DISSERTATION

ECONOMIC GROWTH AND MONETARY POLICY IN ASIAN DEVELOPING ECONOMIES

THANABALASINGAM VINAYAGATHASAN

2013

GRIPS

National Graduate Institute for Policy Studies

ECONOMIC GROWTH AND MONETARY POLICY IN ASIAN DEVELOPING ECONOMIES

A Dissertation

Submitted to the Faculty of the National Graduate Institute for Policy Studies (GRIPS)

in Partial Fulfillment of the Requirements for the Degree of

DOCTOR OF PHILOSOPHY IN PUBLIC ECONOMICS

by

Thanabalasingam Vinayagathasan

September, 2013

ABSTRACT

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Dissertation Director:

Associate Professor Roberto Leon-Gonzalez

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The issue of sustainably high economic growth is of interest among economists and policy-makers in developing and developed countries alike. In recent decades, there has been an explosion in research on economic growth. Generally speaking, three related issues lie at the heart of this research: (i) the relationship between inflation and growth, (ii) the determinants of growth, and (iii) the impact of monetary policy on the real sector and price level. There is little consensus among economists worldwide on the level at which inflation hinders the economic growth of a region, what factors determine the growth rate of a country or region, and which policy instruments explain most efficiently the monetary policy transmission mechanism of a country. This lack of consensus implies that research findings differ on the basis of a country or region’s economic environment. With this in mind, this study attempts to examine the level at which inflation is detrimental to the economic growth of Asian less-developed countries (LDCs), and which factors have a significant effect on growth rate. In addition, it is also crucial to investigate an appropriate monetary policy instrument that would explain more efficiently the dynamic responses of small, open, and developing economies-like that of Sri Lanka-to macroeconomic variables.

We employ different methodologies to examine these questions. First, in order to estimate the threshold level of inflation, this study uses the conditional least squares method and generalized method of moments (GMM) to assess the impact of inflation threshold and other control variables on growth. For this purpose, this study uses balanced panel data from 32 Asian countries covering the 30-year period of 1980–2009. Second, it applies a Bayesian model averaging (BMA) technique to estimate model uncertainty over several dimensions, such as choice of control variables, set of instruments, and validity of identification restrictions. In this model set-up, we include a nonlinear function of inflation among explanatory variables that allow for threshold effects, to evaluate the probability of the inflation threshold having a nonlinear effect on growth. In addition, we use a reversible-jump Markov chain Monte Carlo (RJMCMC) algorithm to analyze a large number of competing models. Unbalanced panel data from 27 Asian LDCs over the 1980–2009 period is used in this analysis. Finally, a structural vector autoregressive (VAR) model is applied to identify the best monetary policy indicator; this study also estimates the impacts of foreign monetary policy shocks and of oil price shocks on the Sri Lankan economy. To this end, it uses monthly time-series data from Sri Lanka, from January 1978 to December 2011.

The estimated threshold level of inflation for both the full sample (32 Asian countries) and the subsample of 27 Asian LDCs (i.e., the full sample, minus four OECD countries and Singapore) is equal to 5.43%. This study's empirical evidence on the determinants of growth suggests that both trade openness and the investment ratio motivate economic growth, while government consumption expenditure hampers it. The BMA estimation results, meanwhile, identify a substantial probability that inflation impedes economic growth when it exceeds 5.43%. We find that the nearest available lags more strongly correlate with the predetermined regressor than the longer lags. We also report no evidence of conditional convergence or divergence. The use of a robust estimation procedure indicates that although results are sensitive to the model specification, BMA overcomes the specification bias inherent in GMM.

The empirical findings regarding monetary policy shocks on the real economy suggest that shocks to the interest rate play a crucial role in explaining the movement of macroeconomic variables, even more so than a monetary aggregate shock or an exchange rate shock. The response of output and the exchange rate are consistent with theory pertaining to interest rate shock. The interest rate decrease, as expected, when shocks to monetary policy are identified with innovations in reserve money. Moreover, this study's findings clearly show that foreign monetary policy shocks and oil price shocks seem not to be vulnerable to domestic monetary policy.

This research finding could be useful to central banks as they undertake inflation-targeting and formulate other policies.

International Conferences and List of Publications 2011–2013

International Conferences

Vinayagathasan, T. (2012). Inflation and Economic Growth: A Dynamic Panel Threshold Analysis for Asian Economies. This paper was presented at the 1st GRIPS student conference, 4 September 2012, National Graduate Institute for Policy Studies, Tokyo.

Vinayagathasan, T. (2012). Inflation and Economic Growth: A Dynamic Panel Threshold Analysis for Asian Economies. This paper was presented at the 7th Himalayan Policy Research Conference (HPRC), 11 October 2012, University of Wisconsin, Madison.

Leon-Gonzalez, R., Vinayagathasan, T. (2013). Robust determinants of growth in Asian developing economies: A Bayesian panel data model averaging approach. This paper was presented at the EURO-American conference for academic disciplines, 8-11 April 2013, Paris, France.

Journal(s) that have been published

Vinayagathasan, T. (2013). Inflation and Economic Growth: A Dynamic Panel Threshold Analysis for Asian Economies. *Journal of Asian Economics* 26, 31-41.

Discussion Paper(s)

Vinayagathasan, T. (2012). Inflation and Economic Growth: A Dynamic Panel Threshold Analysis for Asian Economies. *GRIPS Discussion Paper 12-17*.

Dedication

To my father, Thambyiah Thanabalasingam; mother, Thanabalasingam Pushparani; wife, Sathana Vinayagathasan; and the late teacher Ponnuthurai Ranjan

Acknowledgement

This research would not have reached this rewarding outcome without irreplaceable supports that I received from numerous sources. Above all, I would like to express my sincere and wholehearted gratitude to my principal advisor, Professor Roberto Leon-Gonzalez for his invaluable encouragement. He was available at all time and committed a vast amount of his time supervising my dissertation. I thank him for his creative and perceptive advice, comments, suggestions and everything I gained from him.

I am grateful to my dissertation committee members Professor Julen Esteban-Pretel, Professor Shinsuke Ikeda, Professor Tetsushi Sonobe and Professor Kakamu for their constructive and useful suggestions and comments for improving the quality of this dissertation. I wish to extend my sincere gratitude to Professor Wade Pfau who taught me computer programming for Matlab and Professor Minchung Hsu for his useful suggestions and advice about macroeconomic theory that helped me a lot on writing my dissertation. Likewise, my heartfelt thankfulness goes to all GRIPS professors who have taught me at GRIPS.

Also, I wish to thank all the administrative staff of GRIPS for their vigorous support and cooperation and Ministry of education in Japan and GRIPS for offering the scholarship during my Masters and PhD study period in Japan.

I am deeply indebted to Professor Anoma Abeyratne, Mr. Thangathurai Rajeswaran and Mr. K. Gnaneswaran for their positive motivation of my higher studies. My special appreciation goes to my fellow colleagues Mr. Abu Nur Rashed Ahamed, from Bangladesh, Mr. Kiprono Philemon, Dr. Tim Njagi from Kenya, Mr. Francis Mwesigye, Mr. Patric Okettayot from Uganda, Mr. Tom Kasahun from Ethiopia, Dr. Chakara Pani Acharya from Nepal, Mr. Xuan Anh Le from Vietnam, Mr. Xiangcai Meng from China and other all friends at GRIPS who supported me in many ways for the successful completion of my study in Japan. I also would like to thank Dr. Pallegedara Asankha, Dr. N. S. Kumanayake, Dr. Ajantha Sisira Kumara, Dr. Aazim Muhammad, and Ms. Susanthi Medha from Sri Lanka for their valuable support on writing my dissertation.

Most importantly, I am greatly indebted to my parents, Thambyiah Thanabalasingam and Pushparani Thanabalasingam and my wife Sathana Vinayagathasan for their boundless love, encouragement, support and for enduring enormous sacrifices. Lastly, I am thankful to my brothers, sisters and brother in law for providing me inspiration and love for my successful academic life.

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Appendices

Acronyms

2SLS : Two stage least square

AD : Aggregate demand

ADB : Asian development bank

ADF : Augmented Dickey-Fuller

AIC : Akaike information criterion

AS : Aggregate supply

BACE : Bayesian averaging classical estimate

BAT : Bayesian averaging threshold

BMA : Bayesian model averaging

CBSL : Central bank of Sri Lanka

CPI : Consumer price index

EBA : Extreme bound analysis

EW : Economic watch

FE : Fixed effect

FFR : Federal Fund rate

FOD : Forward orthogonal deviation

GDP : Gross domestic product

GMM : Generalized method of moments

HQIC : Hannan-Quinn information criterion

IMF : International monetary fund

IV : Instrumental variables

LDC : Less developed countries

LSDVC: Bias corrected least squared dummy variable estimate

OLS : Ordinary least square

PWT : Penn world table

RJMCMC: Reversible jump Markov Chain Monte Carlo

RSS : Residual sum of square

SC : Schwarz information criterion

SEM : Simultaneous equation model

SVAR : Structural Vector autoregression

TVP : Total visited probability

VAR : Vector autoregression

WB : World Bank

WDI : World development indicator

WOP : World oil price

CHAPTER 1

INTRODUCTION

1.1 Significance of the Issue

The primary goal of a majority of macroeconomic policies is to promote high and sustained economic growth and maintain price levels at desirable rates. The central banks of many countries have implemented monetary policy with the aim of achieving such goals. However, why does the gross domestic product (GDP) of some countries grow faster than those of others? There has been a boom in research into economic growth in recent decades, and in general, three related issues lie at the heart of this research: inflation, economic growth, and monetary policy. However, there is no agreement among the world's economists on the level at which inflation hinders the economic growth of a region, what factors determine the growth rate of a country or region, and which policy instruments explain the monetary policy transmission mechanism of a country most efficiently. This implies that findings may differ with the country or region's economic environment.

First, the relationship between inflation and economic growth has been a subject of debate for some time among economists. One group of researchers proposes that a low inflation rate promotes welfare gain within an economy (e.g., Feldstein, 1997), whereas other groups of economists believe that very high inflation rates will quickly put an economy into a severe condition (e.g., Temple, 2000). Less-developed countries (LDCs) often suffer from economic instability and rely on international agencies—such as the International Monetary Fund (IMF), the World Bank (WB), or the Asian Development Bank (ADB)—to stabilize their economies. However, different agencies have come up with different guidelines and suggestions, such as reducing or increasing prices—in many cases, without instilling proper coordination with each other. This makes it more difficult for policy-makers to determine the levels of inflation that Asian countries should maintain to stabilize their economies. There is no consensus among economists with regard to appropriate inflation targets for LDCs; they range from 8% to 40% (e.g., Bruno and Easterly, 1998; Khan and Senhadji, 2001; Kremer et al., 2009; Bick, 2010; among many others). Therefore, it is important to ask: How low of an inflation rate is *too low* for Asian economies?

Most studies estimate inflation thresholds by using only exogenous explanatory regressors in a panel data setting (e.g., Bick, 2010; Druker et al., 2005; Khan and Senhadji, 2001; among others). However, estimates are inconsistent in a cross-country growth regression, for reasons relating to the country-specific fixed effect (FE) and endogeneity problem (see Caselli et al., 1996). Only a few studies deal with this problem in a growth regression context (e.g., Kremer et al., 2009), but their samples include both developed countries and LDCs from a region different from that in their panel set-up. However, "one should probably be quite careful about extrapolating findings from one set of countries to another" and, "In general, it would seem best to study inflation's effect within OECD or a sample of relatively similar developing countries and not mix the two" (Temple, 2000 p. 412). This work departs from the existing literature by considering only Asian LDCs.

The second issue is model uncertainty. There is considerable variation among the economic growth rates of Asian countries; therefore, part of this research asks why the output of some countries or regions grows at rates faster than those of other countries or regions. Naturally, economic growth is determined by many factors, including those that are social, economic, political, environmental, and cultural; however, not all factors affect the growth rates of all countries or regions significantly, and few economists would agree on a set of right-hand side regressors that would have an impact on growth. There is typically only a fractional overlap among the myriad of explanatory variables that have been considered in the various empirical studies (e.g., Barro, 1991; Sala-i-Martin, 1997a, b; Fernandez et al., 2001a [FLS, henceforth]; Fernandez et al., 2001b; Sala-i-Martin et al., 2004 [SDM, henceforth]; Mora-Benito, 2010; 2012; Leon-Gonzalez and Montolio, 2012 [LM, henceforth]).

The past economic growth studies propose a variety of econometric techniques to address the problem of model uncertainty. However, most economists use the Bayesian model averaging (BMA) technique to overcome the problem associated with the selection of a single model in the growth regression (e.g., FLS; SDM; Ciccone and Jarocinski, 2010; Moral-Benito, 2010, 2012; Koop et al., 2011 [KLS, henceforth]; LM), and other areas of economics (e.g., Koop and Tole, 2004a; Chen et al., 2011). A few studies extend BMA for the threshold models that are relevant to growth and other areas of economics (Cuaresma and Doppelhofer, 2007; Koop and Tole, 2004b).

Several previous studies account for model uncertainty only in terms of the choice of control variables, while using a cross-country growth model (e.g., FLS; SDM). Apart from the control variables used, empirical results can be affected by the choice of instruments, identification restrictions, and exogeneity restriction (KLS; LM).

Most researchers have investigated model uncertainty under the assumption of a linear relationship between economic growth and its determinants. However, there is some evidence that some of the explanatory variables—such as inflation (e.g., Fischer, 1993;

Khan and Senhadji, 2001; Bick, 2010; Yilmazkuday, 2011; among others), government size, the number of years the economy has been open, and initial income per capita (e.g., Cuaresma and Doppelhofer, 2007; Yilmazkuday, 2011)—may affect growth in a nonlinear way. Therefore, this study extends the model of KLS and LM by including a nonlinear function of inflation that allows for threshold effects among the explanatory variables, to estimate model uncertainty over several dimensions and investigate the impact of a threshold level of inflation on economic growth.

Finally, we link monetary policy and real economic activities. Monetary policy is broadly used by central banks as a stabilization policy toolkit, to guide an economy in a way that achieves sustainably high economic growth and keeps inflation at a desirable rate. Existing monetary research addresses a variety of questions regarding the association between macroeconomic nonpolicy variables and monetary policy instruments. Since the publication of seminal works by Sims (1972, 1980), the vector autoregressive (VAR) model has been broadly used by researchers to answer those questions. Researchers suggest a variety of policy instruments, such as interest rate (IRs) (e.g., Sims, 1992; Bernanke and Blinder, 1992), nonborrowed reserves (e.g., Strongin, 1995; Eichenbaum and Evans, 1995), and exchange rates (ERs) (e.g., Cushman and Zha, 1997; Fung, 2002), all of which play significant roles in explaining the dynamic responses of economic variables.

The several empirical works that examine the impact of monetary policy shocks have found evidence of a number of puzzles in both closed and open economy settings. Thus, to sidestep such puzzles, some of those studies include within their VAR frameworks expected inflation as a proxy variable (e.g., Gorden and Leeper, 1994; Sims and Zha, 1998; Grilli and Roubini, 1995; Christiano et al., 1996). For example, Kim and Roubini (2000) include the oil price, while Christiano et al. (1996) admit measures of commodity price in their VAR system, each to avoid the problem of such puzzles.

One group of previous empirical studies includes only domestic policy variables in their VAR systems (e.g., Bagliano and Favero, 1998; Bernanke and Mihov, 1998; Amarasekara, 2009), whereas another group includes domestic and foreign policy and nonpolicy variables (e.g., Cushman and Zha, 1997; Kim and Roubini, 2000; Fung, 2002; Kim, 2003). The existing empirical studies of the Sri Lankan monetary policy transmission mechanism uses only domestic variables in their VAR approaches (see, for variable details, Amarasekara, 2009). However, Cushman and Zha (1997) note that a "small open economy is likely to be quite sensitive to a variety of foreign variables" (p. 435). With this in mind, we include the federal funds rate (FFR) as well as the world oil price (WOP) index in our model set-up, to isolate any exogenous change in monetary policy. For this reason, the current study differs from past empirical research that explores the movements of macroeconomic variables in response to monetary policy shock in the Sri Lankan context.

The results of those existing studies reveal that in Asian LDCs, the identification of a desirable inflation rate (i.e., that which can urge economic growth), determinants of growth, and the precise relationship between monetary policy and real economic activities is very important to achieving economic performance targets.

1.2 Research Objective

Given the rising importance of the various components of macroeconomic concerns with regard to the universal policy agenda, this dissertation looks to contribute to the macroeconomic literature, and to assist policy-makers and academics by analyzing three fundamental problems associated with economic growth and monetary policy. The first crucial objective of this dissertation is to estimate the threshold level of inflation for Asian economies. This study contributes to the macroeconomic literature by using a more reliable and appropriate estimation technique for dynamic panel data growth regression. Concurrently, we attempt to quantify the inflation threshold only for Asian developing economies, whereas the existing literature tends to assess both developed countries and LDCs.

Next, this study estimates model uncertainty over several dimensions, including the set of controlling regressors, the set of instruments, and the validity of identifying restrictions; it also focuses on very large model spaces. We attempt to contribute to the literature by including a nonlinear function of inflation that allows for a threshold effect in the panel setting—unlike previous studies, which assume that all explanatory regressors take a linear function.

The final objective of this dissertation is to identify the monetary policy indicator that explains most effectively the monetary policy transmission mechanism of Sri Lanka. The chapter devoted to this objective also looks to estimate how shocks stemming from foreign monetary policy and/or oil price affect domestic macroeconomic variables, and to determine whether the inclusion of the WOP does indeed resolve the empirical puzzles. This study contributes to the monetary literature by including foreign IRs (i.e., FFR) and the WOP index, to isolate any exogenous change in monetary policy—unlike in the existing literature with respect to Sri Lanka, which includes only domestic policy and nonpolicy variables in the model set-ups.

1.3 Dissertation Outline and Research Framework

This dissertation consists of five chapters, which are organized as follows. The importance and background of the research problem, as well as this study's main objectives, are described in chapter 1. This chapter also provides a study outline.

Chapter 2 estimates the inflation threshold and its impact on economic growth, using a dynamic panel threshold model. We use balanced panel data from 32 Asian countries, from the 1980–2009 period; we also conduct an econometric estimation analysis for this purpose. In our estimation procedure, first, we deal with negative inflation observations and transform the data into a semi-log form to eliminate the sample's asymmetric distribution. Second, we eliminate individual FEs by using forward orthogonal deviation (FOD) transformation. The endogeneity problem is resolved through the two-stage least squares (2SLS) method. Third, we estimate the threshold level of inflation, using the conditional least squares method. Finally, once we determine the threshold level of inflation, we examine the impact of that threshold on economic growth, using the generalized method of moments (GMM). The linear combination test is used to examine the significance of the threshold level. The estimated results reveal that the inflation threshold for Asian economies is 5.43%; we also detected the same inflation threshold for the sample of 27 Asian LDCs. We find that inflation is detrimental to growth when it exceeds 5.43%, but that it has no effect below this level.

Chapter 3 examines model uncertainty over several dimensions, together with the probability that an inflation level exceeding the threshold would have a negative coefficient. We also focus on a very large model space, while using unbalanced panel data from 27 Asian LDCs, from the 1980–2009 period. This study uses the BMA technique to achieve these objectives. In this chapter, we first briefly introduce and review the relevant literature. We next describe the econometric framework and the estimation process of the parameters. We use FOD transformation to eliminate country-specific FEs from the model, and employ the Bayesian analogue of the 2SLS method to deal with the endogeneity issue. Second, we briefly discuss the choice of model. Finally, BMA techniques are discussed. The estimation results suggest that investment and trade openness correlate positively with growth, whereas government consumption expenditure correlates negatively. There is a substantial probability that inflation impedes economic growth when it exceeds 5.43%, and there is no evidence of conditional convergence or divergence.

In chapter 4, we measure the effect of both domestic and foreign monetary policy shocks on the real sector and price level in the context of Sri Lanka, using a structural VAR (SVAR) model. For this purpose, we use monthly time-series data from January 1978 to December 2011. We introduce and review the literature, in the first two sections, while section 3 explains the monetary policy system of Sri Lanka and describes the data and variables used in this research. The modeling of the SVAR is discussed in section 4; the estimation results show that the IR channel plays a crucial role in explaining the dynamic responses of macroeconomic variables. Further, U.S. IR shocks and oil price shocks do not seem to be vulnerable to the domestic economy.

Chapter 5 concludes and discusses the research findings of this dissertation. This chapter also explains the importance of this study, in how it presents some ideas for policy-makers and academics. Moreover, we discuss the limitations of this study and provide suggestions for future research.

CHAPTER 2

INFLATION AND ECONOMIC GROWTH: A DYNAMIC PANEL THRESHOLD ANALYSIS FOR ASIAN ECONOMIES

2.1 Introduction

A sustainably high growth rate of output and a low inflation rate are the two main goals of a majority of macroeconomic policies. Price stability is a key factor in determining the growth rate of an economy. The central banks of many countries implement monetary policy so as to keep inflation at a desirable rate. A very high inflation rate affects the economy drastically and detrimentally, but there is some evidence that even moderate inflation slows growth (Temple, 2000 cited from Little et al., 1993). In addition, Aiyagari (1990) and Cooley and Hansen (1991) each suggest that the cost of lowering the inflation rate to zero is greater than the benefit of doing so.

In recent decades, there has been a substantial body of theoretical and empirical research that investigates the inflation/growth trade-off. The results of existing research have been mixed, and based on their findings; studies can be categorized as making one of four possible predictions. The first of these is that inflation has no effect on economic growth (e.g., Dorrance, 1963; Sidrauski, 1967; Cameron et al., 1996). The second is that there is a positive relationship between inflation and economic growth (e.g., Tobin, 1965; Shi, 1999; Mallik and Chowdhury, 2001). The third is that inflation has a negative effect on growth (e.g., Friedman, 1956; Stockman, 1981; De Gregorio, 1992; Gylfason, 1991, 1998; Barro, 1996; Andrés and Hernando, 1997; Saeed, 2007). In addition, Feldstein (1996) notes that “shifting the equilibrium rate of inflation from two percent to zero would cause a perpetual welfare gain equal to about one percent of GDP a year” (pp. 50–51).

The last of the four types of studies suggests that the correlation between inflation and growth is nonlinear, and that the association between the inflation rate and economic growth is positive or nonexistent below some critical value, threshold level, but that it affects the economy when it exceeds that level. Fischer (1993) was one of the first authors to identify the possibility of such a nonlinear relationship; he argues that inflation can boost economic growth when it is below a threshold value, but has a negative influence when it exceeds that value. Sarel (1996) demonstrates the existence of a point of inflection, which is equal to 8%. Ghosh and Phillips (1998) identified a considerably lower threshold effect: a 2.5% per-annum inflation rate. In contrast, Bruno and Easterly (1998) determined that, for the 31 countries studied, 40% was the “natural” breakeven point between low and high inflation rates. In that study, countries were examined based on their level of inflation crisis during a set period; the authors also demonstrate that a high inflation rate crisis leads to a sharp decrease in the growth rate, but that the growth rate recovers as inflation falls.

Khan and Senhadji (2001) calculate the threshold as being 1–3% for developed countries and 11–12% for LDCs. They claim that inflation significantly impedes economic growth beyond this level, but has no significant effect below it. Drukker et al. (2005) suggest that 19.16% is the critical threshold for the 138 countries studied (full sample), but that there were two different threshold points (i.e., 2.57% and 12.61%) for developed countries. Bick (2010) concludes that the inclusion of difference in the intercept regime reduces the threshold from 19% to 12% and doubles the magnitude and marginal effect of inflation on growth. Kremer et al. (2009) found that the threshold level differs between developed countries and LDCs, and state that the target inflation rate should be 2% for developed countries and 17% for LDCs.

A majority of the existing empirical work uses data that include both developed countries and LDCs, from a variety of regions. However, "One should probably be careful about extrapolating findings from one set of countries to another. In general, it would seem best to study inflation's effect within OECD or a sample of relatively similar developing countries and not mix the two" (Temple, 2000 p. 412). Bearing this in mind, in this study, we consider only Asian countries.[1]

Moreover, most of the empirical growth metrics by which researchers look to identify a threshold inflation level are pinpointed through approaches that explicitly ignore any potential endogeneity bias (Khan and Senhadji, 2001; Bick, 2010). Some empirical literature, however, resolves the problem of endogeneity bias by excluding initial income from the growth regression (Drukker et al., 2005). Hansen (1999) assumes in his panel threshold model that all variables are exogenous;[2] however, with regard to the panel data growth regression, we are uncertain about exogeneity restrictions, because some of the explanatory variables are endogenous by construction, such as initial income. Caselli et al. (1996) argue that estimates could be inconsistent in cross-country growth regressions, for reasons related to country-specific FEs and the inclusion of endogenous variables among explanatory regressors in the model. In this study, we appropriately model these two issues to obtain consistent estimates. Therefore, the problem of endogeneity bias has been mitigated in this growth regression.

[1]Our sample does, however, consist of 4 OECD countries (Japan, Korea, Israel, and Turkey) and 1 developed country (Singapore). We have thus also dropped these five countries from our analysis and re-calculated the threshold point and its effect on economic growth to check the robustness of our result.

[2]Kremer et al. (2009) have considered initial income as an endogenous variable in their growth regression, but their sample includes both developed and developing countries.

As mentioned, LDCs often suffer from macroeconomic instability and rely on international agencies such as the IMF, the WB, or the ADB to stabilize their economies. Various agencies have come up with a variety of guidelines and suggestions, such as reducing or increasing prices—in many cases, without properly coordinating with each other. This makes it more difficult for policy-makers to determine the levels of inflation that Asian countries should maintain in order to stabilize their economies.

This study employs the dynamic panel threshold model to deal with country-specific heterogeneity and endogeneity issues. We apply the FOD operator to eliminate the individual FE, and use an entire set of lags on the initial income as instruments by which to deal with endogeneity, thus utilizing Roodman's (2009a) "collapsed-form" GMM-style instruments. This study estimates the potential threshold point and investigates the effect of inflation on economic growth for 32 Asian countries over the 1980–2009 period. The sample size has been reduced by taking the average of the data at two-year intervals, in order to eliminate fluctuations in the business cycle.

The empirical results of this study provide existing evidence of a nonlinear correlation between inflation and growth. The estimated threshold is 5.43%, which differs statistically from existing empirical research findings, where the threshold ranges from 8% to 40% for LDCs' economies and from 1% to 3% for developed economies (Bruno and Easterly, 1998; Khan and Senhadji, 2001; Bick, 2010; Kremer et al., 2009). We find that inflation impedes growth significantly when it exceeds 5.43%.

Below, section 2 discusses the literature related to this study, section 3 outlines the data and variables used in this study. Section 4 describes the construction of the dynamic panel threshold model and describes the estimation method used. Section 5 provides an estimation result for the model. Finally, conclusions and the policy implications of this study are presented in section 6.

2.2 Literature Review

Despite there being many factors that affect the growth rate of an economy, price stability is the most prominent goal of macroeconomic policy. Recent decades have seen an explosion in research, both theoretical and empirical, that attempts to focus on the correlation between inflation and economic growth. Thus, it is crucial that we review the existing relevant literature, if we are to understand the precise relationship between inflation and economic growth. This section briefly reviews the relevant theoretical studies, and then goes on to discuss the findings of existing empirical studies that pertain to the inflation–growth nexus.

2.2.1 Theoretical Studies

This subsection reviews the various growth theories, including classical, neoclassical, Keynesian, monetarism, and endogenous growth models. Theoretical studies have reached a variety of conclusions regarding the responsiveness of economic growth to inflation, and they can be divided into four main strands.

In the first strand, there is an inverse relationship between inflation and the economic growth rate. As part of classical growth theory, Adam Smith proposes that saving is an initial factor for investment, and therefore for growth. Further, he implicitly suggests that there is an inverse relationship between inflation and the economic growth rate. However, as many researchers have emphasized, the usual argument is that inflation has an impact on saving through the real deposit rate. Thus, changes in saving could affect the output via a change in domestic investment. Gylfason (1991) states that increase in inflation reduce savings on account of the lower real deposit rate, thereby impeding economic growth. On the other hand, Gylfason (1998) suggests that while the effect of inflation on saving is ambiguous, it distorts production; he concludes that price stability improves capital utilization and thereby increases the full-time employment output level.

Monetarists link the economic growth and price level through monetary growth. Friedman (1956) emphasizes the role of money growth in determining inflation, by way of quantity theory of money and the neutrality of money. He reports that inflation occurs when an increase in money supply growth (or velocity of money) is greater than the output growth rate, but that inflation would not hamper the GDP growth rate when the neutrality of money holds. Hence, real variables—including the output growth rate—are independent of the level of the money supply. However, in practice, inflation has real consequences on other macroeconomic variables, through its effect on the levels of physical capital, investment, and trade (Gokal and Hanif, 2004). In summary, monetary growth theory emphasizes that the money growth rate does have an effect on prices in the long term, even though it does not have a real effect on the GDP growth rate.

Using the cash-in-advance model, Stockman (1981) suggests that money is complementary to capital, and that it causes an inverse correlation between inflation and the output growth rate. This implies that an increase in inflation reduces the purchasing power of money balances and that this in turn tends to reduce the purchase of consumption and capital goods and thereby reduces the long-term output.

In the second strand of research, the prediction is that there is a positive relationship between the inflation rate and economic growth. Neoclassical economists articulate the impact of inflation on economic growth through its effect on investment and capital accumulation. Tobin (1965) argues that inflation increases the cost of holding money. As a result, the public would tend to hold less in money balances and move more money towards other assets; this would drive down IRs and spur economic growth. Hence, Tobin's portfolio mechanism suggests a positive association between inflation and growth. In addition, Shi (1999) concludes that an increase in money growth will increase capital accumulation and hence output. However, Temple (2000) argues that, typically, money balances constitute a small fraction of capital stock, and so it is difficult to justify its inclusion as an important consideration.

In the third strand, there is no correlation between inflation and growth. Sidrauski (1967), in his infinitely-lived representative agent model, assumes that money is "super neutral." He demonstrates that an increase in inflation has no effect on the steady-state capital stock, and so it has no effect on either output or the output growth rate. Using aggregate supply (AS) and aggregate demand (AD) curves, Keynesian theory suggests there is no change in output and price level in the long term, but that there is a short-term trade-off. However, Dornbusch et al. (1996) demonstrate that a change in AD affects both prices and output level.

Finally, in the fourth strand, inflation affects economic growth in a nonlinear manner (e.g., Huybens and Smith, 1998, 1999; Choi et al., 1996). Using a monetary growth model, Huybens and Smith find a strong and adverse relationship between inflation and financial market activities, and inflation and real activities. They show that inflation hurts economic growth by impeding financial-sector resource reallocation, but only if the inflation rate exceeds a certain critical value. Choi et al. propose that a high inflation rate gives rise to credit-rationing or an adverse selection mechanism in the financial market; hence, they claim, a high inflation rate reduces real returns. When inflation increases, the economic agent will reallocate money toward human or physical capital—and, in so doing, alter output growth.

2.2.2 Empirical Studies

As with those of theoretical studies, the results of the existing empirical literature also make four possible conclusions regarding the effect of inflation on the output growth rate: (1) there is no correlation between the inflation rate and the economic growth rate, (2) inflation does have a negative impact on economic growth, (3) the effect of inflation on output growth is positive, or (4) the effect of inflation on economic growth is nonlinear. Thus, the trade-off between inflation and growth is not stable, and depends upon the data being used (i.e., results vary with the sample period and countries/regions examined). This section briefly reviews the relevant empirical research on the association between inflation and economic growth.

