

# **ESSAYS ON FINANCIAL STABILITY IN EMEAP COUNTRIES**

Thesis submitted for the degree of

Doctor of Philosophy

At the University of Leicester

By

Hossein Sedghi Khorasgani

Department of Economics

University of Leicester

November 2011

## QUICK TABLE OF CONTENTS

Title.....	i
Quick table of contents.....	ii
Abstract.....	iii
Acknowledgements.....	vi
Table of Contents.....	vii
List of Tables.....	ix
List of Figures.....	ix
Introduction.....	1
Chapter 2: Exchnage rate volatility, financial imbalances and monetary policy...	12
Chapter 3: Financial system structure, banks' financial soundness and financial stability: Empirical evidence of some EMEAP members.....	41
Chapter 4: Stress-test of loan loss of banks in some members of the EMEAP.....	84
Chapter 5: Conclusion.....	121
Appendices.....	128
References.....	140

# ESSAYS ON FINANCIAL STABILITY IN EMEAP COUNTRIES

Hossein Sedghi Khorasgani

## **Abstract**

This thesis analyses financial stability in eight members<sup>1</sup> of the Executives' Meeting of East Asia-Pacific Central Banks (EMEAP) economies. One of the factors that may increase financial imbalances (and hence it affects financial stability of an economy) is the accumulated outstanding debt of the economic agents. For example, the corporate sector's outstanding debt can negatively affect activity of lenders and hence the capabilities of the economy. Since banks are important financial intermediaries in most financial systems, the financial status of banking sector is also important to analyse financial stability of a country. Macroeconomic conditions and financial system structure are some of the important factors that can affect financial conditions (financial soundness) of banks and hence the banking sector. Financial soundness of banks can secure the stability of the financial system. Chapter 2 shows that financial imbalances that arise from accumulated outstanding debt within the corporate sector have a negative effect on the technical capabilities (total factor productivity) of the economy. Therefore, monetary authority (central bank) should control over the debt level. To address this, chapter 2 focuses on the design of monetary policy rule for a small open economy in the context of a Dynamic Stochastic General Equilibrium (DSGE) model. This model is extended to show the effects of financial imbalances on the economy. Real exchange rate is another important factor that affects the firm's real marginal cost, aggregate supply and aggregate demand as discussed in this chapter. The derived optimal monetary policy rule indicates that the monetary authority responds to financial imbalances through output gap when financial imbalances exist due to accumulated outstanding debt. Moreover, the optimal policy rule shows that the response of the monetary authority to exchange rate movements is indirect, through the domestic inflation and output gap. Chapter 3 describes the effect of the financial system structure on financial stability through investigating the financial soundness of the banking sector. Bank financial soundness is the measure of the stability of the financial system and is defined by return on assets, equity capital-asset ratio and return volatility. The first two items increase financial soundness, whereas return volatility decreases financial soundness of a bank. The structure of the financial system is

---

<sup>1</sup> Hong Kong, Indonesia, South Korea, Japan, Malaysia, Philippines, Singapore and Thailand

described as market-based or bank-based. Given interrelations between financial sectors and between economies of the EMEAP countries, chapter 3 uses the global (infinite dimensional) vector autoregressive (VAR) model that has been proposed recently to estimate the generalised impulse responses of financial stability measure. Results show that the market-based financial system can increase financial stability through increasing financial soundness of the banking system. Chapter 4 uses nonperforming loans (NPLs) (as one of the main factors behind Asian financial crisis in 1997/8) to analyse financial soundness of banks. NPLs determine loans default rates that decreases banks' financial soundness. Chapter 4 tests the resistance of the banking system of the EMEAP countries to large macroeconomic shocks (stresses) in a stress-test framework, computing frequency distributions of default rates in three main macroeconomic scenarios (baseline model, stressed real GDP growth and stressed real interest rate). Default rate indicates the possible loss of banks and hence it is an indicator of credit risk which weakens banks' financial strength. The stress-test indicates that stressing real GDP growth with negative extreme shocks leads to an increase in frequency of higher default rates (in comparison with the baseline model), whereas positive shock to real interest rate may secure financial stability through increasing the frequency of lower default rates and decreasing frequency of higher default rate.

**Key words:** DSGE model; exchange rate; debt; financial stability; financial system structure; stress-test.

**To my wife, Tayebah  
and to my parents and in-laws**

## **Acknowledgements**

It is a great honour for me to have this opportunity to appreciate and acknowledge the contribution of people who have helped me to conduct my research and write this PhD thesis.

I would like to express my special appreciation to my thesis supervisors, Professor Wojciech Charemza and Dr. Dan Ladley for their support, advice and encouragement. I have benefited extensively from the discussions I have had with them.

I am indebted to the academic staff at the University of Leicester, Department of Economics, whose lectures I attended. They helped me greatly to maintain my study and do my research. My thanks also go to the other staff of the Department for their support and kind help.

I must acknowledge the Central Bank of Iran (CBI) for providing me with a scholarship for my PhD studies. The support of the staff of the Training and Human Resource Department at CBI is appreciated.

Last, but not least, I would like to express my gratitude to my wife for her love, support and constant encouragement. I am greatly indebted to my parents and in-laws for their endless support.

## Table of Contents

<b>CHAPTER 1: Introduction.....</b>	<b>1-11</b>
1.1. Motivation.....	2
1.2. Methodologies and contributions.....	7
1.3. Thesis outline.....	11
<b>CHAPTER 2: Exchange rate volatility, financial imbalances and monetary policy</b>	<b>12-38</b>
2.1. Introduction.....	13
2.2. The model .....	16
2.2.1. Households .....	16
2.2.2. Firms .....	21
2.2.3. Marginal cost .....	24
2.3. Dynamics of output and inflation, IS curve, financial imbalances and economy instability .....	25
2.4. Financial and economic imbalances and optimal monetary policy rule .....	30
2.5. Impulse Responses.....	33
2.6. Conclusion .....	38
<b>CHAPTER 3: Financial system structure, banks' financial soundness and financial stability: Empirical evidence of some EMEAP members .....</b>	<b>41-80</b>
3.1. Introduction.....	42
3.2. Financial structure and financial stability: Theoretical perspective.....	46
3.3. Interrelations between members of EMEAP .....	48
3.4. Empirical analysis.....	50
3.4.1. The Infinite dimensional VAR (IVAR) .....	50
3.4.2. Empirical model.....	52
3.5. Measurement.....	54
3.5.1. Data.....	57
3.5.1.1. Applying Kalman Filter technique to generate Z-score quarterly data.....	59
3.6. An overview of economic situations and the financial system structure of the countries .....	63
3.7. Estimating the dynamic responses .....	68
3.7.1. Model specification .....	68
3.8. Conclusion .....	81

<b>CHAPTER 4: Stress-test of loan loss of banks in some members of the EMEAP...</b>	<b>84-115</b>
4.1. Introduction.....	86
4.2. Tempered stable distribution.....	90
4.3. The empirical model .....	94
4.4. Estimation results.....	101
4.5. Stress-test framework.....	103
4.6. Simulation results.....	107
4.7. Conclusion .....	117
<b>Chapter 5: Conclusion.....</b>	<b>121-122</b>
5.1. Summary .....	122
5.2. Conclusions.....	123
<b>Appendices .....</b>	<b>128-132</b>
<b>Chapter A: Correlation Matrix, CD test and robustness check (for chapter 3).....</b>	<b>128</b>
3.1A. Principal components .....	129
3.2A. Pesaran's cross-section dependence (CD) test.....	130
3.3A. Estimating country-specific VARs without cross-section averages (or neighbouring effect).....	131
3.4A. Co- integration and impulse responses .....	132
<b>Chapter B: Estimation results and robustness check (for chapter 4) .....</b>	<b>135</b>
4.1B. Robustness check .....	138
4.2B. Common (neighbouring) effects among countries .....	138
<b>References .....</b>	<b>140</b>



## **List of Tables**

### **Chapter 3**

Table 3.1: Data description and sources.....	56
Table 3.2: Stock markets and banks activity.....	61
Table 3.3: Unit root test results.....	67
Table 3.4: Cross-section Dependence test.....	68
Table 3.5: The significance test of dominant effect.....	70

### **Chapter 4**

Table 4.1: Data description and sources.....	92
Table 4.2: Unit root test results .....	97
Table 4.3: Stress scenarios.....	101
Table 4.4: Simulated default rates.....	103
Table 4.5: The length of time that stress effects last.....	108
Table 4.6: VaR statistics of banks' loan loss.....	110

## **List of figures**

### **Chapter 2**

Figure 2.1: Impulse responses to outstanding debt shock.....	34
Figure 2.2: Impulse responses to a foreign output shock.....	35

### **Chapter 3**

Figure 3.1: Kalman filter inference for the Z-score.....	59
Figure 3.2: Generalised impulse response of financial stability to financial structure.....	75
Figure 3.3: Generalised impulse response of financial structure to financial stability.....	76
Figure 3.4: Generalised impulse response of financial stability to nominal interest rate.....	75

### **Chapter 4**

Figure 4.1: Frequency distributions of loan default rates.....	105
Figure 4.2: Comparison of VaR information with equity capital of banks.....	111

**CHAPTER 1: Introduction**

## **1.1. Motivation**

Financial instability and crisis can have a negative effect on the economy through decreasing economic growth and increasing unemployment. For example, the Asian financial crisis that originated from the financial collapse of the Thailand currency in 1997 led to an increase in unemployment, poverty and private debt (see for example, Lane, 1999, amongst others). This crisis was transmitted to other countries of the region of East and Southeast Asia and, most countries of the region, including Japan, suffered from the financial crisis. Bean (2004) also argues that financial instability that arises from the outstanding debt of borrowers negatively affects the economy through decreasing the capabilities of the economy. Hence, financial stability is a necessary factor for the economy's performance. Thus, this thesis addresses policy and factors that contribute to secure financial stability in the economy.

Despite the importance of stability in the financial system for the economy, there is no unique definition for financial stability and hence for its opposite concept, which is financial instability (or financial imbalances). Some definitions emphasise the effect of accumulated outstanding debt on financial stability. Since outstanding debt will result in reducing the accessibility to money (assuming that lenders do not lend indebted borrowers any more), it is considered one of the important measures of financial imbalances. For instance, Allen and Wood (2006) argue that

“If a household encounters financial pressures which mean that its access to money is sharply and unexpectedly reduced, so that it has to reduce its spending abruptly and by a large amount, then that could be described as a financial crisis, or an episode of financial instability, for that household” (Allen and Wood, 2006).

Schwartz (1986) offers a related definition: “a financial crisis is fuelled by fears that means of payment will be unobtainable at any price”.

Other authors emphasise financial soundness of main financial institutions such as banks as a necessary concept to define financial stability. For example, Crockett (1997) argues that “financial stability (refers) to the stability of the key institutions and markets that go to make up the financial system”. According to this definition, the stability of key financial institutions is important for financial stability of a country. Finally, Aspachs *et al.* (2007) propose that financial instability is “a combination of probability of default (PD) – variously measured – together with bank profitability”. Thus, Aspachs *et al.* (2007) argue that financial instability arise from both high PDs and low profitability.

According to above definitions, debt and banks’ financial soundness can be used to measure financial stability. From the Allen and Wood’s (2006) and Schwartz’s (1986) definitions of financial imbalances, outstanding debt can lead to decreasing the accessibility of economic agents to money; and hence financial pressures on the economic agents increase. Therefore, outstanding debt can be used to measure how the financial status of the economic agents is imbalanced (that is, financial imbalances). According to Aspachs *et al.*’s (2007) and Crockett’s (1997) approaches in defining financial stability, financial stability of an economy can be measured by financial soundness of important financial institutions. One of the key financial institutions is bank. A bank has financial soundness when it has high returns on assets and equity capital and low returns volatility (De Nicolo, 2000). De Nicolo (2000) implies that an increase in financial soundness of a bank decreases the probability of insolvency, and increases distance-to-default of the bank. Therefore,

when large and important financial institutions of the financial system such as banks are far from default, the stability of the financial system is secured. Thus, in this thesis, the level of financial (in)stability is measured by outstanding debt of borrowers and financial soundness of banks in three main chapters.

Since the definition of the financial stability has not been uniquely provided, there has not been a unique recommended policy for policy makers (such as monetary authority) to secure the financial stability. Chapter 2 investigates the effects of accumulated outstanding debt of firms (the measure of financial imbalances in this chapter) on the economy in a DSGE-type model to design a monetary policy to secure financial stability. This chapter extends a DSGE model to show how the financial imbalances affect the economy and the design of optimal monetary policy rule. Moreover, in this model, real exchange rate is shown to impact on firms' real marginal cost, the dynamics of output and inflation in a small open economy. The objective is to show how central bank should consider debt outstanding of firms in its optimal monetary policy rule under commitment.

