ESSAYS ON EXTERNAL SHOCKS AND MONETARY POLICY IN THE SRI LANKAN ECONOMY

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Canberra, Australia

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I certify that the content of this thesis is my original work. To the best of my knowledge, it contains no materials previously published by another individual, except where due reference is made in the text of this thesis. Further, this thesis has not previously been submitted for a degree at this or any other university.

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15 December 2016
Dedicated to the ‘wind beneath my wings’:
my parents,
Manjula
and
my precious daughter, Gimna.
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ABSTRACT

The past few decades have been marked with episodes of global economic turbulence that have created macroeconomic instability in both developed and developing economies. With its gradual economic integration with global markets, Sri Lanka is increasingly exposed to unanticipated shocks emanating from foreign economies. This dissertation, comprising of three independent essays, aims to deepen the knowledge on the effects of external shocks, their cross-border transmission channels and appropriate monetary policy responses for the Sri Lankan economy.

External shocks transmitted through trade and financial market linkages have a considerable welfare effect on small open economies such as Sri Lanka. The monetary policy regime of a country plays a vital role in minimizing the social welfare losses arising from external shocks. The first essay of this thesis (Chapter 2) investigates the welfare implications of six alternative monetary policy rules for the Sri Lankan economy using a calibrated DSGE model with nominal rigidities, delayed exchange rate pass-through and financial frictions. The model is solved numerically by taking second-order approximation of the full set of model equations. Domestic goods inflation targeting rule minimizes the welfare losses caused by foreign interest rate and foreign output shocks. Social welfare is lowest under the strict exchange rate targeting rule when the economy is affected by external shocks. This essay demonstrates the importance of taking second-order approximations of the full set of model equations in welfare analysis.

The second essay of this dissertation (Chapter 3) empirically investigates the effects of external shocks on the Sri Lankan economy using a Structural Vector Auto-Regression (SVAR) model with a block exogeneity assumption and long-run and short-run restrictions. This essay examines the impact of foreign monetary policy shocks on the domestic economy using alternative measures: the effective federal funds rate and the US shadow short rate. Although domestic shocks are the primary source of macroeconomic fluctuations in Sri Lanka, foreign shocks also play a considerable role in explaining the variability in output growth and domestic inflation. Shocks to foreign output growth and oil price inflation have a notable effect on the growth of domestic output. Shocks to the effective federal funds rate explain the variance of Sri Lanka’s output growth better than the shocks to the US shadow short rate. Further, the impacts of oil price inflation and the
effective federal funds rate shocks on domestic inflation are noteworthy. The foreign shocks are transmitted to the domestic economy through the trade channel as well as through the financial market channel.

The deteriorating terms of trade in the past two decades has been a concern for the policy-makers of Sri Lanka. The recent literature has argued that the effect of the terms of trade shocks on an economy depends on the characteristics of the underlying shock. Using a sign restricted VAR model, the third essay (Chapter 4) examines the effect on the Sri Lankan economy of external shocks that cause terms of trade fluctuations. Three external shocks, viz., world demand shocks, world supply shocks and globalization shocks are considered in this study. The world demand shocks do not have a significant long-term effect on Sri Lanka’s real output, but the negative world supply shocks are contractionary. Conversely, positive globalization shocks increase domestic output permanently. Both positive world demand shocks and globalization shocks are inflationary while negative world supply shocks increase domestic prices initially but reduce the prices after two quarters. World demand shocks have largely contributed to the fluctuations in trade balance in Sri Lanka since 2007, whereas the importance of globalization shocks on the imports, exports and trade balance has increased since 2010. Contribution from globalization shocks to the variance in domestic output and price levels has increased since 2007.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>TITLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ACKNOWLEDGMENTS</td>
<td>iv</td>
</tr>
<tr>
<td></td>
<td>ABSTRACT</td>
<td>vii</td>
</tr>
</tbody>
</table>

## CHAPTERS

1 INTRODUCTION

1.1 Motivation | 1 |
1.2 Structure of the thesis | 3 |

2 EXTERNAL SHOCKS AND MONETARY POLICY IN SRI LANKA

2.1 Introduction | 6 |
2.2 Model | 13 |
2.2.1 Consumers | 13 |
2.2.2 Firms | 15 |
2.2.3 Inflation, terms of trade and the real exchange rate | 20 |
2.2.4 Monetary authority | 21 |
2.2.5 Foreign country | 21 |
2.2.6 Equilibrium | 22 |
2.2.7 Calibration | 23 |
2.3 Alternative monetary policy rules and external and domestic shocks | 27 |
2.3.1 Domestic productivity shock | 27 |
2.3.2 Foreign interest rate shock | 32 |
2.3.3 Foreign output shock | 33 |
2.3.4 Evaluation of monetary policy rules | 36 |
2.3.5 Robustness analysis | 48 |
2.4 Conclusion | 48 |

Appendix 1.A Graphical representation of the model | 50 |

3 EXTERNAL SHOCKS AND THE SRI LANKAN ECONOMY: A SVAR APPROACH

3.1 Introduction | 51 |
3.2 Methodology | 55 |
3.2.1 SVAR model framework | 55 |
3.2.2 Block exogeneity assumption | 57 |
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>FIGURE</th>
<th>DESCRIPTION</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>External debt of Sri Lanka (2000-2014)</td>
<td>11</td>
</tr>
<tr>
<td>2.2</td>
<td>Quarter on quarter CPI inflation in Sri Lanka</td>
<td>11</td>
</tr>
<tr>
<td>2.3</td>
<td>Dynamic responses of real variables to a negative domestic productivity shock</td>
<td>28</td>
</tr>
<tr>
<td>2.4</td>
<td>Dynamic responses of nominal and financial variables to a negative domestic productivity shock</td>
<td>29</td>
</tr>
<tr>
<td>2.5</td>
<td>Dynamic responses of real variables to a contractionary foreign interest rate shock</td>
<td>30</td>
</tr>
<tr>
<td>2.6</td>
<td>Dynamic responses of nominal and financial variables to a contractionary foreign interest rate shock</td>
<td>31</td>
</tr>
<tr>
<td>2.7</td>
<td>Dynamic responses of real variables to a negative foreign output shock</td>
<td>34</td>
</tr>
<tr>
<td>2.8</td>
<td>Dynamic responses of nominal and financial variables to a negative foreign output shock</td>
<td>35</td>
</tr>
<tr>
<td>2.A.1</td>
<td>DSGE model for Sri Lanka</td>
<td>50</td>
</tr>
<tr>
<td>3.1</td>
<td>Foreign and domestic macroeconomic data (1996Q2 – 2014Q4)</td>
<td>61</td>
</tr>
<tr>
<td>3.2</td>
<td>Impulse responses to a domestic contractionary monetary policy shock (EFFR model)</td>
<td>64</td>
</tr>
<tr>
<td>3.3</td>
<td>Impulse responses to a foreign contractionary monetary policy shock (EFFR model)</td>
<td>65</td>
</tr>
<tr>
<td>3.4</td>
<td>Impulse responses to an oil price shock (EFFR model)</td>
<td>67</td>
</tr>
<tr>
<td>3.5</td>
<td>Impulse responses to a foreign output shock (EFFR model)</td>
<td>70</td>
</tr>
<tr>
<td>3.6</td>
<td>Historical decomposition of domestic output growth (EFFR model)</td>
<td>73</td>
</tr>
<tr>
<td>3.7</td>
<td>Historical decomposition of domestic inflation (EFFR model)</td>
<td>74</td>
</tr>
<tr>
<td>3.8</td>
<td>Quarterly US shadow short rate</td>
<td>76</td>
</tr>
<tr>
<td>3.B.1</td>
<td>Impulse responses to a domestic output growth shock (EFFR model)</td>
<td>81</td>
</tr>
<tr>
<td>3.B.2</td>
<td>Impulse responses to a domestic inflation shock (EFFR model)</td>
<td>82</td>
</tr>
<tr>
<td>3.B.3</td>
<td>Impulse responses to an exchange rate shock (EFFR model)</td>
<td>83</td>
</tr>
<tr>
<td>3.C.1</td>
<td>Historical decomposition of change in the domestic interest rate (EFFR model)</td>
<td>84</td>
</tr>
<tr>
<td>Section</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>------</td>
</tr>
<tr>
<td>3.C.2</td>
<td>Historical decomposition of change in the real effective exchange rate (EFFR model)</td>
<td>85</td>
</tr>
<tr>
<td>3.D.1</td>
<td>Impulse responses to a contractionary monetary policy shock with the Cholesky identification</td>
<td>86</td>
</tr>
<tr>
<td>3.E.1</td>
<td>Impulse responses to an oil inflation shock (SSR model)</td>
<td>87</td>
</tr>
<tr>
<td>3.E.2</td>
<td>Impulse responses to a foreign output growth shock (SSR model)</td>
<td>88</td>
</tr>
<tr>
<td>3.E.3</td>
<td>Impulse responses to a foreign contractionary monetary policy shock (SSR model)</td>
<td>89</td>
</tr>
<tr>
<td>3.E.4</td>
<td>Impulse responses to a domestic output growth shock (SSR model)</td>
<td>90</td>
</tr>
<tr>
<td>3.E.5</td>
<td>Impulse responses to a domestic inflation shock (SSR model)</td>
<td>91</td>
</tr>
<tr>
<td>3.E.6</td>
<td>Impulse responses to domestic contractionary monetary policy shock (SSR model)</td>
<td>92</td>
</tr>
<tr>
<td>3.E.7</td>
<td>Impulse responses to an exchange rate shock (SSR model)</td>
<td>93</td>
</tr>
<tr>
<td>3.F.1</td>
<td>Historical decomposition of domestic output (SRR model)</td>
<td>94</td>
</tr>
<tr>
<td>3.F.2</td>
<td>Historical decomposition of domestic inflation (SRR model)</td>
<td>95</td>
</tr>
<tr>
<td>3.F.3</td>
<td>Historical decomposition of change in the domestic interest rate (SRR model)</td>
<td>96</td>
</tr>
<tr>
<td>3.F.4</td>
<td>Historical decomposition of change in the real effective exchange rate (SRR model)</td>
<td>97</td>
</tr>
<tr>
<td>4.1</td>
<td>Selected macroeconomic variables of Sri Lanka</td>
<td>100</td>
</tr>
<tr>
<td>4.2</td>
<td>Impulse responses of foreign variables to a positive world demand shock</td>
<td>110</td>
</tr>
<tr>
<td>4.3</td>
<td>Impulse responses of foreign variables to a negative world supply shock</td>
<td>111</td>
</tr>
<tr>
<td>4.4</td>
<td>Impulse responses of foreign variables to a positive globalization shock</td>
<td>112</td>
</tr>
<tr>
<td>4.5</td>
<td>Impulse responses of domestic variables to a positive world demand shock</td>
<td>115</td>
</tr>
<tr>
<td>4.6</td>
<td>Impulse responses of domestic variables to a negative world supply shock</td>
<td>116</td>
</tr>
<tr>
<td>4.7</td>
<td>Impulse responses of domestic variables to a positive globalization shock</td>
<td>117</td>
</tr>
<tr>
<td>4.8</td>
<td>Historical decomposition (baseline model)</td>
<td>122</td>
</tr>
</tbody>
</table>
4.9 Impulse responses of the trade related variables to a positive world demand shock ................................................................. 124
4.10 Impulse responses of the trade related variables to a negative world supply shock................................................................. 125
4.11 Impulse responses of the trade related variables to a positive globalization shock................................................................. 126
4.12 Historical decomposition of the trade balance, exports and imports. 128
4.B.1 Export prices................................................................. 135
4.B.2 Import prices................................................................. 135
4.B.3 Foreign output............................................................... 135
4.B.4 Domestic output........................................................... 135
4.B.5 Domestic prices......................................................... 135
4.B.6 Domestic interest rate.................................................... 135
4.B.7 Real effective exchange rate.......................................... 136
4.B.8 Trade balance............................................................. 136
4.B.9 Exports................................................................. 136
4.B.10 Imports................................................................. 136
4.D.1 Impulse responses to a positive world demand shock - VAR (1)..... 138
4.D.2 Impulse responses for to a negative world supply shock - VAR (1).. 139
4.D.3 Impulse responses to a positive globalization shock - VAR (1)...... 140
4.D.4 Impulse responses to a positive world demand shock - VAR (2)..... 141
4.D.5 Impulse responses for to a negative world supply shock - VAR (2).. 142
4.D.6 Impulse responses to a positive globalization shock - VAR (2)...... 143
4.D.7 Impulse responses to a positive world demand shock - VAR (3)..... 144
4.D.8 Impulse responses for to a negative world supply shock - VAR (3).. 145
4.D.9 Impulse responses to a positive globalization shock - VAR (3)...... 146
4.D.10 Impulse responses to a positive world demand shock - VAR (4)..... 147
4.D.11 Impulse responses for to a negative world supply shock - VAR (4).. 148
4.D.12 Impulse responses to a positive globalization shock - VAR (4)...... 149
## LIST OF TABLES

<table>
<thead>
<tr>
<th>TABLE</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>Calibration of the model</td>
</tr>
<tr>
<td>2.2</td>
<td>Mean and standard deviation of the domestic variables under domestic productivity shocks</td>
</tr>
<tr>
<td>2.3</td>
<td>Mean and standard deviation of the domestic variables under foreign interest rate shocks</td>
</tr>
<tr>
<td>2.4</td>
<td>Mean and standard deviation of the domestic variables under negative foreign output shocks</td>
</tr>
<tr>
<td>2.5</td>
<td>Unconditional welfare measures</td>
</tr>
<tr>
<td>2.6</td>
<td>Conditional welfare measures</td>
</tr>
<tr>
<td>3.1</td>
<td>Lag structure of the model</td>
</tr>
<tr>
<td>3.2</td>
<td>Forecast error variance decomposition (EFFR model)</td>
</tr>
<tr>
<td>3.3</td>
<td>Forecast error variance decomposition (SSR model)</td>
</tr>
<tr>
<td>3.A.1</td>
<td>Summary of unit root tests</td>
</tr>
<tr>
<td>4.1</td>
<td>Lag structure of the model</td>
</tr>
<tr>
<td>4.2</td>
<td>Sign-restrictions</td>
</tr>
<tr>
<td>4.3</td>
<td>Forecast error variance decomposition</td>
</tr>
<tr>
<td>4.C.1</td>
<td>Summary of unit root tests</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

1.1 Motivation
During the past few decades, economic shocks originating from unbalanced demand, unanticipated supply-side disturbances and financial market failures have rippled across the global economy numerous times. The ramifications of the global financial crisis in 2007-2009 have been a stark reminder of the economic interdependence of both developed and developing countries. Consequently, policy-makers around the world are becoming increasingly concerned about the uncertain impact of such foreign shocks on their domestic economies. These recent events also call for a thorough examination of appropriate domestic policy responses that strengthen the economic resilience towards possible external shocks.

Small-open economies are inherently vulnerable to foreign shocks due to their inability to influence global markets. In addition, less-developed countries are more susceptible to external shocks due to their domestic structural weaknesses and poor policy responses. There exists a plethora of literature dealing with cross-border transmission of external shocks to small open economies. Part of this literature investigates the impact of foreign shocks on the macroeconomic variables of small open economies and the shock propagation channels (Kim 2001, Canova 2005, Maćkowiak 2007, Dungey and Pagan 2000, Otto 2003, Easterly et al. 1993). Another strand of literature examines the domestic structural characteristics that influence the effect of foreign shocks on small open economies (Loayza and Raddatz, 2007, Broda and Tille 2003, Broda 2004). Yet other work deals with the welfare implications of domestic policy responses of small open economies in relation to external shocks (Devereux et al. 2006, Elekdag and Tchakarov 2007, Kolas and Lombardo 2011, McKibbin and Singh 2003, Schmitt-Grohe and Uribe 2007). Despite the numerous studies pertaining to external shocks and small open economies, the effect of foreign shocks on the South Asian region has been relatively less investigated. Therefore, this dissertation is primarily focusing on investigating the effect of external shocks, their cross-border transmission channels and appropriate monetary policy responses for a small South Asian economy, namely, Sri Lanka.
Sri Lanka’s trade liberalization process was initiated in 1977, ahead of its neighbours, as a response to the dismal economic outcomes of protectionist trade policies. Although Sri Lanka’s trade reforms progressed at a ‘mixed pace’, it remained committed to integrating with global markets during past four decades. Sri Lanka’s international trade was boosted substantially due to the trade reforms but the trade balance continued to be a deficit over the years. Liberalization of both the current and capital account of Sri Lanka also commenced parallel to the trade liberalization process. Although Sri Lanka’s current account was fully liberalized by 1994, policy-makers of Sri Lanka have been more cautious and reluctant in fully liberalizing the capital account. This is not surprising given the country’s perpetual fiscal imbalances and the large external debt stock.

The Central Bank of Sri Lanka adopted a floating exchange rate regime in 2001, but by and large the exchange rate has been tightly managed over the years to avoid potential difficulties in foreign debt servicing due to excessive currency depreciation. Further, the Central Bank of Sri Lanka still follows a monetary aggregate targeting regime. However, Anand et al. (2011) show that the Central Bank gives higher weight to the domestic output growth and lower weight to domestic inflation, which is a sub-optimal monetary policy rule under domestic shocks.

Most of the economic issues faced by the Sri Lankan economy during the past four decades were home-grown, mainly driven by the thirty years long ethnic conflict, political instability and social unrest, weak fiscal and monetary policy, unfavourable weather conditions and natural disasters. Nevertheless, Sri Lanka is becoming increasing exposed to foreign shocks through trade and financial market linkages with the rest of the world. Conversely, the economic policy of Sri Lanka, particularly the monetary policy, may not be geared towards strengthening the country’s resilience to external disturbances. Given this backdrop, the primary objective of this thesis is to deepen our understanding about the impact of external shocks on the Sri Lankan economy, the shock propagation mechanisms and the welfare implications of various monetary policy rules under both foreign and domestic shocks. This dissertation makes empirical and theoretical contributions to the literature pertaining to cross-border shock propagation and monetary policy of small open economies.
1.2 Structure of the thesis

This dissertation consists of five chapters. Chapters 2 to 4 present three self-contained essays. The last chapter concludes, highlighting the policy implications and future research directions.

Chapter 2, titled ‘External shocks and monetary policy in Sri Lanka’ investigates, the role of monetary policy in insulating the domestic economy from both domestic and external shocks. This chapter uses a small open economy Dynamic Stochastic General Equilibrium (DSGE) model with financial frictions, delayed exchange rate pass-through and nominal price rigidities to assess the welfare implications of alternative monetary policy rules. This study compares six monetary policy rules, namely, consumer price inflation targeting, domestic goods inflation targeting, monetary aggregate targeting, nominal income targeting, real income targeting and fixed exchange rate targeting rules. The welfare losses under domestic productivity shocks, foreign interest rate shocks and foreign output shocks are estimated for the six alternative policy rules. The model is calibrated to represent the Sri Lankan economy.

The alternative monetary policy rules are compared and ranked based on the conditional and unconditional welfare of the households, taking second-order approximation of the full set of model equations. Further, the welfare losses under alternative monetary policy rules are decomposed into two parts: the welfare effects of uncertainty on the variance and the welfare effects of uncertainty on the means of the macro-variables. As the effect of uncertainty on the means of the macro-variables have a significant welfare implication, this study highlights the need for taking the second-order approximation of the full set of model equations in welfare analysis.

Chapter 3, titled ‘External shocks and the Sri Lankan economy: a SVAR approach’, examines the effects of three external shocks commonly faced by the Sri Lankan economy and their transmission channels. In this study, Sri Lanka is modelled as a small open economy within a Structural Vector Autoregression (SVAR) framework, using the block exogeneity assumption and short-run and long-run restrictions. This model identification scheme enabled the avoidance of exchange rate puzzle that is common in SVAR literature, especially in the case of Sri Lankan economy models. Three external shocks have been considered in this essay, viz., oil price inflation shock, foreign output shock (represented by US GDP growth) and US monetary policy shock. This study investigates
the effect of US monetary policy using two measures: the Effective Federal Funds Rate (EFFR) and the US Shadow Short Rate (SSR). While the EFFR is the policy rate, the SSR captures the overall monetary policy stance of the Federal Reserves of the US including the unconventional monetary policy measures such as quantitative easing. To the best of my knowledge, this is the first paper that investigates the effect of overall monetary policy stance of the US on the Sri Lankan economy using a SVAR framework.

Chapter 4, titled ‘Terms of trade and the Sri Lankan economy: a sign-restricted VAR approach’, investigates the effect on the Sri Lankan economy of external shocks that cause terms of trade fluctuations. The traditional approach of modelling the terms of trade shocks in the SVAR literature is to incorporate the terms of trade variable directly into the model with the rest of the foreign and domestic variables. However, in the recent literature, such as that contributed by Jääskelä and Smith (2013) and Karagedikli and Price (2012), it has been argued that the fluctuations in the terms of trade are driven by different underlying external shocks. If these underlying shocks are not specified in the VAR model, the reverse causality coming from other foreign variables on the terms of trade variable may not be captured properly. Further, they argue that the effect of terms of trade shocks on the domestic macroeconomy depends on the characteristics of external shocks underlying the terms of trade fluctuations.

Following the approach of Jääskelä and Smith (2013) and Karagedikli and Price (2012), this paper uses a sign-restricted VAR model to investigate the effect on the Sri Lankan macroeconomic variables from the external shocks that cause movements in terms of trade. The terms of trade fluctuations for the Sri Lankan economy are assumed to be driven by world demand shocks, world supply shocks and globalization shocks. To the best of my knowledge, this is the first research paper that applies the sign-restricted VAR methodology for the Sri Lankan economy. Further, the model uses a newly constructed foreign output variable, which represents the output of 13 major trading partners of Sri Lanka. Extending the model of Jääskelä and Smith (2013) and Karagedikli and Price (2012), this essay also investigates the effect of terms of trade fluctuations on the exports, imports and the trade balance of Sri Lanka. The findings of this chapter show that the effects of terms of trade fluctuations on domestic macroeconomic variables depend on the nature of the underlying external shock. The shocks that cause terms of trade movements have a notable impact on domestic output and price levels. The results of this study also show that the managed exchange rate regime of Sri Lanka is less efficient in
insulating the domestic economy compared to the free float exchange rate policy used in Australia and New Zealand.

The last chapter summarizes the findings of the overall thesis and provide policy recommendations and future research directions. Overall, this dissertation shows the importance of foreign shocks to macroeconomic fluctuations in Sri Lanka and the necessity of considering the foreign sector for modelling and forecasting purposes. The findings of this thesis affirm that the existing monetary and exchange rate policies of the Central Bank need to be changed to strengthen the country’s resilience towards external shocks and to improve social welfare.
2.1 Introduction

With increasing globalization, external shocks have become an important source of macroeconomic fluctuations in developing and emerging economies. This is evident from developing countries’ experience in the past few decades, especially during the periods of oil and commodity price escalation and the Asian and global financial crises. Unanticipated macroeconomic fluctuations caused by external shocks can have a considerable welfare effect on developing countries. Within this milieu, the monetary authority of a small open economy needs to consider the welfare effect of external shocks when selecting an appropriate monetary policy regime for the country. Following the example of many developed countries, should the central banks of small open economies allow the exchange rates to float and target inflation? What measure of inflation would best insulate the economy from external shocks? Is an inflation targeting regime harmful for the welfare of economies burdened with foreign currency denominated debt? Is a monetary policy regime geared to target domestic output more welfare-superior than an inflation targeting regime for developing economies? These are some of the questions that many economists still debate (Monacelli, 2005, Devereux et al., 2006, Elekdag & Tchakarov, 2007, Schmitt-Grohe & Uribe, 2004, McKibbin & Singh 2003, Alba et al. 2011, Summer 2011).

While there is an extensive body of literature devoted to investigate the appropriate monetary policy regimes for a small open economy, the consensus among economists over the optimal policies is low. This essay therefore investigates the welfare implications of six alternative monetary policy rules under external and domestic shocks, using a small open economy DSGE model. The model is calibrated with the data for Sri Lanka, a small South Asian economy with a large external debt stock. This model features the monopolistic price setting, financial frictions and delayed exchange rate pass-through to imports. The financial frictions are incorporated in the form of the financial accelerator where capital financing is entirely coming from foreign borrowings. In addition, the country risk premium, which depends on the total borrowings of the economy, amplifies the financial distress of the economy during an external shock.
Many theoretical studies have shown the welfare-superiority of inflation targeting and Taylor-type rules over other monetary policy rules. Using a small open economy DSGE model with staggered-prices, complete exchange rate pass-through and complete financial markets, Gali and Monacelli (2005) show that the domestic inflation-based Taylor rule performs better than the Consumer Price Index (CPI)-based Taylor rule and the exchange rate peg in terms of minimizing social welfare losses. Alba et al. (2011) use a similar model and assert that the Taylor-rule is appropriate for countries with very low import-to-GDP ratio as it simultaneously stabilizes the output and inflation. In contrast, the CPI-based inflation targeting rule is suitable for countries with high import dependency. If the import dependency is very high (i.e., the imports-to-GDP ratio is one or more), exchange rate targeting and CPI-based inflation targeting provide equally better results.

Moving forward, Devereux et al. (2006) assume incomplete exchange rate pass-through and external borrowing constraints in addition to the staggered price setting behaviour in a small open economy. They assert that external financing constraints do not have a significant effect on the ranking of the monetary policy rules, but such constraints magnify the responses of macroeconomic variables to the external shocks. Conversely, the degree of exchange rate pass-through is an important factor affecting the ranking of monetary policy rules. Their findings affirm the results of Gali and Monacelli (2005) and posit that domestic inflation targeting is appropriate for economies with high exchange rate pass-through. But in economies with low-exchange rate pass-through, the prices of both domestic and imported goods adjust slowly, making CPI-based inflation targeting more effective.

However, the governments and central banks of developing countries with an external debt burden are afraid of floating their currency. In a liability-dollarized economy, substantial depreciation of foreign currency can create difficulties in debt servicing. For example, Elekdag and Tchakarov (2007) argue that emerging market economies with foreign currency denominated debt even at moderate levels may benefit from stabilizing their exchange rates. They investigate the welfare implications of fixed and floating exchange rate regimes under various levels of foreign debt, assuming financial accelerator and liability dollarization. They find that the floating exchange rate regime is welfare-superior to the fixed exchange rate regime under perfect capital mobility and liability
dollarization if the debt-to-GDP ratio is low. However, a fixed exchange rate regime can be more welfare-superior than a floating exchange rate regime when the debt-to-GDP ratio exceeds 79 per cent. They claim that a fixed exchange rate regime can outperform the floating exchange rate regime particularly when the shocks are emanating from external sources. Kolasa and Lombardo (2011) also argue that pure inflation targeting can be sub-optimal when the economy has foreign-currency-denominated debt. Moreover, Eichengreen (2002) concludes that conventional inflation targeting will be viable as long as the shocks and the corresponding exchange rate movements are small, and the desire to intervene and stabilize the exchange rate will dominate when they grow large. Further, De Paoli (2009) asserts that for sufficiently large values of inter-temporal elasticity of substitution, the exchange rate targeting rule will outperform the domestic inflation targeting rule in terms of welfare.

On the other hand, some economists favour the concept of nominal income targeting policies (Hall & Mankew 1993, McCallum & Nelson 1999) over inflation targeting. Although many developed and developing countries embraced the inflation targeting regime during the past two decades, the recent global economic crisis has raised questions regarding the welfare-superiority of inflation targeting regimes. The central banks that were adopting the inflation targeting rules were not able to prevent economic downturn as they were solely focusing on inflation management. Hence, the concept of nominal income targeting, which was introduced in 1980s, is now receiving revived interest (Summer 2011). McKibbin and Singh (2003) use the MSG2 model, which is a fully specified dynamic inter-temporal general equilibrium model, to investigate the effective monetary policy regimes for the Indian economy. This study shows that monetary aggregate and nominal output targeting rules are performing better than the inflation targeting rule in terms of stabilizing real output. Hence, nominal income targeting could be an appropriate monetary policy rule for countries that undergo significant structural adjustment. In contrast, Schmitt-Grohe and Uribe (2007) posit that interest rate rules that respond to real output lead to substantial welfare losses.

While there is a growing body of theoretical literature on optimal monetary policy for a small open economy, Anand et al. (2011) investigate appropriate monetary policy regimes for the Sri Lankan economy using a simple new-Keynesian model. The model has been analysed using Bayesian techniques, considering the United States as the relevant foreign sector for Sri Lanka. They claim that the optimal monetary policy rule
has a higher weight on the inflation gap and a lower weight on the output gap than the weights in the empirically estimated model for Sri Lanka. They also assert that an inflation targeting regime would have a more superior performance than would a monetary targeting regime in terms of stabilizing the macro-economic variables. However, Anand et al. (2011) have considered only domestic shocks and have not taken in to account any external shocks.