Some earlier studies find inflation not to be a decisive factor in determining growth (Dorrance, 1963). In addition, Cameron et al. (1996) demonstrate that there is no trade-off between the inflation rate and output. In their study, they use the quarterly and annual datasets of four countries (i.e., Canada, United States, United Kingdom, and West Germany). They highlight the strong link between the inflation rate and productivity growth, but the link is incredibly internally inconsistent.

Tobin (1965) finds that an increase in inflation increases economic growth, even as most economists demonstrate a negative trade-off between the inflation rate and economic growth (Saeed, 2007; Barro, 1997; Andrés and Hernando, 1997; De Gregorio, 1992).

Saeed (2007) investigates the correlation between inflation and the output growth rate, using annual data from Kuwait from 1985 to 2005. He applies cointegration and an error-correction technique to evaluate the model, ultimately proposing a statistically significant and negative correlation between inflation and growth. Andrés and Hernando (1997) find an inverse link between inflation and the output growth rate, but investigators do not obtain a negative correlation in high-inflation economies. In addition, they report that the cost of inflation remains significant when one allows country-specific FEs into the model. They point out that when inflation declines by one percentage point, the output level increases by 0.5–2.5 percentage points. Using panel data from OECD countries from 1960 to 1992, the authors undertook an empirical study via the linear version of the convergence equation[3] by applying ordinary least squares (OLS) and instrumental variable (IV) techniques.

Barro (1995, 1996) suggests that inflation is unfavorable to economic growth. Particularly, the estimated negative effect comes from experiences with high inflation rates. He points out that the magnitude of the effect is too small to be considered significant. The results indicate a decline in the per-capita GDP growth rate of between 0.2 and 0.3 percentage points per year whenever inflation increases by 10 percentage points per year—although the negative effect of inflation on output growth seems to be small and its impact on living standards substantial in the long term. There is no clear evidence of whether low

[3]They split the data set as two parts: First, when demand shock was predominant that is 1961-1972 and 1989-1992. Second, when supply shocks were significant that is 1973-1988.

inflation rates bring about the same results. Barro used panel data from over 100 countries from the 1960–90 period, took 10-year averages, and employed the IV variable estimation technique to evaluate the co-efficient of growth regression. De Gregorio (1992) explored the impact of inflation on the growth rate by using an endogenous growth model. De Gregorio used data for 12 Latin American countries over the 1951–85 period, and each observation corresponds to a six-year interval. He assessed the estimators by employing the generalized least squares method, and found there to be a negative correlation between inflation and economic growth.

A few relatively recent empirical studies have shown a positive relationship between inflation and economic growth. Mallik and Chowdhury (2001) investigated the relationship between inflation and real GDP growth for four south Asian countries (Sri Lanka, India, Pakistan, and Bangladesh), using unbalanced annual data. They estimated growth regression by employing cointegration and an error-correction model. The authors found evidence of a long-term positive link between the inflation rate and economic growth, for all four countries. They also demonstrate that the sensitivity of growth in response to changes in inflation rates is smaller than that of inflation to changes in growth rates.

Recently, many empirical studies have found there to be a nonlinear and concave relationship between inflation and economic growth. Bick (2010) investigates the correlation through the use of a panel threshold model that includes the regime intercept. In the absence of the regime intercept, he finds evidence of a positive and significant effect on growth when inflation rates are below the threshold, but that inflation rate values in excess of the threshold have a negative impact on growth, albeit not statistically significant. He found that the inclusion of differences in the intercept regime reduces the threshold from

19% to 12%, and doubles the magnitude; he also found that the marginal effect of inflation rate on output growth was significant at the 5% level, whether above or below the threshold value. He used panel data from 40 LDCs from the 1960–2004 period and the OLS technique to obtain estimates.

Kremer et al. (2009) introduce a panel threshold model with endogenous regressors to determine the threshold value of inflation. In their study, they used panel datasets from 124 countries from the 1950–2004 period. The authors applied FOD transformation to remove the individual FEs, and they employed the IV and OLS approaches to estimate the parameters after country-specific FEs were eliminated. The authors conclude that inflation impedes economic growth when it exceeds a certain level, but that that level differs between developed countries and LDCs. For developed countries, the inflation target should be 2.5%, while 17.2% is the target for LDCs. Inflation affects the growth rates of developed countries positively, but it is detrimental to those of LDCs when it is below the threshold level.

Drukker et al. (2005) explored the existence of threshold inflation for 138 countries—i.e., both developed countries and LDCs—over the 1950–2000 period. They found a threshold of 19.16% for the full sample. An increase in inflation was found to have no significant effect on output growth, when the initial inflation rate was less than 19.16%. In contrast, they found there to be a statistically significant negative association between these two variables whenever the initial inflation rate exceeded 19.16%. In addition, they identified two threshold points for developed countries, i.e., 2.57% and 12.61%.

Khan and Senhadji (2001) estimated the inflation–economic growth relationship for 140 countries—both developed countries and LDCs—using a panel dataset from the 1960–1998 period. They employed the nonlinear least squares method to deal with nonlinearity and nondifferentiability. The researchers applied the conditional least squares method to calculate the threshold estimates, eventually finding a threshold value of inflation of 1–3% for developed countries and 11–12% for LDCs. This study found evidence of a negative and statistically significant correlation between inflation and economic growth whenever inflation exceeds the threshold level; on the other hand, inflation below the threshold level was found to be conducive to economic growth.

Gylfason and Herbertsson (2001) investigated whether there is a nonlinear relationship between inflation and growth, for 170 countries over the 1960–92 period. They applied a random-effects panel model for two sets of unbalanced panel data. The authors found that interaction between inflation and economic growth was stronger in the Penn World Tables (PWTs) datasets than in the WB datasets. Economic growth decreased by 1.3% as inflation increased 5–50% in a year. In contrast, the economic growth rate fell 0.6% when they used WB datasets. In conclusion, they suggest that cross-country associations between inflation and growth are significant both economically and statistically, and that an inflation rate exceeding 10–20% per annum is detrimental to long-term economic growth.

Bruno and Easterly (1998) conducted a study of the connection between inflation and economic growth among 31 countries that had high-inflation crises over the 1961–94 period. They found there to be a negative correlation between inflation and growth. In that period of discrete high-inflation crises, growth declined sharply, but recovered rapidly as the inflation rate fell. The authors conclude that the threshold level of inflation is around

40%, and that a government should look to keep inflation below this critical level. They also found that moderate inflation reduces economic growth.

Fischer (1993) was one of the first to recognize such a nonlinear association, by using data from 93 countries. He made use of cross-section and panel regression to study the inflation–economic growth relationship. Fischer divided the sample into two time periods: 1960–72 and 1973–88. He found a supply shock in the first period, but the results were similar across the two samples. He concludes that the effect of inflation on output is nonlinear, with the threshold level being between 15% and 40%. He asserts that a low level of inflation is favorable to creating sustainable economic growth, but that extremely high inflation hampers the economic growth rate.

From the theoretical and empirical studies reviewed above, it is obvious that the existence of any interaction between inflation and economic growth is ambiguous and controversial; thus, it is necessary to investigate the trade-off between inflation and economic growth. If high inflation is detrimental to economic growth, just how high should inflation be?

We explore below the hypothesis and determine whether or not inflation affects long-term economic growth in a nonlinear manner.

2.3 Data and Variables

We use balanced panel data from the World Development Indicators (WDI), PWTs 6.3 and 7.0, and Economy Watch (EW) databases, from 32 Asian countries (see Table 2.1 for a list of the countries and summary statistics), to determine potential threshold points and estimate the impact of inflation on economic growth. To that end, we employ a dynamic panel threshold model. The dataset covers the 1980–2009 period.[4] Table 2.2 shows the variables used in our growth regression, as well as definitions and data sources. This study uses two-year averages from the data to smooth out business-cycle fluctuations, reducing the time dimension from 30 to 15 observations.

According to Table 2.2 (see Appendix), the average inflation rate value over the sample period was 12.6%—a value much lower than that given in the work of some previous growth empirics.[5] Figure 2.1a (see Appendix) shows that the distribution of inflation is asymmetrical; thus, following Sarel (1996) and Ghosh and Phillips (1998), we use the log of inflation rather than an absolute level. These authors suggest that the use of the log transformation eliminates strong asymmetry in the initial distribution of inflation—at least partially—and provides the best fit for the nonlinear models. Our sample includes some negative inflation observations, and we prohibit the use of the log of inflation. To deal with negative inflation observations, we use a semi-log transformation, following Khan and Senhadji (2001). The transformation involved is

$$\tilde{\pi}_{it} = \begin{cases} (\pi_{it} - 1), if\ \pi_{it} \leq 1 \\ \log(\pi_{it}), if\ \pi_{it} > 1 \end{cases}, \tag{2.1}$$

[4]Since we want to have a balanced dataset and data in some countries is produced with a lag, we only cover the period until 2009.

[5]For example, Kremer et al. (2009) computed an average value of inflation of 33.64%for 101 developing countries, while Khan and Senhadji (2001) found an average inflation rate of 28.06 % among 140 countries.

where $\tilde{\pi}_{it}$ denotes a continuous function that allows us to take into account both positive and negative inflation observations. Hence, $\tilde{\pi}_{it}$ is a hybrid function of inflation that is linear for inflation ≤ 1 and logarithmic for inflation > 1. A semi-logged transformation implies that the distributions of inflation rates are symmetrical and in line with the normal distribution (see Figure 2.1b, in Appendix).

The descriptive findings (see Figure 2.2) suggest that it is difficult to pinpoint the exact relationship between inflation and economic growth. This motivated us to utilize another commonly used econometric analysis to estimate the inflation–growth trade-off. The next section describes the econometric framework of this study.

2.4 Econometric Frameworks

In this empirical study, we work with a dynamic panel threshold model that takes the following form:

$$y_{it} = \mu_i + \beta_1 \tilde{\pi}_{it} d[\tilde{\pi}_{it} \leq \gamma] + \beta_2 \tilde{\pi}_{it}(1 - d[\tilde{\pi}_{it} \leq \gamma]) + \theta' x_{it} + \varepsilon_{it}, \quad (2.2)$$

where $\{y_{it}, x_{it}, \ \pi_{it}: 1 \leq i \leq N, 1 \leq t \leq T\}$ and ε_{it} is the error term with a 0 mean and not serially correlated. The dependent variable y_{it} is the real per-capita GDP growth rate of country i at time t; μ_i is a country-specific FE; $\tilde{\pi}_{it}$ is a threshold variable that is exogenous and time-variant; γ is the threshold level of inflation; and $d[.]$ represents the indicator function, taking a value of either 1 or 0, depending on whether the threshold variable is less or greater than the threshold level. That is, $d = \begin{cases} 1 \ \ if \ \tilde{\pi}_{it} \leq \gamma \\ 0 \ \ otherwise \end{cases}$. This effectively splits the sample observations into two groups: one with slope β_1, and another with slope β_2. X_{it} is the k-dimensional vector of explanatory variables, and it can be divided into two parts:

(i) predetermined variables,[6] where we assume the initial income ($x_{1it} = initial_{it} = gdppc_{it-1}$) to be a predetermined regressor, and (ii) all remaining explanatory variables are exogenous ($x_{2it} = \{inv_{it}, gpop_{it}, open_{it}, tot_{it}, sdopen_{it}, sdtot_{it}\}$)[7], which do not correlate with ε_{it}. We have chosen these control variables based on the existing empirical studies that use similar covariates (e.g., Bick, 2010; Kremer et al., 2009; Drukker et al., 2005; Khan and Senhadji, 2001).

2.4.1 Elimination of Fixed Effect

In the first step of the computation technique, we should eliminate the country-specific FE μ_i from the model, to estimate the slope coefficients and the potential threshold point. Nickell (1981) and Bond (2002) suggest that a within-group transformation does not eliminate dynamic panel bias, because the transformed lagged dependent variable x^*_{1it} negatively correlates with the transformed error term (ε^*_{it}). This motivated us to use another common transformation method called FOD, proposed by Arellano and Bover (1995). We apply FOD transformation to eliminate individual FEs. Therefore, for the error term, the required transformation is given by:

$$\varepsilon^*_{it} = c_t \left[\varepsilon_{it} - \frac{1}{(T-t)}(\varepsilon_{i(t+1)} + \cdots + \varepsilon_{iT})\right], \qquad (2.3)$$

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[6]Predetermined variables: The current error term is uncorrelated with the current and past values of the predetermined variable but may be correlated with future values, that is, $E(\varepsilon_{is}|x^1_{it})\begin{cases}\neq 0 & if \quad s < t \\ = 0 & otherwise\end{cases}$. For example, in our growth model with rational expectations, initial income is predetermined. As such, unpredictable income shock is uncorrelated with past (and potentially current) GDP per capita, but certainly correlated with future GDP per capita.

[7] However, some other explanatory variables also might be endogenous such as investment and population growth. Islam (1995) suggests that investment and population growth are endogenous, but preferences are iso-elastic where investment and population are independent with the error term. Thus, we assume all explanatory variables as exogenous except initial income for the simplicity.

where $c_t = \sqrt{\frac{T-t}{T-t+1}}$ and $Var(\varepsilon_{it}) = \sigma^2 I_T$ are not serially correlated, and $Var(\varepsilon_{it}^*) = \sigma^2 I_{T-1}$ also has no serial correlation. Applying this procedure to equation (2.2) yields:

$$y_{it}^* = \beta_0 + \beta_1 \tilde{\pi}_{it}^* d[\tilde{\pi}_{it} \le \gamma] + \beta_2 \tilde{\pi}_{it}^* (1 - d[\tilde{\pi}_{it} \le \gamma]) + \theta' x_{it}^* + \varepsilon_{it}^*, \qquad (2.4)$$

where $t = 1, \ldots, T-1$ and the superscript * denotes post-transformation data.

2.4.2 Dealing with Endogeneity

Structural equation (2.2) requires a set of suitable instruments by which to resolve the endogeneity problem. We use the lags of initial income as instruments for the predetermined regressor. For the transformed initial income x_{1it}^*, we use the untransformed value x_{1it}. As there are no clear guidelines regarding identification restrictions, by following Roodman's (2009a) collapsed-form instrument method, we use the following $(T-1)$ moment condition—in other words, we employ the entire available set of lags as instruments:

$$E(x_{1it}, \varepsilon_{it}^*) = 0, \text{ where } t = 2, \ldots., T-1.$$

Using a two-step technique, we then estimate the IV parameter or 2SLS estimator. In the first step, we construct a reduced-form regression for the endogenous regressor, x_{1it}^*, as a function of the instruments z_{it} and all exogenous variables:

$$x_{1it}^* = \lambda_0 + \lambda_1' \sum_{j=1}^{T} z_{i,t-j} + \lambda_2 \tilde{\pi}_{it}^* d[\tilde{\pi}_{it} \le \gamma] + \lambda_3 \tilde{\pi}_{it}^* (1 - d[\tilde{\pi}_{it} \le \gamma]) + \theta' x_{2it}^* + \upsilon_{it}, \qquad (2.5)$$

where $E(v_{it}, z_{it}) = 0$. Then, we compute the reduced-form parameter λ by the least squares method, and the fitted value of the endogenous variable $\hat{x}_{1it}^*$. Following that, we replace x_{1it}^* with its fitted value $\hat{x}_{1it}^*$ in equation (2.4), which can be written as

$$y^*_{it} = \beta_0 + \rho\, \hat{x}^*_{1it} + \beta_1 \tilde{\pi}^*_{it} d[\tilde{\pi}_{it} \le \gamma] + \beta_2 \tilde{\pi}^*_{it}(1 - d[\tilde{\pi}_{it} \le \gamma]) + \theta' x^*_{2it} + \varepsilon^*_{it}. \qquad (2.6)$$

In the second step, we estimate the IV parameter $\hat{\beta}_{iv}$ from equation (2.6) for any given threshold γ. Then, we find the residual sum of square (RSS) as a function of γ.

$$\hat{\varepsilon}_i = Y - X\hat{\beta}_{IV} \qquad (2.7)$$

$$S(\gamma) = \hat{\varepsilon}'_i * \hat{\varepsilon}_i, \qquad (2.8)$$

where S is the RSS.

2.4.3 Estimation Procedure for Threshold Value and Other Coefficients

In the third step, the inflation threshold level is calculated by using the conditional least squares method. To estimate the threshold γ, we repeat the procedure described above by changing the threshold level of inflation (ranging from $\underline{\gamma}$ to $\overline{\gamma}$) to a decimal value of the increment. Finally, the threshold value γ is selected as the value associated with the smallest RSS. The minimization search takes the form of

$$\hat{\gamma} = \underset{\gamma}{\operatorname{argmin}}\, S_n(\gamma). \qquad (2.9)$$

In practice, the length of the inflation may be an unusually large number. If we consider the full length of inflation to search for the optimal threshold level, the optimization search method described above may lead to a numerically intensive process. Hansen (2000) suggests narrowing the range of inflation values by searching for the optimal threshold, which is the region in which we expect the value to be. In addition, Hansen (1999) proposes that this search be restricted to a smaller set of threshold values, instead of to the overall values of π_{it}, using a set increment that can be integer-valued. With this in mind, we employ a graphical analysis to determine the range of inflation (see Figure 2.1b, in the Appendix) and the optimal threshold level, before minimizing the RSS.

Once the threshold value of $\hat{\gamma}$ is determined, in the second stage, we estimate the slope coefficients (β_1 and β_2) and the impact of other control variables on growth from structural equation (2.2) in levels, using GMM.[8] In this case, we apply the previously used instruments and the previous estimated threshold $\hat{\gamma}$. We can test whether the threshold level is significant by testing $\beta_1 = \beta_2$, which is the same as testing the following null hypothesis:

$$H_0: \beta_1 = \beta_2.$$

2.5 Estimation Results

We use the conditional least squares method for equation (2.6), to evaluate the potential threshold point. At this point, we assume that only initial income is a predetermined regressor; we also consider the remaining control variables exogenous, and choose all valid sets of lags as instruments, following Roodman's (2009a) collapsed-form GMM-style instruments matrix. In the second stage, we investigate the impact of inflation on economic growth from equation (2.2), using the GMM method. In this stage, we assume that initial income is a predetermined variable, and that the remaining control variables are exogenous.[9] For the instruments, we consider all the available lags of the predetermined

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[8] Arellano and Bond (1991) suggest that differenced GMM is more efficient than the Anderson-Hsiao estimator. In contrast, Kiviet (1995) finds that there is no appropriate estimator for all circumstances. Blundell and Bond (1998) propose that a system GMM estimator is more efficient than first-differenced IV or GMM estimators, which may suffer from severe small sample bias, because they are weak instruments applied to highly persistent data. Judson and Owen (1999) support the bias-corrected least square dummy variable (LSDVC) estimator, based on a Monte Carlo analysis, when N is small or moderately large and $T \leq 30$ for a balanced panel data set. In this study, we apply system GMM procedures to estimate slope coefficient and fixed effect (FE) estimator, as well as LSDVC for robustness.

[9] The above model can be extended by allowing further explanatory variables to be endogenous. For this reason, in the second stage of our empirical application, we have considered two benchmarks. First, initial

variable as instruments by which to increase efficiency (see Table 2.3). However, to be robust and to preclude the over-fitting of IVs, we also consider the current lag of the predetermined variable as an instrument. The results are robust to the choice of instruments (see Table 2.4, column 3).

2.5.1 Estimation Results of Threshold Value

We employ the conditional least squares method to calculate the threshold level of inflation, with the goal of minimizing the RSS in equation (2.6) as conditional on any given threshold level. We repeat the procedure for different threshold values from 0.1% to 1.25% (inflation rates are in natural logarithms), at 0.005% increments. Figure 2.3 (see Appendix) illustrates how the RSS changes with increases in inflation rates. The minimum is reached at 0.735% (converting a log 0.735% to a level value we derive 5.43%).

The empirical results indicate that the threshold level of inflation is approximately 5.43%[10] (see Figure 2.3); this level is statistically significant at the 1% level. The estimated threshold value is statistically different from that found in previous empirical research that has focused on LDCs. For example, Bruno and Easterly (1998) calculated a 40% threshold, Khan and Senhadji (2001) estimated 11–12%, Kremer et al. (2009) identified a threshold of 17.2%, and Bick (2010) calculated 19.16%. Moreover, we arrived at the same threshold value of about 5.43% (see Figure 2.4) when we extracted from the sample data four OECD countries (Japan, Israel, South Korea, and Turkey)[11] and Singapore, in order to address our

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income is a predetermined variable while any remaining regressors are strictly exogenous. Second, all regressors are predetermined. However, the choice of endogeneity has almost the same impact on this empirical result (see Table 2.3, column 1 & 3).

[10]If we use only the current lag ($m = 1$) of the initial income as an instrument, we find that the threshold level of inflation is around 3.63%. These estimation results are not presented here but up on available on request.

[11]We also arrived at the same threshold level, 5.43% when we included Turkey in our sample (making a total of 28 developing countries) since it is currently going through the development process. However, the

first research motivation. The effects of inflation on growth were also found to be the same as those for the full sample (see Table 2.3, column 2), suggesting that inflation impedes GDP growth significantly when its rate exceeds 5.43%.

2.5.2 Estimation Results of Impact of Inflation Threshold and Other Control Variables on Economic Growth

Once we determine the threshold level, we estimate equation (2.2) to analyze the impact of inflation on growth. Table 2.3 (see Appendix) presents the results obtained from equation (2.2) for Asian countries, through the application of GMM.[12] The upper panel of the table shows the estimated threshold level of inflation. The effect of inflation on growth is presented in the middle section of the table. In particular, $\hat{\beta}_1$ and $\hat{\beta}_2$ indicate the marginal impact of inflation on growth when inflation is below or above the estimated threshold value, respectively. Finally, the lower part of the table displays the coefficients of the control variables. When we reduce the instrument count to 1, the estimation results from equation (2.2) are found to be similar to those obtained using all available lags of initial income (see Table 2.4, column 3).

The results obtained in this study for Asian countries differ from those of existing empirical studies, in three important respects. First, the estimated inflation threshold is statistically different and much lower than those found in existing empirical studies that investigate LDCs. We find a threshold level of 5.43%, whereas the existing literature offers figures that vary from 8% to 40%. Our low inflation threshold could be explained by our use of the indexation system, which shows that most Asian countries have a history of

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threshold value and coefficients are insignificant in that case, except for the investment ratio. The results are not presented here but are available on request.

[12] In order to control for time effects, we included time dummies in equation (2.2). Inclusion of time dummies in the growth regression (2.2) did not change our main results (see Table 2.5).

moderate or less-than-moderate inflation. It could be that different countries have different inflation threshold values. For example, country-specific trade barriers might make threshold values vary across countries. However, from our statistical perspective, it is difficult to estimate a different threshold for each country.[13] For example, if we were to use data from only one country, the threshold estimate would be too imprecise; therefore, our result can be interpreted as guidance for regional inflation policy.

Second, the coefficient of inflation above the threshold is negative ($\hat{\beta}_2 = -1.627$) and statistically significant at the 1% level, indicating that inflation hampers the growth rates of Asian economies when it exceeds 5.43%. In contrast, some past studies—such as that of Drukker et al. (2005)—found that while inflation thresholds can be statistically significant, the effect of inflation on growth is not significant in any regime. Finally, in the current study, inflation below the threshold was not found to have any significant effect on growth, although the coefficient was positive($\hat{\beta}_1 = 0.043$). However, Kremer et al. (2009) detected the negative sign, which is not statistically significant, when inflation is less than the threshold value. Meanwhile, Bick (2010) identified a plausible sign that is positive and significant when inflation is below the threshold.

The current study also arrived at other interesting findings. First, the coefficient of initial income is negative and significant at the 5% level, indicating that rich countries grow slowly while poor countries grow quickly. Therefore, our results strongly support the concept of conditional convergence. Second, the coefficient of investment has a plausible sign that is positive and significant at the 1% level. The standard growth model predicts that

[13] In some countries such as Japan, inflation level has been too low and it has been said that this may have damaged the growth prospect of the economy. To evaluate this hypothesis we would need to incorporate one more threshold, the lower bound, into the analysis. However, given that the countries in our sample have not suffered from a low inflation problem, we are not taking this issue in to consideration.

investment has a positive impact on growth and suggests that the governments of Asian countries can promote economic growth by motivating investment. Third, we find that a positive relationship exists between the level of openness of an economy and the per-capita GDP growth rate; as such, we recommend that the governments of Asian countries reduce trade barriers further, in order to increase the health of their economies. Some existing empirical studies have also found an inverse correlation between level of openness and economic growth.

2.5.3 Estimation Results for Robustness Check

To ensure consistency in our results, we apply different estimation methods to equation (2.2), such as the bias-corrected least squares dummy variable (LSDVC) method and the FE estimation technique (see Table 2.4 in Appendix). We find that the impact of inflation on growth was quite similar across different estimation procedures when the inflation rate was above the threshold value. Column 1 of Table 2.3 and columns 1 and 2 of Table 2.4 show that the effect of inflation on growth is negative and statistically significant when the inflation rate exceeds 5.43%; in contrast, inflation does not have any significant effect on growth when it is below the 5.43% threshold value, and this finding is consistent with our main finding. In addition, the impact of control variables on economic growth changed our results slightly when we used the LSDVC and FE estimation methods (see Table 2.4).

2.6 Conclusion and Discussion

In this empirical study, we examined the relationship between inflation and growth by allowing for a threshold level of inflation. We used panel data from 32 Asian countries, covering the period from 1980 to 2009. We estimated a threshold point and slope coefficients through the use of the dynamic panel threshold model, which allowed us to include endogenous regressors, as proposed by Kremer et al. (2009). The sample size was reduced by using the data averages at two-year intervals, which smoothed out business-cycle fluctuations. The FOD transformation was applied to remove individual-specific characteristics from the panel set-up. We applied a conditional least squares technique to estimate the potential threshold point. Once we determined the threshold for inflation, we estimated the impact of covariates by using a GMM procedure for equation (2.2).

We observed a nonlinear relationship between inflation and economic growth, implying that when inflation exceeds the detected threshold level of inflation (5.43%, over the long term), growth is hampered. We also found that higher initial income decreases economic growth (conditional convergence). In addition, we determined that the investment ratio stimulates economic growth. Finally, we found evidence that maintaining a greater level of openness promotes economic growth.

Our results with regard to the effect of the threshold level of inflation on growth are consistent with those of existing empirical studies: inflation has not been found to have any significant effect on growth, until it reached 5.43%; after that point, it was found to slow down economic growth significantly. However, we found that the threshold level of inflation for Asian countries was lower than the values cited in previous empirical studies of LDCs, which range from 8% to 40%.

The results of this study with regard to the impact of inflation on economic growth over the long term are consistent with those arrived at through other estimation methods when inflation exceeds the threshold value. The effect of investment on growth is robust in all cases, whereas the impact of other control variables on growth differs, depending on the estimation methods involved.

This study is not without its limitations. First, the exclusion of some relevant control variables and the inclusion of other, less-important variables in the growth equation may have led to specification bias, and relevant control variables should have been chosen through the application of an appropriate econometric technique (e.g., BMA technique). Second, owing to the exogeneity restriction—under which not only is initial income predetermined, but other control variables may also be endogenous—our estimated coefficient may be biased. Third, our estimate does not imply a causality relationship; it only reveals a correlation. Finally, one should bear in mind that as every country has geographic and economic environments that differ from those of other countries, optimal inflation targets may be country-specific. We regard these limitations as providing direction for further research.

Overall, our empirical solution could be of use in providing policy guidance to policy-makers. Policy-makers in Asian countries need to consider 5.43% a maximum inflation rate target in maintaining economic stability. Economic growth can also be enhanced by reducing trade barriers and motivating investment.

CHAPTER 3

ROBUST DETERMINANTS OF GROWTH IN ASIAN DEVELOPING ECONOMIES: A BAYESIAN PANEL DATA MODEL AVERAGING APPROACH

3.1 Introduction

Some countries grow faster than others. Why does this happen? Many empirical studies have focused on this problem by regressing the observed growth rate of GDP per capita on a number of explanatory variables (e.g., Kormendi and Meguire, 1985; Romer, 1990; Barro, 1991; Aghion and Howitt, 1992; Sala-i-Martin, 1997a, b; Hall and Jones, 1999; Durlauf and Quach, 1999; Temple, 1999; FLS; Fernandez et al., 2001b; SDM). However, the number of potential regressors suggested by competing growth theories is large and there is a potential problem of over-parameterization (see, for example, Koop and Tole, 2004b). For this reason it is not recommended to include all potential regressors in a model.

On theoretical grounds there is no consensus among researchers regarding the set of explanatory variables that have an effect on growth. Furthermore, there is a myriad of possibilities in the empirical literature. For example, Sala-i-Martin (1997a, b) claim 22 variables of 59; FLS propose four variables of 41; SDM found 18 variables of 67; Moral-Benito (2010) recognizes only one of 10 variables; and LM identified three regressors that are significantly associated with long-term economic growth. In summary, each empirical work within the literature identifies at least one regressor associated with the growth rate.

The past empirical growth literature has proposed different econometric techniques to address the issue of model uncertainty —uncertainty regarding which factors seems to explain growth differences across countries. Typically researchers have to deal with a large number of empirical growth models, each one consisting of a different combination of explanatory variables. Each model has some probability of being the “true” model. Bayesian Model Averaging (BMA) is a widely accepted technique to overcome the problems associated with selection of a single model, and has been used in many recent empirical growth studies. It was popularized in the growth literature by the seminar works of FLS and SDM and since then it has been applied in several growth empirical studies (e.g., Ciccone and Jarocinski, 2010; Moral-Benito, 2010; 2012, KLS; LM) and other areas of economics (e.g., Koop and Tole, 2004a; Chen et al., 2011). A few studies have extended BMA to apply the threshold models that are relevant to growth and other areas of economics (Crespo-Cuaresma and Doppelhofer, 2007; Koop and Tole, 2004b).

Most previous empirical studies that used BMA dealt only with the model uncertainty that results from different choices of control variables. However, as noted by Caselli et al. (1996), failure to account for country-specific FE and endogeneity of regressors might render cross-country growth regression estimates inconsistent. These problems might arise because of measurement error, omitted variable bias and simultaneous effects. However, the econometric techniques that solve these problems need to rely on a choice of instruments, and exogeneity restrictions. This adds one more layer of difficulty to the model selection problem. To take this into account KLS and LM have extended the BMA approach to consider the additional dimensions of the model space.

Many of the aforementioned empirical growth models investigate model uncertainty under the assumption of a linear relationship between growth and its determinants—that is, the impact of a particular variable on growth is either positive or negative. However, there is some evidence that some of the growth determinant might have an effect on growth in a nonlinear manner. For instance, inflation (see, Fischer, 1993; Khan and Senhadji, 2001; Bick, 2010; Yilmazkuday, 2011), government size, number of years the economy has been open, and initial per-capita income (e.g. Crespo-Cuaresma and Doppelhofer, 2007; Yilmazkuday, 2011) each has a nonlinear effect on growth. Moreover, Azariadis and Drazen (1990) suggest that the growth model provides multiple steady states.

Thus, following KLS and LM, we extend the model with the inclusion of a nonlinear function of inflation that allows for threshold effects among the explanatory variables. The purpose of this study is to use the BMA technique to surmount model uncertainty over several dimensions, such as a set of control regressors, a set of instruments, and exogeneity restriction. We also investigate the impact of the threshold level of inflation[14] on economic growth by applying dynamic panel data growth regression. Since in our empirical application we have a large model space, approximately 2^{181}, for the computations we use the reversible jump Markov chain Monte Carlo (RJMCMC) algorithm suggested by KLS.

In this study, we use unbalanced panel data from 27 Asian LDCs over the 1980–2009 period that include 14 explanatory variables in the growth regression. The dataset has been reduced by taking two-year averages of each variable, to eliminate business-cycle fluctuations.

