THE DEMAND FOR INTERNATIONAL RESERVES IN BARBADOS: EMPIRICAL EVIDENCE FOR THE PAST THREE DECADES

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ABSTRACT

This article empirically investigates the factors influencing the demand for the net international reserves in Barbados over the past three decades, using the dynamic OLS (DOLS) method developed by Saikkonen (1991) and generalised by Stock and Watson (1993). This estimation technique is appropriate for small samples and allows for the explicit account of endogenity. The paper builds on previous studies for developed and developing countries in the sense that other explanatory variables, such as the level of foreign debt service payments and an index of capital account liberalisation, are included in the empirical reserve demand function to reflect the current economic environment. The results indicate that long-run reserve policy appears to have been guided primarily by real income, the propensity to import and capital account liberalisation. In the short-run, reserve movements were also found to be driven by these three variables. However, reserve holdings were influenced negatively by central bank lending to the central government, which conflicts with *a priori* reasoning.

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Introduction

Over the past thirty years, the cumulative growth in the net international reserves (NIR) of the monetary authorities has been fairly impressive. At the end of 2005, the NIR totalled nearly $1.3 billion, compared to $82 million at the end of 1975, representing an average annual increase of around 17 percent or about $40 million per year. As shown in Figure 1, the NIR rose sharply between 1993 and the early part of the new millennium, a period characterised as Barbados' longest phase of economic expansion. It is important to note, however, that the growth performance of the NIR in those years was bolstered by external borrowings and divestment proceeds. In anticipation of the harsh realities of a liberalised economic environment and the uncertainties created by the increasing global geo-political tensions, the Government of Barbados prudently sought to boost the NIR to provide a buffer against such exogenous shocks. Indeed, the NIR has come under severe pressure in recent years, registering a decline of $43.8 million on average each year since 2002. The proximate causes of the sluggish reserve accumulation include strong import growth, which has been fuelled by a surge in investment spending by the public and private sectors, cross-border investment and lacklustre export activity. In fact, one could argue that the liberalisation of both external current account transactions and exchange controls have led to lower net purchases of foreign exchange by the central bank from the banking system. This state of affairs warrants careful attention given the immense importance attached to holding adequate foreign reserves in small, open fixed exchange rate economies such as Barbados.

The preceding discussion underscores the relevance of an investigation of the main determinants of the demand for international reserves in Barbados. The limited empirical research done for Barbados [Coppin and Craigwell (1988) Coppin (1994)] have typically focussed on the volume of imports or income, the marginal propensity to import, the opportunity costs of holding reserves, a variability measure of the balance of payments and a monetary variable to test the monetary approach to the balance of payments as relevant explanatory variables, in line with the majority of studies undertaken for developed and developing countries [see Bahmani-Oskooee and Brown (2002) for an excellent survey]. This paper builds on these studies in the sense that other explanatory variables, such as the level of foreign debt service payments and an index of capital account liberalisation, are included in the empirical reserve demand function to reflect the

current economic environment. In addition, this study follows recent studies on the demand for international reserves [Elbadawi (1990); Ford and Huang (1994); Badinger (2004)] by explicitly accounting for the nonstationarity of the variables. However, unlike these previous efforts, issues of endogeneity and small samples are explicitly taken into account by using the dynamic OLS (DOLS) method developed by Saikkonen (1991) and generalised by Stock and Watson (1993).

The results from estimating the demand for international reserves function using annual Barbadian data suggest that, in the short run and long run, the demand for reserves is positively related to real national income, which proxies transactions demand, the propensity to import and the liberalisation measure. Surprisingly, no empirical evidence was found regarding the relationship between net lending to the central government by the central bank and reserve demand.

The remainder of this article is structured into five sections. Following the introduction, section 2 looks at the main theoretical issues influencing the specification of the empirical demand model. Section 3 presents the empirical framework, while section 4 discusses the sample data and outlines the econometric methodology. In the next section, the estimation results are presented and some concluding remarks are offered in the final section.