Based on Aspachs *et al.*'s (2007) and Crockett's (1997) definitions, chapters 3 and 4 of this thesis analyse the financial stability using the financial soundness of banks in the banking system as a measure of financial stability of the economy. Banks lie at the heart of the financial and payment systems, especially in the developing economies. Assets, profitability and equity capital are the items that determine the financial soundness of a bank. If banks are not able to make profit and/or do not have enough capital to smooth the effect of shocks, they would be unable to meet financial obligations and manage risks and hence they lose financial soundness; and hence they may come close to insolvency. Insolvency of banks can be transmitted to

other parts of the financial system and thus destabilising the system. For example, when large shocks strike some banks, they may become insolvent and fail. If the effects of shocks are sufficiently large the default of the troubled banks is transmitted to other banks (through the interrelations between banks via different mechanisms such as the inter-bank market) and their creditors and hence the effects of shocks become contagious. This contagion effect can be very severe and cause the system to fail (see for example, Eisenberg and Noe, 2001; Gai and Kapadia, 2010; Kahn and Santos, 2010; Ladley, 2010). Financial soundness of banks, therefore, indicates the distance-to-default for banks and hence is important for financial stability studies (see, for example, Goodhart *et al.*, 2006; Tsomocos, 2003; Uhde and Heimeshoff, 2009).

Among financial factors that affect financial soundness of banks and hence financial stability of the system, the structure of the financial system is recognized as an important factor for the stability of the financial system and even for the economic growth (see for example, Demircug-kunt and Huzinga, 2000, among others). However, according to my knowledge, no studies have analysed explicitly the effects of a market-based structure of the financial system (or moving toward a market-based financial system) on banks financial soundness and hence financial stability of EMEAP countries. The objective of chapter 3, therefore, is to describe the effects of the financial system structure on the financial stability through investigating the financial soundness of the banking sector. Following De Nicolo (2000), the measure of bank's financial soundness in this chapter is the Z-score that is defined as the ratio of return on assets (ROA) and equity capital-asset ratio to the volatility of ROA. Bank profitability and high capital-asset ratio increase financial

soundness (or decrease probability of insolvency of a bank), while ROA volatility decreases the financial soundness (De Nicolo, 2000). The measure of the type of the financial structure is defined by the activity and size of the stock market in comparison with the activity of the banking sector. For example, if stock market capitalization and/or the value of total traded shares are greater than banks' loans, the financial system structure will be read as the market-based structure (Levine, 2002).

Macroeconomic deterioration is one of the causes of banks' failure (see Dovern *et al.*, 2010 and Gavin and Hausmann, 1995). Given this and the importance of the financial soundness of banks for the stability of the financial system, the public authorities may be interested in testing the resistance of the banking system against macroeconomic adverse shocks. Therefore, policy makers can identify vulnerability of the financial system to macroeconomic adverse shocks with this type of analysis. One of the methods to describe the effects of extreme shocks on the financial system is stress-testing which is discussed in chapter 4. The objective of chapter 4 is to indicate how resistant the banking systems of the countries are against macroeconomic extreme shocks (stresses) in a stress-test framework. For this, banks loans default rates are used as a proxy for banks' likely loan loss (and hence credit risk), and then responses of default rates to 'extreme but plausible' shocks (stresses) are analysed in three main macroeconomic scenarios (the baseline, stressed real GDP growth and stressed real interest rate scenarios) with computing probability distributions of default rates.

## 1.2. Methodologies and contributions

Chapter 2 is based on a DSGE model with households, firms and a monetary authority (central bank). Solving optimisation problems of economic agents in this model, chapter 2 derives optimal monetary policy rule that is affected by real exchange rate and accumulated debt of firms. This model is different from those proposed by Gali and Monacelli (2005), and Clarida, Gali and Gertler (2001) in terms of representation of the New-Keynesian Phillips curve. Moreover, chapter 2 focuses on the design of optimal monetary policy rule (unlike the literature where a rule of thumb is used for the policy instrument or nominal interest rate) for a small open economy. This optimal rule answers to the question of how the central bank should respond to financial imbalances under the policy rule to secure the stability in the economy. Finally, in order to contribute to an understanding of the dynamics of the variables and the effects of financial imbalances, using calibrated data from Gali and Monacelli (2005) and doing a stochastic simulation, an impulse response analysis is also provided in this chapter. With impulse responses, policy maker can track the effects of financial imbalances in subsequent time steps after the shock time.

Chapter 3 investigates the effect of moving towards a market-based financial system on financial stability through impacting on banks returns, capital-assets ratio and volatility of returns. These items determine financial soundness of banks. For this, with the assumptions of dominant economies in the region and common factors among economies, the global (infinite dimensional) VAR model that has been proposed by Pesaran *et al.* (2004) and Chudik and Pesaran (2009) is used with time series data from 1990 to 2007 for eight members of EMEAP economies. This model



has some advantages. First, it is able to capture the inter-relations between economies and hence is useful for economies that are interrelated. Second, constructing a panel VAR of the countries to study regional economy or the world economy restricts us to a modest number of endogenous variables because of the problems of dimensionality. This problem may result in omitting some important variables from the analysis. The global VAR model can solve the dimensionality problem.

There is a lack of studies on the relationship of the financial structure and financial stability for EMEAP countries. Allen's (2001) study is one of the first studies that investigate the relationship between financial structure and financial stability; however, he only describes the issue in the context of a crisis theory without estimating the effects of financial structure on financial stability with an econometric model. Ruiz-Porras (2009) also analyses the relationship between financial structure and financial instability (it is an international study), using time episodes of bank crisis as a proxy of financial crisis. In this way, the crisis data are a series of 0 and 1 (they obtain value 1 in crisis time and zero otherwise) that are used as a variable in these studies. In contrast, this thesis uses Z-score (see De Nicolo, 2000) to measure financial soundness of banks and hence as an indicator for financial stability in chapter 3. This indicator is defined by the items of banks' balance sheet (that is, the ratio of banks' returns on assets and equity capital-asset ratio to the volatility of the return). It then yields a continual time series unlike the time episodes of the crisis. Thus, this thesis attempts to shed a new light on the effects of the financial structure on financial stability by using the Z-score (as an indicator of financial stability) to analysis financial stability.

Chapter 4 analyses the resistance of the banking systems of the countries against predefined macroeconomic extreme shocks. By estimating VAR models based on the global VAR model over the time series of EMEAP countries, from 2000 to 2008, probability distributions of banks loan default rates (as a proxy for banks loss) are simulated under the baseline, stressed real GDP and stressed real interest rate scenarios for up to four periods ahead after 2008. The simulation in this chapter is a stochastic simulation. In the stochastic simulation, unlike the deterministic simulation, the probability of occurring each scenario and hence the probability of each response of the simulated variable are determined. This would be more meaningful in the forecast of the behaviour of a variable in the future. In contrast, this is not a subject in deterministic approach where one has to imagine a single way for the evolution of a variable in the future. In the stochastic simulation one has to deal with disturbances by assuming that disturbances are generated by a statistical distribution. In this chapter, unlike some empirical studies where disturbances are assumed to be Gaussian, a Tempered Stable (TS) distribution is used to generate the distribution of disturbances. TS distributions have fatter tails than normal distributions and hence can capture tail events (or extreme events) of variables since fat tails are observed in some macroeconomic data, especially financial variables.

Since financial stability can be secured if the financial system, especially banking sector, is robust to extreme shocks, public authorities need to analyse all possible responses of the system to probable extreme shocks. This contributes to analyse the strength of the system. This might be analytically a hard work to forecast the behaviour of the system in the future. Stochastic simulation in the context of stress testing is a useful tool to solve the problem. Therefore, simulation can be used for

tackling problems that are not analytically solvable. Moreover, simulation enables one to analyse a system under a lot of conditions (or scenarios). Hence, instead of the ‘best estimate’ approach, one may construct different scenarios to analyse a system under a specific hypothetical condition. In the stress-testing part of this thesis (chapter 4), testing the robustness of the banking system to proposed stresses is undertaken through a simulation. In this method, the probability distribution of the variable under study (loan default rate) is generated and different possible responses of default rate to a stress are computed. This is a probabilistic approach to stress testing that yields impulse responses where the probability of each response occurring is determined.

Chapters 3 and 4, as well as a section of chapter 2, are based on impulse response analysis where impulse responses are used to analyse financial stability. Impulse response function (IRF) is widely used in macroeconomics to describe how the economy reacts to impulses or shocks. In general, impulse response refers to the reaction of a dynamic system to some shocks. Using impulse response functions enables one to describe the effects of a particular shock on a variable (especially macroeconomic variables) at the time of shock and subsequent time steps after it. Therefore, it is a useful tool to track the impact of the changes to a variable on others in a system of economic equations, and to investigate the length of time that the effects of a particular shock last, after the shock occurs. IRF controls the impact of correlation between residuals. In the context of the vector autoregressive (VAR) model, there is contemporaneous shock dependence. The orthogonalizing approach can control the impact of correlation among residuals. However, there is not a unique impulse response since the approach depends on the ordering of variables. In this

thesis, to resolve the ordering problem, generalised impulse response function (GIRF) that has been developed by Koop *et al.* (1996), is used (which is discussed further in chapter 3). Instead of controlling the impact of correlation between residuals, GIRF allows for the varying of other variables when one variable is shocked. In fact, GIRF integrates all other contemporaneous and future shocks. Hence, the impulse responses are not dependent on the order of variables in the model.

### **1.3. Thesis outline**

The rest of this thesis is organised as follows: chapter 2 investigates the effect of financial imbalances (originating from the corporate sector of a small open economy) on optimal monetary policy of the monetary authority. The new optimal policy rule is presented in section 2.4 of this chapter. Chapter 3 investigates financial stability in the financial sector through analysing the financial soundness of banks in the banking sector. This chapter estimates the impact of financial system structure on banks' financial soundness and hence financial stability for eight members of the EMEAP economies. Generalised impulse responses are discussed in section 3.7 of this chapter. Chapter 4 investigates the impulse responses of banks' financial soundness to macroeconomic stresses in the context of a stress-test framework. In this chapter, banks' loan default rate is the measure of likely loan loss of banks (and hence it determines banks financial soundness). Section 4.6 in this chapter provides the results of a simulation and forecast of loan default rates for the same countries as in chapter 3. Finally, chapter 5 concludes the thesis. Appendices provide information about econometric tests, correlation matrices and robustness checks for chapters 3 and 4.

## **CHAPTER 2: Exchange rate volatility, financial imbalances and monetary policy**

## 2.1. Introduction

It is recognised by academics and policy makers that bad financial status (for example, inability to meet financial obligations) of the economic agents such as households and firms can lead to financial instability and even financial crisis. For instance, when borrowers do not repay loans, this negatively affects lenders' balance sheet and hence they may encounter financial pressures. Allen and Wood (2006) and Schwartz (1986) argue that this financial pressure fuels financial instability and hence they use it to define financial instability. Financial instability can also be transmitted to the real sector of the economy. For example, suppose that firms that borrow money to accumulate capital or inputs of production do not repay loans on time and accumulate debt. This accumulated outstanding debt of firms can then lead to deterioration in the lenders' balance sheet, which in turn prompts them to stop lending. In such a situation, firms may face financial problems because their access to money has decreased and, this can then negatively affect the production of firms (Bean, 2004).

