} \\ p_{21} & p_{22} \end{pmatrix}$$

[5] Hamilton (1990) used this approach to study long swings in the exchange rate market.

where $p_{12} = \Pr(s_t = 2|s_{t-1} = 1)$ denotes the probability, at time t, that the government expenditure is at the low expenditure regime ($s_t = 2$) given that it was at the high expenditure regime ($s_{t-1} = 1$) the previous period.

The economic agents observe the process of government expenditures but they do not now its regime. Therefore, they formulate probabilities regarding the state of the government expenditure process. In their inference, the economic agents use all available information. According to the theoretical model, this information comes from the joint process of inflation and interest rates, and previous values of government expenditures. The measurement of the policy credibility is based on these probabilities. If, after the announcement of an economic program, the economic agents conclude that the joint process of inflation, interest rates and government expenditure is generated by a high expenditure regime, then this program lacks credibility.

According to the theoretical model, the transition probabilities are expressed as $\Pr(s_{t-1}= 2|I_t)$, denoting the probability inferred at time t by the economic agents about the expenditure regime at time t-1, given the information set that includes the joint process of inflation, interest rates and government expenditure. If $\Pr(s_{t-1}= 2|I_t) > 0.5$, then the program is credible at time t, otherwise if $\Pr(s_{t-1}= 2|I_t) < 0.5$, then the economic program is not credible.

Substituting (1) and the matrix of transition probabilities into the theoretical model, the reduced form is:

$$G_t = \beta_{st} + \phi G_{t-1} + \sigma_{st}\varepsilon_t$$

$$\pi_t = k + \lambda_1\pi_{t-1} + \gamma\beta_{s_t} + \gamma(\phi + \delta\phi + \theta)G_{t-1} - \gamma\delta\phi G_{t-2} + \gamma(L_{t-1} - L_{t-2})HB + \gamma\sigma_{s_t}\varepsilon_t + u_t + \alpha v_t + \theta u_{t-1} + \alpha\theta v_{t-1}$$

$$\Delta i_t = \lambda_1 k + \lambda_1(1-\lambda_1)\pi_{t-1} + \frac{\gamma}{\alpha}(\delta\phi+\theta)G_{t-1} - \frac{\gamma}{\alpha}\delta\phi G_{t-2} + \frac{\gamma}{\alpha}(L_{t-1}-L_{t-2})HB +$$
$$+ v_t + \frac{\theta}{\alpha}u_{t-1} + \theta v_{t-1}$$

where $\delta = \frac{\lambda\phi + \psi(\lambda-\phi)}{(\lambda-\phi)(\lambda-\psi)} > 0$ and $H = (P+\lambda\delta I)P(\lambda I-P)^{-1}$. The vector $B = [\beta_1, \beta_2]'$ includes the values of the state dependent constant. The vector $L_{t-1} = [\Pr(s_{t-1}= 1|I_t)\ \Pr(s_{t-1}= 2|I_t)]$ includes the probabilities built by the economic agents about the regime of the government expenditure at time t-1. The term $(L_{t-1} - L_{t-2})$ shows the revision of their probabilities about government expenditures as the economic agents obtained more information. P is the matrix with the transition probabilities and I is the identity matrix.

According to the model, the inflation rate and the interest rate differential depend on the lagged value of the inflation rate, the previous levels of government expenditures and the probabilities built by the economic agents about the state of government expenditures. This last term $(L_{t-1} - L_{t-2})HB$ includes the revision of the government expenditures given additional information and the transition probabilities for each state.

Methodology

The estimation of this model implements Hamilton's procedure to estimate state-space models when the state variable is discrete. This nonlinear procedure estimates structural parameters through the maximization of the likelihood function. From the reduced form of the model, Θ defines the set of parameters (β_1, β_2 , σ_1 , σ_2 , σ_u , σ_v , p_{11} , p_{22} , ρ_{eu}, k, γ , λ , λ_1 ,ϕ), and $S_t = \{s_t , s_{t-1} \}$ defines the states of the government expenditures process. Z_t is defined as $Z_t = [G_t , \pi_t, \Delta i_t]$

the vector of dependent variables. Recalling the assumption of normal distribution for ε_t , u_t , v_t , then the conditional density for a given observation of the system is

$$\Pr(Z_t|S_t,I_t;\Theta) = \frac{1}{(2\pi)^{3/2}|\Omega_{s_t}|^{1/2}} \times \exp\left\{\frac{-[Z_t - E(Z_t|S_t,I_t;\Theta)]'\Omega^{-1}[Z_t - E(Z_t|S_t,I_t;\Theta)]}{2}\right\}$$

The variance and covariance of the residuals is given by

$$\Omega_{s_t} = \begin{Bmatrix} \sigma_{s_t}^2 & \gamma\sigma_{s_t}^2 + \sigma_{s_t}\rho_{\varepsilon u}\sigma_u & 0 \\ \gamma\sigma_{s_t}^2 + \sigma_{s_t}\rho_{\varepsilon u}\sigma_u & \gamma\sigma_{s_t}^2 + 2\gamma\sigma_{s_t}\rho_{\varepsilon u}\sigma_u + \alpha^2\sigma_v^2 + \sigma_u^2 & \alpha^2\sigma_v^2 \\ 0 & \alpha^2\sigma_v^2 & \sigma_v^2 \end{Bmatrix}$$

where ρ_{eu} is the correlation coefficient between ε_t and u_t.