A Brief Look at the Theoretical Issues Influencing the Specification of the Empirical Model

The theoretical considerations underpinning the need for a country to hold international reserves depend on the exchange rate regime. In the case of fixed exchange rate countries, holding an adequate level of reserves is critical to the maintenance of the pegged rate. If the country experiences persistent deficits on the external current account, then it is most likely that the foreign reserves are being used up to support the parity of the exchange rate. In the event that reserve losses become too severe, immediate remedial action must be taken to address the disequilibrium in the balance of payments. This suggests that the balance of payments is of major importance in fixed exchange rate economies and, therefore, the demand for international reserves takes precedence. On the other hand, economic theory posits zero requirements for

foreign reserves under a pure floating exchange rate regime. This is because the extent of disruption in the balance of payments is not persistent, since currencies fluctuate against each other according to demand and supply conditions in the foreign exchange market thus correcting for any disequilibrium. Under a managed float, which can be considered a hybrid of the two polar cases previously described, central banks intervene in the foreign exchange market to limit wide fluctuations in the exchange rate. Therefore to achieve some measure of success, countries with managed floats also need adequate reserve holdings.

In their review article, Bahmani-Oskooee and Brown (2002) distinguishes two sub-periods (pre-1973 and 1973-present) in the empirical literature on the demand for international reserves. In the pre-1973 era, the empirical studies of reserve demand identified five theoretically sound variables: the level of world trade (Triffin, 1961), the money supply (Johnson, 1965), the marginal propensity to import and an opportunity cost measure (Heller, 1966) and a payments variability measure as postulated by Malchup (1966). Trifin (1961) argues that the demand for international reserves grows proportionally with the absolute level of world trade. Therefore, a suitable reserves-to-import ratio was seen as a good measure of a country's reserve adequacy. However, Malchup (1966) proposed that the variability of trade was a better indicator of the adequacy of a country's foreign reserves. Heller (1966) went further by introducing the opportunity cost of holding international reserves, predicated on the assumption that there should be a negative relationship between reserve demand and opportunity cost. In addition, Heller also incorporated a country's marginal propensity to import (m) derived from the theory that the marginal cost of adjustment for a country is equal to the inverse of its marginal propensity to import. He hypothesised that when a country uses expenditure-reducing policies a high marginal propensity to import impacts negatively on (or diminish) the demand for reserves. Therefore, if the adjustment costs for a country are large, then the demand for international reserves is expected to be substantial. If the converse holds, the demand for reserves would not be that great.

There is also a general view in the literature that changes in the demand for international reserves can be explained by changes in the domestic money supply [Johnson (1965)]. Using the basic equilibrium money relationship $\Delta R = \Delta M^d - \Delta M^s$, where ΔR is the change in international

reserves, ΔM^d is the change in the demand for money and ΔM^s is the change in the money supply, Johnson posits that if the domestic money supply increases at a slower rate than the demand for money, the foreign reserves will grow, as the excess demand is satisfied by the foreign sector. If the demand for money is greater than the supply, excessive spending by domestic residents leads to a loss in foreign reserves. Indeed, excessive borrowing by the government from the central bank in the case of a fixed exchange rate economy can lead to the latter result, which can only continue until the reserves are exhausted.

In the post-1973 period[1], most countries moved away from pegged exchange rate regimes to floating exchange rate systems. As a result, the focus shifted to investigating whether the move to flexible exchange rates would have reduced the demand for international reserves. In addition, the studies looked at the stability of the reserve demand function, particularly in light of the oil price shocks after 1973, whether the deviation of the price of gold from its official price had an impact on the demand for international reserves, and finally, the speed of adjustment of reserve demand to its desired level. It is these latter studies that issues of non-stationarity of the data (see footnote 1) were incorporated through the utilisation of error correction models [Elbadawi (1990); Ford and Huang (1994); Badinger (2004)]. Although not stated explicitly in those studies, error correction models (ECMs) via the Granger Representation Theorem (see Engle and Granger, 1987) are linked to co-integration. In essence, the Granger Representation Theorem states that ECMs exist if and only if the variables are co-integrated. The methodology used in this paper builds on this literature.