A precise answer is lacking to how a monetary authority (or central bank) should respond to financial imbalances among the economic agents. This chapter therefore, uses a small open economy DSGE-type model akin to Gali and Monacelli (2005) and Divino (2009), to design an optimal monetary policy rule for a small open economy, considering the financial imbalances of the economic agents. Gali and Monacelli (2005) investigate the effect of volatility of real exchange rate on the dynamics of aggregate supply and aggregate demand in a small open economy where openness of the economy affects only the coefficients of new Keynesian Phillips curve and aggregate demand function. Then, they use an ad-hoc policy rule for the

nominal interest rate to analyse the effect of domestic and foreign shocks on the economy. Unlike Galli and Monacelli's study where the optimal rule has been constructed under some simplifying assumptions which render an ad-hoc model, this chapter focuses on the design of an optimal monetary policy rule for a small open economy through constructing a DSGE model and solving optimization problems of economic agents in the model. In addition, the new policy rule in this chapter shows how the central bank should respond to financial imbalances with the policy instrument to secure stability in the economy. Besides, in a small open economy, exchange rates (as a financial asset price) play a significant role in determining terms of trade, inflation and even output gap. This study also answers to the question of how monetary authority should respond to exchange rate movements since, in this chapter, real exchange rate is shown that it also affects debt rising and capital formation of firms. In this study, financial imbalances originate from firms' debt accumulation. Firms accumulate debt through borrowing from households to finance capital accumulation. Debt outstanding may cause lenders to stop lending, decreases the access of firms to money, and hence financial imbalances may arise. Thus, in this context, debt is a proxy for financial imbalances. This study assumes that financial imbalances are transmitted to the economy through the total factor productivity in the production function. More precisely, financial imbalances decrease total factor productivity (negatively affects technical capabilities of the economy) and hence output. Besides the central bank, there are two other economic agents: households and firms. The representative household seeks to maximise its utility function. The staggered price setting, following Calvo (1983), is used by firms to maximise their profit function.

This study also considers a special class of asset price, namely the exchange rate channel, in the model. The fluctuation of the exchange rate might be important for the stability of national economy and output. For example, the higher the exchange rates that is, the exchange rate depreciation, the higher the devaluation, meaning more expensive imports and increasing Consumer Price Index (CPI). In this chapter, firms' real marginal cost positively responds to real exchange rate and also to outstanding debt, given that firms borrow entirely from households to finance capital (or production inputs).

The model is akin to that of Gali and Monacelli (2005). However, in canonical representation, the present model is different from that proposed by Clarida, Gali and Gertler (2001) and Gali and Monacelli (2005) in terms of the New-Keynesian Phillips curve. Svensson (2000), Taylor (2001), Benigno (2004) and Devereux (2004) are some recent studies about the role of exchange rate and its channels in the transmission of the monetary policy. This study nevertheless contributes to the literature by adding a financial stability issue to the model. Moreover, this study uses calibration data from Gali and Monacelli (2005) to demonstrate a quantitative analysis of the model under the derived optimal monetary policy rule.

The remainder of this chapter is organised as follows. Section 2.2 focuses on the structure of the economy model which consists of the household section of the model, production section and profit maximisation behaviour of firms. Section 2.3 displays dynamics of inflation, output, the IS curve, financial imbalances and the stability of the economy. Section 2.4 describes financial imbalances and optimal monetary policy, and derives the optimal policy rule considering the financial imbalances. Section 2.5 indicates the impulse response analysis which is a



quantitative analysis of the model and section 2.6 presents the summary and conclusions reached after analysing all the information.

## 2.2. The model

The model is a small open economy which is related to the rest of the world by a foreign country. The economy is inhabited by infinity-lived households and firms who form consumer-producer agents. Here, it is assumed that households consume both home produced and foreign produced goods. The amount of consumption of goods is determined by the degree of openness of the economy. Households also supply labour to firms. Firms use labour and capital (inputs) to produce domestic good and borrow from households to finance the capital that is needed for production. It is assumed that debt lasts one period and capital has been installed in advance. Variables of the foreign country are pointed by *star*.  $P_{f,t}$  and  $C_{f,t}$  denotes the domestic price and the domestic consumption of the foreign country produced good.

### 2.2.1. Households

There are two classes of consumptions. Consumption index ( $C$ ), therefore, is a composite of consumption of home produced and foreign produced goods which is defined by

$$C_t = [(1 - \alpha)^{\frac{1}{\varphi}} C_{h,t}^{\frac{\varphi-1}{\varphi}} + \alpha^{\frac{1}{\varphi}} C_{f,t}^{\frac{\varphi-1}{\varphi}}]^{\frac{\varphi}{\varphi-1}} \quad (1)$$

where,  $\varphi$  is positive and defined as the elasticity of substitution between home and foreign country goods and  $\alpha$  denotes degree of openness of the economy . According to Dixit and Stiglitz (1977), CES aggregator is used to indicate consumption sub

indices. Therefore,  $C_{h,t} = [\int_0^1 C_{h,t}^{\frac{\varepsilon-1}{\varepsilon}}(j) dj]^{\frac{\varepsilon}{\varepsilon-1}}$  denotes domestic consumption of home-produced good and  $C_{f,t} = [\int_0^1 C_{f,t}^{\frac{\varepsilon-1}{\varepsilon}}(j) dj]^{\frac{\varepsilon}{\varepsilon-1}}$  denotes domestic consumption of the foreign country produced good, where  $\varepsilon > 1$  is the elasticity of substitution across goods in a country.

The representative household seeks to maximize the utility function:

$$\text{Max } E_t \sum_{k=0}^{\infty} \beta^k \left[ U \left( C_{t+k}, \frac{M_{t+k}}{P_{t+k}} \right) - \frac{(N_{t+k})^{1+\delta}}{1+\delta} \right] \quad (2)$$

$$\text{where } U \left( C_{t+k}, \frac{M_{t+k}}{P_{t+k}} \right) = \frac{C_{t+k}^{1-\sigma}}{1-\sigma} + \left( \frac{\chi \left( \frac{M_{t+k}}{P_{t+k}} \right)^{1-\gamma}}{1-\gamma} \right)$$

$C_t$  is the composite consumption index.  $N_t$  denotes labour supply of household,  $M_t$  is money balance of household and  $P_t$  denotes Consumer Price Index (CPI)<sup>2</sup>. Wages are flexible and it is assumed that wages are identical for all workers. In addition, workers work the same number of hours. Moreover,  $\sigma$ ,  $\delta$ ,  $\chi$  and  $\gamma$  are greater than zero and  $\beta \in [0,1]$ .  $\sigma$  denotes the inverse of elasticity of intertemporal substitution in consumptions.  $\delta$  represents the inverse of elasticity of labour supply.  $\chi$  determines utility of money balances.

The household's budget constraint is:

$$P_t C_t + V_{t,1} F_t + M_t + \vartheta_t V_{t,1}^* F_t^* \leq W_t N_t + \Pi_t + F_{t-1} + M_{t-1}(1 + R_{t-1}^d) + \vartheta_t F_{t-1}^* + T_t \quad (3)$$

where  $F_t$  denotes home country financial assets such as bond.  $F_t^*$  is corresponding foreign country financial assets and  $\vartheta_t$  is the nominal exchange rate.  $W_t$  denotes wage paid to the labour and  $V_{t,1}$  can be read as the period price of financial assets

---

<sup>2</sup> It is standard to have real money balance in the utility of household as a shortcut to getting money valued in equilibrium. Therefore, it is assumed that household gain utility from holding money. This utility approximates benefits from using money in transactions.

such as the price of one-period domestic bond. It is formally assumed that  $V_{t,1} = \frac{1}{R_t}$  where  $1 + R_t = 1 + i_t$ .  $M_t$  denotes money balances of household that may be lent to firms and  $R_t^d$  is the real interest rate on loans.  $T_t$  is total lump-sum transfer from the government,  $\Pi_t$  are total profits from the ownership shares of the firm.

From optimal allocation of income within each category of goods the demand functions can be written as  $C_{h,t}(j) = (\frac{P_{h,t}(j)}{P_{h,t}})^{-\varepsilon} C_{h,t}$  and  $C_{f,t}(j) = (\frac{P_{f,t}(j)}{P_{f,t}})^{-\varepsilon} C_{f,t}$  where, according to Dixit and Stiglitz (1977),  $P_{h,t} = [\int_0^1 P_{h,t}^{1-\varepsilon}(j) dj]^{\frac{1}{1-\varepsilon}}$  is the domestic price of home produced good i.e producer price index (PPI) and  $P_{f,t} = [\int_0^1 P_{f,t}^{1-\varepsilon}(j) dj]^{\frac{1}{1-\varepsilon}}$  is the home price of foreign produced good. Thus, consumer price index (CPI) can be defined similar to total home consumption as  $P_t = [(1 - \alpha)P_{h,t}^{1-\varphi} + \alpha P_{f,t}^{1-\varphi}]^{\frac{1}{1-\varphi}}$ .

Using the standard Bellman equation for maximization of household's utility function subject to the budget constraint after taking expectation conditional on information of period  $t$  yields the following first order conditions:

$$V_{t,1} = \beta \left( \frac{C_{t+1}^{-\sigma}}{C_t^{-\sigma}} \frac{P_t}{P_{t+1}} \right). \quad (4)$$

Equation (4) is the consumption Euler equation.

$$V_{t,1}^* \vartheta_t C_t^{-\sigma} = \beta (C_{t+1}^{-\sigma} \vartheta_{t+1} \frac{P_t}{P_{t+1}}) \quad (5)$$

This condition shows the relation between consumption and saving in one period foreign assets e.g. bond for a representative household decision making about consumption and saving.

$$\chi \left( \frac{M_t}{P_t} \right)^{-\gamma} + \beta \left( C_{t+1}^{-\sigma} \frac{P_t}{P_{t+1}} \right) (1 + R_t^d) = C_t^{-\sigma} \quad (6)$$

$$C_t^{-\sigma} \left( \frac{W_t}{P_t} \right) = N_t^\delta \quad (7)$$

Equation (6) is money demand equation and equation (7) indicates optimal labour supply of households. It is also assumed that the foreign country has the same Euler equation as the home country:

$$V_{t,1}^* = \beta \left( \frac{C_{t+1}^*}{C_t^*} \right)^{-\sigma} \left( \frac{P_t^*}{P_{t+1}^*} \right) \quad (8)$$

From the first order conditions and consumption Euler equations the relation between prices can be presented as  $V_{t,1}^* \frac{\vartheta_t}{\vartheta_{t+1}} = V_{t,1}$  in which after some simple manipulation the nominal exchange rate can be written in a log-linear form as:

$$e_t - E_t e_{t+1} = i_t^* - i_t + \zeta_t \quad (9)$$

where,  $e_t = \log(\vartheta_t)$  is (log of) nominal exchange rate,  $i_t \simeq \log(1 + i_t)$  is domestic nominal interest rate,  $i_t^*$  denotes foreign country nominal interest rate and  $\zeta_t$  is the risk premia.  $\zeta_t$  indicates any deviation from the Uncovered Interest Parity (UIP) condition. The well known assumption is that there is no arbitrage in international financial markets. Equation (9) or UIP, in fact, indicates the relation between exchange rate and interest rates differential in the small open economy and is an equilibrium condition in the model.

Different compositions of home and foreign country consumption over time lead to the swing of the real exchange rate. Therefore, real exchange rate may changes with the change in the price differentials (Divino, 2009). Therefore, one may define real exchange rate in a log linear version as:

$$q_t = e_t + P_t^* - P_t \quad (10)$$

where  $q_t$  is the real exchange rate,  $P_t^*$  denotes foreign country CPI and  $P_t$  is domestic CPI. From the Euler equations of both countries, equation (5) and the corresponding equation for the foreign country, under no arbitrage condition and after ignoring constant term which depends on the initial conditions, the relation between consumptions and real exchange rate, in log-linear version, can be written as the following equation<sup>3</sup>:

$$c_t = c_t^* + \frac{1}{\sigma} q_t \quad (11)$$

It shows that, for a given exchange rate, the difference between home country consumption ( $c_t$ ) and its foreign counterpart ( $c_t^*$ ) changes according to elasticity of inter-temporal substitution in consumption  $\frac{1}{\sigma}$ . It means that, given the real exchange rate, if elasticity of inter-temporal substitution in consumption is high, the consumption differential would be high.

To derive the relation between inflations and asset prices (exchange rates) I use the concept of *terms of trade* which is defined as  $S_t = \frac{P_{f,t}}{P_{h,t}}$ . From the CPI formula and its log-linear version one can write the dynamics of CPI as following equation

$$\begin{aligned} p_t &= (1 - \alpha)p_{h,t} + \alpha p_{f,t} \\ &= p_{h,t} + \alpha s_t \end{aligned} \quad (12)$$

where  $s_t = p_{f,t} - p_{h,t}$  denotes the log effective terms of trade.  $\alpha$  refers to the degree of openness of the economy. In fact, it reads the share of home consumption of foreign produced goods in home total consumption. Under the one price assumption in the model and no difference between CPI and domestic price level,  $s_t = e_t +$

---

<sup>3</sup> Chari, Kehoe and McGrattan (2002) and Gali and Monacelli (2005) discuss the assumptions and derivation of this relation in details.