The remainder of this section is structured as follows. Section 2 reviews some of the literature that is most relevant to this study. Section 3 briefly discusses the econometric framework of this study, while the data and the details of the variables are described in

[14]Since we already detected the threshold level of inflation for Asian LDCs, is 5.43%, in chapter 2, we are not going to estimate it again in this section. Thus, we apply 5.43% as the threshold level of inflation and defined inflation sample into two: (i) inflation below the threshold and (ii) Inflation above threshold. We then include these two variables into the model in order to estimate the posterior probability of inclusion.

section 4. Section 5 presents the estimation results of the econometric model and further findings. Finally, section 6 provides concluding remarks and offers policy implications.

3.2 Literature Review

One of the main aims of macroeconomic policy is to maintain high and sustained economic growth rates. It is known that many factors—including social, economic, environmental, political, and cultural factors—and policies determine the growth rate of an economy. However, researchers disagree on the determinants of growth. Thus, it is essential to review the most relevant growth literature, to identify the factors that significantly affect economic growth and to construct, through empirical study, a valid econometric model.

KLS developed the RJMCMC algorithm to avoid statistical issues associated with a very large model space. They used an IV regression model that allowed them to deal with uncertainty regarding a set of exogenous regressors, exogeneity restriction, sets of instruments, and the validity of identifying restriction. The authors applied this econometric technique to a returns-to-schooling empirical application; they show "how to calculate the probability of any relevant restrictions such as exogeneity or over-identification" (KLS, p. 2). LM introduced the RJMCMC algorithm for a dynamic panel data model with and without FE, to overcome the problem associated with a huge number of models. They developed the BMA technique to surmount model uncertainty regarding the set of control variables, exogeneity restrictions, choice of instruments, and identification restrictions. Using this technique, they investigated the impact of foreign aid on the GDP growth rate, and they found that the nearest lags more strongly correlate with a predetermined regressor than the longer lags. The authors suggest that BMA is an effective tool for panel data growth regression analysis when results are sensitive to the assumptions of the model.

Moral-Benito (2010) proposes a likelihood-based estimation method and a Bayesian averaging approach to measure model uncertainty in a dynamic panel data growth regression model. In this model, he considers both the choice of control variables, and exogeneity restrictions. Using Monte Carlo simulations, he found that the commonly used standard GMM estimator to be less desirable than that of the finite-sample performance of the proposed estimator. He detected only one variable, the investment ratio, to significantly correlate with long-term economic growth.

Crespo-Cuaresma and Doppelhofer (2007) analyzed whether growth determinants have a nonlinear effect on growth. They suggest the use of the Bayesian averaging of threshold (BAT) technique to examine the existence of a threshold level and its effect on growth, whenever model uncertainty is accounted for. They applied this method to a cross-section of 88 countries. The authors conclude that "there is no evidence for robust threshold effects caused by the initial income, measured by GDP per capita in 1960, but that the number of years an economy has been open is a significant source of nonlinear effects on growth" (Crespo-Cuaresma and Doppelhofer, 2007 p. 541).

The stylized facts with respect to the economic growth rate tend to cause two serious problems, whenever we analyze a growth model by using a formal econometric framework (Durlauf et al., 2005). The first problem relates to the question of convergence, while the second concerns the identification of determinants of growth, i.e., model uncertainty. These two problems arise in both the estimation of the model and the selection of that model. They propose 145 regressors as proxies and 43 different growth theories, as drawn from the empirical growth literature.

SDM estimated the robustness of the explanatory regressor in cross-country growth empirics. They introduced the Bayesian averaging classical estimate (BACE), to deal with model uncertainty regarding choice of control variables. SDM found 18 of 67 variables to be robustly, partially, and significantly associated with long-term economic growth. In addition, they suggest three other regressors that marginally correlate with growth. SDM found stronger evidence for only three variables, such as primary school enrollment rate, investment price, and initial level of per-capita GDP. FLS used a pure BMA technique to estimate the model uncertainty in a cross-country growth regression model; FLS suggest that some variables are useful explanatory regressors in the determination of growth in a linear growth model, and they concur with the findings of Sala-i-Martin (1997b).

Sala-i-Martin (1997b) applied the confidence level test to each variable, to test the significance of growth determinants. He found that 22 of 59 variables significantly affect growth. In addition, he always includes in his growth model three variables, such as GDP level, life expectancy, and primary school enrollment rate. Levine and Renalt (1992) examined the robustness of the existing empirical results of cross-country growth regression, employing a variant of Leamer's (1983, 1985) extreme bound analysis (EBA), and suggest that only a few variables satisfy the extreme-bound test.

In summary, researchers seem to agree that BMA is the most capable solution by which to address model uncertainty, but disagree on the explanatory regressors that are most prominent *a priori*. There is typically only fractional overlap among the myriad of explanatory variables. Moreover, no study to date has estimated the determinants of growth and investigated the effect of threshold-level inflation on growth while using a dynamic panel data model and the BMA approach, within the context of Asian LDCs.

3.3 Data and Variables

Given the availability of data in the panel context and while following the lead of existing empirical works (e.g., Sala-i-Martin, 1997a, b; FLS; SDM; Moral-Benito, 2010, 2012) that identify the factors that significantly correlate with growth, we consider the following set of growth determinants that are most relevant from a policy-makers' perspective.

- ✓ Initial income: The neoclassical growth model predicts a low coefficient on the initial level of per-capita GDP—that is, if we keep constant other determinants of growth, then the economy will tend to move towards its long-term position at the rate specified by the magnitude of the coefficient.

- ✓ Investment: In neoclassical growth theory, the ratio of investment to output denotes the rate of saving. This model reveals that a higher saving rate increases the output per effective worker at the steady-state level and thereby increases the rate of growth for a given GDP value.

- ✓ Inflation rate: Since the seminal work of Fischer (1993), many authors have entered into the growth model the inflation rate as a nonlinear function. Huyben and Smith (1998, 1999) illustrate that inflation hampers economic growth by impeding the financial sector resource reallocation, but only if the level of inflation exceeds a certain critical value. Thus, in this dissertation, we allow inflation to be entered as a nonlinear function that allows for threshold effects on economic growth.

- ✓ Population growth: Standard growth theory and the neoclassical growth model each proposes that a higher population growth rate will lower the steady-state level of output per effective worker, due to the fact that a fraction of investment is dedicated to new workers rather than to increasing the capital per effective worker.

- ✓ Trade openness: Economies' external environments or trade regimes are captured by degree of openness, as measured by exports plus imports as a percentage of GDP. It is often argued that a greater level of openness affects growth positively.

- ✓ Terms of trade: Many studies consider movements in the terms of trade—measured by changes in the relative prices of exports and imports—crucial growth factors. The most common aspect among these studies is that the terms of trade affect economic growth positively.

- ✓ Labor force participation rate: It has been found that an increase in the labor force participation rate stimulates economic growth: Bilinder and Yellen (2002) consider growth in the labor force and productivity as the driving forces of economic performance. Hence, we include in this model growth in the labor force.

- ✓ Government consumption expenditure: Since the seminal work of Barro (1991), several researchers have considered the share of government consumption a measure of distortion in the economy (Moral-Benito, 2010). Although the ratio of government consumption does not affect private productivity directly, it decreases saving and growth via a distortion effect from the government expenditure program or taxation (Moral-Benito, 2010).

- ✓ School enrollment rate: Since the seminal study by Lucas (1988), several studies have broadened the concept of capital, with the inclusion of human capital in addition to physical capital. Many empirical studies use education as a proxy for quality of human capital (e.g., Barro, 1991; MRW; FLS; SDM); thus, we consider the school enrollment rate in primary and secondary education as a proxy for this.

- ✓ Price level of investment: Since the seminal work by Agarwala (1983), many authors have come to consider investment price a proxy for the distortion of market price (e.g., Barro, 1991; Easterly, 1993; Moral-Benito, 2010). It is often argued that the distortion of market price has a negative impact on economic growth; hence, following Barro (1991), we consider the price level of investment a proxy for market price distortion.

- ✓ Population: Aghion and Howitt (1992) and Romer (1990) each explain the benefits of a large economic scale by using an endogenous growth model. Particularly, if there is a substantial set-up cost for adapting or inventing new products or production techniques at the country level, then larger economies would perform better on this basis. Many authors include a country's population, in millions, to examine the country-wide scale effect (Moral-Benito, 2010).

- ✓ Population density: There are several arguments about the impact of population density on the economy. First, low but growing population densities facilitate a more productive agriculture sector and greater specialization and exchange within society (Boserup, 1965). Most planners argue that the rising population density is beneficial to the economy, because "there are economies of density in the production of certain services" (Ladd, 1992 p. 274). On the other hand, Ladd (1992) argues that a higher density increases the harshness of the environment by increasing crime, which would in turn increase public safety costs.

From the very large number of explanatory regressors cited in the literature, we selected 14 variables.[15] The datasets cover the 1980–2009 period; however, there are some constraints with regard to dataset construction—that is, data pertaining to the school enrollment rate at the primary and secondary education levels from some countries either have shorter spans or are unavailable for some periods. Thus, we use unbalanced panel data from 27 Asian developing economies for this empirical application, given the uneven coverage of education data for some countries.

Some researchers include in their growth regression both developed countries and LDCs, from different regions (e.g., Khan and Senhadji, 2001; Kremer et al., 2009; Ghosh and Phillips, 1998; among many others). Other groups of studies consider only LDCs from a variety of regions (e.g., Bick, 2010). In contrast, Bruno and Easterly (1998) chose countries that had a high-inflation crisis at some point during the period under examination. However, in this study, we consider 27 countries only from Asia that are still under development[16] (see Table 3.3 for list of countries).

Table 3.1 (see Appendix) shows the list of the variables, definitions, and data sources of this growth regression. Although several studies estimate the determinants of growth based on data broken into four-year periods (e.g., LM, 2012; Chen et al., 2011), five-year

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[15]See Table 3.1 & 3.2 in Appendix for variable description, source of data, and summary statistics.

[16] The United Nations' human development reports explains that the development of a country is measured by human development index (HDI), a compound indicator that consist of GDP, life expectancy, the rate of literacy, and many other statistics. The countries with a relatively undeveloped industrial base, low living standard, and a moderate to low HDI score are defined as underdeveloped countries. According to the IMF, in developing countries, there is low per capita income, widespread poverty, and low capital formation. So, it is very hard to have a single definition for the term under development since the level of development varies widely within such countries. Some of developing countries have high average standards of living and can be classified neither developed nor developing. So, they are referred as "newly industrialized countries." Therefore, we consider that the countries are underdevelopment whenever a country satisfies one of the above mentioned issues.

periods (e.g., Bick, 2010; Hauk and Wacziarg, 2004; Gylfason and Herbertsson, 2001), or 10-year periods (e.g., Moral-Benito, 2010), this study uses nonoverlapping two-year averaged data to preclude business-cycle fluctuations. By using two-year periods, we keep the number of observations as large as that seen in the empirical literature, since we are working with a relatively small number of countries.

Of 14 explanatory variables, we assume that 13 regressors are exogenous and one is a predetermined regressor. For the predetermined variable, we construct the instruments from its lagged value based on Roodman's (2009a) GMM-style instruments strategy. Thus, we work with 105 instruments. Allowing different combinations of instruments and exogenous regressor, a total of 2^{181} models are under consideration.

3.4 Methodology

3.4.1 Econometric Framework

In our basic model setup, we use a simultaneous equations model (SEM) with dynamics in a panel data framework. This allows us to control for individual fixed effects and simultaneity. First we define the main structural equation as follows:

$$g_{it} = \gamma' h_{it} + \beta' x_{it} + \mu_i + u_{it}, \qquad (3.1)$$

where i denotes the cross-sectional dimension (for $i = 1, \dots, N$), t is the time dimension (for $t = 1, .., T$), g_{it} is the per-capita GDP growth rate for country i at time t, h_{it} denotes an $M \times 1$ vector of endogenous regressors[17] for the country i at time t, x_{it} is the $k_1 \times 1$ vector of exogenous explanatory variables for country i at time t, μ_i indicates unobserved country-specific FEs, and u_{it} is the error term with a 0 mean and which is not serially correlated.

[17]For simplicity, in our empirical application we assumed to have only one endogenous variable, which is the initial level of GDP per capita. Thus, h_{it} is1×1.

3.4.2 Fixed Effect Elimination

The application of the SEM allows us to deal with country-level heterogeneity in a dynamic panel data model. In the first phase of the estimation method, we should eliminate any unobserved, country-specific FEs from the equation of interest by using a standard FE transformation. To these ends, we apply an FOD transformation for dynamic equation (3.1), since the first-differencing of this equation does not eliminate dynamic panel bias; this implies that the error terms (also transformed error terms) negatively and serially correlate with the lagged dependent variable, which in turn leads to inconsistent estimates. This transformation derives the average of all future available observation of a variable, instead of deducting the earlier observations from the contemporaneous one. Thus, for the variable u_{it}, the required transformation is given by:

$$u_{it}^{*} = \sqrt{\frac{T-t}{T-t+1}}\left[u_{it} - \frac{1}{(T-t)}\left(u_{i(t+1)} + \cdots + u_{iT}\right)\right]. \tag{3.2}$$

Applying this procedure to equation (3.1) will yield:

$$g_{it}^{*} = \gamma' h_{it}^{*} + \beta' x_{it}^{*} + u_{it}^{*}, \tag{3.3}$$

where $t = 1, \ldots., T-1$. This transformation ensures that if $\mathrm{Var}(u_{it}) = \sigma^2 I_T$ with no serial correlation, then we also have that $\mathrm{Var}(u_{it}^{*}) = \sigma^2 I_{T-1}$ with no serial correlation. Moreover, as noted by LM, this transformation can also be explained from a Bayesian perspective. It arises from integrating out the fixed individual effect from the posterior using a flat prior.

3.4.3 Solving the Problem of Endogeneity

In the second step of the estimation process, one needs to resolve the endogeneity problem. As an explanatory regressor, the initial level of per-capita GDP—which is simultaneously determined with the dependent variable—when used with the OLS method, will yield bias and inconsistent estimates. To preclude this from happening, the structural equation (3.1) requires an appropriate estimation technique with relevant instruments. Hayashi and Sims (1982) suggest the use of the IV estimation method with predetermined instruments,[18] after applying a FOD transformation for a time-series model. In this study, however, we apply the Bayesian analogue of a 2SLS estimator, following LM (2012). Then, the auxiliary equation for h_{it}^* can be defined as follows:

$$\begin{aligned} g_{it}^* &= \gamma' h_{it}^* + \beta' x_{it}^* + u_{it}^* \\ h_{it}^* &= \Pi_x x_{it}^* + \Pi_z z_{it} + v_{it}^*, \end{aligned} \tag{3.4}$$

where z_{it} is a vector of predetermined instruments, and the error terms u_{it}^* and v_{it}^* are normally distributed with a 0 mean and are mutually uncorrelated across cross-sections and over time. That is, $E\left(u_{it}^*, v_{js}^*\right) = 0$, for either $i \neq j$ or $t \neq s$, or both. We assume that the variables x_i and z_i are exogenous; thus:

$$E\left(x_{it}^*, \begin{bmatrix} u_{it}^* \\ v_{it}^* \end{bmatrix}'\right) = 0 \text{ and } E\left(z_{it}, \begin{bmatrix} u_{it}^* \\ v_{it}^* \end{bmatrix}'\right) = 0.$$

The predetermined instruments are typically constructed using a lag of h_{it}. Hence, for the transformed initial income, h_{it}^*, we use the untransformed value (h_{it}). There is no clear

[18]Predetermined instruments are those that are assumed to be independent with current and future values of the error term, but may be correlated with past values of the error term. This correlation does not affect consistency or asymptotic variance of IV estimator (see, for more detail, LM 2012).

guideline regarding the set of instruments. Using a Monte Carlo simulation, Roodman (2009a) proposes that increases in instrument counts tend to increase the estimate of a parameter. Windmeijer (2005) reports that reducing the instrument count by a certain amount reduces the average bias of the parameter of interest, whereas Ruud (2000) suggests estimates will be biased when the instruments are few in number. However, Arellano and Bond (1991) and Holtz-Eakin et al. (1988), among many others, used further lags as an instrument in a GMM framework. However, there is the possibility of losing time observations in our framework, if we use further lags as instruments (Roodman, 2009a). Thus, we follow Roodman's (2009a) strategy to avoid this issue, and we construct GMM-style predetermined instruments for h^*_{it} as:

$$\begin{bmatrix} h_{i1} & 0 & 0 & 0 & 0 & 0 & & & \cdots & 0 \\ 0 & h_{i1} & h_{i2} & 0 & 0 & 0 & & & \cdots & 0 \\ 0 & 0 & 0 & h_{i1} & h_{i2} & h_{i3} & & & \dots & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & & & \cdots & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & & & \cdots & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \cdots & h_{i1} & \cdots & h_{i,T-1} \end{bmatrix}. \tag{3.5}$$

The above uncollapsed form of the predetermined instruments matrix generates one column for each IV for each period, and the lag available for that period. Thus, we used a $(\mathrm{T}-1) \times \mathrm{T}(\mathrm{T}-1)/2$ matrix of the lagged values of dependent variables as instruments. The moment condition of the above instruments matrix for each period and each lag can be defined separately as:

$$E\left(u^*_{it}, h_{i,t-s}\right) = 0 \quad \text{for } t = 1, \dots \dots, \mathrm{T}-1 \text{ and } s = 1, \dots . \mathrm{t}-1. \tag{3.6}$$

3.4.4 Choice of Model

The dimension-of-parameter (Π_x, Π_z, β) matrices might differ over the model space. As per KLS, in our empirical application, we include all the just-identified or over-identified model space that allows for imposing the restriction $k_2 \geq M$. Further, we assume that the coefficient of the instruments matrix Π_z has full rank. Therefore, as shown in KLS, the models differ in terms of the following aspects:

- ✓ Variables in x_i: x_i constitutes a subset of larger group of potential exogenous regressors denoted by X, which are not allowed to be instruments. Therefore, there is uncertainty regarding the dimension of x_i and β.
- ✓ Set of instruments: Typically, the instruments can be categorized into two groups: (i) strictly exogenous instruments, and (ii) predetermined instruments (KLS, 2011). In this study, since we have only a predetermined regressor (the initial level of per-capita GDP), we use only predetermined instruments, which are constructed using the lagged value of the dependent variable. There exists a very large number of predetermined instruments denoted by Z. There is uncertainty about what instruments are to be entered into z_i; this implies uncertainty about the parameter matrix of the Π_z column dimension.
- ✓ Exogeneity restriction: Although in principle some of the covariances between the error terms (u_{it} and v_{it}) could be restricted to be zero, in our setup we only have one endogenous variable (initial level of GDP per capita) which we are certain must be treated as endogenous. Therefore, in our setup there is no uncertainty regarding exogeneity restrictions.
- ✓ Restrictions on the endogenous or predetermined regressors' coefficients: some of the coefficients of γ might be restricted to be zero. In our case γ is a scalar parameter. In

some models it will be restricted to be equal to zero. A zero value of γ implies that there is neither conditional convergence nor divergence among countries.

As shown in KLS, the model space consists of $2^{2m}N^{A}$ number of models, where N^{A} takes the form:

$$N^{A} = \sum_{j=m}^{k_2} 2^{k_1+k_2-j} C_j^{k_2}, \qquad (3.7)$$

where k_1 denotes the number of variables in x_i, k_2 is the number of variables in z_i, and $C_j^{k_2}$ denotes the combinatorial number. In our empirical analysis, we have only two endogenous regressors that include a dependent variable ($m = 2$), 105 potential instruments($z = 105$), and 13 exogenous variables ($x = 13$). Thus, the number of models can be estimated as being around 2^{181}.

3.4.5 Bayesian Model Averaging Approach in Panel Data

There potentially exist many empirical growth models, each of which consists of a different combination of explanatory variables, and each of which has some probability of being the "true" model. The use of BMA is a widely accepted way of overcoming problems associated with selecting a single model. A basic strategy for model selection is to choose the most plausible model H_j—specifically, the one with the highest posterior model probability, $p(H_j|Y)$. Alternatively, when one considers the full posterior mass of the model space H instead of just one model H_j, then the posterior model probabilities become a weighted average of all the possible models concentrated in our model set-up. Thus, weights for BMA are equivalent to the model posterior probabilities, which take the form:

$$p(H_j|Y) = \frac{f(Y|H_j)\, p(H_j)}{\sum_{r=1}^{K} f(Y|H_j) p(H_j)}, \tag{3.8}$$

where Y is all the observed data, $f(Y|H_j)$ is the marginal likelihood of model H_j, $p(H_j)$ is the prior model probability when model H_j is true, $K = 2^{2m}N^{A}(= 2^{181})$ represents the total number of models, and the summation indicates the full model space that has been considered. Thus, equation (3.8) implies that the posterior probability of model H_j is proportional to the prior model probability times the marginal likelihood of the model. The marginal likelihood of model H_j is:

$$f(Y|H_j) = \int f(Y|\theta, H_j) p(\theta)\, d\theta, \tag{3.9}$$

where θ denotes the vector of regression parameters of model H_j, $p(\theta)$ is the prior for parameter θ under model H_j, and $f(Y|\theta, H_j)$ is the likelihood of that model.

Suppose θ comprises the quantities of interest—i.e., the future observable parameter of a model; then, the inference for θ can be constructed on the basis of the posterior distribution:

$$f(\theta|Y) = \sum_{j=1}^{K} f(\theta|H_j, Y)\, p(H_j|Y). \tag{3.10}$$

Equation (3.10) reveals that the full posterior distribution of the quantity of interest is the weighted average of the distribution of the posterior under each model, where weights are the probabilities of the posterior model $p(H_j|Y)$. BMA allows us to compute the probability of inclusion—i.e., the probability that the regressor has a nonzero coefficient—for each explanatory variable from linear regression model (3.4):

$$p(X_i|Y) = \sum_{j=1}^{K} I(X_i|H_j)\ p(H_j|Y), \tag{3.11}$$

where X_i is an explanatory variable that has been considered under model H_j, and I is an indicator function that takes the value of either 1 or 0, depending on whether or not $X_i \in H_j$. Using the posterior distribution of (3.10), BMA allows the computation of the posterior mean for θ:

$$E(\theta_i|Y) = \sum_{j=1}^{K} E(\theta_i|Y, H_j)p(H_j|Y). \tag{3.12}$$

The posterior mean for θ is a weighted average of the posterior mean of each model.

The implementation of the BMA procedure presents three challenges. The first pertains to the choice of prior probabilities of model $p(H_j)$ and the parameters $p(\theta|H_j)$. In our empirical study we assume that all models exhibit equal prior probabilities, which implies that the prior over the model space is uniform: $p(H_1) = p(H_2) = \cdots = p(H_K) = \frac{1}{K}$. Regarding the choice of priors for parameters, we follow the same setup as in LM. Secondly, the marginal likelihood $f(H_j|Y)$ depends on an integral that does not have an analytical solution. It can only be calculated using a computationally intensive numerical approach. Finally, the model space in our empirical application contains approximately 2^{181} models, which is computationally challenging. To surmount these challenges, as a computational strategy we apply the RJMCMC algorithm developed by KLS. This algorithm iteratively obtains values for models (H_j) and parameters (θ). Given arbitrarily fixed initial values for $(\theta,\ H_j)$, we can use the generated values as a sample from the posterior of (θ, H_j) after an adequate number of iterations. We use this sample to compute quantities of interest such as posterior probabilities of models and confidence intervals for parameters.

3.5 Estimation Results

We now apply the BMA technique to identify the determinants of growth and the effect of inflation threshold level on growth. In this empirical application, we assume that there is no prior partiality for a specific model, indicating that we treat all models with equal prior model probabilities. We run BMA for equation (3.4) to estimate the posterior model probability, the posterior distribution for all parameters, the inclusion probability of all explanatory variables, and the posterior mean, which are given by equations (3.8)–(3.12), respectively.

Given the vast model space involved, to identify a model with higher posterior probability, one needs to run the regression with a fairly large number of iterations.[19] In order to do the BMA we run the RJMCMC algorithm for 300000 iterations after discarding the initial 10000 values. In order to check the convergence of the algorithm, we calculated the total visited probability (TVP)[20]—as shown in George and McCulloch (1997) and LM (2012)—obtaining a value near to 1 (99.9%) when using the current lag of initial income as an instrument in equation (3.4); this implies that the algorithm has good convergence. We run the model many more times, and with randomly drawn initial values, and obtain almost the same results (see Table 3.4 in the Appendix for the 10 best models).

[19] The analysis carried out using GAUSS software, which takes approximately 36 hours for the estimation.
[20] Total visited probability is an estimate of the fraction of the total probability mass that was visited by the chain (see, for more detail, LM 2012).

3.5.1 BMA Estimation Results for Exogenous Variables

First, we present the BMA estimates of equation (3.4) by using two benchmark specifications. First, we use the full valid set of lags as instruments; we then reduce the instrument count to one. The results obtained from BMA are presented in Table 3.5 (see Appendix).

Table 3.5 (see Appendix) reports the posterior probability of being included as exogenous explanatory variables in structural equation (3.1), with a 95% confidence level for parameters, the posterior mean conditional on inclusion, and the probability of having a positive effect on growth; these are indicated by "probability," "2.5% and 97.5%," "mean," and "positive," respectively. Result 1 is calculated using all the possible lags of the predetermined variable as instruments, while result 2 is calculated using only the most recent lag as an instrument.

When using all the available predetermined instruments, the variables found to have a posterior probability of inclusion close to 1 are investment ratio, trade openness, terms of trade, secondary school enrollment rate, and population. Although the estimated coefficients of these regressors are clearly positive, the probabilities that those coefficients are positive are not conclusive (76.1%, 66.5%, 62%, 67%, and 67.9%, respectively). Further, government consumption expenditure, population density, and inflation above the threshold level have an approximately 40% probability (44.8%, 39.7%, and 40.5%, respectively) of having a nonzero impact on growth. The remaining regressors (inflation below the threshold level, population growth rate, labor force participation rate, primary school enrollment rate, and price level of investment goods) have exceptionally small probabilities of inclusion; thus, they do not seem to explain economic growth in Asian LDCs. However, the impact of these variables might be country-specific.

3.5.2 BMA Estimation Results for Instruments

Table 3.6 (see Appendix) shows that of the very large number of potential predetermined instruments, only a few can selected as valid instruments (i.e., $\mathrm{ZG2L0}$, $\mathrm{ZG2L1}$, $\mathrm{ZG3L0}$, $\mathrm{ZG3L1}$, $\mathrm{ZG7L0}$, and $\mathrm{ZG7L1}$). The nearest available lags more strongly correlate with the predetermined regressor; for this reason, they are selected as instruments. These findings accord with those of LM (2012) and Roodman (2009b), who suggest that models that use fewer but stronger instruments are better in terms of inference.

Since the nearest lags are strong instruments, we re-estimate equation (3.4) by reducing the instrument count to one. The result is presented in the second panel of Table 3.5. We observe three significant changes under result 2. First, the probability of an inflation rate above the threshold entering the model has increased from 40.5% to 53.6%, and the probability of this variable having a positive effect on growth is only 0.3%; this indicates that inflation has a 53.3% probability of impeding economic growth when it exceeds a threshold level. The probability of the inclusion of government consumption expenditure rose from 39.7% to 85.1%, and the probability that it will impede growth increased from 36.8% to 85.1%. Second, the posterior inclusion probability of the terms of trade was reduced from nearly 1 to around 30%. Finally, although the posterior inclusion probabilities of the regressors (i.e., the investment ratio, the population, and secondary school enrollment rate) are still close to 1, the probabilities of the first two regressors having a positive effect on economic growth increased from 76.1% to 98.8% and from 67.9% to 73.8%, respectively, whereas the probabilities of the later regressor having a positive effect on the growth rate decreased from 67% to 52.2%. With respect to similarities, the probability of the inclusion of trade openness is 1, with it having an approximately 66% probability of having a positive effect on growth rate in both cases.

Although the probability of inclusion of the population is close to 1 and with a positive effect, the impact effect on growth is unusually negligible. Note that our sample contains China and India, which are outliers in our sample in terms of the level of population. This might be why population has a positive impact on growth, even as the magnitude is very small. When we carry out the BMA analysis-using most recent lags as instruments- without those two countries the posterior inclusion probability of population becomes nearly 0 while other results are very similar to our main findings (see Table 3.7). Therefore, China and India seem to play a significant role in explaining the positive impact of population on growth.

Overall, we found that the investment ratio to be positively associated with growth, whereas the government consumption expenditure correlates negatively. There is also evidence that trade openness stimulates growth. Furthermore, there is substantial evidence that inflation hinders economic growth whenever it exceeds the threshold value and that below the threshold value, it has no significant effect on growth.

3.5.3 BMA Estimation Results for Endogenous Variables

We next report the posterior probability of the initial level of per-capita GDP being included as a predetermined regressor in structural equation (3.4). In Table 3.8 (see Appendix), "probability" denotes the posterior inclusion probability of initial income, "mean" is the posterior mean of the coefficient of initial income, "(2.5%, 5%, 95%, 97.5%)"

are the posterior percentiles of the coefficient of the initial income conditional on inclusion, and "negative" denotes the probability that the initial income will have a negative coefficient. The meanings of results 1 and 2 are described under Table 3.5.

According to Table 3.8, the posterior probability of initial income being included in structural equation (3.4) is close to 1, under result 1; on the other hand, in result 2, the probability of inclusion is reduced to 17.2%. Recall that we have treated initial income as an endogenous regressor. Under result 1, the probability of the coefficient on initial income being positive (43.16%) is almost as large as the probability that the coefficient will be negative (53.15%); therefore, we cannot say with certainty whether countries are conditionally converging or diverging. However, under result 2, the probability that the coefficient of initial income will be 0 is as high as 82.8%; this indicates that countries are neither conditionally converging nor diverging. That is, if we keep constant other determinants of growth, then the initial value of GDP becomes unimportant. Note that each country has a different resource endowment, and that we are already controlling for this by including the FE. This might be why we find neither conditional convergence nor divergence. Although the neoclassical growth model (Solow, 1956) proposes conditional convergence, LM (2012) suggests that countries are neither conditionally converging nor diverging when using the whole sample with FE.

3.5.4 Comparison to Other Estimation Methods

3.5.4.1 Estimation Results of Standard BMA

Thus far, we have explained the result of equation (3.4) while assuming the initial income is a predetermined regressor. Here, we compare the BMA estimation of the previous section with the standard BMA, which assumes that all regressors are exogenous in a pooled regression context.[21] The results changed in three different aspects (see Table 3.9). First, the regressors population density and labor force participation rate, both of which had an unusually small probability of inclusion, become significantly and positively correlated to growth with higher posterior inclusion probabilities (93.2% and 67.2%, respectively). Second, the probability of the inclusion of the regressor trade openness decreased from nearly 1 to close to 0. Finally, inflation above the threshold level became insignificant, with a probability of inclusion being close to 0. With respect to similarities, the investment ratio positively correlated with growth, with probability of inclusion close to 1 in both cases.

3.5.4.2 GMM, FE, and LSDVC Estimation Results

In addition to standard BMA, we also use estimation methods that allow for endogeneity and FE, but not for model uncertainty, such as GMM (Arellano and Bond, 1991), FE (Wooldridge, 2010 chapter 10), and LSDVC (Judson and Owen, 1999) estimators. Although GMM, FE, and LSDVC are not directly comparable, because they follow different philosophies, frequentist approaches have been used often in this literature by other researchers. Therefore it is of some interest to compare the BMA with frequentist approaches (see Table 3.10).