The Empirical Framework

The majority of the empirical studies on the demand for international reserves mentioned in the previous section have estimated functions that take into account the volume of imports or income, the marginal propensity to import, the opportunity costs of holding reserves and a variability measure of the balance of payments. These variables form the basis for the empirical

[1] Within this period, a distinction could, perhaps, also be made between those studies that consider the non-stationarity of the data and those that do not.

model estimated in this study, which includes a scale variable (transaction motive), uncertainty (precautionary motive), the cost of adjustment to a balance of payment disequilibrium and the opportunity cost of holding reserves (profitability considerations). To these set of standard variables, foreign debt service payments, net lending to the central government by the central bank and a capital account liberalisation measure are added to the reserve demand function. As mentioned earlier, these variables are included because the Government of Barbados has borrowed heavily on the international capital market since the late 1990s and consequently, debt service payments have risen sharply since 2002 (see Figure 2). In addition, excessive lending by the central bank to the government during the late 1980s has been identified as a proximate cause of the balance of payments crisis in the early 1990s. With regard to capital account liberalisation, Barbados has been gradually liberalising exchange controls and has virtually removed all restrictions on current account transactions. Therefore, it is important to determine whether these measures are influencing the demand for reserves.

The basic model to be estimated is:

$$lr_t = \mathrm{B}'_X X_t + \mu_t \tag{2}$$

where $X = [ly, lu, ls, ld, lp, lcg, CAL]$ and B_x is a vector of β-coefficients, so that β_y, for example, is the coefficient with respect to *y*. The supply of reserves is assumed to adjust to the demand within the period. Therefore, *lr* represents the demand for international reserves, *ly* is real gross domestic product, *lu* is an uncertainty variable, *l*s is an opportunity cost measure of holding foreign reserves, *ld* is the public foreign debt service payments, *lp* is the average propensity to import, *CAL* is a capital account liberalisation measure developed by Greenidge (2005), and *lcg* is net lending to the government by the central bank.

Of the variables in Equation (1), a positive sign is expected for the transactions, uncertainty and debt service payments variables (i.e., ly, lu and ld, respectively). However, the *a priori* sign on the average propensity to import variable (lp) is theoretically ambiguous. On the one hand, *lp* may proxy the marginal propensity to import, which, under the Keynesian open economy model, should have negative effects on the demand for reserves, since the higher the marginal

propensity to import, the more powerful is the income policy in affecting the external current account and the less reserves will be held. On the other hand, Frankel (1974, 1980) argue that *lp* represents the degree of openness of an economy to external risks and should have positive effects. The opportunity cost variable, which is measured as an interest rate differential between domestic and foreign rates, *l*s, is expected to enter the equation with a negative sign because the opportunity cost of holding foreign reserves is to tied-up financial resources that could have been employed for domestic economic development. This argument is supported by the fact that funds not needed immediately for international payments for goods and services should be invested to yield maximum returns, as earnings on the liquid reserves reduce the opportunity costs of holding those reserves. With the removal of exchange control restrictions on capital account transactions, there is expected to be a higher demand for foreign reserves, while an increase in net lending by the central bank to the government, ceteris paribus, is expected to increase the demand for reserves.

Data and Econometric Methodology

The data used in this study are annual observations covering the thirty-year period 1975 to 2005. All the data were procured from various Central Bank of Barbados data files. Except for the capital account liberalisation measure, the variables were converted to logarithms and to real terms, using, in the case of the latter, the GDP deflator. As in the majority of studies, real data is used because international reserves are held to finance real transactions and to mitigate against real shocks (see Edwards (1984)). In terms of the specific definitions of the variables, *lr* is real net international reserves at the Central Bank, *ly* represents real gross domestic product at factor cost; real imports of goods and services were also tried as a proxy for transactions but *ly* gave the better fit. *lp* is real imports of goods and services divided by real gross domestic product in percentages. *ld* is real public foreign debt service payments. The uncertainty (or variability) variable (*lu*) is the conditional standard deviation of a GARCH (1,1) model of the logarithm of reserves, where the conditional standard deviation represents the variability or volatility in the data series. The opportunity cost (*ls*) is one plus the difference between the yield on Barbados government bonds and the US discount rate, in percentages per annum. Net lending to the central government by the central bank, *lcg*, is the difference between advances to the central

government plus purchases of government securities and central government deposits at the central bank. Finally, the capital account liberalisation variable, CAL, is constructed by coding the detailed text of the International Monetary Fund's Annual Report of Exchange Arrangements and Exchange Restrictions. More specifically, the specific controls on capital account transactions for each year is coded and as such is intended to capture the impact of polices that would have affected the movement of capital across borders [see Greenidge (2005) for details].

