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STAFF STUDIES

CONTENTS

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CENTRAL BANK OF SRI LANKA

38 වැනි කලාපය, අංක 1 සහ 2 – 2008   Volume 38, Nos. 1 & 2 – 2008

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The Impact of Monetary Policy on Economic Growth and Inflation in Sri Lanka

C.Amarasekara[1]

Abstract

Based on a vector autoregressive (VAR) framework and utilising both recursive and structural specifications, this study analyses the effects of interest rate, money growth and the movements in nominal exchange rate on real GDP growth and inflation in Sri Lanka for the period from 1978 to 2005.

The results of the recursive VARs are broadly in line with the established empirical findings, especially when the interest rate is considered the monetary policy variable. Following a positive innovation in interest rate, GDP growth and inflation decrease while the exchange rate appreciates. When money growth and exchange rate are used as policy indicators, the impact on GDP growth contrasts with established findings. However, as expected, an exchange rate appreciation has an immediate impact on the reduction of inflation. Interest rate innovations are persistent, supporting the view that the monetary authority adjusts interest rates gradually, while innovations in money growth and exchange rate appreciation are not persistent. Several puzzling results emerge from the study: for most sub-samples, inflation does not decline following a contractionary policy shock; innovations to money growth raises the interest rate; when inflation does respond, it reacts to monetary innovations faster than GDP growth does; and exchange rate appreciations almost always lead to an increase in GDP growth.

The results from the semi-structural VARs, which impose identification restrictions only on the policy block, are not different from those obtained from recursive VARs. The results show that none of the sub-samples since 1978 can be identified with a particular targeting regime. In contrast, the interest rate, monetary aggregates and the exchange rate, contain important information in relation to the monetary policy stance. Based on this premise, a monetary policy index is estimated for Sri Lanka. The index displays that unanticipated monetary policy forms a smaller portion of monetary policy action in comparison to anticipated monetary policy. It is also observed that a decline in GDP growth is associated with anticipated policy with a short lag, while reductions in inflation are associated with both anticipated and unanticipated components of monetary policy with a longer lag of 28 to 36 months.

[1] I wish to thank Dr. George Chouliarakis of the University of Manchester and the reviewer, Prof. S.S. Colombage of the Open University of Sri Lanka for their valuable comments. Any errors and omissions are, however, mine.

1. Introduction

The objective of this paper is to assess the effects of monetary policy on economic growth and inflation in the small open developing economy of Sri Lanka. To this end, this paper presents the results of an empirical investigation using monthly data for the period from 1978 to 2005. The specific contribution of this paper is to measure the impact of monetary policy – as measured by the movements of interest rates, money growth and the exchange rate – utilising the semi-structural VAR methodology *a la* Bernanke and Mihov (1995), where identifying restrictions are imposed only on the policy block of variables. Using the Bernanke and Mihov methodology also facilitates the derivation of a monetary policy index for Sri Lanka, and the implications of the index are also discussed briefly.

The paper is organised as follows: Section 1 provides an introduction to the established evidence on the effects of monetary policy in the long-run and short run as well as a brief introduction to monetary policy in Sri Lanka. Section 2 reviews the existing literature with regard to the methods of assessing the effects of monetary policy on macroeconomic variables. Section 3 explains the methodology and data used in the analysis. Section 4 analyses the results obtained while Section 5 summarises and concludes the discussion.

1.1 Relationship between Money, Output and Prices

There is a general agreement among economists in relation to the long run relationship between money, output and inflation. However, this consensus becomes blurred with regard to short run relationships. Understanding both long run and short run relationships is essential for the conduct of monetary policy since a central bank aims to influence the macroeconomic variables mainly through regulating the cost and availability of money (i.e., interest rates and credit availability). Although monetary aggregates have increasingly fallen out of favour as intermediate targets, the relationship between monetary policy and macroeconomic variables is unquestionably at the heart of the study of monetary economics.

McCandless and Weber (1995) examine data for 110 countries over a 30-year period, and obtain correlations revealing three long-run monetary facts: (a) there is a high (almost unity) correlation between the rate of growth of the money supply and the rate of inflation, (b) there is no correlation between the growth rates of money and real output with the exception of a subsample of countries in the OECD, where the correlation seems to be positive, and (c) there is no correlation between inflation and real output growth. Walsh (2003) explains that McCandless and Weber's analysis "provide evidence on relationships that are unlikely to be dependent on unique, country-specific events (such as the particular means employed to implement monetary policy) that might influence the actual evolution of money, prices, and output in a particular country" (p.9). According to Walsh, the high correlation between inflation and the growth rate of money supply supports the quantity-theoretic argument that the growth of money supply leads to an equal rise in the price level. Romer (2006) also confirms this view: “when it comes to understanding inflation over the longer term, economists typically emphasize just one factor: growth of the money supply” (p.497). Geweke (1986) finds that money is superneutral on its effects on real output growth while Boschen and Mills (1995) display that in the United States, permanent monetary shocks do not contribute to permanent shifts in real output. McCandless and Weber (1995) argue that “[w]hile correlations are not direct evidence of causality, they do lend support to causal hypotheses that yield predictions consistent with the correlation” (p.2). Further, they maintain that if these correlations can be interpreted as causal relationships, they suggest that long-run inflation can be adjusted by adjusting the growth rate of money, while “the fact that the growth rates of money and real output are not correlated suggests that monetary policy has no long-run effects on real output” (p.4).

Although the long-run monetary facts explained above reveal that money or monetary policy could only affect the nominal variables in the long run, with little or no effect on real variables, they do not rule out the fact that monetary policy could also have real effects in the short-run. With regard to the relationship between money and prices, King (2002) shows that the strong correlation between them disappears as the time horizon shortens indicating that the effects of money growth should emerge in the changes in real variables. Moreover, Walsh (2003) demonstrates that, “[t]he consensus from the empirical literature on the short-run effects of money is that exogenous monetary policy shocks produce hump-shaped movements in real economic activity. The peak effects occur after a lag of several quarters (as much as two or three years in some of the estimates) and then die out” (p.40). Blanchard and Fischer (1989) also show that “[n]ominal interest rate innovations are positively correlated with current and lagged GNP innovations but negatively correlated with GNP two to five quarters later” (p.19).

Unlike long-run relationships, the short-run correlations do not provide conclusive evidence on causal relationships. For instance, Tobin (1970) shows that Friedman and Schwartz’s (1963) argument that money leads output movements could be reinterpreted as output innovations lead to changes in money growth, as monetary authorities react to the state of the economy. Walsh (2003) explains that since the short-run relationships between money, inflation, and output incorporate reactions of private economic agents as well as the monetary authority to economic disturbances, “short-run correlations are likely to vary both across countries, as different central banks implement policy in different ways, and across time in a single country, as the sources of economic disturbances vary” (p.12).

1.2 Monetary Policy in Sri Lanka

Similar to many central banks especially in developing economies, the objectives of the Central Bank of Sri Lanka (CBSL) were stabilisation of the domestic value of the rupee, stabilisation of the external value of the rupee, and promotion of economic growth. However, the CBSL has increasingly focussed on the stabilisation objectives than the development objective, and with the amendments in 2002 to the Monetary Law Act under which the CBSL is established, these objectives were revised in accordance with the international trends in central banking and are now stated as maintaining economic and price stability and maintaining financial system stability.

The CBSL has gradually moved away from direct controls towards more market oriented policy tools since 1977. While credit controls were gradually eliminated and the administratively determined bank rate was gradually abandoned, the CBSL has increasingly utilised open market operations for the conduct of monetary policy. The floating of the exchange rate in 2001 has added to the operational independence of monetary policy.

Currently, the CBSL conducts monetary policy based on a monetary targeting framework with interest rates as the policy instrument, with the view of achieving economic and price stability. A monetary programme is prepared "considering the economic outlook of the country and projections based on the desired rate of monetary expansion to achieve a target rate of inflation, consistent with the projected rate of economic growth, balance of payments forecast and expected fiscal operations of the government. Accordingly, a reserve money target is established, which is the operating target for monetary policy" (Jayamaha *et al* (2001/02), p.17).

To meet the reserve money targets, open market operations are conducted with Repo and reverse Repo rates as the key policy instruments forming the lower and upper bounds of the interest rate corridor in which the interbank call money market operates. However, in practice, the fact that the CBSL is also concerned about movements of exchange rates, economic growth, as well as bi-directional relationships between monetary and fiscal policies cannot be ruled out.

2. Literature Review

2.1 Different Approaches of Measuring the Effects of Monetary Policy

Perhaps the most important problem in measuring the effects of monetary policy is its endogeneity. This arises because the monetary authorities respond to macroeconomic conditions similar to other economic agents, and therefore, "[t]he question of practical importance in central banking is never "should we create some random noise this month?," but rather "does this month's news justify a change in the level of interest rates?"" (Woodford (2003), p.7). One of the earliest attempts to tackle this problem of endogeneity in analysing the effects of monetary policy on macroeconomic variables is the work of Friedman and Schwartz (1963) who use a historical method to isolate exogenous monetary policy shocks. More recent examples for the use of historical analysis of monetary policy are Romer and Romer (1989) and Boschen and Mills (1991). Bernanke and Mihov (1995) appreciate the Romer and Romer, and Boschen and Mills approaches for "being "nonparametric", in that its implementation does not require any modelling of the details of the Fed's operating procedures or of the financial system and is potentially robust to changes in those structures" (p.4). However, the historical or "narrative" approach of Friedman and Schwartz, Romer and Romer, and Boschen and Mills, "are of little use in determining the details of policy's effects. For example, because Friedman and Schwartz and Romer and Romer identify only a few episodes, their evidence cannot be used to obtain precise quantitative estimates of policy's impact on output or to shed much light on the exact timing of different variables' responses to monetary changes" (Romer (2006), p.262). Also, several economists including Bernanke and Mihov (1995), and Leeper, Sims, and Zha (1996) show that the narrative indices are inherently subjective and "capture both exogenous shifts in policy and the endogenous response of monetary policy to economic developments" and "that most movements in monetary policy instruments represent responses to the state of the economy, not exogenous policy shifts" (Walsh (2003), p.39).

The major class of alternatives to the historical approach is time series macroeconometrics, and early examples of this approach include Friedman and Meiselman (1963), Andersen and Jordon (1968), Sims (1972), and Barro (1977, 1978, 1979). During the 1960s and early 1970s economists used large-scale structural macroeconometric models to assess the effects of monetary policy. According to Walsh (2003), "[a] key maintained hypothesis, one necessary to justify this type of analysis, was that the estimated parameters of the model would be invariant to the specification of the policy rule" (p.35). However, this hypothesis was challenged by Lucas (1976), who argues that expectations adjust adaptively to past outcomes and therefore the parameters of the model would not be invariant. This changed the course of macroeconomics drastically and Sims (1980) provides an easy alternative for economists to analyse the effects of monetary policy on macroeconomic variables through the introduction of vector autoregression (VAR) to monetary economics.

2.2 The Use of VARs in Measuring the Effects of Monetary Policy

Walsh (2003) explains the evolution of VARs as follows: "[t]he use of VARs to estimate the impact of money on the economy was pioneered by sims (1972, 1980). The development of the approach as it has moved from bivariate (Sims 1972) to trivariate (Sims 1980) to larger and larger systems" (p.24). Lütkepohl (2004) argues that VARs "are a suitable model class for describing the data generation process (DGP) of a small or moderate set of time series variables. In these models all variables are often treated as being *a priori* endogenous, and allowance is made for rich dynamics. Restrictions are usually imposed with statistical techniques instead of prior beliefs based on uncertain theoretical considerations" (p.86). Stock and Watson (2001) show that there are three varieties of VARs, namely, reduced form, recursive and structural. Reduced form VARs impose no structure on the system, and Cooley and LeRoy (1985) argue that "[e]arly VARs put little or no structure on the system. As a result, attempts to make inferences from them about the effects of monetary policy suffered from the same problems of omitted variables, reverse causation, and money-demand shifts that doom the St.Louis equation" (p.283).

Through the introduction of structural VARs, Economists then attempted to bring in theoretical foundations to the system through various identification schemes. Breitung, Brüggemann, and Lütkepohl (2004) show that "[i]nstead of identifying the (autoregressive) coefficients, identification focuses on the errors of the system, which are interpreted as (linear combinations of) exogenous shocks" (p.159). Attempts are made to incorporate identification structures to the system through ordering of variables that resulted in recursive VARs, a first step towards structural identification. Stock and Watson (2001) distinguish between recursive and structural VARs as follows: "recursive VARs use an arbitrary mechanical method to model contemporaneous correlation in the variables, while structural VARs use economic theory to associate these correlations with causal relationships. Unfortunately, in the empirical literature the distinction is often murky. It is tempting to develop economic "theories" that, conveniently, lead to a particular recursive ordering of the variables, so that their "structural" VAR simplifies to a recursive VAR, a structure called a 'Wold causal chain'" (p.112). Major works on structural VARs include Bernanke (1986), Blanchard and Watson (1986), Sims (1986), Shapiro & Watson (1988), and Blanchard and Quah (1989).

Within Structural VARs, Blanchard and Quah (1989) as well as King, Plosser, Stock and Watson (1991) promote the use of long-run restrictions such as the long-run neutrality of money to identify monetary policy shocks. Important work involving short-run restrictions include Sims (1986), Gorden and Leeper (1994), Leeper, Sims, and Zha (1996), Sims and Zha (1998), and Christiano, Eichenbaum, and Evans (1996, 1999) They impose contemporaneous restrictions on all economic variables in a VAR system. An interesting alternative is the method suggested by Bernanke and Mihov (1995), which divides the variables into policy and non-policy sectors, and imposes short run restrictions only on the policy sector. Whatever the identification scheme is used, according to Villani and Warne (2003), "successful application of structural VARs hinges on a proper identification of the structural shocks" (p.14).

Results of VARs are typically analysed using Granger-causality tests, impulse responses and forecast error variance decompositions. Using these techniques, practitioners who use VARs have obtained results that make economic sense. Sims (1992) who estimates monetary VARs for France, Germany, Japan, the United Kingdom, and the United States, finds that monetary shocks lead to a hump-shaped output response, where the negative effect of a contractionary shock on output peaks after several months and then gradually disappears. Christiano, Eichenbaum and Evans (1996) present stylised facts on the VAR responses to a contractionary monetary shock: the initial response of the price level is small; interest rate rises initially; and the initial output response is negative with no long run impact. Christiano, Eichenbaum and Evans (1999) confirm their earlier findings as follows: "after a contractionary monetary policy shock, short term interest rates rise, aggregate output, employment, profits and various monetary aggregates fall, the aggregate price level responds very slowly, and various measures of wages fall, albeit by very modest amounts" (p. 69).

There is little consensus, however, on the use of variance decompositions to interpret VAR results. In the VAR analysis, Policy shocks are usually found to explain only a limited amount of variance in output or inflation. For instance, Christiano, Eichenbaum, and Evans (1999) find that a very small variance of the price level can be attributed to monetary policy shocks. This is attributed to the anticipated monetary policy playing a major role in contrast to unanticipated monetary policy. Leeper, Sims, and Zha (1996) explain that "[a]nother robust conclusion […] is that a large fraction of the variation in monetary policy instruments can be attributed to the systematic reaction of policy authorities to the state of the economy. This is what one would expect of good monetary policy" (p.2). Bernanke and Mihov (1995) also discourage the use of variance decompositions.

A researcher faces a great dilemma when it comes to selecting variables to be included in the VAR. Christiano, Eichenbaum, and Evans (1996) show that "we would like, in principle, to include all of the variables in our analysis in one large unconstrained VAR and report the implied system of dynamic response functions. However, this strategy is not feasible because of the large number of variables which we wish to analyze. […] On the other hand, if we include too few variables in the VAR then we would encounter significant omitted variable bias" (p.18). Therefore, researchers have traditionally included an indicator of aggregate economic activity, an indicator of inflation, and a monetary policy variable at a minimum. Other variables which are "of potential interest to the [monetary authority] can be included either because they represent ultimate policy objectives or because they provide information about these objectives" (Kasa and Popper (1997), p.285).

The other problem in relation to the choice of variables is when there is no clear single policy variable. "There is a long tradition in monetary economics of searching for a single policy variable – perhaps a monetary aggregate, perhaps an interest rate – that is more or less controlled by policy and stably related to economic activity. Whether the variable is conceived of as an indicator of policy or a measure of policy stance, correlations between the variable and macroeconomic time series are taken to reflect the effects of monetary policy" (Leeper, Sims, and Zha (1996), p.1).

Studies using different policy variables have led to conflicting results and Walsh (2003) argues that "The exact manner in which policy is measured makes a difference, and using an incorrect measure of monetary policy can significantly affect the empirical estimates one obtains" (p.40). Early VARs such as Sims (1980) and Litterman and Weiss (1985) use money stock as the policy variables but find that the inclusion of interest rates tend to absorb the predictive power of money. McCallum (1983) argues that this finding does not mean that monetary policy is ineffective, but instead the interest rate is perhaps a better indicator of monetary policy. Building on this argument, Bernanke and Blinder (1992) use a short-term interest rate or an interest rate spread. Christiano and Eichenbaum (1992), and Christiano, Eichenbaum, and Evans (1996) use non-borrowed reserves while Strongin (1995) uses the portion of non-borrowed reserves that is orthogonal to total reserve growth as the monetary policy variable.

In relation to the choice of policy variables, Bernanke and Mihov's (1995, 1998) analysis make some important contributions. Arguing that "it may be the case that we have only a vector of policy indicators […] which contain information about the stance of policy but are affected by other forces as well" (Bernanke and Mihov (1995), p.10), they study the reserve market carefully to identify monetary policy shocks rather than simply assuming a monetary policy indicator, thereby allow for more than one policy variable in the VAR. Bernanke and Mihov (1998) list the advantages of their method as follows: "[f]irst, because our specification nests the best known quantitative indicators of monetary policy used recently in VAR modelling, including all those mentioned above, we are able to perform explicit statistical comparisons of these and other potential measures, including hybrid measures that combine the basic indicators. Second, our analysis leads directly to estimates of a new policy indicator that is optima, in the sense of being most consistent with the estimated parameters describing the central bank's operating procedure and the market for bank reserves. Third, by estimating the model over different sample periods, we are able to allow for changes in the structure of the economy and in operating procedures, while imposing a minimal set of identifying assumptions. Finally, although we consider only the post-1965 US case in this paper, our method is applicable to other countries and periods, and to alternative institutional setups" (p.872). Accordingly, several researchers have adopted the Bernanke-Mihov approach *mutatis mutandis* for different economies and policy frameworks. Fung (2002), who uses this methodology to analyse the effects of monetary policy in several East Asian countries, shows that it has been applied to Germany (Bernanke and Mihov (1997)), Italy (De Arcangelis and Di Giorgio (1998)) and Canada (Fung and Yuan (2000)). Some other applications are Kasa and Popper (1997) and Nakashima (2004) who apply the methodology to Japan, Piffanelli (2001) to Germany, and De Arcangelis and Di Giorgio (2001) to Italy.

VARs do not always result in interpretable results. Eichenbaum (1992), and Gordon and Leeper (1994) discuss how different measures of policy shocks can produce "puzzles" or results contrary to existing theoretical explanations. Typical puzzles have included the liquidity puzzle where interest rates decline following innovations in money, price puzzle where prices fall immediately following a contractionary shock, and exchange rate puzzle where contractionary monetary policy leads to a depreciation of the domestic currency.

Several economists have attempted to address the puzzling results obtained from VARs. For instance, in relation to the prize puzzle, economists have argued that the variables included in the VARs do not control for the information set of the monetary authorities, and including forward-looking variables in the VAR system often solves the puzzle. Sims (1992), Chari, Christiano, and Eichenbaum (1995), Christiano, Eichenbaum, and Evans (1996, 1999) show that commodity prices or nominal exchange rate can be included in the VARs as proxies for forward-looking information of monetary authorities.

In addition to the simple solution of incorporating one or two forward-variables to the VAR to address the prize puzzle, there have been at least two advanced methods of broadening the data horizon covered in VAR systems, the first is by using Baysian VARs while the second is the use of Factor-augmented VARs.

Stock and Watson (1996) argue that "small VARs of two or three variables are often unstable and thus poor predictors of the future [but] adding variables to the VAR creates complications" (p.110). In order to address this problem, Stock and Watson (2001) show that Litterman (1986) pioneered the use of Baysian methods which impose a common structure on the coefficients. McNees (1990), Sims (1993), and Villani and Warne (2003) are some important work that use Baysian VARs.

Bernanke, Boivin, Eliasz (2004, 2005) use a novel method to address potential problem of the information set being too small and real activity often not being adequately represented. Using factor analysis, they summarise information from a large number of macroeconomic time series by a relatively small set of estimated indexes, or factors, which are then used to augment standard VARs. Lagana and Mountford (2005) carry out a similar FAVAR framework for the UK monetary policy.

Many attempts have been made to extend benchmark closed economy VAR models to open economies. Such extensions usually add foreign variables such as foreign interest rates and inflation, as well as the exchange rate movements to the VAR specification. Using a two-economy model Eichenbaum and Evans (1995) "find that a contractionary shock to US monetary policy leads to (i) persistent, significant appreciation in US nominal and real exchange rates and (ii) persistent decreases in the spread between foreign and US interest rates, and (iii) significant, persistent deviations from uncovered interest rate parity in favor of US investments" (Christiano, Eichenbaum, and Evans (1999), pp.94-95).

However, according to Christiano, Eichenbaum, and Evans (1999) "[i]dentifying exogenous monetary policy shocks in an open economy can lead to substantial complications relative to the closed economy case" (p.94). As De Arcangelis and Di Giorgio (2001) explain, these difficulties "are usually due to the simultaneous reaction between interest and exchange rate innovations, which in turn, can be responsible for the emergence of new empirical puzzles, as the one of an impact depreciation of the exchange rate following a monetary policy contraction in the domestic country" (p.82). Vonnák, (2005) further explains that that "[d]ue to the quick reaction of monetary policy to exchange rate movements and the exchange rate to monetary policy surprises, the simultaneity problem seems to be highly relevant, ruling out *a priori* the adoption of recursive identification" (p.9). Favero (2001) concludes that "[v]arious papers have examined the effects of monetary shocks in open economies, but this strand of literature has been distinctly less successful in providing accepted empirical evidence than the VAR approach in closed economies" (p.180).

The interaction between exchange rates and interest rates, which is at the heart of the open economy framework has attracted much attention in recent times. Structural identification schemes to address this issue have been introduced by Kim and Roubini (2000), and by Cushman and Zha (1997), who incorporate the trade sector into the VAR specification. Ball (1998, 2000) among others, attempts to include exchange rates into traditional policy rules, while many central banks have devised "monetary conditions indices" based on both interest rates and exchange rates.

A discussion on measuring the effects of monetary policy using VARs will be incomplete if various criticisms on VARs are not examined. VARs have been criticised on several grounds by Sheffrin (1995), Rudebusch (1998) and McCallum (1999), etc. With regard to identification restrictions, this method has been subjected to various criticisms including the arbitrary ordering and identification assumptions. Many argue that some impulse responses contradicts economists' priors, residuals from VAR regressions are not compatible with the findings of others who use historical analyses with regard to contractionary and expansionary policies, and the policy reaction functions implied in VARs are different to those obtained using other direct methods.

Other criticism includes that VAR accounts for only unanticipated shocks, that VAR does not identify the effects of systematic monetary policy rules, and that VARs usually use final data that are not available to policymakers at the time of making monetary policy decisions.

Counter-arguments to these criticisms have been presented by Sims (1998) and Stock and Watson (2001) etc., and many of the criticisms have been met by various improvements to VARs as described above, while many improvements that are needed are identified. For instance, Sims (1998) states that "[t]he restriction of identified VAR modeling to handling only either just-identified models or over-identified models that restrict only contemporaneous coefficients is artificial. It is time for some move in the direction of relaxing this computationally based constraint" (p.941). Although economists are yet to reach a consensus, VARs provide a useful and practical tool for applied monetary economists to measure the effects of monetary policy.

However, an irony remains valid with regard to the present-day VAR methodology. Breitung, Brüggemann, and Lütkepohl (2004) summarise this as follows: "it may be worth remembering that Sims (1980) advocated VAR models as alternatives to econometric simultaneous equations models because he regarded the identifying restrictions used for them as "incredible." Thus, structural VAR modelling may be criticized on the same grounds" (p.195-196).

3. Hypotheses and Methodology

The key hypotheses that will be tested in this paper is whether empirical evidence from Sri Lanka on the effects of monetary policy on output and prices obtained from VARs accords with the existing theoretical explanations and empirical findings. Specifically, it will be tested whether output growth and inflation declines following a contractionary monetary policy shock, whether the reaction of output growth to monetary policy is faster than the reaction of inflation to monetary policy, whether money supply contracts following an increase in the interest rate, and finally, whether the exchange rate appreciates following an increase in the interest rate.

To test the above hypotheses, VARs with recursive structures as well as semi-structural VARs with a structure imposed only on the policy block, in the lines of Bernanke and Mihov (1995, 1998) will be utilised. Although a general discussion on estimation of a reduced form VAR methodology is avoided since it is widely available in textbooks on time-series econometrics such as Lütkepohl (1993), Hamilton (1994) and Enders (2004), the recursive identification methodology and the Bernanke-Mihov methodology are described below. Prior to that, a brief discussion on the requirement of statistical identification is provided.

Breitung, Brüggemann, and Lütkepohl (2004) discuss the problem of statistical identification and show that "structural shocks are the central quantities in an SVAR model" and "[t]he shocks are associated with an economic meaning such as an oil price shock, exchange rate shock, or a monetary shock. Because the shocks are not directly observed, assumptions are needed to identify them" (p.161). Supposing the relationship between the elements of VAR residuals and structural residuals (shocks) take the form

$$Au = Bv \tag{3.01}$$

which relates the reduced-form disturbances u to the underlying structural shocks v. Breitung, Brüggemann, and Lütkepohl (2004) show that the most popular kinds of restrictions used in structural VAR models "can be classified as follows: [2]

i) $B=I_K$. The vector of innovations v_t is modeled as an interdependent system of linear equations such that $Au=v$…

ii) $A=I_K$. In this case the model for the innovations is $u=Bv$…

iii) The so-called *AB*-model of Amisano & Giannini (1997) combines the restrictions for *A* and *B* from (i) and (ii)…

iv) There may be prior information on the long-run effects of some shocks. They are measured by considering the responses of the system variables to the shocks…" (p.163).

Given this framework, they compute the number of restrictions required to identify a Structural VAR: "The number of parameters of the reduced form VAR (leaving out the parameters attached to the lagged variables) is given by the number of nonredundant elements of the covariance matrix Σ_u, that is, K(K+1)/2. Accordingly, it is not possible to identify more than K(K+1)/2 parameters of the structural form. However, the overall number of elements of the structural form matrices A and B is $2K^2$. It follows that

$$2K^2 - \frac{K(K+1)}{2} = K^2 + \frac{K(K-1)}{2} \tag{3.02}$$

restrictions are required to identify the full model. If we set one of the matrices *A* or *B* equal to the identity matrix, then K(K-1)/2 restrictions remain to be imposed" (p.163). For instance, a "recursive structure implies just the required K(K-1)/2 zero restrictions" (P.164).

Recursive VAR Methodology

Recursive VARs as explained by Sims (1980) based on the Choleski decomposition of matrices, are the simplest among the structural VAR schemes. In terms of equation (3.01), the *A* and *B* matrices then take the form;

$$A = \begin{bmatrix} 1 & 0 & 0 & . & 0 \\ a_{21} & 1 & 0 & . & 0 \\ . & . & 1 & . & . \\ a_{n1} . & . & . & a_{nn-1} & 1 \end{bmatrix}, \quad B = \begin{bmatrix} b_{11} & 0 & 0 & . & 0 \\ 0 & b_{22} & 0 & . & 0 \\ . & . & b_{ii} & . & . \\ 0 & 0 & 0 & . & b_{nn} \end{bmatrix}. \tag{3.03}$$

[2] Throughout Sections 3 and 4, notation has been changed to maintain consistency.

Favero (2001) further notes that "[t]his is obviously a just-identification scheme, where the identification of structural shocks depends on the ordering of variables. It corresponds to a recursive economic structure, with the most endogenous variables ordered last" (p. 165).

Expanding, this decomposition results in,

$$\begin{bmatrix} 1 & 0 & 0 & . & 0 \\ a_{21} & 1 & 0 & . & 0 \\ . & . & 1 & . & . \\ a_{n1} . & . & . & a_{nn-1} & 1 \end{bmatrix} \begin{bmatrix} u^1 \\ u^2 \\ u^i \\ . \\ u^n \end{bmatrix} = \begin{bmatrix} b_{11} & 0 & 0 & . & 0 \\ 0 & b_{22} & 0 & . & 0 \\ . & . & b_{ii} & . & . \\ 0 & 0 & 0 & . & b_{nn} \end{bmatrix} \begin{bmatrix} v^1 \\ v^2 \\ v^i \\ . \\ v^n \end{bmatrix} \tag{3.04}$$

that is,

$$\begin{bmatrix} 1 & 0 & 0 & . & 0 \\ a_{21} & 1 & 0 & . & 0 \\ . & . & 1 & . & . \\ a_{n1} . & . & . & a_{nn-1} & 1 \end{bmatrix} \begin{bmatrix} u^1 \\ u^2 \\ u^i \\ . \\ u^n \end{bmatrix} = \begin{bmatrix} b_{11}v^1 \\ b_{22}v^2 \\ b_{ii}v^i \\ . \\ b_{nn}v^n \end{bmatrix} \tag{3.05}$$

Although Sims (1980) used the monetary policy variables first on the assumption that policy does not respond to the contemporaneous movements in macroeconomic variables (mainly due to macroeconomic variables being unobserved contemporaneously), later analysts such as Bernanke and Blinder (1992) have ordered the policy instrument last.