The results reveal that two of the regressors that were significant with our main BMA analysis—namely, initial income and secondary school enrollment rate—became insignificant. Further, the effect of the threshold variable (i.e., inflation above the threshold level) on growth was significant and hindered growth in all three cases (see Table 3.10). Moreover, as with BMA, GMM also detected trade openness as a vital factor to determining the growth rate; FE and LSDVC estimators, on the other hand, did not. Finally,

[21]The analysis carried out using R software with 'BMA R package' of 3.15.1 version.

the investment ratio, which was significant with our main BMA approach, was also significant with all three approaches. Meanwhile, the standard BMA analysis have not taken into account endogeneity or FE, and none of the three approaches of GMM, FE, or LSDVC considered the issue of model uncertainty. Nonetheless, our main BMA analysis considered both the issue of model uncertainty, and endogeneity and FE.

3.6 Conclusions

The existing empirical work discusses various approaches by which to explain model uncertainty in the growth regression. Among many techniques in the empirical growth literature, BMA has been widely used and is the most prominent approach to overcome model uncertainty. In this paper we have used a recent technique to carry out BMA in the context of a dynamic panel data model with fixed effects. Only a few empirical growth studies have considered these issues in their model setup. Furthermore, our study is novel because it allows for the presence of a threshold in the way that inflation impacts on economic growth and because we focus on Asian countries.

Our empirical evidence of the determinants of growth suggested that two variables (investment and trade openness) had a positive effect on growth in both results 1 and 2; furthermore, the terms of trade became important factor under result 1, while government consumption expenditure was a crucial factor in result 2. Although population was found to affect growth positively and bear a higher probability of inclusion in the full sample, it became unimportant when we dropped the population outliers China and India from the sample. In both theoretical and empirical study, researchers have used initial income as measures of convergence. We found there to be no evidence of conditional convergence or divergence, since the probability of the coefficient on initial income being positive

(43.16%) was almost as large as the probability of it being negative (53.15%) under result 1; the probability of the coefficient on initial income being 0, meanwhile, was as high as 82.8% under result 2.

In addition, inflation above the threshold level impedes growth with 35.6% probability under result 1, and with 53.3% probability under result 2; these results indicate that there is an approximately 60% and 46% probability, respectively, and that inflation above the threshold is neither favorable nor harmful to growth. This finding accords with monetarist thinking (e.g., Friedman, 1956; Sidrauski, 1967). Friedman argues that inflation does not hamper growth if the neutrality of money holds, and Sidrauski demonstrates that an increase in inflation has no significant impact on steady-state capital stock, and hence no effect on either output or the output growth rate. Our results suggest that inflation impedes the growth rates of Asian economies with only 35.6% probability, if inflation exceeds 5.43%.[22] This scenario may occur, owing to the high volatility of inflation, which might be distressing for an economy. Some Asian countries frequently bear evidence of unusually high and episodic rates of inflation, while a few economies there more frequently have exceptionally low rates of inflation, or deflation.[23] This implies that inflation differs year to year and country to country, and with high volatility; this may be why inflation impedes growth with only 35.6% probability, and it also suggests that the effect of inflation on growth might be country-specific. Furthermore, the problem of high volatility can be resolved by considering the variance or standard deviation of inflation in the model. We leave this extension for future research.

[22] We found the threshold level of inflation for Asian economies is 5.43% (see, for more details, chapter 2).
[23] For example, average inflation for Laos over the sample period is 33.11%, whereas average inflation for Bahrain over the sample period is 1.66% (see Table 3.3) and average inflation for the full sample is 8.148% (see Table 3.2).

Finally, findings stemming derived from our robust estimation procedure indicate that although results are sensitive to the model specification, BMA overcomes the specification bias of GMM. The threshold variable is significant and is found to adversely affect the economy when it exceeds 5.43%, in all cases except result 1.

CHAPTER 4

MONETARY POLICY AND THE REAL ECONOMY: A STRUCTURAL VAR APPROACH FOR SRI LANKA

4.1 Introduction

Monetary policy is broadly used by central banks as a stabilization policy toolkit in guiding their respective economies, to achieve sustained and high output growth rates and maintain low inflation rates. The effectiveness of monetary policy relies on the policy-makers' ability to make accurate assessments of the effects of monetary policy on price stability and economic activities, as well as those of the timing of policy implementation. The existing monetary literature addresses many questions regarding the relationship between macroeconomic variables and monetary policy. Since the seminal work of Sims (1980), the VAR model has been broadly used by researchers to answer this question. However, there is no consensus among scholars with regard to the effect of monetary policy shock on macroeconomic variables.

The vast body of empirical literature—much of which investigates the monetary policy transmission mechanism by using VAR analyses of open and closed economies—has identified several empirical anomalies. The results of these studies contrast with standard economic theory. Typically, such "puzzles" consist of price puzzles where the price level increases rather than decreases following IR innovations (e.g., Sims, 1992). Second, there are liquidity puzzles where the nominal IR increases rather than decreases following monetary aggregate shock (e.g., Leeper and Gordon, 1991). Third, there are ER puzzles where domestic currency depreciates relative to the U.S. dollar, rather than appreciates, followed by a positive IR shock (see Sims, 1992; Grilli and Roubini, 1995). Finally, there are forward discount bias puzzles where “positive interest differentials on domestic assets are associated with persistent appreciations of the domestic currency” (Kim and Roubini, 2000 p. 562).

Sims (1992) demonstrates that IR innovations partly reflect inflationary pressures, which cause an increase in the price level. Therefore, some of the past empirical studies that take a VAR approach include inflationary expectation as a proxy variable (e.g., Gorden and Leeper, 1994; Christiano et al., 1996; Sims and Zha, 1998) to explain the price puzzles. Sims and Zha suggest a SVAR model with contemporaneous restrictions, which includes proxy variables for expected inflation. Grilli and Roubini (1995) include moments in long-term interest rates to solve the ER puzzle. Kim and Roubini (2000) suggest the WOP as a proxy for expected inflation, to surmount the problems of price puzzles and endogeneity; some economists, however, include measures of commodity price in their information sets to sidestep the price puzzle (e.g., Christiano et al., 1996).

The existing empirical literature reveals two trends in the analysis of the dynamic responses of macroeconomic variables following monetary policy shocks. In the first trend, only domestic policy variables are included in the policy block (e.g., Bernanke and Blinder, 1992; Bagliano and Favero, 1998; Bernanke and Mihov, 1998; Amarasekara, 2009). In the second trend, both domestic and foreign policy and nonpolicy variables are included (e.g., Eichenbaum and Evans, 1995; Cushman and Zha, 1997; Kim and Roubini, 2000; Kim, 2003; Fung, 2002; Raghavan et al., 2009; Mishra and Mishra, 2010). Thus, many empirical studies have extended the closed economy benchmark VAR model so as to make it an open economy model. Such an extension with the VAR approach typically involves the addition of some foreign variables, such as WOP index, foreign IR, and movement of ER.

Economists do not agree on what is the best monetary policy indicator. Some researchers propose the IR (e.g., for the United States, the FFR) as the best policy tool (e.g., McCallum, 1983; Bernanke and Blinder, 1992). However, Gordon and Leeper (1994) challenge this argument and find that the shocks to the FFR, as well as monetary aggregates, generate some dynamic responses. In contrast, among many others, Strongin (1995), Eichenbaum and Evans (1995), and Eichenbaum (1992) suggest that shocks to monetary policy with nonborrowed reserves may serve as a good proxy in describing changes in monetary policy. Moreover, Sims (1992) suggests the short-term IR as a good indicator in expressing change in monetary policy, while Bagliano and Favero (1998) find that "the inclusion of the long-term interest rate in a benchmark VAR delivers a more precise estimation of the structural parameters capturing behavior in the market for reserves and shows that contemporaneous fluctuations in long-term interest rate are an important determinant of the monetary authority's reaction function" (p. 1069). Other groups of literature suggest that the exchange rate plays an important role in describing the monetary policy transmission mechanism (e.g., Cushman and Zha, 1997; Fung, 2002).

There has been an increasing number of studies that focus mainly on the transmission mechanism of monetary policy, within the contexts of the United States, the non-United States G7 countries, and the Eurozone area. With this in mind, recently, many researchers have applied a similar technique to analyses of their own countries. However, quantitative assessments of the effect of monetary policy shocks on macroeconomic variables in a Sri Lankan context are limited and otherwise inadequate. Existing studies of the Sri Lankan monetary policy transmission mechanism include only domestic monetary policy and macroeconomic nonpolicy variables (see, Amarasekara, 2009) in their VAR approach.

However, Cushman and Zha (1997) note that a "small open economy is likely to be quite sensitive to a variety of foreign variables" (p. 435); with this in mind, we include in our model set-up the FFR as well as the WOP index, to isolate any "exogenous" change in monetary policy. In this way, our study differs from past empirical studies that investigate the transmission mechanism of Sri Lankan monetary policy.

Empirical studies that use various policy variables have obtained inconsistent results. Walsh (2003) illustrates that "the exact manner in which policy is measured makes a difference, and using incorrect measures of monetary policy can significantly affect the empirical estimate one obtains" (p. 40). This motivated us to investigate the transmission mechanism of Sri Lankan monetary policy.

Another motivation of this study is that there are no clear relationships among the key economic indicators of Sri Lanka (see Figure 4.1). In some periods, economic indicators move as expected in response to the use of monetary policy tools, while in other periods they move in directions that run counter to those suggested by standard theory. This motivated us to investigate the impulse responses of key macroeconomic variables in response to monetary policy shock.

A review of past empirical works reveals that no study has examined the effect of foreign and domestic monetary policy shocks on macroeconomic variables, while using a SVAR framework and examining the Sri Lankan context. This study seeks to answer the following research questions: (i) Which policy instrument plays a significant role in explaining movement in the economic activities of Sri Lanka? (ii) Do foreign monetary policy shocks—defined as U.S. FFR shocks—affect the domestic variables? and (iii) Does the inclusion of oil price resolve the problem of price puzzles, and how much do variations in oil price account for output and price fluctuations?

By examining monthly data from January 1978 to December 2011, this study found that Sri Lankan output decreased significantly and domestic currency appreciated, following contractionary IR shocks. Second, it found that shocks to monetary aggregate tend to reduce the IR over some time horizon. Finally, the U.S. IR shock and oil price shock were found to have no significant impact on the domestic variables.

The remainder of this chapter is structured as follows. Section 2 reviews the past empirical literature, to garner a better understanding of the association between policy and nonpolicy variables. The current trends of the Sri Lankan monetary policy system and a selection of variables are discussed in section 3. Section 4 describes the construction of VAR models and the identification scheme. In section 5, we present the estimation results of the econometric model and related findings. Finally, in section 6, we make concluding remarks and assess policy implications.

4.2 Literature Review

It is essential to understand the monetary policy transmission mechanism, which helps a central bank to choose the efficient monetary policy instruments by which it can achieve its primary goals (e.g., price and economic stability). Since the seminal work of Sims (1972, 1980), the VAR model has become the most prominent and broadly used technique to measure the effect of monetary policy shocks on key economic variables. This section reviews some of the past empirical studies that use the VAR model to explain the dynamic responses of economic variables.

There is no consensus among economists worldwide with regard to what constitutes appropriate policy instruments: empirical studies that use a variety of techniques have generated contradictory results. For example, McCallum (1983) and Bernanke and Blinder (1992) demonstrate that the IR plays a crucial role in monetary policy formulation. Using two forms of identifying assumptions, Bernanke and Blinder suggest the FFR as the best policy indicator. One type of identifying assumption orders policy variables at first, whereas another type of the assumption orders policy variables at last. The authors argue that the FFR is tremendously informative about the dynamic responses of real macroeconomic variables, and they show that the FFR is sensitive in recording the supply shocks of bank reserves. They also suggest that the monetary policy transmission mechanism works at least partly via bank loans and bank deposits.

In contrast, other groups of studies propose innovation in nonborrowed reserves as a better policy indicator (e.g., Eichenbaum, 1992; Christiano and Eichenbaum, 1992). Eichenbaum and Evans (1995) extend the model from a closed economic approach to an open one, and investigate the effect of U.S. monetary policy shocks on the ER while ordering nonpolicy variables such as output and inflation at first. The authors find evidence of the persistent and significant appreciation of the real and nominal U.S. ERs and a persistently significant decline between U.S. and foreign IRs. Using exactly identified model with the ordering of foreign blocks, nonpolicy blocks, and policy blocks, Mishra and Mishra (2010) conclude that the effect of shocks to monetary policy on macroeconomic variables, including the ER, is consistent with standard theoretical models' predictions.

There is no consensus among researchers with regard to identifying restrictions. One group of scholars encourages the application of long-term restrictions (e.g., Blanchard and

Quah, 1989), whereas other groups of economists impose short-term restrictions (see, among many others, Sims, 1986; Gordon and Leeper, 1994; Sims and Zha, 1998). On the other hand, some researchers impose short-term restrictions only on policy blocks (e.g., Bernanke and Mihov, 1995). However, Villani and Warne (2003) emphasize that the "successful application of structural VARs hinges on proper identification of the structural shocks" (p. 14).

Using a six-variable VAR model with quarterly postwar data from the U.S. economy, Sims (1986) shows that the dynamic structure of the economy can be explained through the extension of ordering of the Wold causal chain. He used a variety of identifying assumptions. First, he assumed that the monetary authority can observe the IR and moments of the monetary aggregates instantaneously, while reacting to the remaining variables with delay. Second, innovations in the money stock enter only in the money demand and money supply equation, and shocks to monetary policy affect other variables in an economy only through the IR. Finally, he includes innovations in money stock in the price equation. Assuming elasticity of demand and supply for reserve money, Gordon and Leeper (1994) investigate the dynamic responses of economic variables when monetary policy shocks are determined through innovations in short-term FFR or reserves. The authors compute demand and supply shocks in the reserve and the broad money market for the 1980s, and compare them with 1970s results. They suggest that monetary policy shocks produce results that are consistent with those of conventional analyses on macroeconomic variables.

Most of the existing literature identifies several empirical anomalies; Kim and Roubini (2000) categorize these into four groups. One of these is the price puzzle: money and output are expected to fall in the wake of a positive IR shock, but the price level instead increases (see, Eichenbaum, 1992; Sims, 1992). Using a six-variable VAR model and data from five developed countries, Sims (1992) concludes that monetary aggregates may not describe the change in monetary policy in the presence of demand shocks, and he concludes that the short-term IR is a good indicator in explaining the movement of economic activities. However, the author suggests that shocks to the IR may increase the price level, thus creating a price puzzle.

The second anomaly is the liquidity puzzle, which relates to the situation of an increase in nominal IR when a shock to monetary policy references monetary aggregates (see, for instance, Reichenstein, 1987; Leeper and Gordon, 1991). The third of these are ER anomalies. Standard theory proposes that tightened monetary policy—defined as innovation in IR—tends to appreciate domestic currency immediately, relative to foreign currency, leading to future currency depreciation. However, numerous empirical studies identify the depreciation of domestic currency relative to the U.S. dollar, following such an unexpected monetary policy shock (e.g., Sims, 1992; Grilli and Roubini, 1995). The last type of anomaly is the forward discount bias puzzle: "If uncovered interest parity holds," say Kim and Roubini (2000), "a positive innovation in domestic interest rates relative to foreign ones should lead to a persistent depreciation of the domestic currency over time after the impact appreciation, as the positive interest rate differential implies an expected depreciation of the currency. However, the evidence suggests that positive interest differentials on domestic assets are associated with persistent appreciations of the domestic currency" (p. 562).

Sims (1992) states that innovations in IR partly reflect inflationary pressures that lead to an increase in the price level. He illustrates that a central bank's information set cannot contain information about future inflation. Therefore, to overcome the price puzzle, some of the existing studies include inflationary expectation as a proxy variable in their VAR system (e.g., Gorden and Leeper, 1994; Christiano et al., 1996; Sims and Zha, 1998).

Grilli and Roubini (1995) explore the effect of monetary policy on the ER, among non-United States G7 countries; they suggest that to avoid the ER puzzle, "we need to find better proxies for expected inflation" (p. 6). They note that "moments in long-term interest rates might be capturing quite well agents' expectations about long-term inflationary trend. Then, a good proxy of the degree of the tightness of monetary policy might be the difference between short-term and long-term interest rates" (p. 6). Moreover, Christiano et al. (1996) include commodity price in the U.S. Federal Reserve's information sets, to avoid the price puzzle.

Using an open economy SVAR model, Kim and Roubini (2000) assume that the WOP and the FFR are contemporaneously exogenous to the variables in the system of the domestic economy. They found that the responses of the ER and the other economic variables are in line with the predictions of the theoretical model following monetary policy shock in the G7 countries (i.e., G8 countries, minus the United States). The authors found that the inclusion of oil price solves the problem of price puzzles. Overall, they suggest that their identification scheme contributes to the resolution of empirical anomalies regarding the effects of shocks to monetary policy, which have been found in the past literature.

Amarasekara (2009) examines the effect of monetary policy shocks on output and inflation in the context of Sri Lanka, using recursive and semi-SVAR specifications. He imposed identification restrictions only on the policy block of the SVAR model. He found the same results from both VAR systems, i.e., both inflation and economic growth decrease and the ER appreciates following a positive IR shock. However, the impact on economic growth contrasts with the established empirical findings that derive from the use of the ER and monetary aggregates as monetary policy tool. He also found that price decreases immediately as the ER appreciates. He suggests that innovations in IR are persistent, while innovations in the ER and money growth are not persistent.

In summary, past empirical studies have revealed there is no single policy variable that explains the dynamic response of macroeconomic variables as suggested by standard theory. This indicates that empirical works that use different policy variables lead to a variety of results. Therefore, "the exact manner in which policy is measured makes a difference and using incorrect measures of monetary policy can significantly affect the empirical estimates one obtains" (Walsh, 2003 p. 40).

An increased number of studies focus mainly on the monetary policy transmission mechanisms of the United States, the non-United States G7 countries, and the Eurozone, using the VAR technique. However, recently, many researchers have applied similar techniques to analyze their own countries' transmission mechanisms; nonetheless, quantitative assessments of the effect of monetary policy shocks on real macroeconomic variables in the Sri Lankan context are limited and otherwise inadequate. Existing empirical studies of Sri Lankan monetary transmission mechanism use only domestic variables in their VAR approach (see, Amarasekara, 2009). However, Cushman and Zha (1997) state that a “small open economy is likely to be quite sensitive to a variety of foreign variables” (p. 435). With this in mind, we included the FFR and the WOP to isolate “exogenous” change in monetary policy. In this sense, this study differs from past empirical studies that investigate the Sri Lankan monetary policy transmission mechanism. We include the FFR as a proxy for foreign monetary policy, to control for the component of the home country’s monetary policy. The WOP is included as a proxy variable for inflationary and negative supply shocks. These variables will help us solve the puzzles within the economy.

The main purpose of this study is to identify the policy instrument that best represents the dynamic response of the economic variables following monetary policy shocks. We next investigate the impact of a foreign IR shock and an oil price shock on domestic economic activities. Finally, we examine whether the inclusion of oil price resolves the aforementioned puzzles.

4.3 Monetary Policies in Sri Lanka

The Central Bank of Sri Lanka (CBSL) is the national authority responsible for implementing monetary policy in, and providing currency to, that country. As mentioned, the main goal of monetary policy is to promote a high and sustained level of output growth while keeping inflation at a desirable rate. Therefore, similar to many countries’ central banks, the CBSL also sets price stability as its main monetary policy objective goal. Many Asian countries floated their ERs soon after the 1997 Asian financial crisis; Sri Lanka, too, added a floating ER in 2001 as a part of operational monetary policy independence.

Monetary policy in Sri Lanka has undergone significant changes in the last four decades. Since 1977, the CBSL has progressively moved toward the use of market-oriented monetary policy tools. The CBSL has changed its priority of focus from ER stability to price stability, in the name of maintaining economic stability. In particular, the CBSL mainly focuses on stabilization objective rather than development objective. However, in 2002, the CBSL revised its monetary policy objectives, based on international trends and objectives that are now oriented toward (i) economic and price stability and (ii) financial system stability. Currently, the CBSL uses the IR as a tool by which to conduct monetary policy; it uses it in conjunction with a monetary targeting framework to achieve its objectives.

Amarasekara (2009) states that "To meet the reserve money targets, open market operations are conducted with Repo and reserve Repo rates as the key policy instruments forming the lower and upper bounds of the interest rate corridor in which the interbank call money market operates" (p. 4). In practice, the CBSL also considers ER movements, economic growth, and bidirectional correlations between fiscal and monetary policies.

In such a monetary management environment, Sri Lanka's monetary policy-setting has moved toward the broader adoption of inflation-targeting practices, in preference over either an ER or monetary aggregate. IRs and open market operations (OMO) are policy instruments by which the CBSL looks to achieve such a goal in a given monetary target.

4.4 Data and Variables

This section examines the domestic and international variables used to denote the Sri Lankan monetary policy framework. We chose variables similar to those used by Kim and Roubini (2000)—that is, we use a seven-variable[24] SVAR model to explain the all-possible interrelations among nonpolicy and policy variables. These seven variables are adequate in explaining the monetary policy frameworks of small open economies (Kim and Roubini, 2000; Brischetto and Voss, 1999). Of the seven variables used in the model, two variables are foreign block, which contains the WOP, and the U.S. FFR. As discussed, the inclusion of foreign block is crucial in a VAR system to representing the model of an open economy. The foreign block is assumed to be exogenous in our model set-up—that is, we include these variables to isolate any exogenous change in monetary policy. Therefore, domestic variables do not enter the foreign variables equation, either with a lag or instantaneously. We made this assumption, given that the Sri Lankan economy is unusually small compared to the world economy.[25] We include WOP as a proxy variable for expected inflation and FFR as a proxy for foreign IR.

The remaining five variables represent the Sri Lankan domestic economy that can be devoted to two blocks, such as the policy variables block and the nonpolicy variables block. Similar to other studies and as discussed earlier, the policy variables included in this model are the nominal ER, the interbank call money market rate, and reserve money. These policy variables are categorized in three broader contexts: ER, IR, and monetary aggregate.

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[24]See Table 4.2 for variable definitions and data source(s).

[25]In the world economy case, domestic variables can describe foreign variables movements either with a lag or contemporaneously.

Real GDP and consumer price index (CPI) are considered target variables of macroeconomic nonpolicy variables. Using real GDP with other macroeconomic nonpolicy and policy variables in nominal terms is a standard practice in the monetary literature (see, for example, Bagliano and Favero, 1998; Bernanke and Mihov, 1998; Brischetto and Voss, 1999; Cheng, 2006; Amarasekara, 2009). Therefore, in line with past empirical work, we too use GDP (real value) while the remaining variables were in nominal terms. In addition, for robustness, we also used nominal GDP (in current U.S. dollars) instead of real GDP, to be consistent with the other variables; however, the results are qualitatively the same (compare Figures 4.2, 4.3 and 4.4 [obtained using real GDP] and Figures 4.12, 4.13, and 4.14 [obtained using nominal GDP]). Including CPI inflation rather than a GDP deflator in an identified VAR is now common practice (e.g., Leeper and Gordon, 1991; Eichenbaum, 1992; Sims, 1992; Cushman and Zha, 1997; Bagliano and Favero, 1998; Kim and Roubini, 2000; Fung, 2002; Kim, 2003) in the 'monetary policy analysis' literature. Therefore, we also include in our model CPI inflation as a variable. On the other hand, data on the GDP deflator is not accessible at the monthly level; they are available only on a quarterly basis.

We use monthly data from Sri Lanka, from the January 1978–December 2011 period.[26] Since we do not have monthly GDP data, we interpolate the series using Chow and Lin's (1971) annualized approach from the annual GDP series.[27] All the variables used in this model are transformed into logarithm, except IRs. Moreover, all the data series are seasonally adjusted using the census X-12 approach.

[26] Sri Lankan economy is liberalized in late 1977, and CBSL has progressively moved towards market oriented monetary policy tools since 1977. Therefore, we have chosen 1978 as a starting period in order to analyze the small open economy situation.
[27] Although quarterly real GDP series is available from 1996, we used annual GDP series for the whole period for the interpolation.

4.4.1 Test for Stationarity, Lags Length Selection, and Cointegration

We perform an Augmented Dickey–Fuller (ADF) unit root test to ensure that data series possessed the time series property of stationarity. For the ADF test, we assume there to be no autocorrelation among the error terms when deciding the number of lags included in a series to test for the unit root.

However, several papers have proposed methods to test the null hypothesis of a unit root against a time series stationary that exhibits breaks (Perron, 1989; 1997; 2005; Zivot and Andrews, 1992; Lumisdaine and Papell, 1998) or nonlinearities (Hwan Seo, 2008; Balke and Fomby, 1997). These studies show how bias in the commonly used unit root test can be reduced by endogenously determining the time of structural breaks or nonlinearities. However, the unit root test that we used here is not robust to the above mentioned issues. We leave this issue for future research.

The model estimating the causal relationship between variables is highly sensitive to the lag length involved. This implies how many lagged values should enter the system of equation. The appropriate number of lags for the estimated VAR model has been decided based on Schwarz's Bayesian information criterion (SBIC), the Akaike information criterion (AIC), and the Hannan–Quin information criterion (HQIC).

Johansen's cointegration test is applied to confirm that the series are not cointegrated or cointegrated with an "N" relationship; this is done to ensure that the VAR is stable. In addition, we also use a residual correlation test to determine whether the residuals are correlated.

4.5 Methodology

4.5.1 Modeling of Structural VAR

In our basic model setup, we use a seven variable SVAR model, similar to that used by Kim and Roubini (2000), to represent a small, open, and developing economy while including foreign block variables. The VAR model assumes that the Sri Lankan economy is represented by a structural-form equation as follows:

$$A(L)Y_t + B(L)X_t = v_t \qquad (4.1)$$

where $A(L)$ and $B(L)$ are the $n \times n$ and $n \times k$ matrix polynomial of the lag operator, respectively; and Y_t is an $n \times 1$ vector of endogenous domestic variables of interest that can be divided into two blocks, such as vector of nonpolicy (NP) variables and vector of policy (P) variables. We assume that the policy variables are controlled by the central bank. X_t is a $k \times 1$ vector of exogenous foreign variables of interest, and v_t is an $n \times 1$ vector of structural disturbances that contains a vector of policy disturbances (v^p), nonpolicy disturbances (v^{NP}), and foreign variable disturbances (v^F) with a 0 mean and $var(v_t) = \Psi$ (where Ψ denotes a diagonal matrix). The elements of the diagonal matrix represent variances of structural disturbances; therefore, we assume that the structural disturbances are mutually uncorrelated.

The estimation of the reduced-form equation of the structural model (4.1) can be described as follows:

$$Y_t = C(L)Y_t + D(L)X_t + u_t, \qquad (4.2)$$

where $\mathrm{C(L)}$ and $\mathrm{D(L)}$ are the matrix polynomial of the lag operator and u is a vector of the VAR residuals with a 0 mean and $var(u_t) = \Sigma$.

Given the reduced-form estimation, we could estimate the parameters in the structural-form equation in many ways. However, the estimation of structural parameters requires the imposition of some restrictions on the elements of matrix A. Past studies of VAR models have employed various restriction methods based on existing theory and model preferences. One group of studies identifies the model through the commonly used Cholesky decomposition of orthogonalized reduced-form disturbances (e.g., Sims, 1980). However, this identification approach assumes only a recursive method; in this case, the ordering of variables changes the estimation results obtained. On the other hand, other groups of studies use a generalized method with nonrecursive structures (defined as SVAR), which impose restrictions only on contemporaneous structural parameters (e.g., Sims, 1986; Bernanke, 1986; Blanchard and Watson, 1986; Kim and Roubini, 2000).

The VAR residual u_t can be obtained by estimating the "N" equations from (4.2), using OLS. Let H be the contemporaneous coefficient matrix (nonsingular) in the structural-form equation, and $\mathrm{M(L)}$ be the coefficient matrix without a contemporaneous coefficient in the structural equation. That is, the relationship can be represented as:

$$\mathrm{A(L)} = \mathrm{H} + \mathrm{M(L)}. \tag{4.3}$$

Then, the structural-form equation parameters and those in the reduced-form equation are correlated by:

$$\mathrm{C(L)} = -\mathrm{H}^{-1}\mathrm{M(L)} \text{ and } \mathrm{D(L)} = \mathrm{H}^{-1}\mathrm{B(L)}. \tag{4.4}$$

Moreover, the structural disturbances and the VAR residuals of the reduced-form equation are related by:

$$v_t = Hu_t, \tag{4.5}$$

which indicates that

$$E(u_t u_t') = H^{-1}(v_t v_t')H^{-1}$$

$$\Sigma = H^{-1}\Psi\, H^{-1}. \tag{4.6}$$

Consistent estimates of H and Ψ are obtained using sample estimates of Σ, which can be calculated through the use of the maximum likelihood estimation technique. In equation (4.6), H contains $n \times (n+1)$ free parameters to be estimated. The summation (Σ) comprises only $n \times (n+1)/2$ parameters, which requires at least $n \times (n+1)/2$ restrictions on the system of equation. However, since we normalize the diagonal elements of H to be unity, we need at least $n \times (n-1)/2$ additional restrictions on H to attain identification. We impose the restrictions based on past empirical findings and on economic theory.

4.5.2 Identification Scheme: Nonrecursive Approach

In this model, the exogenous vector $\{X_t: \text{FFR}, \text{WOP}\}$ of variables is assumed to be a foreign block. The foreign variables are included to control for exogenous change in the global economic stance. The endogenous vector $\{Y_t: \text{GDP}, \text{CPI}, \text{M0}, \text{IR}, \text{ER}\}$ is assumed to be a domestic block, which comprises two blocks in the system: one is the nonpolicy block with two variables $\{\text{NP}: \text{GDP}, \text{CPI}\}$, and the other is the policy block with three variables $\{\text{P}: \text{M0}, \text{IR}, \text{ER}\}$.

The GDP, consumer price, IR, and money are the most popular variables in the literature of the monetary business cycle. Real GDP and CPI are chosen as the target variables, and known to be macroeconomic nonpolicy variables of the monetary policy model. We include these variables to measure the impact of the identified monetary policy shock on the real sector and the price level. The IR and money are taken as monetary policy instruments commonly used by the central banks of many countries as a stabilization policy toolkit. The ER is taken as an information market variable. The WOP and U.S. FFR are introduced to represents the small open economy stands—that is, the FFR was chosen as a proxy for the foreign monetary policy variable, and the WOP was taken as a proxy for expected inflation in the Sri Lankan SVAR system.

For the restrictions on the contemporaneous matrix of structural parameters H, we follow the general idea of Kim and Roubini (2000); however, doing so substantially modifies the monetary policy reaction function based on existing theory and empirical findings. Equation (4.7) summarizes the nonrecursive identification approach based on equation (4.6), as below:

$$\begin{bmatrix} v_{GDP} \\ v_{CPI} \\ v_{MS} \\ v_{MD} \\ v_{ER} \\ v_{OP} \\ v_{FFR} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & a_{16} & 0 \\ a_{21} & 1 & 0 & 0 & 0 & a_{26} & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 & a_{36} & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & a_{57} \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{76} & 1 \end{bmatrix} \begin{bmatrix} u_{GDP} \\ u_{CPI} \\ u_{IR} \\ u_{M0} \\ u_{ER} \\ u_{WOP} \\ u_{FFR} \end{bmatrix}, \tag{4.7}$$

where v_{GDP}, v_{CPI}, v_{MS}, v_{MD}, v_{ER}, v_{WOP}, and v_{FFR} are the structural disturbances—output shocks, domestic inflationary shocks, money supply shocks, money demand shocks, ER shocks, oil price shocks, and foreign monetary policy shocks, respectively—and u_{GDP}, u_{CPI},

u_{IR}, u_{M0}, u_{ER}, u_{WOP}, and u_{FFR} are reduced-form residuals that describe the unanticipated movements of each regressor, respectively.