$P_t^* - P_{h,t}$  and then  $e_t + P_t^* = s_t + P_{h,t}$ . Using this and from equation (10), the relation between real exchange rate and terms of trade can be derived as:

$$\begin{aligned} q_t &= s_t + p_{h,t} - p_t \\ &= (1 - \alpha) s_t \end{aligned} \tag{13}$$

Using the relationship between real exchange rate and terms of trade, equation (12) is rewritten (in logarithm) as  $p_t = p_{h,t} + \frac{\alpha}{1-\alpha} q_t$  and CPI inflation then might be derived as  $\pi_t = \pi_{h,t} + \frac{\alpha}{1-\alpha} \Delta q_t$ .  $\pi_t$  denotes CPI inflation and  $\pi_{h,t}$  is producer price index (PPI) inflation or domestic inflation.

### 2.2.2. Firms

Firm  $j$  combines labor and capital to produce differentiated good. The production technology is Cobb-Douglas:

$$Y_t(j) = A_t N_t^{1-\mu}(j) K_t^\mu(j) \tag{14}$$

Let the aggregate output be  $Y_t = [\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj]^{\frac{\varepsilon}{\varepsilon-1}}$  analogous to the definition of consumption index. Let also  $N_t = \int_0^1 N_t(j) dj$  and  $K_t = \int_0^1 K_t(j) dj$  one can then show that, as Galí and Monacelli (2005) discuss, the aggregate relation can be written in log linear form as:

$$y_t = a_t + (1 - \mu)n_t + \mu k_t \tag{15}$$

$a_t$  is total factor productivity,  $n_t$  is employment, and  $k_t$  is the capital stock at the start of the period. Following Bean (2004), I assume that firms borrow directly from households to finance capital and accumulate outstanding debt. This negatively impacts on total factor productivity and hence the factor productivity (in log-linear

version) is defined with the state of the technology and whether or not there is a considerable accumulated outstanding debt:

$$a_t = b_t - \rho_t^d [\bar{\omega}^d + \omega^d (d_t - E_{t-1} y_t)] \quad (16)$$

$b_t$  is log of shock to technology,  $d_t$  is (log) of debt outstanding. When accumulated outstanding debt is huge, it is quite possible that lender does not lend anymore, and a type of credit crunch occurs. Therefore, outstanding debt creates financial imbalances.  $\rho_t^d$  will obtain value unity if debt accumulation is huge and it creates financial imbalances and zero otherwise. The expected output instead of current level of output is used in defining debt ratio. It is because of considering the output that has not been affected by outstanding debt of firms at period  $t$  (Bean, 2004). Although financial imbalances usually reflects a situation in financial markets, here the concept is used to show how debt accumulation and limited access to the money by firms after that may change the technical capabilities of the economy through impacting on total factor productivity and hence real marginal cost of firms. Thus, the effect of debt accumulation is to lower the level of supply in the economy. One rationalization is that debt accumulation and likely associated credit crunch limit the access of firms to working capital within the period in order to pay workers and buy inputs. Hence, supply would decrease.

After minimizing the total cost of firms, demand for capital is determined by following equation:

$$E_t k_{t+1} = E_t w_{t+1} - E_t p_{h,t+1} + E_t n_{t+1} - r_t^d \quad (17)$$

where  $w_t$  is (log of) the nominal wage,  $p_{h,t}$  is (log of) the price of home produced goods and  $r_t^d$  is the real rate of return on debt. With the relationship between

employment and output (equation (15)), equation (17) shows that capital requirement is conditional on the expected future output. Outstanding debt (the interest on debt from previous period) restricts firms to demand capital. That is, the higher debt, the lower capability of firms to demand capital.

For goods market clearing, the aggregate output must be equal to aggregate demand. Therefore, the following equality can be considered

$$Y_t(j) = C_{h,t}(j) + C_{h,t}^*(j) \quad (18)$$

It is assumed that the open economy does not affect on foreign country. Therefore,  $C_t^* = C_{f,t}^*$  (that is, total consumption of the foreign country is the consumption of the foreign country produced goods in the foreign country) and  $P_t^* = P_{f,t}^*$  (that is, producer price index of the foreign country is identical to the the price of foreign country produced goods in the foreign country). Then, from  $C_t = \kappa C_t^* Q_t^{\frac{1}{\sigma}}$  which is before-log version of equation (11) with constant, the definitions of  $C_{h,t}(j)$  and  $C_{h,t}^*(j)$  and corresponding definitions for the foreign country, the definition of real exchange rate, and the index for aggregate output, the relationship between outputs (in log-linear form) can be written as<sup>4</sup>:

$$y_t = y_t^* + \frac{1}{\sigma}(\psi s_t) \quad (19)$$

where,  $\psi = 1 + \alpha(2 - \alpha)(\sigma\varphi - 1)$  which is positive when it is assumed that  $\sigma\varphi \geq 1$ .  $y_t$  is domestic output and  $y_t^*$  denotes (log) foreign country output. Equation (19) indicates that output differential depends on terms of trade. Elasticity of inter-

---

<sup>4</sup> Using the mentioned assumptions along with a condition for a balances steady state trade balance in the small open economy (or  $\frac{\alpha^*}{\kappa} = \alpha$ ) that explain in details in Galí and Monacelli(2000,2005) and used by Divino(2009), one may rewrite equation (18) as  $Y_t = \kappa Y_t^* S_t^\varphi [(1 - \alpha)Q_t^{\frac{1}{\sigma} - \varphi} + \alpha]$ . Log-linearizing this equation after omitting the constant term yields equation (19).



temporal substitution in consumption and degree of openness determine the sensitivity of the output differential to terms of trade. In fact, when terms of trade increases output differential between two countries increases, given that  $\psi$  is positive.

From the equilibrium condition for foreign country ( $y_t^* = c_t^*$ ) and equations (11), (13) and (19), the following relationship can be derived for log of domestic consumption:

$$c_t = \omega y_t + (1 - \omega)y_t^* \quad (20)$$

where,  $\omega = \frac{1-\alpha}{\psi}$  and  $0 < \omega \leq 1$  which implies  $\sigma\varphi$  is equal to or greater than 1.

### 2.2.3. Marginal cost

The real marginal cost of the technology,  $m_t$  (in logarithm), which is used by firms is given by:

$$m_t = w_t - p_{h,t} + n_t - y_t \quad (21)$$

Equation (7), the optimal condition of labour supply of household, in log linear version yields

$$w_t - p_t = \delta n_t + \sigma c_t \quad (22)$$

where  $\delta$  is wage elasticity of labour supply. Using equations (20), (21), (22) and the relation between CPI and domestic prices, the real marginal cost of the firm can be rewritten as:

$$m_t = \left(\frac{\delta+\mu}{1-\mu} + \sigma\omega\right)y_t + \sigma(1-\omega)y_t^* - \left(\frac{1+\delta}{1-\mu}\right)(a_t + \mu k_t) + \left(\frac{\alpha}{1-\alpha}\right)q_t \quad (23)$$

Equation (23) shows that in addition to outputs, domestic productivity and capital, real exchange rate also impacts directly on firms' real marginal cost. The increase in

real exchange rate leads to increase in imported inflation and CPI inflation and hence cost of inputs for firms increases. Debt accumulation and then likely credit crunch after that restrict firms to finance required capital (or production inputs) and hence total factor productivity falls. This leads in turn to the rise in real marginal cost. Wage elasticity of labour supply and share of capital in production technology impact on the relationship between factor productivity and real marginal cost. The higher share of capital in production would lead to higher debt ratio and hence higher real marginal cost. Finally, with a positive shock to aggregate demand, either foreign or domestic output, consumption of the domestic produced goods increases which in turns this affects labour and capital demand and hence firms real marginal cost.

### 2.3. Dynamics of output and inflation, IS curve and, financial imbalances

Equation (20) indicates that consumption depends on the weighted combination of domestic and foreign outputs. Using this equation and combining with Euler equation (4) in log linear form,  $c_t = E_t c_{t+1} - \frac{1}{\sigma} [i_t - E_t \pi_{t+1} - \rho]$ , and  $V_{t,1} = \frac{1}{R_t}$  and  $1 + R_t = 1 + i_t$  where  $R_t$  is the gross nominal interest rate, the dynamics of output can be written as:

$$y_t = E y_{t+1} - \frac{1}{\sigma_c} [i_t - E \pi_{h,t+1} - \rho] + (\psi - 1) E \Delta y_{t+1}^* \quad (24)$$

where  $\sigma_c = \frac{\sigma}{\psi}$  and  $\rho = -\log \beta$ . It is clear from the output equation that domestic output is sensitive to the degree of openness of the economy and fluctuation of the exchange rate because oscillation of the exchange rate can affect on imports, prices level and then interest rate. If the future change of the foreign output is positive, an increase in foreign aggregate demand leads to the increase in the domestic aggregate demand.

Firms are assumed to set prices according to staggered price setting of Calvo(1983). Therefore, following Calvo(1983), let  $(1-\theta)$  of firms set new prices each period. In fact,  $(1-\theta)$  is the probability that a firm resets its price in a given period. Hence, the price level follows the following relationship overtime:

$$p_{h,t} = \theta p_{h,t-1} + (1 - \theta)p_{h,t}^0 \quad (25)$$

where,  $p_{h,t}^0$  is a price setting rule (in log) which is used by the firm. In fact, it is the optimal rule that a typical firm follows to reset its prices to maximize the firms' value (Gali and Monacelli, 2005):

$$p_{h,t}^0 = \mu^p + (1 - \beta\theta) \sum_{k=0}^{\infty} (\beta\theta)^k E_t(m_{t+k}^n + p_{h,t}) \quad (26)$$

It shows that mark up and weighted average of current and expected future nominal marginal costs ( $m_t^n$ ) are determinants of the price setting rule. As Gali and Monacelli (2005) point out, in a flexible price setting where  $\theta \rightarrow 0$  the price setting rule (or mark up rule) can be read as  $p_{h,t}^0 = \mu^p + m_t^n + p_{h,t}$ . Let  $\mu_{t,t+k}^p = p_{h,t}^0 - m_{t+k}^n$  then after rearranging of equation (26) to derive the mark-up and then from equation (25) and (26) one can write the dynamics of inflation as:

$$\pi_{h,t} = \beta E_t \pi_{h,t+1} + \Omega \hat{m}_t \quad (27)$$

where  $\pi_{h,t} = p_{h,t} - p_{h,t-1}$ ,  $\Omega = \theta^{-1}(1 - \theta)(1 - \beta\theta)$  and  $\hat{m}_t$  is the deviation of real marginal cost from the marginal cost under fully flexible prices that is defined as  $\hat{m}_t = m_t - \bar{m}$ . Let  $x_t = y_t - \bar{y}_t$  defined as output gap where,  $\bar{y}_t$  is the output under fully flexible prices then  $\hat{m}_t$  can be derived as:

$$\hat{m}_t = \Phi x_t + \frac{\alpha}{1-\alpha} q_t \quad (28)$$

where  $\Phi = \frac{\delta + \mu}{1 - \mu} + \sigma\omega$ . Substituting (28) into (27) derives the new Keynesian Phillips curve or the supply curve which is affected by the real exchange rate directly<sup>5</sup>:

$$\pi_{h,t} = \beta E_t \pi_{h,t+1} + Mx_t + \Lambda q_t \quad (29)$$

where,  $M = \Omega\Phi$ , and  $\Lambda = \Omega \frac{\alpha}{1-\alpha}$ . Equation (29) is aggregate supply equation which is positively depends on the output gap and the real exchange rate as a financial asset price. Sensitivity of domestic inflation to the movements of output gap and real exchange rate depends on the degree of openness of the economy. The higher is the degree of openness, the greater is sensitivity of domestic inflation to the real exchange rate. Domestic inflation is also affected by the probability that firms reset their prices. If this probability increases it would increase the sensitivity of inflation to real exchange rate because price setting behaviour of firms depends on the nominal marginal cost which depends in turn on real exchange rate movement.