The recursive VAR structure and the notation used by Bernanke and Blinder (1992) are worth noting as a preamble to introducing the Bernanke-Mihov methodology. Bernanke and Blinder assume that the "true" economic structure can be written as,

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=0}^{k} C_i p_{t-i} + A^y v_t^y \tag{3.06}$$

$$p_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=1}^{k} g_i p_{t-i} + v_t^p \tag{3.07}$$

where *Y* represents non-policy variables and *p* is the policy variable, and *A, B,C,D, and g* are relevant matrices and vectors as defined in traditional VAR methodology. To identify this system econometrically restrictions are needed. Equating *D* to 0 means that the policy variable is ordered first since non-policy variables will then, not have a contemporaneous effect on policy. In a system where *i*=0,1, this means that

$$p_t = D_1 Y_{t-1} + g p_{t-1} + v_t \tag{3.08}$$

and

$$Y_t = (I - B_0)^{-1}\left[(B_1 + C_0 D_1) Y_{t-1} + (C_0 g + C_1) p_{t-1} + u_t + C_0 v_t\right] \tag{3.09}$$

Alternatively, if C=0, the policy variable would be ordered last, and

$$Y_t = (I - B_0)^{-1}\left[B_1 Y_{t-1} + C_1 p_{t-1} + u_t\right] \tag{3.10}$$

and

$$p_t = \left(D_1 + D_0 (I - B_0)^{-1} B_1\right) Y_{t-1} + \left(g + D_0 (I - B_0)^{-1} C_1\right) p_{t-1} + v_t + D_0 (I - B_0)^{-1} u_t \tag{3.11}$$

Bernanke-Mihov Methodology

Bernanke and Blinder's policy variable *p* is a scalar measure (i.e., interest rate or interest rate spread). However, as explained in section 2, and as Bernanke and Mihov (1998) show "[i]t may be the case that we have only a vector of policy indicators *P*, which contains information about the stance of policy" (p.875). If so,

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=1}^{k} C_i P_{t-i} + A^y v_t^y \tag{3.12}$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-i} + \sum_{i=0}^{k} G_i P_{t-i} + A^p v_t^p \tag{3.13}$$

With *u* indicating an (observable) VAR residual and *v* indicating an (unobservable) structural disturbance, any policy shock can be measured as,

$$u_t^p = (I - G_0)^{-1} A^p v_t^p \tag{3.14}$$

or ignoring the subscripts and superscripts,

$$u = Gu + Av \tag{3.15}$$

Bernanke and Mihov (1995) then introduce their "“semi-structural” VAR model which leaves the relationships among macroeconomic variables in the system unrestricted, but imposes contemporaneous identification restrictions on a set of variables relevant to the market for commercial bank reserves" (p.2). Specifically, they use the Federal funds rate, non-borrowed reserves, borrowed reserves and total reserves in their model of the reserves market. They assume that one element of the vector v^p is a policy disturbance, while it could also include "shocks to money demand or whatever disturbances affect the policy indicators" (pp.10-11), and use different restrictions based on various assumptions on the market for commercial bank reserves to identify policy shocks and their effects on macroeconomic variables.

The relationships between non-policy variables and policy variables in the Bernanke-Mihov methodology are summarised by De Arcangelis and Di Giorgio (2001). According to them "[i]n the estimation of the orthogonalized, economically meaningful (structural) innovations in the second stage, a recursive causal block-order is assumed to form the set of non policy variables to the set of policy variables. Moreover, the recursive causal order is also established for the nonpolicy variables in y. In terms of the relationship between the fundamental innovations, u_y and u_p and the structural innovations v_y and v_p which are mutually and serially uncorrelated, this implies

$$\begin{pmatrix} A_{1,1} & 0 \\ A_{2,1} & A_{2,2} \end{pmatrix} \begin{pmatrix} u_y \\ u_p \end{pmatrix} = \begin{pmatrix} B_{1,1} & 0 \\ 0 & B_{2,2} \end{pmatrix} \begin{pmatrix} v_y \\ v_p \end{pmatrix} \tag{3.16}$$

Where $A_{1,1}$ is lower-triangular and $B_{1,1}$ is diagonal so that there is a Wold recursive (causal) ordering among the nonpolicy variables in *y*. Moreover, $A_{2,1}$ is a full matrix so that there is a Wold block-recursive (causal) ordering between nonpolicy and policy variables" (pp.85-86). They further explain that "the core of the [Bernanke-Mihov] analysis focuses on the shape that the matrices $A_{2,2}$ and $B_{2,2}$ must take for the different operating procedures to work properly" (p.86).

Two open economy extensions to the Bernanke-Mihov methodology are provided by De Arcangelis and Di Giorgio (2001) and Fung (2002). The former consider the exchange rate as a nonpolicy variable, but since the contemporaneous reaction of the exchange rate to innovations in the policy variables cannot be excluded, they order it after the policy block. Fung's (2002) semi-structural VAR is simpler, and he models the short run monetary policy behaviour and the foreign exchange market for the analysis of monetary policy in East Asia using the following two equations:

Interest rate: $$u_R = v^s + b_{12} v^x \tag{3.17}$$

Exchange rate: $$u_X = b_{21} v^s + v^x \tag{3.18}$$

Where v^x and v^s represent the exogenous exchange rate and monetary policy shocks, respectively. Fung shows that "[s]etting b_{12}=0, means that the central bank does not contemporaneously respond to the exchange rate shock and the innovations in the interest rate are thus due purely to monetary policy shocks [while] the restriction b_{21}=0 […] implies that the innovation in the exchange rate does not respond to the interest rate contemporaneously" (p.4). However, since the policy block has only two variables, this methodology reduces to a recursive VAR when either restriction advocated by Fung is used.

3.1 Deriving a Monetary Policy Index

An important by-product of the Bernanke-Mihov methodology is the derivation of a monetary policy index. Arguing that "it is also desirable to have indicators of the overall thrust of policy, including the endogenous or anticipated portion of policy" (p.3), Bernanke and Mihov (1995) use their semi-structural VAR methodology to derive both measures. They show that an overall measure of monetary policy derived using their method is similar to a monetary conditions index "intended to provide assessments of overall tightness or ease, in their day-to-day policy-making" (Bernanke and Mihov (1998), pp.896-897).

Bernanke-Mihov monetary policy index has a simple derivation. From the relationship given in equation (3.15) and the vector of policy variables *P*, the following vector of variables can be obtained

$$A^{-1}(I-G)P \tag{3.19}$$

According to Bernanke and Mihov (1995), these variables, "which are linear combinations of the policy indicators *P*, have the property that their orthogonalized VAR innovations correspond to the structural disturbances *v*. In particular, one of these variables, call it *p*, has the property that its VAR innovations correspond to innovations in the monetary policy shock" (p.13). They propose using the estimated linear combination of policy indicators *p* as a measure of overall monetary policy stance.

Bernanke and Mihov (1998) identify two shortcomings of this measure: "first this indicator is not even approximately continuous over changes in regime […] Second, this measure does not provide a natural metric for thinking about whether policy at a given time is "tight" or "easy"" (p.898). They continue to argue that "a simple transformation of this variable seems to correct both problems. Analogous to the normalization applied to the reserves aggregates in the estimation, to construct a final total policy measure we normalize *p* at each date by subtracting from it a 36-month moving average of its own past values. This has the effects of greatly moderating the incommensurable units problem, as well as defining zero as the benchmark for "normal" monetary policy" (p.898).

3.2 Modelling the Policy Block for Sri Lankan Monetary Policy

In the case of Sri Lanka, three time series variables are selected to be included in the policy block. The first is reserve money (RM), which is the operating target for monetary policy in Sri Lanka. The second is the interbank call-money market rate (CR) which is an overnight interest rate closely influenced by the CBSL policy action. The third is the exchange rate (Sri Lankan rupees per SDR) (XRT). The choice of these variables will be discussed in the next section. However, it should be noted that the negative of RM and XRT are used in the model, so that an increase in any variable in the policy block would mean a policy contraction, as explained at a later point in this analysis. Accordingly, a positive sign in front of NXRT would mean an appreciation of the Sri Lankan rupee.

The following three equations explain (in innovation terms) the model used for the present analysis (The derivation is not shown but straight-forward).

$$u^{NRM} = \alpha u^{CR} - \beta u^{NXRT} + \phi^{NRM} v^{d} \tag{3.20}$$

$$u^{NXRT} = \gamma u^{CR} + \phi^{NXRT} v^e \tag{3.21}$$

$$u^{CR} = \phi^d v^d + \phi^e v^e + v^s \tag{3.22}$$

Equation (3.20) shows that the demand for RM is negatively related to CR and positively to an appreciation of the rupee (through its effects on net foreign assets of the CBSL). The structural demand shock is depicted by v^d. Equation (3.21) shows that an increase in CR results in an appreciation of the rupee, while v^e represents a structural external shock. Equation (3.22) is the CBSL policy reaction function, and the VAR residual u^{CR} would include the CBSL reaction to structural demand shocks, structural external shocks, as well as structural monetary policy innovations.[3]

Residuals obtained from VAR (u) can then be interpreted as

$$u = A^{-1}Bv \tag{3.27}$$

$$\begin{bmatrix} u^{NRM} \\ u^{NXRT} \\ u^{CR} \end{bmatrix} = \begin{bmatrix} \phi^{NRM} + \phi^d(\alpha - \beta\gamma) & -\beta\phi^{NXRT} + (\alpha - \beta\gamma)\phi^e & \alpha - \beta\gamma \\ \gamma\phi^d & \phi^{NXRT} + \gamma\phi^e & \gamma \\ \phi^d & \phi^e & 1 \end{bmatrix} \begin{bmatrix} v^d \\ v^e \\ v^s \end{bmatrix} \tag{3.36}$$

Furthermore, structural innovations v, can be isolated as follows:

$$B^{-1}Au = v \tag{3.44}$$

$$\begin{bmatrix} v^d \\ v^e \\ v^s \end{bmatrix} = \begin{bmatrix} \left(\frac{1}{\phi^{NRM}}\right) & \left(\frac{\beta}{\phi^{NRM}}\right) & -\left(\frac{\alpha}{\phi^{NRM}}\right) \\ 0 & \left(\frac{1}{\phi^{NXRT}}\right) & -\left(\frac{\gamma}{\phi^{NXRT}}\right) \\ -\left(\frac{\phi^d}{\phi^{NRM}}\right) & -\left(\frac{\beta\phi^d}{\phi^{NRM}} + \frac{\phi^e}{\phi^{NXRT}}\right) & \left(\frac{\alpha\phi^d}{\phi^{NRM}} + \frac{\gamma\phi^e}{\phi^{NXRT}} + 1\right) \end{bmatrix} \begin{bmatrix} u^{NRM} \\ u^{NXRT} \\ u^{CR} \end{bmatrix} \tag{3.51}$$

The model (3.26) is not identified. The number of restrictions required for just-identification on A and B matrices is, according to equation (3.02) is

$$2K^2 - \frac{K(K+1)}{2} = K^2 + \frac{K(K-1)}{2}$$

[3] Piffanelli (2001), who uses the Bernanke-Mihov methodology, also employs a policy interest rate, exchange rate and money supply in the policy block in her study of monetary policy in Germany.

$$=3^2+\frac{3(3-1)}{2}=9+3=12\,. \tag{3.55}$$

whereas there are only 11 restrictions. Just identification can be achieved in the following ways by imposing one additional restriction:

i) *Restricted capital account:* This means that the exchange rate does not react to interest rate innovations, i.e.,

$$\gamma=0 \tag{3.56}$$

Then, the structural shock v^s reduces to,

$$v^s=-\left(\frac{\phi^d}{\phi^{NRM}}\right)u^{NRM}-\left(\frac{\beta\phi^d}{\phi^{NRM}}+\frac{\phi^e}{\phi^{NXRT}}\right)u^{NXRT}+\left(\frac{\alpha\phi^d}{\phi^{NRM}}+1\right)u^{CR} \tag{3.57}$$

ii) *Fully floating exchange rate regime: This* means that the net foreign assets, which is a part of reserve money remains unchanged, i.e.,

$$\beta=0 \tag{3.58}$$

Then, the structural innovation becomes

$$v^s=-\left(\frac{\phi^d}{\phi^{NRM}}\right)u^{NRM}-\left(\frac{\phi^e}{\phi^{NXRT}}\right)u^{NXRT}+\left(\frac{\alpha\phi^d}{\phi^{NRM}}+\frac{\gamma\phi^e}{\phi^{NXRT}}+1\right)u^{CR} \tag{3.59}$$

iii) *Strongin assumption:* Following Strongin (1992), Bernanke and Mihov (1995,1998) assume that reserve money does not react to interest rate innovations contemporaneously, i.e.,

$$\alpha=0 \tag{3.60}$$

The structural shock then reduces to,

$$v^s=-\left(\frac{\phi^d}{\phi^{NRM}}\right)u^{NRM}-\left(\frac{\beta\phi^d}{\phi^{NRM}}+\frac{\phi^e}{\phi^{NXRT}}\right)u^{NXRT}+\left(\frac{\gamma\phi^e}{\phi^{NXRT}}+1\right)u^{CR} \tag{3.61}$$

However, the need to identify different targeting regimes would mean that the model may need to be overidentified. Accordingly, the following three targeting regimes are considered:

i) *Interest rate targeting:* The imposition of the following two restrictions leads to the model being overidentified by 1 restriction.

$$\phi^d=\phi^e=0 \tag{3.62}$$

The structural shock then becomes,

$$v^s = u^{CR} \tag{3.64}$$

i.e., the VAR residual u^{CR} represents the structural shock.

ii) *Reserve money targeting:* The imposition of the following three restrictions leads to the model being overidentified by 2 restrictions.

$$\alpha = \beta = 0 \text{ and } \phi^{NRM} = 1 \tag{3.65}$$

Structural innovation v^s then reduces to

$$v^s = -\phi^d u^{NRM} - \left(\frac{\phi^e}{\phi^{NXRT}}\right) u^{NXRT} + \left(\frac{\gamma\phi^e}{\phi^{NXRT}} + 1\right) u^{CR} \tag{3.68}$$

while the innovation to money demand becomes the relevant structural shock.

$$v^d = u^{NRM} \tag{3.71}$$

iii) Exchange rate targeting: The following restrictions lead to the model being overidentified by one restriction.

$$\gamma = 0 \text{ and } \phi^{NXRT} = 1 \tag{3.72}$$

Structural innovation v^s then becomes,

$$v^s = -\left(\frac{\phi^d}{\phi^{NRM}}\right) u^{NRM} - \left(\frac{\beta\phi^d}{\phi^{NRM}} + \phi^e\right) u^{NXRT} + \left(\frac{\alpha\phi^d}{\phi^{NRM}} + 1\right) u^{CR} \tag{3.73}$$

while the external shock v^e becomes the relevant structural shock.

$$v^e = u^{NXRT} \tag{3.76}$$

3.3 Deriving a Monetary Policy Index for Sri Lanka

Following equation (3.19), and using the policy block model for Sri Lanka a monetary policy index can be derived as follows:

$$\left(B^{-1}A\right)P$$

$$= \begin{bmatrix} \left(\frac{1}{\phi^{NRM}}\right) & \left(\frac{\beta}{\phi^{NRM}}\right) & -\left(\frac{\alpha}{\phi^{NRM}}\right) \\ 0 & \left(\frac{1}{\phi^{NXRT}}\right) & -\left(\frac{\gamma}{\phi^{NXRT}}\right) \\ -\left(\frac{\phi^{d}}{\phi^{NRM}}\right) & -\left(\frac{\beta\phi^{d}}{\phi^{NRM}}+\frac{\phi^{e}}{\phi^{NXRT}}\right) & \left(\frac{\alpha\phi^{d}}{\phi^{NRM}}+\frac{\gamma\phi^{e}}{\phi^{NXRT}}+1\right) \end{bmatrix} \begin{bmatrix} NRM \\ NXRT \\ CR \end{bmatrix}$$

$$= -\left(\frac{\phi^{d}}{\phi^{NRM}}\right)NRM - \left(\frac{\beta\phi^{d}}{\phi^{NRM}}+\frac{\phi^{e}}{\phi^{NXRT}}\right)NXRT + \left(\frac{\alpha\phi^{d}}{\phi^{NRM}}+\frac{\gamma\phi^{e}}{\phi^{NXRT}}+1\right)CR \qquad (3.77)$$

As explained by Bernanke and Mihov (1995, 1998), the monetary policy measure so derived is a linear combination of all variables in the monetary policy block and is a useful index for observing the direction of monetary policy.

3.4 Data Description

The main data sources in this analysis are the IMF's International Financial Statistics and the publications of Central Bank of Sri Lanka. Although many data series required are available from 1950s, this study uses data since 1978 in order to focus on the effects of Sri Lanka's monetary policy in an open economy framework.

The key non-policy variables that will be used are real gross domestic product (GDP) and consumer price level (CPI). Similar to the case of other economies as explained earlier, one faces some difficulty in choosing a suitable monetary policy variable in the context of Sri Lanka. Potential monetary policy indicators can be categorised under three broad classes, namely, monetary aggregates, interest rates, or exchange rate.

Table 1
Data Series Used in the Analysis

Series	Units	Source	Remarks
Gross Domestic Product at 1996 Constant Factor Cost Prices (GDPSA)	Sri Lankan Rupees Million Base year =1996	CBSL-Annual Reports and GDP Press Releases	Interpolated from Annual series for the period from 1978-1995 and from Quarterly Seasonally adjusted series from 1996-2005
Colombo Consumers' Price Index (CCPISA)	Units: Index No Base year =2000 (=100)	IFS Line 64...ZF CPI:COLOMBO 455 MNUAL WRKRFAM	Seasonally adjusted using Census X-12 ARIMA

SDR Exchange Rate (XRTSDRAVGSA)	Sri Lankan Rupees per SDR	IFS Line ..AA.ZF MARKET RATE	Monthly Average Seasonally adjusted using Census X-12 ARIMA
Reserve Money (RMSA)	Sri Lankan Rupees Million	IFS Line 14...ZF RESERVE MONEY	End Period Seasonally adjusted using Census X-12 ARIMA
Interbank Call Money Market rate (CALLRTSA)	Percentage points	IFS Line 60B..ZF INTERBANK CALL LOANS	End period Seasonally adjusted using Census X-12 ARIMA

Of the monetary aggregates, reserve money, which is the operating target of monetary policy implementation and closely monitored by the Central Bank on a weekly basis, is a preferred candidate over the narrow money (M1) or broad money (M2 or M2b) aggregates.

Although the Repo rate and the reverse Repo rate (and earlier the bank rate) are the direct policy instruments, these do not span over the full sample. For instance the active use of the bank rate was discontinued in 1985, while the Repurchase rate was introduced only in 1993. However, the interbank call money market rate, which is not a policy variable *per se*, is an overnight interest rate closely monitored by the Central Bank while its policy actions are swiftly reflected in the changes in this rate. This suggests that the interbank call money market rate could be used as an appropriate indicator of monetary policy.

Finally, since the exchange rate has been a managed float through the most of the sample period, it also has the potential of being used as a monetary policy indicator. Although the exchange rate was floated in 2001, being a small open economy with heavy trade dependency, the exchange rate still attracts much attention in monetary policy discussions, which justify its use as a monetary policy variable in the present analysis. Also, as Fung (2002) states in the context of East Asian economies "[t]he exchange rate channel is one of the key channels of monetary transmission. A contractionary monetary policy leads to an appreciation of the local currency, which in turn will reduce exports and exert downward pressure on inflation. The currency appreciation will also reduce domestic inflation through lower import prices. The more open the economy, the more important the exchange rate channel" (p.2).

All the data series used are monthly. Since a monthly real GDP or aggregate production series is not available, the annual series (and the quarterly series from 1996) is interpolated using the Goldstein and Khan (1976) method.[4] Using monthly series is

[4] Attempts to assess the effects of monetary policy in Sri Lanka face a major drawback as a long time series of high frequency aggregate production is not available. However, several methods exist to derive high frequency (e.g. monthly) data series from available

important since the identifying assumption of there being "no feedback from policy variables to the economy within the period […] or the alternative assumption that policy-makers do not respond to contemporaneous information" cannot be defended if one uses quarterly or annual data. (Bernanke and Mihov (1995), pp.19-20) Also, as IMF (2004) states, "[w]hile the CBSL does not observe GDP contemporaneously (within a quarter) when deciding on interest rates, they do observe variables strongly correlated with it – such as rainfall, government revenue, exports, or industrial production; data on prices and reserve money, which is strongly correlated with broad money, are available with a very short lag" (p.7, n.).

There are two schools of thought as to whether the variables used in the VAR need to be stationary. One school argues against differencing even when the variables are I(1) and against detrending as well. Sims (1988), Sims, Stock, and Watson (1990), Leeper, Sims, and Zha (1996), Bernanke and Mihov (1997), and Bagliano and Favero (1998) belong to this category and argue that differencing throws away valuable information and the standard asymptotic tests are still valid even if the VAR is estimated in levels.

With regard to possible cointegrating relationships Bernanke and Mihov (1997) argue that the "levels specification will yield consistent estimates whether cointegration exists or not, whereas a differences specification is inconsistent if some variables are cointegrated" (p.1037, n.6). Most researchers neglect cointegration constraints "motivated by the following considerations. First, the analysis is generally focused on short-run constraints and the short-run dynamic response of the system. When cointegration constraints are excluded, this only implies that the long-run responses of some variables are not constrained and might follow a divergent path. However, the short-run analysis is still valid" (De Arcangelis and Di Giorgio (2001), p.86 n.11). Not imposing cointegrating relations also allows to "avoid a long-run identification problem, which may be in principle difficult to solve" (Bagliano and Favero (1998)).

The proponents of the other school of thought argue that "the majority view is that the form of the variables in the VAR should mimic the true data generating process. This is particularly true if the aim is to estimate a structural model" (Enders (2004), p.270). Enders shows that if the variables included in the VAR are not cointegrated "it is preferable to use the first differences" and if the VAR is estimated in levels "[t]ests lose power because you estimate n^2 more parameters (one extra lag of each variable in each equation)," and "the impulse responses at long forecast horizons are inconsistent estimates of the true responses. Since the impulse responses need not decay, any imprecision in the coefficient estimates will have a permanent effect on the impulse responses. If the VAR is estimated in first differences, the impulse responses decay to zero and so the estimated responses are consistent" (Enders (2004), p.358). Gujarati (2003) also agrees with Enders and advocates differencing if the variables are non-stationary. The price for transforming data by first-differencing is however, as Harvey (1990) notes, the results being not as satisfactory as using levels.

low frequency (e.g. Annual or Quarterly) data series and the method introduced by Goldstein and Khan (1976) is used in the current analysis.

In the present analysis, the latter method is used and appropriate transformations will be used if some variables are found to be non-stationary.

Descriptive Statistics and Unit Root Tests

Unit root tests (which are not shown here) confirm that while the interest rate (CALLRTSA) is stationary at the 5 per cent level of significance, all other variables become stationary only after a log- difference transformation. That is, CALLRTSA is I(0) while the other series under consideration are I(1). Although the I(1) variables may be cointegrated, since the interest rate, which is of primary importance, is I(0) and because estimating long run equilibrium relationships are not the primary objective of the present analysis, CALLRTSA will be used in levels, while the other series are transformed by taking log-differences. [5]

The descriptive statistics of the final data series used in the analysis after required transformations for the full Sample are given in Table 2. The logarithmic difference transformation of GDP, CPI, reserve money, and exchange rate also allow the series to be interpreted as GDP growth, inflation, reserve money growth and exchange rate depreciation in percentage points. Note that none of the series used as well as the results obtained is annualised.

Table 2
Descriptive Statistics of Data Series after Required Transformations

	DLGDPSA	DLCCPISA	DLRMSA	DLXRTSDRSA	CALLRTSA
Mean	0.0039	0.0090	0.0115	0.0061	0.1827
Median	0.0041	0.0089	0.0112	0.0050	0.1636
Maximum	0.0136	0.0808	0.0989	0.0879	0.7988
Minimum	-0.0136	-0.0357	-0.1613	-0.0614	0.0785
Std. Dev.	0.0030	0.0121	0.0232	0.0176	0.0835
Observations	335	335	335	335	336

Table 2 shows that, on average, GDP has grown by around 0.4 per cent per month, while prices have increased by around 0.9 per cent monthly. As observed by IMF (2004), "[r]eserve money has grown on average by less than broad money as reserve requirements have declined gradually", but broad money growth is "entirely consistent with the quantity theory and a very small decline in the velocity of money" (pp.4-5). Although, the present study covers a longer period than IMF (2004), their observations seem to apply for this study as well. The Sri Lankan rupee has depreciated

[5] Also, as Lütkepohl (2004) notes, cointegration analysis is sometimes used even if the system has both I(1) and I(0) variables "by calling any linear combination that is I(0) a cointegration relation, although this terminology is not in the spirit of the original definition because it can happen that a linear combination of I(0) variables is called a cointegration relation" (p.89).

against SDR by around 0.6 per cent per month, while the call rate has been, on average, around 18 per cent. All variables, perhaps except for GDP growth, show considerable volatility.

4. Analysis

This section begins with estimating a series of recursive VAR specifications. The semi-structural VAR methodology explained in section 3 will then be executed and its results will be analysed. Finally, a monetary policy index is derived using the estimated semi-structural VARs.

A clarification is needed with regard to a simple transformation of reserve money growth and exchange rate depreciation series used in the analysis. An increase in the interest rate (CALLRTSA) can be obviously treated as a monetary policy contraction. However, an increase in the exchange rate (DLXRTSDRAVGSA), as defined in the data description in section 3, indicates exchange rate depreciation, while an increase in the series DLRMSA shows a positive money growth. Both exchange rate depreciation and positive money growth have expansionary effects on output and prices. To bring the latter two series in line with the interest rate, they are redefined by inverting. That is, using the negative of reserve money growth (NRM) and the negative of exchange rate depreciation (NXRT), i.e., exchange rate appreciation, would allow increases in all three series in the policy block to be treated as contractionary shocks. These modified series will be used in the analysis hereafter. Note that the modified definitions were also used in the derivation of the model for the policy block in section 3.

4.1 Recursive VAR Estimates

The first recursive VAR to analyse is a model with real GDP, inflation, negative of reserve money growth, exchange rate appreciation, and call rate, in that order. The choice of the order indicates that the last three variables, which are generally considered as policy variables in the present analysis are informed contemporaneously by the macroeconomic variables of GDP growth and inflation. Innovations in policy variables do not affect the macroeconomic variables contemporaneously. The recursive structure employed assumes that the call rate is the most endogenous variable since it is affected contemporaneously by the innovations of reserve money and exchange rate but not *vice versa*. The ordering of reserve money and exchange rate cannot be theoretically explained, but a different ordering of these two variables do not affect the results of the analysis significantly.

Lag length selection criteria are considered in determining a suitable number of lags to be included in the specification. Schwartz and Hannan-Quinn criteria select a short lag length of one lag, while Akaike criterion selects seven lags. The likelihood ratio statistic prefers a longer lag length and recommends the selection of 19 lags. Considering these criteria and the fact that the analysis employs monthly series, an interim approach of using 12 lags is utilised.

However, Wald tests of the null hypotheses of the possibility of exclusion reveal that some interim lags within the 12-lagged specification may be unimportant.

Accordingly, only lags 1, 2, 4, 5, 6 and 12 which are significant at standard levels of significance are used in this recursive VAR.

The specification satisfies the stability properties as shown in Figure 4.1, since all inverse roots of the characteristic polynomial lie inside the unit circle as explained by Lütkepohl (1993) among others.

Mainly due to the use of log differences in the analysis, the goodness of fit is affected. In particular, the exchange rate equation has very low adjusted R^2 and F-statistics. R^2 and F-statistics improve significantly when recursive VARs with the same specification is used in log levels. However, due to the reasons given in section 3, stationary variables are used in the current VAR analysis.

Table 3 (Summary)
Recursive VAR – Full Sample
Vector Autoregression Estimates

Sample (adjusted): 1979M02 2005M12
Included observations: 323 after adjustments

	DLGDP	DLCCPI	NDLRM	NDLXRTSDR	CALLRT
R-squared	0.408577	0.175883	0.194516	0.113073	0.676403
Adj. R-squared	0.347815	0.091214	0.111761	0.021950	0.643157
Sum sq. resids	0.001752	0.036481	0.141684	0.086364	0.723303
S.E. equation	0.002450	0.011177	0.022028	0.017198	0.049770
F-statistic	6.724157	2.077289	2.350501	1.240889	20.34525
Log likelihood	1499.806	1009.495	790.3701	870.3162	527.0879
Akaike AIC	-9.094771	-6.058794	-4.701982	-5.197005	-3.071752
Schwarz SC	-8.732210	-5.696232	-4.339421	-4.834444	-2.709191
Mean dependent	0.003795	0.008893	-0.011705	-0.006109	0.186183
S.D. dependent	0.003033	0.011725	0.023372	0.017390	0.083316

The impulse responses obtained from the first recursive VAR show that as a result of a one standard deviation shock of the policy rate, the GDP growth rate falls by around 0.02 percentage points each month for about a year with the peak effect in the fifth month following the shock. The peak effect of an interest rate shock on inflation occurs in the third month following the shock with inflation decreasing by around 0.1 percentage points. However, the effect on inflation is short-lived and the reduction in inflation reverses after 6 months. The effect of a positive innovation of interest rate on reserve money is unclear. Although the exchange rate depreciates for about four months following an interest rate increase, it is followed by a continuous appreciation till the 13th month by around 0.05 percentage points each month. The increase in the interest rate dies out only gradually indicating further tightening of monetary policy that follows an initial tightening.

A one standard deviation exchange rate appreciation has a positive effect on GDP which is counter-intuitive, but it has a significant effect on reducing inflation, with inflation decreasing by 0.15 percentage points in the third month following the shock. Interest rate responds to a one standard deviation exchange rate appreciation immediately by reducing the interest rate by around 0.75 percentage points for two months.

Innovations in reserve money growth do not show any significant result, perhaps because the inclusion of an interest rate absorbs the predictive power of reserve money.

In respect of accumulated responses, it can be seen that a one standard deviation innovation to the interest rate reduces GDP growth by a total of around 0.2 percentage points within a year and the output growth recovers only gradually. The accumulated negative effect on inflation totals 0.2 percentage points after 6 months, and the accumulated impact remains positive from 9 months onwards. Reserve money increases at first, but the accumulated result is a decline in reserve money. Similarly, following a brief depreciation of the exchange rate, the accumulate effect is a continuous appreciation.

