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STAFF STUDIES

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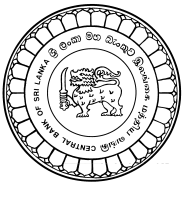

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ABOUT THE AUTHORS

Dr. H. N. Thenuwara is the Director of Economic Research Department of the Central Bank of Sri Lanka. He has received a B.Sc. Degree in Pure Maths, Physics and Industrial Management from the University of Kelaniya, Sri Lanka, an M.Sc. Degree in Applied Statistics from the University of Colombo, Sri Lanka, an M.A. Degree in Econometrics from the University of Manchester, UK, and a Ph.D. Degree from the University of Iowa, USA. His research interests are in Economic Theory, Monetary Policy, Economic Growth, International Finance, International Trade Policy and Real Sector Developments leading to economic growth.

Dr. D S Wijesinghe is the Director of the Domestic Operation Department of the Central Bank of Sri Lanka. He has received B.A. in Economics from the University of Colombo and M.A. and Ph.D. Degrees in Economics from University of Warwick, England. His research interests are in the fields of Exchange Rate Policy, Monetary Policy and Macroeconomic Modeling.

Mrs. Rupa Dheerasinghe is a Deputy Director of the Domestic Operations Department of the Central Bank of Sri Lanka. She received a B.A. Degree in Economics from the University of Peradeniya, a Post Graduate Diploma in Applied Statistics from the University of Colombo and a M.A. Degree in Economics from the Monash University, Australia. Her research interests are in International Trade and Monetary Policy.

Mrs. H K J Ekanayake is an Economist attached to the Money and Banking Division in the Economic Research Department of the Central Bank of Sri Lanka. She has received a B.Sc. Degree in Agricultural Economics from University of Ruhuna, Sri Lanka. She is currently reading for her Masters Degree at University of Monash, Australia. Her current research interests are in the fields of Monetary Policy and Agriculture Policies.

Communication Policy of Central Banks
The Case of Sri Lanka

Dr. H N Thenuwara[1]

Abstract

Communication policies are important for central banks for two reasons. First, being public institutions it is important to disclose their actions to the general public for maintaining democratic accountability that comes with independence. Second, the policy effectiveness is enhanced if the general public is aware of policies of central banks, and reasons. Realising this, the Central Bank of Sri Lanka is in the process of developing a comprehensive communi-cation policy to portray its accountability and to allow economic agents to make informed judgements about performance of the economy and Central Bank policies. However, there are several issues to be addressed in Sri Lanka before any communication policy takes its intended full effect. (JEL D83, E58)

I. Introduction

Broadly, there are two types of monetary authorities; central banks and currency boards. Central banks are different from currency boards in terms of objectives and the degree of complexity. The major function of currency boards is to issue currency backed by 100 per cent of reserve assets and through it to maintain the external value of domestic currency, and this sole objective is clearly understood and stated. Many central banks, on the contrary, often have multiple objectives, and are different from each other in terms of the number and nature of these objectives.

According to Brunner (1981), central banking has been traditionally surrounded by a peculiar and protective political mystique. The mystique has thrived on an impression that central banking is an esoteric art. The esoteric nature of the art is moreover revealed by an inherent impossibility to articulate

1/ The author is the Director of Economic Research of Central Bank of Sri Lanka. The author wishes to acknowledge the valuable comments made by *Deshamanya* Sunil Mendis, Former Governor, Central Bank of Sri Lanka, Miss Kumudinee Saravanamuttu and Mrs. C.K. Nanayakkara.

its insights in explicit and intelligible words and sentences. However, with the development in markets and market forces, objectives of central banks could not be met solely though central bank actions, and a fair degree of cooperation was required from market participants. This paved the way for the demystifying process of central banks. The process was intensified with the failure of some of the central banks in achieving the most important objective of maintaining price stability, and facing serious crises while attempting to attain other objectives, especially, maintain the international value of their currencies.

The failure in simultaneously realising multiple objectives has prompted several central banks to adopt a single objective. With the introduction of inflation targeting as the single overriding objective by the Reserve Bank of New Zealand in 1990, a remarkable change has occurred regarding the central banks' choice of objectives, targets, instruments, decision making procedures, implementation procedures, and communication. Inflation targeting central banks have been accorded greater independence and accountability. Thus, such central banks are required communicate their policies partly to fulfil their accountability, and partly to ensure that economic agents formulate expectations in line with the desired direction of central bank policies.

The nature of communication becomes increasingly complex with the complexity of central bank objectives, and the way policies are conducted. As illustrated in Blinder *et al* (2001), the complexity of communication increases with the multiplicity of objectives of central banks (Figure 1).

Figure 1 – Policy Regimes and the Nature of Communication

Rule-based Regime ⟵ Discretion-based Regime

Currency Boards	Exchange Rate		Inflation Targeting		Multiple Objectives
	Hard peg	Crawling Peg	Point	Range	
Argentina	China	Hungary	Sweden	Australia	Japan
Estonia	Denmark	Poland	UK	New Zealand	USA
Hong Kong				Euro Area	SAARC central banks

Simple Communication ⟵ Complex Communication

Central banks in South Asia still continue with multiple objectives due to a large number of economic and political realities, although this has made communication by those banks complex. The development objective of a central bank in South Asia cannot be easily dropped. Ensuring the external value of domestic currency remains a sensitive concern even after many central banks have floated their currencies. In the case of Sri Lanka, the hiving off of many activities inherited by central banks, that are not core central banking activities such as public debt management, management of the Employees Provident Fund, and to a certain extent, supervision activities have to be done gradually, and the process has already been started. In addition to these issues, the transition to an inflation targeting framework has been hindered due to a range of issues such as different views on available measures of accepted price indices and core inflation, insufficient improvements in the policy transmission mechanism and some of the fiscal sector concerns (Jayamaha *et al* 2001/2).

II. International Initiatives in Promoting Communication

International financial agencies have been taking steps to improve communication and transparency in relation to the conduct of economic policies by central banks and other authorities. The need for increased transparency has emerged mainly due to three reasons.

i. Financial markets, especially in developed economies, have increasingly felt that central bank actions are affecting their performance, which prompted markets to demand for accurate and timely information from central banks and other relevant authorities. On the other hand, central banks have also realised that increased communication and transparency help reduce undue volatility in financial markets.

ii. High inflation scenarios in many countries in the 1980s, prompted central banks to focus more on maintaining price stability. Following the initiative by the Reserve Bank of New Zealand, there has been an increasing tendency for central banks to adopt inflation targeting as the framework for monetary policy, which requires greater independence as well as a high degree of transparency.

iii. It has been recognised that the damage caused by the Asian Crisis in 1997, particularly the contagious effect of the crisis could have been minimised if there were higher transparency and good communication policies.

As a result of the developments highlighted above, international institutions, especially, the International Monetary Fund (IMF), the World Bank and the Bank of International Settlements (BIS) have designed codes and standards of transparency practices for monetary and financial policies, in cooperation with appropriate institutions, with a view to strengthen the architecture of the international monetary and financial system.

Under Reports on the Observance of Standards and Codes (ROSCs), one such initiative to improve transparency, the IMF has recognized 12 areas and associated standards as useful for the operational work of the IMF and the World Bank. These comprise data dissemination; accounting; auditing; anti-money laundering and countering the financing of terrorism; banking supervision; corporate governance; fiscal transparency; insolvency and creditor rights; insurance supervision; monetary and financial policy transparency; payments systems; and securities regulation. The reports covering these areas and standards are used to facilitate the institutions' policy discussions with national authorities and with the private sector.

To strengthen the availability of data for economic analysis, the IMF has developed two data dissemination standards namely the General Data Dissemination System (GDDS) and Special Data Dissemination Standard (SDDS). The purpose was to set up a common platform to disseminate data on a number of key macroeconomic variables in a homogenous way by different countries. The SDDS requires provision of data on key economic aggregates in the four sectors, namely, the real sector, fiscal sector, financial sector and external sector. The GDDS is a lower tier in disseminating similar data categories, which is less demanding than the SDDS. The GDDS is mainly for countries that recognize the importance of providing high quality data, yet whose data preparation and dissemination systems are still in the process of being developed and hence, there are deficiencies in the data. The GDDS also requires publishing data on the same four dimensions mentioned above. Sri Lanka is a participatory country to GDDS and is planning to subscribe to SDDS.

The IMF, working together with the BIS, and in consultation with a representative group of central banks, financial agencies, other relevant international and regional organizations, and selected academic experts, has developed a 'Code of Good Practices on Transparency in Monetary and Financial Policies' as well as the 'Code of Good Practices in Fiscal Transparency'.

The 'Code of Good Practices on Transparency in Monetary and Financial Policies' identifies desirable transparency practices for central banks in their conduct of monetary policy and for central banks and other financial agencies in their conduct of financial policies. The transparency practices listed in the

Code concentrate on a series of issues; (1) clarity of roles, responsibilities and objectives of central banks and financial agencies; (2) the processes for formulating and reporting of monetary policy decisions by the central bank and of financial policies by financial agencies; (3) public availability of information on monetary and financial policies; and (4) accountability and assurances of integrity by the central bank and financial agencies. The 'Code of Good Practices in Fiscal Transparency' focuses on similar issues with regard to fiscal policy formulation.

III. Nature of Communication Policy

Communication, by definition, implies choice - what to say and what not to say. Traditionally, central banks all over the world chose not to say much about their activities, because they thought that maintaining secrecy was necessary for the fulfilment of their tasks and the attaining their objectives (Issing, 2005). As economies became more liberal and markets became fundamental forces in changing economic events, central banks had to share their thoughts with the markets, for attaining their objectives. The new thinking now accepts that clear communications by central banks make their policies more effective and communication plays a significant role in fulfilment of transparency of central banks.

The main component of the communications policy is the content of communications. Other important components are the way of communication and modes of communication. The content should encompass what it is trying to accomplish with regard to the objectives of a central bank and the way of achieving the objectives. This entails communicating on the objectives of policies, methods of policy formulation, decisions and views on future developments. In addition, the public should be made aware of the complexities of the central bank's tasks and that the policy environment is uncertain and constantly changing, specially in an environment where there is uncertainty about prevailing and future economic conditions, the nature and extent of economic shocks and the market expectations process. Communication is also a key tool in portraying the governance, transparency and accountability of a central bank

Characteristics of effective communications as outlined in many studies, and as experienced by the CBSL are as follows (Saravanamuttu 2005).

i. ***Clarity and Simplicity*** – Communications should be clear and simple to ensure that the target audience easily understands the communication and to avoid misinterpretation.

ii. ***Transparency and Credibility*** – Communications should be transparent and credible in order to increase their effectiveness. In this regard, information on policy decisions should always be accompanied by the rationale for the particular decision. Matching deeds with words is important to achieve credibility.

iii. ***Adequacy and Comprehensiveness*** – Communications should provide sufficient information to enable users to take informed decisions.

iv. ***Accuracy and Reliability*** – Information contained in the communications should be accurate and reliable. The quality of information disseminated is more important than the quantity.

v. ***Timeliness*** – Communications should be disseminated at appropriate times to be of use to target groups and the public. Communications should strive to be forward looking.

vi. ***Accessibility and Outreach*** – The target groups and the public should have easy access to information.

Objectives of communication policy range from providing guidelines to the staff involved in communication and ensuring the effectiveness of central bank policies, while meeting democratic accountability. Some of these objectives are as follows (Saravanamuttu 2005):

To raise awareness among staff of the importance of organized and coordinated communications for the achievement of central bank objectives.

i. To assist the staff to present the central bank and its activities in a unanimous manner and to project the distinctive features of its identity as a professional and accountable institution.

ii. To raise public understanding on how central bank policies and financial sector regulations works and for acceptance of the role of the central bank.

iii. To focus external and internal communications so that it effectively and efficiently contributes to the fulfilment of the central bank objectives.

Central banks use a variety of methods to communicate to markets and the public. With the advent of information technology applications central banks could reach a wide cross section of the public easily and simultaneously. Central banks use press conferences and other means such as public lectures, and periodic publications to reach the public.

IV. Evolving Communication Policy and Strategy of the Central Bank of Sri Lanka

The main objective of the evolving communication policy of the CBSL is to provide information on economic developments both in relation to banking and finance as well as other socio-economic aspects, with a high level of accuracy and integrity to a wider audience so that economic agents could make informed decisions. An open and coherent communication strategy helps central banks in several ways. First and foremost, it enhances the effectiveness of monetary policy. A clear communication policy also helps to reduce risks and volatility in financial markets, which is another key concern of many central banks. To achieve the objectives of the Central Bank, transparency, accountability and credibility in its policies and working methods will be helpful.

An important feature in the communication policy of the CBSL is the procedure adopted in communication. As the authority that makes policy decisions, the Monetary Board is responsible for the overall communication policy. The Board has delegated its authority on communication policy to the Governor and the Deputy Governors. Several officers have also been authorised to disseminate information that are of routine nature. However, the accountability of the communication lies with the Monetary Board.

The Monetary Law Act of 1949 (Government of Sri Lanka , 1949) establishing the Central Bank of Sri Lanka (CBSL) requires the Monetary Board of the CBSL to disseminate information on Central Bank assets and liabilities monthly, an annual report containing details of the condition of the Central Bank, review of policies and measures adopted by the Monetary Board, and an analysis of the economic and financial circumstances which prompted those policies and measures. The Law further requires the Monetary Board to include in the annual report several series of data on the monthly movements of the money supply, the monthly movements of purchases and sales of exchange and of the international reserve of the Bank, the annual balance of payments of Sri Lanka, the monthly indices of wages, of the cost of living, and of import and export prices, the monthly movement of exports and imports, the monthly movement of the accounts of the Central Bank and, in consolidated form, of the commercial banks, as well as the principal data on government receipts and expenditures and on the state of the public debt.

In view of the structural changes and developments in the economy particularly following the liberalisation of the economy in 1977, there has been a growing demand for timely and comprehensive information. This has been augmented in the aftermath of the Asian financial crises, especially for greater transparency of financial policies and wider spectrum of data.

The need for a well-articulated communication policy was further intensified with the modernisation of the CBSL (Central Bank, 2001). The challenges brought about by ever increasing complexities in financial systems and new thinking on economic policy and the role of central banks in a changing world have prompted the CBSL embarked on a modernisation programme. The Monetary Law Act under which the CBSL has been established was amended in 2002 to move away from multiple objectives to focus on two core objectives, (*a*) economic and price stability and (*b*) financial system stability, with a view to encouraging and promoting the development of the productive resources of Sri Lanka. Achieving the objectives was further facilitated by establishing several committees in the CBSL.

Since monetary policy is the means by which the CBSL attempts to attain the objective of economic and price stability, monetary policy communication has become one of the major components of the overall communication policy. To strengthen the institutional arrangement for the determination of the monetary policy decision-making process and to improve transparency and accountability, the CBSL established the Monetary Policy Committee (MPC) in 2000. Furthermore, to enhance the effectiveness of monetary policy operations, the CBSL moved to a more market-oriented open market operation system. With the shift to this system in March 2003, the CBSL commenced reviewing the monetary policy stance on a monthly basis and issuing press releases on the monetary policy stance, with explanatory notes providing more information to the market on monetary and other economic developments. An advance release calendar of monetary policy reviews is also published giving the dates on which the monetary policy is reviewed. In addition, the overall monetary policy framework and monetary policy targets are posted on the Bank's website.[2]

Since maintaining financial stability is the second objective, measures have also been taken to improve the financial system stability. The Financial Stability Committee (FSC) was established in 2002. One of the main tasks of the FSC is to prepare and publish a Financial Stability Report (FSR) assessing the risks and vulnerabilities leading to financial system instabilities of a significant scale in the country (Central Bank, 2005).

To make its financial statements internationally comparable and adopt disclosure and accounting policies in line with international best practices, the CBSL has adopted International Accounting Standards (IAS) as the accounting framework for producing its financial statements. The Bank was able to achieve substantial IAS compliance in 2001, 2002, and 2003, and it intends to achieve the full compliance in 2004. A more detailed description of financial statements prepared for the year 2003 on the basis of International

2/ www.centralbanklanka.org

Financial Reporting Standards (IFRS) was published as a separate document. The CBSL also publishes a monthly general balance sheet, giving information on the volume and composition of foreign assets, domestic assets and foreign liabilities and domestic liabilities.

A large audience consisting of both domestic and foreign constituencies could be the recipients of information disseminated by the CBSL. In general, the domestic audience includes government officials, politicians, financial market participants, the academic and other professionals and the general public. Foreign constituents include multilateral financial institutions and the donor community including the International Monetary Fund, the World Bank, the Asian Development Bank and other institutions such as regional organisations and international research institutions. As the level of expertise and the required details of various constituencies are diverse, the CBSL always tries to maintain clarity and provide the necessary details to strike a balance in catering to these different needs.

The CBSL has always made a conscious attempt at maintaining integrity and ethical standards in communication. The Bank always issues its major publications, and press releases and conduct press conferences in all three languages used in Sri Lanka, *viz.*, Sinhala, Tamil and English. Information is always released simultaneously to all concerned parties.

Although there could be restraints in disclosing confidential information and financial policy related issues that could destabilise markets, the goal of the CBSL is to provide accurate and timely information. When a clarification is sought or when news appears in media questioning policies or activities, the Bank responds promptly.

Another important factor in respect of the Bank's communication policy is the procedure adopted in communication. As the Monetary Board of the CBSL is the authority that makes policy decisions, the Monetary Board is responsible for overall communication policy. The Board has delegated its authority to communicate on policy matters to the Governor and the Deputy Governors. However, other authorised officers would disseminate information of routine nature.

Sri Lanka has participated in many of these initiatives undertaken by international financial institutions to assess the quality of the dissemination of information and the level of transparency. For instance, an evaluation of Sri Lanka's position against these codes was made under the Financial Sector Assessment Program (FSAP) and for the Report on Observance of Standards and Codes (ROSC), which are the frameworks for enhanced financial system surveillance developed by the IMF and the World Bank. Sri Lanka is one of the first countries to participate in GDDS. The graduation to SDDS is only

two steps away, the compilation of international investment position and the reduction of lag in some of the variables, which are being speedily resolved.

To enhance the awareness among participants in the payment systems work in Sri Lanka, the CBSL jointly with Committee on Payment and Settlement Systems (CPSS) of the central banks of G-10 countries has prepared the Red Book, 'Payment Systems in Sri Lanka' which was published by the BIS in 2004 (Central Bank 2004). Since the inception of the CPSS in 1990, BIS has published Red Books for 15 countries and Sri Lanka became the sixteenth country in the world to publish its Red Book. In the Asian region, Sri Lanka was the third to publish this report, after Singapore and Korea.

The CBSL has published an advance release calendar of all information, press releases and publications (Table 1 and 2). Most important communication made to the general public is the monthly press release on the changes in monetary policy stance. In addition, The CBSL issues a number of publications in all three languages. The Annual Report of the CBSL provides a detailed coverage of macroeconomic developments and of the operational activities of the Central Bank. The Bank also issues the Recent Economic Developments and Prospects covering the developments during the first half of each year and future prospects. The Financial Stability Review provides an assessment of the banking and financial sector. In addition, the CBSL publishes several monthly and ad-hoc reports covering economic developments to meet requirements of different audiences. Many of these publications are available in all three languages. These are complemented with periodicals, published in all three languages containing articles on economic and finance/banking and

Table 1 – List of Major Regular Publications by the Central Bank of Sri Lanka

Publication	*Frequency*	*Language*
1. Economic Indicators	Weekly, Monthly	Sinhala, Tamil, English
2. Monthly Bulletin	Monthly	Sinhala, Tamil, English
3. Satahana	Quarterly	Sinhala
4. News Survey	Quarterly	English
5. Kurippedu	Quarterly	Tamil
6. Financial Stability Review	Bi-annaully	English
7. Staff Studies	Bi-annaully	English
8. Annual Report	Annually	Sinhala, Tamil, English
9. Recent Economic Developments	Annually	Sinhala, Tamil, English
10. Economic and Social Statistics	Annually	English, Sinhala
11. Consumer Finance Survey Report	Once in 5 years	English

Table 2 – Advance Release Calendar

Information	*Date*
1. Sri Lanka Inter Bank Offered Rates	Daily at 10 am
2. Open Market Operations Auction Results	Daily at 11.30 am
3. Exchange Rates	Daily at 12 noon
4. Call Market Rates	Daily at 4 pm
5. Secondary Market Rates of Government Securities	Daily at 4 pm
6. Government Securities Auction Results	As pre announced
7. Consumer Prices	Last day of Month at 3 pm
8. External Trade Performance	Second week of Month
9. Monetary Policy Statements – 2005	January 15 February 16 March 16 April 12 May 13 June 15 July 15 August 17 September 16 October 14 November 16 December 16
10. Estimates of Gross Domestic Product	Last Day of Each Quarter

other areas of current economic interest. The Bank also publishes research studies and articles in its journal of Staff Studies.

With a view to providing information on monetary operations and other key macroeconomic aggregates on a regular basis, the CBSL issues regular updates through press releases as new data become available. At present, regular press releases are issued on monetary policy, price developments, external sector developments and economic growth. In addition, the Bank organises press conferences on matters of public interest as well as to clarify specific issues and senior officials of the Bank conduct these.

Bank holds regular discussions with the financial sector market participants, where major changes to policy are discussed to obtain a feedback before implementing. The Bank also holds monthly meetings with the Chief Executive Officers of banking institutions where important policy changes are discussed. In addition, the CBSL holds regular meetings with primary dealers in government securities, finance companies and foreign exchange dealers.

On specific issues, the CBSL conducts several public awareness programmes in the form of paper notices, special publications and meetings to educate the general public. The Bank undertook a special programme to educate the pubic on unauthorised institutions soliciting deposits from the public. In this regard, the public was mainly informed of the following:

- The public have to bear the risks involved in their transactions with financial institutions
- Regulation and supervision does not involve a guarantee of deposits or any other transaction or the safety of any institution.
- There may be institutions accepting deposits from the public without legal permission and risks involved in those institutions would be greater since they are not regulated or supervised by the CBSL or any other authority.

During 2004, attention of the CBSL was drawn to pyramid schemes that were operating in the country. In the absence of necessary legislation against such schemes, which pose a threat to the country's financial stability, the CBSL undertook an awareness programme among the members of the public on the risks and dangers associated with pyramid schemes.

The CBSL conducts awareness programs for the benefit of students and teachers on issues relating to banking, finance and economics. Several articles on these areas are included, for example in the CBSL regular publications such as 'Kauluwa', 'Satahana' and 'News Survey'. The CBSL issues updates on key macroeconomic aggregates weekly and monthly.

In addition, the dissemination of information through electronic means is now becoming increasingly important as it provides instantaneous access not only to domestic audience but also to a wider global audience. The CBSL maintains a website and makes regular updates with latest information. The CBSL also participates in exhibitions, conducts public seminars, and operates a currency museum and a library in its effort to disseminate information to a wider audience.

The CBSL has recognised that internal communication is also a major factor in reinforcing its organisational identity and command. The staff of the CBSL should have the opportunity to be well informed so that information about the bank will be released externally in a correct and uniform manner. Internal communications are made through both electronic and paper based publications. The intranet is the most commonly used mode. It is supplemented by a monthly in-house magazine. In addition all communications made to the general public are circulated among all members of the staff.

V. Limitations of Communication – The Sri Lanka's Perspective

Communication is a complex task in Sri Lanka due to several important issues that are being resolved. The CBSL operates with two objectives, economic and price stability, and financial system stability, while being mindful of the exchange rate behaviour. Those objectives are not articulated in terms of explicit targets. This has become even more complicated due to diverse views on crucial measures such as inflation. Furthermore, the efficacy of transmission mechanism of monetary policy has to be improved further. In addition, some of the large fiscal operations could pose challenges to monetary operations. Thus, there exists room for diverse interpretations of central bank communiqués.

In the past, there are occasions when media has misinterpreted and miscommunicated central bank information, causing wide fluctuations in market behaviour. The diversity of recipients of communications of the CBSL, their ability to decipher those communications, and the thin financial markets have partly contributed to those misinterpretations. Such misinterpretations are also due to the insufficient developments in economic journalism in the country. The CBSL has conducted several programs to educate the media personnel on important economic and financial issues.