With eight variables and at most twenty-eight observations a single equation estimation was adopted as opposed to the Johansen (1988, 1995) multivariate maximum-likelihood framework, which requires a relatively large sample in order to produce reliable estimates. The use of the single equation estimation technique raises issues of endogenity, since in the presence of simultaneity even though cointegration regressions are consistent estimators they may be bias in small samples. Therefore, the dynamic OLS (DOLS) method developed by Saikkonen (1991) and generalised by Stock and Watson (1993), which allows for the explicit account of endogenity, is employed.

The DOLS procedure provides unbiased and asymptotically efficient estimates of the long-run relation, even in the presence of endogenous regressors. Thus, the endogeneity of any of the regressors has no effect, asymptotically, on the robustness of the estimates. Further, statistical inference on the parameters of the cointegrating vector is facilitated by the fact that the t-statistics of the estimated coefficients have an asymptotic normal distribution, even with endogenous regressors (Stock and Watson, 1993). Another advantage of DOLS is that it allows for direct estimation of a mixture of *I(1)* and *I(0)* variables[2]. In addition, Stock and Watson (1993) shows that the DOLS estimator is asymptotically equivalent to the maximum likelihood estimator of Johansen (1988, 1995) in the case where the variables are *I(1)* and even in the presence of multiple long-run relations if there are no cross equation restrictions (see also Park and Phillips, 1988; Phillips, 1991; Watson, 1994; Caporale and Pittis, 1999). Moreover, it performs well in small samples. The potential biases due to endogeneity among the regressors

[2] This is an important plus since the Johansen multivariate procedure does not admit *I(0)* variables to the cointegrating vector but often the interest is in the long-run effects of such variables (for example, the interest rate differential which is often *I(0)*) and it would be incorrect to assume that because it is *I(0)* it can not exert an influence on the dependent variable in the long run.

and small sample size are dealt with by the inclusion of lags and leads of the first differences of the *I(1)* variables. Thus, the estimation of the long-run relation for Equation (1) is based on the following regression:

$$lr_t = B^{'} X_t + \sum_{j=-k}^{k} \lambda_j^{'} \Delta X_{t-j}^{i} + \xi_t \tag{2}$$

where X^I denotes the sub-set of *I(1)* variables of *X*, *B* is the vector of long-run coefficients and the inclusion of ΔX_{t+j}^{I} takes care of the possible endogenity of *X*. The equation is estimated in most cases with *K=1*, but then a 'general to specific' procedure[3] is applied to reduce the model to a more parsimonious congruent specification where only significant variables are retained.

In order to investigate the short-run dynamics, the estimates from Equation (2) can be used to formulate a general error correction model (GECM) of the form:

$$\Delta lr_t = \sum_{j=1}^{p} \varphi_j \Delta lr_{t-j} + \sum_{j=0}^{p} \phi_j^{'} \Delta X_{t-j}^{1} + \sum_{j=o}^{p} \gamma_j^{'} Z_{t-j} + \varsigma_j \sum_{j=1}^{p} \left(ly_{t-1} - B^{'} X_{t-1}^{*} \right) + \varepsilon_t \tag{3}$$

which specifies changes in real net international reserves as a function of lagged values of the first difference of the nonstationary variables, stationary variables that may have short-run effects (*Z*), and stationary combinations of the nonstationary variables, which represents the long-run relation between real international reserves and the forcing variables. This long-run relation among variables is given by the elements of *B* and the rate at which real international reserves respond to disequilibrium in the long-run relation is given by ζ . In estimating Equation (3), a general to specific approach will be used in order to reduce it to a more parsimonious representation.

[3] See Campos *et al*. (2005) for detailed expositions on the general-to-specific approach to econometric modelling.