GDP growth remains positive following an exchange rate appreciation, which is a counter-intuitive result. Inflation declines throughout as a result of an appreciation. An exchange rate innovation (appreciation) leads to the interest rate declines for a long period.

Variance decompositions show that own variance is very important with respect to all variables while monetary policy indicators contribute very little in explaining variance of non policy variables. Perhaps the only exception is the call rate variance due to inflation which is about 15 per cent. Following Bernanke and Mihov (1995, 1998) variance decompositions will be largely ignored in the ensuing discussion.

Table 4.1
Recursive VAR-Full Sample
Direction of Responses to a Contractionary Interest Rate Shock

Variable	Expected	Observed		
		On Impact	Peak	Accumulated
GDP	↓	↓	↓(5)	↓
CPI	↓	↓	↓(3), ↑(7)	↑
NRM	↑	↓	↑(6)	↑
NXRT	↑	↓	↑(5)	↑
IR	↑	↑	↑	↑

Table 4.2

Recursive VAR-Full Sample
Direction of Responses to a Contractionary Exchange Rate Shock (Appreciation)

Variable	Expected	Observed		
		On Impact	Peak	Accumulated
GDP	↓	↑	↑(3)	↑
CPI	↓	↓	↓(2)	↓
NRM	Ambiguous	↓	↓(3), ↑(13)	↓
NXRT	↑	↑	↑	↑
IR	↓	↓	↓(1)	↑

Table 4.3
Recursive VAR-Full Sample
Direction of Responses to a Contractionary Reserve Money Shock

Variable	Expected	Observed		
		On Impact	Peak	Accumulated
GDP	↓	↑	↓(6)	↓
CPI	↓	↓	↑(5)	None
NRM	↑	↑	↑	↑
NXRT	None	↑	↓(3)	↓
IR	↑	↓	↑(5)	None

Notes:
1. Expected column indicates the expected direction at the peak.
2. On impact column indicates the direction of the first available response.
3. In the peak column, the number within parenthesis is the lag of the peak response.
4. Accumulated column indicates the direction of accumulated response after 36 months.

The summary provided in Table 4 assesses the results obtained from the first recursive VAR against expected results. Results are broadly in line with consensus views when an interest rate innovation is considered. However, exchange rate and reserve money innovations provide some puzzling results.

Since the full sample from January 1978 to December 2005 is marked with several important monetary policy changes, the first recursive VAR specification is tested using several sub-samples to see whether results obtained for the full sample change for sub-samples. The determination of sub-samples is as follows:

Table 5
Determination of Sub-samples

Sample Period	Reason
January 1978-December 2005	Full sample

January 1978-September 1993	Period covers from the beginning of the sample up to the introduction of the Repo rate
October 1993-December 2000	Period covers from the introduction of the Repo rate up to the floating of the exchange rate
January 2001-December 2005	Period covers from the floating of the exchange rate up to the end of the sample period

The sub-samples fail to improve the ambiguous results obtained from the full sample relating to both reserve money and exchange rate, while recent sub-samples are plagued with the perverse seasonality problem caused by the behaviour of the real GDP series. Standard errors of all impulse responses are high, questioning the statistical significance of the findings. However, some common patterns can be observed from the above results. Innovations to the interest rate reduce GDP growth. The response of inflation to an interest rate shock is often positive.[6] The increase in inflation following an interest rate innovation is the price puzzle and the inclusion of crude oil prices does not provide a solution, as in the case of Fung (2002) who finds that "[i]ncluding the commodity price index or US variables in the VARs, however, does not resolve this price puzzle" (pp.7-8) for many East Asian economies.

The relationship between interest rates and exchange rate appreciation is positive, as expected. The persistence of interest rate innovations suggests that the CBSL changes interest rate gradually, and confirms an earlier finding of IMF (2004) for Sri Lanka. Contractionary exchange rate innovations (appreciations) result in increasing GDP growth at all times. This is somewhat surprising given the export-oriented nature of Sri Lanka's economy where one expects an exchange rate appreciation to discourage exports and thereby reduce GDP growth. IMF (2004) also finds that "[a]n unexpected depreciation […] is associated with a significant decline in output, which suggests that such an innovation may be a proxy for some underlying macroeconomic weakness" (p.11). Innovations in reserve money growth do not lead to significant findings, and the reserve money contractions and interest rates often have a negative relationship, giving rise to what Leeper, Sims, and Zha (1996) called the liquidity puzzle. Fung (2002) also finds a similar puzzling result for Korea.

Although the theory dictates that monetary policy does not have a long run impact on GDP, accumulated responses of GDP growth die out only sluggishly in most occasions.

The next section employs the Bernanke-Mihov methodology instead of recursive VAR methodology to assess whether impulse responses generated from structural VARs provide different results to the ones obtained in the present section.

[6] IMF (2004) also finds that in Sri Lanka, "changes in policy interest rate have a significant effect on output but a small impact on inflation. […] Inflation in Sri Lanka is very volatile and the effect of monetary shocks is dwarfed by supply-side shocks, in particular to agricultural production given the large weight of food in the CPI. […] Since the weight of food in the price index is about 2/3, it is not surprising that the link between monetary policy shocks and inflation is weak" (pp.9-11).

4.2 Semi Structural VAR estimates

As explained in detail in Sections 2 and 3, recursive VARs generally assume that a good scalar policy variable is available, and obtain impulse responses by ordering the policy variable last. However, the recursive VARs discussed in previous section showed that as in many other economies, in Sri Lanka also there is a vector of potential policy indicators and one may need to assess the impact of all these policy variables on macroeconomic variables simultaneously. Such a requirement can be met by utilising the Bernanke-Mihov methodology as described in the relationships described in equations (3.20) through (3.22) in Section 3. Accordingly, this section estimates the structural VARs for several sub-samples. The estimates of the structural VARs with different identification schemes will then be compared.

Just Identified Structural VAR (SVAR-JI)

The first Structural VAR that will be estimated is a just-identified specification for the full sample period. As described in Section 3, there are several ways to achieve just-identification, and the restriction $\gamma = 0$ (equation 3.56) which means that the exchange rate does not react to interest rate innovations contemporaneously will be utilised in this analysis.

The analysis of impulse responses shows that GDP growth and inflation decline following a structural interest rate innovation. The reaction of reserve money growth to an interest rate innovation is still ambiguous, although reserve money growth is negative initially. The exchange rate initially depreciates, but is followed by a continuous appreciation as a result of an interest rate shock. An appreciation of the exchange rate (positive innovation), raises GDP growth, while reducing inflation. A contractionary reserve money growth shock also raises GDP growth while reducing inflation in the very short-run.

The results of the impulse response analysis are summarised in Table 6.

Table 6.1
Structural VAR-JI – Full Sample
Direction of Responses to a Contractionary Interest Rate Shock

Variable	Expected	Observed		
		On Impact	Peak	Accumulated
GDP	↓	↑	↓(5)	↓
CPI	↓	↓	↓(3), ↑(7)	↑
NRM	↑	↑	↑(1)	↑
NXRT	↑	↓	↓ (3)	↑
IR	↑	↑	↑	↑

Table 6.2
Structural VAR-JI – Full Sample

Direction of Responses to a Contractionary Exchange Rate Shock (Appreciation)

Variable	Expected	Observed		
		On Impact	Peak	Accumulated
GDP	↓	↑	↑(3)	↑
CPI	↓	↓	↓(2)	↓
NRM	Ambiguous	↑	↓(3)	↑
NXRT	↑	↑	↑	↑
IR	↓	↓	↓(1)	↓

Table 6.3
Structural VAR-JI – Full Sample
Direction of Responses to a Contractionary Reserve Money Shock

Variable	Expected	Observed		
		On Impact	Peak	Accumulated
GDP	↓	↑	↓(6)	↓
CPI	↓	↓	↑(5)	↓
NRM	↑	↑	↑	↑
NXRT	None	↓	↓(3)	↓
IR	↑	↓	↓ (1)	↓

Notes:
1. Expected column indicates the expected direction at the peak.
2. On impact column indicates the direction of the first available response.
3. In the peak column, the number within parenthesis is the lag of the peak response.
4. Accumulated column indicates the direction of accumulated response after 36 months.

The structural VAR results for the sub-sample from January 1978 to September 1993 are comparable with the recursive VAR for the same sub-sample. As a result of a positive interest rate innovation, both GDP growth and inflation increases initially, but inflation starts to fall significantly after nine months for about a further year. Exchange rate appreciates, in general, after an interest rate shock. Following an exchange rate appreciation, GDP growth rises, while inflation falls on impact. Interest rate decreases, while the exchange rate innovation shows no sign of persistence. A negative innovation in reserve money growth has a lagged effect on reducing GDP growth, while inflation starts to decreases four months after the shock. The puzzling result of interest rate falling after a negative reserve money growth is observed again.

As noted earlier, the sub-sample from October 1993 to December 2000 is marked by the volatility of responses with the seasonality effect of GDP. Following an interest rate innovation both GDP growth and inflation fall, although inflation begins to increase seven months after the shock. Exchange rate appreciates while interest rate innovations are less persistent disappearing six months after an innovation. As a result of a contractionary exchange rate shock, GDP growth increases, inflation falls, while interest rate decreases. A contractionary reserve money shock raises GDP growth but inflation initially falls. Interest rate increases as expected, while reserve money shocks are less persistent in this sub-sample.

The sub-sample from January 2001 to December 2005 is also plagued with the seasonality effect. Although innovations to interest rate and reserve money cause expected negative result on GDP growth, exchange rate shocks continue to affect GDP growth positively. Interest rate innovations do not help reduce inflation. Exchange rate appreciates following an interest rate shock, while the CBSL appears to have changed interest rates gradually, both in terms of magnitude and length of adjustment. Another significant result is that interest rate rises following a negative innovation in reserve money growth similar to the previous sub-sample.

4.3 General Discussion on Structural VAR Results

The results obtained from the just-identified structural VARs are not quite different to the results of recursive VARs. The only puzzle that is resolved is the liquidity puzzle, since in two sub-samples interest rate rises following a contractionary reserve money shock. Monetary policy still appears to have little impact on reining-in inflationary pressures while exchange rate appreciation has a counter-intuitive positive impact on GDP growth.

A logical next-step is to test whether the various sub-samples can be identified as different targeting regimes. Accordingly, restrictions $\phi^{d} = \phi^{e} = 0$ given in equation (3.62) is used to derive estimates under an interest rate targeting regime, restrictions $\alpha = \beta = 0$ and $\phi^{NRM} = 1$ as in equation (3.65) are utilised to obtain estimates under a reserve money targeting regime. An exchange rate targeting regime is defined by $\gamma = 0$ and $\phi^{NXRT} = 1$ as in equation (3.72). A summary of the results obtained are provided in Table 7.

A comparison of the parameter estimates shows that parameters are broadly consistent within each sample. Also, most parameters carry the expected sign. Parameter α from equation (3.20) is the elasticity of (negative) of reserve money growth to interest rate and is expected to have a positive sign. For the full sample as well as all sub-samples this is estimated to be positive. It is also observed that for the sub-sample from January 2001 to December 2005, this parameter is significantly higher than in other sub-samples. Parameter β, which is the elasticity of (negative of) reserve money growth to an exchange rate appreciation, does not carry the expected negative sign for the two sub-samples from October 1993 to December 2000, and January 2001 to December 2005. However, through all samples parameter β is statistically insignificant. Parameter γ shows the effect of interest rate on the exchange rate. This parameter has the expected positive values in all estimates and in the most recent sub-sample has a large and significant value perhaps indicating the impact of the gradual capital account liberalisation that has been taking place in recent times. Parameters ϕ^{NRM} and ϕ^{NXRT}, which show the reaction of (negative of) reserve money and exchange rate to demand

and external shocks, respectively, have positive signs as expected. Parameters ϕ^d and ϕ^e, which show the reaction of the interest rate to demand innovations and external shock, respectively, change signs throughout samples displaying that interest rates have reacted differently to shocks at different times. The analysis of overidentifying restrictions proves futile since all overidentifying restrictions are rejected by the model,[7] possibly indicating that any sub-sample in the post-1978 monetary history of Sri Lanka cannot be identified with one targeting regime. The CBSL has paid attention to all three policy variables included in the model in the conduct of monetary policy and VAR estimates using different identification schemes are unlikely to improve the results obtained from the just-identified models any further.

Table 7
Parameter Estimates for All Structural VAR Models

Sample	Model	α	β	γ	ϕ^{NRM}	ϕ^{NXRT}	ϕ^d	ϕ^e	Log likelihood
1979M02 -2005M12 (Full Sample)	JI-1	0.0454 [0.9978]	-0.0993 [0.9908]	0	0.0217 [0.0000]	0.0171 [0.0000]	0.0000 [1.0000]	-0.0090 [0.8719]	3814.6
	IRT	0.0466 [0.0000]	-0.0988 [0.1683]	0.0625 [0.0000]	0.0217 [0.0000]	0.0168 [0.0000]	0	0	3820.0
	RMT	0	0	0.0608 [0.0323]	1	0.0168 [0.0000]	-0.0330 [0.5537]	0.0000 [1.0000]	2744.0
	XRTT	0.0456 [0.9833]	-0.0973 [0.9315]	0	0.0217 [0.0000]	1	0.0004 [1.0000]	-0.5207 [0.0000]	2661.9
1979M02 -1993M09	JI-1	0.0470 [0.9846]	-0.0232 [0.9795]	0	0.0180 [0.0000]	0.0175 [0.0000]	-0.0004 [1.0000]	-0.0065 [0.9317]	2234.8
	IRT	0.0547 [0.0000]	-0.0212 [0.7870]	0.0767 [0.0000]	0.0180 [0.0000]	0.0173 [0.0000]	0	0	2237.3
	RMT	0	0	0.0647 [0.0653]	1	0.0173 [0.0000]	0.0371 [0.6224]	-0.0006 [0.9998]	1618.4
	XRTT	0.0514 [0.9908]	-0.0214 [0.9896]	0	0.0180 [0.0000]	1	0.0002 [1.0000]	-0.3686 [0.0000]	1611.0
1993M10 -2000M12	JI-1	0.0745 [0.9907]	0.0054 [0.9996]	0	0.0298 [0.0000]	0.0135 [0.0000]	0.0004 [0.0000]	-0.0248 [0.8170]	1007.0
	IRT	0.0720 [0.0000]	0.0010 [0.9969]	0.0608 [0.0000]	0.0298 [0.0000]	0.0128 [0.0000]	0	0	1012.1
	RMT	0	0	0.0610 [0.0000]	1	0.0128 [0.0000]	-0.3329 [0.0019]	0.0000 [1.0000]	749.9
	XRTT	0.0719 [0.9973]	0.0054 [0.9999]	0	0.0298 [0.0000]	1	0.0001 [1.0000]	-1.7576 [0.0000]	676.2
2001M01 -2005M12	JI-1	0.1398 [0.9359]	0.0529 [0.7585]	0	0.0163 [0.0000]	0.0196 [0.0000]	-0.0009 [1.0000]	-0.0015 [0.9906]	705.7
	IRT	0.3240 [0.0000]	0.0732 [0.5020]	0.4400 [0.0000]	0.0162 [0.0000]	0.0192 [0.0000]	0	0	707.4
	RMT	0	0	0.1034 [0.4288]	1	0.0194 [0.0000]	-0.0192 [0.8819]	-0.0008 [0.9999]	489.2
	XRTT	0.1428 [0.9433]	0.0523 [0.7385]	0	0.0163 [0.0000]	1	-0.0007 [1.0000]	-0.0780 [0.5457]	499.8

Note: P-values are in parentheses

[7] Bernanke and Mihov (1995) advocates that since tests for overidentifying restrictions "gives only the statistical, and not economic, significance of model rejections…an alternative strategy is to […] get just-identification; and then, conditional on that restriction, to observe how closely the estimated parameter values of the more general model correspond to those assumed by the more restricted models" (p.26), as performed in the current analysis.

4.4 Estimating the Monetary Policy Index

Using the methodology explained in Section 3 and based on equation (3.77), an attempt is made to derive a monetary policy index for Sri Lanka. Although many authors, including Bernanke and Mihov (1995, 1998), and Kasa and Popper (1997) have used the parameter estimates from the just-identified model for the full sample to derive such an index, in this analysis, it is proposed to use an average of parameter estimates (ignoring restricted values) to derive the index. Although, parameter estimates are roughly equal within a sample as already mentioned, taking average values further helps to avoid estimating an index biased toward any particular identifying assumption. The average parameter values for the full sample are as follows:

Table 8
Parameter Values used for the Monetary Policy Index

α	0.0459
β	-0.0985
γ	0.0616
ϕ^{NRM}	0.2170
ϕ^{NXRT}	0.0169
ϕ^{d}	-0.0109
ϕ^{e}	-0.1766

The estimated monetary policy index is displayed in Figure 1. As suggested by Bernanke and Mihov (1995), policy variables are transformed by subtracting them from their own 36-month moving averages before estimating the monetary policy index given by equation (3.77). The estimated parameter values determine the weight on each policy variable, and as expected from the foregoing impulse response analyses, the interest rate has a greater weight than reserve money and the exchange rate. This makes the three policy variables to have comparable units and defined the zero line as "normal" monetary policy.[8] When the index is above the zero line, it can be interpreted as a contractionary monetary policy stance, and vice versa.

[8] Bernanke and Mihov warn that the index defines "normal" monetary policy compared with the recent past. Kasa and Popper (1997) concur: "since only second moments are being used here, these plots cannot say anything about the stance of policy in some absolute sense. Only the stance of policy relative to the historical average is identified" (p.291 n.26).

Figure 1

Monetary Policy Index for Sri Lanka

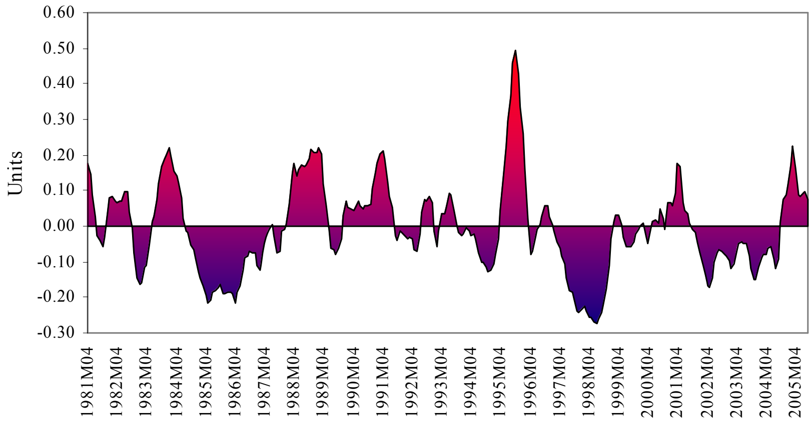
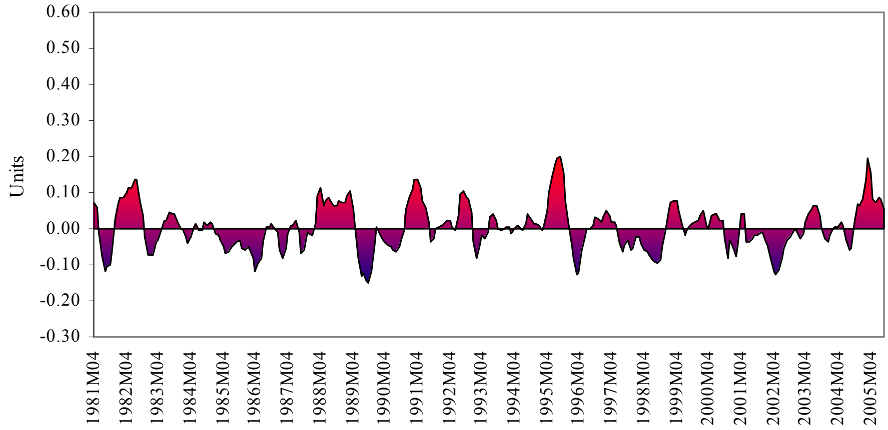


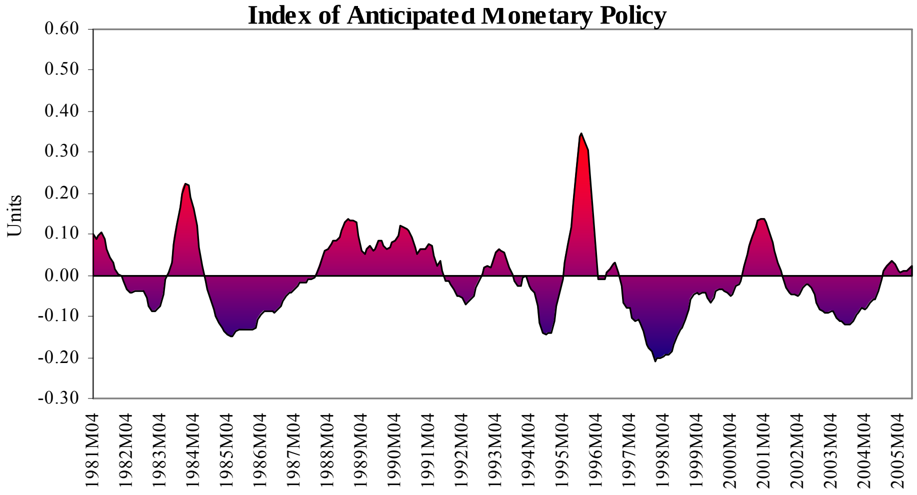
Figure 2 plots the estimated structural monetary policy shocks (v^s) obtained from the model with a similar transformation to make it comparable with Figure 1. Structural monetary policy shocks can be defined as the unanticipated monetary policy. According to Kasa and Popper (1997) who estimate a similar index for Japan, [t]he overall stance reflects both endogenous responses to economic conditions and unanticipated changes in the stance of policy" (p. 291). Similar to their observation for Japan, in Sri Lanka also the unanticipated component of monetary policy is relatively small compared with the overall stance of monetary policy. Kasa and Popper, interpret this observation as indicating "that the recent, striking changes in the stance of Japanese monetary policy took place largely in response to the prevailing economic condition" (p.292). This interpretation is applicable to Sri Lanka as well. For instance, even the high interest rate regime observed during the late 1995, it has largely been in response to the existing economic situation of the country.

Figure 2
Estimated Structural Monetary Policy Shocks (Unanticipated)



The difference between the monetary policy index and exogenous shocks provides the endogenous responses of monetary policy to the current economic condition, and are presented in Figure 3.

Figure 3
Index of Anticipated Monetary Policy



There are several potential uses for such a monetary policy index. As Bernanke and Mihov (1995) argue, this "total measure of policy stance is potentially useful for evaluating the overall direction of policy, and for making comparisons of current policy stance with policies chosen under similar circumstances in the past" (p.13). The index could be used as scalar measure of composite monetary policy index in future econometric analysis as well. The measure estimated in the present analysis is closer to the monetary conditions index because it comprises the exchange rate in addition to the two monetary indicators of reserve money and interest rate.

Although a detailed analysis using the monetary policy index derived above is not undertaken in the present study, it may be worthwhile to analyse the correlations of GDP growth and inflation (6-month centred moving averages) with the index and its components, as presented in Figure 4.

Figure 4
Dynamic Correlations between the Monetary Policy Index and Macroeconomic Variables

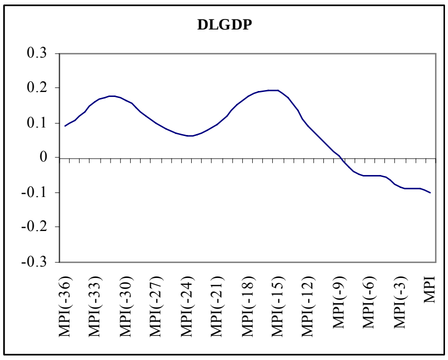


Figure 4.1.1

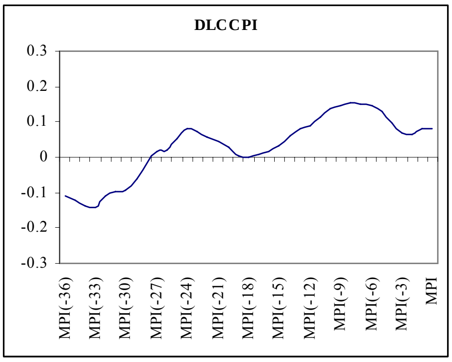


Figure 4.2.1

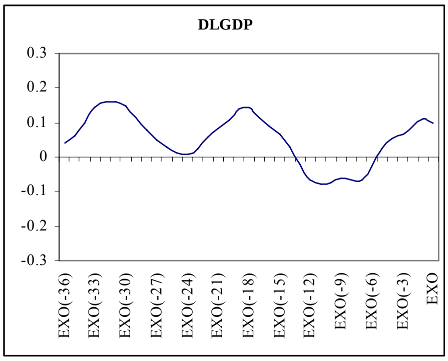


Figure 4.1.2

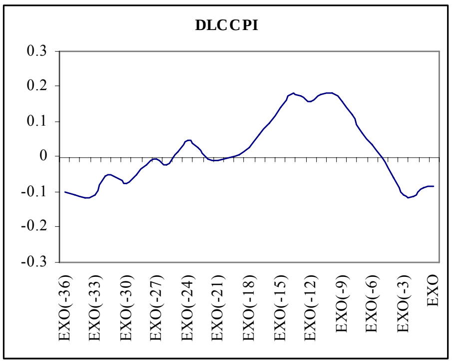


Figure 4.2.2

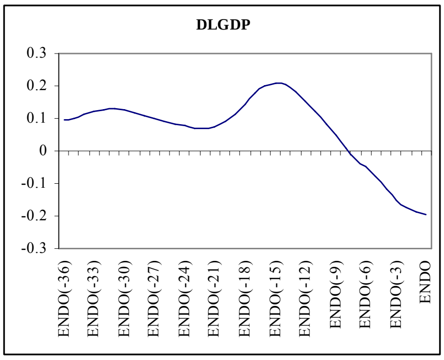


Figure 4.1.3

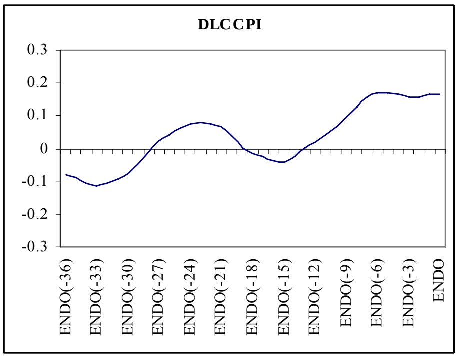


Figure 4.2.3

As stated earlier, simple correlations do not provide an ultimate proof of causation, although they can lend support to possible causal relations. Bearing this in mind, the dynamic correlations shown in Figure 4 can be interpreted as follows: contractionary monetary policy has a negative impact on GDP growth with a short-lag from about 9 months; GDP growth is affected mainly by anticipated (endogenous) monetary policy. Agents adjust their economic activity expecting the CBSL to take policy action to address economic conditions; Inflation responds to contractions in both exogenous and endogenous components of monetary policy with a longer-lag of about 28 to 36 months. Unanticipated monetary contractions are also negatively correlated with inflation in the short-run.

Bernanke and Mihov (1995, 1998) compare the index derived using this method with the existing monetary policy measures such as the Romer and Romer dates and the Boschen and Mills index. However, in the context of Sri Lanka, no alternative measure is available, and illustrates the need for further research in this direction.

5. Summary and Conclusions

With the aim of analysing the effects of monetary policy on key macroeconomic variables in Sri Lanka, this paper employed methods which can be broadly categorised as structural vector autoregressions. Section 1 discussed the established findings on the relationships between monetary policy and macroeconomic variables, and also provided a brief introduction to Sri Lanka's monetary policy framework. Section 2 reviewed the literature with regard to estimating the effects of monetary policy on macroeconomic variables, and discussed in detail, the vector autoregressive approach to monetary policy. Section 3 formally defined the objective of the present analysis, explained the Bernanke-Mihov methodology and described the data used in the analysis. Section 4 presented the results of the analysis. In this Section, a summary of key findings and limitations and possible future extensions will be discussed.

5.1 Summary of Key Findings

Similar to most other economies, in Sri Lanka also, there is a multitude of variables that characterise the monetary policy stance at any given time. The present study analysed the results of a series of recursive VARs for various sample periods and observed that the results are broadly in line with the established empirical findings, especially when the interest rate is considered the monetary policy variable. Following a positive innovation in interest rate, the GDP growth and inflation decreases while the exchange rate appreciates. When money growth and exchange rate are used as policy indicators, the impact on GDP growth contrasts with the established findings. However, as expected, an exchange rate appreciation has an immediate impact on the reduction of inflation. Interest rate innovations are persistent supporting the view that the monetary authority adjusts interest rates gradually, while innovations in money growth and exchange rate appreciation are not persistent. Several puzzling results emerge from the study: for most sub-samples, inflation does not decline following a contractionary policy shock, possibly due to the longer lag effect; innovations to money growth raises the interest rate; when inflation does respond, it reacts to monetary innovations faster than GDP growth does; and, exchange rate appreciations almost always lead to an increase in GDP growth. Results obtained from the Bernanke-Mihov semi-structural VARs, which consider the predictive ability of reserve money, exchange rate and interest rate as monetary policy indicators simultaneously, do not significantly change the impulse responses. However, it was observed that no sub-sample can be considered as purely an interest rate targeting regime, a reserve money targeting regime or an exchange rate targeting regime. The monetary policy index derived using an extension of the Bernanke-Mihov approach revealed results similar to other economies; the behaviour of policy indicators can be explained as a combination of both anticipated an unanticipated monetary policy. Unanticipated monetary policy is relatively a small portion of the overall monetary policy stance, while anticipated monetary policy, i.e., the CBSL's reaction to economic developments explains a large part of monetary policy action. It was also observed that anticipated monetary policy contractions are negatively correlated with GDP growth with a lag of 0-9 months, while both anticipated and unanticipated monetary policy contractions are negatively correlated with inflation with a lag of 28-36 months. The monetary policy index derived can be used in future research as a combined measure of monetary policy or to compare findings of similar indices obtained from different approaches to analyse Sri Lanka's monetary policy in the future.