The communications on financial stability is also tricky. Often, prompt and factual communications on any adverse developments in the financial sector could lead to undesirable and adverse outcomes, especially in view of self-fulfilling nature of economic prophecies. Thus, communications on financial system stability have to be made delicately. However, the CBSL has been insisting on financial institutions to disclose their information on a wide spectrum of issues such as performance, interest rates, financial charges and other prudential indicators, while making available to the public a set of important indicators as well as a biannual report on financial stability.

In view of those concerns, the CBSL has to continue to address a wide array of issues to further ensure the efficacy of its communication.

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Active Open Market Operations
A Review of Experience

Dr. D S Wijesinghe[1]

Abstract

The Central Bank of Sri Lanka introduced a system of active Open Market Operations (OMO) on 03 March 2003 in order to manage liquidity at its own discretion and thereby to achieve monetary policy targets. Under this system, monetary policy operations are conducted to achieve a path of reserve money targets, while maintaining short term interest rates stable around a level, which is consistent with the reserve money targets. This paper reviews the experience under the system during March 2003-June 2005 and presents suggestions, on the basis of the review, for improving the effectiveness of monetary policy operations in achieving their objectives. The paper highlights the need for focusing on overnight interest rates, instead of reserve money, as the operating target, determining the size of daily operations under OMO entirely on the basis of their outcome on interest rates and introducing long term repurchase transactions and auctions for multiple maturities for managing liquidity on a long term basis. (JEL E44, E52)

I. Introduction

The Central Bank of Sri Lanka introduced on 3 March 2003, a system of active Open Market Operations (OMO) in order to manage market liquidity actively at its own discretion and thereby to achieve monetary policy targets. The Central Bank conducts monetary policy within a framework of targeting monetary aggregates. In this framework, the final objective of economic and price stability is expected to be achieved through an intermediate target on broadly defined money supply with an operational target on reserve money. Accordingly, monetary policy operations are conducted to achieve a path of

1/ The author wishes to thank Dr. A. G. Karunasena, Asst. Governor, Central Bank of Sri Lanka for his valuable comments on an earlier draft of this paper. The assistance of Mrs. K. Dassanayake, Senior Asst. Director and Mrs. K. Mayadunne, Asst. Director, Central Bank of Sri Lanka in the preparation of this paper is acknowledged with thanks.

reserve money targets while maintaining interest rates stable around a level consistent with the path of reserve money targets.

The objectives of monetary policy operations under this system were well realized in 2003. However, in 2004, reserve money tended to remain above the targets and interest rates displayed some volatile changes. This paper reviews the experience under this system with a view to present suggestions for improving the effectiveness of the system in achieving the objectives of monetary policy operations. The paper begins with an outline of the key elements of the system in Section 1. A review of experience during March 2003 – June 2005 is presented in Section 2. Section 3, outlines the approach adopted by the Central Bank, amidst difficult economic conditions prevailed in the country, to bring the reserve money to the target path and examines contributory factors for interest rate volatility. Suggestions for further improving the system are outlined in Section 4.

II. Key Elements of the System

The key elements of the present system of monetary policy operations are,

(*i*) Interest Rate Corridor formed by the overnight repurchase (Repo) rate and the reverse repurchase (Reverse Repo) rate of the Central Bank.

(*ii*) Daily Auction of Repo or Reverse Repo transactions, either to absorb liquidity from the market or inject liquidity to the market.

(*iii*) Standing facility.

(*iv*) Outright Sales/Purchases of government securities to address long term (structural) liquidity imbalances.

The interest rate corridor is the instrument to achieve the reserve money target. The corridor has an implicit target on overnight interest rates (usually in the middle of the corridor) which is considered compatible with the reserve money target. If reserve money is consistently above (below) the target, it is an indication that the corridor is not compatible with the reserve money target and therefore, needs to be shifted up (down). Usually, such adjustments are introduced at regular reviews of monetary policy which are conducted normally on a monthly interval. However, if there is a concern for adjusting the corridor, in view of other macro economic considerations, interest rates are allowed to adjust within the corridor. Such within the corridor adjustments are usually temporary, pending an eventual adjustment to the corridor.

The daily auction is the instrument to maintain the comparable overnight interest rates, stable around the implicit target. Accordingly, whenever there is excess liquidity, it is absorbed through a daily auction of

repurchase transactions. Similarly, liquidity is injected through an auction of reverse repurchase transactions when there is a liquidity shortage. The implicit target is achieved by appropriately managing market liquidity, specially by adjusting the volume of liquidity absorbed or injected through the auction.

Standing facilities are provided at the Central Bank's Repo rate and Reverse Repo rate to those who were unable to obtain their requirements at the daily auction. A sufficient margin is maintained between the Repo rate and the Reverse Repo rate in order to make them penalty rates and thereby to encourage participating institutions to obtain their requirements at the auction.

A long term or structural liquidity imbalance is indicated by the existence of a large surplus or deficit of liquidity consistently for a long period and such imbalances are removed through outright sales or purchases of government securities.

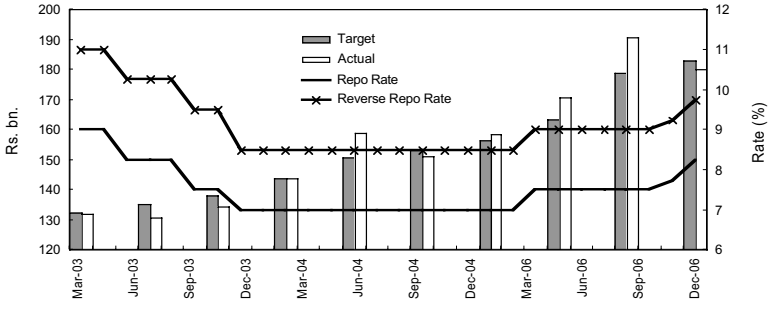
III. Experience during March 2003 – June 2005

A. Interest Rate Corridor and Reserve Money Target

The present system of open market operations was introduced with an interest rate corridor of 11 per cent (Reverse Repo Rate) and 9 per cent (Repo Rate). However, as actual reserve money continued to be consistently below the target the corridor was revised down in three steps to 8.5 per cent (Reverse Repo Rate) and 7.0 per cent (Repo Rate) by October 2003, and quarterly targets on reserve money were comfortably met (Chart 1). In 2004, reserve money tended to remain above the target path and the Central Bank first conducted

Chart 01

Interest Rate Corridor
Reserve Money: Actual Vs Target



its OMO aggressively allowing an upward movement in interest rates within the corridor and subsequently shifted the corridor up by 50 bps in November 2004. The monetary policy was tightened further by shifting the corridor by 25 bps in May and 50 bps in June 2005 to 9.75 per cent (Reverse Repo Rate) and 8.25 per cent (Repo Rate). Reserve money was brought to the target path by June 2005.

B. Daily Auction and Interest Rate Stability

During 2003, as reserve money continued to remain below the target, the Central Bank had been quite conservative in absorbing liquidity through the daily auction. Accordingly an amount equivalent to the estimated excess liquidity less the leeway between the reserve money target and the actual reserve money was offered and absorbed through the auction (Chart 2). On average, the amount offered was around 58 per cent of the estimated excess liquidity (Table I). Therefore, competitive forces pushed the weighted average yield rate at the auction down and it remained closer to the lower bound of the corridor.

During most of this period, short term interest rates remained remarkably stable (Chart 3). The stability was largely attributed to the effort made by the Central Bank to maintain liquidity in the market at a sufficiently high level (Table 2). Due to stringent limits of some banks on their lendings to other banks, normally, volatility had been observed in short term rates whenever, the liquidity surplus declines below Rs. 3 – 5 billion level. Particularly during festive seasons when the demand for liquidity is high temporarily, the Central Bank injected liquidity through purchases of Treasury bills. During March – December 2003, on average, excess liquidity in the market remained around

Chart 02

Daily OMO Auction
Estimated Excess Liquidity, Amount Offered and Average Yield

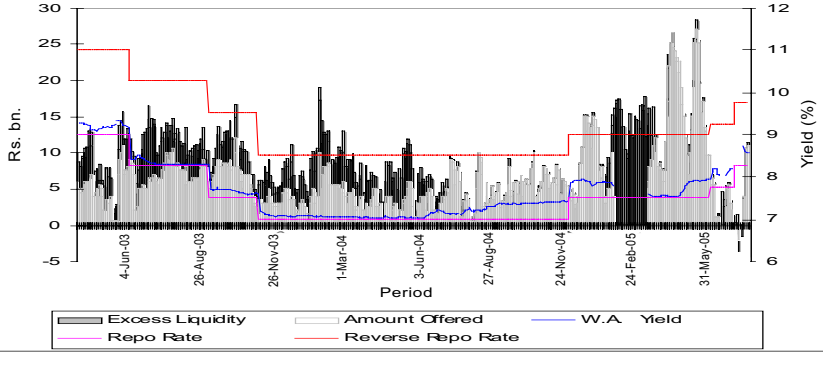


Table-01

Daily OMO Auction

Estimated Excess Liquidity, Amount Offered, Bids Received & Accepted and Yield

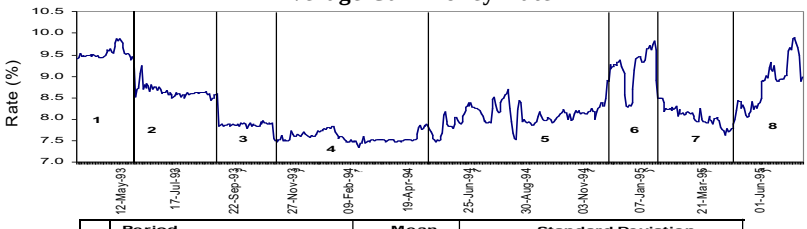
Monthly Average

		Estimated Excess Liqudity (Rs.bn)	Amount Offered		Bid Received (Rs.bn)	Bid Accepted (Rs.bn)	Yield (%)		
			Rs.bn	As % of Excess Liquidity			Weighted Average	Min.	Max.
2003	Mar	9.23	5.38	58	9.93	5.38	9.17	9.14	9.19
	Apr	6.56	3.60	55	4.70	3.48	8.70	8.64	8.74
	May	6.56	3.60	55	4.70	3.48	8.70	8.64	8.74
	Jun	12.65	6.86	54	11.06	6.58	8.31	8.29	8.32
	Jul	11.42	7.41	65	9.99	7.31	8.29	8.28	8.30
	Aug	9.91	7.23	73	8.91	6.59	7.96	7.93	7.99
	Sep	11.73	7.98	68	10.26	7.89	7.65	7.62	7.66
	Oct	6.50	3.86	59	5.57	3.84	7.34	7.31	7.36
	Nov	6.50	3.45	53	5.26	3.44	7.05	7.04	7.07
	Dec	7.07	3.02	43	4.85	2.96	7.06	7.04	7.08
2004	Jan	11.23	6.48	58	9.16	6.08	7.03	7.03	7.06
	Feb	7.69	3.78	49	6.10	3.42	7.03	7.02	7.03
	Mar	5.37	2.70	50	3.59	2.52	7.02	7.02	7.03
	Apr	7.50	2.92	39	3.36	2.52	7.02	7.02	7.03
	May	5.62	3.33	59	2.68	2.29	7.06	7.04	7.06
	Jun	5.75	4.70	82	4.68	4.03	7.14	7.13	7.16
	Jul	3.91	3.76	96	2.82	2.73	6.84	6.82	6.88
	Aug	4.27	4.19	98	3.48	3.43	7.32	7.28	7.36
	Sep	6.01	5.92	99	5.20	5.11	7.36	7.30	7.39
	Oct	6.15	6.00	98	5.51	5.40	7.39	7.35	7.42
	Nov	5.15	5.10	99	4.39	4.20	7.70	7.67	7.74
	Dec	10.84	9.97	92	10.00	9.40	7.86	7.82	7.90
2005	Jan	13.86	7.00	50	11.73	6.78	7.81	7.78	7.85
	Feb	14.52	7.80	54	12.45	7.36	7.56	7.54	7.57
	Mar	15.83	15.21	96	14.41	13.80	7.55	7.54	7.58
	Apr	17.60	17.17	98	16.63	15.99	7.82	7.77	7.89
	May	7.72	7.24	94	7.02	6.61	8.01	7.96	8.05
	Jun	2.64	2.37	90	2.24	2.03	8.39	8.30	8.53

Rs. 9 billion. With the exception of a few days in April, excess liquidity in the market remained well above Rs. 3 billion on each day. Similarly, during the first four months in 2004, on average, there was excess liquidity of nearly Rs. 8 billion and except for a few days in March – April, excess liquidity remained well above Rs. 3 billion.

Chart 03

Average Call Money Rate



	Period	Mean	Standard Deviation
1	03-Mar 03 - 09-May-03	9.54	0.13
2	12-May-03 - 14-Aug-03	8.65	0.15
3	15-Aug-03 - 15-Oct-03	7.86	0.03
4	16-Oct-03 - 30-Apr-04	7.56	0.12
5	03-May-04 - 10- Nov-04	8.11	0.25
6	12-Nov-04 - 04-Jan-05	9.21	0.43
7	05-Jan-05 - 31-Mar-05	8.10	0.24
8	01-Apr-05 - 30-Jun-05	8.74	0.60

* Sub-period were identified by changes in the policy stance

In May 2004, in view of the higher than desired rate of expansion in reserve money, it was decided to allow market rates to move up within the corridor. Accordingly, the amount offered to the market for absorption through the repurchase auction was gradually increased to almost the entire estimated liquidity surplus. This practice resulted in gradually moving up the average yield rate at the auction from 7.02 per cent at end April 2004 to 7.40 per cent by 14 October 2004, a margin of 40 bps compared to the Repo rate of the Central Bank. With the upward adjustment of the interest rate corridor by 50 bps on 12 November 2004, the auction rate moved up to 7.86 per cent and remained around 7.88 per cent on average during 12 November – 24 December 2004. During the second half of 2004, particularly in July – August, excess liquidity declined sharply, largely due to transactions of the Central Bank in foreign exchange and the Central Bank was rather cautious in injecting liquidity to maintain excess liquidity in view of the higher than desired rate of monetary expansion. Therefore, together with the upward movement in the auction rate, some volatility in interest rates was observed during this period.

Following the Tsunami disaster on 26 December 2004, the absorption of liquidity through the auction was first substantially reduced and then during 5 January – 18 February 2005, temporary suspended to ensure smooth functioning of the money market and the payment and settlement system. In addition, the Central Bank was quite liberal in providing liquidity through purchases of Treasury bills, in view of the needs for relief and rehabilitation work in areas affected by Tsunami. During January – February 2005, excess liquidity remained around Rs. 14 billion on average with a maximum of Rs. 20 billion and a minimum of Rs. 8 billion. These measures led to a sharp decline in call money rates from an average of 9.14 per cent in December

Table 2

Excess Liquidity and Interest Rates

		Excess Liquidity* (Rs.bn)			Average Interest Rates (%)		
		Avg.	Min.	Max.	OMO Auction	Call Money	Market Repo
2003	Mar	9.54	6.44	13.71	9.17	9.46	n.a.
	Apr	6.33	0.43	15.69	8.70	9.65	n.a.
	May	9.71	2.80	14.01	8.70	9.01	n.a.
	Jun	12.67	8.59	16.79	8.31	8.64	n.a.
	Jul	11.28	8.37	14.69	8.29	8.59	n.a.
	Aug	9.81	5.91	13.61	7.96	8.16	8.17
	Sep	10.93	6.36	16.85	7.65	7.85	7.85
	Oct	6.39	2.92	10.25	7.34	7.69	7.60
	Nov	6.21	3.21	11.11	7.05	7.59	7.53
	Dec	6.91	3.78	17.46	7.06	7.70	7.51
2004	Jan	11.47	8.57	18.18	7.03	7.48	7.35
	Feb	7.96	4.60	11.03	7.03	7.48	7.43
	Mar	5.40	1.56	10.97	7.02	7.48	7.41
	Apr	7.27	1.12	12.68	7.02	7.68	7.55
	May	5.34	2.73	7.56	7.06	7.87	7.59
	Jun	5.50	1.83	9.30	7.14	8.18	7.99
	Jul	3.78	0.00	10.37	6.84	8.22	7.96
	Aug	3.90	1.52	8.14	7.32	8.00	7.65
	Sep	5.61	2.42	10.49	7.36	8.05	7.44
	Oct	5.91	2.88	8.67	7.39	8.15	7.52
	Nov	4.84	2.32	10.59	7.70	8.95	7.89
	Dec	10.65	5.76	15.67	7.86	9.14	8.20
2005	Jan	13.86	7.92	19.59	7.81	8.51	7.61
	Feb	14.65	11.17	17.96	7.56	8.10	7.59
	Mar	16.15	6.36	26.87	7.55	7.90	7.61
	Apr	17.38	8.72	27.81	7.82	8.09	7.81
	May	7.44	-2.34	18.08	8.01	8.76	8.18
	Jun	2.68	-3.97	11.03	8.39	9.27	8.76

* Actual excess liquidity as measured by total repurchase transactions with the Central Bank.

2004 to 8.25 per cent by end January 2005 and 8.06 per cent by 18 February 2005. The overnight repurchase rates in the market for transactions among commercial banks and primary dealers, which usually follow the daily OMO auction rate declined and remained closer to the lower bound of the interest corridor.

The daily auction was resumed on 21 February 2005 and in March, the Central Bank decided, in view of the concerns on excessive monetary

expansion, to conduct its open market operations more aggressively which included absorbing the entire excess liquidity through the daily auction, while reducing excess liquidity through permanent absorptions. Accordingly, excess liquidity declined sharply, particularly in May and June 2005. The average yield rate at the daily OMO auction ,which has remained closer to the lower bound of the interest rate corridor for more than a month since the resumption of the auction, moved up gradually from 7.54 per cent at end March 2005 to 7.89 per cent by end April 2005 and 7.95 per cent by 12 May 2005. Following the upward adjustment of the corridor by 25 bps on 12 May 2005, the average auction rate moved to 8.19 per cent by 19 May 2005. At the first auction held on 27 June 2005 following the policy rate adjustment (50 bps) on 15 June 2005, the auction rate moved to 8.72 per cent, but declined to 8.58 per cent by end June due to a sharp increase in excess liquidity.

These movements in the auction rate were reflected in other short term interest rates as well. The average repurchase rate in the market reached nearly 8.0 per cent by 12 May 2005 and with the adjustment of the interest rate corridor, increased to 8.24 per cent on 13 May 2005. On several days, in May and June, the Central Bank did not conduct the daily auction, as the liquidity was broadly in balance. On these days, there were both repurchase and reverse repurchase transactions under the standing facility. However, the repurchase rates in the market remained remarkably stable around the middle of the corridor at 8.50 per cent up to 15 June 2005 and around 9 per cent thereafter. Inter bank call money rates followed a similar pattern and increased from an average of 7.90 per cent in March to 8.09 per cent in April. It increased from 8.20 per cent at end April 2005 to 8.50 per cent by 12 May 2005. With the increase in policy rates, it moved to 8.87 per cent on 13 May 2005 and with the decline in excess liquidity increased sharply to 9.25 by end May 2005. There were volatile changes in call money rates in June 2005 with changes in excess liquidity.

C. Standing Facility

During March 2003 – mid May 2004, since only about 58 per cent of the excess liquidity was absorbed through the daily auction, the balance was absorbed under standing facility (Table 3). Standing facility also played an important role by providing an avenue for those who were unable to borrow in the market, despite there being excess liquidity, to obtain their fund requirements. It has been a generally observed fact, that certain banks with stringent limits on their lending to other banks have generated a large volume of excess liquidity mainly through their operations in the foreign exchange market and their business with corporate customers. As these banks invariably

invest a large portion of their excess money with the Central Bank, when aggregate excess liquidity is relatively small, some banks were unable to borrow from the market and they had to resort to borrowing under standing facility from the Central Bank. Such occasions however, were very rare during March 2003 – May 2004 (only two occasions) as the market was well liquid.

Table 03

Standing Facility

Monthly Average

		Repo Rate (%) (1)	R.Repo Rate (%) (2)	Repo Volume (Rs.bn) (3)	R.Repo Volume (Rs.bn) (4)	Excess Liquidity (Rs.bn) (5)	% of absorbtion through Standing Facility 3 as % of 5
2003	Mar	9.00	11.00	4.17	0.01	9.54	44
	Apr	9.00	11.00	3.04	0.19	6.33	48
	May	9.00	11.00	3.04	0.19	6.33	48
	Jun	8.25	10.25	6.08	0.00	12.67	48
	Jul	8.25	10.25	3.96	0.00	11.28	35
	Aug	7.84	9.84	3.23	0.00	9.81	33
	Sep	7.50	9.50	3.04	0.00	10.93	28
	Oct	7.24	8.98	2.56	0.00	6.39	40
	Nov	7.00	8.50	2.76	0.00	6.21	45
	Dec	7.00	8.50	3.95	0.00	6.91	57
2004	Jan	7.00	8.50	5.39	0.00	11.47	47
	Feb	7.00	8.50	4.54	0.00	7.96	57
	Mar	7.00	8.50	2.88	0.00	5.40	53
	Apr	7.00	8.50	4.79	0.04	7.27	66
	May	7.00	8.50	3.07	0.07	5.34	58
	Jun	7.00	8.50	1.81	0.34	5.50	33
	Jul	7.00	8.50	1.50	0.48	3.78	40
	Aug	7.00	8.50	0.72	0.25	3.90	19
	Sep	7.00	8.50	0.53	0.02	5.61	9
	Oct	7.00	8.50	0.54	0.03	5.91	9
	Nov	7.30	8.80	0.75	0.11	4.84	15
	Dec	7.50	9.00	1.66	0.40	10.65	16
2005	Jan	7.50	9.00	13.11	0.00	13.86	95
	Feb	7.50	9.00	12.66	0.06	14.65	86
	Mar	7.50	9.00	2.35	0.00	16.15	15
	Apr	7.50	9.00	1.40	0.01	17.38	8
	May	7.64	9.14	1.53	0.69	7.44	21
	Jun	8.01	9.51	1.94	1.29	2.68	72

As the volume of excess liquidity was relatively small since June in 2004, some participating institutions resorted to borrowing under standing

facility on several days in every month. Such borrowings were relatively heavy in June, July and August (Rs. 0.636 billion per day for 34 days). These were the months, in which a relatively large volatility in interest rates was observed. Towards end May in 2005, liquidity in the market became broadly in balance and due to limits of certain banks with excess liquidity, some borrowed under sanding facility (Rs. 2.636 billion per day for 5 days) while there were repurchase transactions also of similar magnitudes. Similar developments were observed in June 2005 as well.

D. Outright Sales/Purchases of Government Securities

During the first nine months of operations under the present system, though excess liquidity remained high in general while fluctuating within a wide range, outright sales of Treasury bills in the secondary market were not conducted to absorb a part of it on a permanent basis. However, to some extent, a permanent absorption has taken place at the maturity of the Treasury bills held by the Central Bank as maturity proceeds were not always reinvested. On the other hand, the Central Bank injected liquidity particularly during festive seasons, through purchases of Treasury bills at the primary auctions to ensure that excess liquidity remains broadly above Rs. 3 billion to maintain interest rate stability.

However, towards the end of 2003, excess liquidity exceeded well above Rs. 10 billion and hence, an attempt was made in January 2004, to absorb a part of it permanently through outright sales in the secondary market (Table 4). At first, attempts were made to sell through auctions, but given up after the second auction which was under subscribed and rejected as even the bids received were at rates higher than the comparable rates in the primary market. The first auction was over subscribed, but only Rs. 0.413 billion out of Rs. 1 billion offered was accepted as other bids were at rates higher than the comparable primary market rates. The Central Bank however, managed to sell Treasury bills to a face value of Rs. 1.9 billion in the secondary market in January 2004 through direct dealings. These sales were at rates comparable with the primary auction rates. One advantage of direct dealings was that a counter party could negotiate and purchase bills of his desired tenure (number of dates to maturity), whereas at the auction, bills of only one maturity could be offered at a time.

Outright sales were not conducted during the rest of the year 2004, as there was a tendency for market liquidity to decline particularly due to the transactions of the Central Bank in the foreign exchange market. Instead, the Central Bank purchased Treasury bills outright in the secondary market on three occasions in 2004 to prevent the market becoming short in liquidity.