Empirical Results

All the estimations were done using the econometric software package PC Give. Figure 3 displays the plots of the level data in logarithms, which on inspection reveals trending variables. Therefore, before proceeding with the empirical analysis, each data series was tested for a unit root using the Augmented Dickey Fuller (ADF), Phillips Perron (PP) and Kwiatkowski et al. (KPSS) tests. The results presented in Table 1 indicate that all the variables are integrated of order one, I(1). For each variable, both the ADF and PP tests accept the null hypothesis of a unit root in the level of the variable, but reject the null for the first difference of the variable. For the KPSS test, the null hypothesis of stationarity is rejected for the level of each variable, but not for the first difference.

Table 1: Unit Root Tests, 1975-2005

Variable		ADF	PP	KPSS
lr	Level	-1.029	-1.175	0.409^{+}
	Δ	-4.782***	-4.869***	0.205
ly	Level	-1.139	-1.304	0.697^{++}
	Δ	-3.096***	-2.660*	0.082
ls	Level	-2.507	-2.476	0.365^{+}
	Δ	-5.350***	-9.709***	0.500
ld	Level	-1.912	-1.947	0.529^{++}
	Δ	-5.888***	-5.874***	0.245
lp	Level	-1.470	-1.570	0.302^{+++}
	Δ	-4.931***	4.914***	0.231
lcg	Level	-0.523	-0.350	0.541^{++}
	Δ	-5.090***	-5.442***	0.331

Notes: *, ** and *** are the MacKinnon critical values for rejection of the null hypothesis of a unit root at the 10%, 5%, and 1% levels, respectively, for both the ADF and PP tests. $^{+}$, $^{++}$, $^{+++}$ are the critical values for the LM test statistic of the KPSS test and denotes rejection of the null hypothesis of stationary at the 10%, 5%, and 1%, respectively (based upon the asymptotic results presented in KPSS 1992 Table 1, pp. 166). Δ denotes the first difference of the original series.

Following the tests for the order of integration, the DOLS method was employed to estimate Equation (1) (see Table 2a). Owing to the degrees of freedom problem, Equation (1) was estimated in blocks and the results were then combined to produce Equation (2a)[4]. The diagnostics suggest that the long-run demand model appears to be stable and well defined. The empirical results of this equation indicate that real national income, the average propensity to import and the capital account liberalisation measure have statistically significant positive impacts on the demand for international reserves over the sample period, which agrees with *a priori* reasoning. The impact of the average propensity to import is the strongest, suggesting that a 1 percent change in this variable increases reserve demand by 0.8 percent. In addition, when real national income rises by one percent, the demand for the NIR grows by slightly less than the effect exerted by the average propensity to import. Not surprisingly, the capital account liberalisation measure, which is constructed to capture the removal of restrictions on capital account transactions since the late 1990s, has heightened the long-run demand for foreign reserves, but the estimated impact is half that of real national income and the proclivity to import goods and services. Unexpectedly, net lending to the central government by the central bank and the variability in reserve holdings were found to have negative relationships with the demand for reserves and the long run relationship between public debt service payments and the reserves was statistically insignificant.

Table 2a: DOLS Long-run Estimates

$$lr = \underset{(0.011)^{***}}{0.770ly_t} - \underset{(0.008)^{***}}{0.101lcg} + \underset{(0.399)^{**}}{0.807\Delta lp_{t-1}} - \underset{(0.197)^{***}}{2.075lu_t} + \underset{(0.207)^{*}}{0.374CAL_t}$$

$R^2 = 0.958$; JOINT – F (5,22) = 101.8 [0.000]***; DW = 2.45; AR- F (2,21) = 1.0853 [0.356]; ARCH- F (1,21) = 0.0543[0.818]; Norm. -χ^2 (2) = 2.743[0.254]; HET- F (10,12) = 0.552[0.823]; RESET – F (1,22) = 1.055[0.316]; Chow (1991) = 0.850[0.616]; Chow (2002) = 0.973 [0.394].

[4] This procedure presumes that the power that could be lost in choosing the wrong block in the estimation of Equation (1) outweighs the degrees of freedom problem.