The first two equations relate to real GDP and prices, which represent the goods market equilibrium of the domestic economy. Similar to several past empirical works (e.g., Cheng, 2006; Kim, 2003; Bagliano and Favero, 1998; among many others), we assume that money, IR, ER, and the U.S. IR do not affect the output and price contemporaneously; they are assumed to have affects only with a lag. However, since oil is an essential input for most economic sectors, we assume that the oil price affects the real sector and the domestic price level contemporaneously. The motivation of this identification assumption is that "firms do not change their price and output unexpectedly in response to unexpected changes in financial signals or monetary policy within a month due to the inertia, adjustment cost and planning delays, but they do in response to those in oil prices following their mark-up rule" (Kim and Roubini, 2000 pp. 568–569). Overall, we assume that real GDP responds to the WOP, and that the domestic price level responds to output and oil price contemporaneously.

The next two equations relate to money supply and money demand, which represent the money market equilibrium. The IR equation—that is, the money supply equation—is assumed to be the monetary authority reaction function. We use a standard form of the money supply and money demand function: in other words, the monetary policy reaction function is assumed to be contemporaneously affected by prices, output, and the IR. The contemporaneous inclusion of prices and output in the IR equation gives a form of reaction function similar to that of Taylor rule identification. Further, we allow the WOP to enter contemporaneously into the monetary authority reaction function, to control for the negative supply shocks and inflationary pressure. Next we assume that, similar to cases seen in the work of Kim and Roubini (2000) and Cushman and Zha (1997), the demand for money responds contemporaneously to income, prices, and the nominal IR,[28] and that all other variables—such as the ER, WOP, and FFR—will affect money only with lags.

The fifth equation is the ER equation, which represents the financial market equilibrium. We assume that the ER is contemporaneously affected by all the variables in the system of equation, since the ER is a forward-looking asset price (see, Kim and Roubini, 2000; Cushman and Zha, 1997). Further, through this equation, we allow foreign variables to influence domestic variables implicitly.

The last two equations relate to WOP and U.S. IR, which are assumed to be exogenous shocks that arise from the world economy. This indicates that domestic variables do not affect the oil price and the FFR contemporaneously, since these equations are exogenous to the domestic economy. However, we assume that the U.S. Federal Reserve may tighten monetary policy when it faces oil price related inflationary shocks.

[28]Alternatively, Tang (2006) assumed that the interest rate affect the money only in the lag structure.

4.6 Estimation Results

4.6.1 Estimation Results of the Unit Root Test, Optimal Lag, and Cointegration

4.6.1.1 Estimation Results of the Unit Root Test

The ADF test affirms that only one variable—namely, the IR—had no unit root in level, whereas all the other variables were integrated in order one (see Table 4.3). That is all the variables except the IR become stationary at the 1% significance level, only after either the first difference or the first-difference of the logarithm, while the domestic IR is stationary in levels (see, Table 4.3). Thus, we use the IR in levels, and all other series in the first difference of logarithm.

Note that we use the standard form of the money supply and money demand function, which is normally specified as a function of the inflation in level. For example, Taylor (1993) describes the U.S. monetary policy reaction function through the IR feedback rule, which depends on changes in inflation, output, or other economic conditions. Therefore, by using the first difference of the logarithm of CPI, we are effectively using inflation as one of our variables.

Table 4.4 (see Appendix) displays the summary statistics of the final data series, i.e., the data after the required transformation. According to the table, GDP grows by approximately 0.44%, while consumer prices and the oil price grow by 0.89% and 0.53%, respectively. The domestic IR increases 17.8% while the FFR increases by 1% per month. Reserve money increase, on average, by 1.15%, and the Sri Lankan rupee depreciates by around 0.5% per month against U.S. dollar.

4.6.1.2 Estimation Results of Optimal Lag

The SBIC, AIC, and HQIC lag-length selection criteria each choose one lag as an optimal lag, while the likelihood ratio statistics recommend longer lags and select 20 lags. We, therefore, use one lag to estimate the parameters of the SVAR, and 20 lags for the impulse responses function and variance decomposition, as one lag is inadequate in capturing the dynamic system of the model.

4.6.1.2 Estimation Results of Cointegration

It is also possible to analyze a model bearing a long-term identification restriction, since the Johansen cointegration test detects four cointegrating relationships within our model (see Table 4.5). However, in line with the existing monetary literature (e.g., Bagliano and Favero, 1998; Fung, 2002; Cheng, 2006; among many others), in our analysis we focus on the SVAR model, which implicitly allows economic relationships in the data. In addition, we undertook a residual correlation test to ensure that the residuals are serially uncorrelated, so that the VAR model can be used. We found the residuals not to be correlated when including three lags in the model (see Table 4.6). Therefore, we estimate the system with all variables in log first differences, except the interest rate and no imposition of the cointegrating correlation.

4.6.2 Estimation Results of Contemporaneous Coefficients

Coefficients of the SVAR identification restrictions are estimated using the OLS method; the estimated results are presented in Table 4.7 (see Appendix). According to Table 4.7, some of the estimated structural contemporaneous parameters support their respective equations significantly. In particular, the parameters of the monetary policy reaction function are statistically more significant than are the other equations, indicating that innovations in IR work more efficiently than other monetary policy shocks. The significant and negative coefficient of GDP in the money supply equation indicates that the rise in IR lowers the output. The negative value of the estimated coefficient of the consumer price reveals that the domestic price level declines when the IR increases. The positive value of the estimated coefficient of the oil price index reveals that the monetary authority increases the IR when it detects an unexpected rise in the oil price, indicating that the CBSL tightens monetary policy when it faces inflationary pressure. The coefficient of the oil price enters the output equation positively and the inflation equation negatively—circumstances that run counter to standard economic theory. However, the coefficient of oil price is not statistically significant.

4.6.3 Estimation Results of Impulse Response Function

This section discusses the estimated impulse response function used to understand the dynamic responses of domestic variables to various domestic and foreign monetary policy shocks within the SVAR system. The estimated impulse responses of the variables, over a 20-month period and to structural one-standard-deviation monetary policy shocks, are described. In each figure (Figures 4.2-4.14), each of the two dashed lines represents the 95% confidence band.

4.6.3.1 Responses to a Positive Interest Rate Shocks

Following a monetary contraction, it is expected that prices, output, and money demand will all decline, whereas the IR will increase and the ER will appreciate. Figure 4.2 (see Appendix) presents the estimated impulse responses of key economic variables to the shock to call money market rate.

The model with an IR as a monetary policy tool presents theoretically consistent results for both the output and the ER. That is, positive IR shocks reduce the output significantly over a few months, and then gradually moves to its initial baseline. The domestic currency appreciates after a horizon relative to the U.S. dollar, and such an impact effect appreciation is statistically significant over a longer horizon. Although the price level initially increases[29] and is followed by an IR shock, it is not statistically significant at any level of significance. In addition, this demand-driven inflationary pressure vanishes after a few months and returns to its pre-shock level, leaving no evidence of a price puzzle. Hence, the inclusion of oil price in the system of equation to account for inflationary expectation helps us to surmount the issue related to empirical puzzles. The shock to IR does not change money demand; this is a surprising result in view of money demand theory, which states that money demand decreases as the IR increases. The U.S. IR and WOP are not affected by domestic IR shock—something that is obvious, as the Sri Lankan economy is remarkably small and so it may not affect the foreign market.

Let us now re-examine the money supply equation with alternative identifying restrictions, and compare those results to the previous one. That is, in addition to the traditional Taylor rule, we assume that the money supply responds contemporaneously to the ER and money demand, as restricted by Kim and Roubini (2000). Therefore, we restrict the parameters a_{34} and a_{35}, which are different from 0, both separately and together in the model. The estimated results are no different from those obtained in the system of exclusion of these restrictions. Hence, our discussion in section 4.4.2 and the estimated

[29]Kim and Roubini (2000) stated that " if the monetary contraction is really exogenous in the sense that it is not a systematic response to any shock then almost no theory implies that output or price level increase" (p.572). However, Beaudry and Devereux (1995) derive the theoretical model and suggest that monetary contraction leads to rise in price level.

results suggest that restrictions on the structural parameters, such as $a_{34} = 0$ and $a_{35} = 0$, are reasonable.[30]

4.6.3.2 Responses to Positive Exchange Rate Shocks

Figure 4.3 (see Appendix) shows the responses of Sri Lankan economic variables to a structural one-standard-deviation nominal effective ER shock. Positive ER shocks, representing the domestic currency depreciation, did not produce significant results on major economic variables. The output declines over the first horizon; this is a somewhat surprising finding for Sri Lanka—which became an export-oriented economy in 1977—although it *is* consistent with the empirical findings of Amarasekara (2009). However, the response of output is short-lived and not statistically significant. Although the price level increases as expected, the increase in price is not statistically significant at any level of significance. The consumer price package in Sri Lanka includes only a few imported goods, causing a positive ER shock that does not affect the price level significantly.

The positive ER shock has no significant impact on the IR or money. The Sri Lankan public has no incentive to hold more U.S. dollars for their daily transactions, since the rupee is not dollarized; this might be why the IR is not affected by ER shocks. Note that Sri Lanka's money supply is controlled by the CBSL; therefore, it is obvious that any change in ER may not affect monetary aggregates. Overall, positive ER shocks give rise to no significant findings in major economic activities, since Sri Lanka's level of openness is quite small compared to those of other developing Asian economies, such as China, India, Hong Kong, Malaysia, and Thailand.

[30]The estimated results are not presented, but available upon request.

4.6.3.3 Responses to Positive Reserve Money Shocks

Figure 4.4 (see Appendix) shows the estimated impulse responses of each economic variable to positive money growth shocks. The positive money shock on output did not produce the expected results, as the output declined rather than increased. However, the response of output is short-lived, declining for only a few months and then returning to pre-shock values. Neither the price level nor the ER responded significantly to innovations in monetary aggregates. A positive shock to money causes the nominal IR to decrease in a manner consistent with the liquidity effect, thus suggesting no evidence of liquidity puzzle. The decline in IR is statistically significant at the 10% level. Overall, only one variable—namely, the IR—responds significantly as expected following a positive money growth shock.

4.6.3.4 Responses of Domestic Variables to Positive U.S. Interest Rate Shocks

We next estimate the impact of foreign monetary policy shocks on the Sri Lankan economy. Shocks to the U.S. FFR may reflect not only its own shocks (i.e., U.S. monetary policy shock) but also other structural shocks. Figure 4.5 (see Appendix) displays the responses of domestic variables to a positive U.S. IR shock.

Although domestic output and the price level increase—in moves quite the opposite of what theory suggests—following U.S. monetary policy shocks, the responses of these variables are not statistically significant. This may occur for two reasons. First, despite the United States having been the main destination for Sri Lanka's exports and having absorbed a large proportion of exports since 1977,[31] exports to the United States have been

[31] The U.S. absorbed 25% of the total export in 1990 which has been reduced as 20.3% in 2011.

remarkably small in terms of GDP.[32] Second, Sri Lanka's imports from the United States are negligible, representing 2.6% of the total GDP in 1990 and having been reduced to 0.04% in 2011. The domestic IR increases initially, following a positive U.S. IR shock. This could be why the monetary authorities of other countries may respond immediately by raising their own IR, to invalidate the inflationary effect of domestic currency devaluation in response to an increase in foreign IRs. In any case, the response of domestic IR is not statistically significant. Moreover, domestic currency and monetary aggregates are not affected by FFR shocks. Overall, positive shocks to the U.S. FFR do not generate the expected significant effect on domestic economic variables.

4.6.3.5 Responses of Domestic Variable to World Oil Price Shock

Figure 4.6 (see Appendix) presents the responses of key economic variables to WOP shocks. As expected, although the output decreases and the price level increases initially in response to WOP shocks, the impact on these variables are negligible and not statistically significant. This could be so, for two reasons. First, Sri Lanka's industrial sector hinges largely on "soft" industrial products (e.g., rubber-based products, garments, and textile products), which mainly use labor-intensive technology. Second, the oil consumption expenditure of Sri Lanka is truly negligible, in an amount representing 0.03% of total GDP in 1980 and 0.014% in 2010. Further, shocks to the WOP do not affect the IR, money, or ER significantly. In summary, positive oil price shocks do not generate a significant effect with regard to domestic economic variables.

[32] Sri Lanka's export to US was 6.1% of total GDP in 1990, which has been reduced as 3.6% in 2011.

4.6.4 Estimation Results for Variance Decomposition

The variance decomposition is another useful method by which to investigate interactions among economic variables over the impulse response horizon. Table 4.8 (see Appendix) presents proportion of variations in major economic variables that can be explained by shocks to other economic variables in the equation system. The decomposition values for the 1st, 3rd, 12th, and 20th horizon into the future are displayed in that table.

The results suggest that apart from their own shocks, much of the output variation is explained by the IR innovation and, to a lesser extent, by oil price shocks and U.S. IR shocks. Compared to other shocks, IR shocks seem to explain much of the consumer price variation, while less of the variation is explained by ER and monetary aggregate shocks (i.e., which explain only 0.03% and 0.04% of the volatility in inflation, respectively). In addition, oil price shocks explain about 0.03% of output fluctuations and 0.45% of price fluctuations, at all forecasting horizons except the first month; this finding implies that the oil price does not have a significant effect on output and price.

We can infer that around 25% of IR fluctuations are due to output shocks, at all forecasting horizons. The domestic IR is less likely affected by oil price or U.S. IR shocks, which explain only 0.11% and 0.16% of the IR volatility, respectively, at the forecasting horizons of three months and later. A substantial proportion of money and ER fluctuations are mainly explained by shocks to output, rather than other shocks (except their own shocks).

Overall, variations in output and prices are mainly explained by movements in the IR shock, whereas ER shocks are not. Moreover, shocks to money play a marginal role in explaining the movements of domestic variables. Oil price and U.S. IR shocks are less likely to explain the movement of domestic variables than shocks to domestic variables.

4.6.5 Robustness of the Results

We use various identification restrictions to ensure that these restrictions do indeed produce different impulse responses among the economic variables. First, we change the monetary policy reaction function by imposing the restriction used by Kim and Roubini (2000). Therefore, equation (4.7) can be rewritten as:

$$\begin{bmatrix} v_{GDP} \\ v_{CPI} \\ v_{MS} \\ v_{MD} \\ v_{ER} \\ v_{WOP} \\ v_{FFR} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & a_{16} & 0 \\ a_{21} & 1 & 0 & 0 & 0 & a_{26} & 0 \\ 0 & 0 & 1 & a_{34} & a_{35} & a_{36} & 0 \\ a_{41} & a_{42} & a_{43} & 1 & 0 & 0 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 & a_{56} & a_{57} \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & a_{76} & 1 \end{bmatrix} \begin{bmatrix} u_{GDP} \\ u_{CPI} \\ u_{IR} \\ u_{M0} \\ u_{ER} \\ u_{WOP} \\ u_{FFR} \end{bmatrix} \tag{4.8}$$

The authors assume that data with regard to aggregate output and price level are not available within a month, but that pertaining to IR, money, ER, and oil price are available within a period. Therefore, following the informational assumption, IR, money, ER, and oil price are assumed to affect the money supply function contemporaneously, while both output and consumer price affect only with a lag. The reason for the contemporaneous exclusion of the FFR from this equation is that, although data are available within a period, the monetary authority cares about unexpected changes in the ER relative to the U.S. dollar rather than unexpected changes in the U.S. IR (Kim and Roubini, 2000). They include oil price in the money supply equation to control for the inflationary pressure and current systematic response of supply shocks.

Based on this restriction, positive IR shocks produce results similar to the major findings of this study with regard to price level, ER, and money (see Figures 4.2 and 4.7). However, the response of output is inconsistent with theory and the major findings of this study—that is, the output increases significantly over a few horizons, then falls significantly as expected, followed by an IR shock. This implies that the identification restriction of this study is more credible than the restrictions of Kim and Roubini in explaining the Sri Lankan monetary policy transmission mechanism.

Second, we use narrow money (M1) as an alternative to reserve money (M0) in equation (4.7), for robustness. When using M1, IR shocks reduce the money demand significantly,[33] while all other domestic variables respond as observed in Figure 4.2. However, positive M1 shocks do not generate a significant effect on any of the domestic variables (see Figure 4.8), whereas shocks to reserve money decrease the IR significantly, as expected (see Figure 4.4). We also examine the impulse response of the economic variables using broad money (M2) as monetary policy instruments. Shocks to M2 also have no significant impact on these variables,[34] which indicates that for the Sri Lankan economy, targeting reserve money is more effective than targeting narrow or broad money.

Next, we clarify the estimates of structural identification by taking the commonly used Cholesky decomposition approach, a special case of exactly identified model that is used in several identification schemes. The Cholesky approach raises the recursive ordering or Wold causal chain and prevents simultaneous interaction between certain variables. The recursive approach with numerous ordering does indeed produce empirical puzzles (see, for

[33]The results of interest rate shock do not reported, but available upon request.
[34] The results are not presented, but available upon request.

example, Cushman and Zha, 1997). In this case, we restrict the contemporaneous matrix H to be lower-triangular with ordering of the foreign block, the nonpolicy block, and the policy block, as explained by Cushman and Zha (1997) and Jääskelä and Jennings (2010).[35]

Figures 4.9, 4.10, and 4.11 (see Appendix) show the impacts of one standard deviation of positive IR shocks, ER shocks, and money growth shocks, respectively, on major economic variables, using a recursive VARs approach with the ordering of WOP, FFR, GDP, CPI, IR, M0, and ER.

As expected, the output declined significantly following positive IR shocks, whereas positive ER shocks and money shocks did not produce the expected results on output, with output declining rather than increasing. However, the decline in output was not statistically significant following ER and monetary aggregate shocks. Although innovations in IR, positive ER shocks, and positive money shocks led to an increase in price level, which is not statistically significant at any level. The domestic currency appreciates after a month, as expected, following IR shocks; this provides no evidence of an ER puzzle. Shock to IRs provided no significant results on money growth, while shocks to money growth tended to reduce the IR as expected, at the 10% level of significance. Overall, recursive VARs with the aforementioned ordering produce results similar to the main findings of this study.

[35] Alternatively, Kim (2003) normalized lower triangular order of non-policy block, foreign block and policy block.

4.7 Conclusions

In this study, we used an open-economy SVAR framework to examine the movements of Sri Lankan economic activities. Particularly, we investigated the impact of the domestic and foreign monetary policy shocks and the oil price shocks on domestic major economic variables. The orthogonal policy shocks attained from the SVAR model were employed to assess the success of monetary policy in affecting the output, prices, and other major economic activities in Sri Lanka. Moreover, we applied various policy variables to identify the policy instrument that most effectively explains the Sri Lankan monetary policy transmission mechanism.

For this purpose, we used monthly data from Sri Lanka during the January 1978–December 2011 period. We chose this sample period to cover the post-liberalization period of the Sri Lankan economy. In addition to the domestic variables, we included the U.S. FFR, as well as the WOP index, to account for the dynamic responses of Sri Lanka's economic variables to domestic and foreign monetary policy shocks. The dynamic and contemporaneous restrictions on the domestic blocks and the exogeneity restriction on foreign blocks are imposed to provide the economic structure for Sri Lankan SVAR model.

The model with an IR as a policy tool provides significant results, compared to the model with the ER. There is also substantial evidence that shocks to money explain the volatility of some of the economic variables (e.g., IR) significantly. The output decline and domestic currency appreciates significantly followed positive IR shocks; this was prevalent in several past empirical studies. The ER shocks had no significant impact on output, even though it led to a decline, in contrast to the pertinent theory. Meanwhile, a positive money shock provides significant but inconsistent results on output, that is, output decline rather than increase.

Positive IR shocks had no significant effect on the price level, although the price level increased rather than decreased, suggesting no evidence of a price puzzle. In contrast, Amarasekara (2009) found that inflation decreases initially following IR shocks. As expected, although the price level rose after positive ER and money shocks, the increase in prices were not statistically significant. The interest rate decreased significantly at the 10% level, when the monetary aggregate was used as a policy instrument—indicating no evidence of liquidity puzzles.

Overall, first, our empirical findings suggest that the IR plays a significant role in explaining the monetary policy transmission mechanism of Sri Lanka; this finding contrasts with those of some past empirical studies that proposed the transmission mechanism of monetary policy is driven by the ER, not the IR (see, for example, Cushman and Zha, 1997; Fung, 2002). Second, foreign monetary policy shocks and oil price shocks seem not to be vulnerable to domestic economic activities. Finally, the inclusion of the oil price in the SVAR model helped us overcome the puzzles that are normally inherent in the monetary literature. The results of the variance decomposition and the various identification restrictions used here also support these findings.

This SVAR model provided some useful perceptions about the theoretical framework of Sri Lanka's monetary policy evolution. The inter-bank call money market rate provides theoretically consistent result for output and the ER, and the reserve money shocks produce theoretically consistent results with regard to the IR. Second, targeting reserve money is more effective than narrow money or broad money. Third, ER shocks were found to play no significant role in explaining the volatility of major economic activities. Finally, U.S. monetary policy shocks and oil price shocks did not seem to be vulnerable to the Sri Lankan economy.

The next interesting field for future study will involve the inclusion of fiscal policy instruments to measure the impact of such shocks on principal economic activities. It would be interesting to consider in future research the time-varying parameter structural vector autoregressive (TVP-SVAR) model in a Bayesian framework within the context of the Sri Lankan economy, as well as the Bayesian SVAR.

CHAPTER 5

CONCLUSION

5.1 Introduction

The issue of sustainably high economic growth has become a growing phenomenon among economists and policy-makers in developing and developed countries alike. Many factors tend to determine the growth rate of an economy; however, the determinants of growth differ among countries and regions. Most economists consider price stability one of the main factors that ensure high and sustainable economic growth; to that end, the central banks of many countries implement monetary policies that maintain inflation at a desirable rate. There has been a boom in recent decades in research into economic growth. In general, three related issues lie at the heart of this research: the relationship between inflation and growth, the determinants of growth, and the impact of monetary policy on the real sector and price level. However, there is no consensus among economists about these three issues, which implies that the findings differ by country or by regional economic environment.

This dissertation attempts to investigate the economic growth issues of Asian countries, in terms of three aspects. The first is the association between inflation and the growth rate. To that end, we estimate a threshold level of inflation for Asian LDCs and how it affects the growth rates of these economies. The second aspect involves the determinants of growth among Asian developing nations. For this purpose, we investigated model uncertainty over several dimensions, such as a choice of control variables, instruments, and the validity of identifying restrictions. In addition, we also explore the probability of inflation having a nonlinear impact on growth. A final aspect would be the relationship between monetary policy and real economic activities. For this purpose, we measure the impact of monetary policy shocks on major macroeconomic variables, and which policy instruments help to explain the dynamic responses of these variables more efficiently in the context of Sri Lanka. We also attempt to examine the impact of both a foreign monetary policy shock and an oil price shock on the Sri Lankan economy.

5.2 Summary of the Findings

In chapter 2, we estimated the threshold value of inflation for Asian economies, as well as the significance of this value and its impact, together with other control variables on economic growth. The empirical evidence generated through our model detected approximately 5.43% as the threshold value of inflation for Asian LDCs; this result is statistically significant at the 1% level of significance. Although we found that the effect of the inflation threshold on economic growth is consistent with those of past empirical studies, this former value was lower for Asian LDCs than for LDCs in general, which range from 8% to 40% (e.g., Khan and Senhadji, 2001; Drukker et al., 2005; Kremer et al., 2009; Bick, 2010). Inflation had no significant effect on growth until it reached 5.43%, but from that point on, it appeared to slow growth rather notably. The impact of the threshold level of inflation on long-term economic growth is consistent with the results obtained through other estimation methods. We also found that both a higher investment ratio and a greater level of trade openness motivate economic growth, whereas higher initial income decreases this latter variable.

In chapter 3, we examine model uncertainty over several dimensions, along with the probability that an inflation level above the threshold value would have a negative coefficient. We also focus on a very large model space. Our empirical evidence regarding the determinants of growth shows that three variables significantly affect economic growth:

investment ratio and trade openness each seems to correlate positively with growth, and government consumption expenditure correlates negatively. We also found there to be a substantial probability that inflation impedes economic growth when it exceeds 5.43%. Although the neoclassical growth model (Solow, 1956) suggests conditional convergence, our estimation results report no evidence of either conditional convergence or divergence—that is, although chapter 2 suggests that countries are conditionally converging, the estimation results in chapter 3 reveal that there is no evidence of conditional convergence or divergence. However, we refer to chapter 3 rather than chapter 2, since the econometric framework of that former chapter considers FEs, endogeneity, and model uncertainty, while chapter 2 considers only FEs and endogeneity. Therefore, we conclude that there is no evidence of conditional convergence or divergence. This finding aligns with that of LM (2012), who also suggest that when using the whole sample with FE, the countries are found to be neither conditionally convergent nor divergent.

The current chapter also made use of the most recent lags as valid instruments, from a very large number of potential predetermined instruments, rather than the longer lags. Our findings fit well with those of LM (2012) and Roodman (2009b), each of whom suggest that models that use fewer but stronger instruments are better in terms of facilitating inference. Finally, our robust estimation procedure indicates that although our results are sensitive to the model specification, BMA helped overcome the specification bias of GMM.

In presenting a case study in chapter 4, we attempted to identify the monetary policy indicator that pinpoints the Sri Lankan monetary policy transmission mechanism most efficiently. That chapter also looked to estimate how shocks stemming from foreign monetary policy and/or oil price can affect domestic macroeconomic variables. There are several important findings in this respect. First, IR shocks play a significant and better role in explaining the movement of economic variables than monetary aggregate shocks or ER shocks. Second, the responses of output and ER are consistent with theory that pertains to IR shocks, while the responses of price level run counter to theory, as prices seem to increase rather than decrease; however, the increase in price level does not appear to be statistically significant. On the other hand, although positive money shocks produce a consistent result for IR: the variable declines in a manner consistent with the liquidity effect, but the shocks to output did not produce the expected results, as the output declined rather than increased. Third, the targeting of reserve money is more effective for the Sri Lankan economy than a focus on narrow or broad money. Fourth, our findings clearly show that foreign monetary policy shocks and oil price shocks do not seem to be vulnerable to the domestic economy. Finally, the inclusion of oil price in the SVAR model helped us overcome the puzzles that are normally inherent in the existing literature in monetary economics. The results obtained in this study through the use of variance decomposition and various identification restrictions also seem to support these findings.

5.3 Policy Implication

The primary goal of macroeconomic policy is to promote sustainably high economic growth and maintain the determinants of growth in a desirable manner. Most importantly, price stability is one of the main factors to play a crucial role in determining sustainable economic growth. Overall, our empirical findings could contribute in the provision of policy guidance to decision-makers. In fact, policy-makers in Asian LDCs need to consider a maximum inflation rate of 5.43% as a target in maintaining economic stability. Economic growth can also be enhanced by reducing trade barriers, motivating investment, and reducing government consumption expenditures.

Our empirical evidence from the SVAR model suggests some useful perceptions about the theoretical framework inherent in Sri Lanka's evolving monetary policy, where the CBSL can use the call money market rate as a better monetary policy instrument. Second, it is more effective to target reserve money than to focusing on narrow or broad money. Third, the ER channel plays no significant role in explaining the volatility of major economic activities. Finally, the Sri Lankan economy is not vulnerable to shocks emerging from U.S. monetary policy and/or oil prices.

5.4 Limitations, and Suggestions for Future Research

Like all studies, this study naturally has some limitations that arise in the course of asking questions; we also have suggestions for future research. In chapter 2, we considered initial income the only endogenous regressor; however, inflation, investment, population, and some other variables might also be endogenous in this model set-up. We might consider, therefore, that our estimated coefficient could be biased, but the seriousness of this issue is basically dependent on the results of Granger causality testing. For instance, if inflation causes growth, then any endogeneity problem may not be serious. In contrast, if growth causes inflation, then bias could effectively exist and cause us trouble by virtue of case bias. However, the exact causality between economic growth and inflation (other variables) is still subject to debate, and one of the best ways to test for this is by using Granger causality testing. We regard these limitations as providing useful direction for further studies.

In chapter 3, our results suggested that inflation negatively affects the growth rates of Asian developing economies with a probability of only 36.4% (and 53.4% under result 2) if inflation exceeds 5.43%. This scenario may have occurred because of the high volatility of inflation that might be distressing the economy. Some Asian countries have very frequently demonstrated some episodes of unusually high inflation, while others have had exceptionally low inflation (or even deflation) periods more frequently. This implies that inflation differs among countries and among years with high volatility, and this may be why inflation deters growth with only a 36.4% probability. Hence, it should be borne in mind that as every country has unique geographic and economic environments, optimal inflation targets may also be country-specific. Thus, the issue of high volatility can be resolved by considering the variance or standard deviation of inflation in the model. We leave this extension for further research.

In chapter 4, in our empirical analysis, we assumed that the effect of monetary policy shocks on an economy is constant over time. However, recently, there has been a substantial number of studies that assume that the coefficients and the variance of structural shocks vary over time, following a monetary policy shock (Nakajima, Kasuya and Watanabe, 2009; Primiceri, 2005; Cogly and Sargent, 2005). Therefore, it would be interesting to consider the time-varying parameter structural vector autoregressive (TVP-SVAR) model in a Bayesian framework within the context of the Sri Lankan economy. In addition, in future research, we would like to use a methodology that features Bayesian SVAR (e.g., Porter, 2010; Sims and Zha, 1996; Kociecki, Rubaszek and Zorzi, 2012), and compare the results thereof with those of the approach taken in this chapter.

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Appendices

List of Tables

Table 2.1: List of Countries and Summary Statistics

Country	Observation	Mean		
		Inflation in levels	Log of Inflation	Growth rate of GDP per capita
Bahrain	15	1.6606	-0.4590	-0.4694
Bangladesh	15	7.7788	0.8427	2.2714
Bhutan	15	8.0705	0.8604	6.0256
China	15	5.6970	0.3576	8.6139
Cyprus	15	4.0649	0.5462	2.7504
Hong Kong	15	4.7142	-0.0729	3.6324
India	15	8.0781	0.8815	4.0835
Indonesia	15	9.4723	0.4983	3.4329
Iran	15	19.5005	1.2608	1.1946
Israel	15	43.0075	1.0103	1.7084
Japan	15	1.1617	-0.4144	1.6066
Jordan	15	5.2615	0.5256	0.6974
Korea	15	5.7518	0.6618	5.1772
Kuwait	15	3.5280	0.3407	0.0476
Laos	15	33.1098	0.7396	4.5376
Macao	15	42.4727	0.9462	4.8905
Malaysia	15	3.1782	0.4157	3.6154
Maldives	15	6.5742	0.0992	5.8760
Nepal	15	8.7303	0.8971	1.7144
Oman	15	2.0234	-0.6340	2.1256
Pakistan	15	8.1793	0.8687	1.8409
Papua New Guinea	15	7.5712	0.8097	0.9967
Philippines	15	9.6841	0.8765	1.1287
Qatar	15	4.2107	0.5139	3.1552
Saudi Arabia	15	1.1183	-0.7172	-1.6388
Singapore	15	2.0654	0.0409	4.4564
Sri Lanka	15	11.7156	1.0495	3.6325
Syria	15	12.0104	0.5872	1.3081
Thailand	15	3.8986	0.3103	4.1716
Turkey	15	50.5111	1.5966	2.0600
United Arab Emirates	15	4.7466	0.6279	-0.6579
Vietnam	15	65.2895	1.1733	4.8919

Source: Author's calculation based on data from Penn World Table (PWT 7.0) for growth rate of GDP per capita and Economy Watch (EW) for inflation rate over the period 1980–2009.