Table 04

Outright Sales (Auctions) of Treasury Bills in the Secondry Market

Auction Date		Amount Offered (Rs.bn)	No. of Days to Maturity	Bid Received (Rs.bn)	Bid Accepted (Rs.bn)	Yield (%)		
						Weighted Average	Min.	Max.
2004	8-Jan	1.00	84	1.91	0.41	7.39	7.37	7.40
	14-Jan	0.75	98	0.55	0.00			
Total		**1.75**		**2.46**	**0.41**			
2005	1-Apr	1.00	32	2.95	1.00	7.64	7.63	7.65
	4-Apr	2.00	45	4.53	2.00	7.67	7.65	7.72
	5-Apr	2.00	51	1.49	1.43	7.90	7.80	8.00
	20-Apr	2.00	36	5.83	0.00			
	26-Apr	3.00	37	7.29	3.00	8.06	8.00	8.15
	28-Apr	3.00	42	7.64	3.00	8.12	8.08	8.15
	29-Apr	3.00	45	6.11	3.00	8.13	8.08	8.15
	3-May	3.00	58	1.95	0.83	8.22	8.19	8.25
	6-May	2.00	18	7.39	2.00	7.95	7.95	7.95
	10-May	2.50	44	5.72	2.50	8.19	8.10	8.23
	30-Jun	3.00	14	7.74	3.00	8.84	8.75	8.99
	7-Jul	2.00	7	3.30	2.00	9.00	8.98	8.99
Total		**28.50**		**61.93**	**23.76**			

Note: settlement on the business day fillowing the Auction date.

It was practically not possible to purchase a large volume of securities from the market without their yield rates being affected. Moreover, Treasury bills were not available in sufficient volumes in trading portfolios of dealers and the Central Bank was not dealing in Treasury bonds on an outright basis.

During the first four months in 2005, excess liquidity remained well above Rs. 15 billion on most of the days and this excess liquidity was considered as one of the factors which contributed towards the high monetary expansion. Accordingly, outright sales of Treasury bills out of the Central Bank holding were commenced on 1 April 2005 and by 10 May 2005, 10 auctions were conducted and excess liquidity of Rs. 18.8 billion was absorbed on a permanent basis. Among the auctions, seven were well subscribed and highly successful. One auction was rejected as bids were at unacceptably high yield rates. Two auctions were at relatively high rates and only partially accepted.

Following limitations were observed in the absorption of excess liquidity on a permanent basis.

i. Due to limitations of the portfolio of Treasury bills held by the Central Bank, it may not always be possible to offer for outright sales, securities of which tenure is well demanded by participating institutions. Most often Central Bank had to offer for sales, odd maturities which were not in demand in general. The experience was that, market preferred short maturities of around one to one and half months. The available volume of such maturities may get depleted quickly when the required volume of permanent absorption is relatively large.

ii. The existing electronic system for conducting auctions also has a limitation of not being able to offer for an auction securities of more than one maturity, *i.e.*, inability to conduct multiple auctions simultaneously. If such a facility were available, a large volume could have been offered while providing an opportunity for participating institutions to select preferred maturities. This difficulty however, was overcome through direct dealings. Direct dealings are not much encouraged in view of transparency considerations, particularly as facilities for on the screen firm quotes and dealings are not available.

IV. Reserve Money Targets and Interest Rate Volatility

As noted in Section 2, the Central Bank was successful in 2003, in achieving its targets on reserve money while maintaining short term interest rates stable at a level closer to the lower bound of the interest rate corridor. In 2004, reserve money tended to remain above the desired paths and shot term interest rates displayed some volatility. This section outlines the approach adopted by the Central Bank to bring the reserve money to the target path and examine the factors which contributed to the volatility observed in short term interest rates.

A. Reserve Money Targets

The difficult economic conditions which were brought about by weather related domestic supply disturbances and the escalation of international oil prices that prevailed in 2004 required proper timing and sequencing of monetary policy tightening.[2] Accordingly, as the first step, the Central Bank conducted its OMO aggressively from May by absorbing almost the entire excess liquidity through the daily actions and thereby, induced an upward

2/ Central Bank of Sri Lanka (2004), Annual Report, p116.

adjustment in short-term interest rates. Subsequently in November 2004, the policy rates were increased by 25 bps.

Following the Tsunami disaster on 26 December, 2004, in view of the need for ensuring smooth operations of the payment and settlement system and supporting the needs for relief and rehabilitation of areas affected by Tsunami, the absorption of excess liquidity through the daily OMO auction was, first substantially reduced and then temporarily suspended during 5 January – 18 February, 2005 while maintaining a relatively high volume of excess liquidity in the market. This resulted in a sharp reduction in interest rates. The average call money rates declined from 9.63 per cent on 24 December 2004, to 8.06 per cent by 18 February 2005 while the average market repurchase rate declined from 7.96 per cent to 7.57 per cent during the same period. By end March 2005, reserve money exceeded the target which however, was largly attributed to higher than usual increase in currency in circulation owing to the additional demand created by Tsunami relief and rehabilitation operations.

Excess liquidity which remained around Rs. 15 billion on average, during the first three months of 2005 was one of the main factors which contributed to the higher monetary expansion. Therefore, as an instrument for bringing the reserve money back to its desired path, it was decided in April 2005 to conduct OMO aggressively. This included the absorption of a large part of excess liquidity on a permanent basis, through outright sales of Treasury bills out of the Central Bank holdings and absorbing the balance entirely through the daily OMO auction.

Accordingly, outright sales were commenced on 1 April 2005 and by 11 May 2005, excess liquidity of Rs. 18.8 billion was absorbed on a permanent basis (Table 4) and excess liquidity which was as high as Rs. 28 billion on 26 April, 2005 was brought to below Rs. 10 billion. Treasury Bill holdings of the Central Bank declined from Rs. 85.0 billion (net of repurchase, Rs.62.4 billion) at end March 2005 to Rs.61.9 billion (net of repurchase, Rs.52.4 billion) by 11 May 2005 (Table 5). The yield rate at daily OMO auction moved up to 7.94 per cent from 7.56 per cent at end March 2005. By end May 2005, market liquidity was brought to a balance position and the average repurchase rate in the overnight market moved to 8.49 per cent from 7.59 per cent at end March 2005. These positive developments were consolidated by 25 bps and 50 bps increases in the repurchase rate and the reserve repurchase rate of the Central Bank on 13 May and 15 June 2005, respectively.

The conduct of OMO aggressively, together with subsequent adjustments in policy rates has been instrumental in bringing the reserve money to its target level in June 2005.

B. Interest Rate Volatility

It was expected that the present system of monetary operations would enable the Central Bank to maintain overnight interest rates stable around a level considered consistent with the reserve money target. In 2003, interest rates were quite stable around a level closer to the bottom of the corridor. In fact, as measured by the standard deviation in average call money rates, there had been a significant improvement in interest rate stability in 2003 when compared with the second half of 2002 (Chart 4). However, rates had displayed a high degree of volatility in May 2004. In most of 2004 and early 2005, interest rates moved within a wider range, with changes in excess liquidity (Chart 5).

One of the main reasons for volatile changes in interest rates was the self imposed limits of banks on their lendings to other banks. Such limits of some banks particularly, of foreign banks were quite stringent. When such a bank has built up a large surplus, some may find it extremely difficult to borrow in the inter bank market unless there is a large volume of excess liquidity. Under such a situation, it was not uncommon to observe both repurchase and reverse repurchase transactions with the Central Bank on a same day. This may result in volatile changes in interest rates and the degree of volatility would be higher, the smaller the size of excess liquidity. Normally, excess

Table 05

Tresury Bills holdings of Central Bank

(Rs.bn, End Month)

		Gross Book Value	Net of Repo Book Value			Gross Book Value	Net of Repo Book Value
2003	Mar	38.19	30.44	2004	May	41.40	35.30
	Apr	38.90	22.16		Jun	46.20	37.60
	May	39.77	26.10		Jul	53.00	45.70
	Jun	32.31	20.87		Aug	56.00	47.90
	Jul	27.12	10.53		Sep	61.00	50.50
	Aug	22.16	10.17		Oct	72.70	64.50
	Sep	13.97	2.23		Nov	84.50	73.90
	Oct	11.01	3.52		Dec	82.00	74.80
	Nov	19.07	10.83	2005	Jan	81.94	66.41
	Dec	29.08	11.62		Feb	82.70	66.50
2004	Jan	26.50	14.00		Mar	85.00	62.40
	Feb	26.90	17.00		Apr	73.40	53.90
	Mar	43.30	32.30		May	57.40	52.70
	Apr	42.50	32.10		Jun	62.65	51.62

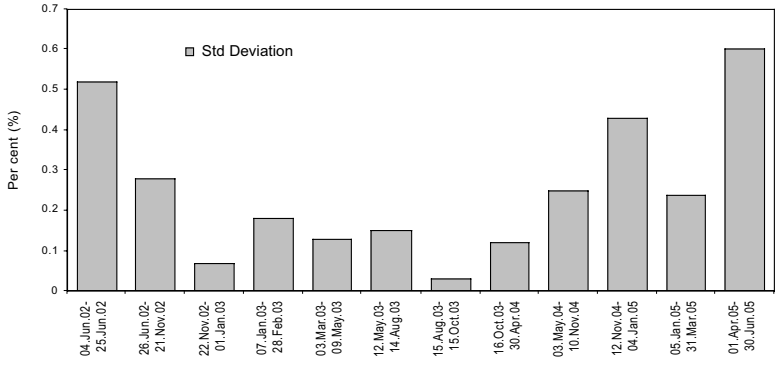
liquidity of around Rs. 3 – 5 billion was required to maintain interest rates stable at their existing level.

Accordingly, as a practice, in 2003 and the first half of 2004, the Central Bank kept the market well liquid, through its purchases of Treasury bills. Particularly during festive seasons, the Central Bank planned in advance its purchases of Treasury bills to ensure that the market is sufficiently liquid. Though this practice had been successful in maintaining interest rates fairly stable, there were instances when rates increased sharply as the liquidity injected was not sufficient due to demand being exceptionally higher than the projection. Since the width of the corridor was 150 bps and the OMO auction rate was closer to the lower bound of the corridor, there was a scope for large fluctuations in rates.

There was also a period in which interest rates displayed a tendency to move up even when there was a sufficiently large volume of excess liquidity in the market. During October – December 2004, call money rates showed an upward trend with a sharper increase in November and December 2004. The increase in November was partly a reflection of the increase in Central Bank policy rates by 50 bps on 12 November 2004. However, even before the policy rate adjustment, the upward trend was observed. For example, the weighted average call money rate increased from 8.25 per cent at end October 2004 to 8.86 per cent on 10 November 2004, despite the market being quite liquid with excess liquidity of around Rs. 4 – 6 billion. Just prior to the policy rate adjustment, the average call money rate exceeded the upper bound of the interest rate corridor and continued to remain above the upper bound with an

Chart 04

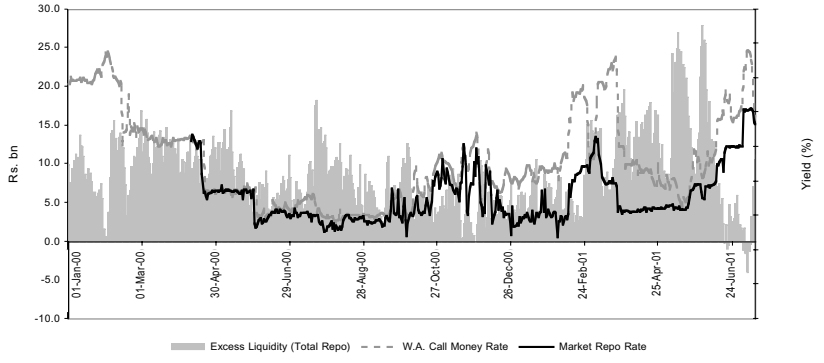
Volatility in Call Money Rates



* Sub-periods were identified by changes in the policy stance.

Chart 05

Excess Liquidity and Interest Rates



upward trend, except for a brief period between end November and 10 December 2004, when the average rate remained relatively low due to a temporary concentration of liquidity in a single bank.[3] During the second half of December 2004, even a sharper movement in rates was observed though the market operated with a liquidity surplus of well above Rs. 6 billion.

The sharp increase in call money rates was partly due to an unusual development in government debt securities market which augmented the implications on the market, of the constraint imposed by limits on inter-bank lending. There was an anomaly in yield rates of government securities as yield rates on 91 day Treasury bills and 182 day Treasury bills (during most of the period) were below the Central Bank repurchase rate. The anomaly was larger when compared with the OMO auction rate. Therefore, there was an advantage in investing on a repurchase basis rather than purchasing those Treasury bills on an outright basis. Moreover, given the fact that inflation was rising and monetary expansion was above the target investors would have presumed that rates were not sustainable.

Therefore, there was a reluctance among some investors to hold government securities, except on a very short term basis. In particular, some foreign banks liquidated a part of their holdings of government securities and invested the proceeds in the repurchase market. They could not invest proceeds in the call market as they have to maintain a stock of government securities in their portfolio of assets in the balance sheets. This led to a concentration of a significant volume of excess liquidity in foreign banks. There was a

3/ For details, see page 31

concentration of liquidity among primary dealers as well. Usually primary dealers borrow funds under repurchase agreements and maintain a stock of securities for trading purposes. However, under these prevailing conditions, some primary dealers, met their customers' demand by selling Treasury bills on a repurchase basis which were backed by, their investment under repurchase transactions with the Central Bank. As some borrowers in overnight money markets did not have securities to borrow in the repurchase market, they had to depend entirely on the call money market in which a significant portion of excess liquidity was not available. The market forces however induced necessary adjustments in rates and the anomaly disappeared within a short period.

There were also instances where some banks lent in the call market at rates which were below the Central Bank repurchase rate. It happened, particularly, in the case of foreign banks when their portfolio limits on government securities were reached. Under such instances, they had no choice but to lend in the call market even at relatively low rates. The situation became worse when their lending limits to major borrowers were rather stringent. There could also be volatile changes in rates due to a concentration of a large volume of liquidity temporarily in a single bank due to an exceptional reason. A case in point was the concentration of a large volume of liquidity in a single bank following a heavy over subscription of Lanka IOC share issue in November 2004. Initially, rates declined sharply as borrowers expected this bank to lend at relatively low rates. Subsequently however, rates improved on the realization that there was a demand for a large volume of funds.

Accordingly, there could be volatile changes in call money rates due to a number of reasons, which included self-imposed limits of banks on their lending to other banks, behaviour of rates in government debt securities market, portfolio limits of banks on holding of various types of assets in their balance sheets, holdings of securities traded in repurchase market *etc*. The volatility created by these factors could not necessarily be addressed by monetary policy operations though attempts have been made in the past, to keep the market sufficiently liquid to overcome the constraints imposed by such factors.

An unsatisfactory feature observed, particularly during most of 2004 and early 2005 was the fluctuation of interest rates, with changes in excess liquidity. Interest rates would have not fluctuated with changes in excess liquidity if lenders were indifferent between lending in the inter-bank market and lending to the Central Bank. However, quite often, there was a divergence between comparable market rates and the OMO auction rate. The divergence existed mainly because the prevailing conditions in the country did not permit countinouse absobtion of the entire excess liquidity through the OMO auction. If the market were operating around the middle of the corridor, and the entire

volume of excess liquidity were absorbed through OMO auction at market rates, market rates would have not fluctuated simply due to changes in excess liquidity.

V. Suggestions for Improving Effectiveness of Monetary Policy Operations

The Central Bank has successfully implemented the present system of monetary policy operations, though during a certain period, the achievement of the expected outcome of the system was constrained by reasons beyond the control of the Central Bank. Nevertheless, as identified through the experiences since March 2003, there is a scope for further improving the system.

A. Operating Target

It seems that there is a need for refocusing on monetary targets and instruments and identifying precisely the role of each instrument. In particular, it seems more appropriate that the operating target is redefined.

It has been a usual practice to consider reserve money which is derived from the balance sheet of the Central Bank and hence presumed as being under the control of the Central Bank as the operating target of monetary policy. However, this presumption is not quite correct, particularly under the present system of monetary policy operations. Reserve money is comprised of balances held by commercial banks with the Central Bank which are governed by Statutory Reserve Requirements (SRR) and hence are fixed, and currency outstanding which are exogenous in the short run. On the other hand, reserve money is released by the accumulation of net foreign assets (NFA) and net domestic assets (NDA) by the Central Bank. Whenever there is an increase in NFA, there would be a corresponding decline in NDA through an increase in sales of Treasury bills on repurchase basis or a decline in purchases of securities on reverse repurchase basis to absorb the liquidity created by the increase in NFA. Even if the Central Bank did not make a discretionary step to absorb the liquidity, the absorption would take place through standing facility. Similarly, the impact of a reduction in NFA would be neutralized through an increase in NDA. More specifically, if the Central Bank sells Treasury bills outright to reduce reserve money, it would not be materialized directly as there would be a corresponding decline in repo sales or an increase in reserve repo purchases, leaving the stock of government securities held by the Central Bank unchanged.

Accordingly, since the Central Bank does not have a direct control over the reserve money, it is not quite appropriate to use it as an operational target.

In fact, it is an intermediate target which is to be achieved by changing interest rates. An operating target of reserve money may lead to excessive volatility in interest rates, which would make it more difficult for the Central Bank to signal its monetary policy stance. The monetary policy operations of the Central Bank affects reserve money, only through their impact on short term interest rates. Therefore, it is more appropriate to consider reserve money as an intermediate target, and short term interest rates as the operating target. The only market based instrument available to achieve the reserve money target is the interest rate corridor and normally it implies an implicit target on interest rates usually in the middle of the corridor. This implicit target is considered as being consistent with the reserve money target.

This approach is consistent with the 'Monetary Target and Instrument Framework' suggested in Peter Dattels' report.[4] However there is a concern in moving to this approach as interest rates may become volatile due to factors as outlined in section 4.2, which are beyond the control of the monetary authority. These factors are rigidities which will eventually be relieved through improved competition and strengthening of financial institutions.

B. Daily Repurchase Auctions

The instrument to achieve the interest rate target is the daily repurchase auction. The size of the auction needs to be set to achieve the desired interest rate outcome. Normally, monetary operating target would be on overnight call money rates. However, in view of the divergence between call money rates and repurchase rates created by a tax credit of 1/9th of interest earned on secondary market operations in government securities in Sri Lanka, the monetary operating target needs to be set on the overnight repurchase rate for transactions among commercial banks and primary dealers, as it is the rate comparable with the policy rates of the Central Bank which are for transactions on a repurchase basis. Accordingly, the daily auction should be conducted to maintain the market repurchase rate around the implicit target which is usually in the middle of the corridor.

Therefore, the size of the auction need to be determined only by considering its outcome on interest rates to achieve the interest rate target (implicit). This is more consistent with the approach adopted by advanced countries and inflation targeting countries and hence, would facilitate eventual move to inflation targeting monetary policy framework.

4/ 'A Strategy for Strengthening the Framework and Implementation of Monetary and Foreign Exchange Operations.' IMF Technical Assistance report prepared by Peter Dattels *etc*. (August 2001).

C. Management of Short Term Liquidity and Interest Rate Stability

As long as the size of the daily auction is set to maintain short term interest rates at the implicit target, preferably in the middle of the corridor, changes in the volume of excess liquidity would not necessarily lead to significant fluctuations in interest rates. Specifically, at the target rate, if there is a liquidity surplus, it should be absorbed through the auction and if there is a deficit, liquidity should be injected to cover the entire deficit. As long as the auction rate converges with the market rate, the target rate could be maintained and there would not be a significant change in interest rates, even if liquidity in the market shifts from a surplus to a deficit. However, in setting the auction size, due attention needs to be paid on constrains arising from rigidities such as limits on inter-bank lending.

As long as the OMO auction rate converges with market rate, there would not be a pressing need to provide liquidity through purchases of Treasury bills to meet seasonal demand in months of March/April and December, as the required liquidity could be injected through daily auction of reverse repurchase transactions. As long as the entire increase in the demand for liquidity is accommodated at the prevailing market rate, it should not lead to fluctuations in interest rates.

D. Management of Long Term Liquidity

Though, interest rates should not fluctuate with changes in the volume of liquidity in principle as long as the daily OMO auction is conducted to maintain the implicit interest rate target, there is a normal tendency for interest rates to decline (increase) when market operates with an excessively large liquidity surplus (deficit). Therefore, it is essential that liquidity surplus or deficit in the market is not allowed to be excessive through outright transactions in government securities. In this regard, it is important that the constraints for outright transactions noted in Section 3 are removed particularly through following actions for which, initiatives have already been taken.

a. introduce long term repurchase transactions as an additional instrument for managing long term liquidity. This would help alleviating the constrain imposed by the lack of securities of tenure, demanded by investors.

b. enhance the facilities available in the electronic system for conducting auctions, to enable the conduct of multiple auctions simultaneously.

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Modeling and Forecasting Currency in Circulation in Sri Lanka

Rupa Dheerasinghe[1]

Abstract

Currency in circulation is typically estimated either by specifying a currency demand equation based on the theory of transaction and portfolio demand for money or univariate time series models. The first approach works well with low frequency data but faces limitations with high frequency data series. Therefore, this paper proposes an alternative approach in modeling the high frequency data series by decomposing the trend, the seasonal, and the cyclical components. Three separate models were estimated with monthly, weekly and daily time series, assembling tools for forecasting trend, seasonal patterns and cycles in individual series separately. Trend and seasonal effects were identified by regressing on trend and seasonal dummies while cyclical dynamics were captured by allowing for ARMA effect in the regression disturbances. The sample period is 1 January 2000 to 31 August 2005 and data for 1 September 2005 to 31 January 2006 were used for post validity test. All three models fit the data well and provide very close forecasts during the post sample period. All three models clearly identify both inter-month and intra-months variations of currency in circulation. The models also identified that the Sinhala/Tamil New Year, elections, Christmas and the day prior to public and bank holidays have significant positive impact on demand for currency in Sri Lanka. This methodology may be used in forecasting currency in circulation with careful assessment of day to day current developments in the economy.

I. Introduction

The Central Bank of Sri Lanka (CBSL) has been conducting its monetary policy within a framework of targeting monetary aggregates, in which reserve

1/ The author wishes to express her sincere gratitude and thanks to Dr. D.S. Wijesinghe, Director, Domestic Operations Department and Dr. P.W.R.B.A.U. Heart, Alternative Executive Director, IMF for their valuable comments and suggestions on the first draft of this paper.

money is the operating target. Reserve money consists of the balances held by commercial banks with the Central Bank under the Statutory Reserve Requirement (SRR) and currency in circulation. In Sri Lanka, currency in circulation accounts for more than 65 per cent of the total reserve money, indicating its importance in overall monetary management. Within the existing framework, monetary policy operations are conducted to achieve a path of reserve money targets, while maintaining interest rates stable around a rate consistent with the path of reserve money targets. Under the current system of active Open Market Operations (OMO)[2], an implicit interest rate is achieved by appropriately managing market liquidity, in particular, by adjusting the volume of liquidity absorbed or injected through the auctions. Therefore, this system requires an accurate assessment of the daily liquidity position in the banking system.

The liquidity of the banking system is influenced by several autonomous factors, which are beyond the direct control of the Central Bank and the banking system. The most important autonomous factors are the government's net borrowings from the Central Bank and other banks, foreign exchange transactions with the Central Bank and the amount of banknotes and coins in circulation. A change in these factors injects or absorbs liquidity. Therefore, it leads to fluctuations in the liquidity position in the banking system. The currency in circulation comprises the outstanding amount of banknotes and coins held by the public and banks, which is determined by the cash demand of both the public and the banking system. Given this background, a systematic study of both short and long run variations in currency demand is extremely important for the banking system, in particular, to the Central Bank.