The IS curve can be derived from the equation (24) and definition of terms of trade in relation to the domestic and foreign output:

$$x_t = E_t x_{t+1} - \frac{1}{\sigma_c} [i_t - E_t \pi_{h,t+1} - \bar{r}_t] - \frac{\alpha}{(1-\alpha)\Phi} \Delta E_t q_{t+1} \quad (30)$$

$$\sigma_c = \frac{\sigma}{\psi}, \quad \bar{r}_t = \rho + \sigma_c z \Delta E_t y_{t+1}^* + \left( \frac{(1+\delta)\sigma_c}{(1-\mu)\Phi} \right) (\Delta E_t a_{t+1} + \mu \Delta E_t k_{t+1}) \quad \text{and}$$

$$z = \left( \frac{\Phi(\psi-1) - \sigma(1-\omega)}{\Phi} \right).$$

Equation (30) indicates that changes in expected future real exchange rate affect directly on output gap. If the change is positive, the current level of output gap falls because in such a situation imports increases and exports decreases at period  $t$ . This may mean that the aggregate demand for domestic output decreases. Natural interest

---

<sup>5</sup> The supply curve is similar as in Divino (2009).

rate also depends on the degree of openness and changes in the foreign country output. With  $\sigma\phi = \omega = 1$  and  $\alpha = 0$ , the output gap equation turns to the form of closed economy output gap. Finally, output gap depends inversely on deviation of real interest rate from the natural rate,  $\bar{r}_t$ . With existence of outstanding debt and hence financial imbalances at time  $t$  in the economy, the current level of natural interest rate and then output gap increases, given that the change of the future productivity is positive, whereas if the economy expects that financial imbalances occur at time  $t+1$ , the current level of natural interest rate<sup>6</sup> will fall and hence output gap decreases. Given that monetary authority knows that financial imbalances will occur in the next period, he may apply for contraction in the monetary policy which results in reduction in economic activities and hence the gap between output and its natural level decreases.

Let  $\hat{y}_t$  is technically feasible output target that the monetary authority looks for when domestic productivity is not affected by the financial imbalances (outstanding debt):

$$\hat{y}_t = v[b_t + \mu k_t] - \Gamma_1[\sigma(1 - \omega)y_t^* + \frac{\alpha}{1-\alpha}q_t] \quad (31)$$

where,  $v = \frac{(1+\delta)}{(1-\mu)\phi}$ ,  $\Gamma_1 = \frac{1}{\phi}$ . In a normal condition that there are no financial imbalances,  $\hat{y}_t$  and  $\bar{y}_t$  are identical. But when financial imbalances issue is taken into account, they would be different from each other. Therefore, in this condition, the policy maker would like to stabilize the economy by minimizing the output gap in

---

<sup>6</sup> According to Wicksell (1936), natural interest rate is a rate that does not affect commodity prices (or ‘it tends neither to raise nor to lower them’).

relation to gap between  $\bar{y}_t$  and  $\hat{y}_t$ . Let  $x_t^*$  be the output gap which is defined as  $x_t^* = y_t - \hat{y}_t$  then this can be written as<sup>7</sup>:

$$\begin{aligned}
 x_t^* &= (y_t - \bar{y}_t) + (\bar{y}_t - \hat{y}_t) \\
 &= x_t + v[a_t + \mu k_t] - \Gamma_1[\sigma(1 - \omega)y_t^* + \frac{\alpha}{1-\alpha}q_t] - v[b_t + \mu k_t] + \\
 &\quad \Gamma_1[\sigma(1 - \omega)y_t^* + \frac{\alpha}{1-\alpha}q_t] \\
 &= x_t - v\rho^d[\bar{\omega}^d + \omega^d(d_t - E_{t-1}y_t)]
 \end{aligned} \tag{32}$$

Equation (32) shows that debt ratio causes a difference between two output gaps. As already mentioned, firms borrow entirely from households to finance their capital requirements. Therefore, firms create debt to households and it can be defined as  $d_t = k_t + r_{t-1}^d + e_t^d$  which is principal plus the interest due and  $e_t^d$  captures shocks to the debt. Using capital demand equation and equation (12), the dynamics of outstanding debt can be rewritten as:

$$d_t = w_t - p_t + (\frac{\alpha}{1-\alpha})q_t + n_t + e_t^d \tag{33}$$

This equation suggests that creating debt by firms depends on real wages and real exchange rate. Equation (32) implies the output cost of debt accumulation and associated financial imbalances. It also shows that real exchange rate also impacts on financial imbalances in the model. The rise of real exchange rate will increase the output cost through the increase in firms real marginal cost and debt accumulation and hence possibility of occurring credit crunch. This leads to weakening the technical capabilities of the economy.

---

<sup>7</sup> The analogues discussion is in Bean (2004).

## 2.4. Financial and economic imbalances and optimal monetary policy rule

It is assumed that the policy instrument for the monetary policy is nominal interest rate. The monetary authority seeks, therefore, to set a nominal interest rate to bring output and inflation to the target values. Keeping output close to its target as much as possible contributes to stabilize economy in a flexible inflation targeting regime. In such a regime, the central bank's preference is not only inflation targeting, but also economy stability, interest rate smoothing and probably some other targets which shall be read as financial stability targets. The monetary authority, under commitment, minimizes the social loss to solve the optimization problem in order to commit itself to the optimal rule where it will not deviate from.

In order to achieve to the stability in the economy, the policy maker looks for a welfare-based objective that can be derived from the representative household's utility function indicated in terms of steady state consumption. Thus, the monetary authority loss function, which also includes deviation of the nominal interest rate from its target, can be written as:

$$\text{Min } E_0 \sum_{k=0}^{\infty} \beta^k L_{t+k} = \text{Min } E_0 \sum_{k=0}^{\infty} \beta^k [(\pi_{h,t+k})^2 + \gamma_x (x_{t+k})^2 + \gamma_i (i_{t+k} - \bar{i})^2] \quad (34)$$

where inflation target is set as zero. Thus, the monetary authority seeks to minimize equation (34) subject to the model (equations (8), (10), (29) and (32)). Equation (29) represents the dynamics of domestic inflation. Here, it is also assumed that monetary authority is aware of effects of debt outstanding on the economy's activity and hence he considers the relationship between two output gaps, that are  $x_t$  and  $x_t^*$  in such a way that he reduces the gap between  $x_t^*$  and  $x_t$ . In fact, output cost of debt accumulation in the corporate sector is also important for the central bank because, as equation (32) shows, output gap  $x_t$  increases above  $x_t^*$  with outstanding debt of

firms. After some manipulation with the constraints, supply curve can be written as following relations:

$$(1 + \Omega\alpha)\pi_{h,t} = \beta E_t \pi_{h,t+1} + Mx_t + \Lambda q_{t-1} + \Omega\alpha(i_{t-1} - i_{t-1}^* + \pi_t^*) \quad (35)$$

For a monetary policy rule under commitment, the Lagrangian as of time zero can be written as:

$$\begin{aligned} \text{Min } E_0 \sum_{t=0}^{\infty} \beta^t \{ & (\pi_{h,t})^2 + \gamma_x(x_t)^2 + \gamma_i(i_t - \bar{i})^2 + \psi_{1,t}[(1+\Omega\alpha)\pi_{h,t} - \beta E_t \pi_{h,t+1} - Mx_t - \\ & \Lambda q_{t-1} - \Omega\alpha(i_{t-1} - i_{t-1}^* + \pi_t^*) + \psi_{2,t}[x_t - E_t x_{t+1} + \frac{1}{\sigma_c}[i_t - E_t \pi_{h,t+1} - \bar{r}_t]] \} \end{aligned} \quad (36)$$

The Lagrangian technique which is implied in Woodford (2003) is used to solve this problem. When the problem is solved under commitment the policy rule is time consistent. The loss function does not apply expected losses from time zero onward and, therefore, it is not conditional on the new state of economy. Thus, as a result, it yields a timeless solution (Woodford, 2003).

The first order conditions for two periods are:

$$\pi_{h,t} + \psi_{1,t}(1 + \Omega\alpha) - \psi_{1,t-1} - \frac{\psi_{2,t-1}}{\sigma_c \beta} = 0 \quad (37)$$

$$\gamma_x(x_t^* + V\rho_t^d(\bar{\omega}^d + \omega^d(d_t - E_{t-1}y_t))) - \psi_{1,t}M + \psi_{2,t} - \frac{\psi_{2,t-1}}{\beta} = 0 \quad (38)$$

$$\gamma_i(i_t - \bar{i}) + \frac{1}{\sigma_c}\psi_{2,t} = 0 \Rightarrow \psi_{2,t} = -\sigma_c\gamma_i(i_t - \bar{i}) \quad (39)$$

where  $\psi_{1,t}$  and  $\psi_{2,t}$  are Lagrangian multipliers. To eliminated the Lagrangian multipliers substitute (39) into (38) and (37) and solve for  $\psi_{1,t}$  in (38). After substitution of the results into (37), the optimal monetary policy rule can be derived as:

$$\begin{aligned} i_t = & \varphi_{0,i}\bar{i} + \varphi_{1,i}i_{t-1} - \varphi_{2,i}i_{t-2} + \varphi_{\pi}\pi_{h,t} + \varphi_{o,x}(x_t^* + V\rho_t^d(\bar{\omega}^d + \omega^d(d_t - \\ & E_{t-1}y_t))) - \varphi_{1,x}x_{t-1} \end{aligned} \quad (40)$$



where the coefficients are:

$$\varphi_{0,i} = 1 - \left( \frac{1}{\beta} + \frac{1}{(1+\Omega\alpha)} + \frac{1}{\sigma_c(1+\Omega\alpha)} - \frac{1}{\beta(1+\Omega\alpha)} \right)$$

$$\varphi_{1,i} = \frac{1}{\beta} + \frac{1}{(1+\Omega\alpha)} + \frac{1}{\sigma_c(1+\Omega\alpha)}$$

$$\varphi_{2,i} = \frac{1}{\beta(1+\Omega\alpha)}$$

$$\varphi_{\pi} = \frac{M}{\sigma_c \gamma_i (1+\Omega\alpha)}$$

$$\varphi_{o,x} = \frac{\gamma_x}{\sigma_c \gamma_i}$$

$$\varphi_{1,x} = \frac{\gamma_x}{\sigma_c \gamma_i (1+\Omega\alpha)}$$

From the optimal policy rule equation (40), the monetary authority should not directly respond to exchange rate movements under the optimal policy. In other words, the response of the monetary policy to exchange rate movements is indirect, through domestic output and inflation. However, the policy maker reacts to financial imbalances (or debt outstanding) when accumulated debt is large enough and a kind of financial imbalances may occur (when  $\rho_t^d$  obtains value 1). In such a situation, this can prevent probable future imbalances and instabilities from arising. If the economic conditions are normal and the policy maker is not worried about financial imbalances, that is  $\rho_t^d = 0$ ,  $x_t$  will be equal to  $x_t^*$ . Therefore, in this situation, monetary authority should not react to changes of firm's debt under the optimal rule. This is unlike the recent related literature such as Divino (2009) and Gali and Monacelli (2005) in terms of role of debt and financial imbalances in monetary

policy transmissions and also role of real exchange rate in capital accumulation and building debt.

The severity of reaction to the financial imbalances depends on the preferences of the monetary authority to stabilize output and smoothing of interest rate. Degree of openness of the economy also affects the coefficients of the policy rule. According to the optimal rule, concerns about economy stability are associated with concerns about financial imbalances under the optimal monetary policy rule. More precisely, the higher  $\gamma_x$  lead to more sensitive monetary authority to outstanding debt in a situation in which financial pressures of firms' debt and imbalances exist.

## 2.5. Impulse Responses

In this section, the dynamic effects of two shocks (positive shock to debt and foreign country output) on several variables are investigated under the optimal monetary policy rule derived in this chapter and Gali and Monacelli's (2005) rule<sup>8</sup>. To solve the model and generate impulse responses I used Dynare<sup>9</sup>. On the whole, given a model (for example, DSGE model of this chapter) and using Dynare, one has to determine endogenous and exogenous variables, assign parameter values and, declare the model to the software (see, Adjemian *et al.*, 2011; Collard *et al.*, 2003). Here, exogenous variables are innovations of shocks that are shock to debt ( $e_t^d$ ), and shock to foreign output, assuming that output of the foreign country ( $y_t^*$ ) follows a (first order) auto regressive process.

---

<sup>8</sup> The nominal interest rate rule in Gali and Monacelli's study is  $i_t = \bar{i}_t + \phi_\pi \pi_{h,t} + \phi_x x_t$ . Under some assumptions they imply that the policy that replicates the flexible price equilibrium allocation is optimal.  $\phi_\pi$  was set 1.5 and  $\phi_x=0.5$ , as in Gali and Monacelli's study.