The estimation starts with the unconditional probabilities given by $P(s_t = 1) = (1-p_{22})/ (2-p_{11}- p_{22})$ and $P(s_t = 2) = (1-p_{11})/ (2- p_{11}- p_{22})$. The filter works recursively taking these probabilities and the conditional likelihood of Z_t. The value of the likelihood function is calculated from

$$\Pr(Z_1^N|\Theta) = \prod_{t=1}^{N} \Pr(Z_t|I_t;\Theta)$$

where N is the number of observations. This likelihood function is maximized numerically with respect to Θ in order to obtain the value of the parameters. Along with this estimation and for each iteration, filtered probabilities are calculated. The filtered probabilities are defined as the probability of the expenditure process to be in a given state at time t -1 conditional to the information set at time t.

5. Empirical Results

The estimation of the empirical model uses data from Peru for September 1988 to June 1995. The data includes government expenditures as percentage of GDP, inflation rates and the differential between interest rates for deposits in domestic and foreign currency. First, the data is tested for the presence of stationarity. Table 1 shows that none of the variables present unit roots. Also, it is necessary to test the validity of the assumptions that were made in the formulation of the theoretical and empirical models. The assumption that government expenditures follow a first-order autoregressive process is supported by the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC). Also the lag length of the other variables was determined to be one by these criteria.

The first specification of the empirical model consists of three univariate estimations where the dependent variables are government expenditures; inflation rate and change in the interest rate are obtained using a univariate estimation. These results are shown in Table 2, and the filtered probabilities for each variable are grouped in Figures 1 to 3, respectively. All three equations show two well-defined regimes, and all estimated coefficients are significantly different from zero. Government expenditures as a percentage of GDP averages 8.2% in the high regime and 5.9% in the low regime. The inflation rate and the change in the interest rate display a larger difference in their means in both the high and low regimes. In the high regime, the inflation rate averages 33.2% per month, and in the low regime the average inflation rate decreases 19.6 percent points to become 13.6% per month. Also, the substantial reduction in the change in the interest rate is 18.8 points. In the high regime, the mean of the change in the interest rate is 19.4 percent points and in the low regime it is 0.7 percentage points.

Government expenditures have a greater variance in the high regime (2.35) than in the low regime (0.97). The change in the interest rate displays the same pattern, in the high regime the variance (356.21) is greater than in the lower regime (0.39). The inflation rate, however, shows lower variability in the high regime (71.51) than in the low regime (2687.82).

According to Table 2, the probability of staying in the same regime as the previous period, $p_{ii} = Pr(s_t = i|s_{t-1} = i)$, is high for all three equations. But the probabilities for the government expenditure are the lowest relative to the probabilities for the inflation rate and the interest rate differential. If the inflation rate is at the high regime in the previous period the probability of staying in the high regime is equal to 94.1%. If the inflation rate is in the low regime, the probability to continue in the low regime is 98.6%. The change in the interest rate presents the same behavior. The probability of continuing in the high regime is 94.6%, and in the low regime is 98.6%. On the other hand, the probability that the government expenditure will remain in the high regime is 93.5%, and the probability of remaining in the low regime is 91.8%. The lower probability of persisting in the same regime in government expenditures suggests the possibility of lack of credibility in the announced policy.

By looking at the filtered probabilities and the original series of the variables, it is possible to see the time of the switch in beliefs about the regime. Figures 1, 2 and 3 show the filtered probabilities at the low regime, $s_t = 2$ and Figures 4 and 5 show the original series. The filtered probability at $s_t = 2$ refers to the probability that the observation at a given date is in the low regime. A switch in beliefs about the regime is observed when $Pr(s_t= 2|I_t) > 0.5$.

In Figure 1, the switch in beliefs about the regime of government expenditures is not as obvious as in the other two variables. In March 1989, it went from belief in high government

expenditures to low government expenditures, and back to a high regime in August 1989. There is a second switch in beliefs to a low regime in December 1990 as part of the stabilization program, but it was interrupted in October 1992. There is an additional temporary change in beliefs to a lower rate of government expenditures in January 1993, but it went back to belief in the high regime in September 1994. In Figure 2, the probability goes from the low inflation regime to the high inflation in September 1988 and returns to low inflation in July 1990, as a result of the orthodox stabilization plan by Alberto Fujimori. The same pattern is shown by the interest rate differential in Figure 3, switching to belief in a low regime in October of 1990.

During the 1980s, high government expenditures were financed with increases in the money supply resulting in high inflation rates. Before September 1988, the policy authority in Peru implemented a heterodox price control program. Prices were liberalized in September 1988, which resulted in high inflation rates. Inflation rates remained high, even though government expenditures declined. This suggests a lack of credibility in the attempt to reduce government expenditures as part of a disinflationary program. Inflation rates only went down after the new government implemented the stabilization program. Low level of government expenditures reinforced this behavior, with some important interruptions in October 1992 and September 1994. A similar case occurs with the interest rate differential. Interest rates were allowed to fluctuate along with the liberalization of the financial system in September 1988. Previously, interest rates were controlled by the Central Bank. Between September 1988 and September 1991, the interest rate differential reflected inflationary expectations. Even though inflation rates went down, the interest rate differential continued to be high, due to the

uncertainty and the adjustment in the financial system that the stabilization program brought until October 1990.