The Sri Lankan economy is particularly vulnerable to external shocks for a number of reasons. Sri Lanka’s export sector heavily relies on a few products such as garments and textiles, tea, rubber and coconut. Most Sri Lankan exports, especially the agricultural commodities, are low value-added, non-differentiated products. Consequently, Sri Lanka does not have significant market power in relation to its exports and the country’s terms of trade is highly volatile, depending on global market prices. Further, lack of diversification of export destination also intensifies the country’s vulnerability to external shocks. During the past decade, the United States and European Union has accounted for more than half of Sri Lankan exports annually. Hence, a decline in demand in advanced economies has a significant impact on Sri Lanka’s export sector as observed during the recent global financial crisis. Further, Sri Lanka is heavily dependent on petroleum imports for energy. For example, 36.9 per cent of Sri Lanka’s primary energy requirement was met by petroleum products in 2013 (Sri Lanka Sustainable Energy Authority, 2013). Moreover, 25.4 per cent of electricity, which is the main secondary energy source in Sri Lanka, was generated by thermal power using petroleum products during the same year (despite this being a year with a very good rainfall and the highest recorded hydropower generation in the history of Sri Lanka). During 2013, petroleum products accounted for 23 per cent of Sri Lanka’s import costs (Central Bank of Sri Lanka, 2013). Hence, price fluctuations in global energy markets tend to have an impact on the inflation and output of Sri Lanka.

Moreover, Sri Lanka has been recording trade and current account deficits consecutively over the past three decades. The country has been heavily relying on foreign capital inflows to finance this perpetuated trade and current account deficits. During 2014, the foreign debt-to-GDP ratio stood at 59.4 per cent (Central Bank of Sri Lanka, 2014). Foreign debt levels held by the government and the private sectors were 31.8 and 27.6 per cent of GDP, respectively. The total external debt position of Sri Lanka from 2000 to 2014 is illustrated in Figure 2.1. With the high foreign currency denominated debt
stock in the economy, Sri Lanka is vulnerable to a balance of payments crisis in the event of a sudden stop or reversal of foreign capital flows.

**Monetary policy in Sri Lanka**

One of the core objectives of the Central Bank of Sri Lanka (CBSL) is economic and price stability. Although many countries have adopted inflation targeting regimes, the CBSL still adopts a monetary aggregate targeting system to implement its monetary policies. The CBSL uses Reserve Money as the operational target and Broad Money (M2b) as the intermediate target to achieve its price stability objective. The main instruments used by the CBSL for its monetary management are (a) policy rates (i.e., Repurchase and Reverse Repurchase Rates) and open market operations (b) Statutory Reserve Ratio (SRR). Nevertheless, the reliance on SRR as a day-to-day monetary management tool has been gradually reduced by the CBSL to enhancing market orientation of monetary policy and to reduce the implicit cost of funds borne by the commercial banks due to SRR.

As depicted in Figure 2.2, the CBSL has been able to manage the country’s inflation at a single digit level since 2009, which is a great achievement compared to the past. Although the country has never gone through any hyper-inflation periods, inflation rates in Sri Lanka have been relatively high until 2009. Hence, multilateral donor organizations such as the International Monetary Fund (IMF) have suggested that the CBSL adopt an inflation targeting framework to better manage domestic inflation and continue with the current low inflation rates (Anand et al. 2011).

As part of its economic liberalization policies, Sri Lanka abandoned its dual exchange rate regime and adopted a unified exchange rate regime in 1977. Initially, the country adopted a free floating system that was eventually abandoned in 1982 since the CBSL used the exchange rate as a nominal anchor to curb inflation. CBSL tightly managed the exchange rate until 2001 when the country had to move into free float again to prevent a sharp fall in foreign assets. Under the present system, the CBSL refrains from announcing any buying and selling rates for the foreign exchange at the beginning of the day. Further, CBSL regularly intervenes in the foreign exchange.
Figure 2.1  
**External debt of Sri Lanka (2000-2014)**

![Graph showing external debt as a percentage of GDP from 2000 to 2014.](image)

**Source:** Annual Report of Central Bank of Sri Lanka, 2014

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Figure 2.2  
**Quarter on quarter CPI inflation in Sri Lanka**

![Graph showing quarter on quarter CPI inflation from 1990Q1 to 2014Q4.](image)

**Source:** International Financial Statistics Database
market by buying/selling foreign currency at or near market rates in order to prevent any substantial exchange rate movements and to build-up reserves. For countries such as Sri Lanka where financial markets are thin and not well-developed, foreign currency market interventions are necessary to manage the excessive volatility of exchange rates. However, as Anand et al. (2011) point out, the real objective of the CBSL in its foreign exchange market intervention is ambiguous due to a relative lack of transparency of the CBSL. For example, it is difficult for the markets to assess whether CBSL is focusing on excess volatility or on the level of the exchange rate because what is considered as excess volatility is usually not well defined, while the pattern of intervention is not always consistent with volatility developments (Anand et al. 2011). Therefore, on many occasions the IMF has advised the CBSL to limit its foreign exchange market intervention and allow the currency to free float.

Currently, there is a debate over whether Sri Lanka can move in to inflation targeting under existing macroeconomic conditions. According to Perera (2010), the statistical relationship between the operating and final targets of an inflation targeting regime is not sufficiently strong, significant and persistent for the Sri Lankan economy. However, Perera (2010) also claims that such linkages are beginning to emerge in the Sri Lankan economy with economic and financial sector developments. However, the conflict of interest of the CBSL will be an obstacle for Sri Lanka to move in to inflation targeting. At present, the Employees’ Provident Fund, which is the biggest domestic lender to the government, and the public debt management department are under the purview of the CBSL. In that context, CBSL may not be able to credibly commit to an inflation targeting system. Nevertheless, the scope of this essay does not entail the investigation of prerequisites for inflation targeting. Instead, this essay focus on assessing the welfare implications of different monetary policy rules under shocks emanating from external sources.

This chapter focuses on the performance of alternative monetary policy rules in an event of external shocks. The remainder of the chapter is structured as follows. Section 2.2 presents the small open economy model, calibration and data. Section 2.3 explains the simulation results and utility-based welfare assessment using unconditional and conditional welfare measures. The concluding remarks in section 2.4 points out that the domestic goods inflation targeting is best under the foreign interest rate and negative foreign output shocks. Further, CPI inflation targeting and monetary aggregate targeting
rules are next in order in terms of welfare. Strict exchange rate targeting is worst in welfare performance under both types of foreign shocks.

2.2 Model
The model consists of households, final goods producing firms, intermediate capital goods producing firms, entrepreneurs, importers, monetary authority and a foreign economy. The model is graphically presented in Appendix 1.A.

2.2.1 Consumers
The small open economy is populated by a continuum of infinitely lived, utility-maximizing households. The inter-temporal utility function of the households depends positively on consumption \((C_t)\) and real money holdings \((M_t/P_t)\) and negatively on the labour supply \((H_t)\). The utility of households can be defined as below:

\[
U = E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{C_t^{1-\sigma}}{1-\sigma} - H_t^{1+\eta} + \frac{M_t}{P_t} \frac{1-\xi}{1-\xi} \right)
\]  

(2.1)

where \(\beta \in (0,1)\) is the discount factor, \(\sigma, \eta\) and \(\xi\) are the inverse of the elasticity of inter-temporal substitution for consumption, labour and real money balance. \(P_t\) is consumer price index. Households consume a basket of differentiated goods comprising of domestic and imported goods. Composite consumption basket is a CES function defined as follows:

\[
C_t = \left[ \left( a^\frac{1}{\theta} \frac{C_{H,t}}{\lambda} \frac{C_{F,t}}{1-\lambda} \right)^{\theta} + \left( 1-a \right)^{\frac{1}{\theta}} \right]^{\theta/(\theta-1)}
\]  

(2.2)

where \(C_H\) and \(C_F\) denote the domestic and imported goods, respectively. \(\theta\) is the elasticity of substitution between domestic and imported goods and \(\theta > 0\). The share of domestic goods in the household consumption basket is \(a\) and \(a \in (0,1)\). \(C_H\) and \(C_F\) can be defined as

\[
C_{H,t} = \int_0^1 C_{H,t} (j)^{1-\lambda} dj \right]^{1/1-\lambda}
\]  

(2.3)

and

\[
C_{F,t} = \int_0^1 C_{F,t} (j)^{1-\lambda} dj \right]^{1/1-\lambda}
\]  

(2.4)

\(C_H(j)\) and \(C_F(j)\) stand for the consumption of variety \(j\) of domestic and imported goods, respectively. \(\lambda > 1\) is the elasticity of substitution across different varieties goods. The
consumer price index, $P_t$, associated with the composite consumption basket in (2.2) is defined as follows:

$$P_t = \left[ (a)^\frac{1}{\theta - 1/\theta} + (1 - a)^\frac{1}{\theta - 1/\theta} \right]^{\theta/\theta - 1}$$  \hspace{1cm} (2.5)$$

where, $P_H(j)$ and $P_F(j)$ are the prices of individual domestic and imported goods $j$, respectively, in terms of domestic currency. $P_H$ and $P_F$ can be expressed as

$$P_{H,t} = \left[ \int_0^1 P_{H,t} (j)^{1-\lambda} dj \right]^{1/1-\lambda}$$  \hspace{1cm} (2.6)$$

and

$$P_{F,t} = \left[ \int_0^1 P_{F,t} (j)^{1-\lambda} dj \right]^{1/1-\lambda}$$  \hspace{1cm} (2.7)$$

The optimal allocation of expenditure between domestic and imported goods can be expressed as follows:

$$\min_{C_H, C_F} P_tC_t = P_HC_H + P_HC_F \quad \text{s.t}$$

$$C_t = \left[ (1 - a)^\frac{1}{\theta - 1/\theta} + (a)^\frac{1}{\theta - 1/\theta} \right]^{\theta/\theta - 1}$$  \hspace{1cm} (2.8)$$

This optimization problem yields the following demand functions for domestic and imported goods:

$$C_{H,t} = (a) \left( \frac{P_{H,t}}{P_t} \right)^{-\theta} C_t$$  \hspace{1cm} (2.9)$$

$$C_{F,t} = (1 - a) \left( \frac{P_{F,t}}{P_t} \right)^{-\theta} C_t$$  \hspace{1cm} (2.10)$$

The households own the monopolistic firms in the economy and also provide labour to the firms. Hence, households receive income in the form of wage ($W_t$) and profits ($\Pi_t$). The household budget constraint in period $t$ can be written as follows:

$$P_tC_t = W_t H_t + (1 + r_t)B_t - B_{t+1} + M_t - M_{t-1} + S_tD_{t+1}$$

$$- (1 + r_t^*)\Psi_{D,t}S_tD_t + \Pi_t$$  \hspace{1cm} (2.11)$$

where $B_t$ and $D_t$ are the nominal stock of domestic-currency denominated bonds and foreign-currency-denominated debt maturing in period $t$.

The domestic-currency bonds earns a nominal interest rate of $r_t$. In period $t$, households have to spend $(1 + r_t^*)\Psi_{D,t}$ amount as the interest payments on foreign debt. $r_t^*$ is the foreign nominal interest rate. The country risk premium denoted by $\Psi_{D,t}$ depends on the aggregate foreign debt level of the economy. The country risk-premium is assumed to be
a modified version of the country risk premium used by Adolfson et al. (2007). Accordingly,
\[ \Psi_{D,t} = \exp[\psi_D(TD_t - \overline{TD})] \] (2.12)
where \(TD_t\) is the aggregate foreign debt level in the economy, \(\overline{TD}\) is the steady state foreign debt level and \(\psi_D\) is the elasticity of the country risk premium with respect to the aggregate foreign debt level. Further,
\[ TD_t = S_t(D_t + D_{E,t})/P_t \] (2.13)
where \(D_{E,t}\) is the foreign debt stock held by the entrepreneurs in the economy.

The household problem can be written as:
\[
\max_{C_t, H_t, E_t, M_t, D_t} U = E_0 \sum_{t=0}^{\infty} \beta^t \left( C_t^{1-\sigma} - \frac{H_t^{1+\eta}}{1+\eta} + \frac{(M_t/P_t)^{1-\xi}}{1-\xi} \right) \quad \text{s.t.} \\
P_t C_t = W_t H_t + (1 + r_t) B_t - B_{t+1} + M_t - M_{t-1} + S_t D_{t+1} - (1 + r_t^*) \Psi_{D,t} S_t D_t + \Pi_t \] (2.14)

The household optimum can be characterized by the following conditions:
\[
\beta_t E \left( \frac{C_t^{\sigma} P_t}{C_{t+1}^{\sigma} P_{t+1}} \right) = \frac{1}{1+r_{t+1}} \] (2.15)
\[
\beta_t E \left( \frac{C_t^{\sigma} P_t}{C_{t+1}^{\sigma} P_{t+1}} \right) = \frac{1}{\psi_{D,t+1}(1+r_{t+1})} \] (2.16)
\[
W_t = P_t H_t^{\eta} C_t^{\sigma} \] (2.17)
\[
\left( \frac{M_t}{P_t} \right)^{-\xi} = C^{-\sigma} \left( 1 - \frac{1}{1+r_{t+1}} \right) \] (2.18)
Equations (2.15) and (2.16) represent the Euler equations for consumption in relation to domestic and foreign interest rates. The supply of labour is given by equation (2.17) while the money demand is described by equation (2.18).

### 2.2.2 Firms
The economy comprises of four types of firms, namely, final goods producing firms, intermediate capital goods producers, entrepreneurs and importers.

**Final goods producing firms**
There is a continuum of monopolistic firms producing final goods using labour and capital with a Cobb-Douglas type production technology. Following Bernanke et al. (1999), the wholesale firms use labour coming from both households and entrepreneurs.
Therefore, the effective labour of production firm $i$ can be defined as

$$L_t(i) = H_t(i) \Omega H_t^e(i)^{1-\Omega}$$  \hspace{1cm} (2.19)

where $L_t(i)$ is the effective labour of the firm, $H_t(i)$ is the labour employed from households and $H_t^e(i)$ is the employment of entrepreneurial labour.

The production technology function of production firm $i$ can be expressed as

$$Y_t(i) = A_t K_t(i) ^{\alpha} L_t(i)^{1-\alpha}$$  \hspace{1cm} (2.20)

where $A_t$ is the technology parameter, $Y_t(i)$ is the output and $K_t(i)$ is the capital of the firm $i$. $\alpha \in (0,1)$ is capital income share. In this study $A_t$ follows an AR(1) process. Then

$$A_t = \zeta A_{t-1} + (1 - \zeta) A + \epsilon_{A_t}$$  \hspace{1cm} (2.21)

The cost minimization problem of the final goods-producing firms can be given as

$$\text{Min}_{K_t, H_t, H_t^e} \ C = R_t K_t + W_t H_t + W_t^e H_t^e \ \text{ s.t.}$$

$$Y_t = A_t K_t^\alpha (H_t^\Omega H_t^{\Omega(1-\Omega)})^{1-\alpha}$$  \hspace{1cm} (2.22)

where $W_t^e$ is the nominal wage of entrepreneurs and $R_t$ is the nominal rental rate of capital.

The final goods producing firms’ optimum conditions can be expressed as follows:

$$R_t = \text{nm}c_t (\alpha) \frac{Y_t}{K_t}$$  \hspace{1cm} (2.23)

$$W_t = \text{nm}c_t (1-\alpha) \Omega \frac{Y_t}{H_t}$$  \hspace{1cm} (2.24)

$$W_t^e = \text{nm}c_t (1-\alpha) (1-\Omega) \frac{Y_t}{H_t^e}$$  \hspace{1cm} (2.25)

where $\text{nm}c_t$ is the nominal marginal cost.

Following Rotemberg (1982), it is assumed that the final goods-producing firms set their prices as monopolistic competitors and each firm has to incur a small direct cost in the event of price adjustment. Consequently, firms adjust their prices gradually rather than instantaneously in response to a shock to the marginal cost or the demand. The final goods producing firms maximize their expected profits stream using the following discount factor:

$$\Gamma_{t+1} = \left( \frac{p_t c_t^e}{p_{t+1} c_{t+1}^e} \right)^{\beta}$$  \hspace{1cm} (2.26)

where $\Gamma_t$ is the firms discount factor and $\Gamma_0=1$. 

16
Accordingly, production firm \((i)\) maximizes the following objective function:

\[
\begin{align*}
E_0 \sum_{t=0}^{\infty} & \Gamma_t \left\{ P_{H,t}(i) Y_t(i) - nmc_t Y_t(i) - P_t \frac{\Psi_P}{2} \left[ \frac{P_{H,t}(i) - P_{H,t-1}(i)}{P_{H,t}(i)} \right]^2 \right\} \quad \text{s.t.} \\
Y_t(i) &= \left( \frac{P_{H,t}(i)}{P_{H,t}} \right)^{-\lambda} Y_t 
\end{align*}
\]

where \(P_{H,t}(i)\) and \(Y_t(i)\) are the price and the demand for the product of firm \((i)\). Further, \(P_t \frac{\Psi_P}{2} \left[ \frac{P_{H,t}(i) - P_{H,t-1}(i)}{P_{H,t}(i)} \right]^2\) represents the price adjustment cost.

Since all the firms in the economy are identical, the optimal price setting equation can be expressed as

\[
P_{H,t} = \frac{\lambda}{\lambda - 1} nmc_t - \frac{\Psi_P}{\lambda - 1} Y_t \left( \frac{P_{H,t}}{P_{H,t-1}} - 1 \right) + \frac{\psi_P}{\lambda - 1} E_t \left[ \frac{l_{t+1}}{l_t} \frac{P_{t+1}}{P_{H,t}} \left( \frac{P_{H,t+1}}{P_{H,t}} - 1 \right) \right] 
\] (2.28)

when \(\psi_P = 0\), the firms’ price is equal to a mark-up over nominal marginal cost.

**Intermediate capital goods producers**

The role of intermediate capital goods producers is to build new intermediate capital using existing depreciated capital and new investments within a competitive market. The capital producers buy a fraction of the domestic final goods and imported goods to produce the investment goods \(I_t\). The mix of domestic goods and imported goods in the capital producers’ purchases is similar to the household consumption basket. Thus the nominal price of unit of investment is equal to \(P_t\). The composite investment good comprised of domestic and imported goods can be expressed as

\[
I_t = \left[ (a)^{\theta} l_{H,t}^{\theta-1/\theta} + (1 - a)^{\theta} l_{F,t}^{\theta-1/\theta} \right]^{\theta/\theta - 1} 
\] (2.29)

where \(l_{H,t}\) and \(l_{F,t}\) are the domestic goods and foreign goods used in private capital production, respectively. Accordingly,

\[
l_{H,t} = (a) \left( \frac{P_{H,t}}{P_t} \right)^{-\theta} l_t 
\] (2.30)

\[
l_{F,t} = (1 - a) \left( \frac{P_{F,t}}{P_t} \right)^{-\theta} l_t 
\] (2.31)

The capital producers face a nominal quadratic adjustment cost in the following form:

\[
\frac{\psi_P}{2} \left( \frac{l_t}{K_t} - \delta \right)^2
\]
where $\psi_l$ is the degree of capital adjustment cost and $\delta$ is the depreciation rate. Therefore, the production technology of intermediate capital goods producers can be represented as

$$\equiv (I_t, K_t) = \left[ \frac{I_t}{K_t} - \frac{\psi_l}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 \right] K_t$$

(2.32)

Then the evolvement of capital in the economy can be expressed as

$$K_{t+1} = \left[ \frac{I_t}{K_t} - \frac{\psi_l}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 \right] K_t + (1 - \delta)K_t$$

(2.33)

The intermediate capital producers sell their intermediate capital product $K_{t+1}$ to entrepreneurs at the price of $Q_t$. Then, the maximization problem of the capital producers can be written as follows:

$$\max_{I_t} \text{Profit} = Q_t \left( \left[ \frac{I_t}{K_t} - \frac{\psi_l}{2} \left( \frac{I_t}{K_t} - \delta \right)^2 \right] K_t + (1 - \delta)K_t \right)$$

$$- P_t I_t - R_{K}^{U} K$$

(2.34)

where $R_{K}^{U}$ is the nominal rental rate paid by the intermediate capital goods producing firms to entrepreneurs who supply the capital. The aforementioned optimization problem yields

$$Q_t = \frac{P_t}{1 - \psi_l \left( \frac{I_t}{K_t} - \delta \right)}$$

(2.35)

**Entrepreneurs**

Entrepreneurs supply capital to both final goods and intermediate capital producing firms. They also supply entrepreneurial labour to the final goods producing firms. In addition, entrepreneurs purchase intermediate capital goods.

Following Bernanke et al. (1999), it is assumed that entrepreneurs are credit-constrained and never accumulate sufficient funds to finance their capital acquisitions entirely. Each firm has a finite expected horizon and will survive for the next period with the probability of $\nu$. Hence, the expected horizon can be expressed as $1/(1 - \nu)$. For simplicity, it is assumed that firms borrow only from the foreign markets. Hence, their debts are denominated in foreign currency. It is assumed that there is asymmetric information between entrepreneurs and foreign lenders. Hence, borrowings from the foreign markets are subjected to a risk premium, which depends on the entrepreneur’s external-financing-premium ($\Phi$) and the country-specific risk-premium ($\Psi_{D}$).
If $Q_t$ and $N_t$ are the price of capital and entrepreneurs’ net worth, respectively, balance sheet of the entrepreneurs can be expressed as follows:

\[ N_{t+1} = Q_t K_{t+1} - S_t D_{E,t+1} \]  

(2.36)

where $S_t$ is the current period nominal exchange rate and $D_{E,t}$ denotes the entrepreneurs’ foreign debt. Equation (2.36) indicates that entrepreneurs’ net worth is the difference between their assets and liabilities. It also shows that unanticipated depreciation of the exchange rate worsens the net worth of the entrepreneurs.

The external-financing-premium of the entrepreneurs depends on the ratio of the internal and external financing:

\[ \Phi_{t+1} = \left( \frac{Q_t K_{t+1}}{N_{t+1}} \right)^\gamma \]  

(2.37)

where $\gamma$ is the elasticity of external-financing-premium with respect to leverage ratio. It is assumed that entrepreneurs are risk-neutral and would chose $K_{t+1}$ and $D_{E,t+1}$ in such a way to maximize their profits. The optimal financial contract between borrower and foreign lender ensures the expected marginal return on capital is equal to the expected marginal cost of external financing at $t+1$ period.

The expected marginal cost of the external borrowing is a function of the firm’s external borrowing premium, world interest rate, country-specific risk premium and unanticipated swings in the exchange rate:

\[ E_t R_{K,t+1} = \Phi_{t+1} (1 + r_{t+1}^*) \psi_{D,t+1} E_t \left( \frac{S_{t+1}}{S_t} \right) \]  

(2.38)

Entrepreneurs’ expected return on capital has three components: the nominal rental on capital paid by the final goods producing firms, the nominal rental on capital paid by the intermediate capital goods producing firms and the value of undepreciated capital stock. Thus, entrepreneurs’ real return on capital after adjusting for asset price fluctuations can be expressed as follows:

\[ R_{K,t+1} = \frac{R_{t+1}}{Q_t} + \left[ 1 - \delta + \psi_t \left( \frac{l_{t+1}}{K_{t+1}} - \delta \right) \frac{l_{t+1}}{K_{t+1}} - \frac{\psi_t}{2} \left( \frac{l_{t+1}}{K_{t+1}} - \delta \right)^2 \right] \frac{Q_{t+1}}{Q_t} \]  

(2.39)

Further, it is important to describe the evolution of the net worth of the entrepreneurs. Following Bernanke et al. (1999) it is assumed that entrepreneurs supply their entrepreneurial labour inelastically and the entrepreneurial labour can be normalized to
unity. Hence, the entrepreneurs’ net worth at the end of period $t$, $N_{t+1}$ can be expressed as below:

$$N_{t+1} = v \left[ R_{K,t} Q_{t-1} K_t - \left( \Phi_t (1 + r^*_t) \Psi_{D,t} \left( \frac{S_t}{S_{t-1}} \right) (Q_{t-1} K_t - N_t) \right) \right] + W_t^r \tag{2.40}$$

Entrepreneurs who do not survive for the next period will consume their net wealth. Therefore, the consumption of the entrepreneurs can be written as

$$C_{E,t} = \left\{ (1 - v) \left[ R_{K,t} Q_{t-1} K_t - \left( \Phi_t (1 + r^*_t) \Psi_{D,t} \left( \frac{S_t}{S_{t-1}} \right) (Q_{t-1} K_t - N_t) \right) \right] \right\}^{\frac{1}{P_t}} \tag{2.41}$$

**Importers**

Duma (2008) shows that the exchange rate pass-through in the Sri Lankan economy is low due to the existence of administered prices and government subsidies. Therefore, it is assumed that importers are operating in a monopolistically competitive market and there is incomplete exchange rate pass-through economy. Importers also have to incur a small direct cost of price adjustment. The maximization problem of importer $(i)$ can be expressed as

$$E_0 \sum_{t=0}^{\infty} \Pi_t \left\{ P_{F,t}(i) IM_t(i) - S_t P_F^* IM_t(i) - P_t \frac{\psi_{PP}}{2} \left[ \frac{P_{F,t}(i) - P_{F,t-1}(i)}{P_{F,t}(i)} \right]^2 \right\} \text{ s.t.}$$

$$IM_t(i) = \left( \frac{P_{F,t}(i)}{P_{F,t}} \right)^{-\lambda} IM_t \tag{2.42}$$

where $P_{F,t}(i)$ and $IM_t(i)$ are the price of imported goods in domestic currency and the demand for the imported product of importer $(i)$. The term $P_t \frac{\psi_{PP}}{2} \left[ \frac{P_{F,t}(i) - P_{F,t-1}(i)}{P_{F,t}(i)} \right]^2$ denotes the price adjustment cost.

Since all the importing firms are identical, the optimal price setting equation can be written as

$$P_{F,t} = \frac{\lambda}{\lambda - 1} S_t P_F^* - \frac{\psi_{PP}}{\lambda - 1} P_t \frac{P_{F,t}}{IM_t} \left( \frac{P_{F,t}}{P_{F,t-1}} - 1 \right)$$

$$+ \frac{\psi_{PP}}{\lambda - 1} E_t \left[ \frac{\lambda + 1}{\lambda - 1} \frac{P_{F,t+1}}{IM_t} \frac{P_{F,t+1}}{P_{F,t}} \left( \frac{P_{F,t+1}}{P_{F,t}} - 1 \right) \right] \tag{2.43}$$

2.2.3 Inflation, terms of trade and the real exchange rate

There are three types of inflation in the economy: domestic inflation($\pi_{H,t}$), which is stemming from the price setting structure of the final goods producers; imported
inflation($\pi_{F,t}$), which is based on the price setting structure of the importers; and CPI-based inflation ($\pi_t$). The three types of inflation can be defined as follows:

$$\pi_{H,t} = \left(\frac{P_{H,t}}{P_{H,t-1}}\right)$$  \hspace{1cm} (2.44)
$$\pi_{F,t} = \left(\frac{P_{F,t}}{P_{F,t-1}}\right)$$  \hspace{1cm} (2.45)
$$\pi_t = \left(\frac{P_t}{P_{t-1}}\right)$$  \hspace{1cm} (2.46)

The terms of trade (TOT) can be defined as

$$TOT_t = \left(\frac{P_{H,t}^*}{P_t^*}\right)$$  \hspace{1cm} (2.47)

where $P_{H,t}^*$ is the price of domestic goods in the foreign market and $P_t^*$ is the price of foreign goods (i.e. price of imports in foreign currency). Further, the real exchange rate (RER) can be defined through the following relationship:

$$RER_t = \left(\frac{S_t^*}{P_t^*}\right)$$  \hspace{1cm} (2.48)

### 2.2.4 Monetary authority

The monetary authority uses the short term interest rate as the monetary instrument. It is assumed that the monetary authority uses a feedback rule for interest rate on a particular target variable such as CPI inflation relative to target or monetary aggregate relative to the target money stock. The interest rate rule followed by the monetary authority can be written as

$$(1 + r_{t+1}) = \left(\frac{\pi_{H,t}}{\pi_{H}}\right)^{\mu_{\pi_H}} \left(\frac{\pi_t}{\pi}\right)^{\mu_{\pi}} \left(\frac{Y_t}{Y}\right)^{\mu_Y} \left(\frac{P_{H,t}}{P_{H}}\right)^{\mu_{P_{H}}} \left(\frac{S_t}{S}\right)^{\mu_S} \left(\frac{M_t}{M}\right)^{\mu_M} (1 + \bar{r})$$  \hspace{1cm} (2.49)

where $\bar{r}$, $\pi_{H}$, $\pi_H$, $\bar{Y}$, $\bar{P}$, $\bar{S}$ and $\bar{M}$ are the desired level of nominal interest rate, domestic goods inflation, CPI inflation, real output, nominal output, exchange rate and money supply, respectively. The desired level of these variable represent the stochastic steady state. $\mu_{\pi_H}$, $\mu_{\pi}$, $\mu_Y$, $\mu_{P_{H}}$, $\mu_S$ and $\mu_M$ are the weights assigned for the movements in domestic goods price inflation, CPI inflation, real output, nominal output, exchange rate and money supply. For each monetary policy feedback rule, an extreme value is assumed for the relevant coefficient while other coefficients are set to be zero. For example, if the country is following a fixed exchange rate targeting rule, then $\mu_S$ is equal to an extreme value and $\mu_{\pi} = \mu_{\pi_H} = \mu_Y = \mu_{P_{H}} = \mu_S = \mu_M = 0$.