<sup>9</sup> Dynare is software for handling with economic models, in particular, DSGE models. For example, using calibrated data and an economic model, Dynare is able to do simulation and provide desired output (Adjemian *et al.*, 2011)

I followed Gali and Monacelli (2005) and used the values that they have assigned to parameters of their DSGE model, as an example of a small open economy. I considered a special case where  $\sigma = \varphi = 1$  that implies  $\psi=1$  and hence  $\omega = 1-\alpha$ . It means that the weights of domestic and foreign output ( $\omega$ ) in the basket of the domestic consumption are determined by the degree of openness of the economy ( $\alpha$ ). The higher is  $\alpha$ , the higher is the weight of foreign output in the domestic consumption. I assumed  $\delta=3$  which gives labour supply elasticity of  $\frac{1}{3}$  and a value for the mark up,  $\mu^p = 1.2$  which yields  $\varepsilon = 6$  if we assume  $\mu^p = \frac{\varepsilon}{\varepsilon-1}$ .  $\theta$  (the probability that a firm does not reset its price) is set equal to 0.75 and  $\beta$  (the discount factor) equal to 0.99. I assigned  $\alpha = 0.4$ ,  $\rho_{y^*} = 0.86$  (coefficient of first order autoregressive of foreign output process) (see Gali and Monacelli, 2005). I assumed that the coefficient of the first order autoregressive of the shock to debt is equal to 0.90. The last parameter which relates to the existence of financial imbalances in the economy is  $\rho^d$  that I assumed that it equals 1, that is existence of financial imbalances.

To solve an economic model with Dynare, numerical initial conditions should be determined. For this chapter, following Collard *et al.* (2003), I computed deterministic equilibrium of the model with Dynare in absence of shocks. Then, I obtained the values of deterministic equilibrium and then used them as the initial condition of the stochastic simulation. Alternatively, Adjemian *et al.* (2011) and Collard *et al.* (2003) argue that one can provide only guessed values for initial conditions. Dynare would then automatically compute the exact values<sup>10</sup>. Dynare solves a stochastic model, computing Taylor approximation of the functions around

---

<sup>10</sup> I used different guessed values as initial conditions to see whether results (impulse responses) change. I found that impulse responses were robust to the changing the initial values.

steady state. Then, impulse response function are computed as the difference between trajectory of a variable affected by shocks at the beginning of period 1 and its steady state value. I tried to solve the model without a nominal interest rate rule, but it was not solvable without a policy rule. Then, I did simulation once with the optimal rule derived in this chapter and once with the rule that used by Gali and Monacelli (2005). Impulse responses are given in Figure 2.1.

Figure 2.1 indicates impulse response of variables to the positive shock to debt outstanding of production sector under the optimal monetary policy rule of this chapter and the policy rule represented in Gali and Monacelli (2005). This shock has negative impact on domestic productivity and hence can be read as a negative shock to the domestic productivity. With an innovation to debt, nominal interest rate increases as it is needed to reduce capital formation and debt accumulation through its impact on real exchange rate and expected future level of the economy's activity. Uncovered interest parity implies a decrease in real exchange rate (home price of the foreign country currency) in response to the rise in the domestic interest rate. Expected future real exchange rate devaluation has a negative effect on the current level of output gap, given that imports increases and export decreases in the current period. However, output gap is also affected by debt accumulation (the factor that is absent in the Gali and Monacelli's rule) in such a way that existence of huge accumulated debt will increase domestic output gap above its technically feasible level (or  $x^*$ ) through rising the gap between  $\hat{y}_t$  and  $\bar{y}_t$ . Positive shock to debt, thus, increases output gap.

Real exchange rate has direct impact on PPI inflation (domestic inflation) due to its impact on CPI inflation and resulting wage inflation. Domestic inflation,

therefore, decreases and starts to revert to steady state value after five periods. The real exchange rate has not direct effect on the dynamics of domestic inflation in Gali and Monacelli (2005) although the degree of openness of the economy affects only the parameter that determines the sensitivity of domestic inflation to output gap movements. In this chapter, the optimal rule responds to the target interest rate ( $\bar{i}$ ) which comes from the quadratic penalty for nominal interest rate variation in the loss function of the monetary authority. In contrast, Gali and Monacelli use natural interest rate in their policy rule. This leads to more aggressive response to debt shock under Gali and Monacelli's policy rule than the optimal monetary policy rule of this chapter.

On the whole, domestic inflation and output gap responses show opposite directions to each other as a result of the shock to debt. This is due to real exchange rate in the model where the shock that moves output gap in one direction requires a response from nominal interest rate that moves real exchange rate in the opposite direction.

Figure 2.1. Impulse responses to a shock to debt outstanding under the optimal policy rule (solid line) and Gali and Monaceli's policy rule (dotted line)

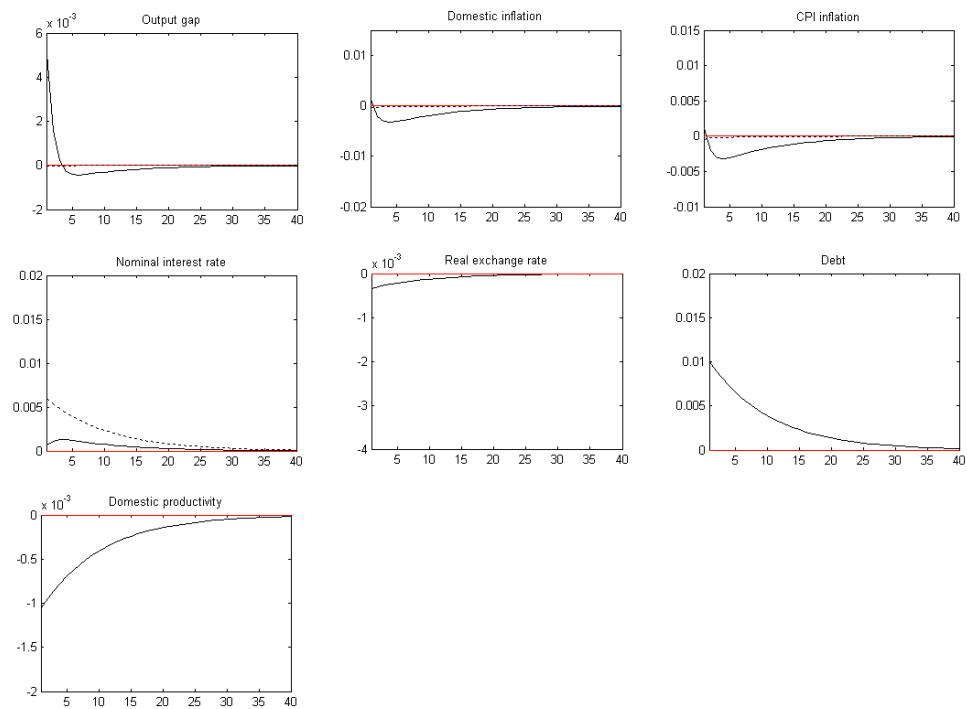
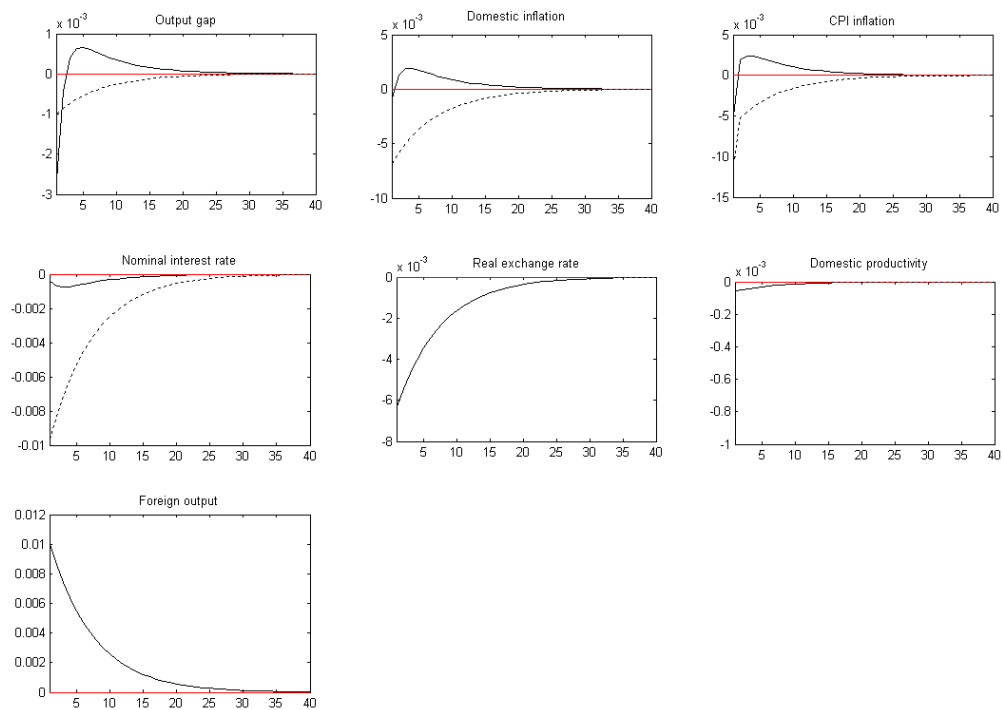


Figure 2.2. Impulse responses to a foreign output shock under the optimal policy rule (solid line), and Gali and Monaceli's policy rule (dotted line)



With a positive shock to the foreign country output, current value of output gap decreases, given the positive changes in the foreign output. The negative response of real exchange rate has also negative impact on the output gap on the current period, assuming positive changes in the expected real exchange rate. This leads to a negative response of the nominal interest rate. The effect of foreign country output on natural interest rate (which happens in the open economy) has negative impact on the activity of the economy for a few periods. This in turn leads to the increase in prices level after some while when output gap starts to increase. After nearly 5 periods, output gap is expected to increase and become positive given that expected output gap is positive.

Response of nominal interest rate to the natural interest rate instead of the deviation of nominal interest rate from its target level in Gali and Monacelli (2005) create more severe reaction of their policy rule to the positive shock to the foreign country output, in comparison of the optimal monetary policy rule in this chapter. The model introduced in this chapter and the resulted optimal monetary policy renders more stable nominal interest rate than the natural interest rate that has been used in Gali and Monacelli (2005).

## **2.6. Conclusion**

In this chapter, a small open economy model based on a DSGE-type model was constructed to examine the impact of real exchange rate and financial imbalances on the dynamics of macroeconomic variables and hence monetary policy. The model is akin to that of Gali and Monacelli (2005) and derived the monetary authority's (central bank's) optimal interest rate rule under commitment where financial imbalances impact on the economy. The real exchange rate plays a significant role in

the small open economy. In this model, it directly affected the dynamics of domestic inflation (aggregate supply) and firm's marginal cost, but had an indirect effect on the aggregate demand.

This chapter obtained capital accumulation and outstanding debt in the corporate sector (firms) as a proxy of financial imbalances in the real sector of the economy. Accumulated outstanding debt of borrowers (firms) may cause lenders to stop lending and this may lead to a credit crunch in response to the accumulated debt. This behaves as a negative shock to domestic productivity and hence reduces the technical capability of the economy. This is the channel through which financial imbalances affect the economic agents, and is the area that policy makers should give consideration to.

The present optimal monetary policy rule indicates that the monetary authority responds to firms' accumulation of debt when the outstanding debt of firms has created financial imbalances. However, if the economy is in a normal situation where outstanding debt does not impact seriously on the technical capability of the economy and domestic productivity, the monetary authority does not react to changes of debt level.

The monetary authority of an open economy may use the monetary policy to improve the terms of trade and purchasing power of domestic consumers through the real appreciation in exchange rate. This may lead to a rise in firms' capital accumulation, debt level and the real marginal cost, and hence aggregate supply of firms. It is, therefore, essential that central bank knows the channel of effects of the real exchange rate and also knows how to respond to exchange rate movements. Under the derived optimal policy rule in this chapter, the response of monetary



authority to exchange rate is indirect since exchange rate affects aggregate supply and output.

The impulse response analysis implied the dynamics of variables in response to shocks to debt and foreign output. It showed that when central bank cares about debt and financial imbalances, it increases nominal interest rate in response to a positive shock to outstanding debt of firms to prevent further imbalances from arising. When the corporate sector (firms) accumulates debt (for capital accumulation) this may prompt lenders to decrease the amount they lend, or stop lending altogether. This reduces the access of firms to money to finance inputs and pay workers, and hence technical capability of the economy and domestic productivity are negatively affected. This has a negative effect on production and output. All of these might be read as the cost arising from outstanding debt and financial imbalances in the economy.

The change in the foreign economy output affected the domestic economy through the exchange rate channel where the positive shock to foreign output reduced real exchange rate. This impacted slightly on the domestic inflation and reduced it for a short period. However, the positive shock to foreign output positively affected domestic consumption which may lead to an increase in prices level. Policy rule (nominal interest rate) of Gali and Monacelli (2005) responds to the shocks more severe than the optimal monetary policy rule derived in this chapter. One reason is that, Gali and monacelli's rule reacts directly to the natural interest rate that in turn it is affected by the degree of openness and changes in the foreign country output.