The previous analysis is based on the individual behavior of the variables. However, the measure of credibility of the economic policy in the theoretical model takes into account the interaction of government expenditures and inflation rate. In the bivariate estimation, the values for the means, variances and the probabilities are estimated using the joint process of government expenditures and inflation rates.

According to the bivariate model, the process of government expenditures for the period between September of 1988 and June of 1995, is described as follows

$$G_t = \underset{(0.5199)}{5.8658} + \underset{(0.1398)}{0.2663}G_{t-1} + \underset{(0.1835)}{1.4320}\varepsilon_t \quad \text{when } s_t = 1 \text{ (high regime)}$$

$$= \underset{(0.7732)}{4.3223} + \underset{(0.1398)}{0.2663}G_{t-1} + \underset{(0.1891)}{1.00993}\varepsilon_t \quad \text{when } s_t = 2 \text{ (low regime)}$$

(Standard errors are in parentheses). There are two regimes of government expenditures. The estimated coefficients in this equation are significantly different from zero at a 90% level of confidence. The switch from high to low regime brings a decline in the government expenditure of $(\beta_1 - \beta_2) = 1.51434$ percent of GDP. Also it brings a decline in the variation of the government expenditure process. In the long run, the decline of the government expenditures would be $(\beta_1 - \beta_2)/(1-\phi) = 2.0640$ percent of the GDP.

The values of the transition probabilities are $p_{11} = 0.94536$ (0.0503) and $p_{22} = 0.93100$ (0.0526) for the high and low regimes. This transition probability indicates that when the government expenditures are in the high regime there is a 94.5% probability to stay in that

regime and if the process is at the low regime, this probability is 93.1% to remain in the same regime. Even though, the probabilities are greater than 90%, it does not indicate a strong persistence in the process of government expenditures. By comparison, Ruge-Murcia (1995, 1997) finds that these probabilities are 99% for p_{11} and 98.5% for p_{22} for the case of Israel.

One of the results of the bivariate estimation is the roots of the second-order difference equation in expectations. The smaller root of the difference equation (λ_1) equals to 0.156695 (0.11189) and the larger root of the difference equation (λ_2) is 32567.3 (294084). According to the theoretical model, λ_1 should be less than one and λ_2 greater than one. These estimates are used in the calculation of other parameters of the theoretical model. The value of the semi-elasticity of money demand with respect to the interest rate (α) can be seen

$$m_t^d - p_t = y_t - 0.000031 i_t + \xi_t$$

Even though α(=0.000031) is positive its magnitude is smaller than previous empirical estimates. Ruge-Murcia (1995) finds a small coefficient (0.88) but it is still greater than the one shown in this case. For the hyperinflationary cases of Poland and Hungary, Cagan (1956) found estimates between 2.3 and 8.7 respectively. However it is important to be cautious with the estimates of these coefficients due to the lack of statistical significance of these roots and the large magnitude of λ_2.

The coefficients of the growth rate of money supply can be calculated as well, these estimates are

$$\vartheta_t^s = c + \underset{(5.0906)}{9.2540} G_t + \underset{(0.1119)}{0.1567} \pi_{t-1} + \varsigma_t$$

The constant c cannot be recovered from the estimated parameters. The coefficient of the government expenditures (γ=9.2540) is greater than zero and larger than expected. It is also statistically significant at 90% confidence level. It supports the assumption in the theoretical model that high-powered money was an important source to finance the fiscal deficit.

The estimate of the coefficient of the lagged value of the inflation rate (ψ=0.1567) is positive but it is not statistically significant. An increase in the inflation rate in the previous period increases the growth rate of money supply in 0.1567 in the current period. These results support the introduction of the money supply as an endogenous process. A decline in government expenditures due to a switch in the regime would decrease the growth in money supply in $\gamma*(\beta_1 - \beta_2)$ = 9.2540 * 1.5143 = 14.0133 percent points and in the long run by 9.2540*2.0640 = 19.1%. The substantial effect of the government expenditures on the growth of money supply shows the importance of the use of the newly printed money to finance large fiscal deficits during the 1980s. It is also necessary to be aware that the magnitude of the roots contributes to the size of γ.

The coefficient for the real tax revenue equation is

$$T_t = \tau - 0.0169\pi_{t-1} + \eta_t$$

The constant τ cannot be recovered from the estimated parameters. The estimated coefficient of the lagged inflation rate on current tax revenues (φ) is negative supporting the theoretical model. An increase in the inflation rate at time t-1 will decrease the current real value of the tax revenues by 0.0169 percent points, agreeing with the Olivera-Tanzi effect. Assuming that any reduction in government expenditures will bring a similar reduction in the inflation rate, then a switch in the government expenditures from high to low regime would increase real tax revenues

in $\varphi^*\gamma^*(\beta_1 - \beta_2) = 0.0169 * 9.2540 * 1.5143 = 0.2368$ as a percent of GDP. The explanation of this small effect on the real value tax revenues is that, despite the negative relationship with the inflation rate, there are other institutional factors that would improve the efficiency of the tax system. After the implementation of the orthodox stabilization program in August 1990 by Alberto Fujimori, there was a tax reform that increased the tax base substantially.