Table 2b: GECM Estimation Results

$$\Delta lr_t = \underset{(0.191)^{**}}{0.545\Delta ly_t} + \underset{(0.275)^{**}}{0.654\Delta ls_{t-1}} - \underset{(0.241)^{**}}{0.686\Delta ld_t} - \underset{(0.265)^{***}}{0.927\Delta ld_{t-1}} - \underset{(0.786)^{**}}{1.627\Delta lp_t} + \underset{(0.333)^{*}}{0.804\Delta CAL_t} - \underset{(0.378)}{0.735 * ect_{t-1}}$$

$R^2 = 0.577$; JOINT - F (7,20) = 3.903 [0.008]***; DW =2; AR- F (2,19) = 0.426 [0.659];

ARCH- F (1,19) = 0.467 [0.503]; Norm. -χ^2 (2) = 2.037[0.361]; HET- F (14,6) = 0.574[0.816];

RESET - F (1,20) = 0.505 [0.486]; Chow (1991) = 0.609[0.795]; Chow (2002) = 0.203 [0.818].

Notes: Heteroskedasticity and autocorrelation consistent standard errors are in parentheses and *, **, *** indicates significance at the 10, 5 and 1 percent level, respectively. The F-statistic for the respective diagnostics tests are shown and the associated p-value in square brackets. R^2 is the fraction of the variance of the dependent variable explained by the model and *JOINT* is a test of the joint significance of the explanatory variables, *DW* is the Durbin Watson statistic, *AR* is the Lagrange multiplier test for *p-th* order residual autocorrelation correlation, *RESET* = Ramsey test for functional form mis-specification (square terms only); *Norm* is the test for normality of the residuals based on the Jarque-Bera test statistic (χ^2 (2)). *ARCH* is the autoregressive conditional heteroskedasticity for up to *p*-th order (see Engle, 1982a). *HET* is the unconditional heteroskedasticity test based on the regression of squared residuals on the squared fitted values. Finally, *Chow (n)* is Chow's (1960) test for parameter constancy based on breakpoints in the sample.

The general-to-specific approach, popularised by Hendry et al (1978), was used to determine the most parsimonious dynamic model, which captures the short-run movements governing the long-run relationship (see Table 2b). The diagnostic tests results indicate that the model is adequately specified, as the residuals do not violate the classical statistical assumptions of normality, serial independence and homoscedasticity. With regard to the short-run dynamics, the capital account measure and real income have the expected *a priori* signs, confirming the earlier analysis. In particular, the short-run impact of capital account liberalisation (0.8 percent), assuming a one percent change, is about twice its long-run effect, while in the case of real income or the transactions variable the long-run impact is about one-third greater than the short-run influence. The estimated coefficient on the average propensity to import indicates a strong negative effect on reserves demand, which is in accordance with the tenets of the Keynesian open economy model, but is opposite to the long-run result, which gives credence to the view point of Frankel (1974, 1980). While no long-run relationships were found between public debt service payments and reserves, statistically significant negative impacts were found in the short run. Even more interesting is that net lending to the central government by the central bank and the variability measure were found not to be statistically significant in either the short run or long run, which is a quite surprising result. The error-correction term indicates a relatively rapid speed of

adjustment (70 percent each period) to the long-run equilibrium. Therefore, a shock to the system would take just about eight months to be corrected.

Concluding Remarks

The policy environment has changed during the past five years. In particular, the process of liberalisation has been associated with an increased demand for reserves and as such a critical look at its impact is warranted. Therefore, the preceding analysis attempted to shed some light on the main determinants of international reserve demand for the small, open, fixed exchange rate economy of Barbados. The long run and short-run results were similar, indicating that the demand for international reserves was positively related to real income, the propensity to import and capital account liberalisation. Quite unexpectedly, reserve holdings were influenced negatively by central bank lending to the central government. In addition, the relatively high speed of adjustment indicates that reserve management has been fairly active, with an average 70 percent deviation from the long-run equilibrium eliminated within one year.