### 2.2.5 Foreign country

The foreign country or the rest of the world is large relative to the domestic economy. Hence, the optimal demand for domestic goods by the foreign country can be written as
where \( Y_t^* = C_t^* \) is the total demand of the foreign country and \( P_{H,t}^* \) is the price of domestic goods in the foreign market. \( a^* \) is the share of foreign goods in the foreign country consumption basket. The elasticity of substitution between domestic and imported goods in the foreign market is \( \theta^* \) and \( \theta^* > 0 \). Domestic exporters operate in a perfectly competitive market and Law of One Price hold for the exports. Hence,

\[
P_{H,t} = S_t P_{H,t}^*
\]

Since home country is a small open economy, price of the domestic goods in the foreign market cannot influence the overall CPI of the foreign country. Therefore, foreign variables are modelled exogenously to the domestic economy. It is assumed that foreign output and foreign interest rate follow an AR(1) process as

\[
Y_t^* = \zeta_Y Y_{t-1}^* + (1 - \zeta_Y^*) Y^* + \varepsilon_{Y^*,t}
\]

\[
r_t^* = \zeta_r r_{t-1}^* + (1 - \zeta_r^*) r^* + \varepsilon_{r^*,t}
\]

where, \( Y^* \) and \( r^* \) are the foreign output and foreign interest rate at the stochastic steady state.

### 2.2.6 Equilibrium

Under the equilibrium condition in the domestic market the aggregate demand for domestic goods can be written as

\[
Y_t = (a) \left( \frac{P_{H,t}}{P_t} \right)^{-\theta} \left( C_t + I_t + C_{E,t} + \frac{\psi_{PH}}{2} \left[ \frac{P_{H,t}(i) - P_{H,t-1}(i)}{P_{H,t}(i)} \right]^2 + \frac{\psi_{PF}}{2} \left[ \frac{P_{F,t}(i) - P_{F,t-1}(i)}{P_{F,t}(i)} \right]^2 \right)
\]

\[
+ C_{H,t}^*
\]

Since the costs of price adjustment for final goods producers and importers are represented in terms of the composite consumption basket, part of these costs must be included in the aggregate demand for domestic goods. Analogously, the demand for imported goods can be defined as

\[
IM_t = (1 - a) \left( \frac{P_{F,t}}{P_t} \right)^{-\theta} \left( C_t + I_t + C_{E,t} + \frac{\psi_{PH}}{2} \left[ \frac{P_{H,t}(i) - P_{H,t-1}(i)}{P_{H,t}(i)} \right]^2 + \frac{\psi_{PF}}{2} \left[ \frac{P_{F,t}(i) - P_{F,t-1}(i)}{P_{F,t}(i)} \right]^2 \right)
\]

\[
+ \frac{\psi_{PF}}{2} \left[ \frac{P_{F,t}(i) - P_{F,t-1}(i)}{P_{F,t}(i)} \right]^2
\]
In the foreign bond market equilibrium
\[ D_{t+1} + D_{E,t+1} = (1 + r_t^*) \Psi_{D,t} D_t + \Phi_t \Psi'_{D,t} (1 + r_t^*) \left( \frac{S_t}{S_{t-1}} \right) D_{E,t} \]
\[-P_{H,t}^* C_{H,t} - IM_t \] (2.56)

The domestic bond market is in equilibrium, implying \( B_t = 0 \). Assuming all households, entrepreneurs and firms behave symmetrically, the stationary rational expectations equilibrium can be expressed as a set of stationary stochastic processes
\[ \{ Y_t, C_t, H_t, M_t, A_t, L_t, I_t, C_{H,t}, C_{E,t}, C_{H,t}, I_{H,t}, I_{E,t}, K_t, IM_t, D_t, D_{E,t}, N_t, W_t, W_{E,t}, P_t, S_t,\]
\[ P_{H,t}, P_{F,t}, Q_t, P_{H,t}^*, r_t, R_{K,t}, Q_t, \text{nmct}_t, r_t^*, Y_t^*, \Psi_{D,t}, \Phi_t, \pi_t, \pi_{H,t}, \pi_{F,t}, TOT_t, RER_t, B_t, TD_t \]
\[ I_{t+1} \}_{t=0}^{\infty} \] that satisfy equations (2.2), (2.5), (2.9), (2.109), (2.12), (2.13), (2.15) - (2.21), (2.23) - (2.26), (2.28) - (2.31), (2.33), (2.35) - (2.41) and (2.43) - (2.56) and the initial condition for \( B_t \). In this model, \( H_t^* \) and \( P_t^* \) are normalized to unity.

2.2.7 Calibration

Model parameterization

The numerical solution of the model is derived through calibration and simulation. The parameter values for the model are summarized in Table 2.1. Most of the parameters are standard and obtained directly from the previous literature while some are calibrated to match the data for the Sri Lankan economy.

As Devereux et al. (2006) and Elekdag and Tchakarov (2007), the inverse of intertemporal elasticity of substitution for consumption and the inverse of elasticity of labour supply are set to 2 and 1, respectively. However, intertemporal elasticity of substitution for real money balance is calibrated to match the Sri Lankan economy. Using quarterly data for 1977 to 2007, Padmasiri and Banda (2014) estimate the elasticity of real money demand with respect to the savings rate to be 0.26. The intertemporal elasticity of substitution for real money balance is set to 0.0039 (or \( \xi = 253 \)) assuming an interest elasticity of money demand of 0.26 and a steady state quarterly nominal interest of 1.52 per cent. Following Devereux et al. (2006), the discount factor \( \beta \) is set at 0.985 implying an annual real interest rate of 6 per cent. This assumption is reasonable, since the real interest rate based on the Average Weighted Lending Rate was 6.5 per cent in the Sri Lankan economy for the period from 2015 to 2016.

The import-to-GDP ratio is used as a proxy for the share of imported goods in domestic consumption, i.e., \((1 - \alpha) \). Since the average import-to-GDP ratio of Sri Lanka was
35.01 per cent for the 2008 to 2014 period, the share of domestic goods in domestic consumption is set at 0.65. Following Alba et al. (2011), the share of labour in production is set at 0.7. Accordingly, $\alpha$ is equal to 0.3. Following Devereux et al. (2006), the share of household labour in effective labour and the quarterly rate of depreciation are set at 0.95 and 0.025, respectively. Consistent with past literature, the elasticity of substitution across different varieties of goods is set at 11, implying a mark-up of 10 per cent for domestic firms and importers. Following Devereux et al. (2006) and Elekdag and Tchakarov (2007), the investment adjustment cost parameter, $\psi$, is set to 12. Further, price adjustment cost parameters for domestic firms and importers (i.e. $\psi_{p_H}$ and $\psi_{F_H}$) are equal to 120.

In line with Schmitt-Grohe and Uribe (2003), the elasticity of country-risk-premium with respect to aggregate foreign debt level is set at 0.000742. Similar studies that used the calibration method have assumed higher leverage ratios for the entrepreneurs, i.e., values such as 2 or 3. Such assumptions lead to substantially high total foreign debt stock in the economy. However, on average, the total foreign debt-to-GDP ratio of Sri Lanka was 56.03 per cent for the 2009 to 2014 period. Moreover, the average level of foreign debt stocks held by the private sector and government sector were 20.93 per cent and 35.10 per cent of the GDP for 2009 to 2014. Hence, a leverage ratio of 2 or 3 is not a reasonable assumption for the Sri Lankan economy. Hence, it is assumed that the entrepreneurs’ foreign debt and household foreign debt at the steady state are 20.9 and 35.1 per cent of the domestic output, respectively.

Further, the steady state external financing premium for entrepreneurs is set at 250 basis points. The average Option-Adjusted Spread for the BofA Merrill Lynch B and Lower Emerging Markets Corporate Plus Index was 10.32 per cent for 1998Q4 to 2015Q1. This implies a quarterly risk-premium of 250 basis points, approximately. Given the steady state debt levels of the households and entrepreneurs and the external financing premium, the model implies the survival rate of entrepreneurs and the elasticity of external financing premium with respect to leverage ratio are 0.95302 and 0.313, respectively. Further, the steady state leverage ratio is 1.082 as per the model implications.

Average annual Sri Lankan exports were USD 9,383 million for 2008 to 2014 period. Further, the average annual GDP of G20 countries was USD 258,329 billion for the same period. Therefore, the share of Sri Lankan goods in foreign consumption (i.e., $(1 - \alpha^*)$)
Table 2.1  
**Calibration of the model**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\sigma$</td>
<td>2</td>
<td>Inverse of intertemporal elasticity of substitution of consumption</td>
</tr>
<tr>
<td>$\eta$</td>
<td>1</td>
<td>Inverse of elasticity of labour supply</td>
</tr>
<tr>
<td>$\xi$</td>
<td>170</td>
<td>Inverse of elasticity of substitution in real money balances</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.98</td>
<td>Quarterly discount factor {quarterly interest rate is [(1/\beta)-1]}</td>
</tr>
<tr>
<td>$\theta$</td>
<td>1.01</td>
<td>Elasticity of substitution between domestic and foreign goods in domestic consumption</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.65</td>
<td>Share of domestic goods in domestic consumption</td>
</tr>
<tr>
<td>$\alpha$</td>
<td>0.3</td>
<td>Share of capital in production</td>
</tr>
<tr>
<td>$\Omega$</td>
<td>0.95</td>
<td>Share of household’s labour in effective labour</td>
</tr>
<tr>
<td>$\delta$</td>
<td>0.025</td>
<td>Quarterly rate of capital depreciation</td>
</tr>
<tr>
<td>$\lambda$</td>
<td>11</td>
<td>Elasticity of substitution across different varieties goods</td>
</tr>
<tr>
<td>$\psi_I$</td>
<td>12</td>
<td>Investment adjustment cost</td>
</tr>
<tr>
<td>$\psi_{PH}$</td>
<td>120</td>
<td>Price adjustment cost of domestic goods</td>
</tr>
<tr>
<td>$\psi_{PF}$</td>
<td>120</td>
<td>Price adjustment cost of imported goods</td>
</tr>
<tr>
<td>$\psi_D$</td>
<td>0.000742</td>
<td>Elasticity of country risk premium with respect to aggregate foreign debt level</td>
</tr>
<tr>
<td>$\nu$</td>
<td>0.95302</td>
<td>Fraction of entrepreneurs surviving in a period</td>
</tr>
<tr>
<td>$\gamma$</td>
<td>0.313</td>
<td>Elasticity of external financing premium with respect to leverage ratio</td>
</tr>
<tr>
<td>$\bar{D}/\bar{Y}$</td>
<td>0.351</td>
<td>Steady-state level of foreign debt held by the households</td>
</tr>
<tr>
<td>$\bar{D}_E/\bar{Y}$</td>
<td>0.209</td>
<td>Steady-state level of foreign debt held by the entrepreneurs</td>
</tr>
<tr>
<td>$\alpha^*$</td>
<td>0.9999</td>
<td>Share of foreign goods in foreign consumption</td>
</tr>
<tr>
<td>$\theta^*$</td>
<td>1.01</td>
<td>Elasticity of substitution between foreign and domestic goods in foreign consumption</td>
</tr>
<tr>
<td>$\zeta_Y^*$</td>
<td>0.82</td>
<td>Persistence of foreign output shock</td>
</tr>
<tr>
<td>$\zeta_R^*$</td>
<td>0.80</td>
<td>Persistence of foreign interest rate shock</td>
</tr>
<tr>
<td>$\zeta_A$</td>
<td>0.58</td>
<td>Persistence of domestic productivity shock</td>
</tr>
<tr>
<td>$\sigma_R$</td>
<td>0.02</td>
<td>Standard deviation of foreign interest rate shock</td>
</tr>
<tr>
<td>$\sigma_Y$</td>
<td>0.01</td>
<td>Standard deviation of foreign output shock</td>
</tr>
<tr>
<td>$\sigma_A$</td>
<td>0.014</td>
<td>Standard deviation of domestic productivity shock</td>
</tr>
</tbody>
</table>
is set at 0.9999. Moreover, the elasticity of substitution between foreign and domestic goods is set at 1.01, which is similar to that of the domestic economy.

The foreign interest rate shock is calibrated with the quarterly US bank prime loan rate data from 1980 to 2014. The monthly interest rate data is converted to quarterly data taking simple 3-month averages. Data is de-trended using the Hodrick-Prescott (HP) method with a smoothing parameter of 1600. The de-trended data is used to estimate equation (2.53) to obtain following parameter estimates: \( \zeta_R^* = 0.80 \) and \( \sigma_R^* = 0.002 \).

For the purpose of calibrating foreign output shocks, quarterly GDP data for G20 countries from 1998 to 2014 is used as a proxy for foreign output. The G20 countries include the majority of main trading partners of Sri Lanka. The raw series is seasonally adjusted, transformed to natural logarithms and de-trended using the HP filter. The de-trended data is used to estimate equation (2.52) and \( \zeta_Y^* = 0.82 \) and \( \sigma_Y^* = 0.0075 \). However, since \( \sigma_Y^* = 0.0075 \) is very small, \( \sigma_Y^* \) is assumed to be 0.01 in this study.

The domestic productivity shock is calibrated using annual total factor productivity data for Sri Lanka from 1960 to 2011. The raw series is seasonally adjusted and de-trended using the HP filter with a smoothing parameter of 100. Using the de-trended data, equation (2.21) is estimated. Accordingly, \( \zeta_A = 0.58 \) and \( \sigma_A = 0.014 \). Although this estimation is done with annual data, \( \zeta_A = 0.58 \) and \( \sigma_A = 0.014 \) can be considered as reasonable values for a quarterly model, since countries such as Sri Lanka are prone to productivity shocks that are more transitory in nature.

**Data Sources**

Data for the Sri Lankan economy are obtained from the Annual Reports of Central Bank of Sri Lanka. The Option-Adjusted Spread for the BofA Merrill Lynch B and Lower Emerging Markets Corporate Plus Index, the US bank prime loan rate data and Sri Lanka’s total factor productivity data series are obtained from the Reserve Bank of St Louis’ FRED database. The GDP data for G20 countries is obtained from the OECD iLibrary database.
2.3 Alternative monetary policy rules and external and domestic shocks

The model is solved numerically by taking a second-order approximation around the non-stochastic steady state of the model using Dynare 4.3.3. The second-order approximation approach yields correct ranking of alternative policy rules and this approach has been used in numerous analyses of optimal policy (Devereux et al. 2006, Schmitt-Grohe and Uribe 2007 and Elekdag and Tchakarov 2007).

Simulation results, including welfare estimates, are reported and discussed in this section. The impulse responses of several domestic variables to domestic and foreign shocks under alternative monetary policy rules are illustrated in Figures 2.3 to 2.8. Two foreign shocks, namely, foreign interest rate shock and foreign output shock, are considered in this essay. Further, the performance of monetary policy rules under domestic productivity shock is also investigated. Dynamic responses of several real variables (i.e., real output, absorption, trade balance, exports, terms of trade and labour) and financial and nominal variables (i.e., nominal and real interest rates, nominal and real exchange rates, CPI inflation and domestic goods inflation) are presented in these figures.

Six alternative monetary policy rules considered in this essay are abbreviated as follows: CPI targeting rule (CPIT), domestic goods inflation targeting rule (DGPIT), monetary aggregate targeting rule (MT), nominal output targeting rule (NYT), real output targeting rule (RYT) and fixed exchange rate targeting rule (FXT).

2.3.1 Domestic productivity shocks

Figures 2.3 and 2.4 illustrate the dynamic responses of domestic variables to a one standard deviation negative productivity shock under alternative monetary policy regimes. A clear trade-off between output stability and inflation management can be observed during a productivity shock. An unexpected decline in domestic productivity tends to increase the demand for labour and raises wages, particularly under RYT, NYT and FXT rules. The monetary authority will raise the domestic interest rates to curb the potential inflation, particularly under the CPIT and DGPIT rules. The increased interest rates rein in inflation under the inflation targeting rules but at the expense of output stability. The instability in output is derived from both absorption and exports sectors. The increase in nominal interest rate appreciates the domestic currency and the exports
Figure 2.3  Dynamic responses of real variables to a negative domestic productivity shock

Note: All variables are reported as percentage deviations from their stochastic steady state. Trade balance was defined as Exports/Imports.
Figure 2.4  Dynamic responses of nominal and financial variables to a negative domestic productivity shock

Note: Nominal and real interest rate, CPI and domestic goods inflation are expressed as percentage point deviation from their stochastic steady state. All other variables are reported as percentage deviations from their stochastic steady state.
Figure 2.5  Dynamic responses of real variables to a contractionary foreign interest rate shock

Note: All variables are reported as percentage deviations from their stochastic steady state. Trade balance was defined as Exports/Imports.
Figure 2.6  Dynamic responses of nominal and financial variables to a contractionary foreign interest rate shock

Note: Nominal and real interest rate, CPI and domestic goods inflation are expressed as percentage point deviation from their stochastic steady state. All other variables are reported as percentage deviations from their stochastic steady state.
become less competitive in the foreign markets. Consequently, exports decline leading to a deterioration of trade. The monetary authority that adopts the NYT rule does not raise interest rates considerably as with the inflation targeting rules. Therefore, output is more stable with the NYT rule relative to the inflation targeting rules, though the inflation is not tightly managed.

Output is more stable under the RYT and FXT rules when the economy is hit by a productivity shock. However, the RYT and FXT rules report the highest inflation rates with a shock to domestic supply. Also, there is substantial fluctuation in financial and trade related variables with the RYT rule indicating an overall instability condition in the economy.

2.3.2 Foreign interest rate shock

Figures 2.5 and 2.6 depict the impulse responses of domestic variables to a one standard deviation increase in the foreign interest rate (i.e., 20 basis points) under six alternative monetary policy rules. The unanticipated increase in the cost of foreign borrowings results in a decrease in consumption and investment leading to a decline in domestic absorption. This decline is more prominent under the FXT rule, as it is necessary to raise the nominal interest rate (and the real interest rate) sharply to uphold the nominal exchange rate. With the increase in foreign interest rate, the nominal exchange rate depreciates instantaneously and gradually appreciates thereafter under all flexible exchange rate monetary policy rules. Consequently, domestic goods become more competitive in foreign markets leading to an expansion in exports. Even under the FXT rule, the exports increase to some extent due to the reduction in cost of production. The sharp decline in absorption leads to a fall in demand for domestic goods under the fixed exchange rate regime. As a result, labour employment decreases while reducing wages and the cost of production.

The effect of a contractionary foreign interest rate shock on domestic output essentially depends on the monetary policy rule adopted in the economy. While real output does not change under the RYT rule, the output expands with the CPIT, DGPIT, NYT and MT rules. Under these policy rules, export expansion out-weighs the reduction in absorption. In contrast, the increase in exports is not sufficient to offset the negative effect on absorption under the FXT rule leading to a sharp decrease in real output.
On the other hand, the CPIT, DGPIT and MT rules are better at managing CPI inflation compared to the output targeting rules and the FXT rule. With the delayed exchange rate pass-through in the economy, the DGPIT and CPIT rules perform equally in managing CPI inflation. Under the FXT and output targeting rules, CPI inflation declines initially as a response to a fall in domestic goods prices. However, inflation increases subsequently due to the gradual decrease in domestic interest rates. This effect is more pronounced under the FXT rule compared to output targeting rules.

Under the five flexible exchange rate rules, output is stabilized by cushioning the effect of foreign interest rate on domestic interest rates. The initial depreciation of the nominal exchange rate dampens the rise in domestic nominal interest rates. The real interest rate also does not increase as much as the foreign interest rate. This is because the real exchange rate is expected to appreciate subsequent to the instantaneous currency depreciation. The negative effect of foreign interest rate shocks on domestic consumption and investment is moderated to a greater extent by the smaller rise in domestic interest rates.

From a qualitative point of view, the CPIT, DGPIT and MT rules outperform the other three rules in managing inflation without jeopardizing output in the event of a foreign interest rate shock. Out of the two output targeting rules, the NYT is better than the RYT rule in managing the inflation and output. However, the FXT rule is least preferred to other monetary policy rules under a foreign interest rate shock due to the notable negative effect on real output and high inflation.

### 2.3.3 Foreign output shocks
Dynamic responses of the domestic variables to a one standard deviation negative foreign output shock are illustrated in Figures 2.7 and 2.8. A negative foreign output shock reduces the demand for local exports leading to a contraction in the export sector. In such a situation, the monetary authority will cut the nominal interest rates under flexible monetary policy rules for different underlying reasons. For example, the central bank reduces the interest rates substantially to prevent potential output contraction under NYT and RYT rules. A decline in domestic output can result in unemployment and a reduction in wages. Hence, a foreign output contraction can cause disinflation in the domestic economy. Therefore, the central bank is compelled to reduce domestic interest rates under the CPIT and DGPIT rules to curb the disinflation. On the other hand, with a negative...
Figure 2.7  Dynamic responses of real variables to a negative foreign output shock

Note: All variables are reported as percentage deviations from their stochastic steady state. Trade balance was defined as Exports/Imports.
Figure 2.8  Dynamic responses of nominal and financial variables to a negative foreign output shock

Note: Nominal and real interest rate, CPI and domestic goods inflation are expressed as percentage point deviation from their stochastic steady state. All other variables are reported as percentage deviations from their stochastic steady state.
foreign output shock, the monetary authority will reduce the nominal interest rates to uphold money demand in the economy through increased consumption. Despite the different underlying reasons, the reduction in nominal interest rates under flexible exchange rate rules boosts domestic consumption and investment. Therefore, the effect on domestic output on negative foreign output shock is mitigated to some extent by the increased absorption. As in the case of foreign interest rate shock, output stability is highest under the RYT rule followed by the NYT, DGPIT, CPIT and MT rules, in the given order. Output stability is lowest under the FXT rule since the central bank is unable to lower the interest rate without depreciating the domestic currency.

Further, the FXT rule performs poorly in terms of inflation management as well since the central bank does not react directly to a foreign output shock. A clear trade-off between output stabilization and inflation management can be observed under the two output targeting rules. This is because the central bank lowers the nominal interest rates significantly under RYT and NYT rules to boost domestic absorption to prevent a contraction in real or nominal output. The result is inflation in CPI and domestic goods prices. On the other hand, the DGPIT, CPIT and MT rules are superior at managing inflation though there is some level of output contraction.

2.3.4 Evaluation of monetary policy rules
This section presents the overall performance of alternative monetary policy rules in terms of social welfare. For this purpose, it is assumed that the small open economy is affected by a domestic productivity shock, a foreign interest rate shock and a foreign output shock separately. Tables 2.2, 2.3 and 2.4 provide the means of several domestic real variables and the standard deviations of several real and nominal variables under external shocks.

Predictably, the variability in real output and inflation are lowest under the RYT rule and the CPIT rule, respectively. Since certain monetary policy rules are inherently superior at stabilizing real output and inflation, standard deviations per se may not provide a fair comparison of the alternative monetary policy rules. Therefore, monetary policy rules are compared by considering the expected utility in the economy and the consumption equivalent welfare measure.
Welfare-based evaluation of alternative monetary policy rules

As Schmitt-Grohe and Uribe (2004) point out, the standard method of log-linearization of model equations implies that linear approximations to the unconditional means of endogenous variables coincide with their non-stochastic steady state values. Therefore, log-linearization method only picks up the variability of social welfare through the fact that individuals prefer lower variability in consumption, leisure and real money balances. However, the unconditional means of endogenous variables can be significantly different from the deterministic steady state value. Thus, the first order perturbation method cannot meaningfully address a range of issues, such as welfare evaluations and risk premia in a stochastic world.

On the other hand, the second-order approximation of the full set of model equations captures the effect of uncertainty on the average levels of the endogenous variables. Thus, social welfare estimated through the second-order approximation of the full set of model equations encompasses the variance of the uncertain consumption, leisure and real money balances and the effect of uncertainty on the means of these variables. Hence, the second-order approximation provides the correct welfare ranking of monetary policy rules than the log-linearization method Schmitt-Grohe and Uribe (2004). Therefore, model equations are solved numerically up to a second-order approximation to obtain the social welfare of the households in the economy.