**CHAPTER 3: Financial system structure, banks' financial soundness and financial stability: Empirical evidence of some EMEAP members**

### 3.1. Introduction

It is widely recognised that the structure of the financial system is an important factor that affects financial stability. Recent studies on this issue include Demirguc-Kunt and Huinga (2000), Allen (2001), Allen and Gale (2001, 2004), Ibrahim (2006) and Ruiz-Porras (2009), among others. Some studies such as Levine (2004) and Luintel *et al.* (2008) imply that financial system structure affects economic performance too. Most empirical studies such as Ruiz-Porras (2009) follow Levine (2002) to describe the structure of the financial system. According to Levine (2002), a financial system is either based on financial markets (that is, financial markets performance determine the performance of the financial system) or on banks (as important financial institutions that lie at the centre of the payment system). Therefore, a financial system can be described as a market-based or bank-based system. Levine (2002) defines a ratio of the stock market activity (or size) to banking system loans. He argues that if this ratio is greater than one, financial system structure would be interpreted as a market-oriented structure. Otherwise, it would be a bank-based structure. Therefore, in the financial system, if the stock market is more active than banks (for example, the value of traded shares or size of stock market is higher than the value of banks' loans for a given period), and then the financial system has a market-based (or market-oriented) structure (Levine, 2002).

This thesis uses financial soundness of the banking system to measure financial stability. Since banks lie at the centre of most financial systems, especially in developing and emerging countries, the status of banks' assets, liabilities and equity are important to the investigation of stability in the financial system. These factors indicate financial soundness and the solvency status of banks (see for example, De

Nicolo, 2000 and Uhde and Heimeshoff, 2009). De Nicolo (2000) defines probability of insolvency of banks as the probability that banks' loss exceeds equity. Then, assuming that bank's return is distributed normally, he implies that probability of insolvency is the inverse of the ratio of a bank returns on assets and capita-asset ratio to the volatility of returns. De Nicolo (2000) refers to this ratio as Z-score. Uhde and Heimeshoff (2009) argue that since Z-score is the inverse of the probability of insolvency of a bank, it can be used to measure the financial soundness of banks. They also conclude that (based on the definition of Z-score) the financial soundness shows the distance-to-default for banks and hence it is important for the study of financial stability (see also Akram *et al.*, 2007; Aspachs *et al.*, 2007; Goodhart *et al.*, 2006; Tsomocos, 2003). Hence, with an increase in bank profitability and equity capital the financial soundness increases and this can secure the stability in the financial system. However, if a bank suffers from the high return volatility, it will lose its financial soundness and hence financial stability will decrease.

Considering the size and activity of the stock market and banks' activity as leading factors that determine the type of the structure of the financial system, different analyses about the effects of financial structure on financial stability can be presented. This is because of different arguments and opinions on the capabilities of financial markets and banking systems to secure financial stability, and the type of relationships between markets and banks. For example, it seems that in a bank-based financial system, insolvency of banks causes the financial system to be more exposed to the risk of financial instability compared to a market-based financial system.

On the other hand, a market-based financial system can be the objective of speculative actions; and hence sudden big collapses in financial markets may lead to financial instability. Thus, this chapter addresses the effects of the financial system structure on the financial stability and investigates whether a market-based financial system can support financial stability.

Demirguc-Kunt and Huzinga (2000) argue that financial indicators, such as activity of stock markets and banks which determine the financial system structure, can affect financial stability. More precisely, they argue that in an underdeveloped financial system, a more active stock market may lead to a fall in banks' margins and profitability. Allen (2001), who conducted one of the first studies about the relationship between financial structure and financial stability, describes the effects of the structure of the financial system in the light of the causes of financial instability with a theory of crisis, and possible actions which can be taken to prevent instability from arising. Indeed, it is a descriptive study that considers crisis of South East Asian countries. Another recent piece of research about the relationship between financial structure and financial instability is that of Ruiz-Porras (2009). The study uses the fixed-effect panel-data to determine the effect of financial structure and development on financial instability, and determined the financial determinant of financial instability from international evidence. He concluded that financial structure has an inverse relationship with financial instability. Therefore, a market-based financial system may contribute to enhance financial stability. Another study is that of Ibrahim (2006) which analyses the dynamic interaction between stock prices and bank loans in Malaysia. He implied that bank loans respond positively to the increase in stock prices. The main implication of his study is that

banks' financial conditions and hence financial stability crucially depend on the stock market activity. Therefore, he implicitly concludes that the financial structure affects financial stability.

Financial structure has been also an important aspect related to the study of economic performance. Luintel *et al.* (2008) used data of 14 developing countries over the period of 1978 to 2005 and, with country-by-country time series analysis, revealed that financial structure significantly explains output levels in most countries. Beck and Levine (2004) also argued that stock market and bank development have a significant effect on economic growth.

In terms of defining financial stability concept and methodology of the study, this study differs from other recent studies, most of which have focused on actual time episodes of banking crisis as a proxy for financial (in) stability, whereas the present study extends the analysis by employing the Z-score ratio<sup>11</sup>. Moreover, this research studies empirically the relationship between financial structure and financial stability in eight economies of the EMEAP, with vector autoregressive model (VAR) that is augmented by the unobserved common factors effect. This model has been proposed in Infinite dimensional VAR or IVAR (the global VAR) model of Pesaran *et al.* (2004) and Chudik and Pesaran (2009). According to this model, instead of estimating a large system of equations (for example a panel VAR) for the global or a regional economy, VAR model of each country is augmented by the common factors among economies of the study and then estimated. According to Chudik and Pesaran (2009), this country-by-country augmented VAR estimation can approximate IVAR model well. Hence, I used this method to estimate the effects of financial structure

---

<sup>11</sup> Ruiz-Porras (2009), Evrensel (2008) and Demirguc-Kunt and Detragiache (1998) have used real episodes of crisis of the banking sector for their analysis.

on financial stability. According to my knowledge, this is the first empirical study about the impact of the financial structure on financial stability for these countries<sup>12</sup>.

The remainder of this chapter consists of section 3.2 that describes theories of financial systems, financial structure and financial stability. Section 3.3 provides information of the interrelations between countries under analysis in this chapter. Section 3.4 describes the empirical analysis. Section 3.5 provides definitions of measures and data. Section 3.6 briefly explains the economic situation and financial system of the countries. Generalised impulse response dynamics are explained in section 3.7, and section 3.8 provides conclusions after analysing all the information and findings.

### **3.2. Financial structure and financial stability: Theoretical perspective**

Allen and Gale (2000) argue that the structure of the financial systems affects possible actions that should be taken against financial shocks. For example, a more competitive banking sector may encourage banks to take risks in their investment actions. This competitive situation may stem from competition between banks in the banking system or between the banking system and financial markets such as the stock market. The banking sector can smooth shocks effects through averaging the effects over time (intertemporal smoothing) by accumulating low-risk liquid assets. Additionally, banks can share the liquidity risk; for instance, in the inter-bank market with holding deposits in other banks (see Allen and Gale, 2001). This mechanism, however, makes banks potentially vulnerable to the contagion effect due to inter-bank linkages. If the failure of a single bank has a sufficiently large effect, it would affect counterparties in the market and hence shock effects spread throughout the

---

<sup>12</sup> Wong *et al.* (2007) have identified leading indicators of banking distress based on real episodes of crisis in Asia- Pacific region countries.

system and further default may occur. Thus, the contagion effect may be very severe (Gai and Kapadia, 2010) and may increase instability risks in the financial system. This can happen, especially if banks experience mismatch between their liquid liabilities on the one hand, and hold illiquid assets in their balance sheets, on the other. Thus, this means that a bank-oriented financial system can expose the system to higher risks and likely financial instability. However, in a market-based financial system in which stock markets are active, banks can hold some proportion of assets in shares (liquid assets). It is very important for banks to match between liquid assets and liabilities, although any likely collapse in stock prices will affect banks' balance sheets. All of these aspects are related to the effects of the structure of the financial system on the stability of the financial system. Therefore, performance of the financial system such as banks' lending activity and stock market performance affect financial risk management. For instance, in the financial system, with active financial markets and investors, the financial risks can be shared between investors using financial instruments. This would be different when the financial system is not complete in terms of financial instruments and participation of people. In this case, financial risks may be managed through smoothing of shocks over time periods (Allen and Gale, 2004). Thus, it is quite possible that financial stability depends on the structure of the financial systems. On the other hand, the Allen and Gale's (2000) theory indicates that less developed and incomplete financial markets may fail to smooth the effects of financial shocks over time, whereas a bank-based financial system can smooth the risks effects as long as there is no competition from financial markets. Competition from markets (such as stock markets) may lead to a rise in investment in financial markets, especially in a healthy economic environment. This



can cause banks to take more risky action to offer more attractive benefits to individuals or institutions to receive more funds; however, this competition may lead to disintermediation and systemic instability.

Hence, the main hypothesis that this study investigates is: An increase in financial structure measure (moving towards a market-based financial system) leads to an increase in financial stability. This hypothesis refers to the idea that the development of stock markets improves the ways in which resources are allocated and decreases the default risks; and hence financial stability increases. Then, the second hypothesis considers the opposite view: An increase in financial structure measure (moving towards a market-based financial system) leads to a decrease in financial stability, implying that the development in stock markets cannot provide financial stability since the markets' functions are not complete, especially in developing countries, and hence it is associated with some abnormal risks (such as market risk) which facilitates instability.

### **3.3. Interrelations between members of the EMEAP<sup>13</sup>**

The Executives' Meeting of East Asia-Pacific Central Banks (EMEAP) is a cooperative organisation of central banks and monetary authorities in the East Asia and Pacific region which was established in 1991. The primary objective of this organisation is to strengthen the cooperative relationships among its members. Its members are central banks of 11 countries: Indonesia, Malaysia, Singapore, the Philippines, Thailand, China, Hong Kong, South Korea, Japan, Australia and New Zealand. The countries under analysis in this thesis are eight of the members;

---

<sup>13</sup> The information of this section has been obtained from the official website of EMEAP: <http://www.emeap.org>. Otherwise, references are in the text.

Indonesia, Malaysia, Singapore, the Philippines, Thailand, Hong Kong, South Korea, and Japan which construct a block of economies in East and Southeast Asia.

In the light of the growing economic interdependence of the countries of EMEAP, this organisation decided to create a scheme of financial integration and collective investment to strengthen Asia financial markets and secure financial stability of the group and the region. Hence, the Asian Bond Fund (ABF) was initiated in 2003 to create a collective investment of the members in the Asia bond market. In order to build greater regional cooperation, the Monetary and Financial Stability Committee was established in 2007. The goal of this Committee is to enhance a monitoring scheme and crisis management mechanism of EMEAP.

Countries under analysis in this thesis have set up a regional network in East and Southeast Asia. As leading economies of Asia, along with China, they have significant effects on the economic condition of the world. For instance, Japan is the most advanced economy in Asia, a member of the Organization for Economic Co-operation and Development (OECD) and the third largest economy<sup>14</sup> in the world after the US and China. Japan, like South Korea, has been characterised by a high-tech and science-based economy. Indonesia is a member of G-20 economies. Hong Kong, Singapore and South Korea are three countries of the Four Asian Tigers. They were called Asian Tigers to reflect their rapid economic growth and development in the financial sector. Thus, this thesis, with the aim of studying Asian economies, chose these countries.

---

<sup>14</sup> Kyung Lah (February 14, 2011). Japan: Economy slips to the third in the world. [www. CNN.com](http://www.CNN.com).

### 3.4. Empirical analysis

#### 3.4.1. *The Infinite dimensional VAR (IVAR)*

To investigate the hypothesis that financial structure affects financial stability, this study estimates a specified VAR model for each country where each country-specific VAR is augmented by factors that are common among countries of studies. Countries in this study are eight members of EMEAP economies: Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore and Thailand over the time period 1990 to 2007. The intuition is that these countries are leading economies in the East and Southeast Asia and their economies are correlated to each other. The common factors in VAR of each country can capture the effects of interrelations between countries. Endogenous variables of each country's VAR comprise financial stability and financial structure measures, bank credit, nominal interest rate and output gap. VARs are useful tools to study and forecast dynamic behaviour of economic and financial time series. Therefore, following Sims (1980), VARs are widely used to explain the complex interactions that exist between variables in macroeconomics and finance. In addition, the VAR model is also used to describe the resulting impacts of unexpected shocks or innovations to specified variables on other variables in the model. Thus, VAR is a useful tool for this study since the aim is to explain the impact of financial and economic shocks on financial stability.