5.2 Limitations of the Study

Several limitations could be identified in this analysis. As noted earlier, the test statistics do not display statistical significance, mainly as a result of the log-differencing of the non-stationary data. Although results improve significantly when log-level series are used, following Enders (2004) and Gujarati (2003), this approach was not taken. It will be interesting to perform the complete analysis using log-levels to see how the results change. Other possible reasons for the lack of significance could be misspecification of the VARs and the existence of important omitted variables.

A number of problems with data series was identified. Reserve money and call money market rate series were as at end-period (end of the month), and using monthly averages may have some impact on estimated results. End-period observations are not necessarily random observations, and this problem could worsen if one used quarterly data. Monthly data for GDP was not available, and the annual (later quarterly) GDP series had to be interpolated. As noted earlier, quarterly GDP series for Sri Lanka is plagued with seasonality which cannot be captured using traditional deseasonalisation methods, and has a perverse impact on econometric estimates. The exchange rate used in this analysis was the nominal exchange rate, and the results may change if the real exchange rate was used. However, the CBSL commenced computing the real exchange rate only in the 1990s, indicating that it was perhaps more interested in the movements in nominal exchange rate. Also, the interest rate used was not a policy rate *per se,* but a closely related short-term money market rate. At least for the recent sample periods, it will be useful to see whether the results change if the policy interest rates are used instead.

Possibly, a major omitted variable in the analysis is an indicator of government finance. Having a high budget deficit and a high debt/GDP ratio, public finance is an important issue in Sri Lanka and the conduct of monetary policy cannot be analysed in isolation. However, in the present analysis, any discussion of government finance was totally avoided for simplicity. The inclusion of an indicator of public finance may help to solve some puzzling results and also explain why the international crude oil price does not have a significant impact on the variables included in the present analysis. Specifically, in Sri Lanka, prices of petroleum products are administered given their impact on GDP growth and inflation, and oil price shock are absorbed largely by the government budget, at least in the short-run.

Being a VAR analysis, the current study focused mainly on residuals or innovations rather than on monetary policy rules. A different model is needed if one is to analyse monetary policy rules for Sri Lanka.

The policy block used in this analysis contained only three variables, namely, reserve money, exchange rate and interest rate. Other potential candidates for the policy block are the international reserve (net foreign assets of the CBSL), the interest rate corridor and the reserve requirement.

Although a monetary policy index was derived using the Bernanke-Mihov methodology, unlike in the USA, in Sri Lanka there are no other indicators of monetary policy. As noted earlier, the development of other indicators will allow a comparison of the performance of these indicators.

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Inflation Targeting versus Monetary Targeting - The Case of Sri Lanka[1]

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Abstract

High and volatile inflation could result in significant negative outcomes leading to loss of social welfare, which underscores the necessity of having in place an effective monetary policy regime. Increasingly larger numbers of countries have shifted to an inflation targeting regime, following the success of those that adopted inflation targeting in the early 1990s. Analysing Sri Lanka's monetary policy regime suggests that, monetary targeting, although appropriate for effectively controlling inflation, seems to lack the institutional features that have enabled inflation targeting regimes to achieve low and stable inflation in the long-run. This makes inflation targeting an attractive alternative to countries presently in a monetary targeting regime, experiencing high or volatile inflation. (JEL E42)

I. Introduction

An increasingly popular framework for the conduct of monetary policy, inflation targeting has been adopted by many central banks since the early 1990s, in both industrialised as well as developing countries. Bernanke et al. (1999) define 'inflation targeting' in terms of its essential characteristics: the public announcement of official quantitative targets (or target ranges) for the inflation rate over specified time horizons; the explicit acknowledgment that the primary goal of monetary policy is low and stable inflation; vigorous efforts on the part of the central bank to communicate with the public about its objectives and plans to achieve those objectives; and mechanisms that strengthen the central bank's accountability for attaining those objectives. Monetary targeting, on the other, hand involves the reliance on information conveyed by monetary aggregates to conduct monetary policy, announcement of targets for monetary aggregates, and an accountability mechanism to preclude significant deviations from the monetary targets, as explained by Mishkin (2000). Inflation targeting central banks are generally considered both more transparent and independent than one operating within any other monetary policy regime due to the last two characteristics of an inflation targeting regime mentioned above. Meanwhile, central bank independence is associated with superior monetary policy performance.

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Given the success associated with inflation targeting regimes in maintaining low and stable inflation, and the benefits of low and stable inflation, in this paper, it is attempted to examine inflation targeting vis-à-vis other mechanisms of controlling inflation, namely, monetary targeting, with the objective of establishing whether it is in fact superior to other methods of controlling inflation. The methodological framework of the paper has particular reference to Sri Lanka, a small open developing country, which conducts monetary policy within a monetary targeting framework.

This paper is organised as follows. Section II of this paper contains the review of literature, which helps understand the two frameworks for conducting monetary policy briefly outlined above. The analytical framework of the paper is discussed in Section III, which gives details of the models being used, the data used for estimating them, as well as the bases for the particular comparisons being made amongst various countries. Analyses and findings from the analyses are contained in Section IV. Section V summarises and concludes the paper.

II. Review of Literature

Literature on inflation targeting, monetary targeting and related topics such as price stability, is reviewed hereunder, with a view to explaining, as well as assessing the merits and demerits of the two frameworks for monetary policy.

A. Inflation Targeting

Svensson (2000), who analyses inflation targeting in terms of a small open economy, concludes that 'flexible CPI-inflation targeting' is successful in limiting not only the variability of CPI[2] inflation but also the variability of the output gap and the real exchange rate. As he clarifies, a central bank could pursue 'strict inflation targeting', the case when its only concern is to stabilise inflation, or 'flexible inflation targeting', in which case it puts some weight on other goals such as output stabilisation and/or interest rate smoothing. With respect to inflation, he further differentiates between domestic inflation, that is inflation in the domestic component of the CPI or GDP[3] inflation, and CPI inflation, and draws attention to the fact that none of the inflation targeting countries have chosen to target domestic inflation, but rather, CPI inflation or some measure of underlying inflation that excludes some components of the CPI, such as the cost of credit services.

The characteristics of inflation targeting, in terms of which Svensson (2000) identifies an inflation-targeting monetary policy regime differ in some respects from

[2] Consumer Price Index
[3] Gross Domestic Product

those put forward by Bernanke et al. (1999) mentioned above. He outlines three main characteristics of an inflation-targeting regime: (i) an explicit quantitative inflation target (interval or point target), (ii) an operating procedure that can be described as “inflation-forecast targeting”, namely, the use of an internal conditional inflation forecast as an intermediate target variable, and (iii) a high degree of transparency and accountability. Svensson’s elaboration of “inflation-forecast targeting” is helpful in comprehending how a central bank that conducts monetary policy to achieve an inflation target operates. As he explains, the central bank’s internal conditional inflation forecast is based on current information, a specific instrument[4] path, the bank’s structural model(s), and judgemental adjustments of model forecasts with the use of extra-model information. While the central bank selects an instrument path that results in a conditional inflation forecast, which is equal to or sufficiently close to the inflation target, this instrument path then constitutes the basis for the current instrument setting of the central bank. As he points out, this operating procedure is a consequence of the lags in the transmission of monetary policy and the central bank’s imperfect control of inflation. He also underlines the fact that within an inflation targeting framework, there is no explicit instrument rule[5], as is apparent from the operating procedure outlined above, but rather, it results in an endogenous reaction function, which expresses the instrument as a function of the information affecting the conditional inflation forecast of the central bank. It is perhaps pertinent to mention at this point that Bernanke et al. (1999) describe monetary policy as “an art rather than a science”. (Bernanke et al., 1999, preface). The *information* taken into consideration in making changes to the instrument path, of course, depends on the different transmission channels of monetary policy, and their relative importance in a given set of circumstances.

Bernanke et al. (1999) also emphasise that, “… in practice, inflation targeting serves as a framework for monetary policy rather than as a rule for monetary policy” (Bernanke et al., 1999, p. 4), and this is a point that merits some elaboration. As they explain, following ideas originally put forward by the ‘Chicago School’ in the 1930s, monetary economists categorise strategies for conducting monetary policy into ‘rule’ based and ‘discretion’ based strategies. As they further explain, “*Rules* are monetary policies that are essentially automatic, requiring little or nothing in the way of macroeconomic analysis or value judgements by the monetary authorities.” (Bernanke et al., 1999, p. 5) An example for monetary policy rules they cite is: “… the constant-money growth rule associated with Milton Friedman, under which some specified measure of the money stock is required to grow by a fixed percentage each year, independent of economic or financial conditions.” (Bernanke et al., 1999, p. 5) Another monetary policy rule is the Taylor rule, developed by John B. Taylor, which, as explained in The Federal Reserve Bank of San Francisco web site, “"recommends" a relatively high interest rate (that is, a "tight" monetary policy) when inflation is above

[4] Typically, a central bank’s primary policy instrument is a short-term nominal interest rate.

[5] An instrument rule, e.g. the Taylor rule, prescribes the current instrument setting as an explicit function of current information.

its target or when the economy is above its full employment level, and a relatively low interest rate ("easy" monetary policy) in the opposite situations" ("Dr. Econ.", Educational Resources, The Federal Reserve Bank of San Francisco web site). Bernanke et al. (1999) explain that the rationale put forward by proponents of monetary policy rules for the adoption of rules is that rules impose discipline on the monetary authorities and therefore lead to credibility. A policy approach based on discretion, which is the polar opposite of rules-based strategy, on the other hand, would mean that the central bank makes no public commitments about its objectives, except perhaps in very vague, general terms, as they explain. The rationale for discretionary policy-making, as put forward by proponents of discretionary monetary policy, is that it enables the central bank to respond to new information or unexpected developments. Bernanke et al. (1999) argue that there is no such thing in practice as an absolute rule for monetary policy and that in practice, only discretion prevails, in varying degrees. They also point out that, while all monetary policy regimes are discretionary, that discretion could either manifest itself as an undisciplined approach leading to policies that change with the personal views of central bankers or with the discretion of politicians, or operate within a clearly articulated framework in which the 'tactics' and the general objectives of the policy makers are committed to in advance. They argue that inflation targeting provides the latter type of framework, which allows monetary policy to operate in an environment of "constrained discretion".

The idea that monetary policy should follow a rule to avoid the time inconsistency and inflation bias problem is attributed to Kydland and Prescott (1977). They argue that discretion implies selecting the decision that is best given the current situation and therefore results in sub-optimal planning or economic instability. They propose putting in place institutional arrangements to ensure that policy rules are adhered to in all but emergency situations. Although monetary policy conducted within an inflation targeting framework involves some discretion, as discussed before, contrary to the conclusions drawn by Kydland and Prescott in respect of optimal monetary and fiscal policy, the institutional framework within which inflation targeting policy regimes operate is one aspect which is in line with the ideas put forth by Kydland and Prescott (1977), and has undoubtedly contributed to the success of inflation targeting regimes in maintaining low and stable inflation. For example, Mishkin (2000) points out that increased transparency and accountability of central banks under inflation targeting help promote central bank independence, which enables them (inflation targeting central banks) to take a longer-run view, thus reducing the likelihood of them falling into the time-inconsistency trap, in which they try to expand output and employment in the short-run by pursuing overly expansionary monetary policy, under political pressures. Obstfeld and Rogoff (1996) lend support to Mishkin's view: "One possible way societies might confront the problem of monetary-policy credibility is to create an independent central bank that places a high weight on inflation stabilization." (Obstfeld and Rogoff, 1996, p. 641) Meanwhile, Barro and Gordon (1983) point out that it is possible that reputational forces can substitute for formal rules. In this sense, by building credibility for maintaining low and stable inflation, inflation targeting central banks may be said to have largely overcome the problems associated with the use of discretion in policy-making identified by Kydland and Prescott.

It is pertinent at this point to define the notions of central bank independence and accountability. Bernanke et al. (1999) discuss the two opposing views on central bank independence: "Monetary policy obviously has a significant influence on the welfare of the citizenry and often involves tradeoffs between the interests of various groups in the society, so there is a presumption that close oversight is warranted. On the other hand, there are strong arguments to support the view that monetary policy works better when it is insulated from short-run manipulation." (Bernanke et al., 1999, p. 37) They then go on to discuss the notions of goal independence and instrument independence: "Under goal independence, the central bank is free to set its own policy objectives, including inflation targets. Under instrument independence, policy goals are set by the government alone or by the government in consultation with the central bank, but the central bank is solely responsible for the instrument settings (such as the level of short-term interest rates) needed to achieve those goals." (Bernanke et al., 1999, p. 38) It can be seen that instrument independence is a compromise between the two opposing stands on central bank independence outlined above, which, Bernanke et al. (1999) point out, was suggested by Debelle and Fischer (1994). While Bernanke et al. (1999) conclude that inflation targeting is fully compatible with instrument independence, they also point out that instrument independence recognises the superior technical expertise of the central bank in implementing monetary policy and the need to insulate the bank from short-run political pressures and arbitrary interventions.

With respect to accountability under inflation targeting, they state: "The bank's accountability is assured in two ways: first, by comparing inflation outcomes with the targets; and second, by the central bank's obligation to provide the public with convincing rationales for the policy choices it makes. Because inflation responds to policy only after long lags, and because inflation targets are rarely hit exactly, this second means of maintaining accountability is essential under an inflation-targeting regime." (Bernanke et al., 1999, p. 38) The reason for issuing regular, detailed inflation reports to the public, as they point out, is to inform the public of the reasons for the policy choices of the central bank, their consequences, and any other relevant developments affecting those outcomes.

B. The Rationale for Inflation Targeting and the Empirical and Theoretical Underpinnings of the Emergence of Inflation Targeting

In explaining the rationale for inflation targeting, Bernanke et al. (1999) point to several reasons for stressing long-run price stability in monetary policy: first, although macroeconomic policy has many goals besides low inflation such as real growth, low unemployment, financial stability and a sustainable external account, most macroeconomists now agree that, in the long run, the inflation rate is the only macroeconomic variable that monetary policy can affect; second, it is now widely accepted that inflation is harmful to economic efficiency and growth; and third, an inflation target serves as a 'nominal anchor' for monetary policy, providing a focus for the expectations of financial markets and the public and a reference point against which the central bank can judge the desirability of short-run policies.

They further explain the empirical and theoretical underpinnings of the shift in the policy focus of central banks from 'activist' monetary policies (stabilisation policy) aimed at achieving output and employment levels close to their 'full employment levels' to long-run price stability; and the emergence of inflation targeting. They explain that activist monetary policy was based on the belief that there was a long-run tradeoff between inflation and unemployment, known as the Phillips curve. However, empirical evidence for the USA for the twenty five year period starting from about 1971 showed clearly that there was no such stable relationship between unemployment and inflation, as Romer (2006), explains. Meanwhile, as Bernanke et al. (1999) point out, Lucas showed that the public's expectations about the future, including expectations about future policy actions, change when policies change, and hence stabilisation policy takes on elements of a strategic game. While Lucas thus provided a technical explanation for why activist policy is counterproductive, Bernanke et al. (1999) point to a more simple reason: monetary policy works with long and variable lags, as observed by Friedman, while the public and politicians (and politically influenced central bankers) in modern democracies tend to take a myopic view of public policy issues. The result of the interaction of long policy lags and short political horizons, they point out, is that over-manipulation of the levers of monetary policy to achieve politically popular goals in the short-run, such as high employment, may lead to the economy overheating in the longer term, and hence high inflation, thus necessitating another sharp policy shift. The ultimate result is economic instability, as they explain.

From a theoretical standpoint, another blow to activist policy was dealt by Friedman's 'natural rate' hypothesis about output and employment and similar arguments by Edmund Phelps, as Bernanke et al. (1999) explain. As they explain, Friedman criticised the Phillips curve tradeoff although he agreed that higher inflation might stimulate the economy for short periods, given that, if wages are fixed by contract and if prices rise unexpectedly, profit margins increase giving firms an incentive to produce more goods and services. However, he pointed out that workers are no more likely than firms to ignore their economic interests, and will demand wage increases to compensate for their lost buying power. Therefore, profit margins of firms and their rate of production will return to their normal or 'natural' levels. He thus argued that there is no long-run tradeoff between unemployment and inflation and, if there is such a relationship, he pointed out that "… it goes the "wrong " way: Because inflation inhibits economic growth and efficiency, an increase in inflation may in fact lead to slightly higher (rather than lower) unemployment in the long run." (Bernanke et al., 1999, p. 14) Bernanke et al. (1999) stress this point by pointing out that the benefits of inflation are transitory while the costs of inflation are permanent, absent any countervailing policy. It is perhaps pertinent at this point to mention that, as Barro and Sala-i-Martin (2004) explain, current literature on growth highlight real variables such as (improvements in) technology, as the key determinants of long-run growth.

From a theoretical perspective, a further challenge to activist policy was posed by the 'policy credibility problem' (the time inconsistency problem) analysed by Kydland and Prescott (1977) and Barro and Gordon (1983), which suggests that, "… activist central banks, no matter how much they declare their intention to keep inflation low, will be over-expansionist and hence inflation-prone in practice. As the public comes to understand and anticipate this behaviour, higher inflation will become ingrained in the system, without any compensating increase in output or employment." (Bernanke et. al, 1999, p. 15)

Both empirical and theoretical developments discussed above played an important role in many central banks moving away from activist policy and adopting long-run price stability as the primary goal of monetary policy. Meanwhile, another key development by the early 1990s was that, with the rapid progress of the financial system, the relationship between monetary aggregates and goal variables such as nominal income and inflation, became increasingly unstable in many industrialised countries. As Lim and Subramanian (2003) point out, for example, demand for traditional money assets (such as notes and coins and demand, savings and time deposits) tend to fall as money holders shift to new assets or nonmonetary assets with higher yields, with the development of new payment methods, which render some of them highly liquid. For example, in the USA, by the early 1990s, while high yielding bond and equity mutual funds were popular, as they explain, people could transfer funds easily and speedily among different assets, following the developments in telecommunication and computer technology. Financial deregulation also played a part in this respect. For example, as Guttman (2005) explains, financial deregulation together with the effects of financial innovation made it virtually impossible to discern the implications of a given rate of money growth for economic activity in Australia. The USA and Australia were both monetary targeting countries since the mid-1970s, but had abandoned monetary targeting by the early 1990s, and Australia adopted inflation targeting in 1993. The inability of any monetary aggregate to serve as a reliable indicator of aggregate demand and inflation was chief amongst the reasons for some central banks adopting inflation targeting in place of monetary targeting.

C. Monetary Targeting

As Griffiths and Wood (1981) point out, monetary targeting, that is, the adoption of quantitative targets for the rate of growth of the money supply as the basis of monetary policy, began in the 1970s in industrialised countries. Monetary targeting was adopted as a mechanism to bring the chronic high inflation and fluctuations in output at the time under control, as controlling interest rates and credit conditions, which had up to then been the practice, had failed in this regard.

In explaining the framework within which monetary targeting operates, they point out that, Thomas Saving, who formalised the dictionary of monetary policy, had argued that what monetary authorities are concerned with can be divided into four categories: "First, there are *instruments*-variables directly controllable by the monetary authorities. Second, are *indicators*-these provide preliminary information to the authorities (and, in general also to the private sector) about the stance of policy. Third, are *proximate objectives*-variables which give an early and unambiguous indication of the way in which *ultimate objectives*, the fourth category, will actually move." (Griffiths and Wood, 1981, p. 3) They further go on to say that '*targets'* are, according to Saving, another name for proximate objectives. In terms of this terminology, within a monetary targeting framework[6], the 'ultimate objective' would be a desirable rate of inflation; the principal 'indicator' would be a broadly defined monetary aggregate, that is, a measure of money supply, which reflects the movements of aggregate demand and inflation; the 'target' would be a narrowly defined monetary aggregate such as base money (currency issued by the central bank and held by the public plus commercial banks' deposits with the central bank), which is linked to the broader monetary aggregate chosen as the 'indicator', that link being the velocity with which money changes hands in the economy[7]; while policy interest rates and open market operations, which are conducted with the aim of maintaining market liquidity at appropriate levels, are amongst the key 'instruments' used by central banks.

Meanwhile, Mishkin (2000), who examines monetary targeting and inflation targeting, which he describes as two basic strategies that a central bank which chooses to have an independent domestic monetary policy could choose between; defines monetary targeting in terms of three 'elements': "1) reliance on information conveyed by a monetary aggregate to conduct monetary policy, 2) announcement of targets for monetary aggregates, and 3) some accountability mechanism to preclude large and systematic deviations from the monetary targets." (Mishkin, 2000, p. 1) In this context, the Central Bank of Sri Lanka, a monetary targeting central bank, derives information conveyed by the most broadly defined monetary aggregate for Sri Lanka, 'M_{2b}' (defined as the sum of currency, demand deposits, and some types of savings and time deposits), and its components; announces targets for this monetary aggregate and its key components (from the perspective of the sources of money supply); while the Monetary Law Act, under which the Bank was established, stipulates that[8], if the money supply (M_{2b}) increases or decreases by more than fifteen per cent (or if the cost of living index increases by more than ten per cent) in any month, from the level in the corresponding

[6] Monetary targeting is explained in terms of Saving's terminology in the context of the practices of the Central Bank of Sri Lanka as explained in its website (http://www.cbsl.gov.lk /info/ 04_mp/m_2.htm#3).
[7] As evident from the analysis by Lim and Subramanian (2003), the basis for monetary targeting is the equation of exchange: Money * Money's Velocity = Price level * Real GDP.
[8] Under Section 64 of the Monetary Law Act, posted on the web site of the Central Bank of Sri Lanka (http://www.cbsl.gov.lk).

month of the previous year, the Monetary Board (the governing body of the Bank) should, having taken the appropriate policy action, submit a detailed report to the Minister in charge of the subject of Finance, outlining the conditions leading to the movements in the money supply (or the cost of living index), the effects of the movements in the money supply (or the cost of living index) on the economy, the measures already taken by the Monetary Board as well as those it intends to take, and the measures it recommends for adoption by the government.

As is apparent from the above discussion, monetary targeting differs significantly from inflation targeting, although both frameworks for monetary policy have as the ultimate objective, price stability. Indeed, within an inflation targeting framework too, monetary aggregates would be considered important information variables.

D. Benefits of Price Stability

Given that many central banks have redefined the objective of monetary policy to be long-run price stability, that is, low and stable inflation, during the last decade or so, it seems relevant, at this point, to examine the benefits accruing from price stability. It is easiest to understand the benefits of price stability in terms of the costs of high inflation. Obstfeld and Rogoff (1996) point to several social costs of high inflation. As they point out, higher anticipated inflation (in countries where inflation tends to be high and thus becomes ingrained) reduces the demand for money. But, as they explain, it costs virtually nothing to produce money while money yields liquidity services. With respect to unanticipated inflation they state: "Higher unexpected inflation sharpens random income redistributions, degrades the allocation signals in relative prices, and raises the distortions a nonindexed tax system inflicts. In practice, the latter costs probably dwarf the liquidity cost of expected inflation." (Obstfeld and Rogoff, 1996, p. 636)

Bernanke et al. (1999) also point to costs of inflation, in the context of the importance of low inflation for economic efficiency and growth: "… over-expansion of the financial system, as individuals and businesses devote more and more of their resources to avoiding the effects of inflation on their cash holdings; an increased susceptibility to financial crisis, as difficulties in adjusting to high inflation make the financial system more fragile; poor functioning of product and labour markets, as prices become noisy measures of the relative economic values of goods and services; the costs of frequent re-pricing, along with the costs of monitoring the prices of suppliers and competitors; and distributional effects, often including the destruction of the middle class (much of whose savings become worthless), with the associated social consequences." (Bernanke et al., 1999, p. 16)

Fischer (1993) also notes that uncertainty about the macroeconomy arising from high inflation reduces growth by reducing productivity and the rate of investment. He adds: "Capital flight, which is likely to increase with domestic instability, provides another mechanism through which macroeconomic uncertainty reduces investment in the domestic economy." (Fischer, 1993, P. 6) He further adds that distorted foreign exchange markets, as reflected in a large foreign exchange market premium (in times of high inflation), are bad for growth. He concludes: "… evidence ... supports the conventional view that a stable macroeconomic environment, meaning a reasonably low rate of inflation and a small budget deficit, is conducive to sustained economic growth." (Fischer, 1993, P. 23)

E. Criticisms of Inflation Targeting

Benjamin Friedman (2004), who puts forward arguments for why the Federal Reserve System of the USA should not adopt inflation targeting, is very critical of inflation targeting. For example, he states that inflation targeting central banks exhibit 'anti-transparency', contrary to the commonly accepted view that inflation targeting central banks are highly transparent. Stating that this is most explicit in the inflation targeting framework suggested by Svensson (1997), he explains that, in the case of an inflation targeting central bank, while the decision as to how rapidly inflation should be brought back to the desired rate after some departure from it depends on the strength of the central bank's preferences with respect to inflation vis-à-vis its other objectives, it is not common for inflation targeting central banks to be explicit about the level of output or employment that they regard as desirable or the weights they attach to such objectives. In this regard, it is pertinent to point out that Svensson (2005) in fact states that "inflation-targeting central banks can make substantial additional progress by being more specific, systematic, and transparent about their operational objectives (in the form of using an explicit intertemporal loss function), their forecasts …, and their communication (in the form of announcing optimal projections of the instrument rate and target variables)." (Svensson, 2005, Abstract)

Meanwhile a study by Ball and Sheridan (2003) suggests that no major benefits have occurred so far from inflation targeting, in terms of both inflation variability and the rate of inflation. Their finding is based on an econometric study in which they compare inflation in targeting and non-targeting countries, by controlling for regression to the mean. However, the discussant of their paper has commented that this study might be prone to some problems such as multicollinearity, which makes their conclusions somewhat questionable.

Also, some writers point out that non-inflation targeting central banks such as the US Federal Reserve, under Chairmen Volcker and Greenspan, and Germany's Deutsche Bundesbank, have performed exceptionally well in terms of price stability. However, in relation to monetary targeting countries, Mishkin (2000) states that the special conditions in Germany, which have made monetary targeting work well, are unlikely to be satisfied elsewhere. With respect to the USA, Bernanke (2003), in a speech he made, states that, by moving further in the direction of inflation targeting, the Federal Reserve would be able to lock in the gains already made in relation to price stability (credibility for maintaining low and stable inflation, and anchoring of inflation expectations, i.e., the public continues to expect low and stable inflation even if actual inflation temporarily deviates from its expected inflation).

F. Empirical Evidence in Favour of Inflation Targeting

Beginning in the early 1990s, New Zealand, Canada, the United Kingdom, Sweden, Finland, Australia and Spain, all of which are advanced economies, shifted to inflation targeting, a new monetary policy regime at the time. Thereafter a number of other countries shifted to inflation targeting, amongst which were South Korea, a newly industrialised country, as well as emerging market economies such as Brazil, Chile, Mexico, Israel, South Africa, the Philippines and Thailand. Several transition economies such as the Czech Republic, Hungary and Poland also later adopted this policy framework. Bernanke (2003), in a speech made by him, states that, up to then, all central banks, which had adopted inflation targeting had been pleased with the results they have obtained and that none of them had abandoned the approach.

Explaining the experience of the United Kingdom under inflation targeting, King (2003) states: “Only since 1992 has inflation been consistently below 4 per cent, and in fact it has averaged a fraction under 2.5 per cent of our target for the past ten years, with growth averaging 2.5 per cent a year and a little above the historical trend.” (King, 2003, p. 11) He attributes this success partly to the fact that inflation expectations have been brought down in the United Kingdom, as measured by bond yields, index-linked versus-conventional yields as well as surveys of inflation expectations. He also goes on to state that the Bank of England is therefore not worried that an inflation shock would lead immediately to an upward or downward revision of inflation expectations, “… feeding through very quickly as it might have done before into … wage bargaining, and then prices.” (King, 2003, p. 13) Findings by Gurkaynak et al. (2006), who compare the behaviour of daily bond yield data in the United Kingdom and Sweden, both inflation targeters, to that in the United States, a non-inflation targeter, support King’s statement: “In the U.S., we find that forward inflation compensation exhibits highly significant responses to economic news. In the U.K., we find a level of sensitivity similar to that in the U.S. prior to the Bank of England gaining independence in 1997, but a striking absence of such sensitivity since the central bank became independent.” (Gurkaynak et al., 2006, Abstract)

Mishkin (2000) points to the success of inflation targeting in Australia, where inflation has been near the 2-3 per cent target since its inception. He also underlines the fact that Australia’s monetary policy performed well in response to the East Asian crisis of 1997. Having recognised that it faced a substantial negative terms of trade shock given that a large share of Australia’s foreign trade is conducted with the Asian region, the Reserve Bank of Australia had decided not to fight the inevitable depreciation of the Australian dollar. Instead, its policy stance was eased to prevent an undershooting of the inflation target. As a consequence, real output growth remained strong in Australia throughout the period of the crisis, as Mishkin points out.

Cukierman (2003) meanwhile finds that the announcement of inflation targets has a more potent effect on expectations than the announcement of monetary targets in terms of base money, for instance, because the latter is less visible. However, he stresses that this does not necessarily imply that inflation targeting is superior.

G. Conclusions from the Review of Literature

Literature suggests that inflation targeting is a favourable framework for monetary policy in any country. However, monetary targeting, if implemented with seriousness in countries where the relationship between monetary aggregates and inflation is stable, could also deliver price stability, as Germany has demonstrated.

III. The Analytical Framework

A. Average Inflation and Volatility of Inflation

In order to establish whether an inflation targeting framework for monetary policy does in fact deliver superior results with respect to inflation, first, data on inflation, that is, the average rate of inflation as well as volatility (the standard deviation) of inflation would be examined graphically. This analysis is in relation to fifteen inflation targeting countries that shifted into an inflation targeting regime in or before 2001 and thirty randomly selected non-inflation targeting countries. Non-inflation targeting countries include both monetary targeting (15) as well as other (15) countries. ‘Other’ countries are those that monitor various indicators (including monetary aggregates) in conducting monetary policy and do not necessarily have an explicitly stated nominal anchor. The classification of countries into ‘inflation targeting’, ‘monetary targeting’ and ‘other’ is in accordance with the classification in the draft ‘Quarterly Report on Exchange Arrangements’ of the International Monetary Fund (IMF) for April-July 2006 (pp. 5-6).