The availability of an accurate assessment of currency demand would enable the Central Bank to plan monetary policy strategies in advance to manage liquidity efficiently, to stabilize the money market in the short run and to maintain the target monetary growth in the long run. Such an assessment would also help the banking system to estimate the currency demand more accurately thus leading to an improvement in the cash flow management. Existing studies in Sri Lanka have mainly focused on modeling money demand functions with annual and quarterly time series. No studies are available of attempts to examine the behaviour in currency in circulation, even with annual data. However, given the recent changes in monetary policy operation techniques, which require close monitoring of money market liquidity, it is extremely important to study the variation in currency in circulation beyond quarterly or monthly frequencies. Therefore, this study attempts to apply modern techniques in the area of modeling and forecasting time series to

2/ The system of active open market operations was introduced by the CBSL on 3 March 2003, aiming at managing market liquidity actively at its own discretion.

understand the daily, weekly, monthly behavioural patterns and to develop a model suitable for short term forecasting of the currency in circulation in Sri Lanka. The model and the findings of the study could be used for monitoring and assessing the liquidity position in the market and planning for liquidity management through open market operations. Section 2 of the paper provides the theoretical aspects of the modeling process and model specifications. Section 3 presents the outcomes of the modeling exercises, while Section 4 provides economic justifications. Section 4 concludes the paper with observations and recommendations.

II. Methodology, Data and Model Specification

A. Theory, Data and Limitations

In general, two types of statistical techniques are used in modeling and forecasting. One approach is the estimation through a standard currency demand function based on the theory of transactions and portfolio demand for money. Such an equation is estimated in isolation or as a part of a macro economic model. Explanatory variables commonly used in such an equation are income, price levels and interest rate to represent the opportunity cost of holding currency. The other approach is based on univariate time series models. In the literature, both approaches are used extensively in modeling annual and quarterly data series. However, the first approach is rarely used in modeling series with high frequencies *i.e.,* beyond quarterly data. This is mainly due to the non availability of income data with high frequencies. It is also difficult to find a proxy for income with frequencies beyond monthly data. Theoretically, univariate models could be applied to any frequency (*i.e.*, monthly, weekly or daily). Nevertheless, the specification of these models with high frequency data is somewhat difficult due to certain factors which are common to any country. Some of these difficulties are discussed below.

- In any economy, intra-month or intra-week variations may change from week to week or month to month. For example, the second and third weeks of April are significantly different from any other month in a year due to the Sinhala/Tamil New Year festival effect in these two weeks in April. Similar differences are common within the months as well.
- Modeling the effect of a particular day in two different years, is rather difficult because of holidays and variations in lag effects. This problem is most pronounced in analyzing daily or weekly data series. For example, if weekly data are used, it is well known that demand for currency is high in the Christmas week and the week prior to the Christmas week. In 2002,

the week prior to the Christmas week ended on 22 December (Sunday), in 2003, on 21 December, in 2004, on 19 December *etc*. Univariate time series models will not be able to capture the effect of one or two extra days in weekly models. This nature of data will make it difficult to explain intra-month variations as well.

- The changing nature of the number of weeks belonging to a month makes it difficult to identify the fluctuations within a month.
- Countries almost universally follow the Gregorian calendar. Sri Lanka too follows the same calendar to set its weekends and all statistics are compiled according to this calendar. However, holidays do not follow the Gregorian calendar, as they are based on the festivals and religious observances of different ethnic groups in the country, which do not necessarily follow the pattern of the Gregorian calendar. This makes it difficult to model high frequency time series.
- Currency in circulation displays a pronounced seasonality, with weekly, monthly and annual patterns. The monthly pattern of the currency in circulation may be determined by the payment of salary advances or salaries. The amount of the currency in circulation may increase on the weekend and decline afterwards the trading day effect. Further, the amount of currency increases before the Sinhala/Tamil New Year, Vesak, Christmas and other national holidays.

Given these constraints, the paper attempts to identify the short term variations, as far as possible, in the currency in circulation in Sri Lanka.[3] To model the currency in circulation it is important to know the factors which affect its movement, especially its trend and seasonality. Limitations in the data and the models specified will be discussed in Section 3 wherever appropriate.

The sample covers the period of 1 January 2000 to 31 August 2005, *i.e.,* 2,070 days. The actual data for the period of 1 September 2005 to 30 November 2005 have been used to test the validity of the forecast. The daily data for currency in circulation compiled by the Central Bank are used for the analysis. On the basis that the currency in circulation on any Friday circulates in the economy during the weekend, all 365/366 days were included in the sample.[4] In the case of holidays, data pertaining to the last working day is applied for the holiday.

3/ The model specification is based on the methodology developed in Diebold in [2004] 'Elements of Forecasting' for modelling and forecasting time series with high frequency.

4/ A five day week is considered at the initial level of estimation. It was found that data series with full calendar year perform well in all models.

B. Model Specification

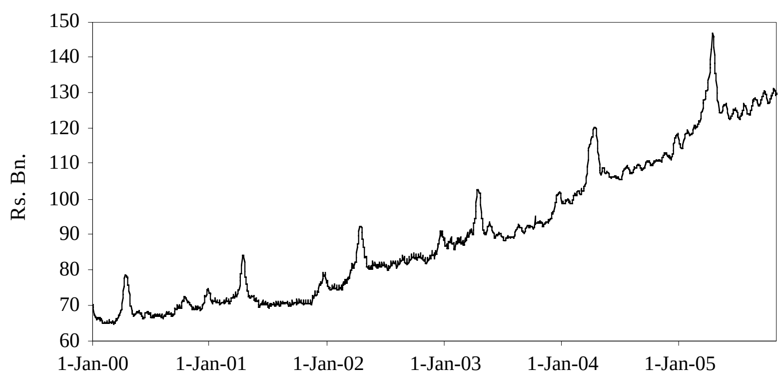
It is empirically obvious that in many economic time series a trend exists. A trend is defined as slow, long run, evolution in the variable. It is produced by slowly evolving factors such as preferences, technologies, institutions and demographics. Chart 1 shows daily data on currency in circulation in Sri Lanka from 1 January 2000 to 31 October 2005, in which the trend appears roughly linear.

That is, a simple liner function of time provides a description of the trend. The variable TIME is constructed artificially and is called time trend or time dummy.

$$T_t = \beta_0 + \beta_1 \, TIME_t \quad \text{(2.1)}$$

Where sample size is n and TIME = (1, 2, 3, …………….n-1,n)

Chart 1 – Currency in Circulation



Sometimes, the trend appears nonlinear, or curved, for example, when a variable increases at an increasing or decreasing rate. A quadratic trend model can capture the nonlinearities.

$$T_t = \beta_0 + \beta_1 \, TIME_t + TIME_t^2 \quad \text{(2.2)}$$

Even though the quadratic trend fits better than the linear trend, it is appropriate to test other types of trend models as well. If the trend is characterized by a constant growth at rate β_1, then the equation is

$$T_t = \beta_0 e^{ß1TIME_t} \quad \text{..... (2.3)}$$

In logarithmic form

$$\ln(T_t) = \ln(\beta_0) + \beta_1 TIME_t \quad \text{..... (2.3a)}$$

Or a quadratic trend regression in logarithmic form

$$\ln(T_t) = \ln(\beta_0) + \beta_1 TIME_t + \beta_2 TIME_t^2 \quad \text{..... (2.4)}$$

Most model selection criteria attempt to find the model with the smallest out-of-sample 1-step ahead mean squared prediction error. Selecting the model with the smallest mean squared error (MSE) is equivalent to selecting the model that maximizes R^2 In sample MSE cannot rise when more variables are added to the model, and typically, it will fall continuously as more variables are added. However, including more variables in the model would not necessarily improve its out of sample forecasting performance, although it will improve the model's fit on historical data. To reduce the bias associated with MSE and related indicators, it is necessary to penalize the in sample residual variance for degrees of freedom. Two very important such criteria are the Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC). The model with the lowest AIC and SIC is considered as the best fit to the data.

Seasonality persists in many economic time series. Chart 1 shows clear seasonal peaks in April each year, associated with the Sinhala/Tamil New Year festival. There may also be seasonality intra month or intra week due to spending habits, salary payments *etc.*, as mentioned earlier. One way to deal with seasonality in a series is simply to remove it and then to model and forecast the seasonally adjusted series. This strategy is often appropriate in economic forecasting where interest typically centres on identifying all the variations in the series. However, if seasonality is responsible for a larger part of the variation in a particular data series, it is important to model with unadjusted data series.

A commonly used technique for modeling seasonality is regression on seasonal dummies. In many countries, four seasons are commonly used. However, in the case of Sri Lanka where four seasons are not visible, such climatic impact on currency in circulation is not expected. If dealing with monthly data 12 seasons can be observed. In the case of weekly data 52 seasons can be identified. Since currency in circulation with daily observations is available, within week and within month variations can be examined.

The seasonal dummy model is

$$Y_t = \sum_{i=1}^{s} \gamma_i D_{it} + \varepsilon_t \quad \text{.....(2.5)}$$

Where *s* is the number of seasons considered.

Inclusion of a full set of seasonal dummies and an intercept produces perfect multicollinearity, and therefore, the intercept is excluded from the model. In the absence of seasonality γ_i *s* are all the same and we can drop the seasonal dummies and include an intercept.

Since the data series exhibits a trend, the model takes the form

$$Y_t = \beta_1 \text{TIME}_t + \sum_{i=1}^{s} \gamma_i D_{it} + \varepsilon_t \quad \text{.....(2.6)}$$

The standard seasonality represents general calendar effects. Two additional important calendar effects are holiday variations and trading day variations.

Holiday variations refer to the fact that the dates of some holidays change over time. That is, although the holiday occurs at approximately the same month each year, the exact date changes. Some examples are the monthly poya holiday, Sinhala/Tamil New Year, Vesak, Deepavali and Easter. The behaviour of the currency in circulation depends, in part, on the timing of such holidays. Therefore, it is important to keep track of them in a forecasting model. As with seasonality, holiday effects may be handled with dummy variables. In addition to seasonal dummies, a dummy variable can be introduced to reflect the effect of special holidays, which would be 1 for holidays and 0 otherwise.

As the number of trading days in a particular month or week may have a higher impact on the currency in circulation, in all models the trading day effect too is examined alternatively for holiday variable. In the monthly model, the number of trading days in that month is the value of this variable. In the daily series, all trading days are indicated as 1 and 0 otherwise. Festival season variation refers to the fact that certain months contain festivals which are important considerations for modeling and forecasting currency in circulation. Therefore, a variable is included in the weekly and daily models to capture the effect of different festival seasons. However, in a monthly model, the effect of the festival could not be isolated from the seasonal factors.

Furthermore, especial events, such as elections might have positive impact on the currency in circulation as the public demand more currency due to uncertainty associated with the election.

The complete model is

$$Y_t = \beta_1 TIME_t + \sum_{i=1}^{s} \gamma_i D_{it} + \sum_{i=1}^{v} \delta_i^{HD} HDV_{it} + \sum_{i=1}^{u} \theta_i^{FS} HDV_{it} + \varepsilon_t \quad \ldots\ldots (2.7)$$

Where HDVs are the relevant holiday variables (number of variables is *v*) and FSVs are relevant festival season variables (the number of variables is *u*; in most cases *u*=1).

It is also important to develop the model to capture any cyclical pattern that may persist in the series, some way in which the present is linked to the past and the future linked to the present. However, this is more difficult than modeling trend or seasonality. First it is necessary to see whether the underlying probabilistic structure of the series is changing over time. If so, there would be no way to predict the future accurately on the basis of the past, as the laws governing the future would differ from those governing the past. Therefore, it is necessary to have its mean and covariance structure stable over time, *i.e.*, the series needs to be covariance stationary. It is true that many economic variables are not covariance stationary. Even in the case of currency in circulation, there exists an upward trend, which corresponds to the γ_i steadily increasing mean, and seasonality, which corresponds to means that vary with the season, both of which violate covariance stationarity. However, it is possible to achieve covariance stationarity with models that give special treatment to such non stationary components such as trend and seasonality, so that the cyclical component left over is likely to be covariance stationary. The right model for any covariance stationary series is some infinite distributed lag of white noise, called the Wold representation, which takes the form

$$Y_t = B(L)\varepsilon_t = \sum_{i=0}^{s} \delta_i b_i \varepsilon_{t-1} \quad \text{where } \varepsilon_t \sim WN\ (0,\sigma^2)$$

$$b_0 = 1 \text{ and } \sum_{i=0} b^2_i <$$

Therefore, after selecting an appropriate model to identify the dynamics operating in the currency in circulation series, correlogram analysis[5] is carried out. Based on the findings, an autoregressive (AR), moving averages (MA) or autoregressive moving averages (ARMA) model is specified. Model selection procedure is discussed in Section 4, together with estimation results.

The tool used in this analysis to model and forecast trend seasonality and cycles is one that regresses on a trend and seasonal dummies to capture the impact of trend and seasonality, and then captures the cyclical dynamics by allowing for ARMA effects in regression disturbances. The full model is

$$Y_t = T_t(\theta) + \sum \gamma_i D_{it} + \sum \delta_i^{HD} HDV_{it} + \sum \theta_i^{FS} FSV_{it} + \varepsilon_t$$

$$\Phi(L)\,\varepsilon_t = \Theta(L)V_t$$

$$\Theta(L) = 1 + \theta_i L + \ldots\ldots\ldots \theta_q L_q$$

$$\Phi(L) = 1 + \varphi_i L + \ldots\ldots\ldots - \varphi_q L_q$$

$$V_t \sim WN(0,\sigma^2)$$

$T_t(\theta)$ is a trend, with underlying parameters θ. For examples a linear trend has $\theta = \beta_1$ and $T_t(\theta) = \beta_1 TIME_t$, while a quadratic trend has $\theta = (\beta_1, \beta_2)$ and $T_t(\theta) = \beta_1 TIME_t + \beta_1 TIME_t^2$

In this equation, the trend, seasonal, holiday/ trading day variables, festival seasons, elections and harvest seasons are included. The disturbance follow an ARMA(p,q) process, of which pure auto regressions and moving averages are special cases. In any particular application, as discussed in Section 4, various trend effects, seasonal and other calendar effects and ARMA cyclical effects may not be required and could be dropped. When seasonal dummies are insignificant and dropped, an intercept could be included.

5/ A correlogram analysis simply means examination of the sample auto correlation and partial auto correlation functions (with two standard error bands), together with related diagnostics, such as Q statistics.

III. Estimation – Results

A. Estimation with Monthly Data

The entire study covers the period 1 January 2000 to 31 December 2005 with daily data on currency in circulation. However, in the case of forecasting liquidity in the system for a long time horizon, it is more important to have a monthly forecast than a weekly or a daily forecast. Using a daily or a weekly forecast for long time horizons tends to produce larger errors in longer-term estimates. Therefore, in order to identify inter month variations and estimate monthly requirements of currency for monitoring monetary targets and planning for liquidity management one or two months ahead, it was decided to examine the behaviour of currency in circulation on a monthly basis. Data on Monthly averages of currency in circulation are used for the estimates.

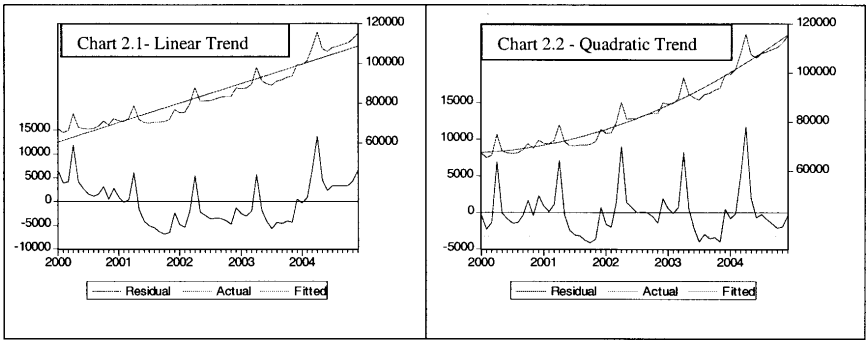
A simple liner function of time, Equation 1, provides a description of the trend. The variable TIME is constructed artificially and is called the time trend or time dummy.

$$CURRENCY_t = 59764 + 816.0147\ TIME_t \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.1)$$
$$(49.4765) \qquad (23.6939)$$

Where sample size is 60 and TIME = (1, 2, 3, …… 60)

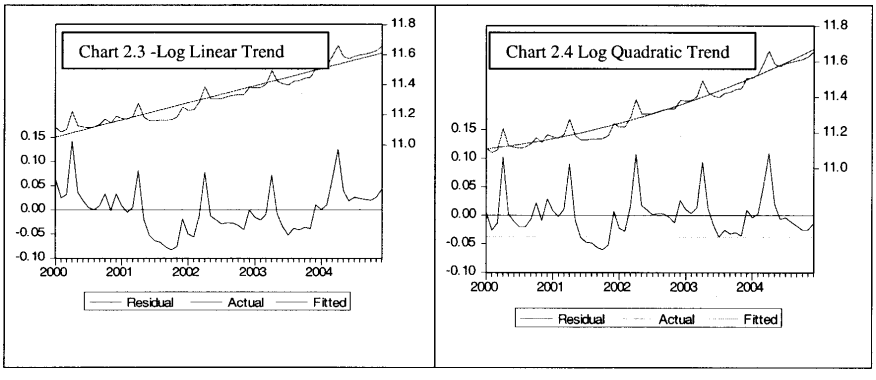
Chart 2.1, which depicts currency in circulation, the fitted trend and residuals, shows a somewhat adequate representation. However, a deviation of actual currency in circulation from the trend is apparent.

Therefore, a quadratic trend model is used to capture the nonlinearities observed in the currency in circulation.



$$CURRENCY_t = 67374 + 79.5716TIME_t + 12.0728\ TIME_t^2 \ldots\ldots\ldots (3.2)$$
$$(51.4490) \quad (0.8033) \quad (7.6704)$$

Chart 2.2 presents the currency in circulation data with a superimposed quadratic trend. Although the quadratic trend fits better than the linear trend, it is still appropriate to test other types of trend models as well.



In Chart 2.3, which shows the logarithm of currency in circulation, the trend appears to be approximately linear. In this data series, the trend appears to be non linear in levels but linear in logarithms, that is, it has a log linear trend. If the trend is characterized by constant growth at rate β_1, then the equation is

$$T_t = \beta_0 e^{\beta 1 TIME_t} \ldots\ldots\ldots (3.3)$$

In logarithmic form

$$\log (CURRENCY_t) = 11.0424 + 0.0095TIME_t \ldots\ldots\ldots (3.3a)$$
$$(900.5412) \quad (27.1168)$$

$$LCURRENCY = 11.1057 + 0.0033 * TIME + 0.0001 * TIME2$$
$$(722.3511) \quad (2.8786) \quad (5.4404)$$

$$R^2 = 0.9502\ AIC = -3.6338\ SCI = -3.5290\ DW = 1.2180 \ldots\ldots (3.4)$$

Based on the selection criteria discussed in Section 2, the above results suggest that the log linear and quadratic trend model in logs fits the data well,

Table 1 – Results of Trend Models

Model	Within sample MSE	Adj. R^2	AIC	SIC
Linear	20666667	0.9047	19.7469	19.8167
Quadratic Trend	10150000	0.9523	19.0714	19.1759
Log Linear	0.002126	0.9269	-3.2489	-3.1791
Log Quadratic Trend	0.001399	0.9502	-3.6338	-3.5290

but that the quadratic trend model performs slightly better in both within the sample and out of sample forecasts. As shown in Chart 2.4 and estimation results given in Equation 3.4, currency in circulation trends upward and the trend appears nonlinear in spite of the fact that logarithms are used. The residual plot shows that the fitted trend increases at a decreasing rate and both the linear and quadratic terms are significant. The adjusted R^2 is 95 per cent, reflecting the fact that the trend is responsible for a large part of the variation in the currency in circulation. The residual plot shows obvious residual seasonality and Durbin-Watson statistics suggests serial correlation in errors. The residual plot also suggests that there may be a cycle in residuals, although it is difficult to establish a clear case as the pervasive seasonality swamps the picture and make it difficult to infer much.

The residual correlogram and its graph confirm the importance of the seasonality. The residual sample auto correlation function has large spikes, far exceeding the confidence levels, at the seasonal displacements, 12, 24 and

Chart 3.1 – Sample Autocorrelation Functions

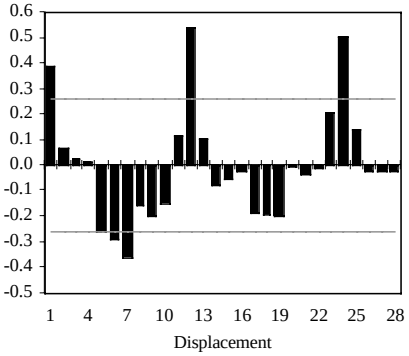
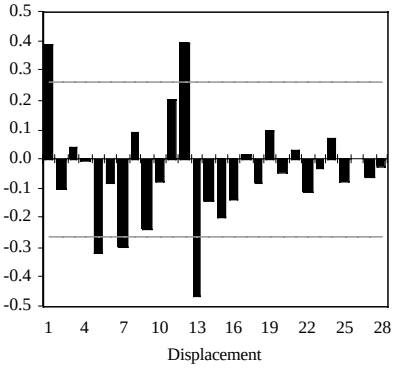


Chart 3.2 – Partial Autocorrelation Functions



36. It indicates some cyclical dynamics as well. Apart from the seasonal spikes, the residual sample auto correlation and partial auto correlation function oscillate, and the Ljung-Box statistic rejects the white noise null hypothesis even at very small, non seasonal displacements.

LCURRENCY = 0.0034 * TIME + 0.0001 * TIME2 + 11.0989 * D1
(6.0231) (11.2575) (963.6170)

+ 11.0887 * D2 + 11.1099 * D3 + 11.1976 * D4 + 11.1065 * D5
(914.6565) (995.3413) (827.9147) (882.1290)

+ 11.0872 * D6 + 11.0792 * D7 + 11.0795 * D8 + 11.0771 * D9
(1010.4070) (1020.9071) (1014.0810) (996.9504)

+ 11.0737 * D10 + 11.0717 * D11 + 11.1035 * D12
(969.5711) (980.8971) (920.0366)

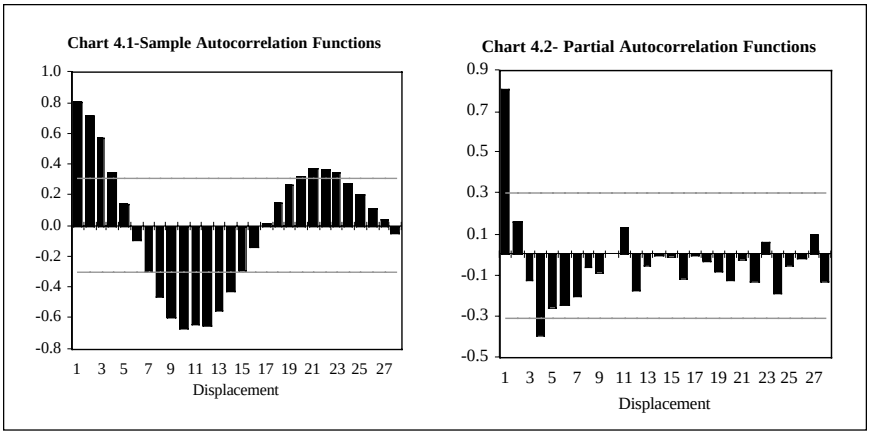
+ 0.0308 * ELECTION + 0.0013 * HOLI …… (3.5)
(2.6042) (0.4668)

R^2 = 0.9915 AIC = -4.9408 SCI = -4.3823 DW = 0.3423

Where,

LCURRENCYD	= Log of Currency in Circulation (1st difference)
HOLI	= Number of holidays per month,
ELECTION	= 1 for the month having election, 0 otherwise
$TIME_t$	= t = 1, 2, n-1, n (n = 60)
D1, D2……D12	= Seasonal factors for January, February…December

Equation 3.5 shows the results of regression on quadratic trend and a full set of seasonal dummies. The quadratic trend remains highly significant. The adjusted R^2 rises to almost 100 per cent and the standard error of the regression falls to 0.0183. The residual plot shows no seasonality as it is now captured by the model, but it confirms the signal given by the Durbin – Watson statistic of serial correlation. The residual correlograms in Chart 4.1 and Chart 4.2 show that the partial auto correlations oscillate and decay slowly and they exceed the Bartlett standard errors frequently. The Ljung-Box test strongly rejects the white noise null at all displacements. The residual sample auto correlations cut off at displacement 1. All of these factors suggest that an AR (1) would provide a good approximation to the disturbance's Wold representation.