Table 2.2: Variables, Definitions, Sources, and Summary Statistics

Variables	Description and Source	Mean	Std. Dev.	Min	Max
Growth rate of GDP per capita (y)	GDP per capita growth rate in purchasing power parity (PPP) 2005 constant prices, from PWT 7.0	2.78	4.97	–22.3	23.1
Initial income ($initial$)	GDP per capita from previous period In PPP 2005 constant prices (in log), from PWT 7.0	3.79	0.57	2.81	5.18
Investment Ratio (inv)	Annual percentage change of the GDP per capita dedicated to investment in PPP 2005 constant prices, from PWT 7.0	28.1	10.8	5.60	67.9
Inflation rate (π)	Average percentage change of CPI for the year, from EW	12.6	32.7	–6.44	406.9
$\tilde{\pi}$	Semi-log transformation of π	0.53	1.08	–7.44	2.61
Population growth rate ($gpop$)	Annual growth rate of population from WDI	2.41	2.06	–5.97	18.1
Trade openness ($open$)	Share of export plus import in percentage of GDP in 2005 constant prices, PWT 7.0	1.86	0.31	0.89	2.64
Terms of Trade (tot)	Export value divided by import value (2000=100), from WDI	1.92	0.14	1.41	2.33
$sdopen$	Standard deviation of trade openness	4.04	5.12	.003	42.9
$sdtot$	Standard deviation of terms of trade	6.58	7.11	0.01	51.1

Source: Author's calculation based on data from Penn World Table (PWT 7.0), Economy Watch (EW) and World Development Indicator (WDI).

*Note***:** All variables are in 2-year arithmetic averages. Total number of observations is 480.

Table 2.3: Results of Inflation Threshold and its Impact on Growth

	(1)		(2)		(3)	
Threshold Value ($\hat{\gamma}$)	5.433%		5.433%		5.433%	
Significance of threshold						
$p-value$	0.010		0.037		0.005	
Impact of inflation on growth						
$\hat{\beta}_1$	0.043	(0.10)	0.030	(0.07)	0.120	(0.31)
$\hat{\beta}_2$	-1.627***	(-3.25)	-1.482**	(-2.64)	-1.481***	(-3.68)
Impact of control variables						
$linitial$	-12.10**	(-2.53)	-8.425*	(-1.85)	5.624*	(-1.75)
inv	0.143***	(2.95)	0.157***	(3.38)	0.147***	(2.82)
$gpop$	0.042	(0.11)	-0.044	(-0.12)	-0.008	(-0.03)
$lopen$	12.60**	(2.04)	9.875	(1.65)	4.041	(1.18)
$ltot$	3.581	(0.79)	4.008	(0.89)	-0.412	(-0.11)
$sdopen$	-0.070	(-1.45)	-0.097	(-1.60)	-0.072*	(-1.66)
$sdtot$	0.019	(0.41)	0.050	(1.08)	0.022	(0.54)
Observation	448		378		448	
Number of countries	32		27		32	

Note: This table describes the system GMM results of equation (2.2), using all available lags of the predetermined variable as instruments. Results 1, and 2 were obtained by assuming that only initial income is predetermined and all other regressors are exogenous variables for the full sample (32 Asian countries), and sample of 27 countries (the full sample minus four OECD countries and Singapore) respectively. Result 3 was estimated by assuming that all explanatory variables are predetermined regressors for the full sample. Robust *t*-statistics are given in the parenthesis.

***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$

Table 2.4: Estimation Results of equation (2.2), Using FE and LSDVC

	(4)		(5)		(6)	
Threshold estimates ($\hat{\gamma}$)	5.433%		5.433%		5.433%	
Significance of threshold ($p - value$)	0.032		0.000		0.010	
Impact of inflation on growth						
$\hat{\beta}_1$	0.133	(0.50)	0.029	(0.12)	0.043	(0.10)
$\hat{\beta}_2$	-1.294**	(2.64)	-1.256***	(-2.46)	-1.626***	(-3.25)
Impact of control variables						
$linitial$	-2.934	(-1.49)	-5.986***	(-2.74)	-12.10**	(-2.53)
inv	0.153***	(4.59)	0.114***	(3.21)	0.143***	(2.95)
$gpop$	-0.073	(-0.53)	0.039	(0.28)	0.042	(0.11)
$lopen$	1.219	(0.55)	4.116*	(1.76)	12.60**	(2.04)
$ltot$	-0.219	(-0.10)	0.226	(0.10)	3.581	(0.79)
$sdopen$	-0.082*	(-1.71)	-0.057	(-1.21)	-0.070	(-1.45)
$sdtot$	0.026	(0.76)	0.021	(0.60)	0.019	(0.41)
$l.y$			0.226***	(4.65)		
Observation	480		416		448	
Number of countries	32		32		32	

Note: These results have been obtained by using the FE, LSDVC, and system GMM methods. For GMM estimation, we used only the current lag of the initial income as an instrument. Robust *t* (for results 4 & 6) and *z* (for results 5) statistics are in parenthesis. $***p < 0.01$, $**p < 0.05$ and $*p < 0.1$

Table 2.5: Inflation Threshold and its Impact on Growth (including time dummies)

	(7)		(8)	
Threshold estimates ($\hat{\gamma}$)	5.433%		5.433%	
Significance of threshold ($p-value$)	0.040		0.064	
Impact of inflation on growth				
$\hat{\beta}_1$	-0.258	(-0.68)	-0.187	(-0.45)
$\hat{\beta}_2$	-1.706**	(-2.61)	-1.347**	(-2.73)
Impact of control variables				
$linitial$	-29.71***	(-4.59)	-15.11***	(-4.63)
$investment$	0.068	(1.34)	0.140***	(3.24)
$gpop$	0.164	(0.38)	0.127	(0.41)
$lopen$	2.192	(0.72)	-1.217	(-0.50)
$ltot$	3.710	(0.74)	-1.144	(-0.33)
$sdopen$	-0.055	(-1.26)	-0.081**	(-2.15)
$sdtot$	-0.002	(-0.03)	0.006	(0.17)
Impact of Time Dummies				
$tim1$	-9.352***	(-3.11)	-6.243***	(-3.54)
$tim2$	-10.72***	(-3.80)	-7.678***	(-4.54)
$tim3$	-10.13***	(-3.84)	-7.040***	(-4.60)
$tim4$	-8.889***	(-3.66)	-5.643***	(-4.36)
$tim5$	-7.035***	(-3.53)	-3.938***	(-3.99)
$tim6$	-6.140***	(-3.16)	-3.379***	(-3.07)
$tim7$	-4.351**	(-2.68)	-2.058**	(-2.38)
$tim8$	-4.851***	(-3.12)	-2.883***	(-3.64)
$tim9$	-4.748***	(-3.44)	-3.057***	(-3.59)
$tim10$	-7.280***	(-6.18)	-5.257***	(-6.96)
$tim11$	-5.133***	(-4.36)	-3.072***	(-4.74)
$tim12$	-3.915***	(-3.90)	-2.174***	(-3.01)
$tim13$	-0.352	(-0.45)	0.602	(0.85)
Observation	448		448	
Number of countries	32		32	

Note: This Table describes estimation results of equation (2.2) with time dummies. Result (7) calculated by considering all available lags of initial income as instrumental variable ($initial_{i,t-1}, \dots, initial_{i,t-m} : t = m$) and others are strictly exogenous. While, result (8) obtained using all available lags of all regressors as instrumental variables, i.e. all independent variables are predetermined. Robust t-statistics are in the parenthesis, ***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$.

Table 3.1: Data Description and Source(s)

Variables	Description	Source(s)
y	GDP per capita growth rate in purchasing power parity (PPP) 2005 Constant prices	PWT 7.0
initial	GDP per capita from previous period in PPP 2005 constant prices (in Log)	PWT 7.0
inv	Annual percentage change of the GDP per capita dedicated to investment in PPP 2005 constant prices	PWT 7.0
infl[36]	Average percentage change of the CPI for the year	EW
gpop	Annual growth rate of population	WDI
open	Share of export plus import in percentage of GDP in 2005 constant prices	PWT 7.0
tot	Export value divided by import value (2000=100)	WDI
lfpr	Percentage of total population ages 15+ and 65-	WDI
gce	Government consumption share of GDP per capita converted in PPP 2005 constant prices	PWT 7.0
prim	Gross enrollment rate in primary education (% of total enrollment Regardless of age)	WDI
secnd	Gross enrollment rate in secondary education (% of total enrollment Regardless of age)	WDI
pi	Price level of investment in PPP 2005 constant prices	PWT 7.0
pop	Total population in million	WDI
popdn	People per sq. km of land area	WDI

Note: PWT represents Penn world table, EW denotes economy watch and WDI indicates world development indicator. Since the data of school enrollment rate for certain period for some of the Asian countries are not available from WDI, I collected the data of primary school enrollment rate for Bangladesh from *http://www.igs-bracu.ac.bd/UserFiles/File/archive_file/Working%20paper.pdf* for the period of 1996-2004 and from *http://www.indexmundi.com/facts/bangladesh/school-enrollment* for the period of 2005-2009). Primary school enrollment rate data for Vietnam is collected from *http://www.indexmundi.com/facts/vietnam/school-enrollment* for the period 2002-2009. We also used Asian economic outlook to collect the secondary school enrolment rate of Bhutan for the period of 1981, 1988 and 1994. Primary school enrollment ratio of Saudi Arabia is collected from *http://www.tradingeconomics.com/saudi-arabia/school-enrollment-primary-percent-gross-wb-data.html* for the period of 1980, 1985, 1990, 1991, 1995 and 2004 and the secondary school enrollment ratio from *http://www.tradingeconomics.com/saudi-arabia/school-enrollment-secondary-percent-gross-wb-data.html* for the period of 1980, 1985, 1990, 1991 and 1995.

[36] We used Inflation as a threshold variable. In our first chapter, we found threshold level of inflation is approximately 5.43%. Thus, we define the inflation data into two: (i) Inflation below threshold (inf_low) and (ii) Inflation above the threshold level (inf_high).

Table 3.2: Summary Statistics of Full Sample

Variable	Observation	Mean	Std. Dev.	Min	Max
g	345	2.837	4.944	-22.28	20.56
log_initial	345	3.737	0.575	2.805	5.176
log_infl	345	0.498	1.067	-7.439	2.046
infl	345	8.148	12.33	-6.439	111.2
inv	345	28.05	11.16	5.605	67.92
gpop	345	2.616	2.271	-5.966	18.06
open	345	90.87	55.84	7.776	386.6
tot	345	82.65	23.72	25.76	192.9
lfpr	345	64.42	9.918	42.50	84.05
gce	345	10.14	5.397	2.747	39.24
prim	345	99.05	16.87	34.43	151.3
secnd	345	59.46	24.95	4.512	99.77
pi	345	51.89	28.75	10.69	259.6
pop	345	1.21e+8	2.97e+8	159278.5	1.33e+9
popdn	345	733.12	575.29	3.928	18743.9

Source: Author's calculation based on data from Penn World Table (PWT 7.0), Economy Watch (EW) and World Development Indicator (WDI). All statistics are in two year arithmetic average of data over the period of 1980-2009.

Table 3.3: List of Countries and Summary Statistics for Inflation and Growth Rate

Region	Country	id	Observation	Mean		
				Inflation	Log of Inflation	Growth rate of GDP per capita
South Asia	Bangladesh	2	13	8.096	0.862	2.392
	Bhutan	3	11	7.319	0.811	5.039
	India	7	15	8.078	0.881	4.083
	Maldives	15	9	4.978	0.155	6.172
	Nepal	16	12	9.095	0.912	1.757
	Pakistan	18	8	8.735	0.892	2.769
	Sri Lanka	23	10	11.986	1.055	3.487
East Asia	China	4	15	5.697	0.358	8.614
	Hong Kong	6	11	3.855	-0.226	4.211
	Macao	13	8	17.077	0.463	6.646
South East Asia	Indonesia	8	15	9.472	0.498	3.433
	Laos	12	15	33.110	0.740	4.538
	Malaysia	14	15	3.178	0.416	3.615
	Papua New Guinea	19	11	7.987	0.869	-0.032
	Philippines	20	15	9.684	0.877	1.129
	Thailand	25	15	3.899	0.310	4.172
	Vietnam	27	8	13.984	0.648	5.820
Western Asia	Bahrain	1	15	1.661	-0.459	-0.469
	Cyprus	5	15	4.065	0.546	2.750
	Iran	9	12	18.764	1.239	2.314
	Jordan	10	15	5.262	0.526	0.697
	Kuwait	11	15	3.528	0.341	0.048
	Oman	17	15	2.023	-0.634	2.126
	Qatar	21	15	4.211	0.514	3.155
	Saudi Arabia	22	7	2.660	-0.130	1.020
	Syria	24	15	12.010	0.587	1.308
	United Arab Emirates	26	15	4.747	0.628	-0.658

Source: Authors calculation based on data from the sources of Penn World Table (PWT 7.0) for growth rate of GDP per capita and Economy Watch (EW) for inflation rate over the period 1980-2009.

Table 3.4: First Ten Best Models among the Many Models

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Posterior probability of inclusion of a variable that entering the model as an exogenous regressor										
inv	1	1	1	1	1	1	1	1	1	1
inf_low	0	0	0	0	0	0	0	0	0	0
inf_high	0	1	0	1	1	0	0	0	1	1
gpop	0	0	0	0	0	0	0	0	0	0
open	1	1	1	1	1	1	1	1	1	1
tot	1	1	1	1	1	1	1	1	1	1
lfpr	0	0	0	0	0	0	0	0	0	1
gce	0	1	0	0	1	1	0	0	1	1
prim	0	0	0	0	1	0	0	0	0	0
secnd	1	1	1	1	1	1	1	1	1	1
pi	0	0	0	0	1	0	1	0	0	0
pop	1	1	1	1	1	1	1	1	1	1
popdn	0	0	1	0	0	0	0	1	0	1
Posterior inclusion probability of a variable that entering the model as an endogenous regressor										
Initial	1	1	1	1	1	1	1	1	1	1
Exogi	1	1	1	1	1	1	1	1	1	1
Posterior Model probability for first 10 Best Models										
P.M.Prob	0.0022	0.0019	0.0016	0.0015	0.0015	0.0014	0.0013	0.0013	0.0013	0.0012

Table 3.5: BMA Estimation Results for Exogenous Variables

Variables	Result (1)					Result (2)				
	Proba bility	2.5%	97.5%	Mean	Posi tive	Proba bility	2.5%	97.5%	Mean	Posi tive
Inv	0.992	-0.193	0.473	0.183	0.761	0.995	0.023	0.185	0.109	0.988
inf_low	0.008	0.000	0.000	1.2e-4	0.004	0.006	0.000	0.000	7.0e-5	0.003
inf_high	0.405	-2.695	0.358	-0.351	0.041	0.536	-2.542	0.000	-0.828	0.003
gpop	0.018	0.000	0.000	-0.003	0.006	0.005	0.000	0.000	-4.4e-4	0.001
open	0.983	-0.120	0.137	0.028	0.665	0.996	-0.023	0.026	0.004	0.654
tot	0.997	-0.174	0.135	0.003	0.622	0.311	-0.046	0.000	-0.008	0.014
lfpr	0.113	0.000	0.479	0.040	0.109	0.281	0.000	0.497	0.097	0.281
gce	0.397	-0.845	0.023	-0.163	0.029	0.851	-0.626	0.000	-0.351	0.000
prim	0.115	-0.126	0.066	-0.004	0.041	0.051	-0.032	0.000	-0.002	0.008
secnd	1.000	-0.399	0.459	0.098	0.670	1.000	-0.088	0.054	-0.002	0.522
pi	0.253	-0.094	0.031	-0.010	0.058	0.012	0.000	0.000	-2.4e-4	0.001
pop	1.000	-1.1e-7	1.3e-7	3.0e-7	0.679	1.000	-1.8e-8	2.1e-8	4.7e-9	0.738
popdn	0.448	-0.005	0.007	0.001	0.332	0.069	-6.9e-6	0.001	2.0e-5	0.043

Note: 'Probability' denotes the posterior inclusion probability of the exogenous regressors, 'Mean' is the posterior mean of the coefficient of the exogenous regressors, '2.5%, 97.5%' represents posterior percentiles of the coefficient of the exogenous variables and 'positive' is the probability that the exogenous variables having a positive coefficient. Result (1) is calculated using all possible lags of the predetermined variable as instruments and result (2) is computed using only the most recent lag as an instrument.

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Table 3.6: BMA Estimation Results for Instruments

Time	Instru-ments	Proba-bility	Time	Instru-ments	Proba-bility	Time	Instru-ments	Proba-bility
T=1	zG1L0	0.168	T=9	zG9L0	0.062	T=12	zG12L6	0.114
T=2	zG2L0	**0.703**		zG9L1	0.076		zG12L7	0.178
	zG2L1	**0.741**		zG9L2	0.047		zG12L8	0.063
T=3	zG3L0	**0.447**		zG9L3	0.060		zG12L9	0.149
	zG3L1	**0.549**		zG9L4	0.053		zG12L10	0.079
	zG3L2	0.351		zG9L5	0.056		zG12L11	0.061
T=4	zG4L0	0.112		zG9L6	0.063	T=13	zG13L0	0.158
	zG4L1	0.150		zG9L7	0.064		zG13L1	0.126
	zG4L2	0.225		zG9L8	0.068		zG13L2	0.093
	zG4L3	0.173	T=10	zG10L0	0.279		zG13L3	0.091
T=5	zG5L0	0.093		zG10L1	0.116		zG13L4	0.066
	zG5L1	0.093		zG10L2	0.096		zG13L5	0.088
	zG5L2	0.077		zG10L3	0.150		zG13L6	0.123
	zG5L3	0.099		zG10L4	0.186		zG13L7	0.212
	zG5L4	0.078		zG10L5	0.109		zG13L8	0.100
T=6	zG6L0	0.076		zG10L6	0.080		zG13L9	0.106
	zG6L1	0.152		zG10L7	0.088		zG13L10	0.075
	zG6L2	0.123		zG10L8	0.099		zG13L11	0.083
	zG6L3	0.086		zG10L9	0.080		zG13L12	0.045
	zG6L4	0.159	T=11	zG11L0	0.114	T=14	zG14L0	0.192
	zG6L5	0.086		zG11L1	0.099		zG14L1	0.128
T=7	zG7L0	**0.448**		zG11L2	0.046		zG14L2	0.147
	zG7L1	**0.458**		zG11L3	0.065		zG14L3	0.153
	zG7L2	0.104		zG11L4	0.092		zG14L4	0.085
	zG7L3	0.067		zG11L5	0.151		zG14L5	0.061
	zG7L4	0.109		zG11L6	0.085		zG14L6	0.106
	zG7L5	0.079		zG11L7	0.054		zG14L7	0.125
	zG7L6	0.069		zG11L8	0.070		zG14L8	0.100
T=8	zG8L0	0.065		zG11L9	0.075		zG14L9	0.093
	zG8L1	0.063		zG11L10	0.036		zG14L10	0.051
	zG8L2	0.114	T=12	zG12L0	0.160		zG14L11	0.111
	zG8L3	0.076		zG12L1	0.114		zG14L12	0.056
	zG8L4	0.064		zG12L2	0.106		zG14L13	0.052
	zG8L5	0.090		zG12L3	0.093			
	zG8L6	0.132		zG12L4	0.066			
	zG8L7	0.092		zG12L5	0.135			

Note: ‘Instruments’ represents the number of lag available to each time period and ‘probability denotes the posterior probability of regressors in Z entering in the equation (3.1) as instruments (in z_i).

Table 3.7: BMA Estimation Results for Exogenous Variables (Sub Sample)

Variables	Probability	2.5%	97.5%	Mean	Positive
inv	0.978	0.000	0.183	0.105	0.970
inf_low	0.005	0.000	0.000	-1.2e-4	0.002
inf_high	0.488	-2.716	0.000	-0.812	0.003
gpop	0.005	0.000	0.000	-4.4e-4	0.002
open	0.998	-0.025	0.025	0.003	0.611
tot	0.407	-0.048	0.001	-0.009	0.027
lfpr	0.216	0.000	0.485	0.074	0.216
gce	0.855	-0.648	0.000	-0.364	0.000
prim	0.009	0.000	0.000	-3.6e-4	0.001
secnd	1.000	-0.086	0.058	0.002	0.580
pi	0.013	0.000	0.000	-2.4e-4	0.001
pop	0.022	0.000	0.000	5.6e-9	0.017
popdn	0.145	-0.001	0.001	4.0e-5	0.091

Note: 'Probability' denotes the posterior inclusion probability of the exogenous regressors, 'Mean' is the posterior mean of the coefficient of the exogenous regressors, '2.5%, 97.5%' represents posterior percentiles of the coefficient of the exogenous variables and 'positive' is the probability that the exogenous variables having a positive coefficient.

Table 3.8: BMA Estimation Results for Endogenous Regressor

	Initial Income						
	Probability	Mean	2.50%	5%	95%	97.50%	negative
Result 1	0.962	-3.918	-108.701	-97.574	94.078	103.755	53.15%
Result 2	0.172	8.746	-12.369	-8.895	27.653	32.045	3.60%

Note: 'Probability' denotes the posterior inclusion probability of initial income, 'Mean' is the posterior mean of the coefficient of the initial income, (2.5%, 5%, 95%, 97.5%) represents posterior percentiles of the coefficient of the initial income conditional on inclusion and 'negative' is the probability that the initial income has a negative coefficient. Result (1) is calculated using all possible lags of the predetermined variable as instruments and result (2) is computed using only the most recent lag as an instrument.

Table 3.9: BMA Estimation of equation (3.4) Assuming all Explanatory Regressors as Exogenous Variables

Variables	Probability	Mean	Standard Deviation
linitial	34.30	-0.5528	0.8270
inv	100.0	0.1056	0.0244
inf_low	0.000	0.0000	0.0000
inf_high	1.100	-0.0066	0.0818
gpop	11.60	-0.0276	0.0741
open	0.000	0.0000	0.0000
tot	60.60	-0.0173	0.0165
lfpr	67.20	0.0468	0.0394
gce	0.000	0.0000	0.0000
prim	6.800	-0.0018	0.0081
secnd	67.70	-0.0269	0.0212
pi	0.000	0.0000	0.0000
pop	95.70	2.28e-9	1.1e-9
popdn	93.20	2.81e-4	1.21e-4

Note: 'Probability' indicates the posterior inclusion probability of a variable entering in the model as an exogenous regressor, 'Mean' denotes posterior mean of the coefficient of that variable and last column represents the standard deviation of parameters (N=345).

Table 3.10: One Step System GMM, FE and LSDVC Estimation of equation (3.4)

Variables	**System GMM**		FE		LSDVC	
linitial	-9.995	(-1.44)	-2.480	(-0.83)	-7.877*	(-1.77)
inv	0.116*	(1.78)	0.148***	(4.05)	0.122**	(2.51)
inf_low	-0.223	(-0.70)	0.034	(0.90)	-0.029	(-0.09)
inf_high	-1.474*	(-1.75)	-1.440**	(-2.42)	-2.257***	(-2.89)
gpop	0.047	(0.13)	-0.063	(-0.42)	0.095	(0.53)
open	0.062**	(2.61)	0.010	(1.01)	0.017	(0.94)
tot	-0.029	(-1.17)	-0.024*	(-1.71)	-0.008	(-0.44)
lfpr	0.522**	(2.51)	0.327***	(2.89)	0.301*	(1.87)
gce	-0.360**	(-2.35)	-0.404***	(-3.50)	-0.258	(-1.47)
prim	-0.071	(-1.09)	-0.015	(-0.52)	-0.040	(-0.89)
secnd	0.002	(0.05)	0.001	(0.04)	0.051	(1.28)
pi	-0.001	(-0.90)	-0.009	(-0.77)	-0.004	(-0.32)
pop	2.4e-8**	(2.15)	1.1e-8	(1.48)	1.21e-8	(1.25)
popdn	0.001	(0.90)	-0.0002	(-0.32)	-0.001	(-0.23)
y.L1					0.244***	(3.72)
Observation	299		345		265	

Note: t-statistics are given in the parenthesis, $***p < 0.01$, $**p < 0.05$ and $*p < 0.1$

Table 4.1: Main Features of Monetary Policy in Sri Lanka

Features	Targets and Instruments
Final objectives	Price and Economic stability Financial system stability
Intermediate objectives	Target monetary aggregate (Broad money supply)
Operating target	Reserve money
Policy instruments	Policy rate and open market operation (OMO) Reserve requirement Bank rate

Source: The central Bank of Sri Lanka

Table 4.2: Variables Included in the Sri Lankan Monetary Policy Model

Variable	Definition	Source	Abbreviation
Foreign			
Oil Price	World oil price index (log) Base year 2005(=100)	IFS	WOP
US interest rate	Federal Funds rate (%)	IFS	FFR
Domestic (Non-Policy)			
Output	Gross domestic product at 2000 Constant prices in US $ (log)	WDI	GDP
Price Index	Colombo consumer price index (logs) Base year 2005(=100)	IFS	CPI
Domestic (Policy)			
Exchange rate	Exchange rate-per US $ (log)	IFS	ER
Interest Rate	Inter-bank call money market rate (%)	IFS	IR
Money	Reserve money (log)	IFS	M0

Note: IFS and WDI represent international financial statistics and world development indicator respectively.

Table 4.3: Unit Root Test

Variable	Level		Log		1st Difference		Log 1st difference	
	test-stat	p-value	test-stat	p-value	test-stat	p-value	test-stat	p-value
CPI	8.950	1.000	-2.756	0.064	-12.26	0.000	-17.05	0.000
GDP	0.708	0.990	-1.102	0.714	-20.73	0.000	-18.27	0.000
M0	8.598	1.000	-1.448	0.558	-21.47	0.000	-25.92	0.000
ER	0.734	0.990	-2.282	0.178	-18.37	0.000	-19.07	0.000
WOP	0.489	0.984	-0.671	0.854	-13.59	0.000	-15.26	0.000
FFR	-1.159	0.691	2.168	0.998	-13.94	0.000	-12.05	0.000
IR	-6.815	0.000	-5.014	0.000	-24.00	0.000	-24.05	0.000

Note: Augmented Dicky-Fuller unit root test for the variables in the model. Test critical value at 1% significance level is -3.447

Table 4.4: Descriptive Statistics of Transformed Data Series

	DLGDP	DLCPI	DIR	DLM0	DLER	DLWOP	DFFR
Mean	0.0044	0.0089	17.828	0.0115	0.0049	0.0053	-0.010
Std.Dev.	0.0513	0.0116	8.6097	0.0226	0.0118	0.0779	0.101
Minimum	-0.3661	-0.0356	7.7586	-0.1613	-0.0525	-0.2890	-0.865
Maximum	0.2923	0.0808	79.882	0.0988	0.0874	0.4277	0.363
Observation	407	407	407	407	407	407	407

Source: Author's calculation based on the international financial statistics and world development indicator data base.

Table 4. 5: Johansen's Cointegration Rank Test

Series: CPI_SA GDP_SA IR_SA ER_SA M0_SA FFR_SA WOP_SA

Hypothesized No of CE(s)	Eigenvalue	Trace Statistics	0.05 Critical Value	Prob. **
None*	0.320087	364.6029	125.6154	0.0000
At most 1*	0.196826	207.9721	95.75366	0.0000
At most 2*	0.136385	118.9837	69.81889	0.0000
At most 3*	0.079225	59.45283	47.85613	0.0028
At most 4	0.043800	25.94168	29.79707	0.1304
At most 5	0.016817	7.757838	15.49471	0.4917
At most 6	0.002146	0.872186	3.841466	0.3504

Note: * denotes rejection of the hypothesis at the 0.05 level, ** denotes the Mackinnon-Haug-Michelis (1999) p-values. Trace test indicates 4 co-integrating equation(s) at the 0.05 level.

Table 4.6: VAR Residual Serial Correlation Test

Lag	LM-stat	Prob
1	86.0022	0.0009
2	86.0570	0.0008
3	56.1968	0.2234

Note: Null hypothesis: no serial correlation at lag. Probability from chi-square with 49 df.

Table 4.7: Estimated Contemporaneous Coefficients of SVARs

Restriction	Estimate	Restriction	Estimate	Restriction	Estimate	Restriction	Estimate
a_{16}	0.0786	a_{32}	-14.608***	a_{43}	-0.0002	a_{54}	0.3534***
	(1.58)		(-294.3)		(-0.00)		(7.12)
a_{21}	-0.0121	a_{36}	0.3544***	a_{51}	-0.0588	a_{56}	0.0055
	(-0.24)		(7.120)		(-0.02)		(0.10)
a_{26}	-0.0022	a_{41}	-0.0240	a_{52}	-0.1367	a_{57}	-0.0054
	(-0.04)		(-0.01)		(-0.19)		(-0.11)
a_{31}	-53.024***	a_{42}	0.1044	a_{53}	0.0001	a_{76}	-0.222***
	(-10.68)		(0.150)		(0.001)		(-4.48)

Notes: Numbers in parenthesis are z-values. ***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$.