Many researchers have compared the welfare loss pertaining to a policy using unconditional welfare (Bergin et al. 2007, Elekdag & Tchakarov 2007, Kollmann 2002). Following past literature, the unconditional welfare loss is computed for each monetary policy rule in this essay. However, Kim et al. (2008) emphasize that it takes time for one steady state to reach another steady state and unconditional welfare neglects the welfare effects during this transitional period leading to nonsensical results in welfare ranking. Kim and Kim (2003) use a two-country DSGE model and compute risk sharing gains from autarky to complete market economy using the second-order approximation method. When welfare is defined as conditional welfare, they show a positive welfare gain from moving from an autarky to a complete market economy. However, for certain parameter values, the unconditional welfare measure can produce paradoxical results by giving higher welfare under the autarky than under the complete market economy (Kim and Kim 2003). Therefore, conditional welfare, which encompasses the transition dynamics
Table 2.2    Mean and standard deviation of the domestic variables under domestic productivity shocks

<table>
<thead>
<tr>
<th></th>
<th>DGPIT</th>
<th>CPIT</th>
<th>MT</th>
<th>NYT</th>
<th>RYT</th>
<th>FXT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means</strong> a</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Output</td>
<td>-0.0813</td>
<td>-0.0688</td>
<td>-0.0517</td>
<td>0.0545</td>
<td>-0.0002</td>
<td>0.0730</td>
</tr>
<tr>
<td>Consumption</td>
<td>-0.0307</td>
<td>-0.0452</td>
<td>-0.0460</td>
<td>-0.1431</td>
<td>-0.3636</td>
<td>-0.1670</td>
</tr>
<tr>
<td>Investment</td>
<td>-0.1115</td>
<td>-0.1024</td>
<td>-0.0373</td>
<td>0.0659</td>
<td>0.3574</td>
<td>0.0680</td>
</tr>
<tr>
<td>Labour</td>
<td>0.0072</td>
<td>0.0240</td>
<td>0.0359</td>
<td>0.1580</td>
<td>0.2408</td>
<td>0.1828</td>
</tr>
<tr>
<td>Capital</td>
<td>-0.0430</td>
<td>-0.0386</td>
<td>-0.0083</td>
<td>0.0750</td>
<td>-0.2912</td>
<td>0.0820</td>
</tr>
<tr>
<td>Household debt</td>
<td>-1.1777</td>
<td>0.2014</td>
<td>0.3911</td>
<td>1.1650</td>
<td>6.1592</td>
<td>1.4735</td>
</tr>
<tr>
<td>Entrepreneurs’ debt</td>
<td>-0.5014</td>
<td>-0.5285</td>
<td>-0.6562</td>
<td>-0.8985</td>
<td>0.5754</td>
<td>-0.9135</td>
</tr>
<tr>
<td><strong>Standard Deviations</strong> b</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Output</td>
<td>1.6331</td>
<td>1.5855</td>
<td>1.2700</td>
<td>0.6015</td>
<td>0.0030</td>
<td>0.5610</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.9865</td>
<td>0.9664</td>
<td>0.8075</td>
<td>0.4413</td>
<td>0.5754</td>
<td>0.3924</td>
</tr>
<tr>
<td>Investment</td>
<td>4.4571</td>
<td>4.2971</td>
<td>2.8561</td>
<td>1.4722</td>
<td>4.6785</td>
<td>1.9310</td>
</tr>
<tr>
<td>Labour</td>
<td>0.2098</td>
<td>0.2820</td>
<td>0.7779</td>
<td>1.8754</td>
<td>2.5408</td>
<td>5.8492</td>
</tr>
<tr>
<td>Capital</td>
<td>0.4849</td>
<td>0.4342</td>
<td>0.3054</td>
<td>0.5437</td>
<td>0.8136</td>
<td>0.6402</td>
</tr>
<tr>
<td>Household debt</td>
<td>8.0148</td>
<td>5.0520</td>
<td>3.0287</td>
<td>6.4912</td>
<td>24.1468</td>
<td>8.5441</td>
</tr>
<tr>
<td>Entrepreneurs’ debt</td>
<td>3.3468</td>
<td>3.5425</td>
<td>4.7316</td>
<td>7.5619</td>
<td>7.0921</td>
<td>7.9489</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.0148</td>
<td>0.0000</td>
<td>0.0833</td>
<td>0.2999</td>
<td>0.5520</td>
<td>0.3261</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>2.5774</td>
<td>2.4564</td>
<td>2.0476</td>
<td>1.0377</td>
<td>1.7454</td>
<td>0.8680</td>
</tr>
<tr>
<td>Real Interest Rate</td>
<td>0.7749</td>
<td>0.7661</td>
<td>0.4855</td>
<td>0.3373</td>
<td>0.5519</td>
<td>0.3311</td>
</tr>
</tbody>
</table>

a Percentage deviation of stochastic steady state from the deterministic steady state.

b Standard deviation of Real output, Consumption, Investment, Labour, Capital, Household debt and Entrepreneurs’ debt refer to the standard deviations of $\tilde{Y}_t$, $\tilde{C}_t$, $\tilde{I}_t$, $\tilde{H}_t$, $\tilde{K}_t$, $\tilde{D}_t$ and $\tilde{D}_E$. All remaining are the standard deviations of the respective variables. All standard deviations have been multiplied by 100.
### Table 2.3  
Mean and standard deviation of the domestic variables under foreign interest rate shocks

<table>
<thead>
<tr>
<th></th>
<th>DGPIT</th>
<th>CPIT</th>
<th>MT</th>
<th>NYT</th>
<th>RYT</th>
<th>FXT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means</strong> (^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Output</td>
<td>-0.0377</td>
<td>-0.0355</td>
<td>-0.0354</td>
<td>-0.0332</td>
<td>0.0000</td>
<td>-0.0159</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.0584</td>
<td>0.0549</td>
<td>0.0548</td>
<td>0.0520</td>
<td>0.0342</td>
<td>0.0265</td>
</tr>
<tr>
<td>Investment</td>
<td>0.0009</td>
<td>0.0003</td>
<td>0.0007</td>
<td>-0.0025</td>
<td>0.0252</td>
<td>-0.0290</td>
</tr>
<tr>
<td>Labour</td>
<td>-0.0573</td>
<td>-0.0538</td>
<td>-0.0538</td>
<td>-0.0501</td>
<td>-0.0167</td>
<td>-0.0229</td>
</tr>
<tr>
<td>Capital</td>
<td>0.0015</td>
<td>0.0009</td>
<td>0.0011</td>
<td>0.0003</td>
<td>0.0362</td>
<td>-0.0020</td>
</tr>
<tr>
<td>Household debt</td>
<td>-5.5194</td>
<td>-5.1120</td>
<td>-5.1276</td>
<td>-4.8400</td>
<td>-5.1606</td>
<td>-4.4067</td>
</tr>
<tr>
<td>Entrepreneurs’ debt</td>
<td>0.0775</td>
<td>0.0755</td>
<td>0.0672</td>
<td>0.1109</td>
<td>0.0660</td>
<td>0.2884</td>
</tr>
<tr>
<td><strong>Standard Deviations</strong> (^b)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Output</td>
<td>0.1869</td>
<td>0.1699</td>
<td>0.1853</td>
<td>0.0939</td>
<td>0.0000</td>
<td>0.3544</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.2567</td>
<td>0.2559</td>
<td>0.2500</td>
<td>0.2938</td>
<td>0.3876</td>
<td>0.4710</td>
</tr>
<tr>
<td>Investment</td>
<td>0.5891</td>
<td>0.6556</td>
<td>0.5758</td>
<td>1.1372</td>
<td>1.8187</td>
<td>3.0368</td>
</tr>
<tr>
<td>Labour</td>
<td>0.3126</td>
<td>0.2850</td>
<td>0.3038</td>
<td>0.1966</td>
<td>0.1604</td>
<td>0.5186</td>
</tr>
<tr>
<td>Capital</td>
<td>0.1431</td>
<td>0.1726</td>
<td>0.1599</td>
<td>0.2571</td>
<td>0.3536</td>
<td>0.5812</td>
</tr>
<tr>
<td>Household debt</td>
<td>6.3707</td>
<td>4.5250</td>
<td>4.7807</td>
<td>2.8667</td>
<td>4.8501</td>
<td>2.6620</td>
</tr>
<tr>
<td>Entrepreneurs’ debt</td>
<td>0.8486</td>
<td>0.7853</td>
<td>0.8377</td>
<td>0.5403</td>
<td>0.5812</td>
<td>1.1990</td>
</tr>
<tr>
<td>Inflation</td>
<td>0.0076</td>
<td>0.0000</td>
<td>0.0050</td>
<td>0.0309</td>
<td>0.0918</td>
<td>0.1457</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>1.2230</td>
<td>1.1661</td>
<td>1.1912</td>
<td>1.0083</td>
<td>0.8928</td>
<td>0.4772</td>
</tr>
<tr>
<td>Real Interest Rate</td>
<td>0.0529</td>
<td>0.0522</td>
<td>0.0452</td>
<td>0.0861</td>
<td>0.1071</td>
<td>0.2967</td>
</tr>
</tbody>
</table>

\(^a\) Percentage deviation of stochastic steady state from the deterministic steady state.

\(^b\) Standard deviation of Real output, Consumption, Investment, Labour, Capital, Household debt and Entrepreneurs’ debt refer to the standard deviations of \(\hat{Y}_t\), \(\hat{C}_t\), \(\hat{I}_t\), \(\hat{K}_t\), \(\hat{H}_t\) and \(\hat{D}_E\). All remaining are the standard deviations of the respective variables. All standard deviations have been multiplied by 100.
## Table 2.4  
Mean and standard deviation of the domestic variables under negative foreign output shocks

<table>
<thead>
<tr>
<th></th>
<th>DGPIT</th>
<th>CPIT</th>
<th>MT</th>
<th>NYT</th>
<th>RYT</th>
<th>FXT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Means</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Output</td>
<td>-0.0075</td>
<td>-0.0069</td>
<td>-0.0070</td>
<td>-0.0055</td>
<td>0.0000</td>
<td>0.0040</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.0091</td>
<td>0.0069</td>
<td>0.0067</td>
<td>0.0054</td>
<td>-0.0109</td>
<td>-0.0145</td>
</tr>
<tr>
<td>Investment</td>
<td>-0.0029</td>
<td>-0.0045</td>
<td>-0.0047</td>
<td>-0.0061</td>
<td>-0.0264</td>
<td>-0.0171</td>
</tr>
<tr>
<td>Labour</td>
<td>-0.0102</td>
<td>-0.0087</td>
<td>-0.5354</td>
<td>-0.0028</td>
<td>0.0050</td>
<td>0.0101</td>
</tr>
<tr>
<td>Capital</td>
<td>-0.0023</td>
<td>-0.0038</td>
<td>-0.0043</td>
<td>-0.0028</td>
<td>-0.0117</td>
<td>-0.0090</td>
</tr>
<tr>
<td>Household debt</td>
<td>-8.5709</td>
<td>-6.1195</td>
<td>-6.0666</td>
<td>-5.4521</td>
<td>-2.3824</td>
<td>-2.1402</td>
</tr>
<tr>
<td>Entrepreneurs’ debt</td>
<td>-0.0592</td>
<td>-0.0592</td>
<td>-0.0555</td>
<td>-0.0642</td>
<td>-0.0323</td>
<td>-0.0295</td>
</tr>
<tr>
<td><strong>Standard Deviations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real Output</td>
<td>0.3881</td>
<td>0.3306</td>
<td>0.3463</td>
<td>0.2756</td>
<td>0.0012</td>
<td>0.5646</td>
</tr>
<tr>
<td>Consumption</td>
<td>0.6545</td>
<td>0.5886</td>
<td>0.5825</td>
<td>0.5958</td>
<td>0.5897</td>
<td>0.4050</td>
</tr>
<tr>
<td>Investment</td>
<td>0.3913</td>
<td>0.4657</td>
<td>0.4486</td>
<td>0.8647</td>
<td>1.9600</td>
<td>1.8850</td>
</tr>
<tr>
<td>Labour</td>
<td>0.6453</td>
<td>0.5766</td>
<td>0.5988</td>
<td>0.4996</td>
<td>0.2099</td>
<td>0.8600</td>
</tr>
<tr>
<td>Capital</td>
<td>0.1684</td>
<td>0.2051</td>
<td>0.2204</td>
<td>0.2001</td>
<td>0.4630</td>
<td>0.5764</td>
</tr>
<tr>
<td>Household debt</td>
<td>40.3949</td>
<td>33.6402</td>
<td>33.4322</td>
<td>31.6657</td>
<td>22.0691</td>
<td>18.9399</td>
</tr>
<tr>
<td>Entrepreneurs’ debt</td>
<td>1.6759</td>
<td>1.6896</td>
<td>1.7829</td>
<td>1.4340</td>
<td>1.4016</td>
<td>2.8296</td>
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<tr>
<td>Inflation</td>
<td>0.0084</td>
<td>0.0000</td>
<td>0.0095</td>
<td>0.0366</td>
<td>0.1295</td>
<td>0.1196</td>
</tr>
<tr>
<td>Real Exchange Rate</td>
<td>1.8185</td>
<td>1.5397</td>
<td>1.5164</td>
<td>1.5564</td>
<td>1.4766</td>
<td>0.7508</td>
</tr>
<tr>
<td>Real Interest Rate</td>
<td>0.1017</td>
<td>0.1038</td>
<td>0.0879</td>
<td>0.1515</td>
<td>0.1799</td>
<td>0.1207</td>
</tr>
</tbody>
</table>

*a* Percentage deviation of stochastic steady state from the deterministic steady state.

*b* Standard deviation of Real output, Consumption, Investment, Labour, Capital, Household debt and Entrepreneurs’ debt refer to the standard deviations of $\hat{Y}_t$, $\hat{C}_t$, $\hat{I}_t$, $\hat{H}_t$, $\hat{K}_t$, $\hat{D}_t$ and $\hat{D}_E$. All remaining are the standard deviations of the respective variables. All standard deviations have been multiplied by 100.
following a new policy rule, is also computed for each monetary policy rule used in this essay.

With the conditional welfare measure, the welfare ranking of alternative policy rules depends on the assumed value (or the distribution) for the initial state vector (Schmitt-Grohe and Uribe 2007). Since the deterministic steady state is common for all the monetary policy rules, the conditional expected utility is computed assuming a non-stochastic steady state as the initial state for all policy rules.

**Unconditional welfare**

Following Bergin et al. (2007) and Elekdag & Tchakarov (2007), the unconditional welfare is defined as the utility level of the unconditional expectation under uncertainty:

\[
E[U(C_t, H_t, (M/P)_t)] = E \left( \frac{C_t^{1-\sigma}}{1-\sigma} - \frac{H_t^{1+\eta}}{1+\eta} + \frac{(M/P)_t^{1-\xi}}{1-\xi} \right)
\]  

(2.57)

By taking second-order approximation of the utility function above, the expected utility can be reformulated as

\[
E[U(C_t, H_t, (M/P)_t)] \approx \bar{U} + \bar{C}^{1-\sigma}E(C_t) - \frac{1}{2} (1-\sigma)\bar{C}^{1-\sigma}Var(C_t) - \\
H^{1+\eta}E(H_t) - \frac{1}{2} (1+\eta) H^{1+\eta}Var(H_t) + (M/P)^{1-\xi}E(\frac{M}{P}_t) - \frac{1}{2} (1-\xi) (M/P)^{1-\xi}Var(M/P)_t
\]

(2.58)

\(\bar{C}, \bar{H}\) and \((M/P)\) are the household consumption, labour and real money balance in the non-stochastic steady state and \(Var(C_t), Var(H_t)\) and \(Var(M/P)_t\) are the variances of \((C_t), (H_t)\) and \((M/P)_t\).

A consumption equivalent welfare measure, \(\Gamma\), is calculated for each monetary policy rule for comparison purposes. The consumption equivalent welfare measure is defined as the fraction of additional deterministic steady state consumption required by the households, to equate the steady state welfare to the unconditional expected utility level of the stochastic world under uncertainty which is expressed as

\[
U \left[ (1 + \Gamma) \bar{C}, \bar{H}, \left(\frac{M}{P}\right)_t \right] = E[U(C_t, H_t, (M/P)_t)]
\]

(2.59)
The consumption equivalent welfare measure can be decomposed into two parts: part due to variance of consumption, labour and real money balances ($\Gamma_{var}$) and the other part due to effect of uncertainty on the means of these variables ($\Gamma_{mean}$). The welfare implication of uncertainty on the means of the variables can be written as

$$U \left[ (1 + \Gamma_{mean}) \bar{c}, \bar{H}, \left( \frac{\bar{M}}{\bar{P}} \right) \right] = \bar{U} + \bar{C}^{1-\sigma}E(\bar{c}_t) - H^{1+\eta}E(\bar{H}_t) + (\bar{M}/\bar{P})^{1-\xi}E(M/P)_t$$

(2.60)

The welfare effect of uncertainty on the variance of the variables can be expressed as

$$U \left[ (1 + \Gamma_{var}) \bar{c}, \bar{H}, \left( \frac{\bar{M}}{\bar{P}} \right) \right] = \bar{U} - \frac{1}{2} (1 - \sigma)\bar{C}^{1-\sigma}Var(\bar{c}_t) - \frac{1}{2} (1 + \eta)\bar{H}^{1+\eta}Var(\bar{H}_t) - \frac{1}{2} (1 - \xi) (\bar{M}/\bar{P})^{1-\xi}Var(M/P)_t$$

(2.61)

Further,

$$(1 + \Gamma)^{1-\sigma} = (1 + \Gamma_{mean})^{1-\sigma} + (1 + \Gamma_{var})^{1-\sigma} - 1$$

(2.62)

Through approximation, $\Gamma \approx \Gamma_{mean} + \Gamma_{var}$, which is more intuitive than what is shown in equation (2.62).

**Conditional welfare**

In line with Schmitt-Grohe and Uribe (2007), conditional welfare ($WF_t$) in the economy is measured by the discounted expected utility of the households:

$$WF_t = E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{(C_t)^{1-\sigma}}{1-\sigma} - \frac{(H_t)^{1+\eta}}{1+\eta} + \frac{(M_t/P_t)^{1-\xi}}{1-\xi} \right)$$

(2.63)

Then $WF_t$ can be written in the recursive form as

$$WF_t = \left( \frac{(C_t)^{1-\sigma}}{1-\sigma} - \frac{(H_t)^{1+\eta}}{1+\eta} + \frac{(M_t/P_t)^{1-\xi}}{1-\xi} \right) + \beta E_t (WF_{t+1})$$

(2.64)

The consumption equivalent welfare measures are derived analogously to those of unconditional welfare. Assuming the conditional consumption equivalent welfare measure is $\Gamma^r$, the relationship between conditional welfare of the stochastic world and deterministic world can be expressed as below:
\[
U[(1 + \Gamma^r)\bar{C}, \bar{H}, (\bar{M}/\bar{P})]/1 - \beta = \\
E_0 \sum_{t=0}^{\infty} \beta^t \left( \frac{(C_1^{1-\sigma} - (H_1^{1+\eta}) + (M_1^{1-\xi})}{1-\sigma} \right) \tag{2.65}
\]

The second-order approximation of the conditional utility around the deterministic steady state can be written as follows:

\[
WF_t \approx \frac{\bar{\eta}}{1 - \beta} + \bar{C}^{1-\sigma} E(d\bar{C}_t) - \frac{1}{2} (1 - \sigma) \bar{C}^{1-\sigma} E(d\bar{C}_t)^2 - \bar{H}^{1+\eta} E(d\bar{H}_t) \\
- \frac{1}{2} (1 + \eta) \bar{H}^{1-\eta} E(d\bar{H}_t)^2 + \frac{\bar{M}}{\bar{P}} \bar{P}^{1-\xi} E\left( d\left(\frac{\bar{M}}{\bar{P}}\right)_t \right) \\
- \frac{1}{2} (1 - \xi) \frac{\bar{M}}{\bar{P}} \bar{P}^{1-\xi} E\left( d\left(\frac{\bar{M}}{\bar{P}}\right)_t \right)^2 \tag{2.66}
\]

where

\[
E(d\bar{C}_t) = E_0 \sum_{t=0}^{\infty} \beta^t \bar{C}_t, \quad E(d\bar{H}_t) = E_0 \sum_{t=0}^{\infty} \beta^t \bar{H}_t \quad \text{and} \quad E(d(\bar{M}/\bar{P})_t) = E_0 \sum_{t=0}^{\infty} \beta^t (\bar{M}/\bar{P})_t
\]

Accordingly, \( \Gamma_{\text{mean}} \) and \( \Gamma_{\text{var}} \) can be defined as below:

\[
U[(1 + \Gamma_{\text{mean}})\bar{C}, \bar{H}, (\bar{M}/\bar{P})]/1 - \beta \\
= \frac{\bar{\eta}}{1 - \beta} + \bar{C}^{1-\sigma} E(d\bar{C}_t) - \bar{H}^{1+\eta} E(d\bar{H}_t) + \frac{\bar{M}}{\bar{P}} \bar{P}^{1-\xi} E\left( d\left(\frac{\bar{M}}{\bar{P}}\right)_t \right) \tag{2.67}
\]

\[
U[(1 + \Gamma_{\text{var}})\bar{C}, \bar{H}, (\bar{M}/\bar{P})]/1 - \beta = \frac{\bar{\eta}}{1 - \beta} - \frac{1}{2} (1 - \sigma) \bar{C}^{1-\sigma} E(d\bar{C}_t)^2 \\
- \frac{1}{2} (1 + \eta) \bar{H}^{1-\eta} E(d\bar{H}_t)^2 - \frac{1}{2} (1 - \xi) \frac{\bar{M}}{\bar{P}} \bar{P}^{1-\xi} E\left( d\left(\frac{\bar{M}}{\bar{P}}\right)_t \right)^2 \tag{2.68}
\]

Tables 2.5 and 2.6 provide the unconditional and conditional welfare losses compared to the deterministic steady state and consumption equivalent welfare measures of alternative monetary policy rules under domestic and foreign shocks separately. The higher the expected utility and consumption equivalent welfare measure, the higher is the social welfare under a given monetary policy rule.

**Welfare under domestic productivity shock**

In the impulse response graphs, the RYT, FXT and NYT rules demonstrated considerable stability in output and absorption but more volatility in the inflation under a domestic productivity shock. Overall the economy was relatively unstable under the RYT rule with
substantial fluctuation in interest rates, exchange rates and trade related variables. Tables 2.5 and 2.6 also point out that the RYT and FXT rules perform poorly in terms of welfare ranking and the welfare loss mainly stems from the effect of uncertainty on the means of consumption, labour and real money balances. On the other hand, welfare is high under the DGPIT rule followed by the CPIT and MT rules. This can be explained more intuitively through the foreign borrowings of the households. An economy that is more prone to domestic productivity shocks becomes more debt burdened if the monetary authority targets the output or exchange rate. This in turn reduces the average level of consumption since considerable fraction of the household income needs to be diverted towards debt repayments. Hence, mean consumption under output targeting and FXT rules is low compared to inflation targeting rules. The lower welfare under output targeting rules is in line with the findings of Schmitt-Grohe and Uribe (2007), who assert that optimal monetary policy features a muted response to output. They argue that monetary policy rules that respond to output have substantial welfare losses.

Welfare under external shocks
As shown in Table 2.5 and 2.6, the DGPIT rule outperforms other monetary policy rules under both types of external shocks as well. The CPIT rule is next in order, closely followed by the MT rule. The NYT rule is in fourth place in terms of welfare ranking. In contrast to domestic productivity shocks, welfare is lowest with the FXT rule under both types of external shocks.

When a Central Bank targets CPI inflation, it partly attempts to moderate the direct effects of the exchange rate on the CPI transmitted via import prices. However, the exchange rate has significant indirect effects on the CPI, particularly under external borrowing constraints. In this small open economy model, borrowing costs of the firms depend on the net worth of entrepreneurs while the exchange rate is a key determinant of net worth since debt is denominated in foreign currency. Hence, marginal costs of firms are affected by exchange rate fluctuations. The aim of a monetary authority is to neutralise the inefficiencies in the economy, such as price dispersion, to reach the equilibrium that is associated with fully-flexible prices. Hence, monetary policy requires targeting a measure of inflation that would stabilize the marginal costs of the firms and eliminate their incentive to change prices. By achieving this objective, the monetary authority is able to

1 Refer Table 2.2. The average household debt level is higher under RYT, FXT and NYT rules compared to deterministic steady state debt level.
Table 2.5  Unconditional welfare measures

<table>
<thead>
<tr>
<th></th>
<th>DGPIT</th>
<th>CPIT</th>
<th>MT</th>
<th>NYT</th>
<th>RYT</th>
<th>FXT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic productivity shock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare (^a)</td>
<td>-0.0439</td>
<td>-0.0737</td>
<td>-0.0881</td>
<td>-0.3183</td>
<td>-0.6452</td>
<td>-0.3693</td>
</tr>
<tr>
<td>Consumption equivalent welfare measure (as a percentage of deterministic steady state consumption)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Gamma)</td>
<td>-0.0467</td>
<td>-0.0750</td>
<td>-0.0854</td>
<td>-0.2918</td>
<td>-0.5932</td>
<td>-0.3385</td>
</tr>
<tr>
<td>(\Gamma_{\text{mean}})</td>
<td>-0.0360</td>
<td>-0.0646</td>
<td>-0.0759</td>
<td>-0.2751</td>
<td>-0.5623</td>
<td>-0.3196</td>
</tr>
<tr>
<td>(\Gamma_{\text{var}})</td>
<td>-0.0107</td>
<td>-0.0104</td>
<td>-0.0095</td>
<td>-0.0167</td>
<td>-0.0308</td>
<td>-0.0189</td>
</tr>
<tr>
<td>Foreign interest rate shock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare (^a)</td>
<td>0.1089</td>
<td>0.1025</td>
<td>0.1022</td>
<td>0.0965</td>
<td>0.0487</td>
<td>0.0437</td>
</tr>
<tr>
<td>Consumption equivalent welfare measure (as a percentage of deterministic steady state consumption)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Gamma)</td>
<td>0.1056</td>
<td>0.0992</td>
<td>0.0991</td>
<td>0.0931</td>
<td>0.0467</td>
<td>0.0423</td>
</tr>
<tr>
<td>(\Gamma_{\text{mean}})</td>
<td>0.1067</td>
<td>0.1002</td>
<td>0.1001</td>
<td>0.0942</td>
<td>0.0483</td>
<td>0.0459</td>
</tr>
<tr>
<td>(\Gamma_{\text{var}})</td>
<td>-0.0011</td>
<td>-0.0010</td>
<td>-0.0010</td>
<td>-0.0011</td>
<td>-0.0016</td>
<td>-0.0035</td>
</tr>
<tr>
<td>Foreign output shock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare (^a)</td>
<td>0.0122</td>
<td>0.0098</td>
<td>0.0093</td>
<td>0.0074</td>
<td>-0.0182</td>
<td>-0.0315</td>
</tr>
<tr>
<td>Consumption equivalent welfare measure (as a percentage of deterministic steady state consumption)</td>
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<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(\Gamma)</td>
<td>0.0116</td>
<td>0.0093</td>
<td>0.0091</td>
<td>0.0068</td>
<td>-0.0187</td>
<td>-0.0277</td>
</tr>
<tr>
<td>(\Gamma_{\text{mean}})</td>
<td>0.0177</td>
<td>0.0142</td>
<td>0.0140</td>
<td>0.0113</td>
<td>-0.0150</td>
<td>-0.0230</td>
</tr>
<tr>
<td>(\Gamma_{\text{var}})</td>
<td>-0.0061</td>
<td>-0.0049</td>
<td>-0.0049</td>
<td>-0.0046</td>
<td>-0.0037</td>
<td>-0.0047</td>
</tr>
</tbody>
</table>

\(^a\) Welfare compared to deterministic steady state

[i.e. (welfare with policy rule – welfare loss in deterministic steady state)*100]
Table 2.6  Conditional welfare measures

<table>
<thead>
<tr>
<th></th>
<th>DGPIT</th>
<th>CPIT</th>
<th>MT</th>
<th>NYT</th>
<th>RYT</th>
<th>FXT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domestic productivity shock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare (^a)</td>
<td>-0.0059</td>
<td>-0.0188</td>
<td>-0.0250</td>
<td>-0.1646</td>
<td>-0.3619</td>
<td>-0.1949</td>
</tr>
<tr>
<td>Consumption equivalent welfare measure (as a percentage of deterministic steady state consumption)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Gamma)</td>
<td>-0.0028</td>
<td>-0.0213</td>
<td>-0.0278</td>
<td>-0.2074</td>
<td>-0.4650</td>
<td>-0.2466</td>
</tr>
<tr>
<td>(\Gamma_{\text{mean}})</td>
<td>-0.0025</td>
<td>-0.0210</td>
<td>-0.0275</td>
<td>-0.2069</td>
<td>-0.4641</td>
<td>-0.2460</td>
</tr>
<tr>
<td>(\Gamma_{\text{var}})</td>
<td>-0.0003</td>
<td>-0.0003</td>
<td>-0.0003</td>
<td>-0.0005</td>
<td>-0.0010</td>
<td>-0.0006</td>
</tr>
<tr>
<td><strong>Foreign interest rate shock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare (^a)</td>
<td>0.0722</td>
<td>0.0682</td>
<td>0.0680</td>
<td>0.0648</td>
<td>0.0331</td>
<td>0.0311</td>
</tr>
<tr>
<td>Consumption equivalent welfare measure (as a percentage of deterministic steady state consumption)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Gamma)</td>
<td>0.1057</td>
<td>0.0998</td>
<td>0.0996</td>
<td>0.0946</td>
<td>0.0489</td>
<td>0.0483</td>
</tr>
<tr>
<td>(\Gamma_{\text{mean}})</td>
<td>0.1058</td>
<td>0.0998</td>
<td>0.0996</td>
<td>0.0946</td>
<td>0.0489</td>
<td>0.0484</td>
</tr>
<tr>
<td>(\Gamma_{\text{var}})</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>0.0000</td>
<td>-0.0001</td>
</tr>
<tr>
<td><strong>Foreign output shock</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Welfare (^a)</td>
<td>0.0079</td>
<td>0.0058</td>
<td>0.0054</td>
<td>0.0039</td>
<td>-0.0124</td>
<td>-0.0217</td>
</tr>
<tr>
<td>Consumption equivalent welfare measure (as a percentage of deterministic steady state consumption)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(\Gamma)</td>
<td>0.0167</td>
<td>0.0127</td>
<td>0.0123</td>
<td>0.0093</td>
<td>-0.0159</td>
<td>-0.0247</td>
</tr>
<tr>
<td>(\Gamma_{\text{mean}})</td>
<td>0.0169</td>
<td>0.0128</td>
<td>0.0124</td>
<td>0.0095</td>
<td>-0.0158</td>
<td>-0.0246</td>
</tr>
<tr>
<td>(\Gamma_{\text{var}})</td>
<td>-0.0002</td>
<td>-0.0002</td>
<td>-0.0002</td>
<td>-0.0001</td>
<td>-0.0001</td>
<td>-0.0001</td>
</tr>
</tbody>
</table>

\(^a\) Welfare compared to deterministic steady state

[i.e. welfare with policy rule – welfare in deterministic steady state]
minimize the ‘inefficiencies’ that are created by resource misallocation (for example, insufficient production of domestic goods and excessive consumption of foreign goods that will result in unsustainable foreign debt positions). Therefore, domestic goods inflation that targets the indirect effects of exchange rate fluctuations is welfare-superior to CPI targeting in this small open economy model, particularly under external shocks.

In line with the findings of Alba et al. (2011), the CPIT rule performs better than the NYT and RYT rules in terms of social welfare. With the NYT and RYT rules, output stability is achieved at the expense of stability in nominal and real interest rate and inflation rate. Consequently, domestic consumption and investment are affected more under output targeting rules compared to CPI targeting. In particularly, the average level of consumption is low with the said rules, leading to lower welfare in the economy. This effect is more substantial under the RYT rule.