A model with a quadratic trend, seasonal dummies and AR(1) improved the R2 to 99.7 per cent and Durbin-Watson statistic confirms that it is free of serial correlation. The standard error of the regression is as small as 0.01. The residual plot in Chart 5 reveals no pattern and looks like white noise. The residual sample auto correlations and partial auto correlations display no patterns, and are mostly inside the Bartlett bands. The Ljung-Box statistics are also good for small and moderate displacements. The histogram and normality test applied to the test suggest that the residuals appear to be fairly well approximated by a normal distribution.

LCURRENCY = 0.0059 * TIME + 6.6887e-05 * TIME2 + 11.0529*D1
(2.8332) (2.6071) (189.5149)

+ 11.0437 * D2 + 11.0676 * D3 + 11.1540 * D4 + 11.0641 * D5
(189.3883) (190.2798) (191.2944) (190.1096)

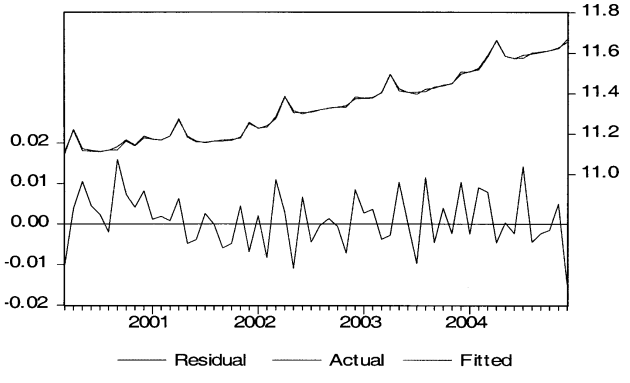
+ 11.0467 * D6 + 11.0399 * D7 + 11.0404 * D8 + 11.0381 * D9
(190.3868) (190.5530) (190.6454) (190.6933)

+ 11.0358 * D10 + 11.0334 * D11 + 11.0655 * D12 + 0.00213 * HOLIDAY
(190.8448) (190.9925) (191.6740) (1.7668)

+ 0.0277 * ELECTION [AR(1) = 0.8541]
(5.5660) (10.0667) ……(3.6)

R^2 = 0.9975 AIC = -6.1191 SCI = -5.5201 DW = 1. 8669

Chart 5 – Results of Equation 3.6



For the purpose of analyzing the economic implications (Section 4) and to measure the monthly changes of currency in circulation, the model is re-estimated with first differences of the data. To estimate the effect of each month of the year separately, and to avoid the dummy variable trap, in the empirical specification the regression has done without a constant term. The monthly effect has been captured by the D*j* (J = 1, 2, 3, 4,….11,12) respectively. In the empirical specification, same variables included in Model 3.6 have been added to capture the effect of bank holidays, elections *etc.*

The regression results reported below find evidence in favour of the earlier findings for monthly data. More importantly, the results reveal that

Chart 6.1 – Sample Autocorrelation Functions

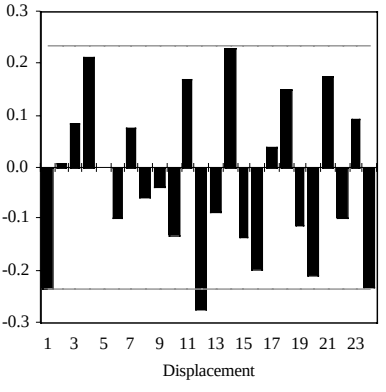


Chart 6.2 – Sample Partial Auto Correlation Functions

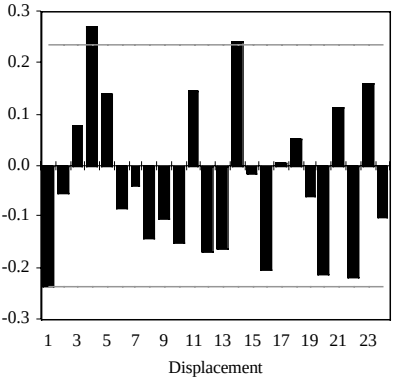
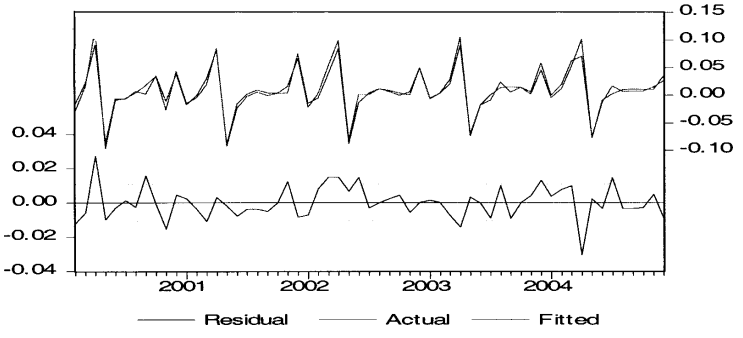


Chart 7 – Results of Equation 3.7



there is a pronounced month of the year effect in the growth rates of currency in circulation. Chart 9 presents the graph of estimated D*j* as a function of *j* (1, 2, 3, ….. 11, 12).

LCURRENCYD = 0.0002 * TIME – 0.0311 * D1 – 0.0216 * D2 + 0.0156 * D3
(2.1988) (-4.251544) (-3.1405) (2.6010)

+ 0.0674 * D4 – 0.1050 * D5 – 0.0248 * D6 – 0.0075 * D7
(8.5818) (-14.6352) (-4.2793) (-1.8639)

– 7.9672 e-05 * D8 – 0.0052 * D9 – 0.0061 * D10 – 0.0124 * D11
(-0.0140) (-0.8749) (-0.9972) (-2.0291)

Chart 8.1 – Sample Autocorrelation Functions

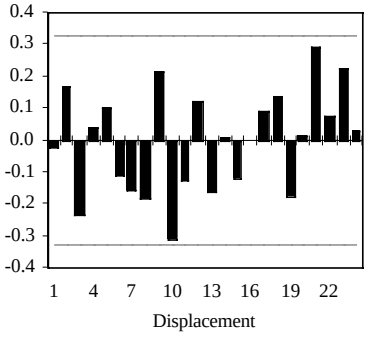
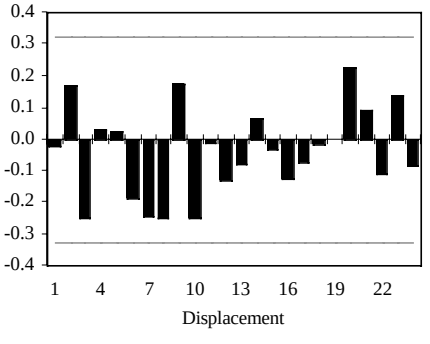


Chart 8.2 – Sample Partial Autocorrelation Functions



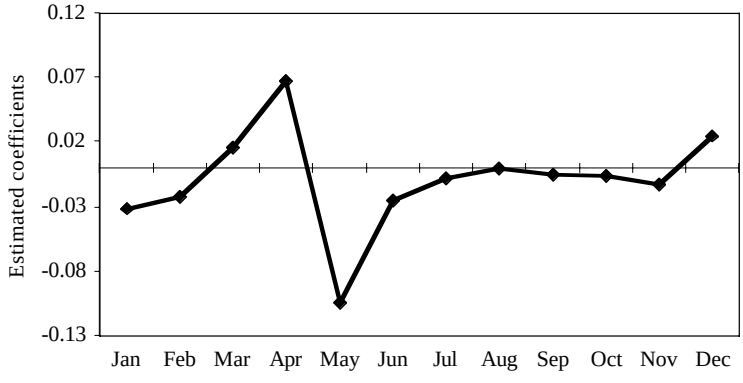
$$+ 0.0248 * D12 + 0.0061 * HOLI + 0.0280 * ELECTION$$
$$(3.6640) \qquad (3.5917) \qquad (4.0093) \ldots\ldots\ldots\ldots\ldots\ldots (3.7)$$

$R^2 = 0.9950$ AIC = -6.1004 SCI = -5.4759 DW = 2.1210

The model produced white noise residuals. The residual sample autocorrelations and partial auto correlations display no patterns and are mostly inside the confidence bands, while the histogram and normality test too performed well.[6]

The model clearly indicates significant positive seasonality in all months except August, September and October The coefficients are positive and relatively higher in April and December. Chart 9, which plotted the coefficients of seasonal dummies, confirms that clear positive seasonality is

Chart 9 – Estimated coefficients for Month of the Year



6/ To select the model that produces an accurate estimate of the 1-step-ahead out of sample prediction error variance, it is necessary to penalize the in sample residual variance (the MSE) reflecting the degrees of freedom used. The model that minimizes the standard error of the regression or the model that maximizes adjusted R^2, are equivalent, and they do penalize for degrees of freedom used. Two very important such criteria currently used in the literature are Akaike Information Criterion (AIC) and the Schwarz Information Criterion (SIC). Comparing the properties of all these criteria, recent literature suggests that MSE is inconsistent because it doesn't penalize for degrees of freedom. S^2 penalizes [What is S2 please] for degrees of freedom but not enough to use as a consistent model selection procedure. The AIC penalizes degrees of freedom more heavily than S^2, but SIC, which penalizes degrees of freedom most heavily, is consistent than S^2 and AIC. The AIC, although inconsistent, is asymptotically efficient, whereas SIC is not. Therefore, the literature suggests examining both AIC and SIC as model selecting criteria, although on many occasions they select the same model by producing minimum values. If these two criteria select different models, the use of the model selected by SIC is recommended.

exhibited in April and December. Within the year, monthly demand tends to increase gradually from March. This was due to the Sinhala/Tamil New Year festival, which occurs on the 13 and 14 of April each year. This growth may also be partly attributable to the Maha harvesting season which coincides with the New Year. However, it is not possible to distinguish the harvesting effect from seasonality in the monthly model, although it may be possible with weekly and daily data. Currency growth thus peaks in April and then starts to fall in May. The seasonality smoothes off during June-November and then increase in December due to the Christmas demand. The demand starts falling in January and picks up in March. Within the month variations will be discussed in Section 3.3 below. The holiday effect and the variable which represents elections were found to be significant. The impact of the Sinhala /Tamil New Year and Christmas are captured by the seasonal dummies for April and December.

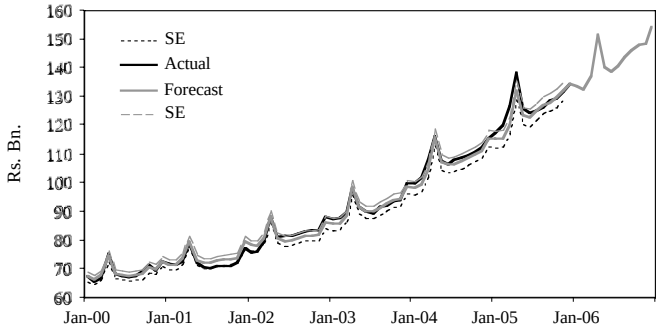
Forecast Based on Monthly Data

	Rs. Billion			As a %		Forecast (Rs. Billion)
	Actual	Forecast	Difference			
2005			**2006**			
January	117.0	116.6	-0.4	-0.3	January	133.4
February	119.5	117.1	-2.4	-2.0	February	132.4
March	127.0	122.8	-4.2	-3.3	March	137.2
April	137.5	135.8	-1.7	-1.2	April	151.5
May	125.3	124.1	-1.2	-0.9	May	140.1
June	124.0	123.9	-0.1	-0.1	June	138.6
July	124.6	124.6	0.1	0.1	July	140.4
August	126.4	127.0	0.6	0.5	August	143.4
September	128.4	127.9	-0.4	-0.3	September	145.7
October	129.4	129.6	0.2	0.2	October	147.9
November	131.8	132.1	0.3	0.2	November	148.3
December	134.3	134.2	-0.1	-0.1	December	154.4
SER (within sample) (a)			1.0108			
Out of sample forecast error						1.5424(b)

(a) Standard Error of Regression (SER) (in Rs.Bn.) = [S (Actual-Forecast) ^{2} /Degrees of Freedom]

(b) This model under estimated reserve money in February, March and April 2005 due to un-expected impact of Tsunami related movements in currency.

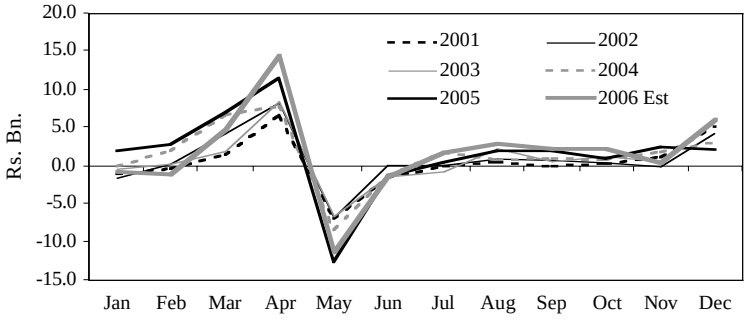
Chart 10 – Currency in Circulation (Based on Monthly Data)



The estimated model is used to forecast historical data on currency in circulation and 12 month-ahead extrapolation forecasts for January – December 2006. Actual data for January – October 2005 were used for post sample validity tests. The forecast appears reasonable. It is visually apparent that the model has the ability to pick up the seasonal patterns that dominate the local behaviour of the series. Chart 10 shows actual historical data, the forecast and the January – September 2005 realization.

The estimate seems reasonable as it closely capture the trend and the seasonal and cyclical patterns in the past, and performs very well in post sample validity tests. During this period, forecast errors in many months were less than 1 per cent and post sample estimation error is less than 2 per cent. Chart 10 which shows changes in currency in circulation over the previous month, shows the monthly estimates for January – December 2006 following a similar pattern shown during 2001–2005. Therefore, the estimates may productively be used as a basic input in long term liquidity assessment.

Chart 11 – Monthly Changes in Currency in Circulation



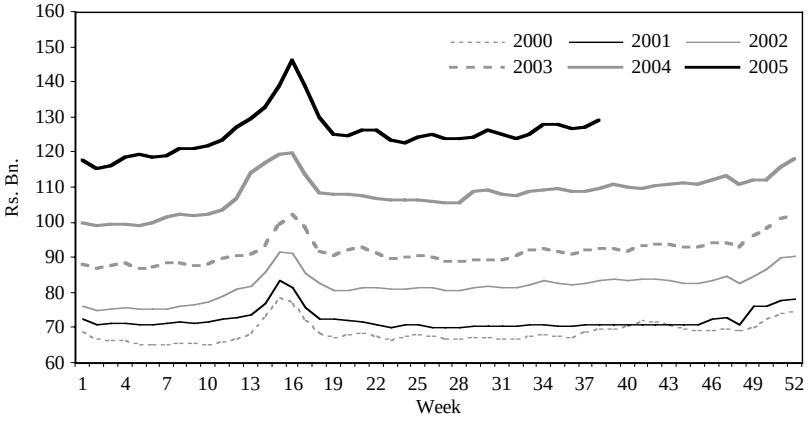
B. Estimation with Weekly Data

Data on currency in circulation are compiled by the CBSL on daily basis. Data from Monday to Friday are averaged to obtain a weekly series of currency in circulation. Chart 12 shows the weekly movements of currency in circulation from 03 January 2000 to 2 September 2005, *i.e.,* 296 weeks. Eight weeks up October 2005 were used for post sample testing of the forecast.

Chart 12 shows clear evidence of a trend in the weekly average of currency in circulation. Using the same methodology developed in Section 3.1 it was found that quadratic trend model in logarithmic form fits data well.

Chart 12 also clearly indicates intra month seasonality in some months (April and December). However, seasonality is not that evident in other months. Therefore, to examine the intra- month seasonality more intensively, the year over year line graphs of currency in circulation are examined. Chart 12 reveals that for all the years, the patterns are very similar, indicating no evidence of a structural break or change in seasonality during the period. The minor variations from year to year occur mostly due to (*a*) shift of the week and (*b*) festivals which do not strictly follow the Gregorian calendar. In order to examine intra-month seasonality in a systematic manner, seasonal dummies were included in the model. To represent the 5^{th} week in some months, a 5^{th} dummy variable was also included.

Chart 12 – Year on Year Weekly Data on Currency in Circulation



$$LCURRENCY = 0.0025 * TIME + 10.9834 * D1 + 10.9850 * D2$$
$$(15.5489) \quad (359.8467) \quad (359.9390)$$

$$+10.9932 * D3 + 10.9917 * D4 + 10.9847 * D5 + 0.01258 * CHRIST$$
$$(360.2060) \quad (360.0916) \quad (359.3079) \quad (4.6214)$$

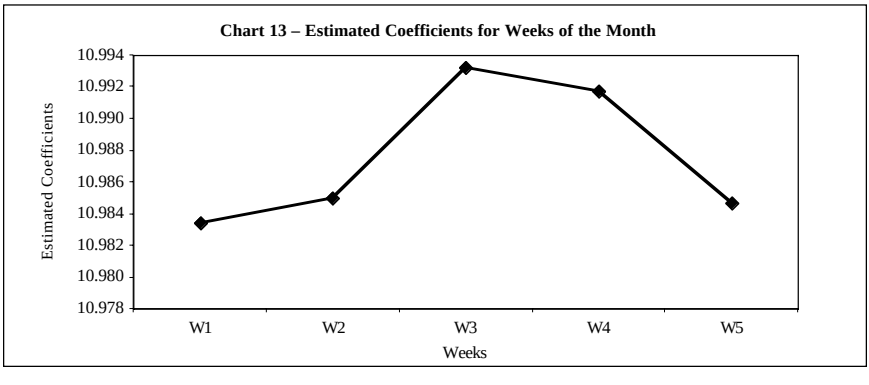
$$+ 0.0408 * NEWYEAR + 0.0017 * HOLIDAY + 0.0082 * HARVEST$$
$$(13.9584) \quad (1.9740) \quad (4.3525)$$

$$+ 0.0195 * ELECTION + [\ AR\ (1) = 0.9382\ ]$$
$$(3.2722) \quad (50.8241) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.8)$$

$R^2 = 0.9957$ AIC = -5.6683 SCI = -5.5184 DW = 1. 8889

The model clearly identifies the significance of the New Year and Christmas seasons in changing demand for currency. In the monthly model, the impact of these two variables is captured by seasonal dummies. The impact of other public holidays was also found significant, but the coefficient is smaller than the coefficients for the New Year and Christmas. The elasticity estimated for the holiday effect in the monthly model is nearly 4 times bigger than the estimate in the weekly model. The elasticity for elections is almost double in the monthly model. Two dummy variables representing the impact of election weeks and two paddy harvesting seasons, Yala and Maha, too were found to be highly significant in this model. However, the effect of the variable for harvest could not be identified separately in the monthly model. All these factors show a positive impact on currency demand.

Chart 13, which presents estimated coefficients of seasonal dummies, indicates clear seasonality among weeks. Within each month, weekly currency

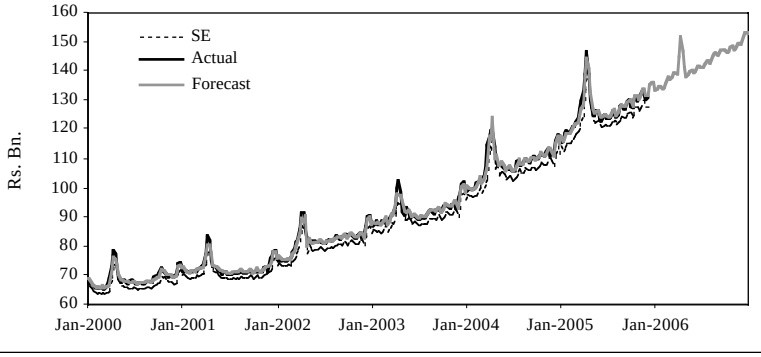


demand tends to increase during the second week and remains high in the third week and then tends to decline. However, the variations among the weeks are small in magnitude. Most of the payments to individuals are made during this time. The government pays salary advances to public school teachers and public servants around the 10th of each month. Teachers' salaries are paid around the 20th while salaries to other government employees, bank employees *etc.* are paid around the 25th of each month.[7] This payment mechanism is likely to create a pronounced 'day of the month' effect in currency in circulation. Within a month, seasonality among weeks varies from 0.001–0.01, but this variation is quite high in April and December.

Forecast Based on Weekly Data

The model developed is used to estimate currency in circulation for past periods and to make 3 month-ahead extrapolation forecasts for January – March 2006. Actual data for 02 September 2005 – 27 January 2006 were used for a post sample validity test. The within sample and out of sample forecast errors were small, while other residual tests such as a Q test, normality test *etc.* suggest that the model fits the data well. Although, the forecast based on average weekly data cannot be compared directly with the forecast based on average monthly data as some weeks extend into the following month, this forecast provides reasonably similar values to these produced by the monthly model.[8] It is visually apparent that the model has the ability to pick up seasonal patterns that dominate the local behaviour of the series. Chart 14 shows actual historical data, the forecast and the January 2005 – January 2006 realization.

Chart 14 – Currency in Circulation (Based on Weekly Data)



7/ This date varies with the weekend, and other holidays that occur.

8/ The first quarter average for 2006 in the monthly model (Rs. 134.3 billion) is more or less the same as the forecast by the weekly model (Rs.134.57 billion).

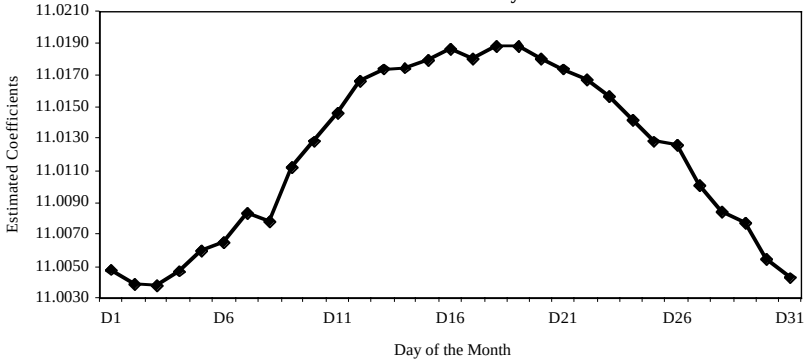
C. Estimation with Daily Data

The intra-month variations with weekly data suggest significant but small variations among the weekly demands. Therefore, it is important to identify the day of the month effect and, if any, intra week variations. Furthermore, some systematic estimate of daily currency demand is useful for daily liquidity estimates to be used in open market operations.

To estimate the effect of each day of the month separately, the regression has done without the constant term in the empirical specification. The daily effect has been captured by the *aj (j = 1, 2, 3, 4, … 30, 31)* respectively. In the empirical specification, a few more variables have been added to capture the effect of bank holidays, harvesting period and festivals.

The regression results reported below find evidence in favour of some of the earlier findings for monthly and weekly data. More importantly, the results reveal that there is a pronounced day of the month effect in the growth rates of currency in circulation. Chart 15 presents the graph of estimated *Dj* as a function of *j (1, 2,3, … 30, 31)*. Starting from a positive value at *j = 1*, estimated *Dj* begins to increase after the 3rd day of a month. The results show that currency in circulation increases at a higher rate after the 7th day of the month the time close to the date that government salary advances are paid. The seasonal co-efficient increases gradually and remains around its peak during the 14th to 21st day of the month. Though the seasonal co-efficient starts to decline thereafter, it continues to remain high until the 23rd day of the month. Since the lowest demand is evident during the first and last week of the month, the results agree with the findings from weekly data (Section 3.2).

Chart 15 – Estimated Coefficients for day of the Month



The estimated equation also shows that the effect of the Sinhala/Tamil New Year festival is strong. The variable which indicates a day prior to a holiday represents all religious and other bank holidays other than the Sinhala/Tamil New Year holidays and Christmas holidays. The alternative variable, *viz*, the trading day effect, better represents the data than the holiday variable. The Christmas holiday is significant only at the 10 per cent level of significance in the model and was subsequently dropped from all specifications. Neither election days nor harvesting season found significance in this model.