The estimated coefficients of the inflationary process for Peru are as follows

$$\pi_t = \underset{(35.2350)}{-49.6471} + \underset{(0.1119)}{0.1567}\pi_{t-1} + \underset{(5.0906)}{9.2539}\beta_{s_t} + 2.464G_{t-1} - 0.000032G_{t-2}$$

$$+ (L_{t-1} - L_{t-2})HB + \underset{(5.0906)}{9.2539}\sigma_{s_t}\varepsilon_t + u_t + 0.000031v_t + 0.000005u_{t-1} + 0.000013v_{t-1}$$

where $\beta_1 = 5.8658$ (0.5199) and $\beta_2 = 4.3223$ (0.7732), $\sigma_1 = 1.4320$ (0.1835) $\sigma_2 = 1.0093$ (0.1891) $\sigma_u = 4.5999$ (0.4310). The correlation coefficient between the disturbance term e_t and u_t is $\rho_{\varepsilon u} = -0.3705$ (0.1647) as expected in the model. The means and the variances are greater than zero and statistically significant. Given that $\beta_1 > \beta_2$, the inflation rate will be higher in the high regime than in the low regime. In this model, the inflation rate depends on the government expenditure regimes and the agents' credibility on the stabilization program.

One of the most important contributions of these results is the estimation of the effects of credibility in the government economic policy on the inflation process. Looking at the filtered probabilities at $s_t = 1$ refers to the probability that the observation at a given date is at the high regime. A switch in the regime is observed when $\Pr(s_t = 1|I_t) > 0.5$. In Figure 6, the probability of being at the high government expenditure regime is greater than 0.5, between September 1988 and January 1991. This coincides with the pre-stabilization period when prices of goods and

services were liberalized as well as the financial system, but government expenditures remained in the high regime even though there were several attempts to reduce its level.

The orthodox stabilization program was implemented in August 1990, and it brought a sharp decline in the inflation rates and government expenditures (Figure 4). Despite of this decline in these variables, and according to these probabilities, the economic agents did not perceive a credible stabilization program until February 1991. The credibility of the program continues until November 1992. Between December 1992 and February 1993, the agents' inference about the government expenditure process is that the probability to switch to the high regime increased. As an anecdotal note, Abimael Guzman, leader of the terrorist group Shining Path was captured in November 1992 providing a positive impact to Alberto Fujimori's government. The increase in government expenditures in the subsequent months might have been a response to the outburst in popular confidence. The probability of being in the high regime decreases again in March 1993 and credibility continues until August 1994. In September 1994, the agents again infer that the stabilization program lacks credibility when government expenditures increase even though inflation rates remain stable and low. This large probability to continue in the high regime continues until June 1995. This increase in government expenditures, contrary to the objectives of the stabilization program, can be explained by the elections in May 1995. During this period, Alberto Fujimori increased government expenditures in education and health services.

Figure 7 shows the behavior of the coefficient for a change in the regime component. This coefficient displays the economic agents' inferences about the true regime of the government policy using the information of both government expenditures and inflation rates.

There is a sharp increase in the coefficient for a change in regime in August 1989, when the stabilization program was implemented but there is a sharp decline in both occasions when the stabilization program became credible according to our definition (February 1991 and March 1993). The coefficient for a change in regime displays a greater variability when the inflation rate fluctuates more between March 1993 and June 1995.

According to the results of the bivariate estimation, the economic agents do not infer that the stabilization program is fully credible during the overall period of implementation. There are periods in which this economic policy has gained credibility. These periods are characterized by low inflation rate and government expenditures. But this credibility is very vulnerable to sudden increases in government expenditures. Even if the level of government expenditures does not go back to the levels of the high regime and the inflation rates are still low, an increase in government expenditures will increase the probability of a switch in the regime and therefore it will signal to the economic agents that the stabilization policy might fail.

Looking at Figures 4 and 6, there is a lag between the actual implementation of the stabilization program in August 1990, shown by a decline in government expenditures and inflation rate, and the time that economic agents infer that this program is credible, February 1991. It took six months for the economic agents to evaluate the behavior of the government, their information about its current and previous expenditures, and the inflation rate to infer that the program was credible.

Policy credibility and persistence of dollarization

One explanation for the presence of hysteresis in currency substitution is the lack of credibility in the stabilization program. If the economic agents do not find the economic program credible, they will expect high government expenditures and high inflation rates, discouraging the holding of domestic currency. If the agents are already holding foreign currency, this lack of credibility will be a disincentive to switch to domestic currency. In Figure 8, the currency substitution ratio, defined as the share of deposits in foreign currency in total deposits, decreases in April 1989 and increases again after the implementation of the stabilization program in August 1990 to continue at an average of 70% until June 1995.