The MT rule is in third place in terms of welfare ranking under both types of external shocks. However, the money demand function is assumed to be stable in this model though in reality it may not be stable for the Sri Lankan economy. Hence, the MT rule may be or may not be welfare-superior to output targeting rules and the FXT rule in real world. Nevertheless, this experiment indicates that moving from the MT rule to an inflation targeting rule will be beneficial for the Sri Lankan economy.

Interestingly, the welfare under foreign interest rate shocks and foreign output shocks is higher than the deterministic steady state. Once again, this can be explained through the foreign debt holding of the households. The economies that are susceptible to external shocks tend to reduce their average foreign debt levels compared to a certain world. This leads to lower debt servicing costs and higher levels of average consumption.

This welfare analysis demonstrates the significant effect of uncertainty on the variance and means of the micro-variables. The effect of uncertainty on the average level of consumption, leisure and real money balances has a significant impact on social welfare. The traditional log-linearization method does not capture this effect and the welfare ranking of the policy rules under the first order approximation approach would be substantially different from the results discussed in this essay. Since second-order approximation of the full set of model equations encompasses the effect of uncertainty on
the average level of the endogenous variables, it provides a more accurate welfare ranking.

2.3.5 Robustness analysis
The robustness of the results to uncertainty of some parameters was also checked. Elekdag & Tchakarov (2007) show that even with moderate levels of external debt, fixed exchange rate targeting can be welfare-superior to inflation targeting. Hence, the robustness of the results to higher external debt levels was checked by increasing the total debt-to-GDP ratio to 70 per cent. Further, the steady state external financing premium was increased from 250 basis points to 350 basis points and its welfare implication was investigated. In addition, the inverse of intertemporal elasticity of substitution of consumption, $\sigma$, was changed between 1.5 and 3 (in the baseline model, $\sigma$ was assumed to be 2). In all these cases, the ranking of monetary policy rules remained unchanged.

2.4 Conclusion
With trade and financial market liberalization, developing countries such as Sri Lanka are increasingly becoming vulnerable to shocks emanating from foreign markets. Hence, the welfare effects of external shocks should be taken into account for the choice of appropriate monetary policy regime for a small open economy. Using a small open economy DSGE model, this essay has investigated the welfare implications of six alternative monetary policy rules under domestic productivity, foreign interest rate and negative foreign output shocks. The model comprises monopolistic competition, financial frictions and delayed exchange rate pass-through. It is calibrated to match with the data for Sri Lankan economy. The monetary policy rules were assessed based on conditional and unconditional welfare, by taking second-order approximation of the full set of model equations.

With both external shocks, welfare loss is minimized under the strict domestic goods inflation targeting rule. Past studies have shown that CPI targeting is appropriate for the countries with delayed exchange rate pass-through. Given the financial frictions in the economy, exchange rate fluctuations have indirect effects on the marginal costs of firms. Therefore, focusing on these indirect effects through domestic goods inflation is welfare-superior to CPI targeting, despite the delayed exchange pass-through assumption. CPI targeting is next in order in terms of welfare ranking. Although the performance of the
monetary aggregate targeting rule is close to the CPI targeting rule, a stable money demand function is a pre-requisite for achieving higher welfare in the real world. Further, output targeting rules show a trade-off between inflation and output stability. Under both types of external shock, the FXT rule is performing poorly. This study shows the welfare effect of uncertainty on the variance and means of the micro-variables. Further, the average level of consumption, labour and real money balances significantly matter for welfare.

This study has considered only the strict form of monetary policy rules and has not considered the flexible rules. Future research will need to focus on these flexible forms of monetary policy rules and the optimal monetary policy rule for the country.
Appendix 1.A  Graphical representation of the model

Figure 1.A.1: DSGE model for Sri Lanka
3.1 Introduction

Over the past four decades, Sri Lanka has gradually integrated with the world economy and as a result, global economic developments have contributed to shaping the domestic economic environment. Recent past events such as the global financial crisis in 2007-2008, the great recession in advanced economies in 2008-2012 and the large swings in petroleum and other commodity prices had an inevitable impact on the Sri Lankan economy due to the country’s trade and financial market linkages. To what extent are the macroeconomic fluctuations in Sri Lanka explained by these foreign shocks? How fast are the external shocks transmitted to the domestic economy? Are the effects of foreign shocks on the domestic economy persistent? Through which channels are the external shocks transmitted to the Sri Lankan economy? These are some of the questions faced by Sri Lankan policymakers. This chapter attempts to answer these questions using an empirical SVAR model.

Sri Lanka commenced its economic liberalization programme in 1977 and became the first South Asian country to embark on an irreversible trade liberalization path (Athukorala et al., 2011). This was the turning point for the Sri Lankan economy to move from an inward-looking, controlled-economy approach to an export-oriented, liberalized-economic strategy. Since then, the Sri Lankan economy has been able to attain far-reaching reforms in every sphere of economic activity (Athukorala & Jayasuriya, 1993). Under a structural adjustment program advocated by the World Bank and the International Monetary Fund (IMF), Sri Lanka’s government introduced financial market reforms, including removal of restrictions on banking products and interest rates, improving private sector participation in the financial sector, the opening-up of financial markets for domestic and foreign competition and unification of the exchange rate (Edirisuriya, 2007). In order to reform the country’s international trade, quantitative restrictions on imports were replaced with tariffs and the tariff structure was revised to achieve greater uniformity. Further, export-oriented foreign investments were incentivized through an attractive free-trade scheme (Athukorala & Rajapatirana, 2000).
During the past two decades, the Sri Lankan government has entered into several bi-
lateral and multi-lateral trade agreements with some major trading partners such as China,
South Korea, India and other South Asian countries. These reforms have enabled the Sri
Lankan economy to gradually strengthen its financial and trade linkages with global
markets. During the 2009-2014 period, the average trade to GDP ratio was 55 per cent
for the Sri Lankan economy. Hence, structural disturbances in global markets are
becoming an important source of macroeconomic fluctuations in Sri Lanka. Therefore,
the policymakers of the country need to understand the impact of foreign shocks on the
Sri Lankan economy, especially the extent of their effects, transmission patterns and
transmission channels.

There is a growing body of literature that investigates the effect of external shocks and
their transmission channels in advanced and emerging economies. Many studies such as
those conducted by Kim (2001), Canova (2005), Maćkowiak (2007), Allegret et al.
(2012), and Sato (2011) have shown that external shocks cause significant
macroeconomic fluctuations in both developed and emerging markets. However,
Raddatz (2007) posits a contradictory viewpoint with regard to low-income countries
using a panel VAR approach. He finds that internal causes are the main source of
fluctuations in output, while external shocks can explain only a small fraction of output
variances in a typical low-income country.

Numerous studies have focused on the cross-border transmission of foreign monetary
policy shocks, particularly the US monetary policy shocks. Kim (2001) examines the
international transmission of US monetary policy shocks using SVAR models for G-6
countries and concludes that expansionary monetary policy in the US leads to booms in
non-US, G-6 countries. Further, he claims that changes in trade balance seem to play a
minor role in the transmission process but a decrease in world real interest rate seems
more important for output expansion in non-US, G-6 countries. Using SVAR models
with sign restrictions, Canova (2005) also finds similar results for Latin American
countries. He shows that US monetary policy shocks cause significant fluctuations in
several Latin American macroeconomic variables though the US demand and supply
shocks fail to induce notable responses in a typical Latin American economy. Further,
Canova (2005) also asserts that the interest rate channel contributes more for foreign
shocks transmission than the trade channel. Maćkowiak (2007) uses SVAR models with
block exogeneity assumptions for several emerging markets and finds that US monetary
policy shocks affect the interest rate and exchange rate of these economies quickly and strongly. Interestingly, output and price levels in emerging markets respond more strongly to US monetary policy shocks than the US output and US price levels. In contrast to the findings of Kim (2001) and Canova (2005), Maćkowiak (2007) conclude that other external shocks affect the emerging economies more than the US monetary policy shocks. Allegret et al. (2012) also find similar results for East Asian economies using a SVAR model with block exogeneity and short and long-run restrictions. They find that US GDP shocks and real oil price shocks have more effect on the output variability in East Asian economies than the US monetary policy and financial shocks. On the other hand, Dungey and Pagan (2000), who have modelled the Australian economy by imposing a block exogeneity assumption and short-run restrictions, posit that both foreign output and asset prices have a considerable effect on the growth of the Australian economy, even though the Australian business cycle is not fully synchronized with the foreign business cycle. These ambiguous past findings suggest that the relative importance of different external shocks and their transmission channels are by and large country specific depending on the economy’s trade and financial market links with the rest of the world.

Although many studies on external shocks focus on the advanced or emerging economies, such studies pertaining to South Asian countries are fairly limited. Duma (2008) investigates the pass-through of external shocks to domestic inflation in Sri Lanka using a VAR model that incorporates the distribution chain of pricing. He observes a low and incomplete pass-through of external shocks to consumer price inflation, which indicates that inflation is being highly influenced by other factors such as administered prices, high content of food in the consumption basket and low persistence and volatility in exchange rate. According to Duma (2008), external shocks explain only 25 per cent of the variation in consumer price inflation in Sri Lanka. Therefore, he concludes that there is scope for inflation management through domestic policies. However, Duma (2008) has considered oil price shocks as the only external structural disturbance. Although he has restricted the domestic variables affecting oil prices contemporaneously through recursive Cholesky orthogonalization, he has not used the block exogeneity assumption for the model. Therefore, he has not strictly assumed Sri Lanka to be a small open economy leaving domestic variables to affect the foreign variables in the lag periods. Further, Perera (2013) uses a SVAR model for Sri Lanka with commodity prices and foreign interest rate as external shocks. However, his research focuses on domestic monetary policy transmission rather than the effect of external shocks. Perera (2013) applies the
identification used by Kim and Roubini (2000) and does not strictly assume Sri Lanka to be a small open economy.

This chapter attempts to fill the gap in the existing body of literature by investigating the effects of multiple external shocks on the Sri Lankan economy. In contrast to previous studies of the Sri Lankan economy, this chapter assumes Sri Lanka to be a small open economy strictly through the imposition of block exogeneity restriction. The block exogeneity assumption implies that all domestic variables do not affect the external variables contemporaneously or with lags. Since Sri Lankan macroeconomic variables are unlikely to affect foreign variables such as oil prices, US interest rate and US output, this is a valid assumption. Further, a non-recursive identification scheme comprising of short and long-run restrictions is used in this study. The usual problems of exchange rate puzzle, price puzzle and output puzzle that are common in the small open economy literature have been avoided by this identification scheme. In addition, this study explores the effect of the overall US monetary policy stance on the domestic economy using the shadow short rate for the US. The US shadow short rate (Krippner, 2015) is an interest rate estimated using a shadow/lower bound terms structure model to capture the overall monetary policy stance of the US, including both conventional and unconventional monetary policy measures.

The results of this study show that internal shocks are more important for domestic economic fluctuations, but external shocks also play a considerable role in explaining domestic output growth and inflation variability. Oil price inflation and foreign output shocks are important in explaining domestic output growth fluctuations. Shocks to the effective federal funds rate better explain the output growth variance than shocks to US shadow short rate. Further, domestic inflation is more prone to shocks to the oil price inflation and the effective federal funds rate. Again, shocks to the effective federal funds rate explain a higher proportion of the domestic inflation variance than shocks to the US shadow short rate. Further, the foreign shocks are transmitted to the Sri Lankan economy through trade channels as well as through interest rate channels.

The remainder of the chapter is organized as follows. Section 3.2 explains the methodological framework including data. The model is first estimated using effective federal funds rate as the foreign monetary policy variable. The results of this estimation, including impulse responses, forecast error variance decomposition and historical
decomposition, are discussed in Section 3.3. Then the model is re-estimated using the US shadow short rate as a proxy for foreign monetary policy and Section 3.4 focuses on discussing the results of this re-estimation. The next section explains the robustness analysis and the last section of this chapter provides the conclusion and policy implications with regard to external shocks and macro-economy of Sri Lanka.

3.2 Methodology

3.2.1 SVAR model framework

Assume $Y_t$ is a vector containing $n$ economic variables at time $t$. The VAR representation of the structural model can be written as

$$D(L) Y_t = \epsilon_t \quad \text{and} \quad E(\epsilon_t \epsilon_t') = \Omega$$

where $D(L) = D_0 + D_1 L + D_2 L^2 + D_3 L^3 + \cdots + D_p L^p$ and $L$ is the lag operator with $L^i Y_t = Y_{t-i}$. The $\epsilon_t$ are the reduced-form residuals while $p$ is the order of the VAR process. If the matrix polynomial $D(L)$ is invertible, the infinite-order, moving-average Wold representation of the model can be expressed as

$$Y_t = C(L) \epsilon_t$$

where $C(L) = D(L)^{-1}$.

Further, the VAR representation of the structural-form can be written as follows:

$$B(L)Y_t = u_t \quad \text{and} \quad E(u_t u_t') = I$$

where the $u_t$s are the structural shocks. The $u_t$s are serially uncorrelated and mutually orthogonal. Without loss of generality, the covariance matrix of structural shocks $u_t$ is normalized to $I$.

If the matrix polynomial $D(L)$ is invertible, then the matrix polynomial $B(L)$ is also invertible. Therefore, the structural infinite-order, moving-average representation can be represented as

$$Y_t = A(L) u_t$$

where $A(L) = B(L)^{-1}$.

The exogenous structural shocks, $u_t$, are not directly observable but need to be observed indirectly through their effects on the elements of $Y_t$. This is achieved through the estimation of the reduced-form VAR in (3.1) and obtaining the reduced-form residuals. From equations (3.2) and (3.4),
\[ A(L) \ u_t = C(L) \ \epsilon_t \]

Let the subscript denote the matrix of coefficients at the corresponding lag. Since equation (3.5) must hold for all \( t \), and \( C_0 = I \),
\[ A_0 \ u_t = \ \epsilon_t \]

Squaring both sides and taking expectation would yield
\[ A_0 \ A_0' = \ \Omega \]

By combining equations (3.5) and (3.6),
\[ A(L) \ u_t = C(L) \ A_0 \ u_t \]

This implies
\[ A(L) = C(L) \ A_0 \]

Since \( C(L) \) can be estimated through the reduced form VAR in equation (3.2), knowledge of \( A_0 \) is sufficient to calculate the structural coefficients of lag polynomial \( A(L) \) and the structural shocks, \( u_t \), using equations (3.6) and (3.9). When identifying the structural VAR model, equation (3.7) places \( n^* \ (n + 1)/2 \) number of restrictions on the elements of \( A_0 \) where \( n \) is the number of variables in the model. Further, at least \( n^* \ (n - 1)/2 \) number of restrictions are needed to fully determine \( A_0 \). There are several methods of imposing these additional restrictions.

The most common method to identify structural shocks is to place restrictions only on \( A_0 \) (i.e., the restrictions on contemporaneous relationships between the variables in the system). For example, Sims (1980), Cushman and Zha (1997), Dungey and Pagan (2000), and Maćkowiak (2007) have used short-run restrictions to identify the SVAR models.

Another method to obtain structural shocks is to incorporate long-run restrictions by imposing restrictions on the long-run multiplier, which is the sum of coefficients in \( A(L) \), and is given by \( A(1) \) evaluated at \( L = 1 \). Accordingly,
\[ A(1) = C(1) \ A_0 \]

where \( C(1) \) is the sum of coefficients in \( C(L) \) evaluated at \( L = 1 \). Once again, \( C(1) \) can be obtained from the estimation of reduced-form VAR in equation (3.2). Therefore, restrictions placed on \( A(1) \) can be used to calculate \( A_0 \) using equation (3.10) and the structural shocks, \( u_t \), using equation (3.6). For example, Shapiro and Watson (1988) and
Blanchard and Quah (1989) have used long-run restrictions to identify structural VAR models.

Further, it is possible to use restrictions on both $A(1)$ and $A_0$ to identify the structural VAR models. Following Gali (1992), Bjørnland (2009), Sato et al. (2011) and Allegret et al. (2012), this study also uses a combination of short-run and long-run restrictions.

The aforementioned identification methods all focus on parametric restrictions. Although this study only applies parametric restrictions to identify structural shocks, it is worthwhile mentioning the sign restriction approach that is increasingly applied within the SVAR literature. On many occasions, SVAR models with only parametric restrictions fail to produce impulse responses with desired properties. Therefore, Canova and De Nicoló (2002), Uhlig (2005), Fry and Pagan (2011) have proposed to identify the structural shocks by sign restrictions that would satisfy prior knowledge regarding how a particular shock should behave. However, since the impulse responses of this model behave in line with economic theory, this study only applies short-run and long-run parametric restrictions.

### 3.2.2 Block exogeneity assumption

In this study, $Y_t$ is partitioned into two blocks, that is a foreign block and a domestic block. Three external variables are considered in the foreign block of this model, namely, oil price inflation (OIL), foreign output growth and the foreign interest rate. US real GDP growth (GDP_US) is used as a proxy for foreign output growth. Initially, the effective federal funds rate (EFFR) is used to represent the foreign monetary policy. Oil price shocks are important for Sri Lanka since the economy is heavily dependent on imported petroleum products for energy. The US GDP shock represents a trade shock for Sri Lanka since the US is the largest export destination for Sri Lanka’s exports. The US absorbed 24.0 percent of Sri Lanka’s exports in 2014. The last foreign shock encompasses the transmission of foreign monetary policy shocks to the Sri Lankan economy. The US Dollar accounts for 19.7 per cent weight in the currency basket used to calculate the real effective exchange rate of Sri Lanka. Hence, the US monetary policy may have a considerable impact on the macroeconomic variables of Sri Lanka’s economy, particularly on the exchange rate. The domestic variables block consists of four variables, viz., domestic real GDP growth (GDP), domestic consumer price inflation (INF), short-term interest rate (INT) and real effective exchange rate (REER). Accordingly,
\[ Y_t' = [\text{OIL, GDP\_US, EFFR, GDP, INF, INT, REER}]. \]

A typical element in \( C(L) \), \( C_{j,k}(L) \), denotes the coefficient of the \( k^{th} \) variable in the reduced form equation of the \( j^{th} \) variable in period \( L \). Following Cushman and Zha (1997), Dungey and Pagan (2000), Maćkowiak (2007) and Sato et al. (2011), this model assumes a block exogeneity restriction implying Sri Lanka is a small open economy. This corresponds to \( C_{j,k,p} = 0 \) for \( j = 1,2,3 \) (i.e., in OIL, GDP\_US and EFFR equations) and \( k = 4,5,6,7 \) (i.e., the coefficients for GDP, INF, INT and REER) in all \( p \)'s where \( p \) is number of lags in the model. Table 3.1 provides the lag structure of the model.

Table 3.1  
<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>OIL</th>
<th>GDP_US</th>
<th>EFFR</th>
<th>GDP</th>
<th>INF</th>
<th>INT</th>
<th>REER</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIL</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>GDP_US</td>
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</tr>
<tr>
<td>EFFR</td>
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<td>*</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>INF</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>INT</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>REER</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

Note: * indicates lags of the independent variable appear in the dependent variable equation

3.2.3  
Non-recursive identification scheme

As pointed out earlier, the identification of the structural form requires at least \( n \times (n - 1)/2 \) number of additional restrictions. Since this model comprises seven variables, the minimum number of restrictions required is twenty one. As mentioned before, a combination of short-run and long-run restrictions is used in this essay and hence twenty-one restrictions are imposed on \( A_0 \) and \( A(1) \) matrices to obtain a just-identified model.

Restrictions of \( A_0 \) matrix (short-run restrictions)

With the block exogeneity assumption, the domestic structural shocks are assumed to have no impact on foreign variables contemporaneously as well as in the lag periods. Hence, this assumption provides twelve short-run restrictions. Following Ito and Sato (2006) and Allegret et al. (2012), oil price inflation is assumed to be not affected by other foreign shocks contemporaneously. This results in two additional restrictions. Further, the effective federal funds rate is assumed to be responding to oil price inflation (Leeper
et al., 1996, Bernanke et al., 1997 and Allegret et al., 2012) and US real GDP growth (Christiano et al., 1999) contemporaneously. Moreover, US real GDP growth is assumed to respond to federal funds rate only with a lag. This assumption provides another restriction.

The domestic block follows the identification scheme in Bjørnland (2009). Accordingly, all domestic variables are affected by the foreign shocks contemporaneously, but domestic real GDP growth is affected by other domestic variables only after one quarter. Moreover, the domestic price level is affected by the real GDP but not by other domestic variables contemporaneously. In addition, both domestic monetary policy that is represented by the short term interest rate and real effective exchange rate are assumed to react contemporaneously to all shocks. The short-run restrictions of the domestic block derive five more restrictions. Accordingly,

\[
[A_0] = \begin{bmatrix}
(a_0)_{11} & 0 & 0 & 0 & 0 & 0 & 0 \\
(a_0)_{21} & (a_0)_{22} & 0 & 0 & 0 & 0 & 0 \\
(a_0)_{31} & (a_0)_{32} & (a_0)_{33} & 0 & 0 & 0 & 0 \\
(a_0)_{41} & (a_0)_{42} & (a_0)_{43} & (a_0)_{44} & 0 & 0 & 0 \\
(a_0)_{51} & (a_0)_{52} & (a_0)_{53} & (a_0)_{54} & (a_0)_{55} & 0 & 0 \\
(a_0)_{61} & (a_0)_{62} & (a_0)_{63} & (a_0)_{64} & (a_0)_{65} & (a_0)_{66} & (a_0)_{67} \\
(a_0)_{71} & (a_0)_{72} & (a_0)_{73} & (a_0)_{74} & (a_0)_{75} & (a_0)_{76} & (a_0)_{77}
\end{bmatrix}
\]

(3.11)

**Restrictions of A(1) matrix (Long-run restrictions)**

With the aforementioned restrictions, identification of the SVAR model is still short of one restriction. Therefore, one long-run restriction is imposed on the domestic block assuming monetary policy has no long run effect on the level of the real exchange rate.

As described by Blanchard and Quah (1989), a neutrality assumption can be imposed by setting

\[
\sum_{p=0}^{\infty} A_{k,j,p} = 0
\]

(3.12)

Accordingly, long-run neutrality of monetary policy on the level of real exchange rate is imposed by setting \(A_{6,7}(1) = 0\).
Therefore,

\[
A(1) = \begin{bmatrix}
    a_{11}(1) & a_{21}(1) & a_{31}(1) & a_{41}(1) & a_{51}(1) & a_{61}(1) & a_{71}(1) \\
    a_{12}(1) & a_{22}(1) & a_{32}(1) & a_{42}(1) & a_{52}(1) & a_{62}(1) & a_{72}(1) \\
    a_{13}(1) & a_{23}(1) & a_{33}(1) & a_{43}(1) & a_{53}(1) & a_{63}(1) & a_{73}(1) \\
    a_{14}(1) & a_{24}(1) & a_{34}(1) & a_{44}(1) & a_{54}(1) & a_{64}(1) & a_{74}(1) \\
    a_{15}(1) & a_{25}(1) & a_{35}(1) & a_{45}(1) & a_{55}(1) & a_{65}(1) & a_{75}(1) \\
    a_{16}(1) & a_{26}(1) & a_{36}(1) & a_{46}(1) & a_{56}(1) & a_{66}(1) & a_{76}(1) \\
    a_{17}(1) & a_{27}(1) & a_{37}(1) & a_{47}(1) & a_{57}(1) & 0 & a_{77}(1)
\end{bmatrix}
\]  \hspace{1cm} (3.13)

With this long-run restriction, the model is just-identified.

### 3.2.4 Data and estimation

The data used in this study are graphically presented in Figure 3.1. The sample period covered in this analysis is from 1996Q2 to 2014Q4 as Sri Lanka started to compile quarterly GDP data only from 1996. Quarterly data are obtained from the Central Bank of Sri Lanka, the IMF International Financial Statistics (IFS) online database and the FRED database of St. Louis Fed. The prices of the WTI Crude and the Colombo Consumer Price Index are used to calculate the oil price and domestic price inflation. Both inflation rates are defined as the inflation relative to the preceding quarter. The money market rate is used as a proxy for the domestic short-term interest rate. Further, US GDP growth and domestic output growth are defined as the growth compared to the previous quarter. The global price of WTI Crude, the Colombo Consumer Price Index, the GDP of Sri Lanka and real effective exchange rate data are seasonally adjusted using the Census X-12 method while US GDP data obtained from the FRED database is already seasonally-adjusted. A dummy variable (GFC) is used to represent the global financial crisis period from 2007Q4 to 2009Q2 in both foreign and domestic blocks. Another dummy variable (PEACE) is used in the domestic block to represent the peace period that prevailed after the end of the civil war in Sri Lanka in the mid-2009.

All variables are checked for stationarity using Augmented Dicky Fuller (ADF), Phillip Perron (PP) and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) tests. A summary of these tests are given in Appendix 3.A. Oil and domestic price inflation rates and foreign and domestic output growth rates are \(I(0)\) variables but interest rates and real effective exchange rate are \(I(1)\) variables. Although interest rates are expected to be \(I(0)\) theoretically, the downward trend in both domestic and foreign interest rate data indicate that they act as \(I(1)\) variables within the sample period.
Figure 3.1  Foreign and domestic macroeconomic data (1996Q2 – 2014Q4)

Note: OIL is the oil price inflation compared to the preceding quarter. The GDP_US and GDP are the output growth rates relative to the previous quarter in the US and Sri Lanka, respectively. EFFR is the quarterly effective federal funds rate in the US. INF is the inflation in Sri Lanka’s CPI compared to the preceding quarter. The INT is the quarterly money market rate in Sri Lanka. REER is the real effective exchange rate. All variables are in percentage terms except REER, which is in natural logarithm.
In order to apply the restriction of long-run neutrality of monetary policy on the real exchange rate, a stationary monetary policy variable is required. Therefore, both interest rate variables are incorporated in the model in their first difference terms. Further, exchange rate also enters into the model in the first difference term to apply the long run restriction. By applying the long-run restriction to the first differenced exchange rate, the effects of monetary policy shocks on the level of the real exchange rate will eventually add-up to zero (Blanchard and Quah, 1989).

In terms of the lag length selection, the HQIC and SBIC lag length selection criteria select one lag while AIC and FPE selected six and four lags, respectively. However, two lags were chosen for the model considering the small sample size and to allow sufficient model dynamics. The Seemingly Unrelated Regression Equation (SURE) estimation technique and RATS 9.0 econometric software is used to estimate this structural near-VAR model.

3.3 Results
3.3.1 Impulse responses
An impulse response function depicts the dynamic response of one variable in the VAR system to a shock in one of the structural form equations. Although this essay focuses on domestic monetary policy and external shocks, the impulse responses for other shocks are given in Appendix 3.B.

Domestic monetary policy shocks
Figure 3.2 illustrates the dynamic response of domestic variables to a one standard deviation shock to the change in the domestic short term interest rate, which is considered to be a monetary policy shock. The real effective exchange rate appreciates instantaneously in response to a domestic monetary policy shock and gradually depreciates thereafter. This is consistent with Dornbusch's (1976) exchange rate overshooting hypothesis, which states that an increase in interest rate should cause an instantaneous appreciation of real exchange rate due to sticky prices in the short-run, and then depreciate steadily in line with the uncovered interest rate parity (UIP). In contrast, Perera (2013) reports an exchange rate puzzle for the Sri Lankan economy where exchange rate depreciates in response to a contractionary monetary policy shock. Perera (2013) follows Kim and Roubini’s (2000) identification scheme and incorporates contemporaneous endogeneity between interest rate and exchange rate. Further, recursive identification of this model also shows a similar exchange rate puzzle (Appendix 3.D).
Therefore, the non-recursive identification scheme used in this essay can be justified by the non-existence of the exchange rate puzzle in the results.

The domestic output growth declines in response to an interest rate shock, but the effect is short-lived and not statistically significant at the 90 per cent confidence level. On the other hand, domestic inflation declines following a domestic monetary policy shock and the peak effect is achieved after two quarters. Hence, there is no price puzzle or output puzzle related to domestic monetary policy shock.