Monthly data pertaining to year-on-year inflation used in this regard are from the International Financial Statistics of the IMF. Monthly data for all countries considered are from January 2002 to December 2006 (five years). Countries which have experienced hyper inflation (e.g. Zambia, classified as monetary targeting, and is known to have inflation of more than a thousand per cent currently and Angola, classified as ‘other’ and had inflation of more than a hundred per cent, year-on-year, in 2002 and 2003) or deflation (e.g., Japan, classified as ‘other’) during this period were omitted from the analysis. Some industrialised countries, which shifted to an inflation targeting regime before 2001 (e.g. New Zealand and Australia) have not been taken into consideration, but these countries have experienced benign inflation comparable with that of industrialised countries, which have been included for analysis.

B. Model I

Second, Model I discussed below would be estimated using the generalised method of moments (GMM) and the method of ordinary least squares (OLS) to identify the preferences of the Central Bank of Sri Lanka in relation to inflation and output during the period from January 2002 to June 2007. The purpose of estimating this model is to identify whether the preferences of the Central Bank of Sri Lanka are in fact in line with its objective in relation to monetary policy, that is, price stability[9]. If this is not the case, it is an indication of monetary targeting central banks' ability to diverge from their objective in respect of monetary policy for significant periods of time without any serious adverse consequences for the continuation of the particular monetary policy regime, i.e., monetary targeting, unlike in the case of inflation targeting central banks.

Model I of this paper adopts the framework developed by Brzozowski (2004) presented below, given its relevance for Sri Lanka. Brzozowski (2004) examines monetary policy in Poland, an inflation targeting country since 2000, by estimating the parameters of the optimal reaction function that he derives for the National Bank of Poland. His objective is to identify the preferences of the National Bank of Poland with respect to inflation and output and any shifts in the weights it attaches to inflation vis-à-vis output. The reaction function he derives is in the form of an implicit instrument rule expressed in terms of a short-term nominal interest rate, the main instrument of monetary policy in Poland. Although the monetary policy reaction function he derives is in the form of an implicit instrument rule, he stresses that the analytical framework of his paper does not require the National Bank of Poland to commit to this rule, but rather it describes the optimal reaction of the Bank in terms of the interest rate time path.

Model I posits that the objective of monetary policy is to minimise the expected value of a loss function of the form:

$$W = E_t [\Sigma^{\infty}_{t=0} \ \beta^t L_t] \qquad (1)$$

where $0< \beta <1$, and denotes the discount factor.
The loss each period is given by:

$$L_t= \tfrac{1}{2} [(\pi_t - \pi^*)^2 +\lambda_x (x_t – x^*)^2 +\lambda_i (i_t – i^*)^2 + \lambda_q (q_t – q^*)^2] \qquad (2)$$

In equation 2 above, π_t denotes inflation in time t, x_t refers to the output gap in time t, that is, $x_t = y_t – y_t^p$ (y_t denotes output and y_t^p denotes potential output); i_t refers to the nominal interest rate in time t (it represents the central bank's policy interest rate), and q_t denotes the real effective exchange rate (REER) in time t (with a higher q_t

[9] The objectives of the Central Bank of Sri Lanka are: (a) economic and price stability; and (b) financial system stability. Economic stability requires both price stability and financial system stability.

implying an appreciation of the currency). In the above loss function, π^*, x^*, i^* and q^* refer to the targeted levels of the respective variables. The weight assigned by the central bank to inflation has been normalised to 1. The coefficients λ_x, λ_i, $\lambda_q > 0$ denote the weights assigned by the central bank to the deviation of the output gap, the nominal interest rate and the real exchange rate, respectively, from their targeted levels.

The first and the second terms of equation 2, as Brzozowski (2004) points out, are standard components of a central bank's loss function and represent its price stability and output stabilisation objectives. The third term reflects its interest rate stabilisation objective, given that high nominal interest rates tend to create distortions in financial markets while a zero nominal interest rate implies limited ability to respond to deflationary shocks. The fourth term in the equation represents the central bank's objective of stabilising the real exchange rate. In Sri Lanka's context, inclusion of this objective is important, given that the central bank has intervened in the past in the foreign exchange market to stabilise the exchange rate vis-à-vis the Sri Lanka rupee, both during times when the currency was under severe pressure to depreciate (e.g. with the recent sharp increase in oil prices and the consequent impact on the import bill) as well as when it tended to appreciate significantly (e.g., August - October 2003 and early 2005, in view of expected large inflows of foreign aid).

The following three equations describe the macroeconomic environment in which the central bank operates in deciding on its optimal policy.

First, the aggregate demand or IS curve is given by:

$$x_t = E_t\, x_{t+1} - \sigma\, E_t\,(i_t - \pi_{t+1}) - \delta q_t \qquad (3)$$

where $\delta > 0$.

Second, on the basis of the simplistic assumption of uncovered interest parity, the following equation describes the behaviour of the real effective exchange rate:

$$q_t = \theta\, E_t\,(i_t - \pi_{t+1}) \qquad (4)$$

where $\theta > 0$.

Third, the aggregate supply curve is given by the following New Keynesian Phillips curve. The basis for this aggregate supply curve is the assumption of staggered nominal price setting behaviour of optimising firms; in particular, it is based on the assumption of Calvo pricing. The aggregate supply curve accordingly relates current inflation to expected future inflation and a measure of current real activity.

$$\pi_t = \kappa\, x_t + \beta E_t \pi_{t+1} \qquad (5)$$

Given the macroeconomic environment described by the above equations, the central bank's problem is to choose π_t, x_t, i_t and q_t to minimise the expected value of its loss function subject to equations 3, 4 and 5. The Lagrangian for this problem can be written as follows.

$$L = E_t \Sigma^{\propto}_{t=0}\ \beta^t \{ \tfrac{1}{2} [(\pi_t - \pi^*)^2 + \lambda_x (x_t - x^*)^2 + \lambda_i (i_t - i^*)^2 + \lambda_q (q_t - q^*)^2]$$
$$+ \varphi_{1t} [x_t - x_{t+1} + \sigma (i_t - \pi_{t+1}) + \delta q_t]$$
$$+ \varphi_{2t} [\pi_t - \kappa x_t - \beta\pi_{t+1}]$$
$$+ \varphi_t [q_t - \theta (i_t - \pi_{t+1})]\} \qquad (6)$$

This optimisation problem can be solved using the law of iterated expectations. While equation 6 goes from t = 0 to t = ∝, for t = t - 1 and t = t, it can be written as follows (the terms in equation 6 relating to other periods 't' remain in the equation but are not written below, as they are not required for obtaining the relevant equations in the model).

$$L = E_{t-1}\ \beta^{t-1} \{ \tfrac{1}{2} [(\pi_{t-1} - \pi^*)^2 + \lambda_x (x_{t-1} - x^*)^2 + \lambda_i (i_{t-1} - i^*)^2 + \lambda_q (q_{t-1} - q^*)^2]$$
$$+ \varphi_{1t-1} [x_{t-1} - x_t + \sigma (i_{t-1} - \pi_t) + \delta q_{t-1}]$$
$$+ \varphi_{2t-1} [\pi_{t-1} - \kappa x_{t-1} - \beta\pi_t]$$
$$+ \varphi_{3\,t-1} [q_{t-1} - \theta (i_{t-1} - \pi_t)]\}$$
$$+ E_t\ \beta^t \{ \tfrac{1}{2} [(\pi_t - \pi^*)^2 + \lambda_x (x_t - x^*)^2 + \lambda_i (i_t - i^*)^2 + \lambda_q (q_t - q^*)^2]$$
$$+ \varphi_{1t} [x_t - x_{t+1} + \sigma (i_t - \pi_{t+1}) + \delta q_t]$$
$$+ \varphi_{2t} [\pi_t - \kappa x_t + \beta\pi_{t+1}]$$
$$+ \varphi_{3\,t} [q_t - \theta (i_t - \pi_{t+1})]\} + \ldots \qquad (7)$$

Differentiating equation 7 with respect to π_t gives the following first order condition.

$$\beta^{t-1} \{\varphi_{1t-1} [-\sigma] + \varphi_{2t-1} [-\beta] + \varphi_{3\,t-1} [\theta]\} + \beta^t \{[(\pi_t - \pi^*) + \varphi_{2t}]\} = 0 \qquad (8)$$

Dividing equation 8 by β^t results in the following equation.

$$\beta^{-1} \{\varphi_{1t-1} [-\sigma] + \varphi_{2t-1} [-\beta] + \varphi_{3\,t-1} [\theta]\} + \{[(\pi_t - \pi^*) + \varphi_{2t}]\} = 0$$

Rearranging terms in the above equation gives equation 9.

$$(\pi_t - \pi^*) - \beta^{-1} \sigma\, \varphi_{1t-1} + \varphi_{2\,t} - \varphi_{2t-1} + \beta^{-1}\theta\, \varphi_{3\,t-1} = 0 \qquad (9)$$

Differentiating equation 7 with respect to x_t gives the following first order condition.

$$-\beta^{t-1}\varphi_{1t-1} + \beta^t[\lambda_x(x_t - x^*) + \varphi_{1t} + \varphi_{2t}(-\kappa)] = 0 \tag{10}$$

Dividing equation 10 by β^t and rearranging terms gives the following equation.

$$\lambda_x(x_t - x^*) + \varphi_{1t} - \beta^{-1}\varphi_{1t-1} + \varphi_{2t}(-\kappa) = 0 \tag{11}$$

Differentiating equation 7 with respect to i_t gives the following first order condition.

$$\beta^t[\lambda_i(i_t - i^*) + \varphi_{1t}\ \sigma - \varphi_{3t}\theta] = 0 \tag{12}$$

Dividing equation 12 by β^t gives equation 13.

$$\lambda_i(i_t - i^*) + \sigma\varphi_{1t} - \theta\varphi_{3t} = 0 \tag{13}$$

Differentiating equation 7 with respect to q_t gives the following first order condition.

$$\beta^t[\lambda_q(q_t - q^*) + \varphi_{1t}\delta + \varphi_{3t}] = 0 \tag{14}$$

Dividing equation 14 by β^t gives equation 15.

$$\lambda_q(q_t - q^*) + \delta\varphi_{1t} + \varphi_{3t} = 0 \tag{15}$$

Next, it is necessary to solve for the three Lagrange multipliers as follows.

Equations 13 and 15 are used to solve for φ_{1t} and φ_{3t}.

Multiplying equation 15 by θ gives:

$$\lambda_q\theta(q_t - q^*) + \delta\theta\varphi_{1t} + \theta\varphi_{3t} = 0 \tag{16}$$

Adding equations 13 and 16 and solving for φ_{1t} gives:

$$\varphi_{1t} = \frac{-[\lambda_i(i_t - i^*) + \lambda_q\theta(q_t - q^*)]}{(\sigma + \delta\theta)}$$

Solving for φ_{3t}:

Multiplying equation 13 by δ and equation 15 by σ give:

$$\lambda_i \delta (i_t - i^*) + \sigma \delta\varphi_{1t} - \theta\delta \varphi_{3t} = 0 \tag{17}$$

$$\lambda_q \sigma (q_t - q^*) + \delta \sigma \varphi_{1t} + \sigma \varphi_{3t} = 0 \tag{18}$$

Deducting equation 18 from equation 17 and solving for φ_{3t} gives:

$$\varphi_{3t} = \frac{\lambda_i \delta (i_t - i^*) - \lambda_q \sigma (q_t - q^*)}{(\sigma + \delta\theta)}$$

Equation 11, which is repeated below, is used to solve for $\varphi_{2t.}$

$$\lambda_x (x_t - x^*) + \varphi_{1t} - \beta^{-1} \varphi_{1t-1} + \varphi_{2t} (-\kappa) = 0 \tag{11}$$

Hence, $\kappa \varphi_{2t} = \lambda_x (x_t - x^*) + \varphi_{1t} - \beta^{-1} \varphi_{1t-1}$

Substituting φ_{1t} and φ_{1t} lagged one period (i.e., φ_{1t-1}), φ_{2t} could be derived as follows.

$$\varphi_{2t} = \frac{\lambda_x (x_t - x^*)}{\kappa} - \frac{[\lambda_i (i_t - i^*) + \lambda_q\theta (q_t - q^*)]}{\kappa (\sigma + \delta\theta)} + \frac{\beta^{-1}[\lambda_i (i_{t-1} - i^*) + \lambda_q\theta (q_{t-1} - q^*)]}{\kappa (\sigma + \delta\theta)}$$

Solutions for φ_{1t}, φ_{2t}, and φ_{3t} are substituted in equation 9, in order to obtain the implicit instrument rule of the central bank in terms of i_t, which gives equation 19 below.

$$(\pi_t - \pi^*) + \beta^{-1}\sigma \frac{[\lambda_i (i_{t-1} - i^*) + \lambda_q \theta (q_{t-1} - q^*)]}{(\sigma + \delta\theta)}$$

$$+ \frac{\lambda_x (x_t - x^*)}{\kappa} - \frac{[\lambda_i (i_t - i^*) + \lambda_q\theta (q_t - q^*)]}{\kappa(\sigma + \delta\theta)} + \frac{\beta^{-1}[\lambda_i (i_{t-1} - i^*) + \lambda_q\theta (q_{t-1} - q^*)]}{\kappa(\sigma + \delta\theta)}$$

$$- \frac{\lambda_x (x_{t-1} - x^*)}{\kappa} + \frac{[\lambda_i (i_{t-1} - i^*) + \lambda_q\theta (q_{t-1} - q^*)]}{\kappa(\sigma + \delta\theta)}$$

$$- \frac{\beta^{-1}[\lambda_i (i_{t-2} - i^*) + \lambda_q\theta (q_{t-2} - q^*)]}{\kappa(\sigma + \delta\theta)} + \frac{\beta^{-1}\theta [\lambda_i \delta (i_{t-1} - i^*) - \lambda_q \sigma (q_{t-1} - q^*)]}{\kappa(\sigma + \delta\theta)} = 0 \quad (19)$$

There is only one term involving i_t in equation 19, i.e., $\lambda_i (i_t) / \kappa(\sigma + \delta\theta)$, which, by taking to the right hand side of equation 19, we can solve for i_t.

Hence, $i_t = \frac{\kappa(\sigma + \delta\theta)}{\lambda_i} * \{\text{other terms in equation 19}\}$

The term: $\frac{\kappa(\sigma + \delta\theta)}{\lambda_i} > 0$ is denoted as A in the expression for i_t below.

Accordingly, following some simplification and rearrangement of terms appearing in equation 19, the expression for i_t, the implicit instrument rule, is as follows.

$$i_t = -A[\pi^* + \frac{\lambda_i}{\beta} i^*] + [1 + A\frac{\lambda_i}{\beta}]\, i_{t-1} + \frac{1}{\beta}\Delta i_{t-1} + A\,\pi_t + A\frac{\lambda_x}{\kappa}\Delta x_t + - B\,\Delta q_t + B\frac{1}{\beta}\Delta q_{t-1} \quad (20)$$

where $B = \frac{\theta \lambda_q}{\lambda_i} > 0$

Equation 20 describes the optimal reaction of the central bank in terms of the interest rate time path, to the inflation rate, the changes in the output gap and the real exchange rate.

Accordingly, it is assumed that the central bank's monetary policy reaction function can be described by:

$$i_t = \rho_0 + \rho_1 \, i_{t-1} + \rho_2 \, \Delta \, i_{t-1} + \rho_3 \, \pi_t + \rho_4 \, \Delta x_t + \rho_5 \, \Delta q_t + \rho_6 \, \Delta q_{t-1} + \varepsilon_t \qquad (21)$$

where ε_t is the error term.

Solving for λ_x reveals that the relative importance or the weight that the central bank attaches to output gap stabilisation (compared to the weight of 1 assigned to inflation stabilisation) is given by:

$$\lambda_x = \kappa\rho_4 / \rho_3$$

where κ is the coefficient on the output gap in the supply curve.

To obtain a numerical value for κ, the generalised method of moments (GMM) will be used to estimate the forward-looking New Keynesian Phillips curve (equation 5). The orthogonality condition that forms the basis for estimating equation 5 via GMM is given by:

$$E_t \, [\, \pi_t - \kappa \, x_t - \beta \, \pi_{t+1} \mid z_t \,] = 0$$

The numerical values of ρ_4 and ρ_3 will be obtained by estimating equation 21 above using the method of ordinary least squares (OLS).

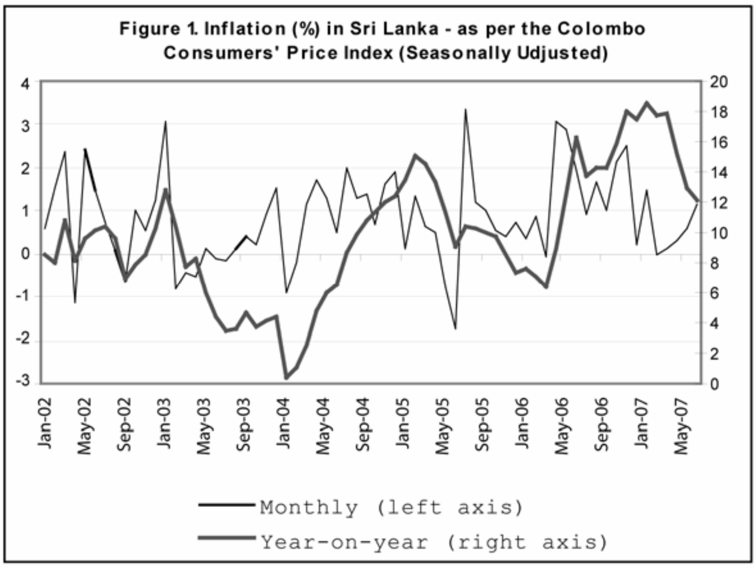
Monthly data pertaining to Sri Lanka used to estimate equations 5 and 21 are for the period from January 2002 to June 2007.[10] All data series excepting the interest rate and the real effective exchange rate are in logarithms and seasonally adjusted. All time-series excepting the interest rate (91-day Treasury bill yield, which is the proxy variable for the policy interest rate of the central bank given that it is considered a

[10] Until January 2001, the exchange rate was also an anchor of monetary policy. Interest rates were gradually brought down throughout 2001, having been raised to defend the crawling peg exchange regime until 23 January 2001, when the Sri Lanka rupee was floated. Years 2000 & 2001 therefore are not 'normal' years in relation to monetary policy.

reference rate by financial market participants in Sri Lanka) were found to be integrated of order 1. The interest rate is I(0). The results of the unit root tests are given in the Appendix. The industrial production volume index for Sri Lanka, computed on a monthly basis, is used as a proxy for output, i.e., real gross domestic product (GDP), given that data on GDP is available on a quarterly basis. The output gap was calculated as the percentage deviation of output from the potential output, which was calculated using the Hodrick-Prescott filter. Consumer price inflation is calculated on the basis of the Colombo Consumers' Price Index (CCPI), the official price index for Sri Lanka. Since a producer price index is not available for Sri Lanka, the wholesale price index for intermediate goods, which tracks the wholesale prices of a large number of intermediate goods used in the industrial and agricultural sectors was used as a proxy for the producer price index.

In estimating the aggregate supply curve using the generalised method of moments, the instruments included are a constant, the lags 1-8 of the output gap (the shortest lag length giving statistically significant results) and lags 1-2 of monthly consumer price inflation (denoted by π_t in the model) and monthly producer price inflation (π^{PPI}). In estimating the implicit instrument rule (equation 21), two dummies were included to test the hypothesis of instability of regression coefficients during the period under consideration due to shifts in the weights that the central bank assigns to inflation and output. Figure 1 below clearly suggests that there is a trend increase in inflation since 2004. Theory of political business cycles also suggests that inflation tends to be high when a leftist or socialist party is in office, while output also tends to be high during the early years of the socialist government's term in office[11]. In Sri Lanka, there was a change of government in April 2004. The present government elected in April 2004 had the support of leftist parties and is commonly considered a socialist government, while the political party in office from December 2001 to April 2004 is widely perceived as being 'capitalistic'. Accordingly, the first dummy ($D \cdot \Delta\pi_t$) takes on the value 0 multiplied by inflation during the period from January 2002 - April 2004, and 1 multiplied by inflation during May 2004 - June 2007. The second dummy ($D \cdot \Delta x_t$) was constructed in the same way but with the output gap in place of inflation.

[11] Sri Lanka's real gross domestic product grew by 4.0 per cent, 6.0 per cent, 5.4 per cent, 6.0 per cent and 7.4 per cent, respectively, in the years 2002 –2006



C. Model II

Model II is a less theoretical, vector error correction model (VECM[12]) estimated for Sri Lanka. Granger causality tests[13] indicate that the money supply (M_2, which is the sum of currency and rupee denominated, demand deposits and some types of savings and time deposits held by the public) Granger causes the interest rate (91-day Treasury bill yield, which is a good proxy for the policy interest rate of the central bank), which suggests that the monetary authority does react to changes in the money supply by way of controlling inflation, which is the case in a monetary targeting regime. Hence M_2 could be used for analysing monetary policy in Sri Lanka. Accordingly, the VECM was estimated with the following variables: money supply, price level (CCPI), output, and the average price of rice (the commodity price index included to avoid any 'price puzzle' effects and to represent supply side shocks). Again, the industrial production volume index is the proxy variable for output. The logarithms of the series (excepting the interest rate) were used, after adjusting for seasonality. A VECM was estimated given that the Johansen Test for cointegration indicated one cointegrating equation among the variables included at the 0.05 per cent significance level.

This model is estimated to assess the effectiveness of the present monetary policy regime in Sri Lanka, that is, monetary targeting. If the money supply is found to have a significant impact on the price level, it would suggest that the Central Bank of Sri Lanka could effectively control inflation through monetary targeting. Gauging the effect of the money supply on the price level is done through impulse response analysis.

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[12] See Hamilton (1994, Chapter 19, pp. 579-580) for a definition of the VECM.
[13] The null hypothesis: 'M2 does not Granger Cause 91-Day Treasury bill yield' can be rejected at a confidence level of 1%, given the test statistic of 9.20259.

IV. Analysis and Findings

A. Average Inflation and the Standard Deviation of Inflation – for Monthly Data (year-on-year) from 2002 to 2006

Figure 2. Average Monthly (Year-on-year) Inflation during the Period 2002-2006 in Selected Monetary Targeting and Inflation Targeting Countries

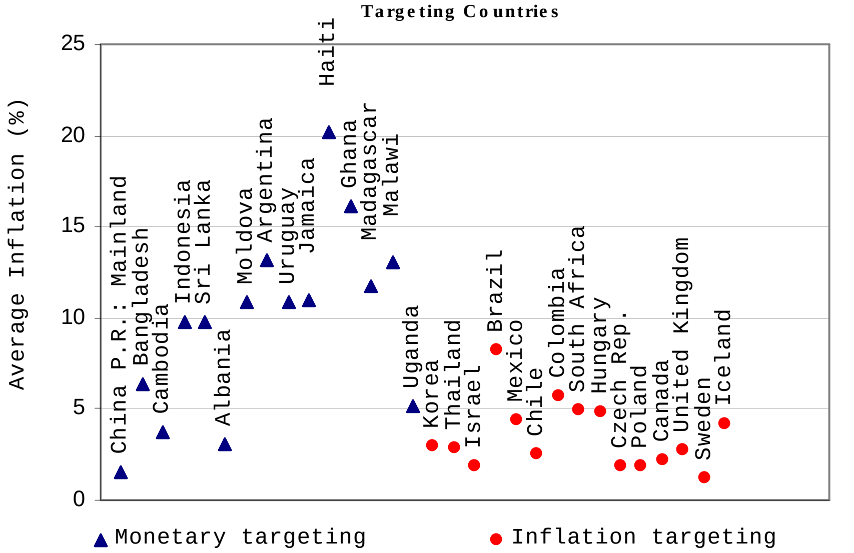


Figure 3. Standard Deviation of Monthly (Year-on-year) Inflation during the Period 2002-2006 in Selected Monetary Targeting and Inflation Targeting Countries

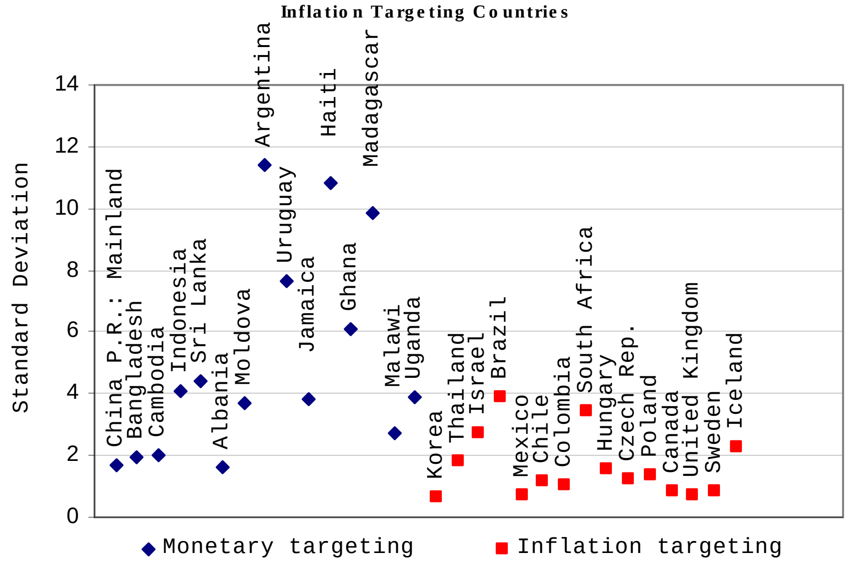


Figure 4. Average Monthly (Year-on-year) Inflation during the Period 2002-2006 in Selected Inflation Targeting and 'Other' Countries

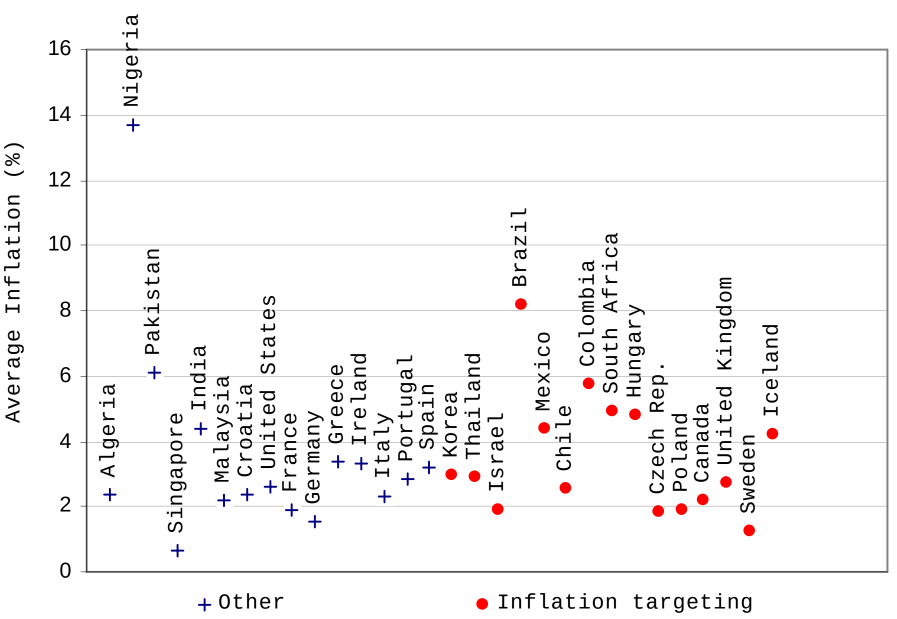
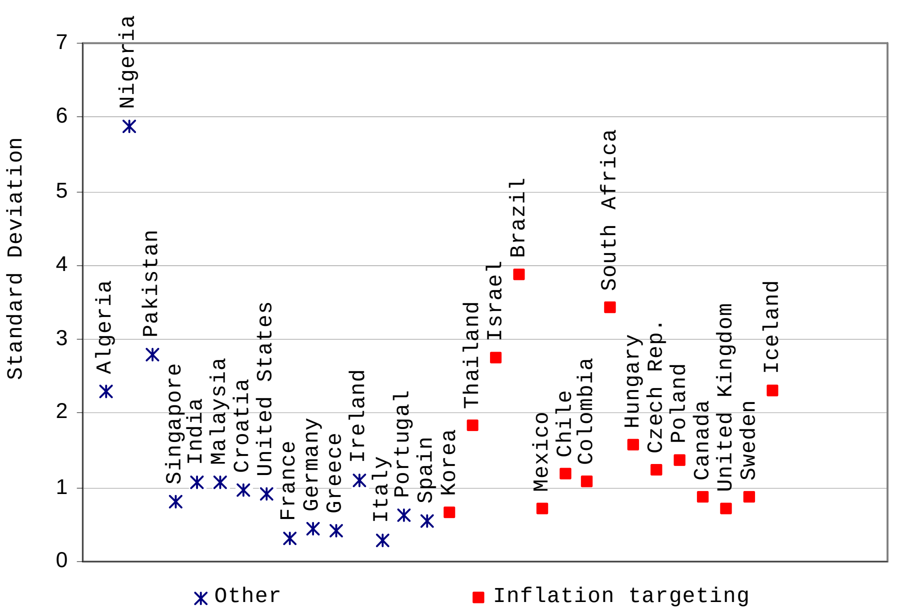


Figure 5. Standard Deviation of Monthly (Year-on-year) Inflation during the Period 2002-2006 in Selected Inflation Targeting and 'Other' Countries



Figures 2 and 3 seem to suggest that inflation targeting outperforms monetary targeting in achieving both low and stable (less volatile) inflation. Inflation targeting countries have, on average, reported lower and more stable inflation for the five year period considered: the arithmetic mean of the monthly average rates of year-on-year inflation during 2002-2006 in the fifteen monetary targeting countries is 9.7 per cent, whereas it is 3.5 per cent for the fifteen inflation targeting countries; the arithmetic mean of the standard deviations of inflation in the former group is 5 while it is 1.6 for the latter group. Sri Lanka, whose monetary policy stance will be examined in the next section, has recorded a higher rate of average inflation as well as a higher standard deviation of inflation for the five-year period considered, when compared with inflation targeting countries.