To test the effect of policy credibility on the process of currency substitution, the expected inflation rate is calculated using the lagged value of inflation rate and the filtered probabilities from the credibility model. The expected inflation rate includes the inferences of the economic agents about the continuation of the economic program based on their observations about government expenditures and inflation rates. For this estimation, the long run formulation for the currency substitution process (Quispe-Agnoli 1997) is used. According to this formulation, the change in the currency substitution ratio depends on the expectations of the inflation rate. Taking the sample from November 1988 to June 1995, the results of the estimation are as follows:

$$\Delta CS_t = \underset{(0.07984)}{0.000265} + \underset{(1.60654)}{0.000142}\Delta\pi_t^e + e_t$$

t-values are in parenthesis. The coefficient of the expected inflation rate is positive but not statistically significant. This is not surprising because during this period the ratio of currency

substitution first increases and then declines between November 1988 and June 1990, at the same time the expected inflation rate is at the high regime. However, after the implementation of the disinflationary program and the switch of the inflation rate to a lower regime, the currency substitution ratio remains at levels 60% or higher. This persistence in currency substitution is related to lack of credibility of economic policy. Therefore, I take the sample only after the implementation of the stabilization policy, from August 1990 to June 1995. The results of this estimation are

$$\Delta CS_t = -0.000967 + 0.000142\Delta\pi_t^e + e_t$$
$$(-0.50263) \quad (2.99011)$$

t-values are in parenthesis. The coefficient of the expected inflation rate is positive and statistically significant. The expected inflation rate includes the inferences of the economic agents about the probability of success of the economic policy as shown in Figure 6. Policy credibility will lead to explain the hysteresis phenomenon in currency substitution. A lack of policy credibility explains why the economic agents may decide to keep their monetary assets in foreign currency even when the inflation rate is low.

6. Conclusions

In the context of stabilization policies, credibility will help to bring inflationary expectations down and to achieve the goal of disinflation. On the other hand, the lack of policy credibility brings an additional restriction to the economic programs implemented by policy authorities. If the economic agents expect that the policy authority cannot commit to his economic program, they will protect themselves from the consequences of the collapse of these programs. If the

economic agents believe that the stabilization program will fail, and the inflation rate will not be reduced, they will allocate some of their monetary assets in foreign currency to offset the loss in their purchasing power. Therefore, the lack of credibility of the economic policy explains the presence of hysteresis in currency substitution.

In order to examine the effect of credibility on currency substitution, I present a theoretical model where the economic agents form their expectations on the continuation of the economic policy based on their information about the fiscal deficit, inflation rates and the interest rate differential. The estimation of the model involves uses Hamilton's switching regime approach.

The empirical evidence comes from the Peruvian experience with the orthodox stabilization program implemented in August 1990. The period of the sample is from November 1988 to June 1995. The probability inferred by the economic agents about the sustainability of the economic policy is formulated using current and lagged values of government expenditures and lagged values of the inflation rate. The results of the estimation show that there are two different regimes in the government expenditure process. According to the economic agents' inferences, the stabilization program in Peru is not credible.

Using the previous results, I examine the effect of policy credibility on the hysteresis in currency substitution. Due to the lack of credibility in stabilization policies, economic agents may have maintained high expectations of inflation. Even if inflation rates decrease, the lack of policy credibility may cause economic agents to continue holding their assets in foreign currency. For the estimation, the expected inflation rate is formulated using the probability built by the economic agents about the regime of the economic policy. Between August 1990 and

June 1995, the expected inflation rate that incorporates the inference of the economic agents about the credibility of the economic policy is statistically significant for the explanation of the change in the ratio of currency substitution. The lack of credibility in the economic policy of the government authority explains the presence of hysteresis in currency substitution.

Table 1
Peru : Unit Root Tests
Augmented Dickey-Fuller Test

Government Expenditures/ Gross Domestic Product	- 14.9708*
Inflation Rate	- 69.2911*
Interest Rate Differential	- 38.5993*

Sample Period = September 1988 to June 1995

Number of Observations = 82

The figures correspond to the t-statistic of the following estimation:

$$\Delta y_t = \alpha + \gamma y_{t-1} + \beta_1 \Delta y_{t-1} + \beta_2 \Delta y_{t-2} + \phi t + \mu_t$$

* indicates the rejection of the hypothesis $\gamma = 0$ (or the presence of unit root in the series)
The critical values are -3.45 and -4.04 for 95% and 99% level of confidence.

Table 2

Results of the Univariate Estimation
Government Expenditures , Inflation rate and Interest Rate Differential
Peru : 1988:09 to 1995:06

Coefficients	Government Expenditures as % of GDP	Inflation Rate (%)	Interest Rate Differential (%)
μ_1	8.2219 (0.2994)	33.1963 (1.9014)	19.4319 (4.0151)
μ_2	5.8968 (0.1880)	13.6462 (6.6084)	0.6529 (0.0803)
σ^2_1	2.3522 (0.5279)	71.5119 (22.8616)	356.2060 (106.7245)
σ^2_2	0.9761 (0.2258)	2687.82 (484.56)	0.3854 (0.0705)
p_{11}	0.9348 (0.0462)	0.9415 (0.0497)	0.9457 (0.0458)
p_{22}	0.9179 (0.0454)	0.9863 (0.0140)	0.9863 (0.0141)
Log-likelihood	-76.26	-337.01	-87.0866

Standard deviations in parenthesis.
All coefficients are significant at 95% confidence level.
Note: The univariate estimation is based on a numerical optimization of the maximum likelihood using Hamilton's procedure.