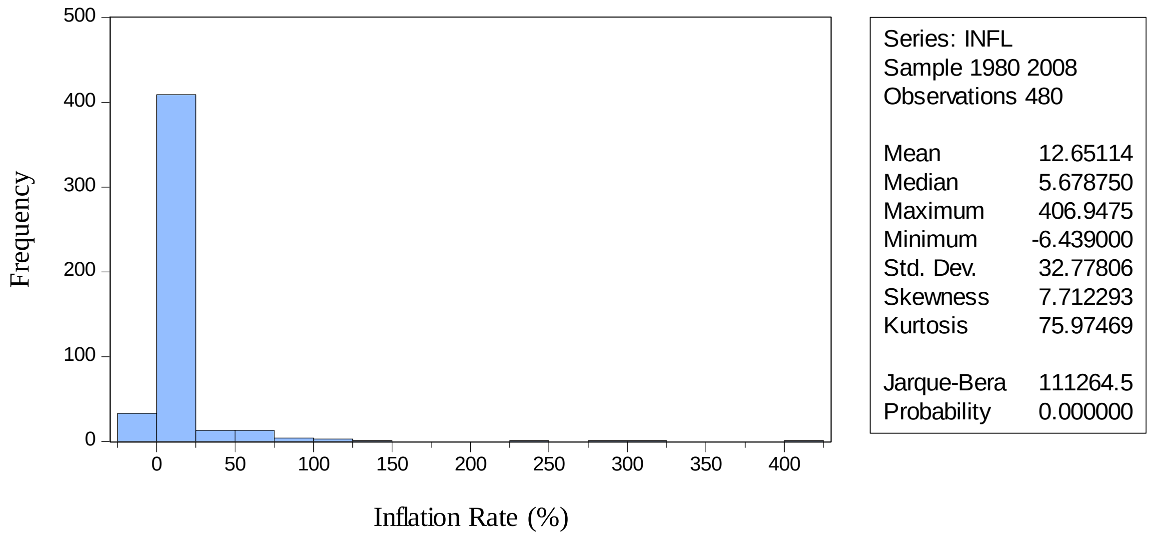
Table 4.8: Forecast Error Variance Decomposition of Major Economic Variables

	% of Variation due to the shocks to						
T	GDP	CPI	IR	M0	ER	WOP	FFR
FEV of GDP							
1	100 (3.7e-17)	0.00(0.000)	0.00(0.000)	0.00(0.000)	0.00(0.000)	0.00(0.000)	0.00(0.000)
3	95.9(.0174)	0.17(.0038)	1.34(.0082)	1.99(.0132)	0.50(.0068)	0.03(.0016)	0.04(.0020)
12	94.7(.0207)	0.21(.0038)	2.47(.0142)	1.97(.0131)	0.49(.0067)	0.03(.0016)	0.05(.0021)
20	94.7(.0208)	0.21(.0038)	2.50(.0143)	1.97(.0131)	0.49(.0067)	0.03(.0016)	0.05(.0021)
FEV of CPI							
1	0.37(.0060)	99.6(.0060)	0.00(0.000)	0.00(0.000)	0.00(0.000)	0.00(0.000)	0.00(0.000)
3	0.40(.0059)	98.2(.0123)	0.31(.0041)	0.04(.0017)	0.03(.0018)	0.43(.0066)	0.50(.0050)
12	0.56(.0063)	97.5(.0171)	0.79(.0096)	0.04(.0017)	0.03(.0018)	0.46(.0069)	0.56(.0076)
20	0.56(.0063)	97.5(.0172)	0.80(.0098)	0.04(.0017)	0.03(.0018)	0.46(.0069)	0.56(.0076)
FEV of IR							
1	26.3(.0375)	0.23(.0041)	73.4(.0375)	0.00(0.000)	0.00(0.000)	0.00(0.000)	0.00(0.000)
3	23.2(.0431)	1.46(.0138)	74.6(.0444)	0.42(.0049)	0.01(.0011)	0.11(.0032)	0.08(.0030)
12	22.4(.0478)	1.96(.0184)	74.9(.0505)	0.41(.0053)	0.01(.0009)	0.11(.0041)	0.16(.0053)
20	22.3(.0480)	1.97(.0185)	74.9(.0507)	0.41(.0053)	0.01(.0009)	0.11(.0041)	0.16(.0054)
FEV of M0							
1	0.74(.0084)	0.26(.0051)	0.20(.0044)	98.7(.0108)	.005(.0006)	0.00(0.000)	0.00(0.000)
3	0.69(.0078)	0.41(.0067)	0.24(.0048)	98.0(.0130)	.005(.0006)	0.37(.0055)	0.19(.0036)
12	0.69(.0078)	0.41(.0067)	0.25(.0049)	98.0(.0132)	.005(.0006)	0.38(.0056)	0.20(.0037)
20	0.69(.0078)	0.41(.0067)	0.25(.0049)	98.0(.0132)	.005(.0006)	0.38(.0056)	0.20(.0037)
FEV of ER							
1	3.48(.0178)	0.67(.0079)	0.06(.0024)	.001(.0003)	95.7(.0195)	0.00(0.000)	0.00(0.000)
3	3.85(.0186)	0.69(.0080)	0.93(.0068)	0.39(.0058)	93.5(.0230)	0.28(.0050)	0.27(.0048)
12	3.94(.0185)	0.71(.0079)	1.50(.0114)	0.39(.0058)	92.8(.0250)	0.31(.0052)	0.28(.0049)
20	3.95(.0185)	0.71(.0079)	1.51(.0115)	0.39(.0058)	92.8(.0251)	0.31(.0052)	0.28(.0049)
FEV of WOP							
1	1.46(.0118)	0.02(.0016)	.003(.0006)	0.06(.0025)	0.02(.0044)	98.2(.0129)	0.00(0.000)
3	1.59(.0129)	0.08(.0024)	.003(.0005)	0.54(.0074)	0.27(.0056)	96.7(.0181)	0.73(.0084)
12	1.59(.0128)	0.08(.0024)	0.01(.0008)	0.54(.0075)	0.27(.0055)	96.6(.0187)	0.81(.0094)
20	1.59(.0128)	0.08(.0024)	0.01(.0008)	0.54(.0075)	0.27(.0055)	96.6(.0187)	0.81(.0094)
FEV of FFR							
1	6.91(.0242)	.008(.0008)	3.07(.0162)	0.11(.0031)	0.01(.0009)	5.11(.0202)	84.7(.0328)
3	6.67(.0259)	0.29(.0060)	3.48(.0184)	0.94(.0101)	0.06(.0029)	9.78(.0329)	78.7(.0414)
12	6.58(.0256)	0.29(.0061)	3.79(.0219)	0.97(.0104)	0.06(.0029)	10.2(.0346)	78.1(.0434)
20	6.58(.0256)	0.29(.0061)	3.80(.0220)	0.97(.0104)	0.06(.0029)	10.1(.0346)	78.1(.0435)

Note: Figures in parenthesis are standard errors.

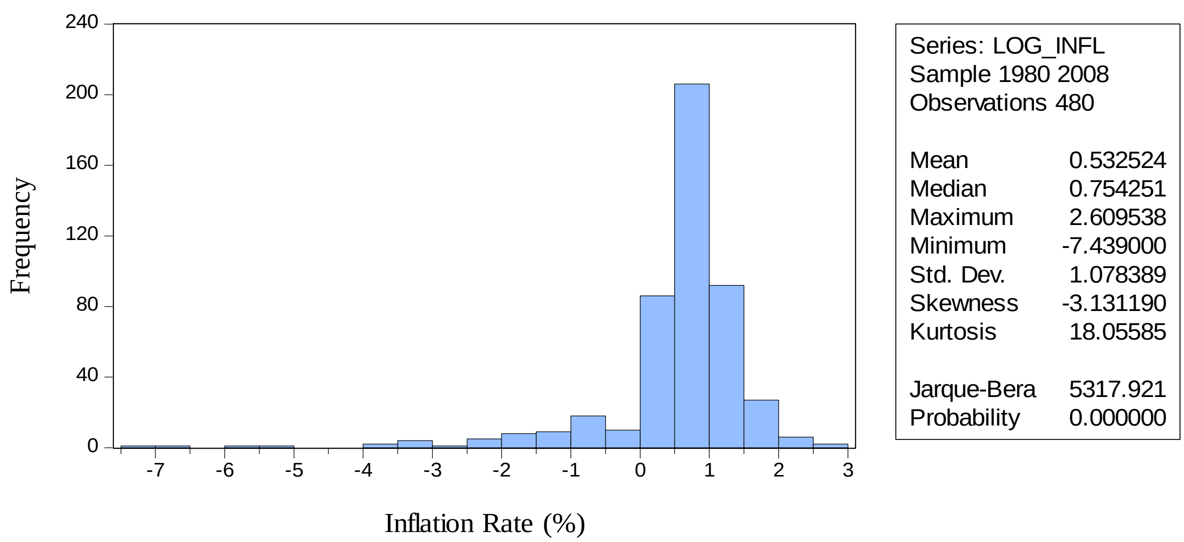
List of Figures

Figure 2.1a: Distribution of Inflation Rate (In Levels)



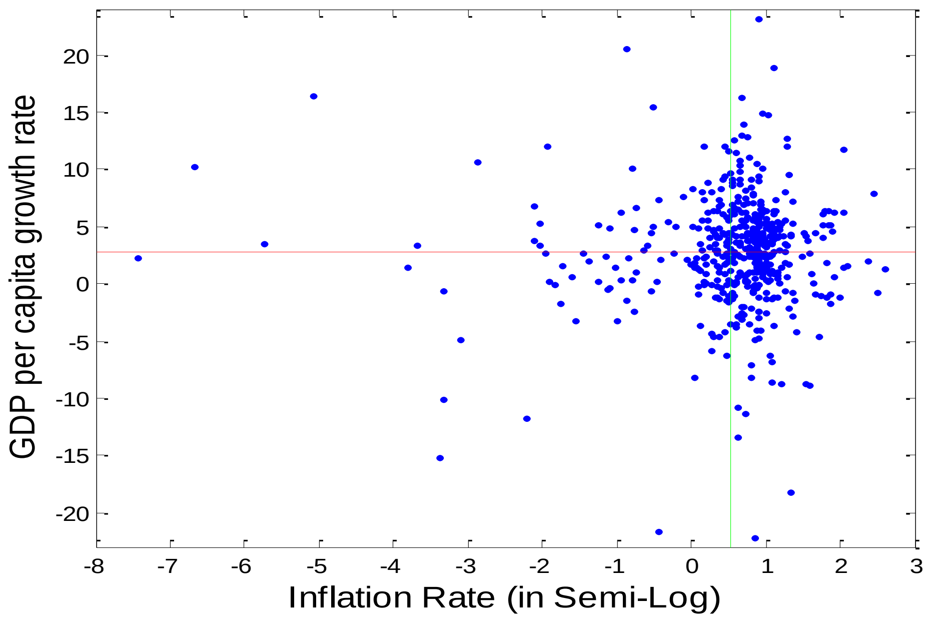
Source: Author's calculation using Economy Watch data base. The figure shows the distribution of 2-year averages of annual inflation rates (%), in level value, for Asian countries over the period of 1980–2009.

Figure 2.1b: Distribution of Inflation Rate (In Semi-Log)



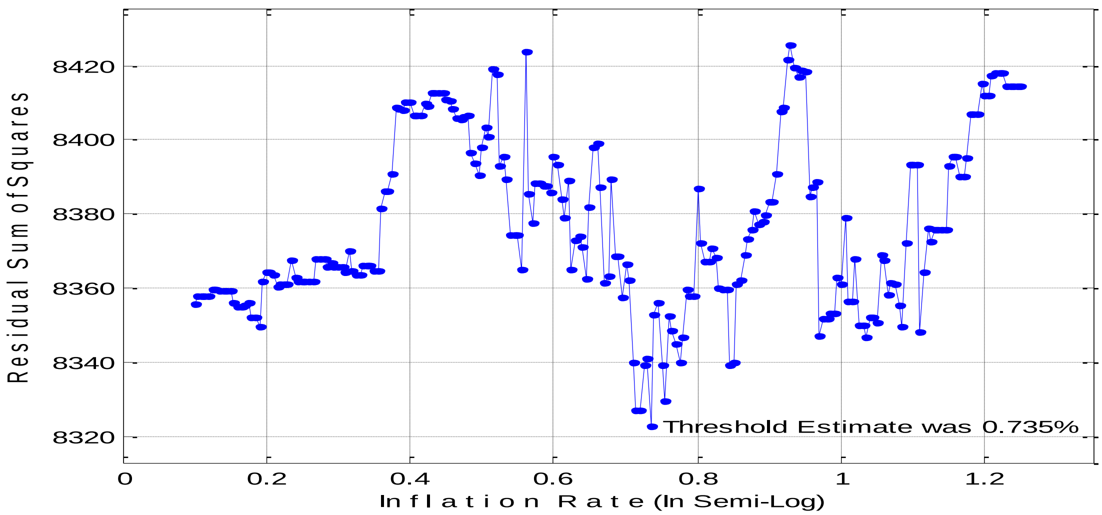
Source: Author's calculation using Economy Watch data base. The figure shows the distribution of 2-year averages of annual inflation rates (%), in semi-logged transformation, for Asian countries over the period 1980 –2009.

Figure 2.2: Relationship between Inflation and Economic Growth



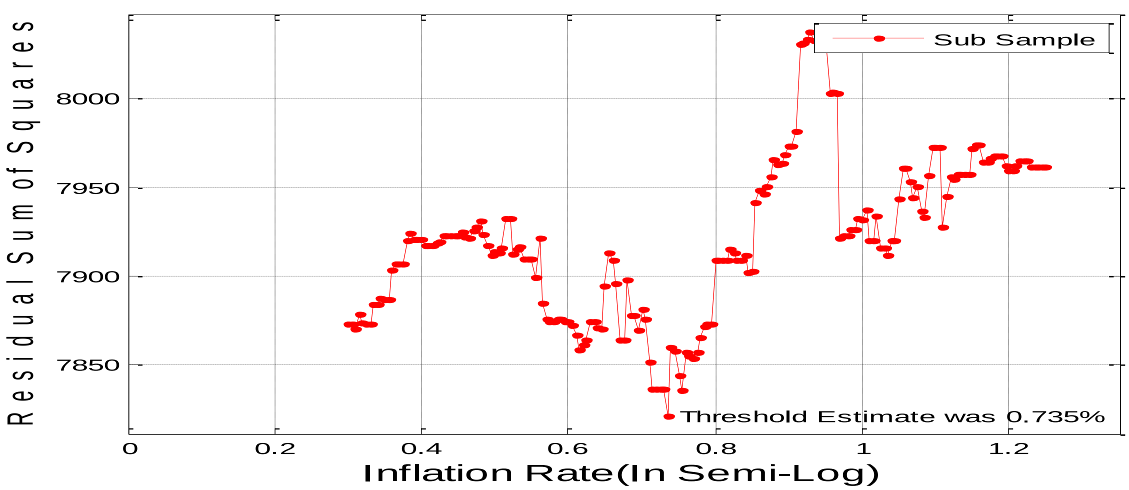
Source: Author's calculation using Penn World Table (PWT 7.0) and Economy Watch (EW) data base for the full sample (32 Asian countries).

Figure 2.3: Estimated Threshold level of Inflation for the Full Sample



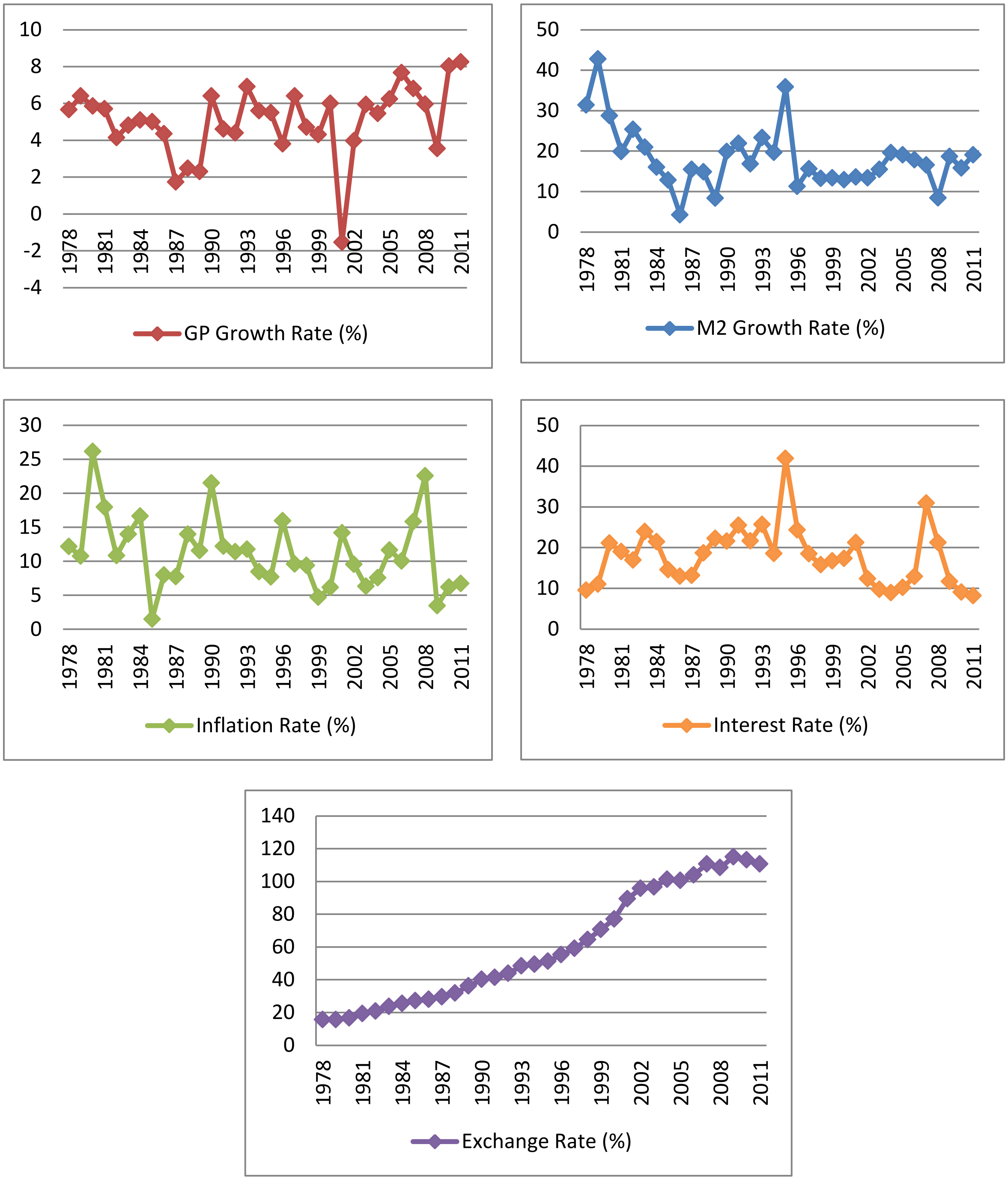
Source: Author's calculation for equation (2.6) using Penn World Table (PWT 7.0), Economy Watch (EW) and World Development Indicator (WDI) data base for the full sample (32 Asian countries).

Figure 2.4: Estimated Threshold Level of Inflation for the Sub-Sample



Source: Author's calculation for equation (2.6) using Penn World Table (PWT 7.0), Economy Watch (EW) and World Development Indicator (WDI) data base for the sample of 27 Asian developing economies (full sample minus 4 OECD countries (Japan, Israel, Korea, and Turkey) and Singapore).

Figure 4.1: Trend of Key Economic Indicators



Source: Author's calculation using data from world development indicator for GDP growth rate, inflation rate and monetary aggregate (M2) growth rate and international financial statistics for exchange rate and inter-bank call money market rate during the period from 1978 to 2011.

Figure 4.2: Impulse Responses to a Positive Interest Rate Shocks: SVAR

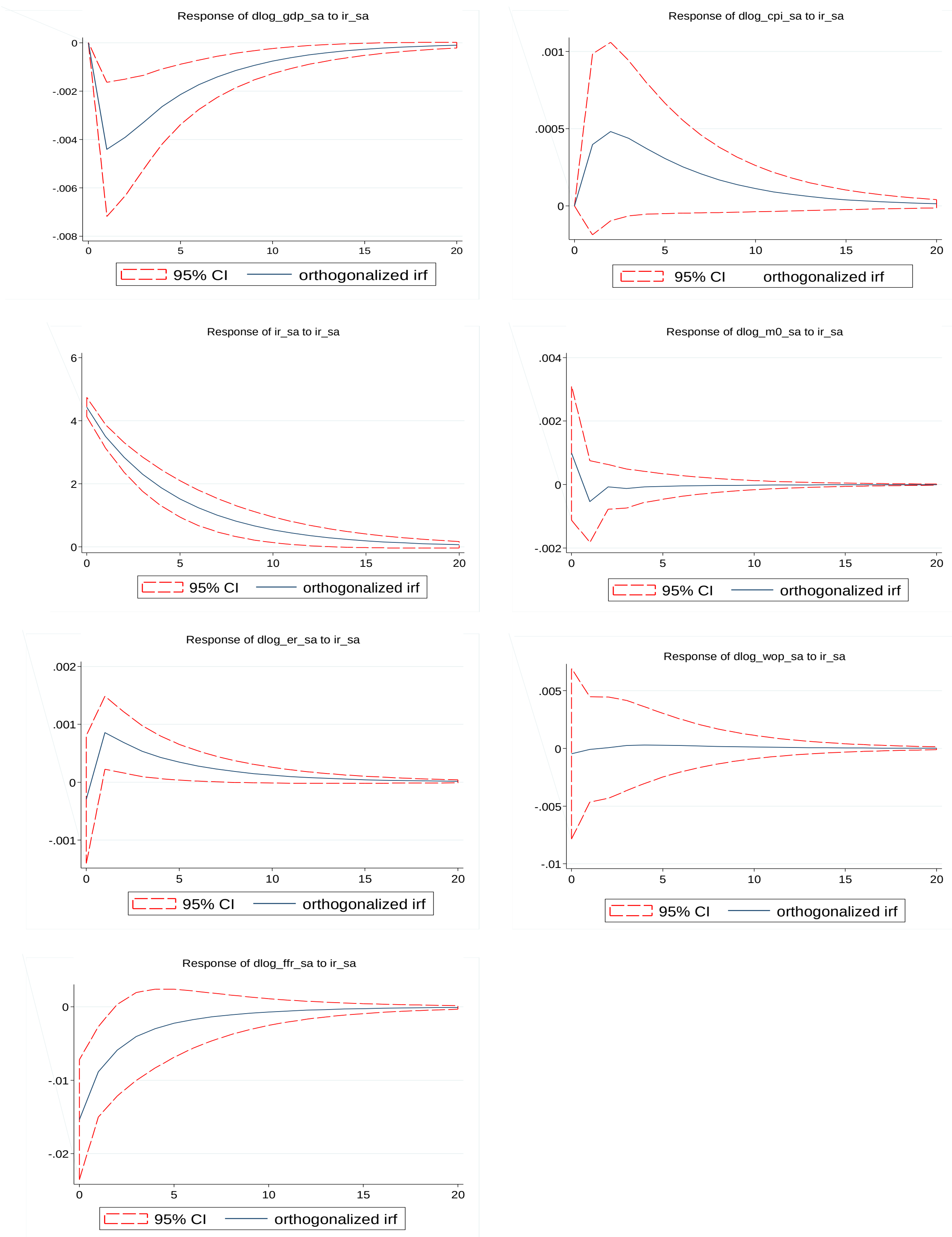


Figure 4.3: Impulse Responses to a Positive Exchange Rate Shocks: SVAR

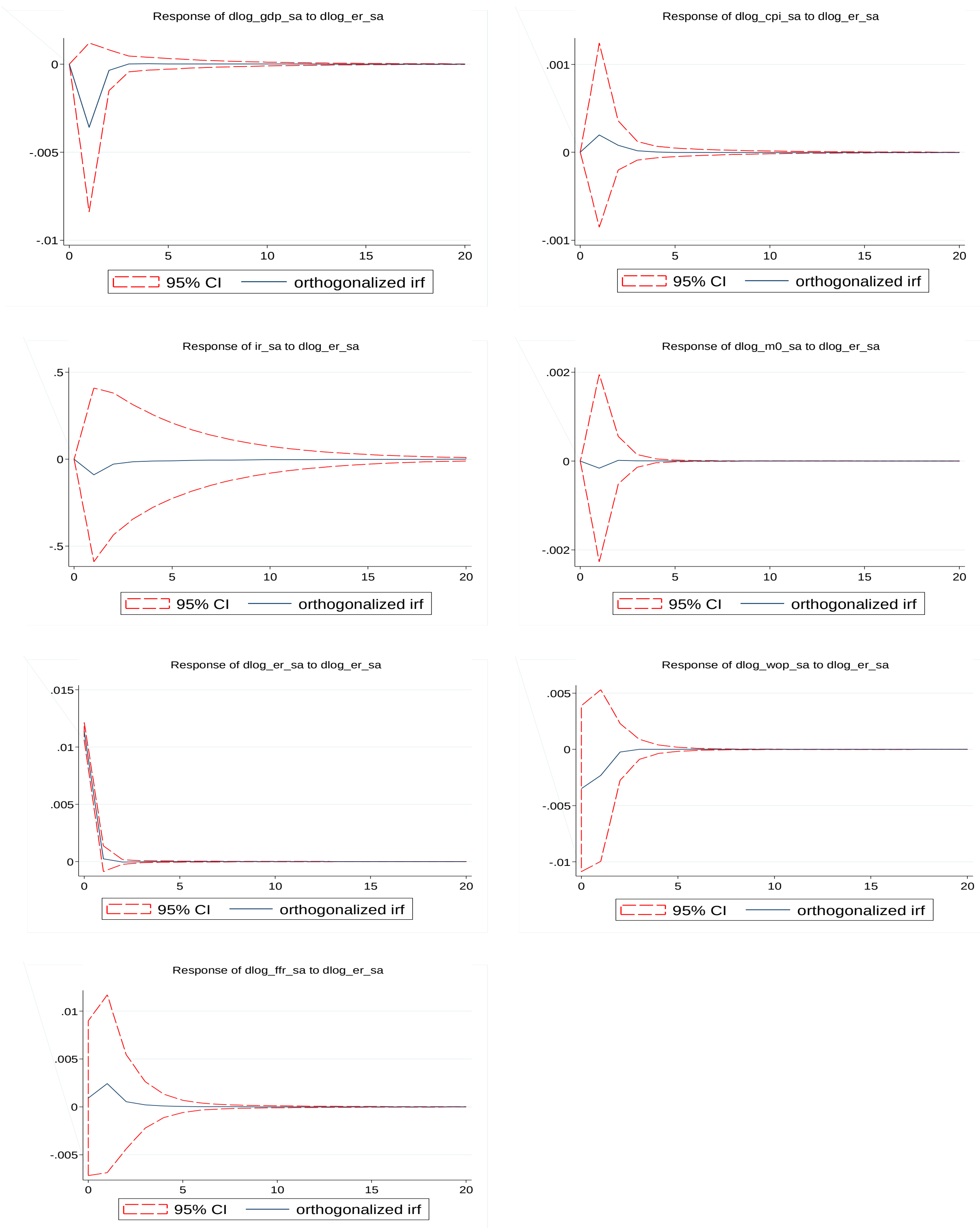


Figure 4.4: Impulse Responses to a Positive Money Growth Shocks (M0): SVAR

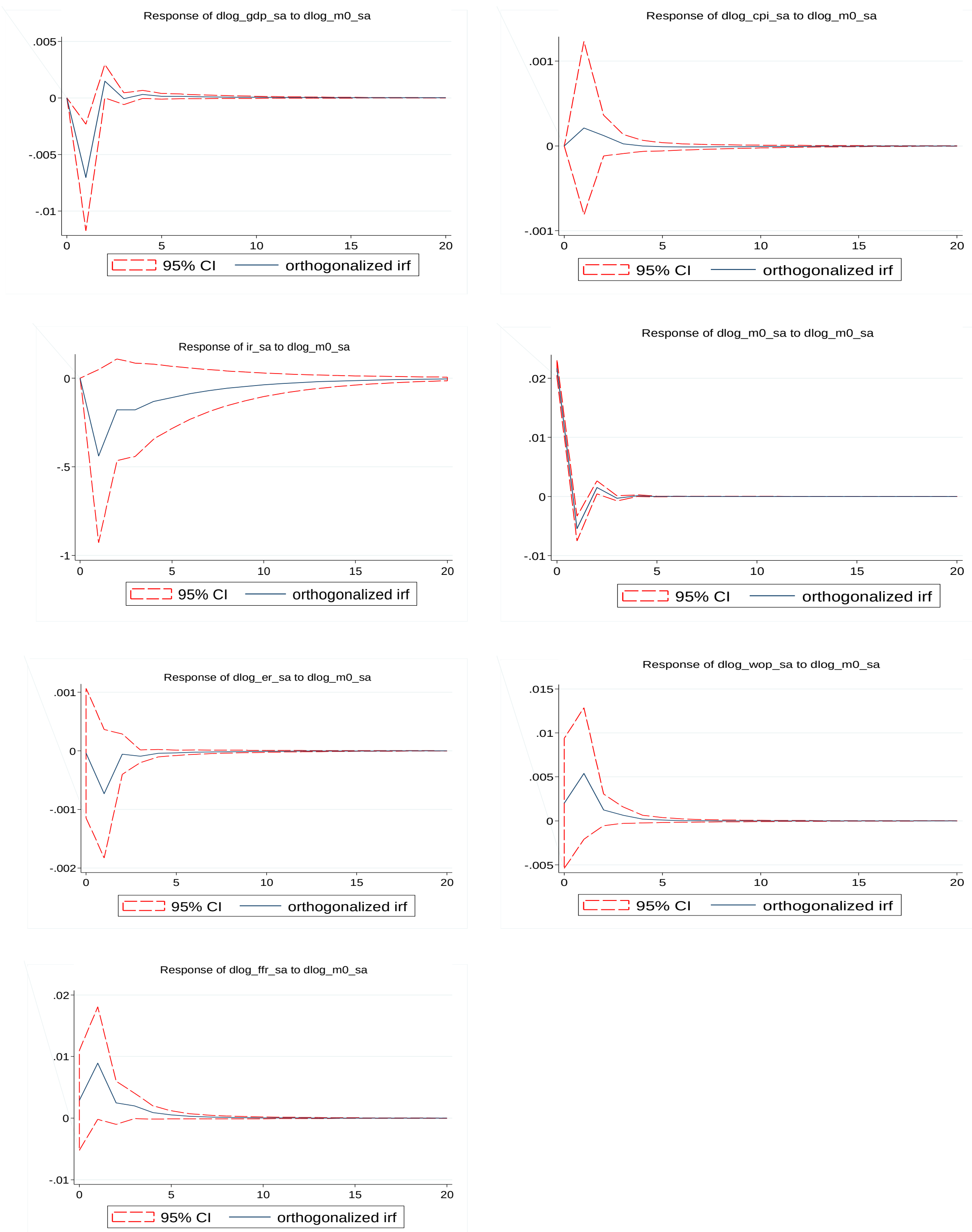


Figure 4.5: Impulse Responses of Domestic Variables to U.S. Interest Rate Shock

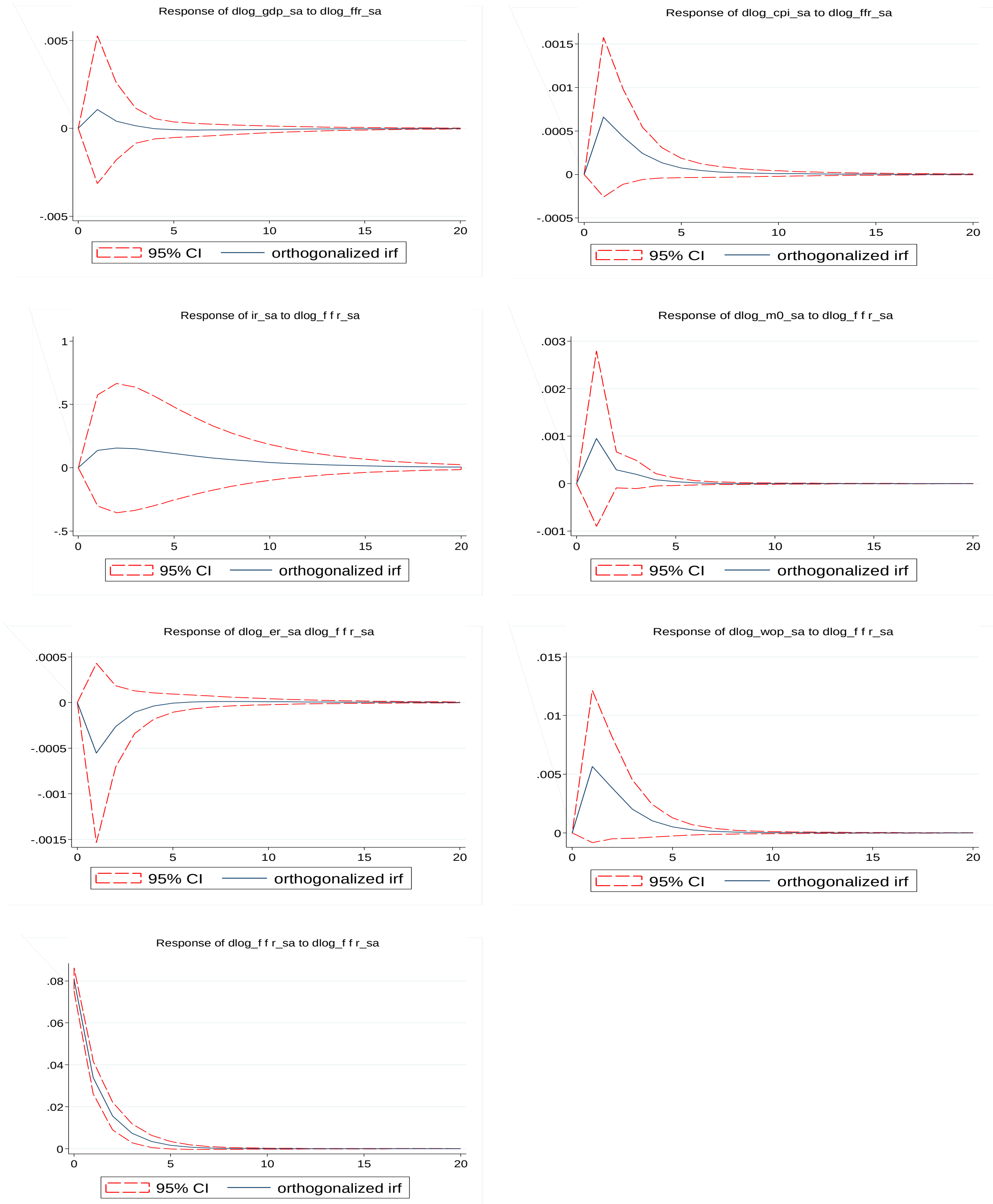
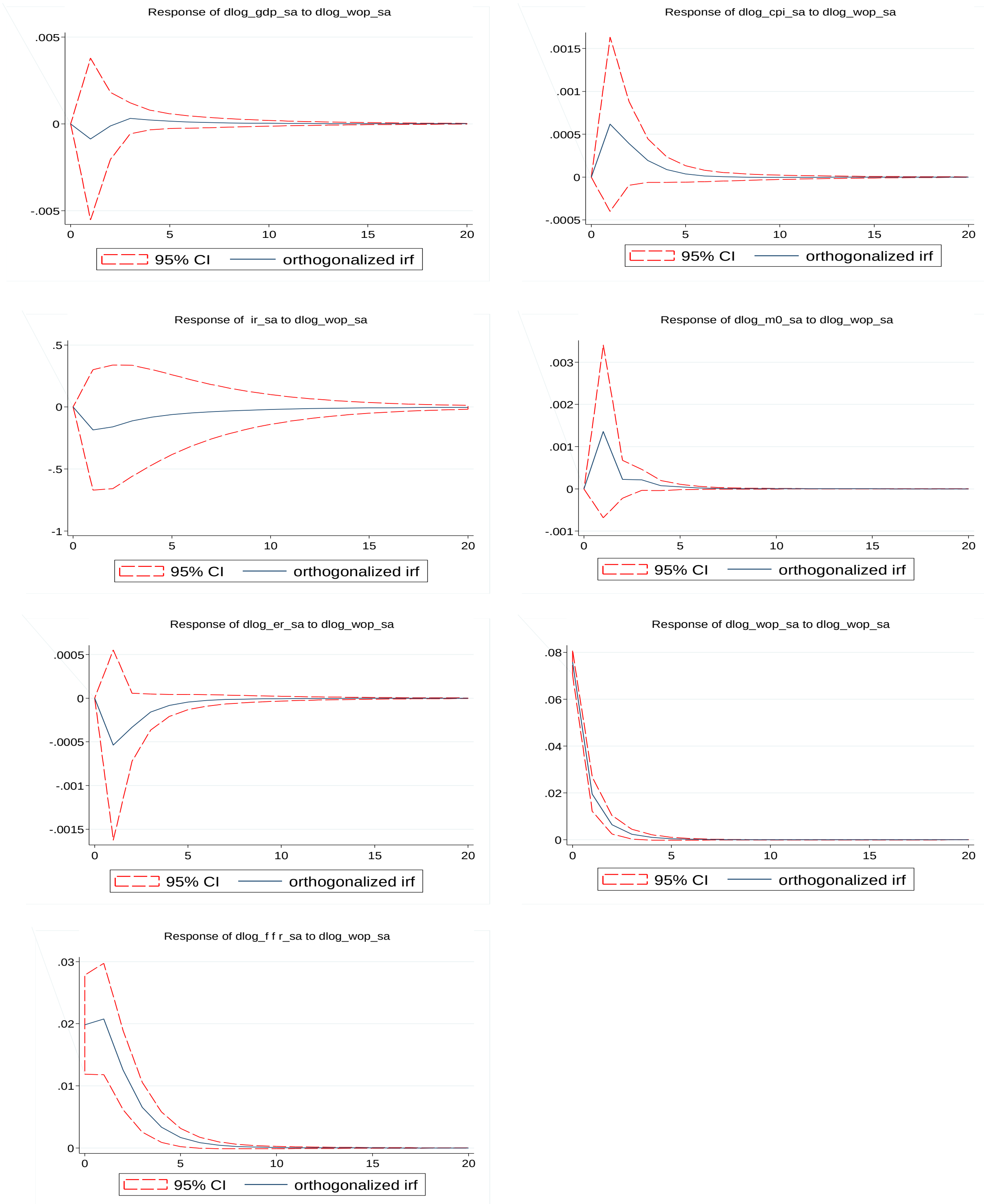