The arithmetic mean of the monthly average rates of year-on-year inflation during 2002-2006 in countries classified as 'other' however is 1.3 per cent, compared to 1.6 per cent for inflation targeting countries. The arithmetic mean of the standard deviations of inflation in the group of countries classified as 'other' is 3.5 per cent, the same as that for inflation targeting countries. Most of the countries classified as 'other' seem to have performed commendably in respect of price stability, recording both low and stable inflation.[14]

B. Model I

The estimates of the parameters of the New Keynesian Phillips curve and the optimal monetary policy reaction function derived for the Central Bank of Sri Lanka (CBSL) are given in Table 1 and Table 2, respectively. The t-statistic (in parentheses) and the level of significance (in italics) are also reported for each coefficient.

Table 1. GMM Estimates of the New Keynesian Phillips Curve

Dependent Variable:	π_t
Instruments:	Constant, $\Sigma^8_{k=1}$ x_{t-k}, $\Sigma^2_{t=1}$ π_{t-j}, $\Sigma^2_{t=1}$ π^{PPI}_{t-j}
x_t	**0.1997** (3.34) *0.12*
$E_t\ \pi_{t+1}$	**0.5986** (7.44) *0.00*

[14] As explained by von Hagen (1995), Germany, which has been classified as 'other' above, is considered by most monetary economists to be a monetary targeting country. As he further explains, Germany has aimed at an inflation rate of 2 per cent since the mid-1980s and the monetary targets are derived from this ultimate objective, which by themselves are not 'sacred'.

Table 2. OLS Estimates of the Monetary Policy Reaction Function

Dependent Variable: i_t (91-day Treasury bill yield)

	Baseline Regression	Regression with Dummies	Regression with Dummies & no Real Effective Exchange Rate terms
constant	**-0.12** (-0.47) *64.90*	**-0.23** (-0.92) *35.93*	**-0.22** (-0.89) *37.50*
i_{t-1}	**1.02***** (41.90) *0.00*	**1.03***** (42.48) *0.00*	**1.03***** (43.06) *0.00*
Δi_{t-1}	**0.40***** (3.25) *0.19*	**0.37***** (2.93) *0.49*	**0.35***** (2.80) *0.68*
π_t	**-5.07** (-0.90) *37.36*	**-13.35*** (-1.69) *9.64*	**-14.45*** (-1.99) *5.15*
Δx_t	**-3.26** (-1.24) *21.95*	**-6.12*** (-1.91) *6.05*	**-5.76*** (-1.83) *7.18*
$D \cdot \Delta\pi_t$		**14.38** (1.65) *10.37*	**14.81*** (1.73) *8.80*
$D \cdot \Delta x_t$		**8.54** (1.62) *11.10*	**8.11** (1.55) *12.61*
Δq_t	**-0.03** (-0.89) *37.66*	**-0.02** (-0.76) *45.12*	
Δq_{t-1}	**0.02** (0.73) *46.46*	**0.03** (0.92) *36.02*	
Adjusted R^2	0.97	0.97	0.91
Durbin-Watson Statistic	2.17	2.18	2.18

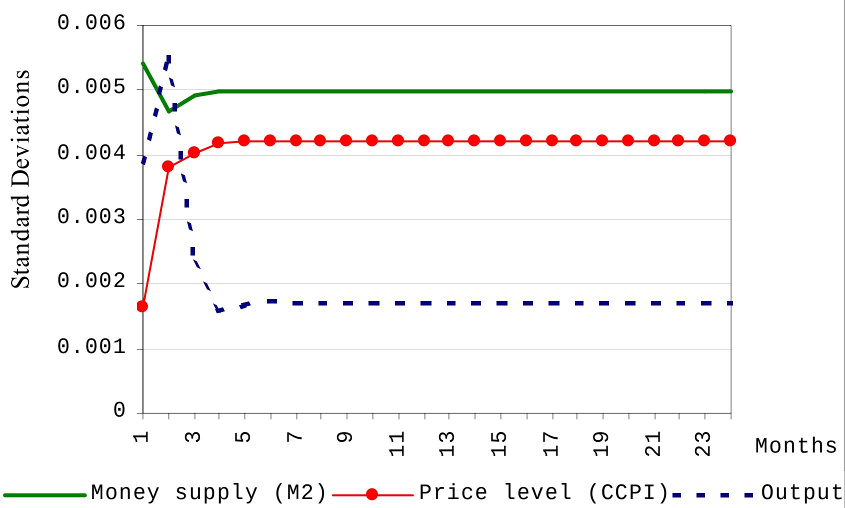
* Statistically significant at 90 per cent confidence level
** Statistically significant at 95 per cent confidence level
*** Statistically significant at 99 per cent confidence level

Given the value of 0.1997 obtained for κ, the weight that the CBSL assigns to output stabilisation (λ_x) relative to the weight of 1 it assigns to inflation stabilisation can be calculated with the estimates of ρ_3 and ρ_4 reported in Table 2. The coefficients for the period beginning May 2004 are those relating to the two dummies, while those of π_t and Δx_t relate to the period before that. Given that the coefficient of $D \cdot \Delta x_t$ is statistically insignificant at the 90 per cent confidence level, it appears that the weight on output stabilisation is zero in the latter period; lower than the weight of 0.08 in the first period. This implies that the relative weight placed on inflation has actually increased in the second period, which is inconsistent with the actual developments, that is, the increase in inflation during the second period. However, it may be that the weight that the CBSL assigns to inflation, though assumed to remain unchanged at 1 throughout the two periods in the model, may have changed from one period to the other. Meanwhile, the change in the signs of the coefficients relating to inflation from one period to the other suggests instability of structural parameters of the model. These results suggest that the implicit monetary policy reaction function derived in Model I cannot accurately describe the way in which monetary policy is implemented in Sri Lanka.

C. Model II

The estimated responses of the money supply (M_2), the price level (CCPI) and the output to a positive one-standard-deviation shock to the money supply are shown in Figure 6[15].

Figure 6. Response to a Positive One-standard-deviation Shock to the Money Supply



[15] The response of the average price of rice is not shown as it is not relevant to the analysis of the issues raised in this paper.

As shown in Figure 6, the money supply, when shocked by a positive standard deviation, which could be interpreted as an unanticipated increase, declines and thereafter adjusts, in about 5 months, to its new long-run equilibrium level. In response, the price level increases to its new long-run equilibrium level, also in about 5 months. Hence, it seems that the price level is highly responsive to changes in the money supply, implying that monetary targeting could be effectively implemented in Sri Lanka.

V. Summary and Conclusions

In the past, many central banks have shifted to new and different monetary policy regimes when doing so was likely to result in superior performance. Over the last one and a half decades or so, inflation targeting has been adopted by a number of central banks, and this number is likely to increase further. Meanwhile, eminent economists like Ben S. Bernanke, the current chairman of the US Federal Reserve, speak favourably of the adoption of inflation targeting even in relation to countries such as the USA, which already enjoy low and stable inflation. Hence, in this paper, inflation targeting was examined vis-à-vis monetary targeting, to establish whether inflation targeting could indeed be superior to monetary targeting, in improving the performance in relation to inflation in countries such as Sri Lanka, which have experienced volatile and sometimes high inflation. In particular, the conduct of monetary policy in Sri Lanka was examined, by way of examining monetary targeting regimes.

Literature on inflation targeting suggests that the more stringent accountability mechanisms which form a part of the inflation targeting framework, and the consequent higher degree of central bank independence have helped inflation targeting countries to achieve price stability. An examination of inflation in countries practising inflation targeting, monetary targeting and other methods of controlling inflation revealed that inflation targeting central banks' performance is on average superior to that of monetary targeting central banks, and ranks on par with that of central banks, which have achieved price stability through other less explicit means.

Some findings of this study in relation to Sri Lanka were not consistent with the actual developments in respect of inflation. In this regard, developing model II explicitly taking into account the possibility of the central bank's weight on inflation changing over time, could perhaps give better results, if one were to further investigate into the issues raised in this paper. However, it was found that Sri Lanka has the potential for good performance in respect of inflation within its existing monetary policy framework, that is, monetary targeting. The fact that Sri Lanka has experienced volatile and sometimes high inflation despite her ability to control inflation effectively, in fact, points to a weakness of the monetary targeting regime: its inability to ensure long run price stability. Moving to an inflation targeting regime in the medium to long run could perhaps improve monetary policy performance in Sri Lanka.

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Appendix

Results of the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Tests for the Presence of a Unit Root[16,17]

Variable	LM-Statistic for Levels	LM-Statistic for First Difference
Average Price of Rice	0.398030**	0.160314
CCPI	1.022646***	0.223145
91-day Treasury bill yield	0.330087	
Industrial Production Volume Index	1.056029***	0.396577**
M_2	0.253663***	0.099971
REER	0.441314**	0.268642
Wholesale price index for intermediate goods	1.041503***	0.248724

*** Null hypothesis: variable is stationary, is rejected at all levels of significance: 1%-10%.

** Null hypothesis: variable is stationary, is accepted at 5% significance level, rejected at 10% significance level.

Not marked by '*': null hypothesis of stationarity is accepted at all levels of significance:
1%-10%.

[16] Augmented Dickey - Fuller (ADF) test gave similar results. A constant was included in all tests; a trend was included for M_2.

[17] All data pertaining to Sri Lanka were obtained from the Central Bank of Sri Lanka.

Is the Export-Led Growth Hypothesis Valid for Sri Lanka? A Time-Series Analysis of Export-Led Growth hypothesis

W.A. Dilrukshini[1]

Abstract

This study examines the validity of the export-led growth hypothesis (ELG) for Sri Lanka using annual data over the period 1960-2005, employing time-series analysis techniques of cointegration, causality, Vector Auto Regressions (VARs) and Impulse Response Functions (IRFs). This study controls for other macroeconomic variables that might have a significant effect on export-economic growth relationship. The findings do not provide empirical support for the export-led growth hypothesis for Sri Lanka.

1. Introduction

The relationship between export growth and economic growth has long been one of the major areas concerned in the theoretical and empirical literature in international trade and development economics. These highlight the importance of export promotion to achieve higher economic growth. Early studies, cross-country as well as time-series analysis, examined the relationship between export growth and economic growth, looking at simple correlation relationships (eg: Balassa 1978, 1985, Kravis 1970). The problems of their methodology were that it does not provide the indication of directional relationships: whether export growth causes economic growth or economic growth causes export growth. Cross-country regressions, in particular, do not capture the dynamics of the relationships between export and economic growth and pay no attention to country-specific factors. Though many, particularly the neoclassical views, suggest with empirical evidences that export growth causes economic growth (i.e. the export-led growth hypothesis), there are still some, who do not believe the export-led growth hypothesis. This present study on export and economic growth employs cointegration technique and causality testing to identify the two-way directional relationships in Sri Lankan context. Moreover, VARs and IRFs are employed to examine the impact of economic shocks.

This study is different from earlier work done on Sri Lanka for mainly three reasons. First, the study tested the ELG hypothesis while controlling for other macroeconomic variables that might have a significant effect on export-economic growth relationship. Second, the study went beyond the earlier two-variable relationship

[1] The author wishes to thank Dr. Tom Kompas and Dr. Satish Chand (Australian National University) for their valuable comments and guidance throughout this study. The views expressed in this paper are the author's own and do not necessarily reflect those of the Central Bank of Sri Lanka.

analyses by employing a VAR model. Third, the study also employed IRFs to investigate the impact of economic shocks. None of the earlier work has employed IRFs on Sri Lanka to analyze ELG hypothesis.

The purpose of this paper is to examine the export-led growth hypothesis by analyzing the relationship between exports and economic growth in Sri Lanka during the period 1960-2005, employing recently developed time-series analyses techniques including cointegration and causality, VAR and IRFs.

The rest of the paper organizes as follows: Section 2 presents the literature review, and the analytical framework is presented in section 3. It follows the methodology and data section, which includes source of data and econometric methods employed in the study. Section 5 presents empirical results. Finally, concluding remarks and policy implications are presented in section 6.

2. Literature Review

The relationship between exports and economic growth has been discussed by many economists and the application of the ELG paradigm was given much attention with the surfacing of the East Asian Tigers. The ELG theory has been analyzed as cross section analyses (eg: Balassa 1978, 1985, Ekanayake 1999, Feder 1983, Jin 1995, Michaely 1977, Tyler 1991) as well as country specific analyses using time-series data (eg: Botho 1996, Chow 1987, Islam 1998, Ram 1985, Shan and Sue 1998,) with mixed results in the past three decades. Among them recent studies (Abou-Stait 2005, Awokuse 2003, Ekanayake 1999, Oxley 1993, Shan and Sun 1998, Sharma and Panagiotidis 2005) on export and economic growth have employed cointegration technique and causality testing to identify the ELG hypothesis. Though some studies accept the ELG paradigm, some other studies illustrate suspicions about it[2]. However, their conclusion supports the ELG hypotheses in developing countries in varying degrees.

Balassa (1978), one of the predominant writers in the area of ELG hypothesis, using data for the period 1960-73 for 11 countries finds a positive effect of export growth on economic growth. Balassa (1978) uses correlation and regression analyses to examine the effect of export growth on economic growth. In addition, Feder (1983), and Ram (1985) find empirical evidence for strong cross country association between exports and economic growth. Time series analyses have also supported the ELG hypothesis (eg: Chow 1987, Doyle 1998, Ram 1987, Abou-Stait 2005, Thornton 1996, Xu 1996).

[2] Some found bi-directional relationship (Chow 1987, Kunst and Marin 1989), and some found uni-directional relationship (eg: Doyle 1998, Thornton 1996, Xu 1996), while others found no causality (eg: Ahmad and Kwan 1991, Giles and Williams 1999, Jung and Marshall 1985, Shan and Sun 1998, Sharma and Panagiotidis 2005, Sims 1972).

Feder (1983), using a sample of 55 semi-indutralized developing countries, finds that export variable is positive and significant at 5 per cent level. Feder (1983) argues that ELG strategy tends to reallocate the resources in a country from less efficient sectors to more dynamic sectors. According to Feder (1983), the production efficiency of a country can be enhanced through the vibrant export sector. The pressure of world competition leads to better quality products and forces domestic producers to increase efficiency. The increased efficiency and positive externalities (such as improved technical know how, efficient managerial skills etc.) gained from export growth have an impact on the non-export sector supporting to increas the overall output of the economy.

Abou-Stait (2005) argues that exports have a significant impact on economic growth in Egypt in spite of Egypt's higher dependency on imported raw materials. Sun and Parikh (2001) highlight that expansion of exports has a positive and significant impact on economic growth in China. Their study employs Feder model, and concludes that positive externalities generated by the export sector to the non-export sector has increased overall economic growth.

In the case of Sri Lanka, Abhayaratne (1996) and Shirazi and Abdul Manap (2005) find no support for the ELG hypothesis. She analyzed the validity of the ELG hypothesis for Sri Lanka using cointegration and causality techniques. She employed only exports, GDP and imports. Some excluded variables may have misled her findings. However, another cointegration study on Sri Lanka Fernando and Colombage (2002) supports the ELG hypothesis. They employed only real export and real GDP data, which might have misled their findings since they have ignored some of the important variables that have an impact on economic growth.

As noted, empirical investigations on the ELG hypothesis show mixed results. According to Ram (1985), export growth is significant for economic growth. However, the impact of exports on economic growth is less significant for low and high level income countries compared to middle income countries (Kravis 1970, Michaely 1977, Poon 1995, Ram 1985). For exports to effectively affect economic growth, a country should reach a minimum level of development (Yaghmaian and Ghorashi 1995). The authors highlight the importance of a sound process of structural changes. All these indicate that the impact of exports on economic growth depends on the level of economic development and economic structure and the dynamic process of structural changes.

Methodologically, though the cross-country studies on ELG hypothesis are well documented, they implicitly assume that developing countries share common characteristics. This is not true since countries differ in their social, political, institutional, and economic structure and thus in the ways of reactions to external shocks. Therefore, cross-country regression analyses can be misleading since they do not take into account country-specific characteristics (Shan and Sun 1998). They do not either capture the dynamics of the relationships between exports and economic growth. On the other hand, apart from the problem of spurious regression with the earlier time-series regression analyses, some problems with recent time-series studies are highlighted (Bewley and Yang 1996, Giles and Williams 1994, Toda 1994), namely, the arbitrariness in the choice of the lag length, the application of F-statistics to causality test, and model specifications (Chow 1987, Darrat 1987, Ghartey 1993, Hatemi-J and Irandoust 2000, Toda and Yamamoto, 1995).

Choosing the correct variables is a tricky issue. Some earlier studies analyzed ELG hypothesis by employing just exports and GDP - two variable relationships - (for example Fernando and Colombage 2002), while others employed multivariate analytical techniques using other relevant macro economic variables. In some cases, instead of GDP, GDP minus exports (non-export GDP) has been used to avoid the 'national income accounting identity issue' because exports are themselves a component of output (Ghatak *et al.* 1997, Feder 1983, Love 1992, Sharma and Panagiotidis 2005).

3. Analytical Framework

In the literature, causality from exports to economic growth in terms of real output growth is recognized as the ELG hypothesis. According to the ELG hypothesis, export-orientation policies contribute to stimulate economic growth both directly and indirectly through the expansion of the export sector[3]. Export expansion directly accelerates output growth as a component of aggregate output in a country (through the Keynesian multiplier). This indirectly stimulates economic growth through the use of advanced technology, which results in efficient allocation of resources and higher productivity (Balassa 1978, Grossman and Helpman 1991), greater capacity utilization and exploitation of economies of scale (Helpman and Krugman 1985) due to foreign market competition and large markets. In addition, the generation of foreign exchange from exports allows not only for increasing levels of imports but the import of high quality inputs including capital and intermediate goods, which in turn raise domestic production and thus stimulate output growth (Awokuse 2003, Balassa 1978, McKinnon 1964).

[3] Moosa (1999) gives three reasons to support this hypothesis. The first reason is that, from Keynsian argument, export growth lead, through the foreign trade multiplier, to output expansion. The second argument is that the accumulation of foreign exchange from exports, which can be used to import capital and intermediate goods, leads in turn to stimulate economic growth. Finally, he argues that competition generates economies of scale and an acceleration of technical progress in production which are important sources of economic growth.

Following early empirical formulation of the new growth framework (Awokuse 2003, Shan and Sun 1998), this study tests the export-led growth hypothesis by expanding the growth equation and including other relevant variables such as real imports, investment, labor, in the production function. Accordingly, the aggregate production function is expressed as:

$$LRGDP_t = f(LREX_t, LRIM_t, LRINV_t, LLA_t) \qquad (1)$$

where $LRGDP_t$ represents real GDP in log term, and $LREX_t$, $LRIM_t$, $LRINV_t$, and LLA_t are real exports, real imports, real investment and labor respectively. All are log terms, and subscript t denotes time.

4.1. Econometric Method

The use of time-series analyses, particularly time-series methods on unit-roots and cointegration, to examine the dynamic relationship between export growth and economic growth has attracted considerable attention among economists. This study employs the Granger causality test methodology with cointegration techniques to test the ELG hypothesis. In addition, VARs and IRFs are employed to investigate the impact of economic shocks.

4.1.1. Test for Non-stationary and Unit Root Tests

To avoid the problem of spurious regression and the failure to account for the appropriate dynamic specification, this study, first, performs unit roots tests on the variables. The examination of stationarity or non-stationarity in a time series is closely related to the test for unit roots. A number of alternative tests are available for testing whether a series is stationary. Among them, the Augmented Dickey-Fuller (ADF) and the Philips-Person (PP) tests are the most common.

Any time-series analysis starts by checking the order of integration of each variable. If the first difference of a non-stationary variable is stationary, that variable is said to be integrated of order one, I(1). If second differences are required to achieve stationary, then the variable is integrated of order two, I(2). A Simple regression should be carried out on variables of the same order of integration. If the individual variable is $y_{t,}$ the general form of ADF test can be written as follows:

$$\Delta y_t = \alpha\, y_{t-1} + \sum_{i}^{m} \beta_i \Delta y_{t-i} + \delta + \gamma t + \varepsilon_t \qquad (\textit{for levels}) \qquad (2)$$

$$\Delta\Delta y_t = \alpha\,\Delta y_{t-1} + \sum_{i}^{m} \beta_i\,\Delta\Delta y_{t-i} + \delta + \gamma t + \varepsilon_t \qquad (\textit{for first diferences}) \quad (3)$$

where m is the number of lags and t is time. The lag lengths (m) should be relatively small in order to save degrees of freedom, but large enough not to allow for the existence of autocorrelation in ε_t. ε_t represents a sequence of uncorrelated stationary error terms with zero mean and constant variance. Having determined the appropriate value of significance, we test H_o: $\alpha = 0$ versus H_a: $\alpha < 0$. Rejection of H_o means that y_t is I(0) while acceptance implies that it is integrated of order (1).

The critical values are chosen on the basis of the degrees of freedom and taken from MacKinnon-Hang-Michelis (1999). If the ADF statistic is smaller than the critical value (in absolute terms), the hypothesis of non-stationary cannot be rejected. It concludes that the series is non-stationary. Hence, it contains a unit root. If the ADF statistic is larger than the critical value, the series is stationary. The ADF test equation is re-run with different lag lengths, and including constant and trend, or only constant, or only trend.

There are several alternative criteria for finding the best model and appropriate lag lengths. Some of the commonly used criterions are the Likelihood ratio test (LR), the Akaike Information Criterion (AIC), and the Schwarz Information Criterion (SIC).

4.1.2. Test for Cointegration

Cointegration is a statistical implication of the existence of a long-run relationship between variables or co-movement of time-series data. If more variables move closely together, even if they themselves are trended, the difference between them is constant. From a statistical point of view, a long-run relationship means that the variables move together over time so that short-run disturbances from the long-run trend will be corrected (Manning and Andrianacos 1993). In other words, a lack of cointegration indicates that such variables have no long-run relationship. The standard approach to investigate both the long-run relationship and short-run dynamic between economic variables is the cointegration analysis and its error correction model (ECM) representation.

There are several techniques for running cointegration tests. Among them, the Engle-Granger (1987) two step test and the Johansen cointegration test developed by Johansen (1988) and Johansen and Juselius (1990) are the most common techniques. Less error is involved in the Johansen technique, which this study also adopts, because it involves only one step. In the Johansen technique for cointegration, we test for r (the maximum number of cointegration relationships) using the maximum eigenvalue statistics (λ_{max}) and Trace statistics.

4.1.3. Granger Causality

The aim of this section is to test whether export Granger causes GDP and to test the causality between exports and investment, and export and manufacturing outputs in Sri Lanka. In economics, Granger (1969) and Sims (1972) developed the operational framework of systematic testing and determination of causal direction. The approach is based on the axiom that the past and present may cause the future but the future cannot cause the past (Granger 1980).

The methodology of the Granger-causality test can be presented as follows. Suppose we test Granger-causality between two variables such as X and Y,

$$Y_t = \sum_{i=1}^{m} \alpha_i X_{t-i} + \sum_{i=1}^{m} \beta_i Y_{t-i} + u_{1t} \qquad (4)$$

$$X_t = \sum_{i=1}^{m} \lambda_i X_{t-i} + \sum_{i=1}^{m} \delta_i Y_{t-i} + u_{2t} \qquad (5)$$

where u_{1t} and u_{2t} are serially uncorrelated random disturbances with zero mean. We test to see if X Granger-causes Y by using the hypothesis as follows:
$H_0 : \alpha_1 = \alpha_2 = \alpha_3 = \dots \alpha_m = 0$ is rejected against the alternative, H_1 : not H_0

Similarly, we test if Y Granger causes X by testing the hypothesis as follows:
$H^*_0 : \delta_1 = \delta_2 = \delta_3 = \dots \delta_m = 0$ is rejected against the alternative, H^*_1 : not H_0

If better predictors of a given series Y can be obtained by adding to lagged values of Y current and lagged values of another given variable X, then X is said to Granger-cause Y.

4.1.4. Vector Autoregression and Impulse Response Function

The study formulates a VAR model and IRFs in order to illustrate the dynamic effect of the impact of unitary shocks on these macroeconomic variables under examined. If all the variables are neither stationary at their level nor cointegrated, the first differences of the variables are used to formulate VAR model (Enders 2004). The following mathematical formation of the VAR was employed in this study.

$$\Delta Y_t = A_1 \Delta Y_{t-1} + \dots + A_k \Delta Y_{t-1} + B \Delta X_t + \upsilon_t \qquad (6)$$

where Y_t is a vector of endogenous variable, X_t is a vector of exogenous variables. A_1, … A_k, and B_t are matrix of coefficients to be estimated. υ_t is the vector of innovations that may be contemporaneously correlated but are uncorrelated with their own lagged values and with all of the right-hand side variables. Output and exports are the endogenous variables, while the other variables are employed as exogenous. The best model is the one that minimizes the AIC and the SIC.

Building a VAR model allows us to generate IRFs. Hence, based on the VAR model, the study is then extended to include the IRFs. A disturbance to one variable not only directly affects the particular variable, but is also transmitted to all the other endogenous variables through the dynamic structure of the VAR (Abou-Stait 2005). In general, an IRF illustrates the effect of a one-time shock to one of the innovations on current and future values of the endogenous variables.

4.2. Data

The data used in this analyses are obtained from the various issues of the Annual Report of the Central Bank of Sri Lanka. GDP deflator is used to deflate the series. The real values are measured in 1996 prices. The series are transformed into natural logarithm terms. The following time-series are analyzed: real GDP (LRGDP), real exports (LREX), real value of imports (LRIM), real investment expenditure (LRINV), and labor force (LLA). We include imports as a variable since imports may play a significant role in explaining export-led growth. Riezmann *et al.* (1996) identified imports as an important variable when examining causality between exports and economic growth. Omitting imports may lead to biased results (Riezmann *et al.* 1996). The data employed are graphically presented in their levels and first differences in Appendix A.

5. Empirical Results

Table 1 summarizes the results for unit root test on level and in the first difference of data. For this study, the ADF test was used, which is based on the SIC, while the PP test bandwidth is based on Newey-West. The results indicate that each variable is integrated of order one, I(1). Hence, each variable is stationary in its first difference.

Table 1 Unit Root Test Results

Variable	Level (with trend and intercept)		First Difference (with intercept)	
	ADF statistic	PP statistic	ADF statistic	PP statistic
GDP	-2.64509 (1)	-2.56963 (1)	-5.51658* (0)	-5.52767* (2)
Non-export GDP	-2.65359 (1)	-2.56591 (1)	-5.49597* (0)	-5.50755* (2)
Export	-2.50282 (1)	-2.54537 (2)	-6.15241* (0)	-6.14983* (2)
Import	-2.46627 (1)	-2.64902 (1)	-6.44883* (0)	-6.46288* (5)
Investment	-1.98231 (0)	-2.13754 (1)	-6.01710* (0)	-6.01476* (4)
Employment	-2.47536 (0)	-2.53901 (1)	-6.65873* (0)	-6.69782* (3)
* 1% critical value	-4.19234	-4.186481	-3.59662	-3.59662
5% critical value	-3.52079	-3.51809	-2.93316	-2.93316

The Johansen cointegration test results are presented in Table 2. On the basis of the results of cointegration tests, we fail to reject the null hypothesis of no cointegration between the macroeconomic variables under consideration at 5% significance level. Hence, the study suggests that there is no cointegration relation between under studied variables in Sri Lanka.

Table 2 Johansen Cointegration Test Results: LRGDP, LREX, LRIM, LRINV, LLA

Number of cointegrating vectors	λ_{Trace}		λ_{Max}	
	Statistics	C (5%)	Statistics	C (5%)
$r = 0$	56.117	69.819	26.844	33.877
$r \leq 1$	29.273	47.856	13.989	27.584
$r \leq 2$	15.284	29.797	9.765	21.132
$r \leq 3$	5.519	15.495	4.884	14.256
$r \leq 4$	0.636	3.842	0.636	3.842

Note: Critical values used are taken from MacKinnon-Hang-Michelis (1999)

We perform the bivariate Granger causality analyses to test different casual relationships among the variables. Since the series are non-stationary for the levels of the variables, this study proceeds with the Granger test using the variables in their stationary forms (their first differences in this case) without incurring in the problem of the spurious regression. Results of the bi-variate analysis are presented in Table 3. The AIC and the SIC are used to choose the lag structure.

Table 3 Ganger Causality Test Results

	Null Hypothesis	Obs.	F-statistic	Probability
1	DLREX does not Granger cause DLRGDP	44	0.00277	0.93829
2	DLRGDP does not Granger cause DLREX	44	0.88692	0.35211
3	DLREX does not Granger cause DLRINV	44	1.66616	0.20437
4	DLRINV does not Granger cause DLREX	44	0.43358	0.51411
5	DLREX does not Granger cause DLLA	44	0.04207	0.83856
6	DLLA does not Granger cause DLREX	44	1.66028	0.20516
7	DLREX does not Granger cause DLRM	44	5.60898	0.02293**
8	DLRM does not Granger cause DLREX	44	0.09749	0.75653
9	DLRGDP does not Granger cause DLRINV	44	1.94366	0.17116
10	DLRINV does not Granger cause DLRGDP	44	0.54765	0.46367
11	DLRGDP does not Granger cause DLRM	44	0.01607	0.89977
12	DLRM does not Granger cause DLRGDP	44	0.02694	0.87048
13	DLRGDP does not Granger cause DLLA	44	0.82697	0.36874
14	DLLA does not Granger cause DLRGDP	44	0.63541	0.43020
15	DLRINV does not Granger cause DLRM	44	0.76898	0.38590
16	DLRM does not Granger cause DLRINV	44	3.70824	0.06146***
17	DLRINV does not Granger cause DLLA	44	0.40048	0.53054
18	DLLA does not Granger cause DLRINV	44	0.11954	0.73039
19	DLRM does not Granger cause DLLA	44	0.18998	0.66534
20	DLLA does not Granger cause DLRM	44	2.41107	0.12856

** at 5% critical value; *** at 10% critical value

As displayed in Table 3, no statistical evidence is found to suggest that the real exports Granger cause the real GDP or vice versa. Nevertheless, at 5% significance level we suggest that real exports Granger cause real imports. The real imports also Granger cause the real investment at 10% level of significance. Though these findings do not provide direct support for the causal relationship between exports and GDP or the ELG hypothesis, the exports Granger cause imports and further imports Granger cause investment (Table 3).