Figure 1

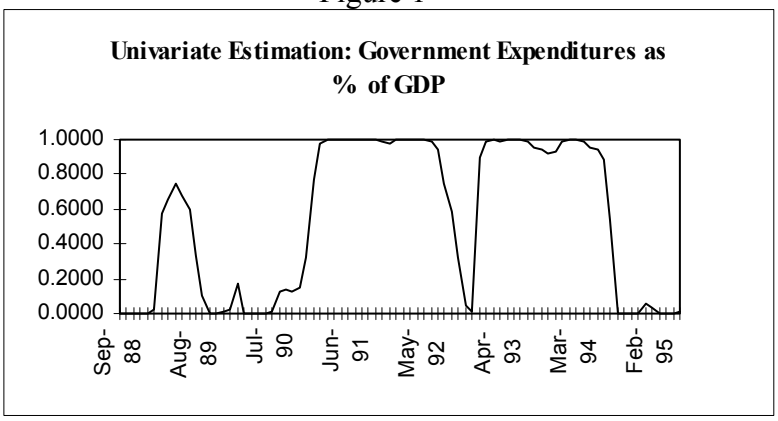


Figure 2

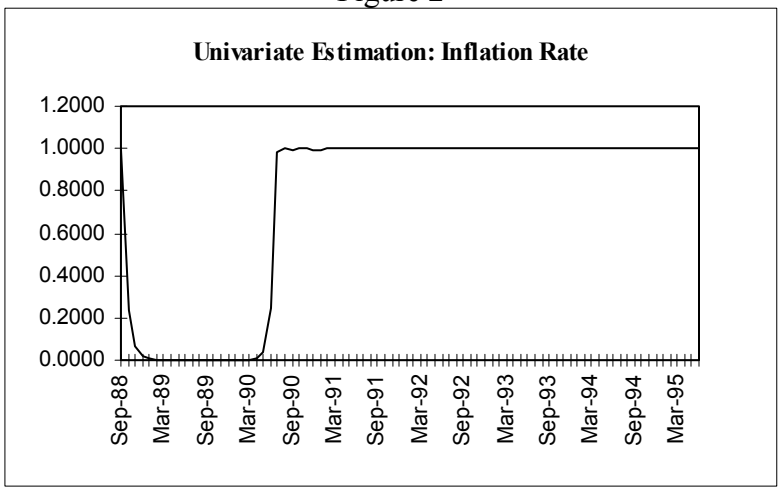


Figure 3

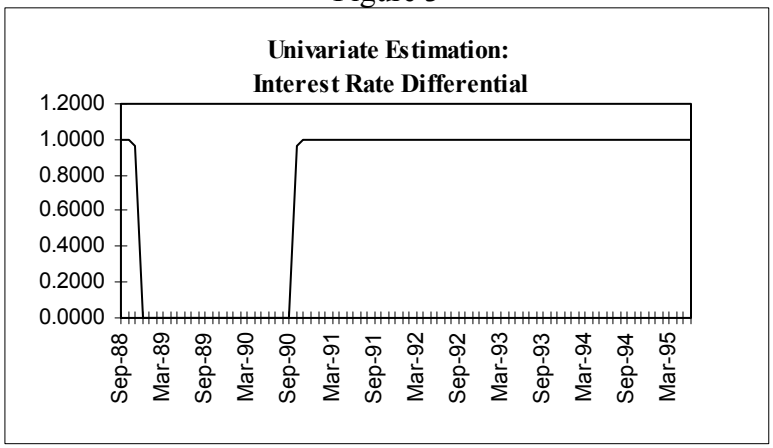


Figure 4