LCURRENCY = 0.0003 * TIME + 11.0048 * A1 + 11.0039 * A2
(17.0191) (428.1711) (428.1503)

+ 11.0038 * A3 + 11.0047 * A4 +11.0060 * A5 + 11.0065 * A6
(428.1704) (428.2245) (428.2907) (428.3446)

+ 11.0083 * A7 + 11.0098 * A8 + 11.0112 * A9 + 11.0129 * A10
(428.4657) (428.5551) (428.6550) (428.7506)

+ 11.0147 * A11 + 11.01667 * A12 + 11.01744 * A13 + 11.0175 * A14
(428.8540) (428.9577) (429.0125) (429.0326)

+ 11.0180 * A15 + 11.0187 * A16 +11.0181 * A17 + 11.01891 * A18
(429.0657) (429.0993) (429.0728) (429.1098)

+ 11.0189 * A19 + 11.0181 * A20 + 11.01742 * A21 + 11.0167 * A22
(429.1085) (429.0639) (429.0227) (428.7506)

+ 11.01565 * A23 + 11.01426 * A24 + 11.01289 * A25
(428.9007) (428.8061) (428.7023)

+ 11.01264 * A26 + 11.0101 * A27 + 11.0084 * A28 + 11.0077 * A29
(428.6573) (428.5156) (428.3979) (428.3111)

+ 11.0055 * A30 + 11.0042 * A31 + 0.0039 * NEWYEAR
(428.1742) (428.0558) (3.6354)

+ 0.0026 * CHRISTMAS + 0.001157 * Holiday + [AR(1) = 0.9822,
(1.5252) (4.4798) (236.5869)

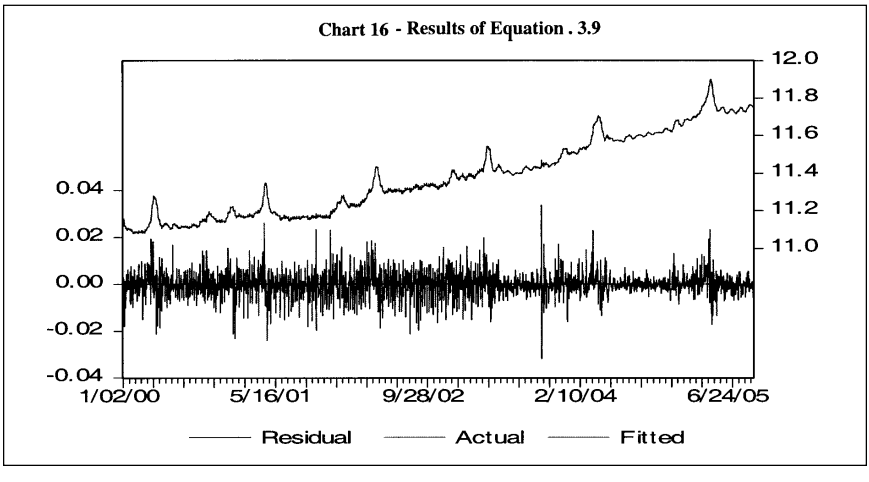
MA(1) = 0.0327, MA(2) = 0.0009, MA(3) = 0.1092, MA(4) = 0.1008,
(2.5909) (0.0431) (5.3187) (4.8833)

MA(5) = 0.0255, MA(6) = 0.0796, MA(7) = 0.3982]
(1.2452) (3.8728) (19.3518) …… (3.9)

R^2 = 0.9993 AIC = -7.5103 SCI = -7.3932 DW = 1.9914

The equation explains the variation in the currency in circulation very well. The Adjusted R^2 is almost 100%. The value of Durbin Watson statistic is very close to 2, implying the residuals are free of first order auto correlation. Further examination of the residuals does not indicate the presence of auto correlation or partial autocorrelation after including ARMA (1,7) lags. SCI and AIC statistics are negative and small.

The residual plot in Chart 16 reveals no pattern and looks like white noise. The residual sample auto correlations and partial auto correlations display no patterns and are mostly inside the Bartlett bands. The Ljung-Box statistics are also good for small and moderate displacements. The histogram and normality test suggest that the residuals appear to be fairly well approximated by a normal distribution.



Forecast Based on Daily Data

The model was used to generate estimates of currency in circulation for past periods and to obtain 3 month- ahead extrapolation forecasts for October – December 2005. Actual daily data for 1 October – 7 November 2005 were used for post sample validity tests. The forecast looks reasonable. It is visually

apparent that the model has the ability to pick up seasonal patterns that dominate the local behaviour of the series. Chart 17 shows actual historical data for 1 January – 7 November 2005 and the forecast. Post sample estimates for 1 October – 7 November 2005 are used for testing the validity of the model.

The results shown in Annex 2 indicate that post sample estimates are very close to the actual data. It also indicates that the model based on daily data can produce more accurate estimate for the short run than the model based on monthly data. The forecasting error for the out of sample period was 0.4432, which is much smaller than those produced by the models based on monthly and weekly data. Further, the estimated monthly average currency in circulation based on daily forecasts is very close to the estimate based on monthly data.

Table 3 – Comparison of Forecasts (Post Sample Estimates)

Rs. Billion

	Actual Data	Model Based on Monthly averages	Model Based on Weekly averages[(a)]	Model Based on Daily data
Sept-2005	128.4	127.9	128.3	128.4
Oct-2005	129.4	129.6	129.1	129.2
Nov-2005	131.8	132.1	131.5	131.8
Dec-2005	134.3	134.2	133.2	133.9
Jan-2006	132.9	133.4	133.6	132.8
Feb-2006		132.4	133.2	132.7

(a) The forecast based on average weekly data cannot be compared directly with the forecast based on average monthly data in certain months as some weeks partly fall into another month.

Chart 17 – Currency in Circulation (Based on daily data)

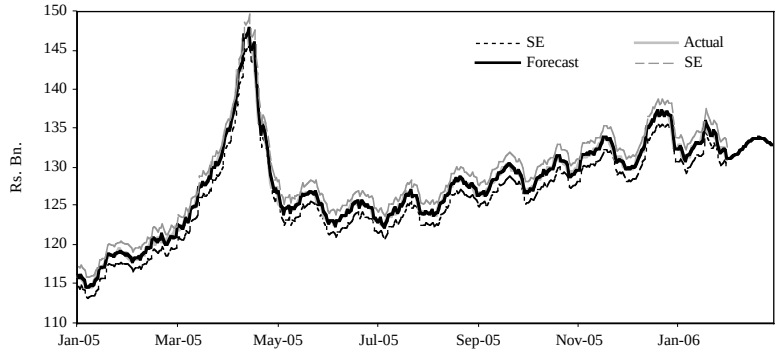


Chart 17 shows historical data on currency in circulation and three months ahead extrapolation forecasts for 1 September 2005 to 28 February 2006. To help visual interpretation, only 9 months of past data are shown in the Chart. The model has performed well in picking up seasonal patterns that dominate the local behaviour of currency in circulation.

IV. An Interpretation of the Econometric Results

According to all validity tests explained in Section 3, all three models, based on monthly, weekly and daily data have tracked well the past movements both within and outside the sample period. Therefore, these models can be used to explain the seasonal effects within the year and within the month. They are also useful to identify the cultural, social and economic factors that influence the demand for currency.

A. Seasonal Effect

To identify the seasonal impact on currency in circulation in relation to January, Equation 3.7 reported above was re- estimated with a constant term. To avoid the dummy variable trap, the monthly effect has been captured by the dummy variables for February to December. Therefore, the estimated coefficients for dummy variables are incremental month effects relative to January of each year. In this model the intercept represents the effect on January, the base month. Accordingly, the significance of monthly differential coefficients for each month should not matter much as it simply states that the variation in currency in circulation from the base is significant.

More specifically, the coefficient of D2, *i.e.*, 0.096, states that, holding all effects constant, the average value of the log of ratio of currency in circulation will be higher than January by 0.096 during the month of February. Given these differential coefficients, one can easily arrive at an average value for each month by adding specific differential coefficients to the base. The interpretation can be made easier by specifying the left hand side of the equation as follows.

$$D[\log(\text{Currency})] = \log(\text{Currency}_t) - \log(\text{Currency}_{t-1})$$

$$= \log\left\{\frac{\text{Currency}_t}{\text{Currency}_{t-1}}\right\}$$

$$\cong \frac{\text{Currency}}{\text{Currency}}$$

In this case, the left hand side of the equation is simply the natural log of the ratio of currency in circulation in two successive months. The original series is thus transformed into a chain of log ratios of currency stocks in consecutive months. Following Halvorsen and Palmquist (1980), differential coefficients are transformed to show differential effects in terms of percentage change. The relative effect for each month is calculated with the help of an exponential transformation and further multiplied by 100 to show percentage changes as noted in Table 4.

Table 4 – Effect of Seasonal and other Selected Variables on Currency in Circulation

Months	Variable	Coefficient	t-Statistic	Per cent Effect
January	C	-0.0311	-4.2515	
February	D2	0.0096	1.3162	0.9597
March	D3	0.0468	6.1355	4.7883
April	D4	0.0986	13.3109	10.3578
May	D5	-0.0739	-10.1766	-7.1237
June	D6	0.0063	0.8310	0.6309
July	D7	0.0236	2.9282	2.3890
August	D8	0.0311	3.9880	3.1556
September	D9	0.0260	3.4304	2.6306
October	D10	0.0250	3.2416	2.5336
November	D11	0.0187	2.5012	1.8895
December	D12	0.0560	7.5153	5.7564
Holiday	HOLI	0.0061	3.5917	0.6079
Election	ELECTION	0.0280	4.0093	2.8410

The relative effect for January is $g = (e^{-0.0311} - 1)$ or in per cent term

$$g * 100 = (e^{-0.0311} - 1) * 100$$

The relative effects represent percentage changes in the average monthly ratio of stock of currency For example; the average ratio of stock of currency in February will be 1 per cent higher than the average in the base month, January. Similarly the average ratio of the stock of currency will be 10.36 per cent higher in April than in January.

B. Sinhala and Tamil New Year Effect

In a model with monthly data, the seasonal dummy for April and December are the same as the dummy variables that represent the Sinhala/Tamil New Year and Christmas, respectively. Although the highly significant coefficient in April is mostly due to the effect of the New Year demand, it is practically impossible to isolate the effect from the seasonal effect. Equation 3.8 and Equation 3.9 too, which represent models for weekly and daily data, respectively, confirm that the Sinhala/Tamil New Year has significant impact on currency in circulation. Estimates based on the daily model, reveal that the effect of Sinhala/Tamil New Year on currency in circulation is around 9.96 per cent in April.[9]

Furthermore, any additional holiday on particular month increases currency in circulation by 0.61 per cent.

C. Christmas Effect

As in the case of the Sinhala/Tamil New Year, the effect of Christmas on currency in circulation could not be captured implicitly in models with weekly data as Christmas falls on different days in different years. However, in the Halvorsen and Palmquist type analysis based on monthly data explained above, the effect of the Christmas demand is represented by the dummy for December. Accordingly, ceteris paribus, the effect of seasonality in December is approximately 5.8 per cent over the level in January. The daily model suggests that the Christmas effect is around 4 per cent. The balance seasonal effect may be due to high spending associated with school and year end vacations and December 31st celebrations.

The holiday effect has an additional increment over the seasonal effect on the average ratio of stock of currency in circulation depending on the number of holidays that fall in December.

D. Holiday Effect

The effect of the number of holidays on currency in circulation is significant in all three models. As noted in Table 5, the average ratio of currency in circulation will change significantly if an additional holiday other than

9/ The effect of the Sinhala/Tamil New Year festival on a particular day, which is estimated by the daily model, is weighted with the dummy variable for the New Year festival. The dummy variable is defined based on the last 5 years' average of currency in circulation in April each year.

Saturday and Sunday also falls in that month. For example, if the month of February has an additional holiday, the average ratio of stock of currency in circulation will be 0.61 per cent higher than the mean value of January; in addition to the 1 per cent. That is, in total, this will be 1.61 per cent higher than the base.

E. Effect of Elections

Similarly, if an election falls in a particular month, the additional change will be 2.8 per cent higher than the normal increment of that particular month. For example, if an election falls in December, the average ratio of stock of currency will be 2.8 per cent higher than the mean value of January in addition to the 5.8 per cent. For example, in December 2001, when the Presidential election was held, the monthly average of currency in circulation increased by 7.9 per cent. This growth is very close to the results shown in the study (*i.e.*, 5.76 + 2.84 + (3 * 0.61) - 3.07 = 7.4 %).

V. Conclusion

The paper presents three models suitable for forecasting currency in circulation, based on monthly, weekly and daily data for the period of 1 January 2000 to 30 September 2005. The data for the period 1 October – 30 November 2005 were used for post sample validity tests. The forecasts produced by all three models accurately matches the shape of the monthly, weekly and daily oscillations, respectively, and capture the trend, seasonal and cyclical effects well. Post sample estimation error is very small and remained less than 1 per cent in all models. The forecasts based on the daily and monthly models performed very well, predicting very similar results, and were close to realized data[10] when used within sample.

The models evidenced clear seasonality in April and December mainly associated with the Sinhala/Tamil New Year and Christmas respectively. In addition, the number of special holidays in a particular month significantly affects currency in circulation. Similarly, having a general election also has significant impact on currency demand. The models based on weekly and daily data clearly indicated high seasonal demand around the 10^{th} – 23^{rd} day (mainly 2^{nd} and 3^{rd} week) of the month.

10/ Estimates based on weekly data are not used in comparing with the other two models due to the interpretation difficulties as the particular week does not include the comparable days and a particular month does not contain an equal number of weeks.

The application of these models and their results may have important implications to researchers and policy makers. The CBSL can particularly benefit by incorporating this method in disaggregating its annual monetary targets into monthly targets thereby smoothening the implementation of its monetary policy.

Systematic projection of currency in circulation is always an important part of the liquidity forecasting mechanism of the Central Bank. Using these results, the demand for liquidity in specific months can be projected with lower error and therefore, subsequent injections or withdrawals through open market operations are likely to lead to better targeting of monetary aggregates.

Nevertheless, it is important to note that a central bank cannot depend purely or mechanically on forecasting models to predict currency in circulation to be used in liquidity management. As currency in circulation is subject to the influence of various unforeseen developments in the economy, including one off events such as the Tsunami, and the September 11^{th} attack in the USA, close monitoring of day to day developments is extremely important. Even in developed economies, like the USA and UK, central banks continuously develop and use time series and structural models to forecast currency demand, but review market conditions daily and do necessary adjustments manually to make the assessment more realistic.

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Annex - 1

Forecast Results (Weekly Data)

Week Ending	(Rs. Billion)			As a (%)	Week Ending	Forcast (Rs.Billion)
	Actual	Fore-cast	Diffe -rence			
2-Sep-05	126.9	127.2	0.3	0.3	3-Feb-06	132.2
9-Sep-05	127.1	127.3	0.2	0.2	10-Feb-06	131.7
16-Sep-05	129.1	128.4	-0.7	-0.5	17-Feb-06	133.2
23-Sep-05	130.0	129.1	-0.9	-0.7	24-Feb-06	135.5
30-Sep-05	128.0	129.3	1.3	1.0	3-Mar-06	134.8
7-Oct-05	127.6	127.0	-0.6	-0.5	10-Mar-06	135.3
14-Oct-05	129.2	128.0	-1.1	-0.9	17-Mar-06	137.0
21-Oct-05	130.9	130.6	-0.3	-0.2	24-Mar-06	137.0
28-Oct-05	129.8	130.6	0.8	0.7	31-Mar-06	138.4
4-Nov-05	130.6	129.4	-1.2	-0.9		
11-Nov-05	131.7	130.5	-1.2	-0.9		
18-Nov-05	133.3	133.1	-0.2	-0.1		
25-Nov-05	131.8	132.9	1.1	0.9		
2-Dec-05	130.0	130.9	0.8	0.6		
9-Dec-05	130.9	130.5	-0.4	-0.3		
16-Dec-05	134.8	134.1	-0.7	-0.5		
23-Dec-05	137.0	134.8	-2.2	-1.6		
30-Dec-05	135.1	135.8	0.7	0.5		
06-Jan-06	131.8	133.4	1.5	1.2		
13-Jan-06	132.6	132.7	0.1	0.1		
20-Jan-06	134.9	133.5	-1.4	-1.0		
27-Jan-06	133.0	134.8	1.8	1.4		
SER (with in sample)			1.0001			
Out sample Forecast error						1.044

Annex 2

Forecast Results (Daily Data)

Date	Rs. Billion		Difference		Date	Rs. Billion		Difference	
	Actual	Fore-cast	Rs. bn	As a %		Actual	Fore-cast	Rs. bn	As a %
1-Sep	126.4	126.4	0.1	0.1	10-Oct	128.7	129.0	0.2	0.2
2-Sep	126.7	126.3	-0.4	-0.3	11-Oct	129.1	129.0	-0.1	-0.1
3-Sep	126.7	126.6	-0.1	-0.1	12-Oct	128.9	129.5	0.6	0.5
4-Sep	126.7	126.8	0.1	0.1	13-Oct	129.3	129.0	-0.3	-0.2
5-Sep	126.5	127.0	0.5	0.4	14-Oct	129.9	129.4	-0.4	-0.3
6-Sep	126.6	126.4	-0.2	-0.1	15-Oct	129.9	129.6	-0.2	-0.2
7-Sep	127.0	126.5	-0.5	-0.4	16-Oct	129.9	129.8	-0.1	-0.1
8-Sep	127.4	127.2	-0.2	-0.2	17-Oct	129.9	129.8	-0.1	-0.1
9-Sep	128.1	127.7	-0.4	-0.3	18-Oct	131.1	130.2	-0.9	-0.7
10-Sep	128.1	128.3	0.2	0.1	19-Oct	131.4	131.0	-0.4	-0.3
11-Sep	128.1	128.4	0.2	0.2	20-Oct	131.3	131.4	0.1	0.1
12-Sep	128.4	128.4	0.1	0.1	21-Oct	130.8	131.5	0.7	0.5
13-Sep	129.1	128.6	-0.5	-0.4	22-Oct	130.8	130.8	0.0	0.0
14-Sep	129.1	129.3	0.2	0.2	23-Oct	130.8	130.8	-0.1	0.0
15-Sep	129.1	129.2	0.1	0.1	24-Oct	130.4	130.8	0.4	0.3
16-Sep	129.9	129.4	-0.5	-0.4	25-Oct	130.2	130.6	0.4	0.3
17-Sep	129.9	129.6	-0.3	-0.2	26-Oct	129.5	130.3	0.8	0.6
18-Sep	129.9	129.9	0.0	0.0	27-Oct	129.3	129.0	-0.3	-0.2
19-Sep	130.2	130.1	-0.1	-0.1	28-Oct	129.5	128.8	-0.7	-0.5
20-Sep	130.5	130.4	-0.1	-0.1	29-Oct	129.5	129.2	-0.3	-0.3
21-Sep	130.2	130.3	0.1	0.1	30-Oct	129.5	129.2	-0.3	-0.3
22-Sep	129.6	130.1	0.4	0.3	31-Oct	129.8	129.4	-0.4	-0.3
23-Sep	129.5	129.7	0.2	0.2	1-Nov	129.8	129.6	-0.2	-0.1
24-Sep	129.5	129.3	-0.2	-0.2	2-Nov	130.7	129.6	-1.1	-0.8
25-Sep	129.5	129.3	-0.2	-0.2	3-Nov	131.2	131.0	-0.3	-0.2
26-Sep	129.3	129.6	0.4	0.3	4-Nov	131.2	131.6	0.3	0.2
27-Sep	128.7	128.9	0.2	0.2	5-Nov	131.2	131.7	0.4	0.3
28-Sep	127.8	128.5	0.7	0.5	6-Nov	131.2	131.6	0.3	0.3
29-Sep	127.1	127.5	0.4	0.3	7-Nov	131.3	131.8	0.5	0.3
30-Sep	127.0	126.7	-0.3	-0.2	8-Nov	131.4	131.6	0.2	0.2
1-Oct	127.0	126.8	-0.2	-0.2	9-Nov	131.6	131.9	0.2	0.2
2-Oct	127.0	126.9	-0.1	-0.1	10-Nov	131.7	131.8	0.1	0.1
3-Oct	127.3	127.0	-0.3	-0.2	11-Nov	132.3	131.7	-0.7	-0.5
4-Oct	127.2	127.3	0.2	0.1	12-Nov	132.3	132.2	-0.2	-0.1
5-Oct	127.5	127.1	-0.4	-0.3	13-Nov	132.3	132.2	-0.1	-0.1
6-Oct	127.6	127.5	-0.1	-0.1	14-Nov	132.9	132.3	-0.6	-0.4
7-Oct	128.4	128.0	-0.4	-0.3	15-Nov	132.9	132.8	-0.1	-0.1
8-Oct	128.4	128.6	0.2	0.1	16-Nov	133.7	133.1	-0.6	-0.5
9-Oct	128.4	128.7	0.3	0.2	17-Nov	133.4	133.7	0.3	0.2

(Contd.)

Date	Rs. Billion		Difference		Date	Rs. Billion		Difference	
	Actual	Fore-cast	Rs. bn	As a %		Actual	Fore-cast	Rs. bn	As a %
18-Nov	133.4	133.8	0.4	0.3	31-Dec	132.4	132.3	1.1	0.8
19-Nov	133.4	133.4	0.0	0.0	1-Jan	132.4	132.2	-0.2	-0.1
20-Nov	133.4	133.4	0.0	0.0	2-Jan	132.8	132.2	-0.3	-0.2
21-Nov	132.9	133.6	0.7	0.5	3-Jan	132.7	132.6	-0.6	-0.5
22-Nov	132.3	132.8	0.5	0.4	4-Jan	131.4	132.2	-0.1	-0.1
23-Nov	131.6	132.3	0.7	0.5	5-Jan	131.0	131.2	0.8	0.6
24-Nov	131.0	131.2	0.2	0.1	6-Jan	131.3	130.7	0.2	0.1
25-Nov	131.2	130.5	-0.6	-0.5	7-Jan	131.3	131.4	-0.6	-0.4
26-Nov	131.2	130.9	-0.3	-0.2	8-Jan	131.3	131.5	0.2	0.1
27-Nov	131.2	130.7	-0.5	-0.4	9-Jan	132.0	131.9	0.3	0.2
28-Nov	130.8	130.8	0.1	0.0	10-Jan	132.6	132.2	0.0	0.0
29-Nov	130.2	130.5	0.4	0.3	11-Jan	132.6	132.4	-0.4	-0.3
30-Nov	129.7	129.7	0.0	0.0	12-Jan	132.9	133.0	-0.2	-0.2
1-Dec	129.8	129.7	0.0	0.0	13-Jan	132.9	133.2	0.1	0.1
2-Dec	129.7	129.9	-0.1	-0.1	14-Jan	132.9	132.9	0.2	0.2
3-Dec	129.7	129.7	0.2	0.2	15-Jan	132.9	132.9	0.0	0.0
4-Dec	129.7	130.1	0.0	0.0	16-Jan	134.7	133.2	0.0	0.0
5-Dec	130.1	130.0	0.3	0.2	17-Jan	135.8	134.8	-1.4	-1.1
6-Dec	130.1	130.0	-0.1	-0.1	18-Jan	135.2	136.0	-1.0	-0.7
7-Dec	131.0	130.4	-0.1	-0.1	19-Jan	134.6	135.3	0.8	0.6
8-Dec	131.4	131.3	-0.6	-0.5	20-Jan	134.1	134.6	0.8	0.6
9-Dec	132.0	131.6	-0.2	-0.1	21-Jan	134.1	133.9	0.5	0.4
10-Dec	132.0	132.2	-0.4	-0.3	22-Jan	134.1	134.0	-0.2	-0.1
11-Dec	132.0	132.2	0.2	0.1	23-Jan	134.0	134.6	-0.1	-0.1
12-Dec	133.3	132.5	0.2	0.2	24-Jan	133.5	134.1	0.6	0.5
13-Dec	134.8	133.5	-0.7	-0.6	25-Jan	132.7	133.0	0.5	0.4
14-Dec	135.0	135.1	-1.3	-1.0	26-Jan	132.4	132.2	0.4	0.3
15-Dec	135.0	135.0	0.1	0.1	27-Jan	132.4	131.8	-0.2	-0.1
16-Dec	136.0	135.6	0.0	0.0	28-Jan	132.4	132.1	-0.6	-0.5
17-Dec	136.0	136.1	-0.4	-0.3	29-Jan	132.4	132.3	-0.1	-0.1
18-Dec	136.0	136.0	0.1	0.1	30-Jan	131.4	132.1	0.8	0.6
19-Dec	136.9	136.5	0.0	0.0	31-Jan	131.0	131.1	0.1	0.1
20-Dec	136.9	137.2	-0.3	-0.2	1-Feb		131.1		
21-Dec	136.9	136.6	0.4	0.3	2-Feb		131.0		
22-Dec	137.3	136.8	-0.2	-0.2	3-Feb		131.3		
23-Dec	137.1	137.2	-0.5	-0.4	4-Feb		131.4		
24-Dec	137.1	136.6	0.1	0.1	5-Feb		131.6		
25-Dec	137.1	136.9	-0.5	-0.4	6-Feb		131.5		
26-Dec	137.1	137.1	-0.2	-0.1	7-Feb		131.8		
27-Dec	136.8	136.7	0.0	0.0	8-Feb		132.0		
28-Dec	135.4	136.7	-0.1	0.0	9-Feb		132.2		
29-Dec	133.9	135.1	1.3	0.9	10-Feb		132.5		
30-Dec	132.4	133.5	1.2	0.9	11-Feb		132.7		

(Contd.)