**Foreign monetary policy shocks**

Figure 3.3 depicts the impulse responses of domestic variables to a one standard deviation shock to the effective federal funds rate. Foreign monetary policy shocks tend to be persistent, taking more than 10 quarters to reach their initial level. Sri Lanka’s interest rate increases gradually in response to a US monetary policy shock indicating a slower spill-over effect on the Sri Lankan economy compared to other emerging markets. The change in the domestic interest rate reaches its maximum after two quarters. This finding is different from the findings of Maćkowiak (2007) who reports an immediate and strong response of the domestic interest rate to US monetary policy shocks in emerging markets such as Korea, Malaysia, Singapore and Mexico. The financial markets in Sri Lanka are not as well-developed or highly integrated with the US markets as the emerging markets considered by Maćkowiak (2007). Hence, slower transmission of foreign monetary policy to Sri Lankan economy is not a surprise.

In contrast, the effects of foreign monetary policy shocks on other domestic variables are relatively short-lived. With a contractionary foreign monetary policy shock, domestic inflation declines instantaneously. This result is different from the findings of Maćkowiak (2007) who reports an increase in domestic inflation in emerging markets in response to a contractionary monetary policy of the US, irrespective of the domestic exchange rate policy. He argues that domestic inflation rises due to increased cost of production in the non-traded sector fuelled by the higher world interest rate. Therefore, he suggests that foreign monetary policy affects domestic inflation mainly though the interest rate channel rather than through the trade channel. But in the case of Sri Lanka, foreign monetary policy initially affects domestic inflation via the trade channel. Given the slow response of the domestic interest rate to foreign monetary policy shocks, the initial fall in domestic inflation can be explained only by the fall in imported inflation.
Figure 3.2  Impulse responses to a domestic contractionary monetary policy shock (EFFR model)
Figure 3.3  Impulse responses to a foreign contractionary monetary policy shock (EFFR model)

Response of GDP to $\Delta$EFFR

Response of INF to $\Delta$EFFR

Response of $\Delta$INT to $\Delta$EFFR

Response of $\Delta$REER to $\Delta$EFFR

Response of $\Delta$EFFR to $\Delta$EFFR

---

90% confidence band  
Structural IRF
With a contractionary foreign monetary policy shock, the foreign inflation reduces, lowering the import prices. Nevertheless, when the domestic interest rate increases slowly due to a higher world interest rate, consumer price inflation in Sri Lanka rises subsequently due to increased borrowing costs of the producers. This indicates a delayed transmission of foreign monetary policy through the interest rate channel.

Since inflation reduces in both foreign and domestic markets, the real exchange rate depreciates only marginally. With the marginal reduction in the real exchange rate, demand for domestic goods expands in the foreign markets. Accordingly, domestic output growth increases in the first two quarters. Therefore, contractionary foreign monetary policy initially affects domestic output growth positively through the trade channel. However, with the gradual increase in the domestic interest rate, the real exchange rate starts to appreciate from the second quarter onwards. As a result, the positive effect of foreign contractionary monetary policy shocks on domestic output growth diminishes within a short period.

**Oil price shocks**

Figure 3.4 shows the impulse responses of Sri Lankan variables to a one standard deviation shock in oil price inflation. The Sri Lankan economy is highly reliant on imported petroleum as a primary and secondary energy source. Generally, oil shocks can adversely affect the output growth of a net oil importing country through different mechanisms. First, oil prices can drive the marginal cost of domestic firms who may cut down their production leading to an output contraction. Second, the monetary authority may tighten monetary policy to curb potential inflation that in turn may reduce output growth as well. Third, the wealth of net oil importing countries transfers to a net oil exporting country with an increase in oil prices. This may lead to reduced savings and investments and low output growth in oil importing countries. Therefore, we may expect a negative effect of oil price shock on output growth in Sri Lanka.
Figure 3.4  Impulse responses to an oil price shock (EFFR model)

- Response of GDP to OIL
- Response of INF to OIL
- Response of ΔINT to OIL
- Response of ΔREER to OIL
- Response of OIL to OIL
- Response of GDP_US to OIL
Interestingly, the results of this essay reveal a different picture and domestic output growth improves due to a shock to oil price inflation for a two-quarter period. This result is similar to the findings of Allegret et al. (2012) who also report a positive effect of oil price shocks on the output in several East Asian economies. As Kilian (2009) points out there are different types of oil price shocks with varying underlying causes: oil price shocks driven by the strong aggregate demand emanating from a booming world economy, precautionary oil price shocks that are explained by precautionary oil demand shocks and oil supply side shocks driven by the disruptions to oil production. Kilian (2009) argues that the oil price escalations driven by strong aggregate demand may not result in output contraction in advanced economies such as the US though the latter two oil price shocks can potentially cause recessions. Further, Killian (2012) emphasises that the surge in oil prices after 2003 was mainly driven by the positive global aggregate demand shocks rather than by the disruptions in oil production or precautionary demand shocks. Allegret et al. (2012) suggest that output expansion in advanced economies can have a positive impact on East Asian economies through trade linkages. Impulse responses of this study also support the argument of Kilian (2009) since they reflect a positive effect of oil price shocks on the US GDP growth. Although an oil price inflation shock is orthogonal to the US output shock in this model, an oil price shock may represent the aggregate demand shocks coming from all advanced economies. Therefore, Sri Lanka benefits from the output expansion in advanced economies during aggregate demand-driven oil price shocks. This result is similar to the East Asian economies in the Allegret et al. (2012) study.

While output growth in advanced economies can be beneficial for overall exports, an increase in oil price inflation is particularly favourable for Sri Lanka’s rubber exporting sector. One of Sri Lanka’s major export categories is natural rubber and natural rubber-based products. Despite low rubber prices in the world market in 2014, rubber and rubber-based products accounted for 8.0 percent of Sri Lanka’s export revenue in that year. Generally, prices for synthetic rubber increase simultaneously alongside oil prices in the world market leading to higher demand for natural rubber products. Therefore, an increase in oil price inflation can have a positive impact on Sri Lanka’s output.

Domestic inflation instantaneously increases due to an oil price shock and this effect is statistically significant. The effect of oil price shock on domestic inflation is relatively more persistent than the effect on domestic output growth. It takes around four quarters
for the domestic inflation rate to reach its original level. The domestic interest rate increases in response to an oil price shock though this increase is not statistically significant. The real exchange rate improves marginally in response to an oil price shock. Foreign inflation can spike due to an oil price shock though this effect is not captured directly here since a foreign inflation variable is not included in the model. However, the effective federal funds rate increases in the event of an oil price shock, but on average this increase is less than the increase in domestic short term interest rate. As a result, the real effective exchange rate appreciates marginally in favour of the domestic economy and the effect reaches its peak by the second quarter.

**Foreign output shocks**

Dynamic responses of domestic variables to a one standard deviation shock in foreign output are illustrated in Figure 3.5. The effect of foreign output shock on domestic output growth is pro-cyclical. However, both the positive innovation in foreign output and the effect on the domestic economy is fairly short-lived. This is probably because the effective federal funds rate is raised to curb foreign output fluctuations. It is important to note that the increase in the federal funds rate in response to output growth shock is small in magnitude compared to its response to an oil price shock. Following a positive shock to foreign output growth, domestic inflation increases and the real effective exchange rate appreciates, but these effects are not statistically significant. Therefore, foreign output fluctuations do not have a strong, persistent effect on the Sri Lankan economy, except on domestic output growth. This result is similar to the findings for East Asian economies noted by Allegret et al. (2012), who reported a small positive effect on domestic output and an insignificant effect on domestic prices following a positive foreign output shock.

### 3.3.2 Forecast error variance decomposition

Another way to assess the effect of external shocks on domestic variables is to look at the Forecasted Error Variance Decomposition (FEVD) of the structural model. Table 3.2 summarizes the estimates of the average fraction of variance in domestic variables explained by external and domestic shocks.

The error variance decomposition indicates notable effects of foreign shocks on the macroeconomic variables of Sri Lanka. On average, external shocks account for 20 per
Figure 3.5  **Impulse responses to a foreign output shock (EFFR model)**

- **Response of GDP to GDP_US**
- **Response of INF to GDP_US**
- **Response of ΔINT to GDP_US**
- **Response of ΔREER to GDP_US**
- **Response of GDP_US to GDP_US**
- **Response of ΔEFFR to GDP_US**

Legend:
- **-.--** 90% confidence band
- **-** Structural IRF
cent of the variation in the domestic output growth, 38 per cent of the variation in the
domestic inflation, 8 per cent the variation in the domestic interest rate and 17 per cent of
the variation in the real effective exchange rate. This indicates a considerable impact of
foreign shocks on the domestic output growth and inflation.

Since the domestic interest rate is least affected by the foreign shocks, the effects of
foreign shocks are transmitted to the Sri Lankan economy mainly through trade linkages
rather than through financial markets. Further, the Central Bank of Sri Lanka appears to
focus on domestic shocks, particularly the real exchange rate, when setting domestic
interest rates. Of the three foreign shocks considered, the foreign interest rate has the
highest impact on domestic short term interest rate. The effects of foreign interest rate
on domestic variables appear to be persistent with such effects increasing over each time
horizon.

Except for the own shock, none of the domestic shocks are as important as the foreign
shocks for the variability in domestic output growth. All three foreign shocks seem to be
equally important for the GDP growth fluctuations in Sri Lanka.

Further, the domestic price level is prone to oil price shocks and more than 18 per cent
variation in domestic inflation is explained by the oil price shocks at all time periods. As
pointed out in Section 3.3.1, the foreign interest rate affects domestic inflation initially through the trade channel and subsequently via the interest rate channel. On average, 16 per cent of the variation in domestic inflation is explained by the foreign interest rate.

3.3.3 Historical decomposition

The impulse responses and forecast error variance decomposition in the preceding sections only reflect the overall effect of external shocks on domestic macroeconomic variables. In contrast, the historical decomposition technique is useful to analyse the role of external shocks in a specific period. Though the overall contribution of a particular external shock is small, its effect might be more prominent during certain sub-periods. Therefore, historical data is decomposed into a base projection and the accumulated effect of past and current structural shocks. The forecast error of domestic variables attributable to each structural shock at each period is calculated by this historical decomposition.

Figures 3.6 and 3.7 illustrate the historical decomposition of domestic output growth and domestic inflation for 2005-2014. The historical decompositions of the other domestic variables are given in Appendix 3.C. In each graph the solid line depicts the actual data. The projected data for each variable based on the reduced from VAR is shown by the dotted lines. The dashed lines illustrate the sum of base projection and the accumulated effect of a particular structural shock.

The historical decomposition of domestic output also reveals that domestic output shocks have mattered most for output growth fluctuations. The role of other domestic variables on output growth fluctuations has been minor at all periods. In comparison to other domestic variables, external shocks have been more important for domestic output growth variation. Particularly, the dip in output growth during the 2008-2009 period can be attributed to the oil price inflation and foreign output growth shocks.

Demand shocks represented by the domestic inflation shocks have been the key source of fluctuations in domestic inflation. Further, oil price and foreign interest rate shocks have contributed considerably to the rise in domestic inflation in the 2007-2008 period and also for the subsequent fall in inflation. Although domestic interest rate shocks have not contributed much to the fluctuation in domestic inflation at other times, it has been important to curb the rising inflation in 2008 to some extent.
Figure 3.6  Historical decomposition of domestic output growth (EFFR model)
Figure 3.7  **Historical decomposition of domestic inflation (EFFR model)**

- Effect of OIL
- Effect of GDP_US
- Effect of ΔEFFR
- Effect of ΔREER
- Effect of GDP
- Effect of INF
- Effect of ΔINT

Legend:
- Actual data
- Base projection
- Sum of base projection and the effect of structural shock
3.4 Alternative measure of foreign monetary policy

In the past, the federal funds rate was the primary instrument of monetary policy for the Federal Reserve (Fed) of the US. The Fed used to raise the federal funds rate to slow down economic activity and curtail inflation, but lowered the interest rate when it was necessary to stimulate the economy. Therefore, many past studies have used the federal funds rate variable to represent US monetary policy (Cushman and Zha 1997 and Maćkowiak 2007). However, the federal funds rate has been near zero level since the beginning of the global financial crisis and lowering this interest rate further has not been an option for the Fed in order to stimulate the US economy. The Fed has relied on unconventional monetary policy measures such as quantitative easing (i.e., large-scale asset purchases from the private sector) and on affecting long-term interest rates through forward guidance. Therefore, several researchers have attempted to summarize the Fed’s overall monetary policy stance by developing a shadow short rate (SSR) that captures the effects of the federal funds rate as well as unconventional monetary policy tools (Krippner 2013, Wu and Xia 2016, Krippner 2015). Although the policy rate may not reflect the overall monetary policy stance due to its constraint at near-zero values, the SSR can freely take negative values to encompass a near-zero policy rate plus unconventional monetary policy actions. Further, Krippner (2015) points out that the SSR estimates from a two-factor shadow/lower bound terms structure models (SLM) are relatively robust and correlate well with the unconventional monetary policy events.

The model mentioned in Section 3.2 is re-analysed using the SSR of the US as the foreign monetary policy measure. Accordingly, the SSR variable replaced the EFFR variable in the model and \( Y_t' = [OIL, GDP, SSR, GDP, INF, INT, REER] \). The SSR data set for the US, which has been created based on the research of Leo Krippner, was obtained from the Reserve Bank of New Zealand website. The SSR data estimates are based on the two-factor SLM model analysed with the data from 1985-2016. The data set was accessed from the following web link: http://www.rbnz.govt.nz/research-and-publications/research-programme/additional-research/measures-of-the-stance-of-united-states-monetary-policy.

Figure 3.8 illustrates the SSR of the US generated from the two-factor SLM model by Krippner (2015). Similar to the effective federal funds rate, the SSR is also an \( I(1) \) variable as per the results of the ADF, PP and KPSS tests (Appendix 3.A). Therefore, the model is analysed with the first difference term of the SSR variable.
From this point onwards, the model with short-run and long-run restrictions and the effective federal funds rate as the foreign monetary policy variable will be referred to as the baseline-EFFR model. The same model analysed with the SSR variable will be referred to as the SSR model.

Figure 3.8  Quarterly US shadow short rate

The impulse response graphs of the SSR model are given in Appendix 3.E. Further, Appendix F provides the historical decomposition of the domestic variables. The impulse responses of the SSR model are qualitatively similar to those of the baseline-EFFR model. The Table 3.3 provides the error variance decomposition of domestic variables with the SSR model. Each error variance estimate is the average figure for the time horizon considered.

The error variance decomposition of domestic variables under the SSR model quantitatively differs from the baseline-EFFR model. In the SSR model, foreign shocks explain 20 percent of the variation in domestic output growth, 28 per cent of the variation in domestic inflation, 6 per cent variation in domestic interest rate and 18 per cent of the variation in real effective exchange rate. On the other hand, external shocks account for 20 percent of the variation in domestic output growth, 38 per cent of the variation in domestic inflation, 8 per cent of the variation in domestic interest rate and 17 per cent of the variation in real effective exchange rate in the baseline-EFFR model.

In the baseline-EFFR model, all three external shocks are more or less equally important for domestic output growth variation, though oil price shocks are more important than other two external shocks in the SSR model. External shocks still explain a higher
proportion of domestic output variation than other domestic shocks, except for the shocks to domestic output growth.

The effect of external shocks on the domestic inflation is lower under the SSR model compared to that of the baseline-EFFR model. Similar to the baseline EFFR model, domestic inflation is more prone to oil price shocks in the SSR model. On average, 17 per cent of the domestic inflation variation is explained by oil price shocks. On the other hand, the effect of the SSR shocks on domestic inflation is considerably lower compared to the effect of EFFR. In the EFFR model, foreign interest rate explains 16 per cent of the variation in domestic inflation, but the same figure is only 9 per cent in the SSR model. Therefore, the shocks to the EFFR are better at explaining the error variance in domestic output growth and inflation than the shocks to the SSR under the given model assumptions.

Table 3.3  Forecast error variance decomposition (SSR model)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Horizon (quarters)</th>
<th>Source of Disturbance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>OIL</td>
<td>GDP_US</td>
</tr>
<tr>
<td>GDP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>9.76</td>
<td>5.36</td>
</tr>
<tr>
<td>5-8</td>
<td>9.11</td>
<td>5.60</td>
</tr>
<tr>
<td>8-12</td>
<td>9.10</td>
<td>5.59</td>
</tr>
<tr>
<td>INF</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>15.41</td>
<td>1.88</td>
</tr>
<tr>
<td>5-8</td>
<td>17.10</td>
<td>2.52</td>
</tr>
<tr>
<td>8-12</td>
<td>17.10</td>
<td>2.52</td>
</tr>
<tr>
<td>INT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>1.80</td>
<td>2.22</td>
</tr>
<tr>
<td>5-8</td>
<td>2.45</td>
<td>2.41</td>
</tr>
<tr>
<td>8-12</td>
<td>2.45</td>
<td>2.41</td>
</tr>
<tr>
<td>REER</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-4</td>
<td>4.85</td>
<td>3.14</td>
</tr>
<tr>
<td>5-8</td>
<td>8.77</td>
<td>4.08</td>
</tr>
<tr>
<td>8-12</td>
<td>8.78</td>
<td>4.08</td>
</tr>
</tbody>
</table>

3.5 Robustness

The SVAR can be very sensitive to model assumptions and the robustness of the model can be checked by estimating it with alternative assumptions. Therefore, the EFFR model is re-estimated using two alternative identification schemes to check for robustness. First, the model is identified with Cholesky decomposition while having the same variable
ordering. The response patterns do not change qualitatively for all other variables except for the interactions between the domestic interest rate and the exchange rate variables. Using the Cholesky decomposition, a shock to the domestic interest rate leads to a depreciation of real exchange rate indicating an exchange rate puzzle (Appendix D). Further, the interest rate does not respond significantly to a real exchange rate shock. This alternative identification scheme justifies the use of the short-run and long-run identification scheme used in this essay to avoid any exchange rate puzzle.

Further, the oil price inflation variable was placed ahead of the US GDP output growth variable in the baseline-EFFR model indicating oil prices inflation affects US output growth only with one quarter lag. Therefore, the EFFR model is re-estimated by placing US GDP growth ahead of the oil price inflation within the order of variables. Accordingly, $Y_t' = [GDP_{US}, OIL, EFFR, GDP, INF, INT, REER]$ 

However, the results of this alternative identification scheme are more or less similar to the results of the baseline-EFFR model.

3.6 Conclusion

This essay has investigated the impact of external shocks on macroeconomic variables of Sri Lanka using a structural VAR model. Sri Lanka is a small open economy and, hence, the model incorporates the block exogeneity assumption. Further, the model is non-recursively identified with a combination of short and long-run restrictions. This essay focuses on oil price inflation shocks, foreign output growth shocks and foreign monetary policy shocks. In most of the related literature, the effective federal funds rate has been used as a proxy for the US monetary policy. Moving one step further, this chapter has investigated the effect of foreign monetary policy on the Sri Lankan economy using the federal funds rate as well as the shadow short rate for the US.

Approximately, 20 percent of the variation in the domestic output growth, 38 per cent of the variation in the domestic inflation, 8 per cent variation in the change in the domestic interest rate and 17 per cent of the variation in the change in real effective exchange rate can be explained by the external shocks in the model with EFFR as the foreign monetary policy variable. The comparative figures of the model with shadow short rate are more or less the same, except for the domestic inflation rate variable. Only 28 per cent of the
variation in domestic inflation is explained by the foreign shocks under the SSR model. This essay indicates that the domestic macro-variables are more prone to shocks to the effective federal funds rate than to shocks to the SSR.

None of the domestic shocks, except the shocks to output growth, are as important as the foreign variables in explaining domestic output growth variation. Shocks to foreign output growth and oil price inflation have considerably influenced the fall in domestic output growth in 2008-2009. However, when the full sample period is considered, all three external shocks have been equally important for domestic output growth fluctuations in the baseline-EFFR model while oil price shocks are more important than other foreign shocks under the SSR model.

On the other hand, oil price inflation and the effective federal funds rate have a notable impact on domestic inflation, but the effect of foreign output growth shocks is minor. The impact of oil price inflation and foreign interest rate on domestic inflation was more prominent during the 2007 to 2008 period.

Foreign interest rate shocks initially affect the domestic inflation through the import prices and subsequently through the domestic interest rate. Therefore, effects of foreign shocks are transmitted to the domestic economy through the trade channel as well as the interest rate channel. This is different from the findings for G-6 countries and Latin American countries where the interest rate channel played a key role in transmitting US shocks to domestic economies (Kim, 2001, Canova, 2005). However, shocks to the real exchange rate have a remarkable effect on domestic short term interest rates. Hence, the Central Bank of Sri Lanka seems to be giving high priority to domestic variables, especially the real exchange rate, when setting domestic interest rates.

The results of this study highlight the importance of external shocks to a small open economy such as Sri Lanka. Even though the country is not highly integrated with global markets as other emerging economies, Sri Lanka is considerably vulnerable to external shocks. Hence, it is crucial to consider such foreign shocks when modelling the Sri Lankan economy as well as in policy making.
## Appendix 3.A

### Unit root tests

#### Table 3.A.1 Summary of unit root tests

<table>
<thead>
<tr>
<th></th>
<th>Level</th>
<th>1st Difference</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ADF</td>
<td>PP</td>
<td>KPSS</td>
</tr>
<tr>
<td></td>
<td>Test statistic</td>
<td>5% critical level</td>
<td>Test statistic</td>
</tr>
<tr>
<td>OIL</td>
<td>-2.903</td>
<td>5.497**</td>
<td>0.463</td>
</tr>
<tr>
<td>GDP_US</td>
<td>-2.901</td>
<td>5.581*</td>
<td>0.463</td>
</tr>
<tr>
<td>EFFR</td>
<td>-2.902</td>
<td>1.441*</td>
<td>0.463</td>
</tr>
<tr>
<td>GDP</td>
<td>-2.902</td>
<td>9.524*</td>
<td>0.463</td>
</tr>
<tr>
<td>INF</td>
<td>-2.901</td>
<td>5.476*</td>
<td>0.463</td>
</tr>
<tr>
<td>INT</td>
<td>-2.901</td>
<td>2.493</td>
<td>0.463</td>
</tr>
<tr>
<td>EX</td>
<td>-2.901</td>
<td>-0.425</td>
<td>0.463</td>
</tr>
<tr>
<td>SSR</td>
<td>-2.902</td>
<td>-1.337</td>
<td>0.463</td>
</tr>
</tbody>
</table>

### Notes:
- * H₀ rejected at 5% probability level.
- ** H₀ rejected at 10% probability level.
- *** H₀ cannot be rejected at 1% probability level.
- NA – Not applicable

**Decision criteria**

- **ADF Test**
  - H₀ : Series has a unit root
  - H₁ : Series is stationary
  - Decision criteria: Reject Null hypothesis (H₀) if ADF test statistic < Critical value

- **Phillips-Perron Test**
  - H₀ : Series has a unit root
  - H₁ : Series is stationary
  - Decision criteria: Reject Null hypothesis (H₀) if Phillips-Perron test statistic < Critical value

- **KPSS Test**
  - H₀ : Series is stationary
  - H₁ : Series is non-stationary
  - Decision criteria: Reject Null hypothesis (H₀) if KPSS test statistic > Critical value
Appendix 3.B  Impulse responses of the EFFR model

Figure 3.B.1  Impulse responses to a domestic output growth shock (EFFR model)
Figure 3.B.2  Impulse responses to a domestic inflation shock (EFFR model)

Response of GDP to INF

Response of ΔINT to INF

Response of INF to INF

Response of ΔREER to INF

---

90% confidence band  Structural IRF
Figure 3.B.3  Impulse responses to an exchange rate shock (EFFR model)

Response of GDP to ΔREER

Response of INF to ΔREER

Response of ΔINT to ΔREER

Response of ΔREER to ΔREER

90% confidence band  Structural IRF
Appendix 3.C  

Historical decomposition of the EFFR model

Figure 3.C.1  Historical decomposition of change in the domestic interest rate (EFFR model)
Figure 3.C.2  **Historical decomposition of change in the real effective exchange rate (EFFR model)**

- **Effect of OIL**
- **Effect of GDP_US**
- **Effect of ΔEFFR**
- **Effect of GDP**
- **Effect of INF**
- **Effect of ΔINT**
- **Effect of ΔREER**

Legend:
- **- - - - - Actual data**
- **- - - - - Base projection**
- **- - Sum of base projection and the effect of structural shock**
Appendix 3.D  Domestic monetary policy shock under the Cholesky identification

Figure 3.D.1  Impulse responses to a contractionary monetary policy shock with the Cholesky identification

![Response of GDP to ΔINT](image1)

![Response of INF to ΔINT](image2)

![Response of ΔINT to ΔINT](image3)

![Response of ΔREER to ΔINT](image4)
Appendix 3.E  Impulse responses of the SSR model

Figure 3.E.1  Impulse responses to an oil inflation shock (SSR model)
Figure 3.E.2  Impulse responses to a foreign output growth shock (SSR model)

- Response of GDP to GDP_US
- Response of INF to GDP_US
- Response of ΔINT to GDP_US
- Response of ΔREER to GDP_US
- Response of ΔEFFR to GDP_US
- Response of GDP_US to GDP_US

---

90% confidence band  Structural IRF
Figure 3.E.3  Impulse responses to a foreign contractionary monetary policy shock (SSR model)
Figure 3.E.4  Impulse responses to a domestic output growth shock (SSR model)

- Response of GDP to GDP
- Response of INF to GDP
- Response of ΔINT to GDP
- Response of ΔREER to GDP

---

90% confidence band  Structural IRF
Figure 3.E.5  Impulse responses to a domestic inflation shock (SSR model)

Response of GDP to INF

Response of INF to INF

Response of ΔINT to INF

Response of ΔREER to INF

- Structural IRF
- 90% confidence band
Figure 3.E.6  Impulse responses to domestic contractionary monetary policy shock (SSR model)

- **Response of GDP to ΔINT**
- **Response of INF to ΔINT**
- **Response of ΔINT to ΔINT**
- **Response of ΔREER to ΔINT**

- 90% confidence band
- Structural IRF
Figure 3.E.7  Impulse responses to an exchange rate shock (SSR model)

Response of GDP to ΔREER

Response of INF to ΔREER

Response of ΔINT to ΔREER

Response of ΔREER to ΔREER

---

90% confidence band  Structural IRF
Appendix 3.F Historical decomposition of the SSR model

Figure 3.F.1 Historical decomposition of domestic output (SRR model)
Figure 3.F.2  
**Historical decomposition of domestic inflation (SRR model)**

- Effect of OIL
- Effect of GDP_US
- Effect of ΔEFFR
- Effect of ΔINT
- Effect of ΔREER
- Effect of GDP

Legend:
- Black line: Actual data
- Dotted line: Base projection
- Dot-dashed line: Sum of base projection and the effect of structural shock
Figure 3.F.3  **Historical decomposition of change in the domestic interest rate (SRR model)**
Figure 3.F.4  Historical decomposition of change in the real effective exchange rate (SRR model)
TERMS OF TRADE AND THE SRI LANKAN ECONOMY: A SIGN-RESTRICTED VAR APPROACH

4.1 Introduction

The terms of trade of a country is one of the crucial relative prices in macroeconomics (Cashin et al. 2004). Recurrent and substantial volatility in terms of trade is widely viewed as a key source of macroeconomic fluctuations, particularly in less-developed economies. Developing countries are more prone to terms of trade fluctuations as they generally export primary commodities and are unable to influence world market prices significantly. The Harberger-Laursen-Metzler hypothesis suggests that a deterioration of terms of trade will negatively affect the trade balance and reduce the real income of a country. However, Jääskelä and Smith (2013) argue that the effect of terms of trade shocks on a domestic economy depends on the nature of the underlying external shock that triggers the terms of trade fluctuation. The downward trend in the net-barter terms of trade and the widening trade deficit in Sri Lanka over the past two decades have been concerns for the country’s policy-makers. What are the sources of terms of trade fluctuations in Sri Lanka? Do all terms of trade shocks have a similar impact on domestic macroeconomic variables? How do the Sri Lankan variables respond to the shocks that cause terms of trade fluctuations? Using a sign-restricted VAR model, this essay attempts to answer these questions by investigating the effects on the Sri Lankan economy from external shocks that cause terms of trade movements.