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Figure1: Net International Rerserves, 1975-2005

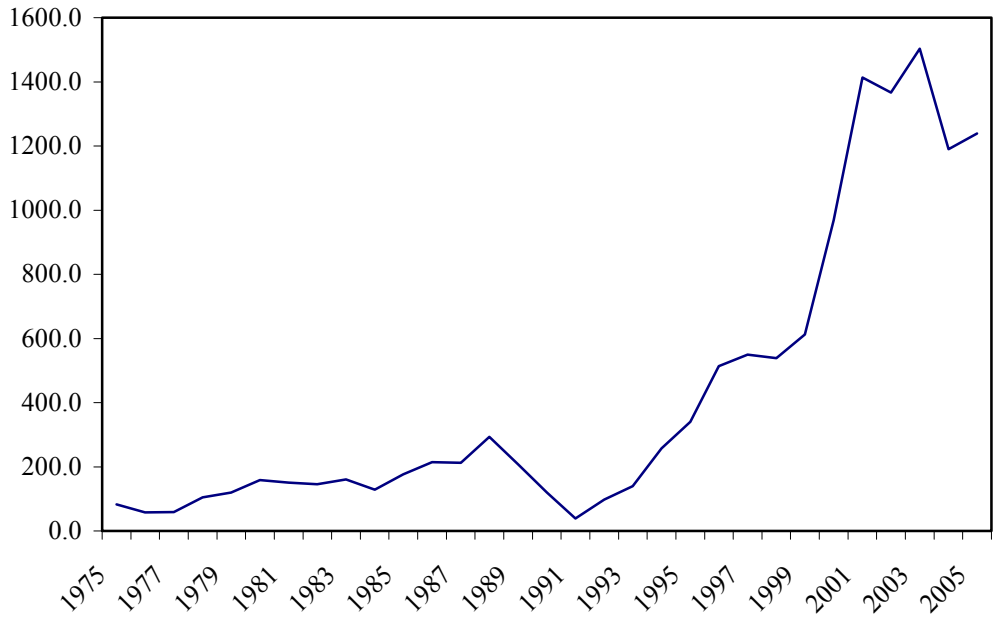

Figure 2: External Debt Service Payments, 1975-2005

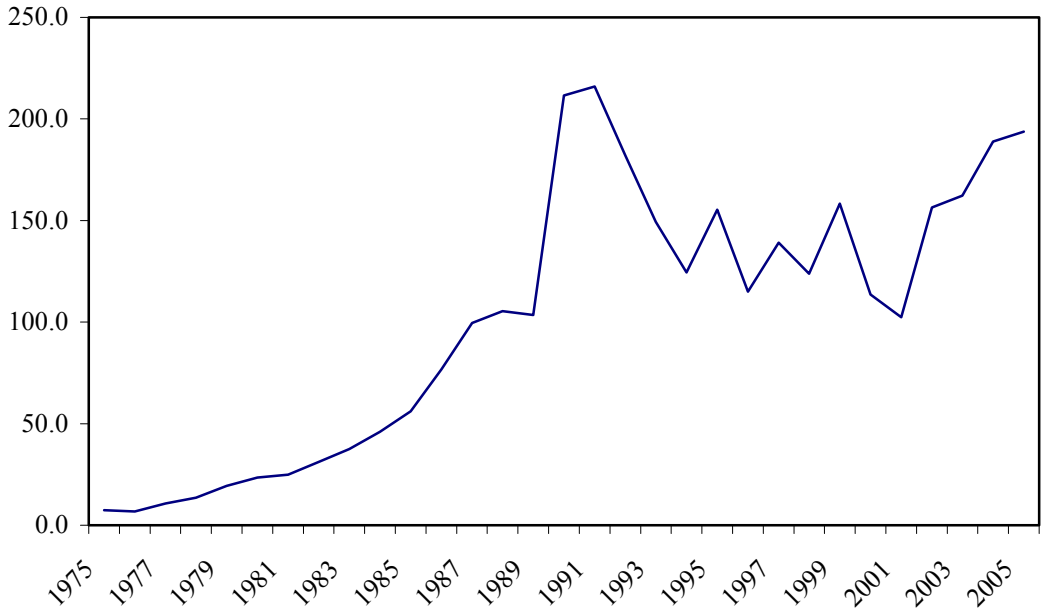

Figure 3: Plots of Data Series in Logarithms