The findings are reasonably interesting for further research on the ELG hypothesis by looking at export compositions and economic structure in the country. This may involve a long process that we could not capture here. However, from a policy point of view, it is suggested that some institutional bottlenecks and or structural problems including tariff reforms[4] might well explain the failure of the ELG hypothesis

[4] For example, while promoting the production of exports, the government should remove tariffs to create an open market. In 1990, the average tariff percentage in Sri Lanka was about 28 percent, though by 2002 that percentage had decreased to 18 per cent.

in Sri Lanka. Exports may increase foreign earnings and allow increases in the capital and intermediate imports and thus, result in the growth of GDP, as described in Section 3 of this study. There might be a bottleneck in this latter process. Therefore, rather than rejecting the ELG hypothesis and export-oriented policies, the country might cautiously need to look at its structural problems.

We also run the same tests by using real GDP without exports (non-export GDP), instead of GDP with exports, (Johansen cointegrtion test results are presented in Appendix C.II results are not reported here), and find the similar outcome and the same conclusion. This study further performs the same analyses employing real industrial exports instead of real total input[5], and finds no different results (Johansen cointegrtion test results are presented in Appendix C.III). It further reinforces our argument for the non-validity of the ELG hypothesis in the case of Sri Lanka.

Appendix B shows the results of IRFs. The aim is to examine the impact of the outcome of introducing a shock to the system. Introducing a positive shock to the exports, there is no response from other variables, GDP, investment and imports. In the case of GDP, a positive response only from exports is seen, but dies out suddenly. Then introducing a positive shock to investment, a positive response can be observed from both exports and GDP. Finally, positive shocks to imports lead a negative response from exports and a positive response from both GDP and investment. All appears to be died out shortly. This also underpins our previous conclusion that there is no significant impact of exports on the economic growth in Sri Lanka.

6. Concluding Remarks and Policy Implications

The study examines the validity of the ELG hypothesis for the case of Sri Lanka. We employed the cointegration test, the Granger causality test, a VAR and IRFs and included previously omitted relevant variables. The study carried out the analyses beyond the traditional two-variable method of testing the ELG using five macroeconomic variables; namely, GDP, exports, imports, investment and labor. The findings of the study fail to support the ELG hypothesis. The lack of support for the ELG hypothesis casts some doubt on the efficiency of the designed policies to stimulate economic growth by promoting the export sector.

Nevertheless, there might be some structural and institutional problems, which obstruct the export-led growth process in the case of Sri Lanka. For example, uncertainty in the political environment, low availability and high prices of basic economic infrastructure facilities such as telephone, and the poor transport network, electricity, an unfriendly regulatory environment including bribery and corruption may result in hampering economic growth in the country. Significant infrastructure development is needed before the export sector development and economic

[5] It is redone for the period of 1973-2005 due to limited availability of data.

development in general could occur. All of these factors also slow down growth of exports. One should integrate these aspects when analyzing the ELG hypothesis and interpreting the results.

The study also does not take into account the relationship between export growth and productivity growth. Future studies in these respects would be worthwhile. It requires a compressive data set, which is also one of the limitations of this study. As Balaguer and Cantavella-Jorda (2004) recently argue, the structural transformation in export composition also becomes a key factor for economic development. It is also interesting to investigate the role played by the composition of exports in explaining economic growth.

Though several structural changes have been taken place in Sri Lanka in different stages, still, there are some unresolved structural problems such as inefficient public sector, inflexible and high public expenditure, tariff reforms, labor regulation and educational reforms. They also should be addressed in future studies on the ELG hypothesis.

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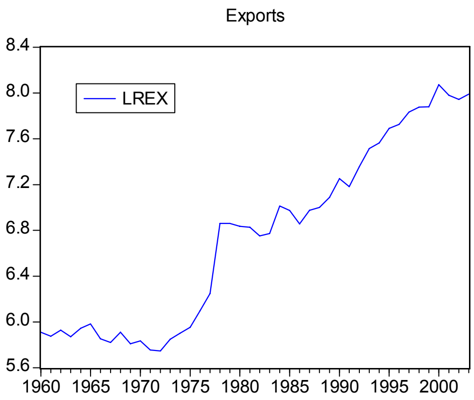
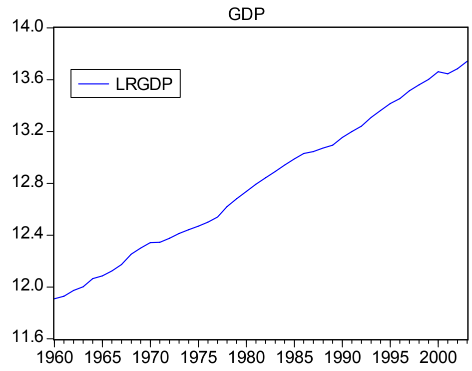
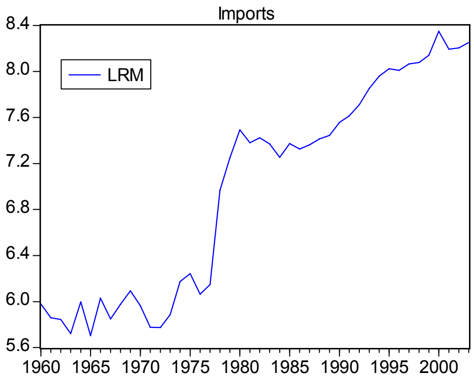
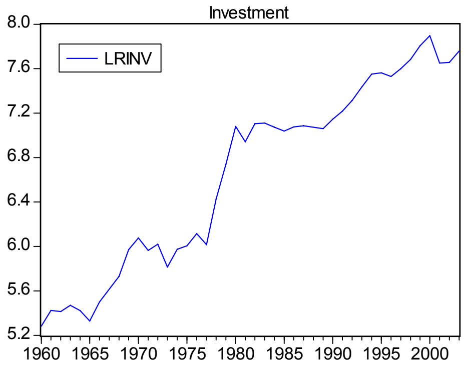
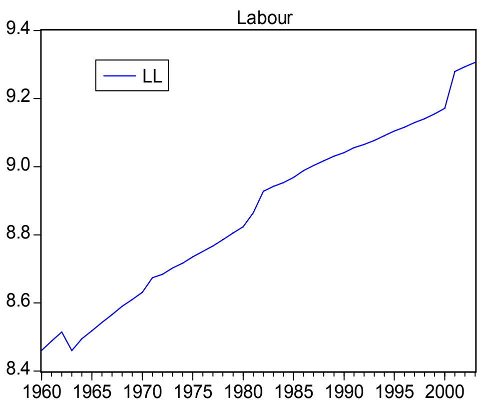
Appendix A.I: Level of Time Series: LRGDP, LREX, LRIM, LRINV, LLA



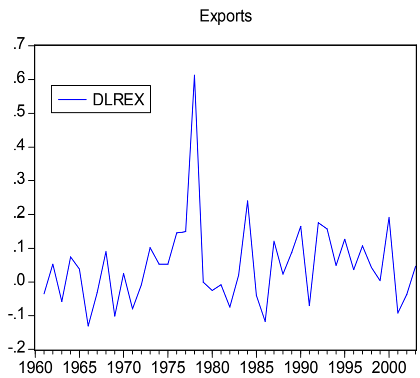


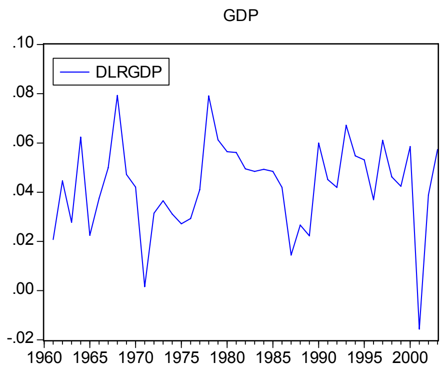


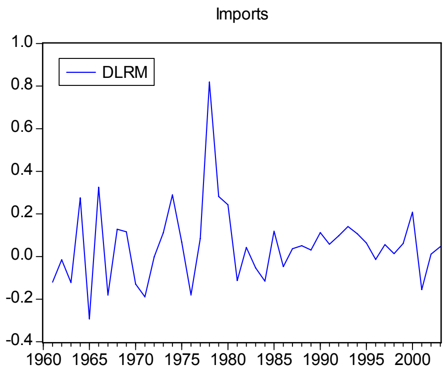


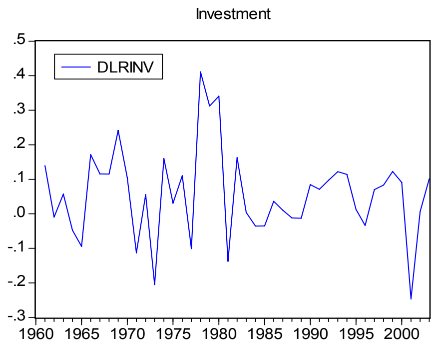


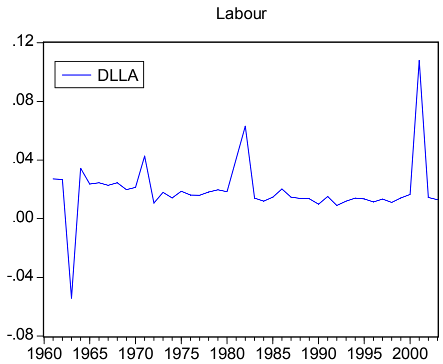
Appendix A.II: First Differences of Time-series: LRGDP, LREX, LRIM, LRINV, LLA



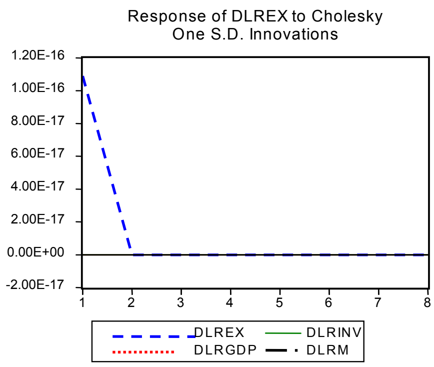


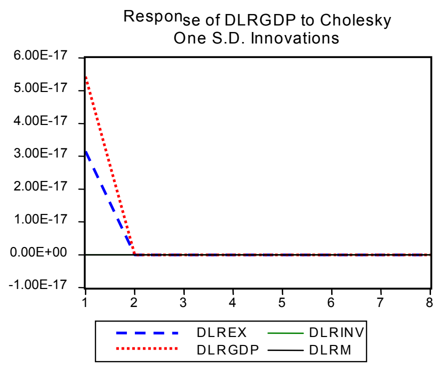


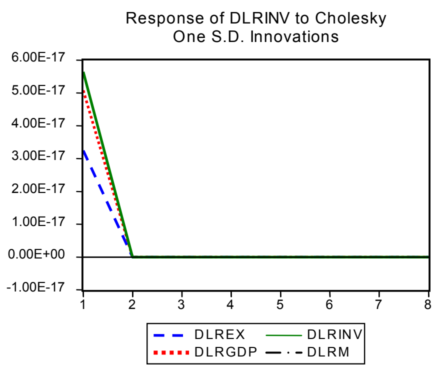


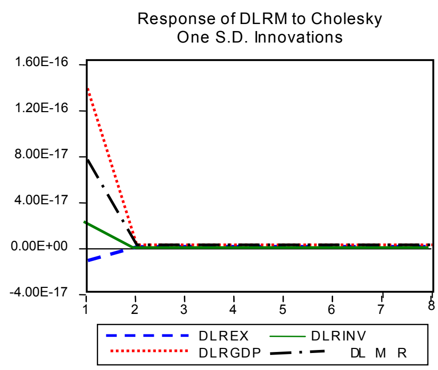


Appendix B: Impulse Response Functions (IRFs)









Appendix C.I

Johansen Cointegration Test Results (1960-2005): Non-export LRGDP, LREX, LRIM, LRINV, LLA

Number of cointegrating vectors	λ_{Trace}		λ_{Max}	
	Statistics	C (5%)	Statistics	C (5%)
r = 0	56.1399	69.819	26.853	33.877
r ≤ 1	29.2870	47.856	13.992	27.584
r ≤ 2	15.2923	29.797	9.766	21.132
r ≤ 3	5.5296	15.495	4.894	14.256
r ≤ 4	0.6361	3.842	0.636	3.842

Note: Critical values used are taken from MacKinnon-Hang-Michelis (1999)

Appendix C.II

Johansen Cointegration Test Results (1973-2005): LRGDP, LRIEX (real industrial export), LRIM, LRINV, LLA

Number of cointegrating vectors	λ_{Trace}		λ_{Max}	
	Statistics	C (5%)	Statistics	C (5%)
r = 0	70.526**	69.819	33.265	33.877
r ≤ 1	37.262	47.856	19.458	27.584
r ≤ 2	17.804	29.797	9.505	21.132
r ≤ 3	8.299	15.495	6.359	14.256
r ≤ 4	1.939	3.842	1.939	3.842

Note: Critical values used are taken from MacKinnon-Hang-Michelis (1999)
** denotes rejection of the hypothesis at the 0.05 level.

Stock Market Efficiency and Integration: A Study of Eight Economies in the Asia-Pacific Region

Dimuthu Samaratunga[1]

Abstract

A stock market is considered to be efficient if it accurately reflects all the relevant information in determining security prices. In international stock markets, if the assets with identical risks offer similar level of expected returns, then markets are said to be integrated.

This paper investigates the stock market efficiency and integration of eight selected economies in the Asia-Pacific region. The sample is composed of 4 Emerging/ Developing (Sri Lanka, China, Malaysia and Pakistan) and 4 Developed (Australia, Hong Kong, Japan and Singapore) markets. The motivation of this paper is two-fold. The first objective is to investigate whether the selected stock markets are efficient at individual level, while the second is to examine whether international diversification is effective.

The results revealed that there is no evidence against the efficiency of Japan's stock market while markets of Sri Lanka, Pakistan and Australia are proved to be inefficient. For China, Malaysia, Hong Kong and Singapore, the tests gave inconclusive results with regard to market efficiency. The cointegration analysis confirmed that there are no long-run co-movements between the stock prices, and thus international diversification within economies in the sample is effective.

[1] This paper is an outcome of a continuation of the initial research conducted by the author for her Masters dissertation at University of Warwick, UK. The author is grateful to Dr. Xing Jin, her supervisor at Warwick, for his valuable comments and technical support rendered, and also wishes to thank Mr. W.A. Wijewardane, Deputy Governor, Dr. D. S. Wijesinghe, Assistant Governor and Dr. P N Weerasinghe, Director, Economic Research Department, Mr. Anil Perera, Ms. Erandi Liyanage and Ms. Kaushalya Subasinghe, all of Central Bank of Sri Lanka, for their advice, encouragement and support in publishing this paper.

1. Introduction

The equity market of a country plays a prominent role in its economic development. It not only encourages savings and investments in the economy, but also enhances corporate governance and social responsibility. Despite the fact that the stock market is a relatively risky mode of investment, it provides greater opportunity for local and global diversification through effective and efficient asset allocation.

A market is considered to be efficient if it fully and correctly reflects all available information in determining stock prices which is referred to as the Efficient Market Hypothesis (EMH) (Fama, 1970). Random walks in stock returns are crucial to the formulation of rational expectation models and testing of the weak form market efficiency (where the current price is assumed to reflect all information included in the past prices). Since the stock prices in an efficient market incorporate all relevant information, the stock returns should display an unpredictable behaviour. On the contrary, if stock returns are predictable, there will be distortions in the pricing of capital and risk, which will ultimately curtail the economic development of the country (Worthington and Higgs, 2003).

In the global scenario, the deregulation and liberalisation of financial markets have led the investors to pay more attention to the international securities markets. If assets of identical risk in different countries lead to a similar level of expected return, then markets are said to be integrated. In modern portfolio theory, the main theme advocates investors to diversify their assets across national borders, as long as returns to stock in the other markets are less than perfectly correlated with the domestic market (Lim, Lee and Liew, 2003). This implies that when the markets are cointegrated, the benefits of international diversifications are not maximised and thus arbitrage profits could be explored.

Based on the above rationalizations, this paper aims to test two objectives: firstly, the equity market efficiency, and secondly, the effectiveness of international diversification of eight economies (China, Malaysia, Pakistan, Sri Lanka, Australia, Hong Kong, Japan and Singapore) in the Asia-Pacific region. Among these stock markets, three markets have secured places in the world's top 10 stock exchanges in terms of Market Capitalisation (as of end 2007) where Japan, China and Hong Kong were ranked second, sixth and seventh respectively. Provided that these markets are ranked among the top, it is worthwhile to find out whether they are individually efficient. Moreover, in the global context, it is of greater interest to investigate whether they give the investors the opportunity for effective international diversification.

The remainder of the paper is organised as follows: Section 2 summarises the 'Literature Review', while Section 3 provides the 'Description and Properties of Data'. Section 4 includes the 'Methodology'. 'Empirical Results' are reported in Section 5 while Section 6 summarises the 'Conclusions' of the study.

2. Literature Review

Lo and MacKinlay (1988) have tested the Random Walk Hypothesis (RWH) for stock market returns by comparing variance estimators derived from data sampled at weekly and monthly frequencies. The RWH was strongly rejected for the entire sample period (1962-1985) and all sub periods for a variety of aggregate returns indices and size sorted portfolios. Although the rejections were due largely to the behaviour of small stocks, they could not be attributed completely to the effects of infrequent trading or time-varying volatilities. As per Lo and MacKinlay (1988), the patterns of rejections of the random walk indicated that the stationary mean-reverting models of earlier researches (example, Shiller and Perron (1985) and Summers (1986)) could not account for the departures of weekly returns from the random walk.

Fama (1970) has reviewed the theoretical and empirical literature on the EMH. The empirical evidence was divided into the three categories of market efficiency depending on the information subset of interest. Strong form tests were concerned with whether individual investors or groups had monopolistic access to any information relevant for price information. In the less restrictive semi-strong form tests, the information subset of interest included all obviously publicly available information, while in the weak form tests, the information subset was just historical prices. Fama (1970) used daily prices for each of thirty stocks of the Dow Jones Industrial Average for the period 1957-1962 and found that the results of the weak form tests of the efficient market were strongly in support of market efficiency. Though there was evidence of autocorrelations, some of which were consistent with the fair game model while the rest did not appear to be sufficient to declare market inefficiency, (Fama, 1970).

The earlier studies on market efficiency had revealed that EMH holds true (with very few exceptions) in most of the markets, such as New York, Australia and London. However, as better data sources (daily stock price data) and more sophisticated econometric methods for data analysis became available, it was later revealed that there are inconsistencies in the past findings, (Jensen, 1978). These anomalies were significant that they could not be neglected. Ball (1978) (as quoted by Jensen, 1978) has found that, as a whole the pieces of scattered evidence stack up in a manner which make a much stronger case for the necessity to carefully review both the acceptance of the EMH and the methodological procedures. To overcome the above issue, in this particular study, more sophisticated test statistics such as LJung-Box Q-statistic, Variance Ratio test and accurate data series are used. Fama (1997) too has suggested that anomalies could be due to methodology and most long-term anomalies tend to disappear with reasonable advancement in technique.

Similar to Jensen's (1978) study, Schwert (2003) has carried out a research on anomalies and market efficiency, which raised the question of whether profit opportunities existed in the past, but has since been arbitraged away, or whether the anomalies were simply statistical aberrations that attracted the attention of academics and practitioners. The study revealed that the size effect, the value effect, weekend effect and the dividend yield effect seem to have disappeared after the papers that highlighted them were published.

Worthington and Higgs (2003) have examined the market efficiency of 10 emerging and 5 developed equity markets in Asia. They have found that none of the emerging markets in their study (China, India, Indonesia, Korea, Malaysia, Pakistan, Philippines, Sri Lanka, Taiwan, Thailand) could be characterised by random walks, and thus those markets were inefficient. Among the developed markets in the study, the stock markets of Hong Kong, New Zealand and Japan were consistent with the most stringent random walk criteria, while Australia and Singapore did not prove to be efficient. A similar study has been carried out by Claessens, Dasgupta and Glen (1995) on the twenty emerging stock markets represented in the International Finance Corporation. They have found evidence for return predictability in all the markets and thus concluded those markets were inefficient.

Chan, Gup and Pan (1997) have carried out a study on 18 international markets to investigate the weak form market efficiency and to check whether those markets are cointegrated. In testing for cointegration, 7 sub-groups were formed depending on their common features such as geographic and economic standings. Their results have revealed that, on individual basis, all markets were efficient, while a small number of stock markets were cointegrated with others. Since the majority of the stock markets in the sample were not cointegrated and thus did not have long-run co-movements, they concluded that international diversification among the selected stock markets could be effective.

A similar study has been carried out by Lim, Lee, and Liew (2003), to examine the stock market integration in the ASEAN region, using a non-parametric cointegration test, called the Bierens's (1997) test. The results have indicated that there is a common force which brings all the five ASEAN stock markets together in the long run and the shocks from any of these five markets may spillover to the other markets in the same region. Thus, they have concluded that international diversification within the ASEAN was ineffective.

3. Description and Properties of Data

The set of data employed in the study is composed of value weighted indices of 4 Emerging/Developing stock markets; China, Malaysia, Pakistan, Sri Lanka and 4 Developed stock markets; Australia, Hong Kong, Japan and Singapore, in the Asia-Pacific region. All the data are obtained from the EconStat and the most representative share price index of each country is used as the price data series. Moreover, in compliance with Lo and MacKinlay (1988), (where they analysed weekly data to avoid issues of bid-ask spread, and infrequent (non-synchronous) trading and pricing), the data series chosen for this study are weekly price indices. Each data series has its own sampling period, where the start date varies depending on the availability of that country's index. However, the end date for all indices is the same, i.e.16 May 2008. It is worth noting that varying sample periods do not affect the EMH conclusions as market efficiency is tested individually. In the cointegration analysis, the varying sample periods of the countries were matched to create a common sampling period that spread from 11 July 1997 to 16 May 2008. For the purpose of analysis, log returns were constructed, i.e. first, log price was obtained and the returns were derived as: $R_t = \ln(P_t) - \ln(P_{t-1})$.

Charts A1-A8 (in Annexure) present the distribution patterns of the weekly returns of each country in the study. Australia records the most stable weekly returns. Returns of Japan and China are dispersed over a narrow spread compared to the rest of the countries indicating stable stock returns. Malaysia, Hong Kong and Singapore show a relatively stable return pattern except for the high volatility during 1997-1998 period, signifying the impact of Asian currency crisis. Pakistan stock returns are the most volatile among the eight countries in the sample while Sri Lanka's stock market is relatively stable except for a few ad hoc shocks in 2001 and 2003.

It can be observed from the descriptive statistics presented in Table 1, that the distributions in the weekly returns of all eight countries have zero means (at two decimal places), with standard deviations varying between 0.02 and 0.04. Australia has the lowest standard deviation, indicating a relatively stable return distribution over the 20 years.

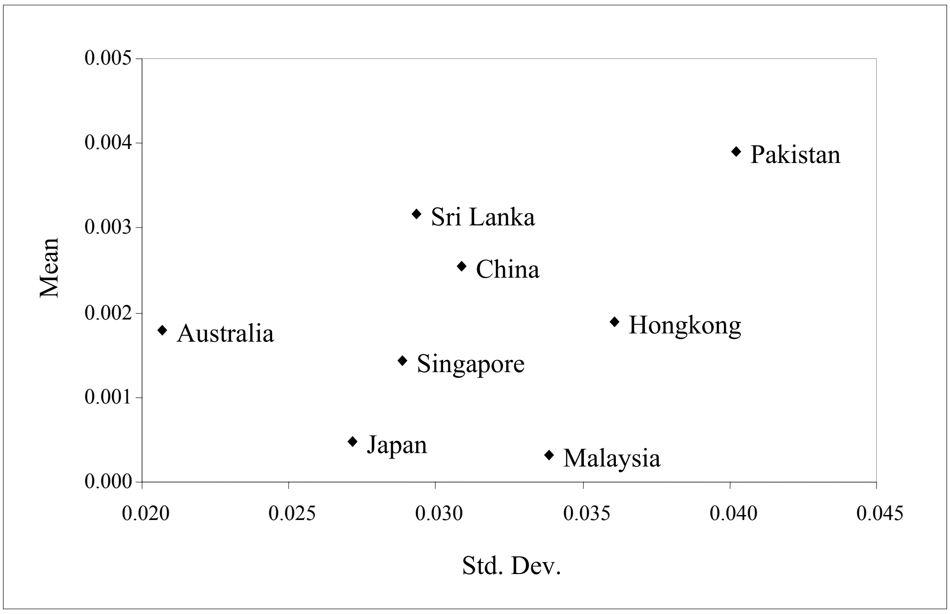
Table 1: Descriptive Statistics

Description	China	Malaysia	Pakistan	Sri Lanka	Australia	H.Kong	Japan	Singapore
Mean	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Median	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00
Maximum	0.13	0.25	0.13	0.18	0.06	0.14	0.11	0.20
Minimum	-0.08	-0.19	-0.18	-0.10	-0.35	-0.42	-0.13	-0.26
Std. Deviation	0.03	0.03	0.04	0.03	0.02	0.04	0.03	0.03
Skewness	0.41	0.19	-0.79	0.67	-4.50	-1.97	-0.27	-0.55
Kurtosis	4.43	10.83	5.69	7.86	74.11	22.79	4.87	13.11
Jarque-Bera	55.58	1799.41	209.11	547.64	254740.70	18052.13	192.11	4368.27
P-Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sharpe Ratio	0.08	0.01	0.10	0.11	0.09	0.05	0.02	0.05

Stock return distributions of China, Malaysia and Sri Lanka are slightly positively skewed indicating the absence of high frequencies of higher returns (i.e. distributions are concentrated around low or negative returns). The rest of the countries have negatively skewed distributions, which indicate a greater probability of high or positive returns compared to low/negative returns. All eight distributions report a kurtosis coefficient greater than 3, indicating leptokurtic distributions with many extreme observations. The zero p-values of Jarque-Bera test statistic indicate that the return distributions do not approximate the normal distributions for any country

The Shape ratio, as measured by mean returns over standard deviation is an indicator of relative risk-return trade off in each market. This measure is useful in comparing the effectiveness of international stock markets. It can be seen that Sri Lanka accounts for the highest Sharpe ratio followed by Pakistan. Since the investors tend to be cautious in developing markets, the risk return trade off is believed to be high in those markets. On the contrary, the developed markets, Japan, Singapore and Hong Kong report relatively low Sharpe Ratios. The Mean-Variance Frontier, which depicts the position of the stock returns against the standard deviations, is presented in Chart 1. It can be observed that only Sri Lanka has an above average mean return and a below average standard deviation, indicating a satisfactory risk-return trade off among the eight countries in the study.

Chart 1: Mean-Variance Frontier



4. Methodology

In this study, several parametric and non-parametric tests are used to investigate whether the stock returns are weak-form efficient, while the cointegration between the international markets is tested using the Vector Autoregression (VAR) models. A description of these tests and their suitability for application are briefed below.

4.1 Random Walk Hypothesis (RWH)

As stated above, an asset market is said to be efficient if the asset prices fully reflect all the available information. Thus in an efficient market, price changes are a result of the arrival of new information. Since information arrives randomly, fluctuations in share prices would be unpredictable. Under the RWH, the market exhibits a weak form as the most recent price contains all the available information and therefore the best predictor of the future price. Further, there will be no autocorrelation as the disturbance term cannot process any systematic forecast errors (Worthington, 2003).

There are 3 versions of the RWH, namely, Random Walk 1 (RW1), Random Walk 2 (RW2), and Random Walk 3 (RW3). RW1, the most restrictive version of the Random Walk Model (RWM) states that errors are independently and identically distributed with mean, zero and variance, σ^2, and thus the returns will be serially uncorrelated, indicating the unpredictability of future price movements or volatility based on the past prices. RW2 is a relaxed version of RW1, where errors are independent but not identically distributed. This allows for unconditional heteroskedasticity, which is particularly a useful feature given the time-variation in volatility of many financial asset return series (Campbell et al., 1997). RW3, the least restrictive form of RWM, states that errors are serially uncorrelated and thus allows for dependence of higher moments.

4.2 Unit Root Test

Unit root test is used to test for non-stationarity as a necessary condition for RW2, (Worthington and Higgs, 2003). According to the RWH, the log price series should have a unit root while the returns series should be stationary. Three methods of unit root tests, namely, the Augmented Dickey Fuller (ADF) (1979), the Phillips-Perron (PP) (1988) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) are used on log price indices as well as on returns.

ADF test (with constant and deterministic tend) has the following form:

$$\Delta Y_t = \mu + \beta t + \alpha Y_{t-1} + \sum_{k=1}^{p} c_k \Delta Y_{t-k} + \varepsilon_t \tag{1}$$

The null hypothesis (α=0) indicates that the series has a unit root, whereas under the alternative hypothesis (α<0), the series is stationary.

PP test is a non-parametric test, which modifies the ADF test statistic such that its asymptotic distribution is unaffected by the serial correlation. Both these tests are used as it will permit to overcome the ambiguity that ADF test has limited power in finite samples to reject the null hypothesis of non-stationarity. The KPSS is a parametric test, with a null hypothesis of 'stationary series' which is opposed to the null of both ADF and PP tests.

4.3 Autocorrelation Function (ACF) and LJung-Box Q- Statistic Test

The significance of ACF at each lag can be tested using the method recommended by Brooks (2002), where the critical value is calculated as $2/\sqrt{T}$, where T is the number of weekly observations.

The LJung-Box Q-Statistic test is a parametric test that is used to find out whether the returns are linearly independent. i.e. it tests the joint significance of the first m ACFs. The test statistic takes the following form:

$$Q(m) = T(T+2)\sum_{k=1}^{m}(\rho_k^2 \ /(T-k)) \rightarrow \chi^2(m) \tag{2}$$

If results reveal there is no autocorrelation, then the return series is assumed to follow a random walk (RW1).