The net-barter terms of trade is the ratio between export prices and import prices of a country. Being a small open economy, Sri Lanka is unable to influence the prices of both its imports and exports and hence the terms of trade of the country is determined exogenously. Sri Lanka is potentially vulnerable to terms of trade fluctuations for a number of reasons. First, a considerable portion of Sri Lankan exports consists of less-value-added products. With the economic reforms introduced in 1977, Sri Lanka partly diversified its exports sector from the traditional agricultural commodities to labour-intensive manufacturing goods. Yet, 25 per cent of the country’s exports during the 2010-2014 period consisted of agricultural commodities. Second, the country’s exports are concentrated in a few goods. When the 2010-2014 period is considered, textile and
garments, tea and industrial rubber products accounted for 41, 15 and 8 per cent of the country’s exports, respectively. Therefore, fluctuations in tea and rubber prices in the world market have a considerable impact on the country’s terms of trade and the exports sector. Third, Sri Lanka relies on imports for its intermediate and capital goods. Within the 2010-2014 period, intermediate goods and capital goods accounted for 60 and 22 per cent of the country’s imports, respectively. During the same time period, on average 24 per cent of the country’s imports were fuel products. Therefore, prices of oil and fertilizers in the global market have a notable impact on the country’s production and as well as on domestic prices.

As depicted in Figure 4.1, the terms of trade of Sri Lanka has gradually declined during the past two decades. Although imports and exports have grown substantially over time, both imports and exports as a percentage of GDP have declined. Nevertheless, the trade deficit as a percentage of GDP has increased, particularly since 2010, raising concerns among the country’s economists and policy-makers. On the other hand, Sri Lanka has recorded an impressive annual average growth rate of 6.75 per cent during the 2005-2014 period despite the deteriorating terms of trade and widening trade deficit. Therefore, it is worthwhile investigating the effect of the terms of trade movements on the Sri Lankan economy.

Harberger (1950) and Laursen and Metzler (1959) were some of the first to investigate the link between terms of trade shocks and the macroeconomy. They assert that a deterioration in the terms of trade would decrease the real income (or raise the real expenditure for a given level of real income) of a country leading to reduced savings (and a worsening of the current account) through consumption smoothing behaviour. This hypothesis is well-known as the Harberger-Laursen-Metzler effect. Otto (2003) finds strong evidence to support the Harberger-Laursen-Metzler hypothesis. This concept is further extended by Obstfeld (1982) and Kent and Cashin (2003), who suggest that the duration or persistence of terms of trade shocks is pivotal in determining their effect on an economy. They suggest that unanticipated and permanent deterioration in terms of trade would lower the real income of a country permanently, leading to a permanent reduction in consumption without disrupting the country’s savings plan or the current account balance. On the other hand, if the unanticipated terms of trade deterioration is more transitory in nature, real income, current account,
Figure 4.1  Selected macroeconomic variables of Sri Lanka

- **Terms of trade**
  - Graph showing the terms of trade (TOT) over time.

- **Trade deficit, exports and imports**
  - Graph showing trade deficit, exports, and imports as a percentage of GDP (TB/GDP, IM/GDP, EX/GDP).

- **GDP Growth**
  - Graph showing quarter over quarter GDP growth.

- **Domestic Inflation**
  - Graph showing quarter over quarter CPI inflation.
consumption and savings would behave as predicted by the Harberger-Laursen-Metzler hypothesis.

In his seminal essay, Mendoza (1995) examines the relationship between the terms of trade and macroeconomic fluctuations in small open economies. He observes the movements in terms of trade and macro-variables and compares them with the predictions of a theoretical model. Mendoza (1995) asserts that a large fraction of the variance in output and exchange rate fluctuations can be explained by terms of trade shocks. Kose (2002) extends Mendoza (1995)’s work by developing a model that better captures the characteristics of developing countries, such as large trade deficit, higher debt-to-GDP ratio and large non-traded goods sector in the economy, and reports similar findings. Numerous other studies have shown that terms of trade volatility accounts for a large fraction in the variance of output, output growth, current account, consumption and public and private savings in developing economies (Easterly et al., 1993, Agénor et al., 2000).

Several studies have shown that the impact of terms of trade shocks on macroeconomic variables is influenced by the structural characteristics of the domestic economy. Applying a semi-structural VAR model to a panel of 88 countries, Loayza and Raddatz (2007) investigate how the domestic structural characteristics related to product and factor market flexibility and openness influence the effect of terms of trade shocks on aggregate output. They find that great trade openness magnifies the effect of terms of trade shock on output while financial openness reduces the impact. Further, the flexibility of labour markets dampens the negative effect of terms of trade shocks and ease of firm-entry magnifies the positive effects. Broda and Tille (2003) show that the countries with flexible exchange rate regimes are less vulnerable to terms of trade shocks than the countries with fixed exchange rate regimes. Broda (2004) also asserts that the output, price and exchange rate responses of a country to a terms of trade shock significantly differ across different exchange rate regimes. These studies indicate that the effect of terms of trade shocks on an economy is by and large country specific depending on the country’s structural characteristics. Therefore, modelling the Sri Lankan economy separately is essential to better understand the effect of terms of trade shocks on the Sri Lankan economy.

In the more recent literature it has been argued that the response of macro-variables to the fluctuations in certain external variables depends on the characteristics of the underlying
shock. For example, the effects of oil price fluctuations on the US and European economies highly depend on the nature of the shock (Kilian, 2009, Peersman and Van Robays, 2009 and Melolinna, 2012). As Kilian (2009) points out, the approach of modelling the oil price shocks as uncorrelated shocks to the rest of the foreign variables in a VAR model is fundamentally incorrect. This is because the oil prices are determined endogenously rather than exogenously within global markets depending on the underlying shocks, such as aggregate demand shocks and supply shocks. Therefore, it is essential to specify these underlying shocks in the VAR model to properly investigate the effect of oil price fluctuations on the domestic economy. Mangadi and Sheen (2016) suggest that the same idea can be applied to the terms of trade shocks as well. Even though the terms of trade is exogenous for a small open economy, this variable will be determined endogenously within the global market. If the underlying shocks that cause terms of trade fluctuations are not specified in the VAR model, the reverse causality coming from other global variables to the terms of trade may not be captured. Therefore, Jääskelä and Smith (2013) and Karagedikli and Price (2012) assume that the export and import prices, which are influenced by various external shocks, would affect the Australian and New Zealand economies directly as well as through the terms of trade.

Jääskelä and Smith (2013) posit that the export and import prices (and in turn, the terms of trade) of Australia are affected by world demand shocks, commodity-specific shocks and globalization shocks. Their ‘world sector’ consists of three variables, i.e., export and import prices of Australia and world output. World demand shock is common to both export and import prices and is associated with the global business cycle. In contrast, commodity-specific shocks are limited to export prices and may or may not have an effect on import prices. The third shock considered by Jääskelä and Smith (2013), i.e., globalization shock, allows export and import prices to move in opposite directions. This shock captures the effect of the entry of large emerging economies to global markets, which leads to an increase in export prices and world output and a decrease in import prices. On the other hand, Karagedikli and Price (2012) incorporate world output, the commodity factor, world prices, export prices and import prices of New Zealand as global variables. They assume that the terms of trade of New Zealand is affected by the world demand, world supply and globalization shocks. They specify world supply shocks as a decrease in world output and an increase in commodity factor and export prices.
There are very few studies that have been conducted with regard to the terms of trade of Sri Lanka or its effect on the domestic economy. Athukorala (2000) investigates the impact of export product diversification in Sri Lanka on the terms of trade of the country. He asserts that product diversification from traditional primary agricultural commodities to labour-intensive manufacturing goods has improved the net-barter terms of trade and income terms of trade of Sri Lanka. However, Athukorala (2000) does not focus on the effect of terms of trade movements on the macro-variables of the domestic economy. Therefore, this essay attempts to fill the gap in the existing literature and investigates the impact of external shocks that triggers the terms of trade fluctuations on Sri Lankan macroeconomic variables.

This essay considers three external shocks that cause terms of trade movements, namely, world demand shocks, world supply shocks and globalization shocks. The results of this study show that positive world demand and negative world supply shocks instantaneously deteriorate Sri Lanka’s terms of trade, but the terms of trade improves after two quarters in response to a world supply shock. Conversely, globalization shocks improve the terms of trade of the country temporarily. This is because, the entry of the emerging markets to the global trading systems drives the export prices high through increased demand and causes a downward pressure on import prices through cheap, manufactured goods. However, the terms of trade will marginally decline relative to the original level after three quarters under a globalization shock and will revert to the initial level after 10-12 quarters. Positive world demand shocks do not have a long-term significant impact on domestic output and negative world supply shocks are contractionary. Positive globalization shocks increase domestic output permanently. Both positive world demand shocks and globalization shocks are inflationary and increase domestic price levels permanently. On the other hand, world supply shocks increase domestic prices initially but reduce the price level after two quarters. The external shocks account for 39 per cent of the variation in output and price levels in Sri Lanka.

The remainder of the essay is structured as follows. Section 4.2 explains the baseline-VAR model, data and the sign restrictions pertaining to the three external shocks. The results of the baseline model, including impulse responses, forecast error variance decomposition and historical decomposition are discussed in Section 4.3. Further, the model is re-estimated with the trade balance, exports and imports variables and the findings are explained in Section 4.4. The checks for robustness of the results of baseline-
VAR model are discussed in Section 4.5. The final section of the essay summarizes the overall findings highlighting the importance of modelling the terms of trade of a small open economy as an endogenous variable within the global economy.

4.2 Methodology

Following Jääskelä and Smith (2013) and Karagedikli and Price (2012), a sign-restricted VAR model is used to identify the external shocks that trigger the terms of trade fluctuations in the Sri Lankan economy. The terms of trade is determined within the global markets due to the relative movements of export and import prices. Hence, the model is specified to include import and export prices separately, instead of incorporating the terms of trade as a single variable.

4.2.1 Baseline VAR model

The baseline structural VAR model can be expressed as

\[
\begin{bmatrix}
    w_t \\
    d_t
\end{bmatrix}
= \beta x_t + \sum_{i=1}^{p} A_i \begin{bmatrix}
    w_{t-i} \\
    d_{t-i}
\end{bmatrix} + B \begin{bmatrix}
    \varepsilon^w_t \\
    \varepsilon^d_t
\end{bmatrix}
\]

where \( w_t \) and \( d_t \) are the vectors of endogenous world and domestic variables respectively; \( x_t \) is a vector of exogenous variables; \( \beta \) is the coefficient matrix of exogenous variables; \( A_i \) is the lag coefficient matrix; \( B \) is the contemporaneous impact matrix of the vectors of mutually uncorrelated world (\( \varepsilon^w_t \)) and domestic (\( \varepsilon^d_t \)) disturbances with a variance-covariance matrix of \( \Omega \). The variance-covariance matrix has the dimensions of \( (m \times m) \) and \( m \) is the number of endogenous variables in the VAR model. Since structural shocks are orthogonal,

\[
E \left( \begin{bmatrix}
    \varepsilon^w_t \\
    \varepsilon^d_t
\end{bmatrix} \begin{bmatrix}
    \varepsilon^w_t \\
    \varepsilon^d_t
\end{bmatrix}^T \right) = \Omega_e = I
\]

where \( I \) is an identity matrix.

Following Jääskelä and Smith (2013), the world-block of the VAR model consists of three variables: \( w_t' = (expr_t, impr_t, y^*_t) \) where \( expr \) is the real export prices; \( impr \) is the real import prices and \( y^*_t \) is the level of trade-weighted output of Sri Lanka’s major trading partners. There are four variables in the domestic block: \( d_t' = (y_t, cpi_t, int_t, reer_t) \) where \( y_t \) is the domestic output level; \( cpi_t \) is the domestic consumer price index; \( int_t \) is the domestic short-term interest rate; and \( reer_t \) is the real effective exchange rate of Sri Lanka. A full description of the data and their sources is given in Appendix 4.A. As Sri
Lanka is a small open economy, the lag coefficients of the domestic variables on the foreign variable equations of the VAR model are restricted to zero. The lag structure of the model is summarized in Table 4.1.

Table 4.1  Lag structure of the model

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>expr</th>
<th>impr</th>
<th>y'</th>
<th>y</th>
<th>cpi</th>
<th>int</th>
<th>reer</th>
</tr>
</thead>
<tbody>
<tr>
<td>expr</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>impr</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$y_t^i$</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$y_t$</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cpi</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>int</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>reer</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: * indicates lags of the independent variable appear in the dependent variable equation

The Hannan–Quinn Information Criterion (HQIC) and Schwarz-Bayesian Information Criterion select 1 lag as the optimal lag length. However, two lags are chosen for the model to allow adequate model dynamics. The Seemingly Unrelated Regression Equation (SURE) estimation technique is used to estimate this baseline near-VAR model.

The sample used for the estimation runs from 1997Q1 to 2014Q4. The start date of the sample is restricted by the commencement date of the compilation of quarterly unit price indices of exports and imports of Sri Lanka. Further, a dummy variable, $gfc$, is used to capture the period of global financial crisis and the resultant economic down-turn in the world economy. Accordingly, $gfc = 1$ from 2007Q4 to 2009Q2.

All variables, except for the interest rate, are expressed in natural logarithm. The Augmented Dicky-Fuller, Phillip-Peron and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests indicate that all variables other than interest rate are $I(1)$ variables. The domestic interest rate is a $I(0)$ variable as per the Augmented Dicky-Fuller and KPSS tests. The Johansen test for cointegration suggests that variables are cointegrated. Therefore, variables are left in non-stationary form and the VAR model is estimated in levels to avoid potential inconsistency in the parameter estimates caused by the imposition of incorrect co-integrating restrictions (Sims et al. 1990). The VAR stability test indicates that all Eigen values are less than one and the base-line VAR model is stable.

105
4.2.2 From reduced-form VAR model to sign-restricted VAR

The reduced-form of the baseline VAR model can be written as

\[
\begin{bmatrix}
    w_t \\
    d_t
\end{bmatrix} = \beta x_t + \sum_{i=1}^{p} A_i \begin{bmatrix}
    w_{t-i} \\
    d_{t-i}
\end{bmatrix} + \begin{bmatrix}
    e^w_t \\
    e^d_t
\end{bmatrix}
\]  

(4.3)

where \( e^w_t \) and \( e^d_t \) are the reduced-form residuals of the world and domestic variables. Further,

\[
\begin{bmatrix}
    e^w_t \\
    e^d_t
\end{bmatrix} = B \begin{bmatrix}
    e^w_t \\
    e^d_t
\end{bmatrix}
\]  

(4.4)

The equation (4.4) can be re-written as

\[
E \begin{bmatrix}
    e^w_t \\
    e^d_t
\end{bmatrix} \begin{bmatrix}
    e^w_t \\
    e^d_t
\end{bmatrix}' = BE \begin{bmatrix}
    e^w_t \\
    e^d_t
\end{bmatrix} \begin{bmatrix}
    e^w_t \\
    e^d_t
\end{bmatrix}' B'
\]  

(4.5)

By combining (4.2) and (4.5)

\[
\Omega_e = BB'
\]  

(4.6)

where \( \Omega_e \) is the variance-covariance matrix of the reduced form VAR.

Since \( \Omega_e \) can be obtained through the reduced-form VAR model, the structural shocks, \( e^w_t \) and \( e^d_t \), can be identified by finding the \( B \) matrix and applying it to equation (4.4). The identification of structural shocks is generally achieved by placing restrictions on the parameters of the VAR model. However, the sign-restrictions approach, which places restrictions on the direction of the movement of variables (over a given time horizon) in response to different types of shocks, is becoming an increasingly popular method of structural shock identification. This approach has been used by Faust (1998), Canova and De Nicoló (2002), and Uhlig (2005).

Given the restrictions on the direction of impulse responses, the sign restrictions technique searches a \( B \) vector over the space of possible impulse vectors that would satisfy the equation (4.6). Therefore, \( B \) is not a lower-triangular matrix under the sign restriction approach as in the Cholesky decomposition. However, the Cholesky decomposition is used as an intermediate step to extract \( B \) in the sign restriction approach. Assume \( P \) is a lower triangular matrix that satisfies \( \Omega_e = PP' \). An orthogonal matrix \( D \) that yields \( B = PD \) and meets \( \Omega_e = BB' \) is selected. The sign restriction procedure adopted in this study consists of the following steps:

1) Generate a draw for the VAR coefficients and covariance matrix using SUR Gibbs procedure.
2) Compute a Cholesky factor and the response to it.
3) Generate a random unit vector $D$ in $m$-space.
4) Weight the impulse responses from step (2) by $D$ to get the responses to the chosen impulse vector.
5) If the impulse response meets the restrictions, save them.
6) Repeat steps (3)-(5) for 10,000 for each main draw.
7) Repeat steps (1)-(6) until 10,000 admissible structural models have been accepted.
8) Using all the admissible structural models, calculate the median values, 16 and 84 percentile values for each response over each time horizon.

Fry and Pagan (2011) criticize the practice of using median response as a measure of central tendency since it mixes the responses of different admissible structural models. Instead, they propose to select a single model (median target) that provides impulse responses that are closest to the median responses across all variables. In this essay, the process of selecting the median target model is similar to the technique proposed by Fry and Pagan (2011). However, this essay uses the inter-quartile range to rescale the responses instead of the standard deviation. The inter-quartile range is a more robust estimator, since the distribution of responses can sometimes be fat-tailed (Doan, 2015).

4.2.3 Identification of shocks
The sign-restriction scheme used in this essay is given in Table 4.2 below. Although there are seven variables in the model, only three shocks have been identified using sign restrictions. The rest of the shocks are identified using orthogonal Cholesky factorization. The identified shocks are specified in terms of their effect on the variables in the world block while their effects on the domestic variables are left unrestricted. Although sign restrictions can be applied to multiple quarters, sign restrictions are applied only to one quarter in the baseline sign restricted VAR model.

Following Jääskelä and Smith (2013) and Karagedikli and Price (2012), the world demand shock is specified to capture the movements in export and import prices due to the changes in aggregate demand in the world. Therefore, a positive world demand shock is represented by an increase in export prices ($expr$), import prices ($impr$) and the world output ($y_t^*$).
Table 4.2  Sign restrictions

<table>
<thead>
<tr>
<th></th>
<th>expr</th>
<th>impr</th>
<th>$y_t^*$</th>
<th>Domestic Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>World demand shock</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>NA</td>
</tr>
<tr>
<td>World supply shock</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>NA</td>
</tr>
<tr>
<td>Globalization shock</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>NA</td>
</tr>
</tbody>
</table>

The world supply shock may be thought of as an idiosyncratic shock to import and exports prices ($impr$ and $expr$) and the world output ($y_t^*$) due to supply-side disturbances. For example, this could represent an oil supply-side shock. An unanticipated negative shock to the world oil production can affect world output negatively while raising general price levels in the world. As a result, both the import and export prices for the Sri Lankan economy can increase simultaneously.

As described by Jääskelä and Smith (2013) and Karagedikli and Price (2012), the globalization shock is specified to capture the integration of large emerging market economies such as India and China into the global trading system. A positive globalization shock should increase the world output ($y_t^*$) and raise export prices ($expr$) due to increased demand for domestic goods in the global market. Simultaneously, import prices ($impr$) should decline due to the downward pressure on the prices of manufactured goods through increased supply. Unlike in ‘world demand’ shock (in which only aggregate demand in the world changes) and in ‘world supply’ shock (in which only aggregate supply in the world changes), both aggregate demand and supply in the world change simultaneously under a globalization shock, driving imports and exports prices for Sri Lanka in the opposite direction.

4.3  Results

A Bayesian approach, which captures both sampling and model uncertainty, is used for estimation and inferences. The median, $84^{th}$ and $16^{th}$ per centiles of the impulse responses are shown using 10,000 successful draws from the posterior. The direction of the response in the first quarter corresponds to the sign restrictions summarized in Table 4.2, but no restrictions are imposed on the magnitude of these responses. In addition, the impulse response graphs also illustrate the median target response, which is the impulse response of the model that is closest to the median across all variables (Fry and Pagan, 2007).
4.3.1 Impulse responses

Effects on the world economy

Figures 4.2, 4.3 and 4.4 depict the impulse responses of export prices, import prices and world output to a positive world demand shock, a negative world supply shock and a positive globalization shock, respectively. They also show the impulse responses of the implied terms of trade variable that is constructed from the responses of export and import prices, by dividing the export price by import price.

With a positive world demand shock, import prices rise by 2.5 per cent instantaneously while export prices increase only by 1.5 per cent. As a result, the terms of trade for the Sri Lankan economy deteriorate immediately by around 0.5-1.0 per cent due to a world demand shock. A larger portion of Sri Lanka’s exports earnings is derived from the textiles and garments industry and generally these apparel exports have sticky prices due to multi-year contracts. Further, the agricultural commodities exported by Sri Lanka are less value-added products. Hence, prices for these goods may not increase as much as the prices of intermediate and capital goods imported into the country during a world demand shock.

The effect on the terms of trade due to a world demand shock is more transitory in nature with the terms of trade reverting to the original level within 4 quarters. This finding is different from the results for the Australian economy described by Jääskelä and Smith (2013), who showed a permanent increase in Australia’s terms of trade due to a positive world demand shock. World output permanently increases by approximately 0.25 per cent due to a positive world demand shock.

Import prices rise instantaneously by 2.0 per cent in response to a negative world supply shock but within three quarters prices declines more than the original level. On the other hand, export prices increase by approximately 1.5 per cent instantaneously. Consequently, the terms of trade of Sri Lanka deteriorates instantaneously by circa 0.5 per cent due to a world supply shock but after two quarters the negative effect reverses and terms of trade improves marginally until 10-12 quarters. World output declines by 0.3-0.4 per cent in response to a world supply shock, but recovers within 6 quarters. Import prices decline for a very short period in response to a positive globalization shock but subsequently rise to a higher level than the original level permanently.
Figure 4.2  Impulse responses of foreign variables to a positive world demand shock

Note: Impulse responses of all variables are multiplied by 100 to obtain percentage increase.
Figure 4.3  Impulse responses of foreign variables to a negative world supply shock

Note: Impulse responses of all variables are multiplied by 100 to obtain percentage increase.
Figure 4.4  Impulse responses of foreign variables to a positive globalization shock

Note: Impulse responses of all variables are multiplied by 100 to obtain percentage increase.
The export prices also increase by about 1.0 per cent permanently due to a globalization shock. The impact response of the terms of trade to a globalization shock is positive and approximately 2.5-3.0 per cent in magnitude, which gradually recedes within three quarters to a level marginally lower than the initial level. The terms of trade reverts back to the original level only after 10-12 quarters. This result is in contrast to the findings for the Australian economy, where globalization shocks improve Australia’s terms of trade permanently (Jääskelä and Smith, 2013). Impulse response function indicates that world output increases permanently by 0.75-1.0 per cent in response to a globalization shock.

Effects of world demand shocks on the domestic economy

Figure 4.5 shows the impulse response of domestic variables to a positive world demand shock. As mentioned earlier, the terms of trade of Sri Lanka deteriorates immediately after the world demand shock but recovers to the original level within four quarters. As per the median target measure, the real output of Sri Lanka declines only for one quarter but recovers quickly. The deterioration of the terms of trade affects the real GDP of a country through its negative effect on production. Even if the weakened terms of trade negatively affect real GDP instantaneously, increasing foreign demand under a world demand shock will counteract this negative effect leading to no significant change in real GDP after the first quarter.

Positive world demand shocks increase the domestic price level quickly and permanently through increased import prices. The median target indicates that the domestic interest rate decreases marginally, which is not sufficient enough to prevent initial real exchange rate appreciation. The real exchange rate appreciates by approximately 1.5 per cent during the first two quarters. However, the real exchange rate gradually depreciates over time and reaches the original level within 12 quarters. With the increasing domestic price levels, the short term interest rate in Sri Lanka is increased marginally by the Central Bank.

Effects of world supply shocks on the domestic economy

The impulse responses of domestic variables to a negative world supply shock are depicted in Figure 4.6. The terms of trade of Sri Lanka deteriorates for two quarters due to a world supply shock, but quickly improves thereafter. The median target indicates that domestic output declines in response to a world supply shock and does not recover
fully even after six quarters. This is in contrast to a world demand shock, where domestic output quickly recovers within a quarter. Under a positive world demand shock, the increasing world output offset the negative effect of weakened terms of trade. But the foreign output also declines during a negative world supply shock, which leads to reduced demand for domestic goods and lower domestic output. Even though the terms of trade improve after two quarters, the negative effect coming from the lower foreign output persists. Hence, domestic output does not reach the previous level even after 6 quarters. Therefore, negative world supply shocks have a relatively long-term effect on domestic output compared to world demand shocks.

While the terms of trade deteriorate initially due to a negative world supply shock, the domestic price level increases marginally. However, the domestic price level declines marginally with the improved terms of trade after two quarters. The domestic interest rate is gradually reduced to boost the domestic economy and the peak effect is observed in the sixth quarter. The real exchange rate appreciates instantaneously in response to a world supply shock though this appreciation is marginal. However, the real exchange rate gradually depreciates over time with the reduction in the domestic interest rate.

**Effects of globalization shocks on the domestic economy**

Figure 4.7 illustrates the impulse responses of the Sri Lankan variables to a positive globalization shock. The terms of trade of Sri Lanka improves instantaneously in response to a globalization shock but reverts back to a level marginally lower than the original level within three quarters. The median target measure indicates that domestic output increases by 0.25-0.5 per cent permanently in response to a positive globalization shock. The improvement in terms of trade and the increased world output positively affect the real GDP of Sri Lanka.

Positive globalization shocks are clearly inflationary and raise the domestic price level gradually. The increase in domestic prices is circa 1.0 per cent by the 12th quarter. The Central Bank of Sri Lanka raises the domestic interest rate gradually to curb inflation. The maximum effect on the domestic interest rate is around 25 basis points and is observed in six to seven quarters after the globalization shock.
Figure 4.5  **Impulse responses of domestic variables to a positive world demand shock**

Note: Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.6  Impulse responses of domestic variables to a negative world supply shock

Note: Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.7  **Impulse responses of domestic variables to a positive globalization shock**

<table>
<thead>
<tr>
<th>Impulse Response of $y$</th>
<th>Impulse Response of CPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>0.50</td>
<td>1.00</td>
</tr>
<tr>
<td>1.00</td>
<td>1.50</td>
</tr>
<tr>
<td>1.50</td>
<td>2.00</td>
</tr>
<tr>
<td>2.00</td>
<td>2.50</td>
</tr>
<tr>
<td>2.50</td>
<td>3.00</td>
</tr>
<tr>
<td>3.00</td>
<td>3.50</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Impulse Response of int</th>
<th>Impulse Response of reer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00</td>
<td>-1.00</td>
</tr>
<tr>
<td>0.50</td>
<td>-0.50</td>
</tr>
<tr>
<td>1.00</td>
<td>0.00</td>
</tr>
<tr>
<td>1.50</td>
<td>0.50</td>
</tr>
<tr>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td>2.50</td>
<td>1.50</td>
</tr>
<tr>
<td>3.00</td>
<td>2.00</td>
</tr>
</tbody>
</table>

Note: Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
As per the median target, the real exchange rate appreciates marginally instantaneously but depreciates more than the original state within two quarters. This is in contrast to a positive world demand shock, where real exchange rate appreciates considerably in the impact period and subsequently depreciates gradually over a relatively longer period.

In summary, both the positive world demand and negative world supply shocks deteriorate Sri Lanka’s terms of trade instantaneously. However, the effects of the two shocks on the domestic variables are significantly different from each other. Therefore, not all negative terms of trade shocks faced by the Sri Lankan economy negatively affect domestic output. The positive globalization shocks improve the country’s terms of trade for a shorter period. Both world demand and globalization shocks are inflationary, though the impact of globalization shock on the domestic prices is more prominent. Further, the Central Bank of Sri Lanka responds differently to the three shocks. Initially, the bank reduces the domestic interest rate under all three shocks but this decrease is not sufficient to prevent the initial real exchange rate appreciation. The Central Bank reduces the domestic interest rate further under a world supply shock to prevent output contraction. On the other hand, the Central Bank of Sri Lanka increases the domestic interest rate after two quarters to curb the increasing inflation under world demand and globalization shocks. The increase in domestic interest rate is much higher under a positive globalization shock compared to a positive world demand shock.

### 4.3.2 Forecast error variance decomposition

The impulse responses indicate how each variable in the model would behave in response to a particular shock. On the other hand, the error variance decomposition shows how important each shock is in explaining the fluctuations in the variables in the model. Table 4.3 summarizes the estimates of the average fraction of variance in domestic variables attributable to the three foreign shocks.

The error variance decomposition indicates all three external shocks are equally important for the variance in domestic output. On average, 39 per cent of the variation in domestic output is explained by foreign shocks. The world demand and world supply shocks are marginally more important than the globalization shocks for the variation in domestic price levels. The foreign shocks contributed to 39 per cent of the fluctuations in domestic prices.
The interest rate is less affected by the external shocks during the first year with only 33 per cent of the variance in the interest rate explained by the three foreign shocks. However, their effect increases over time and by the third year external shocks account for 40 per cent of the fluctuations in the domestic interest rate. The world demand shocks are marginally more important for the variance in the real exchange rate compared to the other two foreign shocks. On average, 40 per cent of the fluctuations in the real exchange rate can be attributed to the external shocks.