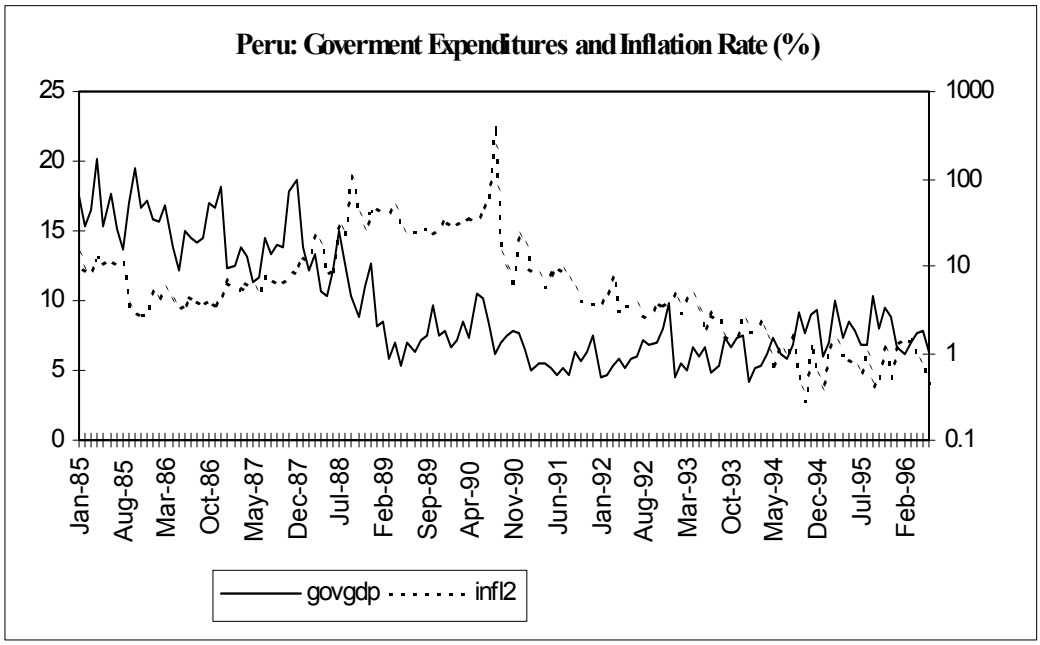


Figure 5

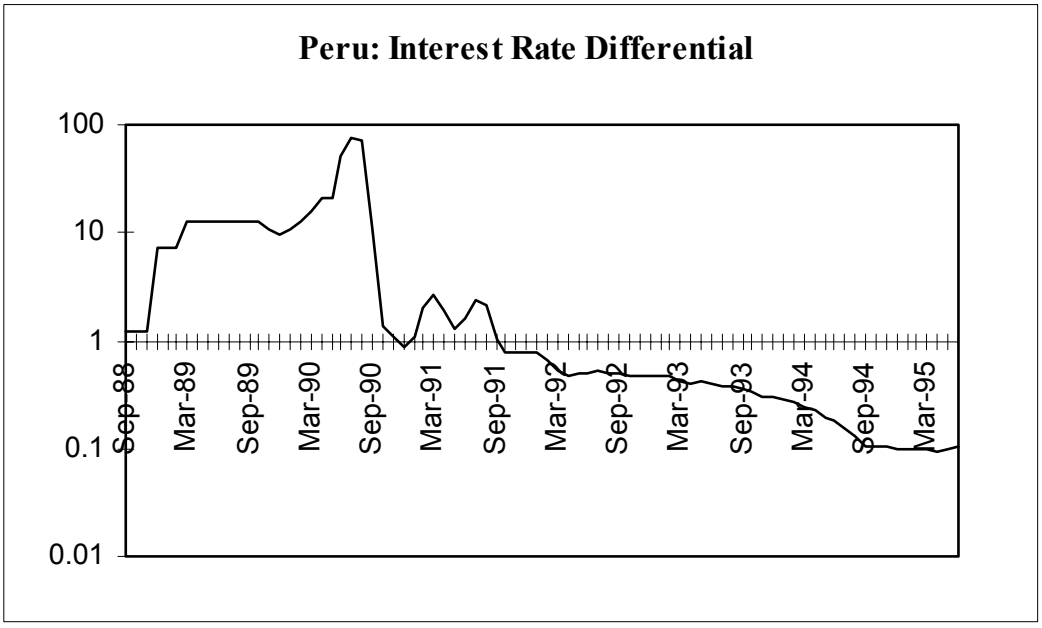


Figure 6

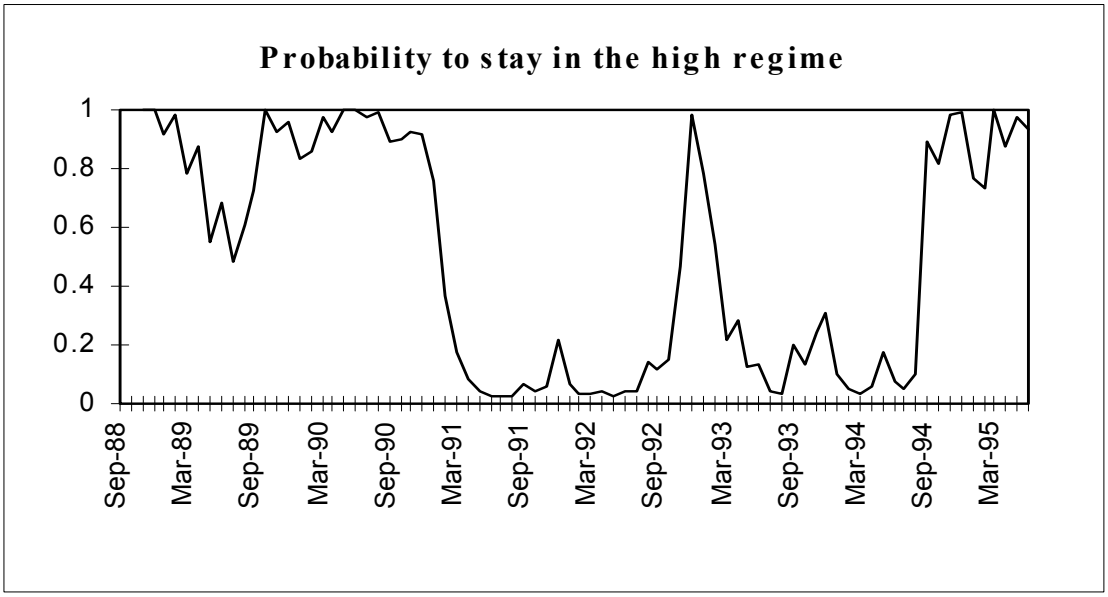


Figure 7

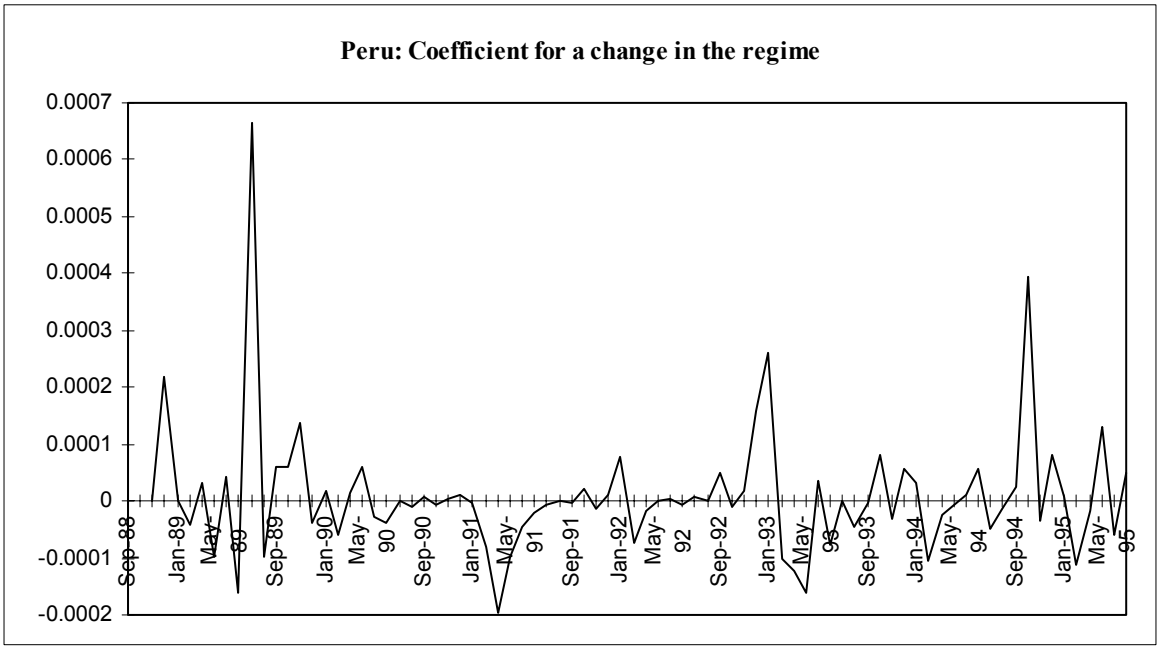