4.4 Variance Ratio (VR) Test (Lo and MacKinlay, 1988)

VR test statistic takes the following form:

$$VR(q) = \text{var}(r,(q))/q\,\text{var}(r) = 1 + 2\sum_{k=1}^{q-1}(1-(k/q))\rho_k \tag{3}$$

This non-parametric test could be used only when the returns are homoskedastic and it allows checking for RW1. Under the null hypothesis, the VR statistic must be equal to 1. If VR exceeds 1, then there exists positive serial correlation whereas if it's less than 1, the returns are negatively correlated. Further, as per Campbell et al. (1997), if the variance of random walk increments is a linear function of time interval, then the RWH holds.

The Standardized VR test statistic takes the form:

$$\phi(q) = (VR(q)-1)(2(2q-1)(q-1)/3Tq)^{-1/2} \rightarrow N(0,1) \quad (4)$$

4.5 Heteroskedastic-Robust Standardized Variance Ratio (VR) Test

When errors are serially uncorrelated, the heteroskedastic-robust standardized VR test can be used to test for RW2 and RW3, which takes the following form:

$$\phi^{*}(q) = \sqrt{T(VR(q)-1)}\theta(q)^{-1/2} \rightarrow N(0,1) \quad (5)$$

4.6 Cointegration Analysis

Cointegration analysis will be carried out to examine whether there exist any long-run cointegrating relationship between the (log) price series of the countries, using the Vector Autoregression (VAR) in Johansen's Maximum Likelihood (Johansen's ML) estimation procedure, (Johenson, 1988; Johenson and Juselius, 1990). Accordingly the VAR of order k for log price (Y) is represented in error correction form as follows:

$$\Delta Y_t = \sum_{i=1}^{k} \Gamma_i \Delta Y_{t-i} + \Pi Y_{t-k} + \varepsilon_t \quad (6)$$

Where: $\Gamma i = (\Pi 1 + \ldots\ldots + \Pi i - I)$
$\Pi = (\Pi 1 + \ldots\ldots + \Pi k - I)$

The rank (r) of the long-run matrix (Π), determines the number of cointegrating vectors in the system, where, r takes any value between 0 and the number of countries in the group (n). The tests used to obtain r are, the Maximum eigenvalue test (λ_{Max}) and Trace (λ_{Trace}) tests. λ_{Trace} tests whether the smallest n-r estimated eigenvalues are significantly different from zero, while λ_{Max} test whether the estimated (r+1)th largest eigenvalue is significantly different from zero.

Maximum eigenvalue statistic for H0: rank ≤ r, Vs. H1: rank = r+1 is given by:

$$\lambda_{Max}(r, r+1) = -T \ln(1-\lambda_{r+1}) \quad (7)$$

Trace statistic for H0: rank ≤ r, Vs. H1: rank ≥ r+1 is given by:

$$\lambda_{Trace}(r) = -T\sum_{i=r+1}^{n}\ln(1-\lambda_i) \tag{8}$$

4.7 Short-run Dynamics

In the event that a long-term cointegrating relationship between the international stock prices does not exist, analysing the short-run dynamics would give an indication of the short term impact of markets on each other. This would be tested using the impulse response analysis, variance decomposition and Granger causality tests under the VAR. Impulse response analysis traces out the responsiveness of the dependent variable in the VAR to shocks of each of the other variables in the sample while variance decomposition gives the proportion of movements in the dependent variable that is due to its own shocks against the shocks to the other variables. Granger causality test determines whether a particular stock price series is useful in forecasting another.

Note: Unit Root tests, LJung-Box Q-Statistic tests and VAR (including impulse response analysis, variance decomposition and Granger causality test) is performed on Eviews 5 while Matlab 7.0.1 will be used to carry out the VR tests.

5. Empirical Results

5.1 Unit Root Tests

Results of the unit root tests are presented in Table 2. The ADF and PP test the null hypothesis of non-stationarity (i.e. the series has a unit root) against the alternative of stationarity. At levels, the test statistics of both ADF and PP for all eight countries do not reject the null hypothesis at 5% significance level, which indicate that log price series are non-stationary. However, at differences, both tests indicate that returns series of all countries are stationary at 5% level. The null of no unit root in KPPS is rejected at levels series, indicating that log prices are non-stationary. Further, the null of stationarity in the difference series is not rejected at 5% level, signifying that returns series of all eight countries are stationary. The necessary condition for RWH to hold is that price series should be non-stationary, while the returns series be stationary. From the results of the ADF, PP and KPSS above, it can be seen that log prices of all countries are non-stationary and thus it can be said that there is no evidence against weak form efficiency in all the eight markets. However, it is known that the above tests for unit roots have a lower power and therefore it is imperative that the weak form efficiency be tested using more sophisticated test statistics.

Table 2: Unit Root Test Results

Test	Indicator	China	Malaysia	Pakistan	Sri Lanka	Australia	H.Kong	Japan	Singapore
ADF – Levels	Statistic	1.20	-1.38	0.51	0.38	-1.09	-1.31	-1.77	-1.80
	P-Value	1.00	0.59	0.99	0.98	0.72	0.62	0.39	0.38
ADF - Differences	Statistic	-20.81*	-25.46*	-18.99*	-19.09*	-28.35*	-29.85*	-35.76*	-30.35*
	P-Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
PP – Levels	Statistic	0.61	-1.88	0.80	0.37	-1.10	-1.30	-1.81	-2.06
	P-Value	0.99	0.34	0.99	0.98	0.72	0.63	0.38	0.26
PP - Differences	Statistic	-21.12*	-25.98*	-19.05*	-19.18*	-28.40*	-29.91*	-35.76*	-30.60*
	P-Value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KPSS - Levels	Statistic	0.48*	0.51*	2.66*	2.43*	4.16*	3.42*	1.54*	1.33*
	5% C.V.	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
KPSS - Differences	Statistic	0.33	0.17	0.43	0.42	0.07	0.06	0.27	0.11
	5% C.V.	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46

* Significant at 5% level

5.2 Autocorrelations and LJung-Box Q-Statistic

Table A1 and A2 (in Annexure) illustrate the ACF and the LJung-Box Q-Statistic for the Emerging / Developing and Developed countries respectively.

It can be seen that the first order ACFs for Pakistan and Sri Lanka, and both first and second order ACF for Australia and Hong Kong are positive and statistically significantly different from zero. This indicates that there exist positive serial correlations between the current and previous week's stock returns for Pakistan and Sri Lanka, while current and previous two weeks returns for Australia and Hong Kong. Thus those markets are inefficient. The first order ACF of Japan is negative while its ACFs at all lags are insignificant. This implies that there is no evidence against Japan's market efficiency. For China, Malaysia, and Singapore, the results are rather vague, where the first and second order ACFs are insignificant, but higher order ACFs appears to be significant.

If the P-value of the Q-Statistic is less than 0.05, then null of all autocorrelation coefficients jointly equal to zero can be rejected at 5% significant level, and it can be concluded that past returns could be used to predict future returns, and thus weak form market efficiency does not hold. The P- values in Table A1 and A2 (in Annexure) show that China, Malaysia and Singapore give ambiguous results, having significant Q-statistics in-between the lags. In Pakistan, Sri Lanka, Australia and Hong Kong, the null hypothesis can clearly be rejected and thus RW1 does not hold and the markets are inefficient. The Q-statistic of Japan is not significant at all lags, which indicates that there is no serial correlation. This implies that there is no evidence against weak form efficiency for Japan's stock returns. However, these conclusions should further be verified using the more advanced Variance Ratio test.

5.3 Variance Ratio (VR) Test

Table 3 presents the results of the VR tests for the lags (q) 2, 4, 8, and 16 respectively. It can be observed that VR test statistic increases as q increases in all the eight countries.

Table 3: Variance Ratio Test Results

Country / Statistic	**Number q of base information aggregated to form VR**			
	2	**4**	**8**	**16**
China				
VR	1.06	1.23	1.45	1.71
Φ(q) (RW1)	1.39	2.70*	3.36*	3.56*
Φ*(q) (RW2 & RW3)	1.16	2.30*	2.89*	3.20*
Malaysia				
VR	1.04	1.16	1.38	1.59
Φ(q) (RW1)	1.07	2.22*	3.40*	3.56*
Φ*(q) (RW2 & RW3)	0.72	1.43	2.12*	2.22*
Pakistan				
VR	1.18	1.36	1.40	1.46
Φ(q) (RW1)	4.05*	4.33*	3.04*	2.35*
Φ*(q) (RW2 & RW3)	3.35*	3.64*	2.51*	1.97*
Sri Lanka				
VR	1.17	1.34	1.49	1.55
Φ(q) (RW1)	3.96*	4.13*	3.75*	2.85*
Φ*(q) (RW2 & RW3)	3.12*	3.37*	3.14*	2.33*
Australia				
VR	1.19	1.39	1.46	1.45
Φ(q) (RW1)	6.71*	7.13*	5.37*	3.44*
Φ*(q) (RW2 & RW3)	4.55*	5.21*	3.86*	2.50*
Hong Kong				
VR	1.09	1.19	1.21	1.23
Φ(q) (RW1)	2.90*	3.35*	2.28*	0.95
Φ*(q) (RW2 & RW3)	2.27*	2.78*	1.89	0.78
Japan				
VR	0.98	1.03	1.10	1.16
Φ(q) (RW1)	-0.83	0.59	1.13	1.27
Φ*(q) (RW2 & RW3)	-0.71	0.49	0.93	1.07
Singapore				
VR	1.05	1.15	1.27	1.41
Φ(q) (RW1)	1.53	2.61*	2.86*	2.93*
Φ*(q) (RW2 & RW3)	1.19	1.87	1.89	2.01*

* Significant at 5% level

According to Lo and MacKinlay (1988), if the VR test statistic exceeds unity, then the return series is said to be positively correlated. This holds true for all countries except Japan, where the VR takes value 0.9763. In the case of q=2, the VR test statistic minus one (i.e. VR – 1) returns the value of ACF, which can be verified with the ACF results of Section 5.2 above (Table A1 and A2 in Annexure). For example, the VR for China is 1.0625, while Table A1 indicates that the ACF at lag 1 is 6.25%. Likewise, it can be seen that Australia has the highest ACF of 19.44% followed by Pakistan (17.81%) and Sri Lanka (17.41%). Japan's VR of 0.9763 indicates its ACF is -2.37%. Thus it can be concluded that for Pakistan, Sri Lanka and Australia, the RWH does not hold while for Japan, it does.

The standardized VR test statistics ($\Phi(q)$) is significant at all levels of q for Pakistan, Sri Lanka and Australia, and thus RW1 can be rejected at 5% significance level. Further, these rejections are not due to the changing variances, as the heteroskedastic robust standardised VR test ($\Phi^*(q)$) too is significant at all levels for above three countries, which permits to reject RW2 and RW3 as well. Another important observation is that in the above three countries, as VR increases with q, the $\Phi(q)$ and $\Phi^*(q)$) decreases. This indicates that as q increases, the significance of the rejection becomes weaker. In observing Japan, both $\Phi(q)$ and $\Phi^*(q)$ are not significant at all levels of q, indicating that RW1, RW2 and RW3 cannot be rejected at 5% level. Therefore at 5% significance level, it can be concluded that there is no evidence against Japan's stock market efficiency, while for Pakistan, Sri Lanka and Australia, the RWH does not hold and hence inefficient.

The VR results of other four markets (China, Malaysia, Hong Kong and Singapore) are vague over the different levels of q. Considering China and Malaysia, it can be observed that at q=2 level RWH holds, but from q=4 onwards both $\Phi(q)$ and $\Phi^*(q)$ are rejected, implying that market is inefficient. In Hong Kong, RWH holds only at q=16. For Singapore, $\Phi(q)$ is significant at q=4, 8,and 16, whereas $\Phi^*(q)$ is only marginally significant at q=16, which implies the rejection of RWH at each level is due to changes in variances. Owing to these ambiguous results, a definite conclusion regarding the market efficiency cannot be reached for China, Malaysia, Hong Kong and Singapore.

However, it is worth noting that rejecting or not rejecting the RWH does not necessarily imply that the markets are inefficient or efficient respectively (Lo and MacKinlay, 1988), since the conclusions of this study are based on samples.

5.4 Cointegration Analysis

First, the unrestricted VAR is estimated to find the lag length, for which Akaike Information Criteria (AIC) and Schwaz Information Criteria (SIC) are used. Both AIC and SIC are minimised at level 2 and the residual serial correlation LM test confirms that there is no autocorrelation. Therefore, lag 2 is selected as the optimal lag length.

The Johansen multivariate cointegration test is then performed on the log price series of the eight countries. The test results of all eight markets as presented in Table 4 indicate that both test statistics, λ_{Max} and λ_{Trace} are lower than the 5% critical value and hence not significant even at r=0 level. Therefore, it can be concluded that at 5% significance level, there is no cointegration among the eight stock markets in the study.

Table 4: Cointegration Test Results - All Markets

Null Hypo	λ_{Trace}	5% CV	λ_{Max}	5% CV
r=0	152.92	159.52	43.98	52.36
r≤1	108.94	125.61	35.42	46.23
r≤2	73.52	95.75	25.00	40.07
r≤3	48.52	69.81	17.96	33.87
r≤4	30.55	47.85	15.85	27.58
r≤5	14.70	29.79	8.53	21.13
r≤6	6.17	15.49	5.75	14.26
r≤7	0.41	3.84	0.41	3.84

However, it would give a more profound understanding if the countries with similar economies are grouped and analysed to see whether they are cointegrated at sub-group levels (Chan, Gup and Pan, 1997). Thus, two groups are formed, namely, Emerging/Developing (China, Malaysia, Pakistan and Sri Lanka) and Developed (Australia, Hong Kong, Japan and Singapore), and the same procedure is carried out to test for cointegration. The respective results are presented in Tables 5, (since there are 4 countries in each group, the maximum value r can take is 3). Similar to the 'all-markets' analysis, both λ_{Max} and λ_{Trace} are less than 5% significance level for the sub-groups and thus it can be concluded that there is no cointegration in either of the groups. This implies that the stock markets of China, Malaysia, Pakistan and Sri Lanka in the Emerging/Developing group and Australia, Hong Kong, Japan and Singapore in the Developed group do not have long-run co-movements within their respective sub groups. Hence, the international diversification within 'all eight markets' as well as within 'sub groups' are effective.

Table 5: Cointegration Test Results – Sub Groups

	Four Emerging / Developing Markets		Four Developed Markets		5% CV	
Null Hypo	λ_{Trace}	λ_{Max}	λ_{Trace}	λ_{Max}	λ_{Trace}	λ_{Max}
r=0	31.09	18.75	33.60	19.49	47.85	27.58
r≤1	12.34	8.49	14.11	10.30	29.79	21.13
r≤2	3.85	3.82	3.81	3.81	15.49	14.26
r≤3	0.02	-	0.05	-	3.84	3.84

5.5 Short-run Dynamics

Impulse response analysis reveals that when there is a shock of 1 standard deviation in the Malaysian market, it will impact China, Pakistan, Sri Lanka in the second week (at peak level) and then vanish gradually by the sixth week. This implies that even the short-term impacts disappear in about one and half months. However, the impacts of the shocks in China, Pakistan and Sri Lanka on rest of the markets are not significant. Even in developed markets, most impacts are insignificant and disappear after about 1 month.

Tables 6 summarises the results of the variance decomposition analysis. In China, Malaysia, Pakistan, Sri Lanka and Australia, even by end of the sixth month, around 95% of the variance comes from itself. This implies that sentiments about own markets have a dominant effect than the direct impacts form other markets in the sample. In Hong Kong 70% of the variance is due to its own variance while the rest comes from Australia. Similarly, in Japan 70% of the variance is due to its own shocks while around 26% comes from Australia and around 4% from Hong Kong. However, in Singapore, 50% of variance is due to its own, while 24% comes from Australia and Hong Kong each followed by 2% from Japan.

Table 6: Variance Decomposition Results Summary

Country	Weeks	CHINA	MALAY	PKSTN	SL
China	1	100	0.00	0.00	0.00
	12	97.57	1.45	0.52	0.45
	24	97.57	1.45	0.52	0.45
Pakistan	1	0.36	1.34	98.31	0.00
	12	0.79	2.81	96.38	0.02
	24	0.79	2.81	96.38	0.02
Malaysia	1	0.35	99.65	0.00	0.00
	12	0.44	99.04	0.31	0.21
	24	0.44	99.04	0.31	0.21
Sri Lanka	1	0.01	1.06	0.73	98.2
	12	0.96	3.08	1.94	94.01
	24	0.96	3.08	1.94	94.01
Country	**Weeks**	**AUS**	**HK**	**JAPAN**	**SIN**
Australia	1	100	0.00	0.00	0.00
	12	99.41	0.28	0.06	0.25
	24	99.41	0.28	0.06	0.25
H.Kong	1	29.99	70.01	0.00	0.00
	12	29.71	69.37	0.18	0.74
	24	29.71	69.37	0.18	0.74
Japan	1	26.16	3.6	70.24	0.00
	12	26.03	3.62	70.02	0.33
	24	26.03	3.62	70.02	0.33
Singapore	1	24.35	23.76	1.12	50.77
	12	24.16	23.97	1.74	50.13
	24	24.16	23.97	1.74	50.13

Granger causality test results presented in Table A3 (in Annexure) reveal that in the short-run (particularly in the second week), Malaysia Granger causes China and Sri Lanka while Hong Kong Granger causes Singapore at 5% significance level. Rest of the markets do not have any influence on each other.

5.6 General Issues and Possible Extensions to the Study

The results of this study revealed that only Japan's stock market is efficient. However, these results contradict with that of Worthington and Higgs's (2003) study. The discrepancies between the results of the two respective studies could possibly be due to different sampling periods and the structural changes that these markets have undergone within the chosen sampling periods.

Referring to market integration, Chan, Gup and Pan (1997) had found out that during the period 1980-1987, the Asian Stock markets were cointegrated, which contradicts with the results of this study. This may simply be due to the different sampling periods. Another reason could be that the impact of globalisation and advanced communication systems may have led to eliminate the long-run co-movements among stock prices by the present day.

Since the stock returns distributions were found to be non-normal, using parametric tests on these data sets could give ambiguous results. Instead, if non-parametric tests such as Runs test, VR test based on signs and ranks are used, then unbiased results on market efficiency could be obtained.

Lo and MacKinlay (1988) had analysed the monthly stock return data and found that significance of rejection of RWH declines when moving from weekly returns to monthly returns. As an extension to this particular study, monthly data of the eight markets could be analysed to check whether they conform to Lo and Mackinlay's (1988) findings.

Another possible extension is 'sub-period-analysis'. It is a well known fact that with globalisation, the stock markets could easily be affected by global or regional economic shocks. If this study could be extended to incorporate sub periods, it would be possible to identify how major economic shocks such as the 1987- stock market crash, Asian financial crisis, September 11 etc, affected the market efficiency and integration.

It is a globally known fact that on Fridays stock returns are positive while returns on Mondays are negative. Since this implies predictability, the markets cannot be distinguished as weak form market efficient. Therefore, to find out the true impact, an extension for the analysis for 'weekend effect' would be more appropriate.

Finally, the collapse of the US sub-prime mortgage market and the aggravation of global financial turmoil in mid September 2008 have affected the stock markets around the world, resulting in high volatility in stock prices. Had the sampling period of the above study included data upto October 2008, the results and the subsequent conclusions might have been different.

6. Conclusion

This paper investigates the stock market efficiency and integration of the eight selected economies in the Asia-Pacific region. The sample is composed of 4 Emerging/Developing (China, Malaysia, Pakistan and Sri Lanka) and 4 Developed (Australia, Hong Kong, Japan and Singapore) markets. The first motivation of the study is to investigate whether the selected stock markets are efficient at individual level, while the second is to examine whether international diversification is effective. If the markets are efficient individually, then no arbitrage profits could be made locally. Likewise, when international markets are not integrated, the arbitrage profit opportunities disappear and international diversification becomes effective.

The stock returns of each country were first examined individually to check for their conformity to Random Walk Hypothesis. The Unit Root test, LJung-Box Q-Statistic and Variance Ratio tests were employed for this analysis. The results revealed that Japan's equity market is weak-form efficient, while the stock markets of Sri Lanka, Pakistan and Australia are inefficient. This indicates that investors in Japan's stock market cannot systematically engage in profitable ventures while the predictability of stock returns in the markets of Sri Lanka, Pakistan and Australia gives investors the opportunity to explore arbitrage profits. Since the Autocorrelation, Q-Statistic and Variance Ratio test, give ambiguous results for the rest of the markets in the sample, no firm conclusion could be made on market efficiency for China, Malaysia, Hong Kong and Singapore.

The Johenson's cointegration test results on all markets (covering all eight economies) and two sub-groups (Emerging/Developing and Developed economies) indicate that there is no cointegration between the selected international equity markets. This implies that there are no long-run co-movements among the stock prices, and therefore, the investors with long-run horizons will benefit from investments made across the countries in the sample. Analysis of short-run dynamics revealed that the impact of markets in the sample on each other is insignificant. Hence, international diversification is effective.

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ANNEXURE

Chart A1-A8: Weekly Returns Distribution

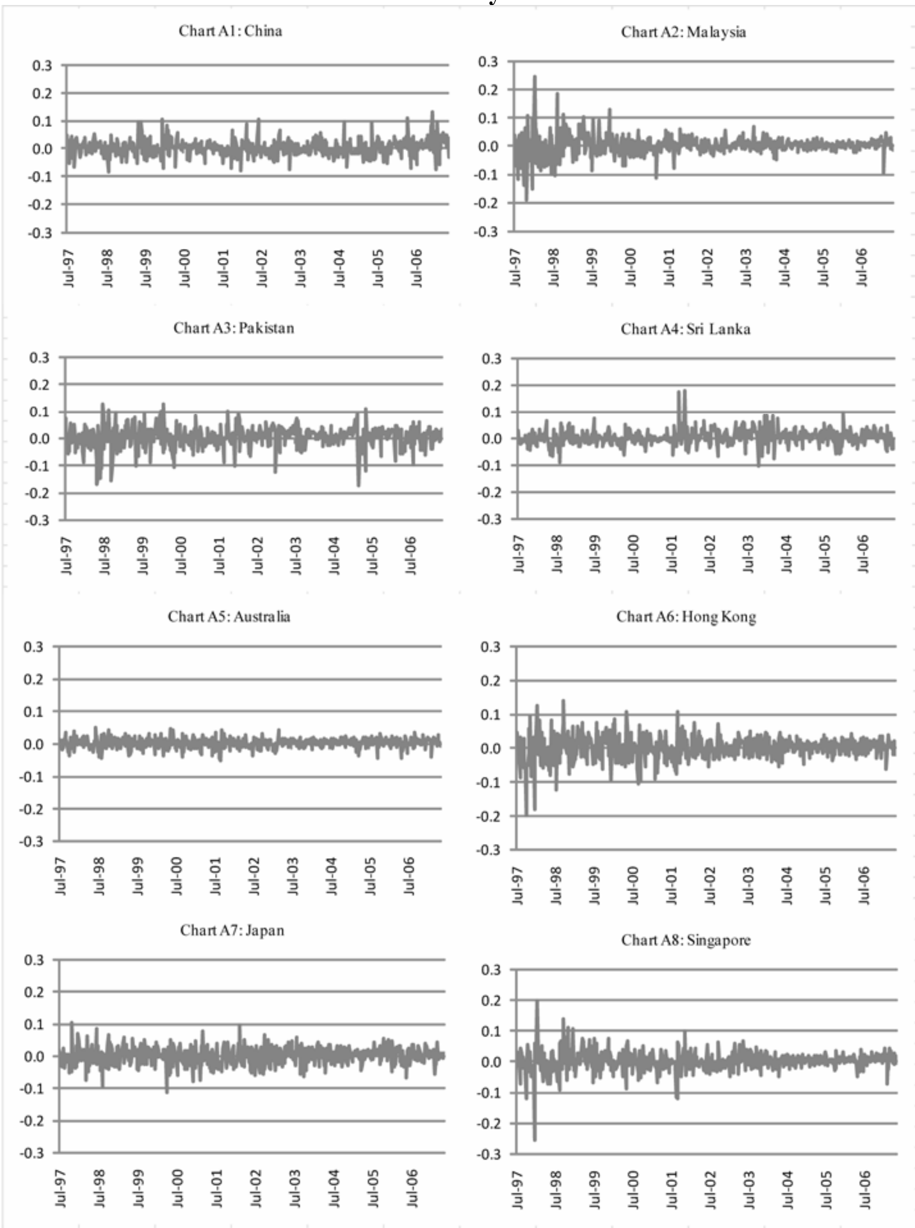

Table A1: Autocorrelations and LJung-Box Q-Statistic –Emerging/Developing Countries

	China			Malaysia			Pakistan			Sri Lanka		
Lag	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	0.06	1.89	0.16	0.04	1.03	0.31	0.17*	15.88*	0.00	0.17*	14.93*	0.00
2	0.07	4.85	0.08	0.07	4.67	0.09	0.08	19.70*	0.00	0.04	15.91*	0.00
3	0.09*	8.96*	0.03	0.06	7.27	0.06	0.00	19.71*	0.00	0.07	18.23*	0.00
4	0.04	9.74*	0.04	0.03	7.91	0.09	-0.02	20.04*	0.00	0.02	18.38*	0.00
5	-0.00	9.75	0.08	0.05	9.93	0.07	-0.04	21.02*	0.00	0.00	18.39*	0.00
6	0.02	10.09	0.12	0.02	10.28	0.11	-0.05	22.41*	0.00	-0.00	18.39*	0.01
7	0.07	12.66	0.08	0.12*	20.42	0.01	0.04	23.38*	0.00	-0.00	18.39*	0.01
8	0.02	12.83	0.11	0.00	20.42*	0.01	0.02	23.60*	0.00	0.01	18.45*	0.02
9	0.07	15.39	0.08	0.08*	25.44*	0.00	0.01	23.61*	0.00	-0.06	20.44*	0.02
10	0.01	15.40	0.11	-0.05	27.01*	0.00	0.03	24.10*	0.01	0.02	20.62*	0.02
$2/\sqrt{T}$ **	0.090			0.076			0.088			0.088		

* Significant at 5% level
** Critical value for the significance of ACF (Brooks, 2002)

Table A2: Autocorrelations and LJung-Box Q-Statistic – Developed Countries

	Australia			Hong Kong			Japan			Singapore		
Lag	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value	ACF	Q-Stat	P-Value
1	0.19*	44.17*	0.00	0.09*	8.05*	0.01	-0.03	0.77	0.38	0.050	2.56	0.10
2	0.08*	51.74*	0.00	0.07*	12.91*	0.00	0.06	4.85	0.08	0.027	3.31	0.19
3	0.02	52.43*	0.00	-0.03	13.56*	0.00	0.01	5.08	0.16	0.098*	13.18*	0.00
4	0.00	52.44*	0.00	-0.00	13.56*	0.01	0.01	5.11	0.27	-0.044	15.19*	0.00
5	-0.04	54.71*	0.00	-0.04	15.48*	0.01	0.02	5.71	0.33	0.007	15.24*	0.01
6	-0.00	54.76*	0.00	0.03	16.66*	0.01	-0.02	6.15	0.40	0.059	18.82*	0.00
7	-0.02	55.77*	0.00	-0.05	19.24*	0.01	0.05	8.77	0.27	0.047	21.08*	0.00
8	-0.05	59.45*	0.00	-0.04	20.54*	0.01	-0.00	8.77	0.36	-0.012	21.24*	0.01
9	-0.02	60.22*	0.00	0.02	20.88*	0.01	0.03	9.69	0.37	0.012	21.39*	0.01
10	0.02	61.22*	0.00	0.01	20.93*	0.02	-0.04	11.3	0.32	0.022	21.88*	0.02
$2/\sqrt{T}$ **	0.058			0.061			0.059			0.063		

* Significant at 5% level
** Critical value for the significance of ACF (Brooks, 2002)

Table A3: Granger Causality Test Results

Null Hypothesis	Lag	F-Statistic	Probability
DLNMALAY does not Granger Cause DLNCHINA	**2**	**3.5848***	**0.0285**
DLNCHINA does not Granger Cause DLNMALAY	2	0.2175	0.8046
DLNPKSTN does not Granger Cause DLNCHINA	2	1.7712	0.1713
DLNCHINA does not Granger Cause DLNPKSTN	2	0.6686	0.5129
DLNSL does not Granger Cause DLNCHINA	2	0.6353	0.5302
DLNCHINA does not Granger Cause DLNSL	2	2.9044	0.0558
DLNPKSTN does not Granger Cause DLNMALAY	2	1.0404	0.3540
DLNMALAY does not Granger Cause DLNPKSTN	2	2.1683	0.1153
DLNSL does not Granger Cause DLNMALAY	2	0.6904	0.5018
DLNMALAY does not Granger Cause DLNSL	**2**	**4.8288***	**0.0083**
DLNSL does not Granger Cause DLNPKSTN	2	0.4267	0.6529
DLNPKSTN does not Granger Cause DLNSL	2	2.6731	0.0699
DLNHK does not Granger Cause DLNAUS	2	0.7000	0.4970
DLNAUS does not Granger Cause DLNHK	2	0.9508	0.3871
DLNJAPAN does not Granger Cause DLNAUS	2	0.5058	0.6033
DLNAUS does not Granger Cause DLNJAPAN	2	1.0527	0.3497
DLNSIN does not Granger Cause DLNAUS	2	1.2766	0.2798
DLNAUS does not Granger Cause DLNSIN	2	0.5520	0.5761
DLNJAPAN does not Granger Cause DLNHK	2	0.0416	0.9593
DLNHK does not Granger Cause DLNJAPAN	2	1.0059	0.3664
DLNSIN does not Granger Cause DLNHK	2	2.3272	0.0985
DLNHK does not Granger Cause DLNSIN	**2**	**2.9939***	**0.0458**
DLNSIN does not Granger Cause DLNJAPAN	2	0.3246	0.7229
DLNJAPAN does not Granger Cause DLNSIN	2	2.2097	0.1107

* Significant at 5% level