Table 4.3  
Forecast error variance decomposition

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source of Disturbance</th>
<th>Time horizon</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>World demand shock</td>
<td>World supply</td>
</tr>
<tr>
<td></td>
<td>shock</td>
<td>shock</td>
</tr>
<tr>
<td>$y$</td>
<td>1-4</td>
<td>12 (6,21)</td>
</tr>
<tr>
<td></td>
<td>5-8</td>
<td>13 (8,20)</td>
</tr>
<tr>
<td></td>
<td>9-12</td>
<td>13 (8,20)</td>
</tr>
<tr>
<td>$cpi$</td>
<td>1-4</td>
<td>14 (6,26)</td>
</tr>
<tr>
<td></td>
<td>5-8</td>
<td>14 (8,22)</td>
</tr>
<tr>
<td></td>
<td>9-12</td>
<td>14 (8,21)</td>
</tr>
<tr>
<td>$int$</td>
<td>1-4</td>
<td>11 (5,23)</td>
</tr>
<tr>
<td></td>
<td>5-8</td>
<td>13 (7,21)</td>
</tr>
<tr>
<td></td>
<td>9-12</td>
<td>13 (8,20)</td>
</tr>
<tr>
<td>$reer$</td>
<td>1-4</td>
<td>15 (8,23)</td>
</tr>
<tr>
<td></td>
<td>5-8</td>
<td>15 (9,22)</td>
</tr>
<tr>
<td></td>
<td>9-12</td>
<td>14 (9,21)</td>
</tr>
</tbody>
</table>

Note: Figures in parenthesis are the 16th and 84th per centile values, respectively

The fraction of variance of the domestic output and price levels explained by the foreign shocks is considerably higher for the Sri Lankan economy in comparison to the findings of Jääskelä and Smith (2013) and Karagedikli and Price (2012) for the Australian and New Zealand economies. Jääskelä and Smith (2013) assert that the foreign shocks underlying the terms of trade movement account for 29 per cent of variation in the output and 27 per cent of variation in domestic inflation in Australia. According to Karagedikli and Price (2012), 20 per cent of the variation in New Zealand output, and 30 per cent of CPI is explained by the foreign shocks.
On the other hand, foreign shocks contribute to 76 per cent of the variation in the real exchange rate of Australia (Jääskelä and Smith, 2013). The same figure is 40 per cent for the New Zealand economy. Jääskelä and Smith (2013) assert that the floating exchange rate regime insulates the Australian economy from the external shocks, which can be explained by the lower fraction of variance of the output and inflation and higher fraction of variance of the real exchange rate attributable to the foreign shocks. The same explanation could be applied to the New Zealand economy as well.

However, external shocks underlying the terms of trade fluctuations explain more-or-less an equal fraction of the variance of domestic output, the price level and real exchange rate of Sri Lanka. Sri Lanka has a managed floating exchange rate regime and, as a result, domestic output and the price level have become more vulnerable to foreign shocks. Therefore, compared to the free floating exchange rate regime in Australia and New Zealand, the managed floating exchange rate regime in Sri Lanka is less efficient in insulating the domestic economy from external shocks.

Jääskelä and Smith (2013) suggest that world demand and commodity specific shocks are more important for the Australian economy than globalization shocks. Further, the error variance decomposition shown by Karagedikli and Price (2012) indicate that world demand shocks are more important for the variation in domestic interest rate and exchange rate than the other shocks, though all three shocks are more or less equally important in explaining New Zealand’s output and inflation. This study shows that all three external shocks play an equally important role in explaining the fluctuations in Sri Lankan macroeconomic variables.

4.3.3 Historical decomposition
The forecast error variance decomposition only shows the overall effect of foreign shocks on domestic macroeconomic variables. Even if the overall impact of a particular shock is smaller, its effect may be more significant during certain sub-periods. The historical decomposition technique evaluates the importance of different external shocks within specific time periods by attributing the error variance of the domestic variables to each structural shock. Figure 4.8 illustrates the accumulated effect of each external shock on the domestic variables using historical decomposition for the 2004 to 2014 period.
Foreign variables
Foreign output has declined during the mid-2008 to mid-2009 period due to negative world demand shocks and this period coincides with the economic slow-down in most countries around the world due to the global financial crisis. However, globalization shocks have positively contributed to foreign output during the mid-2008 to 2013 period.

Between 2007 and mid-2009 world demand shocks have significantly contributed to the fluctuations in both export and import prices in Sri Lanka. Both import prices and export prices increased considerably from 2007 to the first quarter of 2008 due to increased world demand. However, world commodity prices, including petroleum prices, sharply declined in the second half of 2008 to the first half of 2009 due to the dampened global demand caused by the global financial crisis. As a result, both import prices and export prices of Sri Lanka have declined during this period. Globalization shocks have positively affected export and import prices since mid-2008.

Domestic variables
Since 2007, the effect of globalization shocks on the domestic output has been more prominent. World demand shocks also positively contributed to domestic output variance since 2010. The foreign output variables consist of output of major trading partners of Sri Lanka including India and China, which have shown remarkable growth despite the economic slow-down in advanced economies during this period. Therefore, the economic growth of the emerging markets has positively contributed to the growth in Sri Lanka’s output since 2007.

Forecast error variance for the full sample period suggests that world demand and world supply shocks are marginally more important than globalization shocks for domestic price levels. However, globalization shocks have contributed more to the increase in domestic price levels since 2007. On the other hand, the accumulated effect of world supply shocks on the domestic CPI has been considerable during the 2007 to 2011 period. The sharp increase in global oil prices in 2007 had a considerable long-term effect on domestic prices. All three shocks contributed equally to the rise in domestic
Figure 4.8  Historical decomposition (baseline model)

- Contribution from world demand shocks
- Contribution from world supply shocks
- Contribution from globalization shocks
interest rates in 2007 while demand shocks had a more prominent effect than the other two foreign shocks on the real exchange rate of Sri Lanka since 2006.

4.4 External shocks and trade

Neither Jääskelä and Smith (2013) nor Karagedikli and Price (2012) have considered the effect of terms of trade movements on the trade balance. However, exports and imports and the trade balance of a country are the first variables to be affected by terms of trade fluctuations. Therefore, the baseline model of this essay is extended by including additional trade variables to the model.

First, the model is re-estimated with the trade balance in the domestic sector, so that \( w_t' = (expr_t, impr_t, y_t^*) \) and \( d_t' = (tb_t, y_t, cpi_t, int_t, reer_t) \) where \( tb \) is the trade balance. Trade balance is defined as the exports to imports ratio and is converted into natural logarithms. The Augmented Dicky-Fuller, Phillip Peron and KPSS tests suggest that \( tb \) is a \( I(1) \) variable. Eigen values confirm that the model is stable. Second, the model is re-estimated with exports and imports variables in the domestic sector instead of the trade balance. Accordingly, \( w_t' = (expr_t, impr_t, y_t^*) \) and \( d_t' = (ex_t, im_t, y_t, cpi_t, int_t, reer_t) \) where \( ex \) is the total exports and \( im \) is the total imports of Sri Lanka. Both variables are in natural logarithms and are \( I(1) \) variables. The model meets stability conditions.

Impulse responses

Impulse responses of all other variables in the two extended models are very similar to the baseline model and hence will not be repeatedly shown in the essay. Instead, impulse responses of trade balance, exports and imports to three external shocks are presented in Figures 4.9, 4.10 and 4.11 below.

As depicted in Figure 4.2 in Section 4.3, the terms of trade of Sri Lanka deteriorates in response to a positive world demand shock with import prices increasing more than export prices. The world demand for Sri Lankan exports seems to be more price elastic than the domestic demand for imports. As per the median target measure, Sri Lanka’s exports marginally decline due to a world demand shock instantaneously. On the other hand, demand for imported goods in Sri Lanka is relatively less price elastic, which results in an approximately 2.5 per cent increase in the total value of imports. Although
Figure 4.9  **Impulse responses of the trade related variables to a positive world demand shock**

![Impulse Responses](image)

**Note:** Impulse responses of all variables are multiplied by 100 to obtain percentage increase.
Figure 4.10  **Impulse responses of the trade related variables to a world supply shock**

Note: Impulse responses of all variables are multiplied by 100 to obtain percentage increase.
Figure 4.11  **Impulse responses of the trade related variables to a globalization shock**

Note: Impulse responses of all variables are multiplied by 100 to obtain percentage increase.
the exports sector of Sri Lanka recovers within a quarter, the cost of imports reaches the original level only after four quarters. As a result the trade balance worsens for about three quarters in response to a world demand shock.

A negative world supply shock also results in an instantaneous terms of trade deterioration. The decline in the output of major trading partners due to a world supply shock results in a significant 1 per cent decrease in the export sector of Sri Lanka for a considerably longer period. On the other hand, the total value of imports also declines after one quarter, which will reach the original level only after eight quarters. Therefore, the trade balance worsens initially but recovers rapidly.

As Figure 4.4 illustrates, the terms of trade of Sri Lanka improves for a period of three quarters in response to a positive globalization shock. As per the median target, the exports earnings decline while import costs remains the same in the impact quarter, leading to a worsening of trade balance. However, trade balance recovers rapidly with the gradual increase in the country’s exports. Unlike in the world demand shock, both the imports and exports of Sri Lanka permanently increase by 1 per cent due to a globalization shock.

Figure 4.12 shows the historical decomposition of the trade balance, exports and imports of Sri Lanka. The trade balance notably improved during the second half of 2008 but subsequently deteriorated till 2013. The main contributor to this movement was the world demand shocks. World demand declined substantially in the 2008-2009 period due to the global financial crisis, leading to a sharp decline in petroleum prices. Consequently, import costs declined considerably during this period. Although the export sector was negatively affected due to reduced demand for Sri Lankan goods from the global markets, the decline in import prices out-weighed this negative effect leading to an improvement in the trade balance of Sri Lanka in late 2008. However, with the gradual recovery of import prices, the negative demand shocks arising from advanced economies have worsened the trade balance since the mid-2009. On the other hand, globalization shocks have increased both imports and exports particularly since 2010. Yet, the increase in imports is higher than the increase in exports leading to a further deterioration in trade balance since 2010.
Historical decomposition of the trade balance, exports and imports

Figure 4.12
4.5 Robustness check
The results in Sections 4.3 are based on a baseline VAR model with two lags and sign restrictions holding for one quarter. In order to check the robustness of the results in Section 4.3, the VAR model was fitted with alternative lag lengths ($i$), and periods in which sign restrictions are imposed ($k$). Figure 4.D.1 to Figure 4.D.12 in Appendix 4.D show the impulse responses of world and domestic variables when $i = 1, i = 2, i = 3$ and $i = 4$, respectively. Each graph represents how the impulse responses would behave when $k = 1, k = 2, k = 3$ and $k = 4$. As the figures indicate, the impulse responses are similar, except for the different times when peaks and troughs occur. This suggests that the main results of the essay are robust for alternative specifications.

4.6 Conclusion
Numerous studies have shown that the terms of trade plays a key role in explaining the variance in output growth, savings, consumption and trade balance of small open economies. Jääskelä and Smith (2013) argue that the effect of the terms of trade on the economy depends on the nature of the underlying structural shocks. Therefore, this study has investigated the impact of external shocks, which trigger terms of trade movements, on the Sri Lankan economy using a VAR model with sign restrictions.

Positive world demand shocks and negative world supply shocks deteriorate the terms of trade instantaneously, though terms of trade improve after two quarters with the world supply shock. In contrast, positive globalization shocks improve the terms of trade temporarily. However, none of these shocks have a permanent effect on the country’s terms of trade.

World demand shocks do not have a significant long-term effect on Sri Lanka’s real GDP, but negative world supply shocks are contractionary. Globalization shocks increase the domestic output permanently along with world output, which suggests that the growth in emerging markets has a positive impact on Sri Lanka’s real GDP. Both positive world demand shocks and globalization shocks are inflationary increasing domestic price levels permanently. On the other hand, negative world supply shocks increase domestic prices initially but reduce the price level after two quarters when the terms of trade improve for the country. In all three cases, the real exchange rate appreciates instantaneously, but it depreciates rapidly under a globalization shock. In contrast, real exchange rate gradually
depreciates with the world demand and world supply shocks. The Central Bank of Sri Lanka responds to the three shocks differently. The domestic interest rate decreases instantaneously under all three shocks but subsequently the Bank will raise the domestic interest rate under world demand and globalization shocks to control domestic inflation. On the other hand, the Central Bank will reduce the domestic interest rate further to boost the economy under a world supply shock.

All three shocks result in a deterioration of trade balance of Sri Lanka in the impact period, but the effect is not persistent. However, positive globalization shocks permanently and significantly raise both the imports and exports of the country. In contrast, Sri Lanka’s exports decline significantly for a considerably long period due to world supply shocks. However, world supply shocks do not worsen the trade balance significantly in the long-run.

All three foreign shocks are equally important for the variance in domestic output. When the full sample period is considered, world demand and world supply shocks are marginally more important than globalization shocks for the variation in domestic price levels. However, historical decomposition indicates that globalization shocks had a prominent impact on domestic price levels and real GDP since 2007. Foreign shocks have contributed to 39 per cent of the fluctuations in both domestic output and prices. World demand shocks have largely contributed to the fluctuations in trade balance since 2007, whereas the importance of globalization shocks on the imports, exports and trade balance has increased since 2010.

In general, the fraction of error variance explained by foreign shocks is more or less equal for all domestic variables. Further, the external shocks play a larger role in explaining domestic output and price levels in Sri Lanka compared to Australian and New Zealand economies. This indicates that the managed floating exchange rate regime of Sri Lanka is less efficient in insulating the domestic economy from the external shocks compared to the flexible floating exchange rate regime in Australia and New Zealand.

The findings of this essay affirm that the effect of terms of trade movements on the domestic economy depends on the nature of the underlying external shocks. Therefore, this study highlights the importance of modelling the terms of trade of a small open
economy as an endogenous variable within the global economy instead of as a shock orthogonal to other foreign variables.
Appendix 4.A   Data description and data sources

$expr$ = Quarterly chain-linked Merchandise Export Unit Value Index (2010=100) of Sri Lanka is seasonally adjusted using Census X-12 method and is multiplied by $(reer_t/100)$ where $reer$ is the quarterly chain-linked real effective exchange rate (2010=100) series. (Data source: Central Bank of Sri Lanka)

$impr$ = Quarterly chain-linked Merchandise Import Unit Value Index (2010=100) of Sri Lanka is seasonally adjusted using Census X-12 method and is multiplied by $(reer_t/100)$ where $reer$ is the quarterly chain-linked real effective exchange rate (2010=100) series. (Data source: Central Bank of Sri Lanka)

$yw$ = Quarterly trade weighted-GDP of the major trading partners of Sri Lanka is compiled by the author using different data series and sources. Based on the total annual average trade (i.e. both import and exports) during 2005-2014, top thirteen major trading partners of Sri Lanka is selected. The trading partner countries selected are India, United States of America (USA), China, Singapore, United Kingdom, United Arab Emirates (UAE), Islamic Republic of Iran, Japan, Italy, Germany, Belgium, Malaysia and Hong Kong.

Trade weights-

The trade weights are calculated as below.

$$TW_j = \frac{\sum_{t=2005}^{2014} (exports_{t,j} + imports_{t,j})}{\sum_{j=1}^{13} (\sum_{t=2005}^{2014} (exports_{t,j} + imports_{t,j}))^{1/10}}$$

(4.A.1)

where $TW_j$ is the trade weight of country $j$; $exports_{t,j}$ is the exports to country $j$ by Sri Lanka in period $t$; $imports_{t,j}$ is the imports from country $j$ by Sri Lanka in period $t$.

(Data source: Direction of Trade Statistics database of IMF)

Real GDP of USA – Seasonally adjusted annualized chain-linked quarterly real GDP series (2010=100) in terms of US Dollars is used (data source: OECD database).

Real GDP of Belgium, India, Germany, Italy, Japan and UK – Seasonally adjusted annualized chain-linked quarterly real GDP series (2010=100) in terms of home-country currency (data source: OECD database) are converted in to US Dollar terms using quarterly average exchange rate of each country (data source: IFS database of IMF).
GDP of China – A chained-linked real quarterly GDP series in Ren Min Bi (RMB) term (2010=100) is compiled using quarterly nominal GDP of China (data source : CEIC Global database, data code: 369703417 (CAASNW)) for 2000-2014 period, quarterly GDP deflator (2010=100) of China (CEIC Global database, data code : 324175801) for 2000-2014 period and real quarterly Chinese GDP growth rate for 1997-1999 period (Tilak Abeysinge’s homepage - http://courses.nus.edu.sg/course/ecstabey/Tilak.html). The series is seasonally adjusted using Census X-12 method and was converted to US Dollar term using quarterly average USD to RMB exchange rate (CEIC Global data code: 229434801) and later, the series is annualized.

Real GDP of Singapore - Seasonally adjusted chain-linked quarterly real GDP series (2010=100) in terms of Singapore Dollars (data source: CEIC Global database, data code: 359342347) is converted in to US Dollar terms using quarterly average exchange rate of Singapore (data source: CEIC Global database, data code: 225355201). Then the series is annualized.

Real GDP of Malaysia - Chain-linked quarterly nominal GDP series (2010=100) in terms of Malaysian Ringgit (data source: CEIC Global database, data code: 225122401) and the quarterly GDP deflator (2010=100) is used to compile a quarterly real GDP series for Malaysia. Then the series is seasonally adjusted using Census X-12 method and is converted in to US Dollar terms using quarterly average exchange rate of Malaysia (data source: CEIC Global database, data code: 225041001) After that, the series is annualized.

Real GDP of Hong Kong - Chain-linked quarterly real GDP series in terms of Hong Kong Dollar is created through data splicing technique using quarterly real GDP series (2010=100) of Hong Kong (data source: CEIC Global database, data code: 324317101 (HAVVABA)) and quarterly real GDP series (2012=100) of Hong Kong (data source: CEIC Global database, data code: 354569587 (HAVVAMAAAAAARK)). Then the series is seasonally adjusted using Census X-12 method and is converted in to US Dollar terms using quarterly average exchange rate of Hong Kong (data source: CEIC Global database, data code: 224652301).

Real GDP of UAE and Iran – Quarterly GDP data are not available for both UAE and Iran. Hence, annual real GDP (2010=100) series in US Dollar term (data source: CEIC Global database, for UAE - data code: 377889307 and for Iran – data code: 377890327) are used to obtain an interpolated quarterly real GDP series for the two counties. Cubic
spline (cubic-match-last) technique in Eviews is used to create the interpolated series. Both series are seasonally adjusted using Census X-12 method.

The compiled quarterly real GDP series (2010=100) in US Dollar term for each of the major trading partners are used to compile the aggregate trade weighted-GDP:

\[ y_t^{lw} = \sum_{j=1}^{13} (TW_j \times RealGDP_{j,t}) \]  

\( y = \) A chain-linked quarterly real GDP (2010=100) series for Sri Lanka is created using quarterly real GDP series (2000=100), quarterly real GDP series (2006=100) and quarterly real GDP series (2010=100). Series are seasonally adjusted using Census X-12 method. (Data source: Central Bank of Sri Lanka)

\( cpi = \) Consumer price index of Sri Lanka is seasonally adjusted using Census X-12 method. (Data source: IFS database of IMF)

\( int = \) Short-term government securities rate. (Data source: IFS database of IMF)

\( reer = \) Real effective exchange rate (2010=100). (Data source: Central Bank of Sri Lanka)

\( tb = \) Trade balance was calculated using imports and exports of Sri Lanka. \( TB \) is specified as exports/imports. (Data source: IFS database of IMF)

\( ex = \) Chained linked export value index was calculated based on Exports value index (base=1997) and Exports value index (base=2010) (Data source: CEIC Global database, data code: 30920601(LIOK) and 325289302(LIDBA))

\( im = \) Chained linked import value index was calculated based on Imports value index (base=1997) and Imports value index (base=2010) (Data source: CEIC Global database, data code: 30940801(LIOQ) and 325290702(LIDBB)).
Appendix 4.B  Foreign and domestic data

Figure 4.B.1 Export prices
Figure 4.B.2 Import prices
Figure 4.B.3 Foreign output

Figure 4.B.4 Domestic output
Figure 4.B.5 Domestic prices
Figure 4.B.6 Domestic interest rate

Note: All data except interest rate are in natural logarithm. Interest rate is in percentages.
Figure 4.B.7  **Real effective exchange rate**

Figure 4.B.8  **Trade balance**

Figure 4.B.9  **Exports**

Figure 4.B.10  **Imports**

Note: All data are in natural logarithm.
### Appendix 4.C  
**Unit root tests**

#### Table 4.C.1  
**Summary of unit root tests**

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**Note:**
- NS – Series is nonstationary at 5% level
- S - Series is stationary at 5% level
- NA – Not applicable
Appendix 4.D  Impulse responses for robustness check

Figure 4.D.1  Impulse responses to a positive world demand shock - VAR (1)*

Note: Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.

* VAR (1) indicates the VAR model with 1 lag.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.2  Impulse responses for to a negative world supply shock - VAR (1)*

Note:  * VAR (1) indicates the VAR model with 1 lag.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.3  Impulse responses to a positive globalization shock - VAR (1)*

Note:  * VAR (1) indicates the VAR model with 1 lag.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.4  Impulse responses to a positive world demand shock - VAR (2)*

Note:  * VAR (2) indicates the VAR model with 2 lags.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.5  **Impulse responses to a negative world supply shock - VAR (2)**

* VAR (2) indicates the VAR model with 2 lags.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.6  **Impulse responses to a positive globalization shock - VAR (2)**

**Note:**

* VAR (2) indicates the VAR model with 2 lags.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.7  **Impulse responses to a positive world demand shock - VAR (3)**

Note:  * VAR (3) indicates the VAR model with 3 lags.
Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
**Figure 4.D.8  Impulse responses to a negative world supply shock - VAR (3)**

* VAR (3) indicates the VAR model with 3 lags.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.9  **Impulse responses to a positive globalization shock - VAR (3)**

Note:  
* VAR (3) indicates the VAR model with 3 lags.

Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.10  Impulse responses to a positive world demand shock - VAR (4)*

Note: * VAR (4) indicates the VAR model with 4 lags.
Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.11  Impulse responses to a negative world supply shock - VAR model (4)*

Note:  * VAR (4) indicates the VAR model with 4 lags.
Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
Figure 4.D.12  
Impulse responses to a positive globalization shock - VAR (4)*

Note: * VAR (4) indicates the VAR model with 4 lags. 
Impulse responses of all variables, except domestic interest rate, are multiplied by 100 to obtain percentage increase.
CONCLUSION

5.1 Summary of findings and policy recommendation

This dissertation has analysed the impact of external shocks on the Sri Lankan economy and their transmission channels and the welfare implications of alternative monetary policy rules under domestic and external disturbances. The main findings of the thesis are summarized below.

Chapter 2 focused on assessing the welfare implications of six alternative monetary policy rules using a calibrated small open economy DSGE model for Sri Lanka with financial frictions, delayed exchange rate pass-through and nominal price rigidities. The welfare under alternative monetary policy rules were compared and ranked based on both conditional and unconditional welfare of the households. The welfare losses under domestic productivity shocks, foreign monetary policy shocks and foreign output shocks were minimized under domestic goods inflation targeting rule. Consumer price inflation targeting was ranked in the second place in terms of welfare ranking closely followed by the monetary aggregate targeting rule. Under both types of external shocks, the fixed exchange rate targeting rule was performing poorly. The real output targeting rule led into highest welfare losses under domestic productivity shock.

Currently, the Central Bank of Sri Lanka implements a monetary aggregate targeting policy rule and a managed floating exchange rate regime. Even though monetary aggregate targeting was ranked at the third place in terms of welfare ranking, the model assumed a stable money demand function which may not be true in reality. Therefore, a monetary aggregate targeting rule may not perform well in terms of household welfare as the model predictions. Nevertheless, the findings of this thesis suggest that moving from the current policy rule to the domestic goods inflation targeting rule would be beneficial for the Sri Lankan economy. The model predicted a lower average level of external debt in the economy and notable exchange rate fluctuations during external shocks under the inflation targeting rules. This highlights the necessity of reducing the overwhelming external debt level in the economy to move into an inflation targeting regime successfully.
With the reduced debt levels in the economy and lower debt repayments, the welfare of
the households would be higher in the long-run under a domestic inflation targeting rule.

Chapter 3 investigated the impact of external shocks on the Sri Lankan economy and their
transmission channels using a SVAR model with block exogeneity assumption and short-
run and long-run restrictions. This study indicates that oil price inflation shocks, US
output growth shocks and US monetary policy shocks account for 20 per cent of the
variation in domestic output growth and 38 per cent of the variation in domestic inflation
in Sri Lanka. All three shocks were equally important for the variance in output growth,
whereas oil price inflation shocks and US monetary policy shocks are contributing more
for the inflation variance. Therefore, policymakers need to consider these external shocks
when modelling the Sri Lankan economy, especially for forecasting purposes. Further,
the shocks to the effective federal funds rate explain a higher fraction of variance in the
domestic variables than the shocks to the US shadow short rate.

Chapter 4 examined the effect of external shocks, which cause terms of trade fluctuations,
on the Sri Lankan economy using a sign-restricted VAR model. The findings of this essay
showed that the terms of trade of Sri Lanka deteriorates under both positive world demand
shocks and negative world supply shocks. However, positive globalization shocks
improve the terms of trade instantaneously. There is no long-term effect on the domestic
output due to world demand shocks, but negative world supply shocks are contractionary.
On the other hand, globalization shocks improve the domestic output permanently. Both
positive world demand shocks and globalization shocks are inflationary. Therefore,
findings of this study show that the effect of terms of trade shocks on the domestic
macroeconomic variables depend on the nature of the underlying external shock. Hence,
the traditional approach of modelling the terms of trade as an orthogonal shock to the rest
of the shocks in the model is not an appropriate modelling strategy for the Sri Lankan
economy.

Further, globalization shocks, which represent the entry of emerging markets to the global
trading system, have contributed significantly to the domestic output of Sri Lanka since
2007. Hence, the findings of Chapter 4 highlight the importance of strengthening Sri
Lanka’s trade linkages with India and China for the domestic output growth.
In addition, the results of Chapter 4 also show that domestic output and domestic prices
are more prone to external disturbances under a tightly managed floating exchange rate
regime than under a free-float exchange rate regime. Therefore, Sri Lanka would benefit from moving to a free-floating exchange rate policy. Nevertheless, as pointed out earlier a reduction of overall foreign debt levels is imperative prior to a change in existing policies.

5.2 Future research directions

By deepening our understanding on the effect of external shocks on the Sri Lankan economy, this thesis suggests several future research directions.

In Chapter 2, a calibrated model was used to evaluate the monetary policy rules. Although model parameters were carefully selected from the existing literature to match the Sri Lankan economy, it would be more accurate if the model were estimated with the actual data for Sri Lanka. Due to serious data limitations, this approach was not attempted in this thesis. However, a DSGE model for the Sri Lankan economy can be estimated in future once long quarterly time series data for most variables are available for the country. In this study, the government sector was not explicitly modelled, though the government debts were represented through the household borrowings. Nevertheless, modelling the government sector with explicitly by incorporating government’s non-productive expenses and the expenditure on public infrastructure would be the next step in constructing a DSGE model for the Sri Lankan economy. Further, Chapter 2 only focused on the strict-form of the policy rules. Evaluating the welfare implications of flexible form of monetary policy rules and optimal monetary policy are other future research directions.

The second essay (Chapter 3) investigated the effect of US monetary policy shocks since the US can significantly influence the world interest rate. However, the monetary policy shocks originating from other countries, such as India and China, can also affect the Sri Lankan economy through the trade channel. The importance of India and China as major trading partners has increased considerably in the recent past and, hence, the monetary policy of these major trading partners should be investigated in future research.

In the second essay, the effect of oil price shocks on the Sri Lankan economy was examined by assuming oil price shocks are orthogonal to the other shocks in the world block. This is the traditional approach of modelling the oil price shocks in SVAR literature. However, Killian (2009) has pointed out the effect of oil price movements on
the macroeconomy depends on the underlying shocks that triggered the price fluctuations. Therefore, the effect of oil price shocks on the Sri Lankan economy should be further investigated using the sign-restricted VAR approach used in the third essay (Chapter 4). This will enable us to identify the effect of oil price movements that is caused by different external shocks, such as world demand shocks and oil-specific supply shocks.
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