Date	Rs. Billion		Difference		Date	Rs. Billion		Difference	
	Actual	Fore-cast	Rs. bn	As a %		Actual	Fore-cast	Rs. bn	As a %
12-Feb		133.0			21-Feb		133.7		
13-Feb		133.3			22-Feb		133.6		
14-Feb		133.3			23-Feb		133.5		
15-Feb		133.4			24-Feb		133.4		
16-Feb		133.6			25-Feb		133.1		
17-Feb		133.6			26-Feb		133.1		
18-Feb		133.5			27-Feb		133.0		
19-Feb		133.6			28-Feb		132.8		
20-Feb		133.7							
Sep-05	***128.4***	***128.4***	***0.0***	***0.0***	***Dec-05***	***134.3***	***133.9***	***-0.4***	***-0.3***
Oct-05	***129.4***	***129.2***	***-0.2***	***-0.2***	***Jan-06***	***132.9***	***132.8***	***-0.1***	***-0.1***
Nov-05	***131.8***	***131.8***	***0.0***	***0.0***	***Feb-06***		***132.7***	***-0.1***	***-0.1***
SER (with in sample)							1.0056		
Out sample Forecast error								0.4432	

The Impact of Fertilizer Subsidy on Paddy Cultivation in Sri Lanka

H. K. J. Ekanayake[1]

Abstract

The Government of Sri Lanka has been subsidizing fertilizer for more than four decades. This study attempts to analyse the impact of fertilizer subsidies with reference to paddy cultivation in Sri Lanka. The issue is analysed by employing three separate demand functions for major fertilizers by using simple regression model. Regression results indicate that changes in the prices of fertilizer and paddy do not have a significant effect on fertilizer usage, which points to the fact that the fertilizer subsidy is not a key determinant of the use of fertilizer in paddy cultivation. The study also found that there is a relatively higher correlation between fertilizer usage and paddy price than between fertilizer usage and fertilizer price. These findings suggest that the fertilizer subsidy could be withdrawn gradually over time. In its place, appropriate infrastructure and institutional facilities that are required to increase productivity in paddy cultivation and an effective mechanism for marketing the output that would result in favourable prices for paddy may be introduced for a more effective outcome. (JEL N551, Q19)

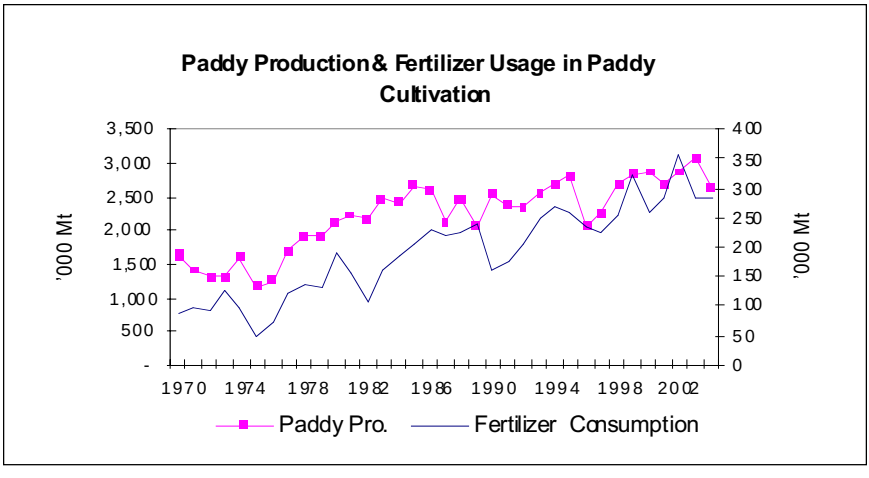
I. Introduction

Paddy production in Sri Lanka has increased considerably during the last three decades as a result of cultivation of high yielding varieties, increase in the area of cultivation under irrigation and greater use of plant nutrients. Successive governments have also provided support to stimulate paddy production by way of introducing guaranteed price schemes, major irrigation schemes and fertilizer subsidy schemes. Introduction of high yielding varieties was the major factor, which contributed to increase in paddy production in the country. Given that high yielding varieties are highly fertilizer responsive, proper fertilizer

1/ The views expressed in this paper are the author's own and do not necessarily reflect those of the Central Bank of Sri Lanka.

application is needed to obtain respective yield levels. With respect to paddy, the supply of three major nutrients namely, Nitrogen (N) Phosporous (P) and Potassium (K) are essential for cultivation. Among these nutrients Nitrogen is a major nutrient demanded by paddy plants to increase yield. Since, over use and misuse of these fertilizer can reduce yields and also make soil less productive, fertilizer recommendations are done by respective crop research institutions of the country. Fertilizer recommendation for paddy is given in Appendix I.

Figure 1 : Annual Paddy Production and Fertilizer usage in Paddy Cultivation



Because of the importance of fertilizers in increasing agricultural output, government intervention in the fertilizer market started in 1962 with the introduction of fertilizer subsidy scheme. The main objective of the subsidy scheme was to make fertilizer available as cheaply as possible in order to encourage its wider use thereby increasing agriculture productivity. The fertilizer subsidy has been available for more than four decades even though with several changes, farmers expect it to be continued in the future. Meanwhile, the government faces great difficulty with the increasing expenditure on the fertilizer subsidy mainly in recent times due to its fiscal implications. Expenditure on fertilizer subsidy in Sri Lanka has gone up from Rs.600 million in 1987 to Rs. 3,572 million in 2004. This was further increased to Rs. 6,846 mn in 2005. Public expenditure on fertilizer subsidy scheme for last 10 years is given in Appendix II. Therefore, the purpose of this study is (*i*) to analyse the fertilizer subsidy scheme on paddy cultivation on the basis of the estimated fertilizer demand functions and (*ii*) to elaborate other measures that can be used as alternatives to the fertilizer subsidy policy.

In order to analyse these issues this paper is organized as follows. The rest of this section explains the history and evolution of fertilizer subsidy policy in Sri Lanka. Section II reviews the existing literature on the subject. Section III discusses the data and econometric tools used in this study while in section IV presents the results of the econometric regressions. Section V concludes the discussion on impact of fertilizer subsidy policy on paddy cultivation.

A. Evolution of Fertilizer subsidy policy in Sri Lanka

As fertilizer is an essential input in agriculture strong fertilizer related policies are crucial for any national effort aiming at improving agricultural productivity. As a major step towards achieving this objective, the government of Sri Lanka introduced a price subsidy for fertilizer in 1962. The main objective of the subsidy scheme was to make fertilizer available as cheaply as possible in order to encourage its wider use. A lower fertilizer price reduces cost of production and increases demand for fertilizer and for other inputs depending on the elasticity of substitution, income effect and elasticity of supply of other inputs. If sufficient quantities of fertilizers are available to meet the increased demand and if the additional fertilizer is properly applied, food production will increase.

Initially four main fertilizers namely, Urea, Sulphate of Amonia, Muriete of Potash (MOP) and Triple Super Phosphate (TSP), which provide Nitrogen (N), Phosperous (P) and Potassium (K), respectively were subsidized at different rates. Until 1975, the subsidy level varied according to the type of crop. This scheme was found to be unsuccessful as it allowed unauthorized leakages of fertilizer between agricultural sub sectors. Hence, in 1975 the government introduced a uniform subsidy scheme for all crop sectors. Subsidy rates were varied according to the type of fertilizer and the subsidy rates were subjected to revision overtime. Later, in 1990 the government completely removed the fertilizer subsidy for all types of fertilizer, as it was heavy burden on the government budget. However, due to various other reasons fertilizer subsidy scheme was reintroduced in 1994. During the period 1994 to 1997, the fertilizer subsidy scheme underwent several changes and in 1997 the government decided to restrict the fertilizer subsidy only to Urea. The objective of the new scheme was to provide a higher benefit to paddy farmers while reducing the burden on the government budget. This scheme was also subjected to revision on a seasonal basis. During this period subsidy had been given in either of the following two ways.

1. Selling price of fertilizer is fixed allowing the subsidy component to vary depending on the import price
2. Subsidy component is fixed allowing the selling price of fertilizer to vary.

During the late 90's the selling price was fixed with the intension of reducing the burden on the farming community due to price fluctuations. Since the price was fixed with a variable subsidy component there was no incentive to the importers to import fertilizer when the world market prices were low. To address this issue the government decided to fix the subsidy component and allow the selling price to vary depending on the world market prices. When the international prices were very high it had an adverse impact on the farmers as the cost of production increased with the increase in fertilizer prices. This situation created financial difficulties particularly for small farmers in the dry zone where paddy cultivation largely exist. Therefore, again in 2004 the government decided to fix retail price of fertilizer. This system continued until December 2005. In December 2005, the government decided to reintroduce subsidy scheme for all types of fertilizer by fixing their selling price. However, this scheme is restricted only for paddy farmers.

II. Literature Review

There are many studies that have estimated the demand for fertilizer or for the specific nutrients (Nitrogen, Phosphorous and Potassium). In developed countries, it is generally agreed that fertilizer demand is price inelastic. This may be due to lack of an economic substitute to chemical fertilizer. Generally, in less developed countries the demand for fertilizer is thought to be more elastic under the assumption of readily available substitutes such as manure and other organic materials. However, the demand for fertilizer may differ from country to country due to the factors such as cultural practices, climate, soil type, crops grown and farm structure. In this section, an attempt is made to review several of impotent research work on the subject.

The demand for fertilizer as a main input in agriculture has been the focus of many studies over the years. The early studies include work by Griliches (1958, 1959), Heady and Yeh, Carman, Gunjal, Roberts and Heady, and others. In general, emphasis has been on national or regional demand estimates for total fertilizer or nutrient application on all crops. Griliches (1958) estimated the aggregate demand functions for fertilizer use on all crops in the United States. He showed that for the 1911 to 1956 period, most of the increase in fertilizer use could be explained by changes in both fertilizer and crop prices, and by the previous period's use. Using the same model, Griliches (1959) estimated regional demand functions for total fertilizer consumption over the 1931 to 1956 period. While the model explained a large portion of the variation in the regional fertilizer use, he found that estimated price elasticities of demand varied across regions, ranging from elastic to inelastic.

Heady and Yeh (1959) estimated fertilizer demand functions for total fertilizer and for individual nutrient used on all crops in the United States. The variables affecting the use included fertilizer prices, crop prices, total cash receipts from crops, total crop acreage, acres of specific crops, wage rates, the wholesale price index, and time. In addition, they estimated relationships for total fertilizer use in ten different geographical regions of the United States. Their study allowed a comparison between aggregate fertilizer and individual demand elasticities. Heady and Yeh estimated a short-run elasticity ranging from about -0.49 to -1.71 for total fertilizers, and elasticities of -0.45, -0.45 and -0.40 for nitrogen, phosphate and potash. Those results confirmed that the demand for N, P and K in the U.S. is inelastic.

There have been many studies conducted on fertilizer demand in countries other than the United States. Boyle (1982) used a cost function approach (translog) to estimate fertilizer demand and to obtain estimates of the demand elasticities of nitrogen, phosphorous and potassium in the Republic of Ireland. The major objective of his paper was to test the hypothesis of nutrient substitution over time. His findings suggested inelastic own-elasticities for phosphorous and potassium, and an elastic own-elasticity for nitrogen, and significant cross-price elasticities between nitrogen, phosphorous, potassium. He found that the adverse effects of own-price increases on the consumption of nitrogen would be offset by substitution of nitrogen for phosphorous and potassium.

Burrell (1982) had estimated the demand for fertilizer in the United Kingdom. He used three different modeling approaches with two different data sets (nitrogen, and all fertilizers). He found that the elasticity with respect to crop price is about -0.4 to -0.5 for nitrogen and between -0.1 and -0.3 for all fertilizer in most versions of the system model. This means that demand for nitrogen fertilizer is more sensitive to its own price than is the case for phosphate and potash fertilizer.

Gunawardena P. and Flinn C.J. (1987) in their analysis of supply response and fertilizer demand in rice sector in Sri Lanka, estimated short run production elasticities by using micro level data. They concluded that, both own price elasticity (0.15) and cross price elasticities with respect to hired labour (-0.12) and fertilizer (-0.01) indicated an inelastic production response implying a relatively small incentive to increase paddy production in response to increase in the price of paddy, or reduction in the price of fertilizer. Hence, the results suggested that the guaranteed price scheme and the fertilizer subsidy provide small incentive to increase paddy production.

Chandrapala H.A. and De Silva S. examined the economics of fertilizer use in Major crop sectors of Sri Lanka in 1988. They analysed some economic aspects of fertilizer use in the tea, rubber, coconut and paddy sectors of Sri

Lanka. Regression models estimated for fertilizer use indicated that the relative price ratio of fertilizer and the output has a significant effect on fertilizer use, which points out the fact that the removal of the subsidy for fertilizer will further worsen the situation with respect to fertilizer use in these sectors.

III. Data and Model used

A. Description of Data

As mentioned earlier, the objective of this paper is to analyse factors affecting fertilizer demand and to investigate the impact of fertilizer subsidy in paddy cultivation. Generally, three main fertilizers are being used in paddy cultivation namely, Urea, Muriate of Potash (MOP), and Triple Super Phosphate (TSP). Therefore, factors affecting the usage (demand) of these fertilizers analysed separately. The Study consists of two main parts.

General analysis of Fertilizer Subsidy Scheme

The Fertilizer Subsidy scheme divided into three periods according to nature of the subsidy.

1. Period I – Subsidy provided for three main fertilizers (1962–1989, 1995–1996)
2. Period II – Period of Subsidy removal (1990–1994)
3. Period III – Subsidy provided only for Urea (1997–2005)

Since, data is not sufficient to run statistical programme for each of these periods, all the variables that relate to fertilizer usage are presented graphically and analysed to illustrate the changes in those variables in different periods.

Estimation of Fertilizer Demand Function

Factors affecting the demand of three main fertilizers namely, Urea, Muriate of Potash (MOP), and Triple Super Phosphate (TSP) analysed separately.

Factors affecting the fertilizer application can be listed as follows:

1. Fertilizer Prices (Rs./mt)

2. Paddy Prices (Rs./mt)
3. Extent under irrigation schemes (Ha)
4. Policy changes

Separate fertilizer demand functions were specified for the three main fertilizers, since the fertilizer subsidy scheme has been changed according to the fertilizer type. Regression models were specified for annual issues of fertilizer at the national level as dependent variables and current fertilizer price and lagged nominal farm gate price and extent under irrigation schemes as independent variables assuming all other factors that influence fertilizer use were remained unchanged. Dummy variables are used to interpret policy changes. Further, it was also assumed that total amount of different fertilizers issued for paddy cultivation during the given year were utilized fully for paddy during the year and no carry over stocks. This assumption was made due to lack of information regarding quantities of paddy fertilizers that were used for the cultivation of other food crops. Own price and cross price elasticities of demand can be obtained from estimated demand function and those elasticities explain the sensitivity (elasiticity) of fertilizer demand to change in fertilizer prices and paddy prices which implies the impact of fertilizer subsidy policy on paddy cultivation.

B. Description of Econometric tools used

Several econometric tests were carried out to estimate the fertilizer demand function and to analyse the impact of fertilizer subsidy scheme in paddy cultivation. These methods are explained bellow.

Unit root test

Before estimating the models, it is essential to verify whether the series analysed are stationary or not, and whether there are one or several long run equilibrium relationships between them. If a series is stationary it means, its variance and autocovariences are independent of time. In order to test for unit root to see whether these variables are level stationary (I) or first difference stationary (I (I)), the Augmented Dickey- Fuller (ADF) test is carried out. If a series is found to be (I (I)) then first difference may have to be used in analyzing the relationship.

Regression Test

The natural logarithm values of all the variables were used to estimate fertilizer demand function by using simple linear regression model. The model is as follows:

$$Q_t = f \{ (P_{(f)(t)}), (P_{(p)(t-1)}), (E_{(p)(t)}), (D) \}$$

Q_t – Quantity of fertilizer (mt) used in year *t*

$P_{(f)(t)}$ – Price of Fertilizer (Rs./mt) in year *t*

$P_{(p)(t-1)}$ – Farm Gate price paddy (Rs./mt) in year *t*-1

$E_{(p)(t)}$ – Paddy Extent under Irrigation in year *t*

D – Dummy for policy changes

IV. Results and Discussion

In this section, the data described in section III are illustrated graphically and those data are used to carry out the analysis of the fertilizer demand functions for paddy cultivation in Sri Lanka by using the statistical and econometric methods explained earlier. Fertilizer demand functions were estimated separately for the different fertilizers, and the results discussed separately under each fertilizer.

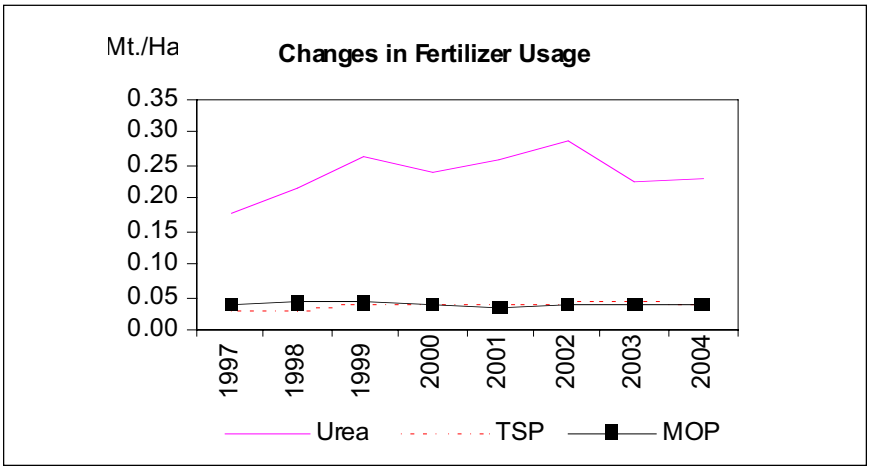
A. General analysis of Fertilizer Subsidy Scheme

Period I – subsidy provided for three main Fertilizers

During the period from 1962 to 1989 the subsidy scheme was continued for all main fertilizers, which provide N, P, K to plants. Since, data are not available from the beginning, data from 1980 to 1989 are used to represent the period.

During the period under review, usage of all three fertilizers increased continuously. However, the ratio between three fertilizers was almost maintained. A remarkable up rise in Urea consumption in 1980 was mainly due to the low level of retail price (Rs.980/mt) prevailed during the year. Fertilizer prices reduced sharply since the government increased its subsidy rate from uniform subsidy of 50 per cent of Cost and Freight (C&F) price of fertilizers to 85 per cent, 75 per cent, 75 per cent of the C&F price of Urea,

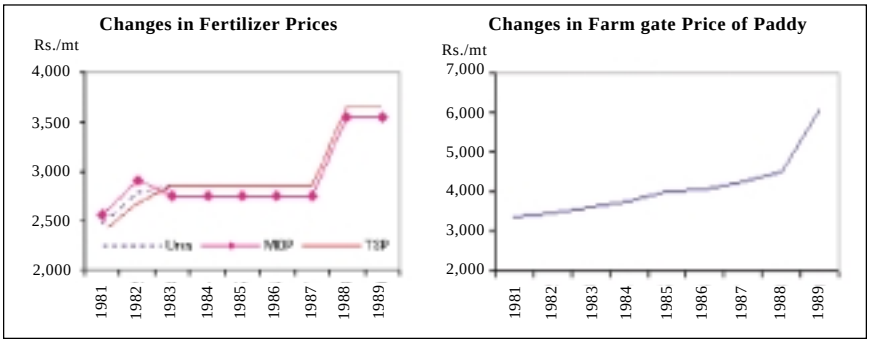
Figure 2 : Changes in Fertilizer Usage in Period I



MOP, TSP respectively. However, in 1981 the world market fertilizer prices increased and its impact was severe with the deterioration of Rs./US$ exchange rate. Hence, the government allowed fertilizer prices to increase by about 30 per cent by rearranging the subsidy components to 65 per cent, 65 per cent and 40 per cent of C&F prices of Urea, MOP and TSP ,respectively.

This resulted in shortfall in fertilizer consumption in paddy cultivation in 1981. Since then until 1984, fertilizer consumption remained almost stable even though with several changes in subsidy components and retail prices. In 1984 while the prices of fertilizer remained stable, farmers enjoyed an increase in the guaranteed price of paddy. As a result fertilizer consumption triggered upward. This trend continued until termination of fertilizer subsidy scheme by the government in 1989.

Figure 3 : Changes in Fertilizer Price and Farm gate Price of Paddy in Period I

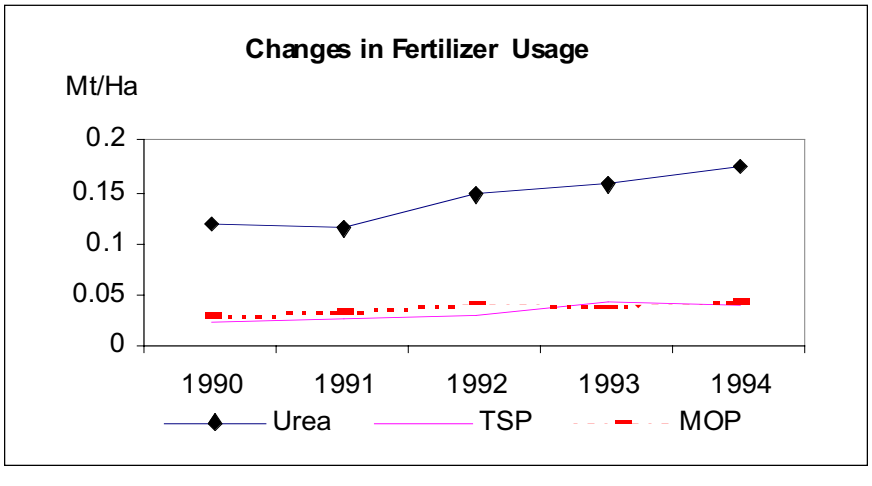


The selling prices of fertilizer during this period is determined by the National Fertilizer Secretariat in consultation with fertilizer whole sellers taking in to consideration the cost of fertilizer and the subsidies made available by the government. Therefore, subsequent to the reduction in the fertilizer subsidies, an increase in the prices of subsidized fertilizers could occur. Accordingly an increase in retail price of fertilizer observed in 1983 due to the reduction of subsidy by around 15 per cent of C&F cost of fertilizer. These fertilizer prices were not revised until 1988. In 1988 there was a sharp escalation in the cost of fertilizer in the international market. Hence it became necessary to increase the local price of fertilizers by reducing subsidy component. Accordingly prices of three major fertilizers increased by around 30 percent in 1988. Increasing trend in paddy prices continued during the period. However, in 1988/89 period, there was a sharp increase in the farm gate price of paddy as the government increased guaranteed price of paddy mainly to cushion farmers from the adverse impact of higher fertilizer prices.