Figure 4.6: Impulse Responses of Domestic Variables to World Oil Price Shock



Using Kim and Roubini (2000) identification Restriction

Figure 4.7: Impulse Responses to a Positive Interest Rate Shocks: SVAR

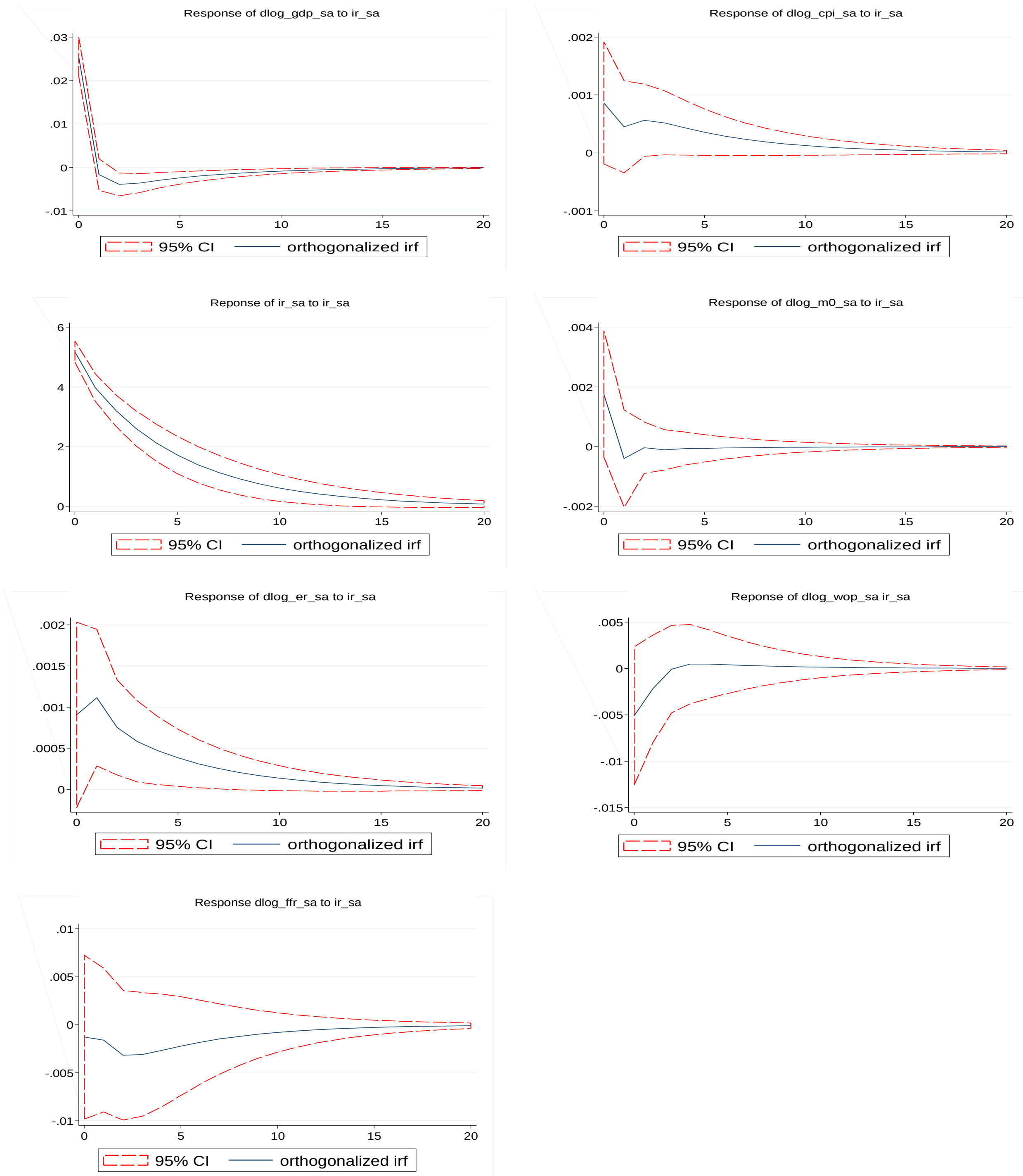


Figure 4.8: Impulse Responses to a Positive Money Growth Shocks (M1): SVAR

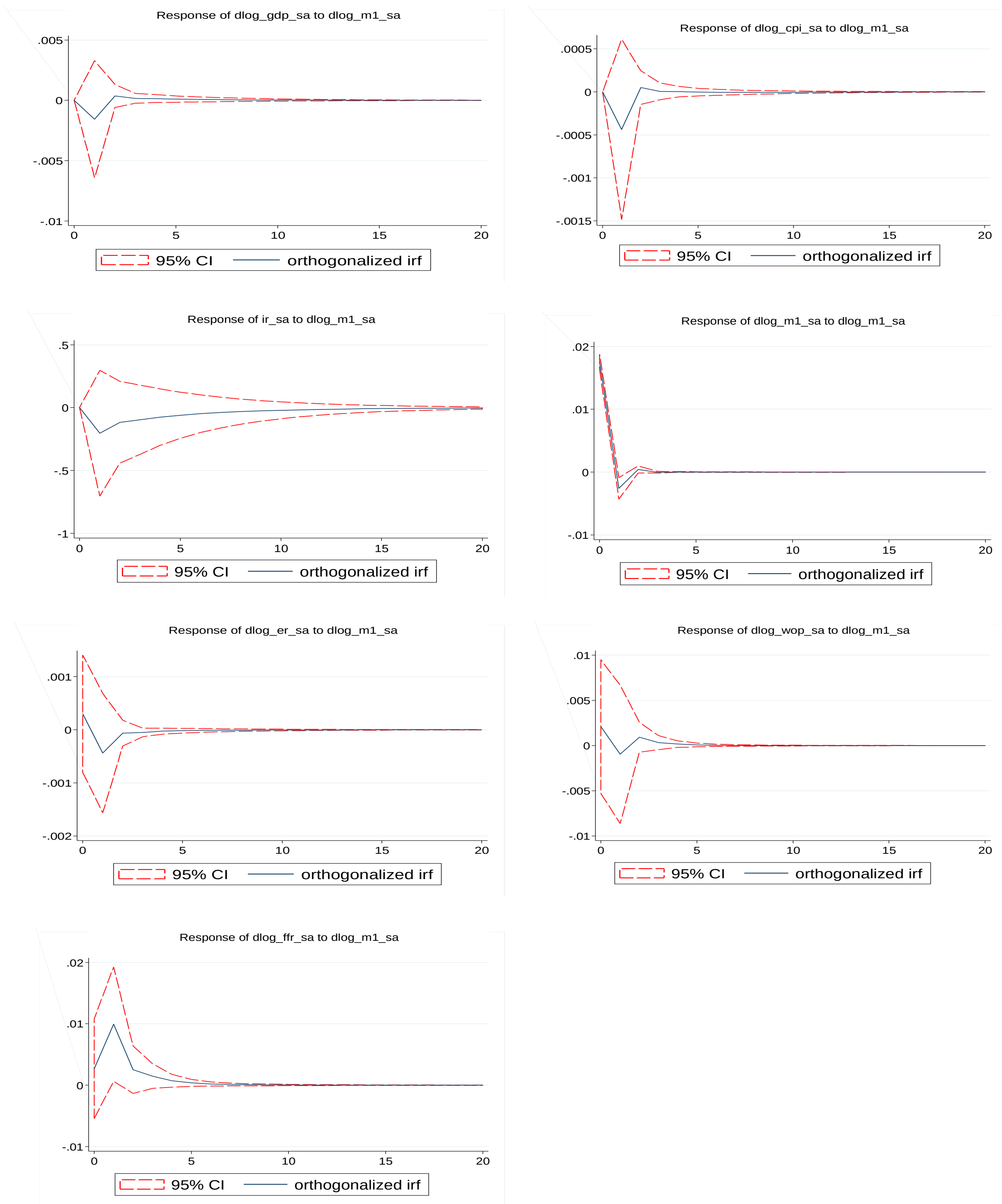


Figure 4.9: Impulse Responses to a Positive Interest Rate Shocks: Recursive VAR

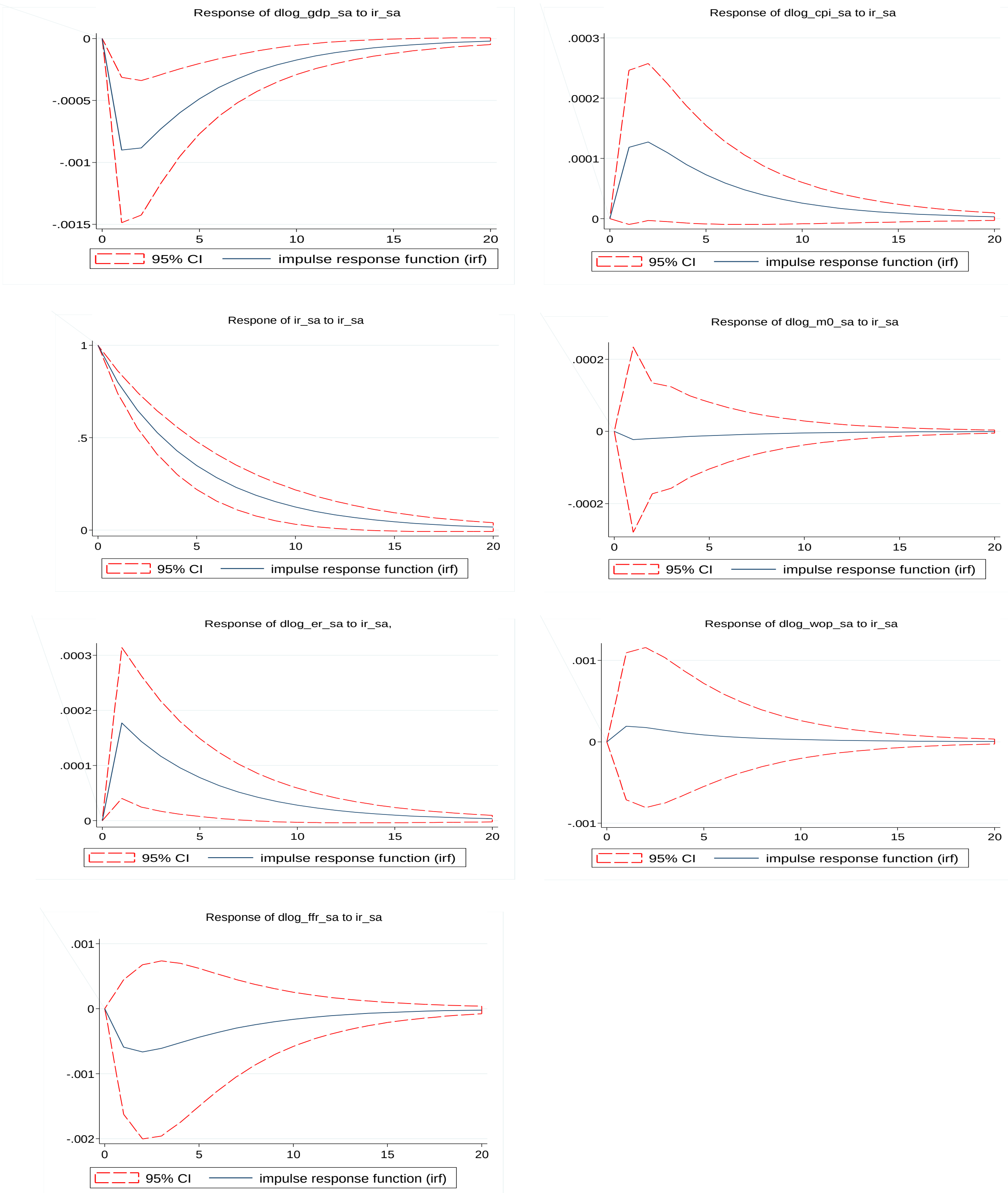


Figure 4.10: Impulse Responses to a Positive Exchange Rate Shocks: Recursive VAR

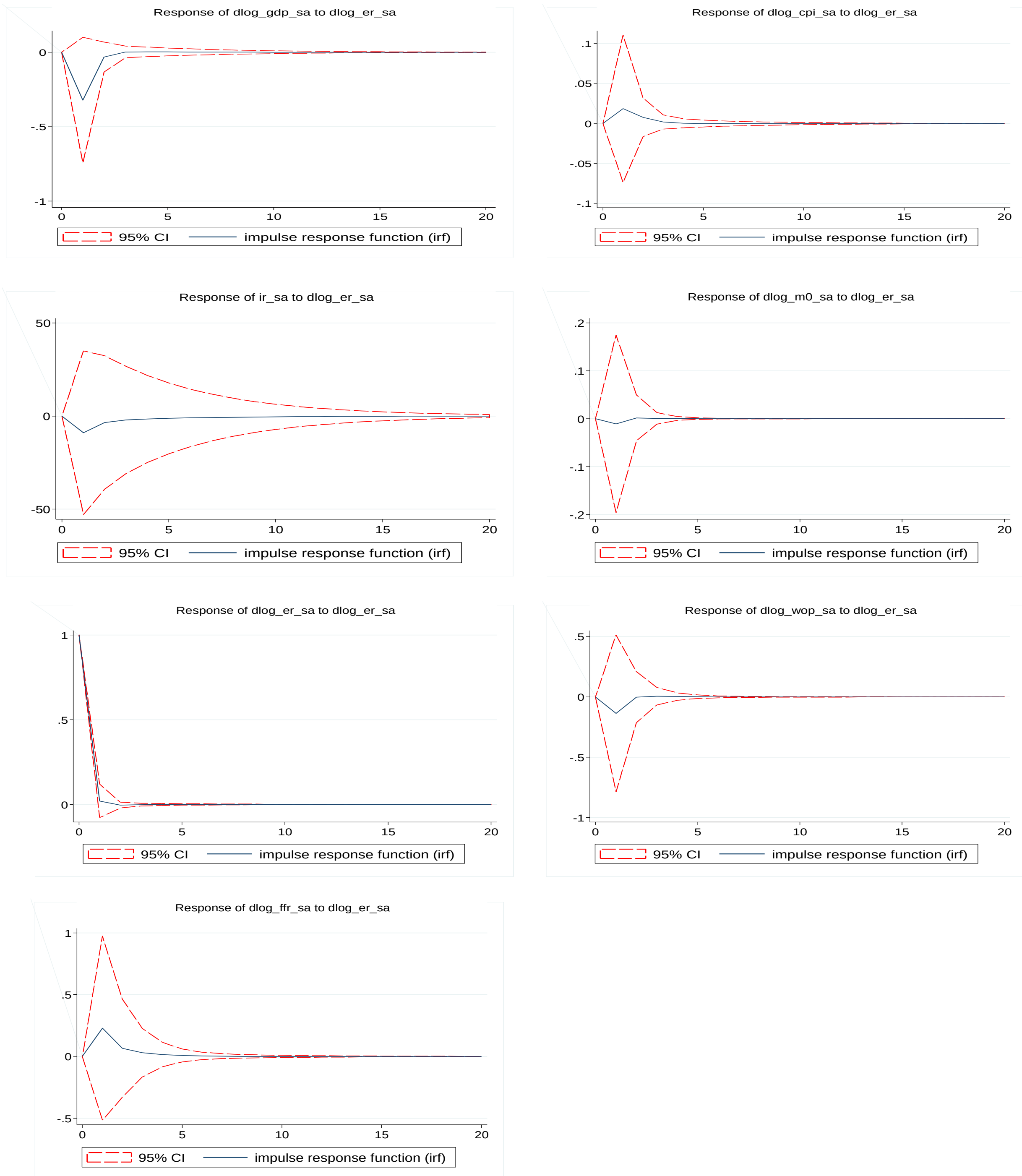
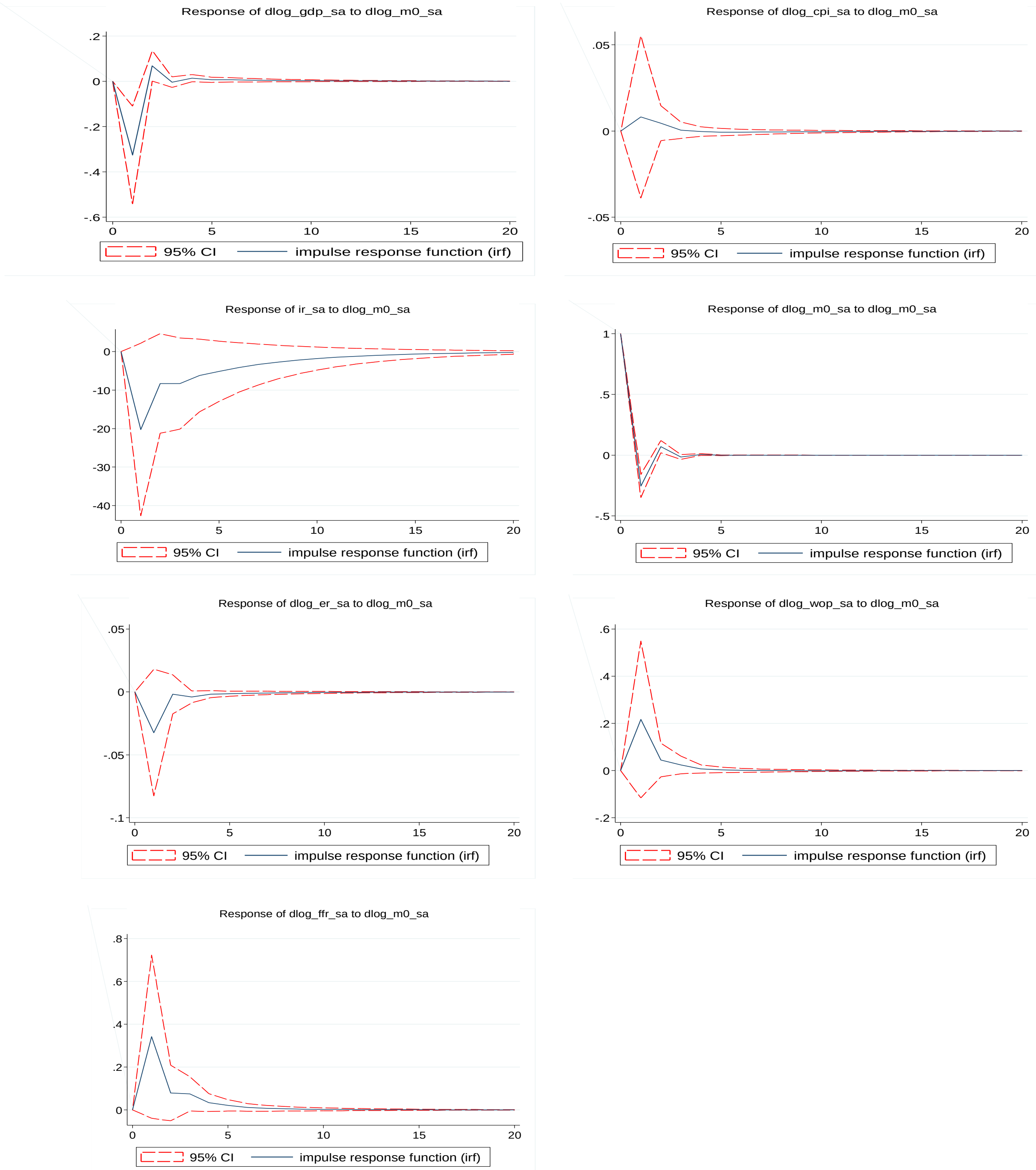


Figure 4.11: Impulse Responses to a Positive Money Shocks: Recursive VAR



Additional Appendix: Impulse Response Function using all Variables in Nominal Terms

Figure 4.12: Impulse Response to a Positive Interest Rate Shock: SVAR

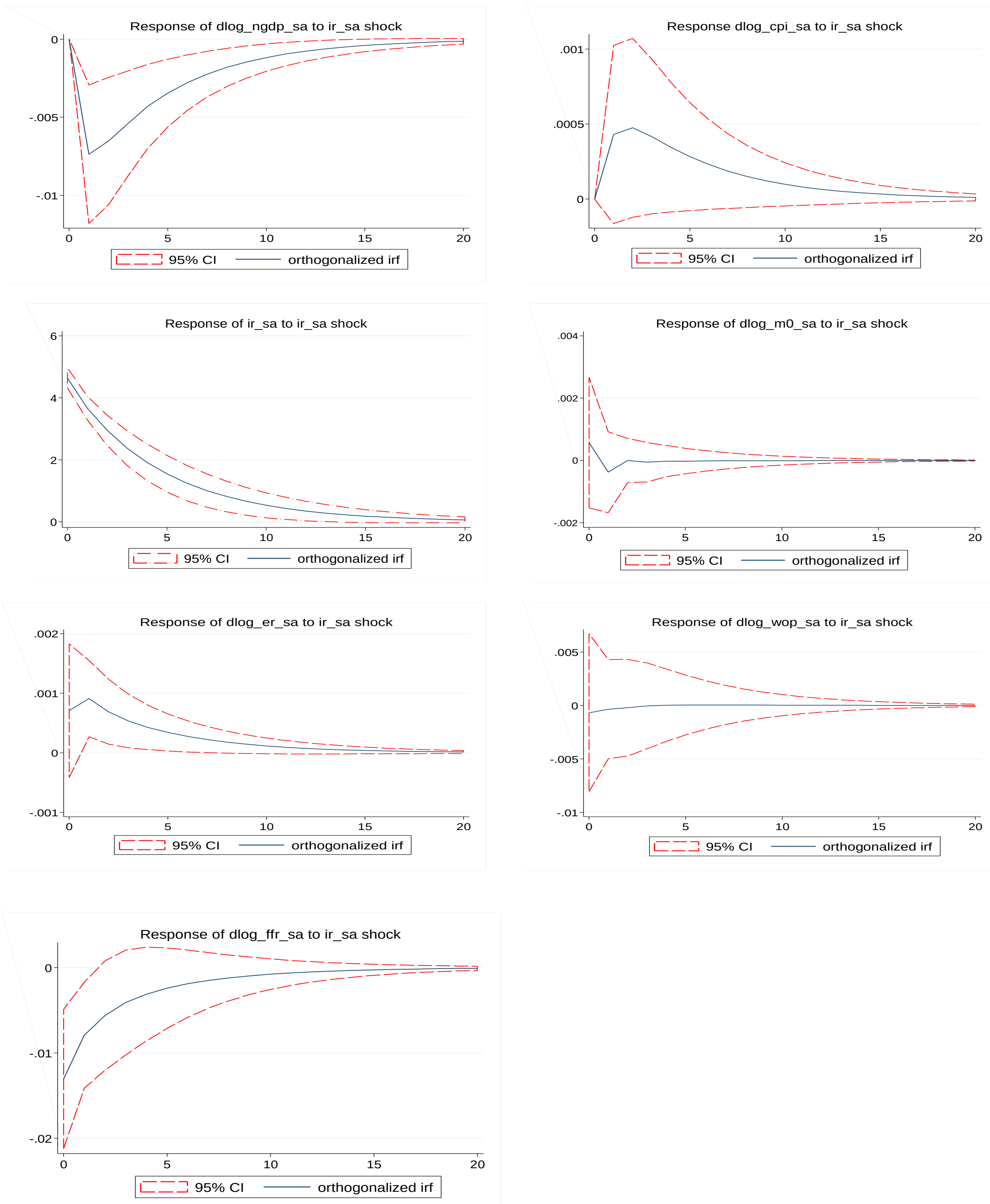


Figure 4.13: Impulse Response to a Positive Exchange Rate Shock: SVAR

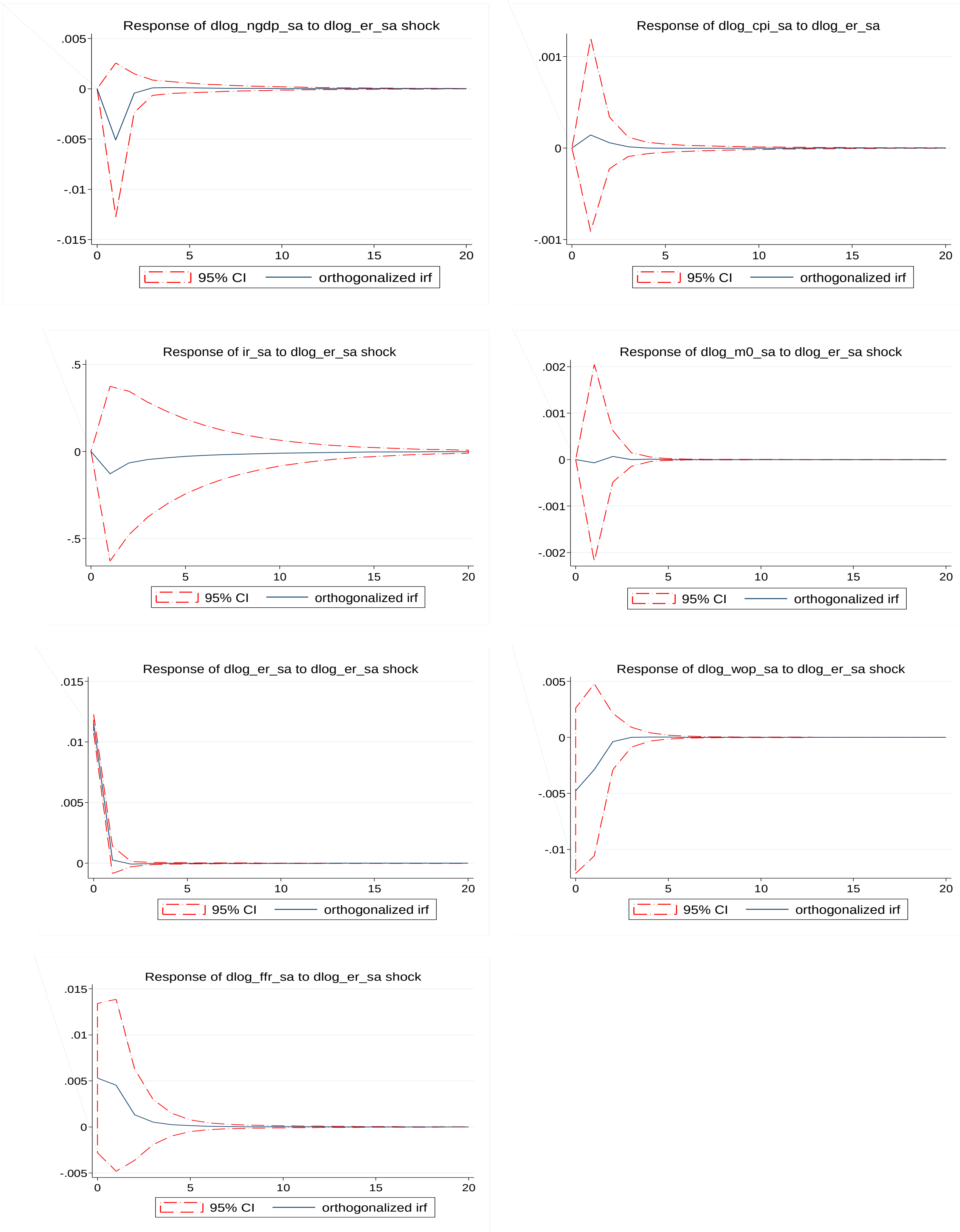


Figure 4.14: Impulse Response to a Positive Money (M0) Shock: SVAR