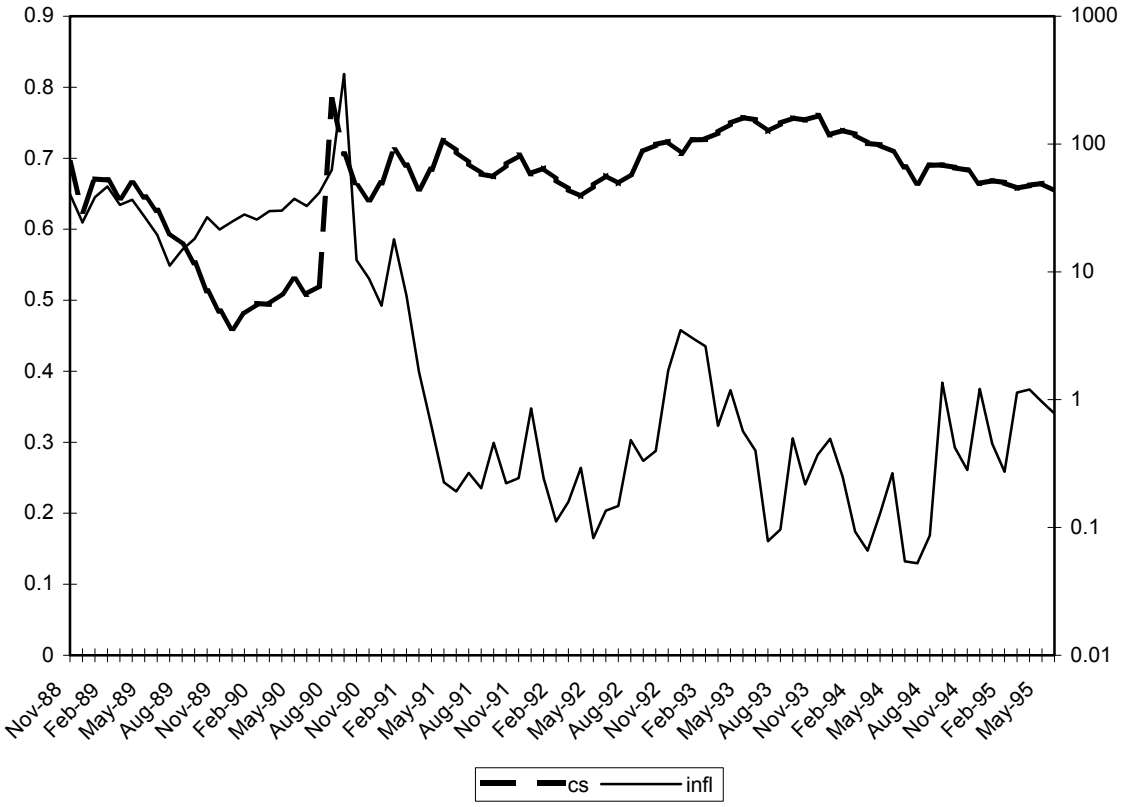


Figure 8

Peru: Currency Substitution Ratio and Expected Inflation Rate



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