Period II (1990-1994) – Period of Subsidy Removal

Increasing fertilizer prices in the international market with rising oil prices together with depreciation of exchange rate caused considerable difficulties in maintaining the fertilizer prices unchanged during 1989. Hence, the fertilizer subsidy was completely withdrawn by the government with effect from 1 January 1990. With the removal of fertilizer subsidy there was sharp escalation of fertilizer prices from the beginning of 1990. The total use of

Figure 4 : Changes in Fertilizer Usage in Period II



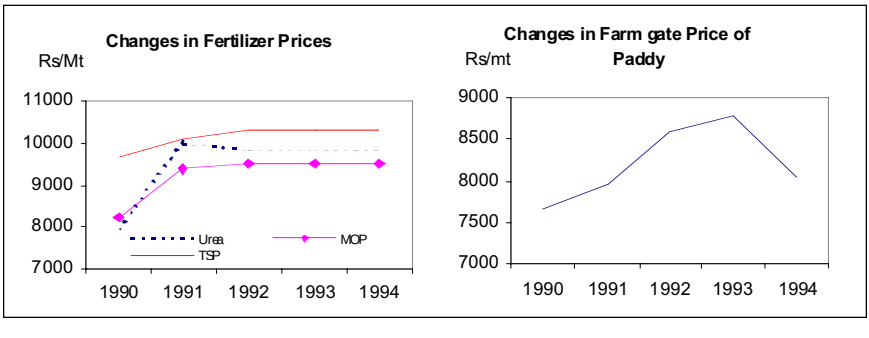
fertilizer declined in 1990, in the wake of increase in fertilizer prices due to the removal of the subsidy. However, the decrease in consumption was not as high as was anticipated. It may well be that in anticipation of a price increase in 1990 after removal of the subsidy farmers stocked their requirement for their crops. Further, with the removal of the subsidy, in order to cushion the adverse impact of sudden price increases of fertilizer, government revised upward the guaranteed price of paddy.

In the years of 1991,1992, and in 1993, the overall consumption of fertilizer increased by 3.5 per cent, 16.0 per cent and 17.0 per cent respectively indicating that most of the farmers were gradually adjusting themselves to the new prices. Furthermore, other scheme such as granting of credit in kind for purchasing of seed and fertilizer under the agricultural trust fund and the favourable farm gate price for paddy were some of the important factors contributed to this improvement.

The sharp increase in fertilizer consumption in 1993 over that of 1992 was mainly due to the increase in area cultivated under paddy during that year which indicates the positive relationship between fertilizer consumption with extent under paddy. Continuing the increasing trend in 1994, the fertilizer usage in paddy sector reached a record level representing around 14 per cent growth over the previous year. Increase in area under paddy around 11 per cent over the previous year and re introduction of fertilizer subsidy in October 1994 were the major factors that contributed to this increase.

Consequent to the removal of fertilizer subsidy, there was about two-fold increase in the prices of all subsidized fertilizers. However, due to the action taken by the government to increase farm gate price of paddy helped farmers to minimize the adverse impact of sudden increase in fertilizer prices. The drastic increase in selling prices of fertilizers were seen in 1991 as several local price revisions were done according to the world market price changes.

Figure 5 : Changes in Fertilizer Prices and Farm gate Price of paddy in Period II



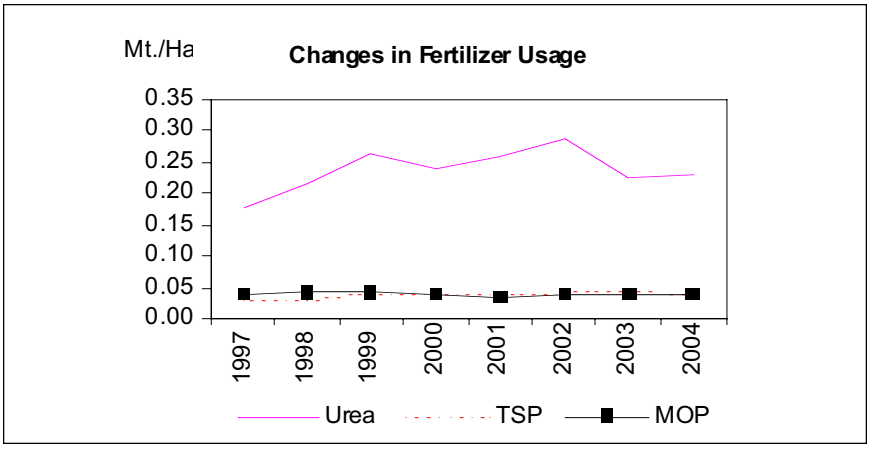
However, during the period 1991 to October 1994, fertilizer prices remained stable. Drastic change in fertilizer prices occurred with the reintroduction of fertilizer subsidy in 10 October 1994 by the new government that came in to power. Accordingly, four main fertilizers were subsidized by about 30 per cent of their retail price.

The increasing trend in farm gate price of paddy that started in 1990 continued until 1993. With the increase in marketable paddy surplus in 1994, the farm gate price of paddy dropped by 13 per cent. However, the drop in paddy prices did not affect fertilizer consumption in 1994 since fertilizer prices were reduced by the reintroduction of fertilizer subsidy during the fourth quarter of the year.

Period III (1997-2004) – Subsidy Provided only for Urea

There was a drastic change in the fertilizer subsidy scheme in October 1997 as it restricted fertilizer subsidy only to urea. The objective of this change was to provide a higher benefit to paddy farmers who were the main users of urea. Past statistics indicate approximately 75 per cent of Urea used in the country was utilized for the paddy sector, which is dominated by small-scale farmers. Therefore, the government decided to confine the subsidy scheme for urea only with a view to pass on the benefits of the scheme to small-scale farmers. The subsidy rates were announced in rupee terms and it was decided to review the subsidy amount on a seasonal basis maintaining the retail price of Urea unchanged during the period. In 2002, the subsidy scheme was revised with increased international prices. Accordingly a fixed sum of subsidy was

Figure 6 : Changes in Fertilizer Usage in Period III



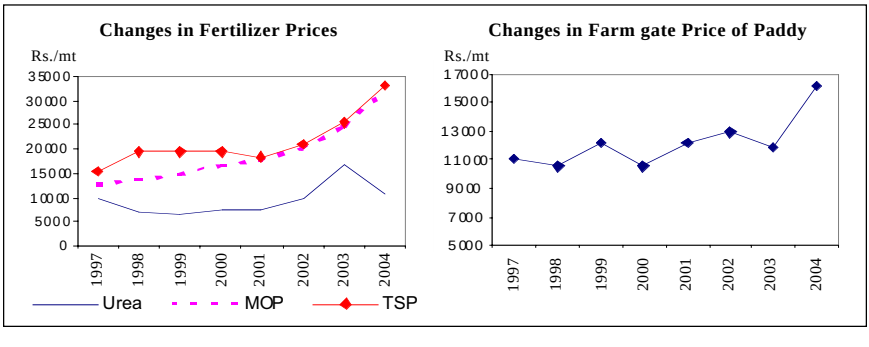
given to urea importers allowing retail prices to be varied according to the world market prices of fertilizer. However, in 2004 the new government came in to power and it was decided to fix retail price of Urea again to avoid severe fluctuations in retail price.

With the commencement of new subsidy scheme in 1997, use of fertilizer for paddy decreased marginally over the previous year. This was entirely due to the reduction in the use of TSP and MOP, since Urea usage increased by 1.6 per cent during the period. Use of fertilizer for paddy recovered in 1998 due to the increase in usage of highly subsidized Urea by 20.6 per cent over that of 1997. However, use of MOP increased marginally while application of TSP decreased over the previous year. In 1999, use of Urea for paddy increased substantially to a record level, indicating that paddy farmers benefited most from the fertilizer subsidy scheme. Use of TSP for paddy too increased in 1999, even though it was not proportionate to maintained the N:P:K ratio in the overall fertilizer use.

In line with the decline in area cultivated in 2000, the total fertilizer use for paddy dropped by 18 per cent. However, it was recovered in 2001 and fertilizer usage for paddy increased by 10.6 per cent despite the drought experienced during the year. This trend continued in 2002 as well. In 2003, use of fertilizer dropped significantly mainly due to the rise in fertilizer prices as a result of the revision of fertilizer subsidy scheme in October 2002 with the increased price in the international market. Under the revised scheme a fixed sum of Rs.6,000 per metric ton was given as a subsidy payment for Urea importers. This scheme was continued until May 2004. The new government reintroduced subsidy scheme with fixed retail price and as a result Urea usage increased slightly over the previous year.

With the introduction of new subsidy scheme in 1997, there were major price revisions during the years. The sale price of Urea was maintained at the

Figure 7 : Changes in Fertilizer Prices and Farm gate Price of paddy in Period III



indicative price under the fertilizer subsidy scheme. Prices of other fertilizers were determined by the market considering the factors such as appreciation of US$, price fluctuations in the international market and freight rates. With the increase demand for Urea owing to the subsidized price there was a stiff competition among sellers and hence the actual price of Urea operated below the indicative price of the government. As a result Urea price came down and remain static until 2002 while prices of other fertilizers moved upward with increase in import prices. In 2002 with the change in fertilizer subsidy scheme annual average price of Urea increased to Rs.9,400 per metric ton in 2002 from Rs.7,000 per metric ton prevailed in 2001. The urea price was further increased in 2003 and reached highest ever retail price of Rs.17,000 per metric ton as at end 2003. However, with the reintroduction of fixed retail price in 2004, the price of urea dropped significantly over that of previous year.

Paddy price, which is mainly determined by the supply conditions, heavily fluctuated during the period. In 1998, with the increased paddy production, the average producer price of paddy declined over the previous year. However, this price remained well above the guaranteed price of paddy. In contrast to the normal behaviour, in 2000 the farm gate price of paddy declined mainly due to rice importation even though the paddy production also dropped. In 2001 the farm gate price increased and maintained at a higher level until 2003. Paddy price dropped in 2003 with the record level harvest and increased again in 2004 with the drop in paddy production due to severe drought prevailed in the country. Fertilizer usage in 2003 was highly affected by the dropped in paddy price and also due to increased fertilizer price under the revised subsidy scheme.

According to the above analyse it reveals that fertilizer usage can be influenced by fertilizer price, producer price of paddy and extent under paddy cultivation. Hence to estimate the sensitivity of these variables to fertilizer usage separate demand functions were employed by using 25 years of data.

B. Estimation of Fertilizer Demand Functions

Demand Function: Urea

Prior to engage in performing econometric analysis, all variables in log form were subjected to Augmented Dicky Fuller (ADF) unit root tests to verify their time series properties. The results were also tested by using Philips Perron (PP) test.

Table 1 : Unit Root Test – Variables in Levels

Variable in levels	ADF	PP
UQ (Urea Usage)	-1.114992	-0.820758
UP (Urea Price)	-1.882988	-1.824195
PP (Paddy Price)	-1.116489	1.681542
EX (Extent)	-1.227110	-0.986910

* Significant at 5% level

Since all the variables were found to be non-stationary on levels, unit root test were carried out on first differences. As indicated below all first difference series were stationary at a very high levels of significance. Therefore, it was concluded that all the series were I(I).

Table 2 : Unit Root Test – Variables in First Difference

Variables in 1st Difference	ADF	PP
UQ1	-4.890511**	-5.319587**
UP1	-5.159817**	-5.214621**
PP1	-5.324109**	-5.359762**
EX1	-5.403066**	7.241751**

** Significant at 1% level

Given that urea usage, urea price, paddy price and extent under irrigation were I(I), simple linear regression analysis was carried out to estimate size and significance of those variables to urea usage. The model used is as follows.

$$\mathbf{Q_t = f\ \{\ (P_{(f)(t)}),\ (P_{(p)(t\text{-}1)}),\ (E_{(p)(t)}),\ (D_1)\ \}}$$

Q_t – Quantity of fertilizer (mt) used in year *t*

$P_{(f)(t)}$ – Price of Fertilizer (Rs./mt) in year *t*

$P_{(p)(t\text{-}1)}$ – Farm Gate price paddy (Rs./mt) in year *t*-1

$E_{(p)(t)}$ – Paddy Extent under Irrigation in year *t*

D_1 – Dummy for policy changes

Table 3 : Results of the regression – Urea

Dependent Variable : UQ1
Method : Least Squares
Sample (adjusted) : 1981–2004
Included observations : 24 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.611588	2.888294	-0.211747	0.8346
UP1	-0.154291	0.087234	-1.768702	0.0930
PP1(-1)	0.330789	0.150557	2.197098	0.0406
EX1	2.532465	0.895402	2.828298	0.0107
DU	0.182554	0.071723	2.545274	0.0198

R-squared	0.913806	Mean dependent var	11.87652
Adjusted R-squared	0.895660	S.D. dependent var	0.287835
S.E. of regression	0.092976	Akaike info criterion	-1.729909
Sum squared resid	0.164245	Schwarz criterion	-1.484481
Log likelihood	25.75891	F-statistic	50.35847
Durbin-Watson stat	1.972436	Prob (F-statistic)	0.000000

Results show that all the selected variables are significant for urea usage with theoretically expected signs. Further, these results indicate that fertilizer demand is inelastic to own price, cross price and policy changes. However, extent under irrigation is highly sensitive to urea usage, which implies that increasing the total area under paddy under irrigation would have a higher impact on the urea application. Previous researches also observed that the input use is higher under irrigated conditions than in rain fed lands in the country.

Inelasticity of urea usage to its own price, cross price and policy changes suggests that unavailability of substitutes for urea encourage farmers to apply urea with out considering price changes. According to the results a one-unit increase in price of a metric ton of urea would reduce annual urea demand for paddy by 0.15 units. If lagged farm gate price increases by one unit per metric ton, urea demand will increase by 0.33 units. This information reveals that fertilizer demand is more sensitive to change in paddy price than to change in fertilizer prices. If fertilizer prices were increased holding paddy prices constant a reduction in urea use would occur.

Demand Function: Muriate of Potash (MOP)

At first all the variables in log form that use to analyse MOP demand function were tested for stationary. The ADF tests showed that all variables are

stationary in first difference, *i.e.*, I(I) and the results were confirmed by Philips Perron tests.

Table 4 : Unit Root Test – Variables in First Difference

Variables in 1st Difference	ADF	PP
MOPQ1 (MOP usage)	-4.164773**	-5.048492**
MOPP1 (MOP price)	-6.095492**	-6.095492**
PP1 (Paddy Price)	-5.324109**	-5.359762**
EX1 (Extent)	-5.403066**	-7.241751**

** Significant at 1% level

A Simple linear regression was carried out to estimate size and significance of those variables to MOP usage. Since there is a tendency to use of urea excessively than other fertilizers due to its lower price, in analyzing MOP demand function, the Urea price is also taken as an independent variable. The model used is as follows.

$$\mathbf{Q_t = f \{ (P_{(f)(t)}), (P_{(p)(t\text{-}1)}), (E_{(p)(t)}), (D_2) \}}$$

Q_t – Quantity of fertilizer (mt) used in year *t*

$P_{(f)(t)}$ – Price of Fertilizer (Rs./mt) in year *t*

$P_{(p)(t-1)}$ – Farm Gate price paddy (Rs./mt) in year *t*-1

$E_{(p)(t)}$ – Paddy Extent under Irrigation in year *t*

D_2 – Dummy for policy changes

Results show that except extent under irrigation all other selected variables are significant for MOP Usage with theoretically expected signs. Similar to the results of the Urea demand function, results of the MOP demand function indicates that MOP demand is inelastic to own price, cross price and policy changes.

Inelasticity of MOP usage to its own price, cross price and policy changes implies that since there are no substitute available for MOP, farmers tend to apply MOP without considering price changes. According to the results, a one-unit increase in price of a metric ton of MOP would reduce its annual demand for paddy by 0.21 units. If lagged farm gate price increases by one unit per metric ton, MOP demand will increase by 0.79 units. These results

Table 5 : Results of the regression – MOP

Dependent Variable : MOPQ1
Method : Least Squares
Sample (adjusted) : 1981–2004
Included observations : 24 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.494407	2.981188	1.507589	0.1481
MOPP1	-0.212730	0.117575	-1.809312	0.0863
PP1(-1)	0.792315	0.235511	3.364243	0.0033
EX1	0.149572	0.978238	0.152900	0.8801
D2	0.248983	0.091279	2.727709	0.0134

R-squared	0.739215	Mean dependent var	10.33500
Adjusted R-squared	0.684313	S.D. dependent var	0.211380
S.E. of regression	0.118766	Akaike info criterion	-1.240272
Sum squared resid	0.268002	Schwarz criterion	-0.994844
Log likelihood	19.88326	F-statistic	13.46425
Durbin-Watson stat	1.337459	Prob (F-statistic)	0.000023

also confirm that the fertilizer demand is more sensitive to change in paddy price than to change in fertilizer prices. Further, in the case of MOP demand, own price and cross price elasticities are relatively higher than in Urea demand.

Demand Function: Triple Super Phosphate (TSP)

Except quantity used and the fertilizer price, all the other variables were similar to the previous estimation. Since the ADF tests confirmed that all variables are stationary in first difference, *i.e.*, I(I), a simple linear regression were carried out to estimate TSP demand function. The Urea price was taken as an independent variable for this analysis too. The Model and variables are given bellow.

$$\mathbf{Q_t = f \{ (P_{(f)(t)}), (P_{(p)(t-1)}), (E_{(p)(t)}), (D_2) \}}$$

Q_t – Quantity of fertilizer (mt) used in year *t*

$P_{(f)(t)}$ – Price of Fertilizer (Rs./mt) in year *t*

$P_{(p)(t-1)}$ – Farm Gate price paddy (Rs./mt) in year *t*-1

$E_{(p)(t)}$ – Paddy Extent under Irrigation in year *t*

D_2 – Dummy for policy changes

Table 6 : Results of the regression – TSP

Dependent Variable : TSPQ1
Method : Least Squares
Sample (adjusted) : 1981–2004
Included observations : 24 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.336310	3.500426	0.381756	0.7069
TSPP1	-0.075420	0.151730	-0.497065	0.6248
EX1	1.365139	1.138181	1.199405	0.2451
PP1(-1)	0.414735	0.290252	1.428878	0.1693
D2	0.273064	0.110374	2.473980	0.0230

R-squared	0.632031	Mean dependent var	10.24918
Adjusted R-squared	0.554564	S.D. dependent var	0.207979
S.E. of regression	0.138807	Akaike info criterion	-0.928408
Sum squared resid	0.366082	Schwarz criterion	-0.682980
Log likelihood	16.14090	F-statistic	8.158690
Durbin-Watson stat	2.058493	Prob (F-statistic)	0.000026

Even though results confirmed theoretically expected signs, most of the variables are not significant for TSP demand. According to the results, changes in fertilizer price, out put price and the cheapest fertilizer price could not influence the TSP demand significantly.

V. Conclusion

Findings in section IV indicate that even though there are some similarities, fertilizer demand functions could vary according to the type of fertilizer. Selected main fertilizers are inelastic to its' own price, output price and policy changes with different significance levels. Therefore, it could be concluded that the fertilizer demand is not significantly affected by changes in own price, output price and related policies in the short run and hence fertilizer subsidy is not a key determinant of fertilizer usage in paddy cultivation. These results were also in line with the findings of related research in other countries. Since the unavailability of substitutes for fertilizer, farmers tend to apply fertilizer with whatever difficulties to ensure the optimum yield levels. However, increase in fertilizer price could reduce farmers' profit since it increases cost of production.

Further, these results also revealed that own price elasticity of demand for fertilizer was smaller than cross price elasticity between demand for

fertilizer and paddy price. Therefore, increasing paddy price would increase demand for fertilizer at a faster rate than when decreasing fertilizer prices. Increasing paddy prices or decreasing fertilizer prices are the alternatives available to the government to provide incentives to the paddy farmers in the short run. Even though increase in output price could play a greater role in this regard, such a policy would spread the farmers' problem over the entire society.

Hence, policy makers should weigh pros and cons of two options available before making a decision. However, a sudden withdrawal of the subsidy will push farmers in low-income groups into worse situation than they were in the past. At least there should be a way to group farmers according to their income levels and to help low income group with subsidies. Therefore, well-targeted subsidy scheme, which is subjected to gradual phase out, is preferred in the short run. The government's decision of restricting fertilizer subsidy only for paddy farmers from 2006 is an important step taken for this direction.

It is also revealed that farmers had not been using correct amount of fertilizer to maintain N:P:K ratio of the field especially during the period III (1997 – 2004) in which only urea was subsidized. This situation should also be corrected through a sound agricultural extension programme. Further, it will reduce cost of production by increasing average yield.

Meanwhile, public expenditure should also be focused on providing infrastructure as well as institutional facilities that are required to improve efficiency in paddy marketing to allow paddy price to be attractive. Once productivity and profitability in paddy cultivation is increased to an acceptable level fertilizer subsidy could be withdrawn completely.

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Appendix 1 : Fertilizer Recommendations for Paddy*

Three months variety	To obtain 100 Bushels per Acre			To obtain 120 Bushels per Acre			To obtain 140 Bushels per Acre		
	Urea Kg/Acre	T.S.P. Kg/Acre	M.O.P. Kg/Acre	Urea Kg/Acre	T.S.P. Kg/Acre	M.O.P. Kg/Acre	Urea Kg/Acre	T.S.P. Kg/Acre	M.O.P. Kg/Acre
Basel Dressing	05	25	15	05	35	15	05	45	15
1st top dressing	35			40			50		
2nd top dressing	50		10	60		15	70		20
Total Requirement	**90**	**25**	**25**	**105**	**35**	**30**	**125**	**45**	**35**

Source: Rice Research Institution, Batalagoda, 2004

* Fertilizer recommendations (Kg/Acre), for three-month paddy variety in Anuradhapura, Polonnaruwa, Moneragala, Hambanthota, Puttlam, Mannar, Vavuniya, Ampara, Kilinochchi, Trincomalee, Batticalo, Kurunegala Districts.

Appendix 2 : Public Expenditure on Fertilizer Subsidy

Year	Expenditure (Rs.mn)	As a Percentage of GDP
1987	600	0.27
1988	347	0.32
1989-1993	–	–
1994	630	0.1
1995	1,345	0.2
1996	1,500	0.2
1997	1,895	0.2
1998	2,152	0.2
1999	1,390	0.1
2000	1,733	0.1
2001	3,650	0.3
2002	2,448	0.2
2003	2,191	0.1
2004	3,572	0.2

Source: Central Bank Annual Reports

Appendix 3 : Annual Average Retail Price of Fertilizer

Rs/Mt

Year	Urea	MOP	TSP	Year	Urea	MOP	TSP
1981	2,463	2,565	2,375	1993	9,850	9,500	10,300
1982	2,785	2,900	2,685	1994	9,850	9,500	10,300
1983	2,850	2,750	2,850	1995	10,200	10,196	11,204
1984	2,850	2,750	2,850	1996	11,000	11,250	12,200
1985	2,850	2,750	2,850	1997	9,400	12,625	15,375
1986	2,850	2,750	2,850	1998	6,800	13,500	19,200
1987	2,850	2,750	2,850	1999	6,300	14,633	19,200
1988	3,650	3,550	3,650	2000	7,000	16,500	19,200
1989	3,650	3,550	3,650	2001	7,000	17,550	18,200
1990	7,900	8,200	9,650	2002	9,450	19,940	21,000
1991	10,000	9,367	10,050	2003	17,000	24,500	25,500
1992	9,850	9,500	10,300	2004	10,740	32,200	33,250

Source: National Fertilizer Secretariat

Appendix 4 : Annual Use of Fertilizer in Paddy Cultivation

000'Mt

Year	Urea	TSP	MOP	Year	Urea	TSP	MOP
1980	116.2	18.3	17.1	1993	136.5	37.7	32.7
1981	94.6	17.7	16.4	1994	161.5	35.2	40.1
1982	97.3	22.2	21.8	1995	157.6	34.6	40.0
1983	97.0	21.8	23.0	1996	147.0	34.8	36.9
1984	112.6	25.1	24.5	1997	149.3	26.8	32.7
1985	125.0	28.0	27.8	1998	180.1	23.7	34.6
1986	139.7	36.3	32.4	1999	234.2	34.1	38.4
1987	133.0	28.8	31.9	2000	193.3	27.1	29.8
1988	131.0	28.6	33.8	2001	214.4	32.9	29.5
1989	139.1	32.0	32.0	2002	270.1	37.2	37.5
1990	99.2	20.5	26.0	2003	201.9	38.2	33.2
1991	98.2	22.8	29.8	2004	222.2	34.8	36.6
1992	118.9	24.2	32.3				

Source: National Fertilizer Secretariat