The economies in this study make a block of economies in the East and Southeast Asia and hence there are economic linkages between them. The standard country-specific VAR model uses variables of a country without making a linkage to the regional and the global economies. For considering the linkages and interrelations between countries, one may construct a global (regional) VAR model (for example, a

panel VAR). One of the well known problems of analysis of dynamic interactions between variables in regional or global economy is dimensionality problem. The number of parameters grows in a quadratic rate with the number of variables in the system. When the system is large enough (or the number of variables tend to infinity) and dominant unit also exists, the VAR model is referred to as Infinite Dimensional VAR or IVAR (Chudik and Pesaran, 2009). Since standard VARs are limited to a modest number of endogenous variables, using a standard VAR model for the global or regional economy may lead to omitting some important variables for avoiding dimensionality problem (the VAR model would be reliable if the number of variable is not more than five to seven (Chudik and Pesaran, 2009)). As Chudik and Pesaran (2009) argue, one of the strategies to deal with the dimensionality problem for studying the regional or global economy is shrinking part of the parameter space with using country-specific VAR model augmented by some exogenous variables in the light of the Global VAR (GVAR) approach proposed by Pesaran *et al.* (2004). In this approach, VAR model of each country is augmented by common factors in the region. The system of dynamics in a IVAR model may include one unit (country) that has dominant effects on other units. Dominant unit acts as a factor in a dynamic factor model. A dominant unit can be read as a dynamic common factor for the remaining countries in the system (Chudik and Pesaran, 2009). It, therefore, allows for interrelations between individual markets. When it is assumed that the common factors are unobservable, Chudik and Pesaran (2009) propose that averaging endogenous variables across countries and augmenting VAR of each country by these cross sectional averages can captures the effect of unobserved common factors among countries as well as neighbouring effects. In this

way, estimation of IVAR can be well approached. Therefore, due to interrelations between economies of Southeast Asian countries, in addition to country specific dynamics, the interdependence of cross sectional markets are considered through the cross sectional augmented VARs to capture the common effects in regional economy.

The technique of cross-sectional augmented VAR model seems to be a plausible technique for the analysis of interaction between the financial structure and financial stability because the countries of EMEAP are related economically. With using VARs, this chapter provides a framework to explain how financial and macroeconomic variables impact on financial stability based on generalized impulse response functions.

### 3.4.2. Empirical model

Let  $\mathbf{z}_{nt} = (\text{FS}_{nt}, \text{FT}_{nt}, \text{BC}_{nt}, \text{NI}_{nt}, \text{OG}_{nt})'$  be the vector of five endogenous variables for country  $n$ ,  $n = 1, 2, \dots, N$  and  $N=8$ . FS denotes financial stability measure; FT is financial structure measure, BC is bank credit, NI is short term nominal interest rate and OG denotes output gap. Then, to see the dimension of the system in a panel model, suppose that all the variables of eight countries in  $\mathbf{Z}_t = (\mathbf{z}'_{1t}, \mathbf{z}'_{2t}, \dots, \mathbf{z}'_{Nt})'$  are endogenously determined within a  $NK \times NK$  panel VAR model

$$\mathbf{Z}_t = \boldsymbol{\alpha} + \boldsymbol{\Phi}(\mathbf{L})\mathbf{Z}_{t-1} + \boldsymbol{\varepsilon}_t \quad (1)$$

For  $t=1, 2, \dots, T$ .  $K=5$  is the number of endogenous variables and  $\boldsymbol{\alpha} = (\boldsymbol{\alpha}'_1, \boldsymbol{\alpha}'_2, \dots, \boldsymbol{\alpha}'_N)'$  is  $NK \times 1$  vector of fixed effects,  $\boldsymbol{\alpha}_n = (\alpha_{n1}, \dots, \alpha_{nK})'$ ,  $\boldsymbol{\Phi}(\mathbf{L})$  is a lag polynomial ( $\rho$  lags) with the VAR coefficients<sup>15</sup>;

---

<sup>15</sup>  $\boldsymbol{\Phi}(\mathbf{L}) = \boldsymbol{\Phi}_1 + \boldsymbol{\Phi}_2\mathbf{L} + \dots + \boldsymbol{\Phi}_{\rho-1}\mathbf{L}^{\rho-1}$

$\boldsymbol{\varepsilon}_t = (\boldsymbol{\varepsilon}'_{1t}, \boldsymbol{\varepsilon}'_{2t} \dots, \boldsymbol{\varepsilon}'_{Nt})'$ ,  $\boldsymbol{\varepsilon}_{nt} = (\varepsilon_{n1t}, \dots, \varepsilon_{nkt})'$ , is the vector of disturbances.

Equation (1), with one lag, can be presented in the following form:

$$\begin{pmatrix} \mathbf{z}_{1t} \\ \mathbf{z}_{2t} \\ \vdots \\ \mathbf{z}_{Nt} \end{pmatrix} = \begin{pmatrix} \boldsymbol{\alpha}_1 \\ \boldsymbol{\alpha}_2 \\ \vdots \\ \boldsymbol{\alpha}_N \end{pmatrix} + \begin{pmatrix} \boldsymbol{\Phi}_{11} & \cdots & \boldsymbol{\Phi}_{1N} \\ \vdots & \ddots & \vdots \\ \boldsymbol{\Phi}_{N1} & \cdots & \boldsymbol{\Phi}_{NN} \end{pmatrix} \begin{pmatrix} \mathbf{z}_{1t-1} \\ \mathbf{z}_{2t-1} \\ \vdots \\ \mathbf{z}_{Nt-1} \end{pmatrix} + \begin{pmatrix} \boldsymbol{\varepsilon}_{1t} \\ \boldsymbol{\varepsilon}_{2t} \\ \vdots \\ \boldsymbol{\varepsilon}_{Nt} \end{pmatrix} \quad (2)$$

where  $\boldsymbol{\Phi}$  has been partitioned to  $K \times K$  dimensional sub-matrices  $\boldsymbol{\Phi}_{ij}$

$$\boldsymbol{\Phi}_{ij} = \begin{pmatrix} \Phi_{11} & \cdots & \Phi_{1k} \\ \vdots & \ddots & \vdots \\ \Phi_{k1} & \cdots & \Phi_{kk} \end{pmatrix}$$

In equation (2), there are cross-section lagged interdependencies whenever  $\boldsymbol{\Phi}_{ij} \neq \mathbf{0}$  for any  $i \neq j$ . Obviously, the presence of cross-section dependence will increase the number of parameters for estimation. Adding some exogenous variables to the system to capture the effect of the global economy will increase the number of parameters to  $p = NK\rho + qr$  in each equation, assuming  $\rho$  lags for the  $K$  endogenous variables and  $r$  lags for  $q$  exogenous variables for  $N$  countries. We assume that there are unobserved common factors among countries of the sample that are a part of error terms and may be correlated with regressors. The common factors origin from inter-relations between economies. Thus, with assumed unobserved common factors in the model, one may augment the panel VAR model (1) with factors,  $\mathbf{f}_t$ <sup>16</sup> in order to capture the effects of common factors:

<sup>16</sup> See Chudik and Pesaran (2009). For the sake of simplicity I show the model for one lag.

$$\mathbf{Z}_t = \alpha + \Phi \mathbf{Z}_{t-1} + \Gamma \mathbf{f}_t - \Phi \Gamma \mathbf{f}_{t-1} + \varepsilon_t \quad (3)$$

where  $\mathbf{f}_t$  is  $m \times 1$  dimensional vector of unobserved common factors and  $\Gamma = (\Gamma'_1, \dots, \Gamma'_N)'$  is  $NK \times m$  dimensional matrix of factor loading ( $m$  denotes the number of unobserved common factors which are relatively small, that is, less than the number of endogenous variables) and  $\varepsilon_t = (\varepsilon'_{1t}, \varepsilon'_{2t} \dots, \varepsilon'_{Nt})'$  is the vector of error terms assumed to be independently distributed of common factors. Chudik and Pesaran (2009) propose a method to estimate this system. In this case, if a country-specific VAR model is augmented with cross-section averages of variables of other countries of the study (equation 4); the model can capture the effect of local dominant and unobserved common factors without the problem of dimensionality. For this, let  $\mathbf{z}_t^* = \mathbf{W}' \cdot \mathbf{z}_t$  where  $\mathbf{W} = (\mathbf{W}_1, \dots, \mathbf{W}_N)'$  is any matrix of predetermined weights. Then, the following augmented VAR model should be estimated for each country  $n$ :

$$\mathbf{z}_{nt} = \alpha_n + \sum_{\ell=1}^{p_n} \Phi_{\ell ii} \mathbf{z}_{n,t-\ell} + \sum_{\ell=0}^{q_n} \Omega_{\ell n} \mathbf{z}_{n,t-\ell}^* + \varepsilon_{nt} \quad (4)$$

where  $\mathbf{z}_n^*$  is the vector of cross sectional averages of variables (except those of country  $n$ ) that have significant effect on the country  $n$  VAR model. Since it is assumed that the number of unobserved common factors ( $m$ ) is lower than the number of endogenous variables per country ( $K$ ), full augmentation of VAR model by averages of all endogenous variables across countries is not necessary for the consistent estimation of the VAR coefficients (Chudik and Pesaran ,2009).

### 3.5. Measurement

In this study, the proxy of financial stability is Z-score ratio. This ratio is defined by bank's profit and equity capital-asset ratio. As De Nicolo (2000) indicates,

insolvency risk is defined as the probability that losses exceed equity (or negative profits exceed equity):  $p(r \leq -k) = \int_{-\infty}^{-k} F(r)dr$  where  $r$  denotes returns on assets (ROA),  $k$  denotes equity capital-asset ratio which is total equity capital divided by total assets and  $F(r)$  denotes a bank's return distribution with mean and variance denoted by  $M$  and  $\sigma^2$ , respectively. As indicated by Roy (1952), with existence of  $M$  and  $\sigma^2$ , Chebyshev inequality implies that  $p(r \leq -k) \leq \frac{\sigma^2}{(M+k)^2} = \frac{1}{N^2}$ ;  $N = \frac{M+k}{\sigma}$ . Hence, the higher  $N$  implies a lower probability of insolvency. Therefore, with the assumption of normality of banks' returns,  $N$  can be used to interpret a bank's insolvency risk. It implies the number of standard deviations that returns on assets has to drop below its expected value in order to deplete the equity. The definition of Z-score ratio stems from the definition of  $N$  and therefore, it is defined as:  $Z_t = \frac{r_t + k_t}{\sigma_t}$ . For this study,  $r_t$  is computed as the average of returns on assets across all banks in a given period for each country. The same method has been used to compute  $k_t$  (the ratio of capital to assets). The standard deviation of returns on assets of banks at time  $t$  is denoted by  $\sigma_t$ <sup>17</sup>. Therefore, Z-score will increase with bank's profitability and capital-asset ratio and decrease with increasing in return volatility. In addition, according to De Nicolo (2000), it implies banks distance-to-default, insolvency risk and hence a measure of financial stability.

One may consider other measures for the distance-to-default of banks and hence financial stability. Amongst these measures, the options-based measure is well known. It is computed as the sum of the ratio of market value of assets to debt and the return on assets, divided by the volatility of assets. For this, market data of equity

---

<sup>17</sup> I obtained the data of Z-score from Beck, Demirguc-Kunt and Levine (2009).  $\sigma_t$  has been computed as a 5-year moving average in this data set.



of banks is used to compute market value of assets and volatility of assets, using Black and Scholes (1973) and Merton (1974) Options pricing model. Since we need stock market data for this model and all banks of the sample countries are not listed in the stock markets, this measure is not applicable for this study to compute the aggregate data of financial stability.

Most related empirical studies (such as Ruiz-Porras, 2009; Evrensel, 2008; Demircuc-Kunt and Detragiache, 1998) use the actual time episodes of banking crisis, which have been announced by country's authorities, as the data of financial instability. Although it is an actual indicator of instability, this may have some drawbacks. Different financial systems may consider different indicators to assess the financial conditions and announce instability. Moreover, even if all countries use the same indicators to announce instability in the financial system, it would not be reasonable because, for instance, when non-performing loans reach 10 percent of banks' total assets; it may cause panic in banks of one country but not in another. Hence, defining and dating the exact beginning and end of bankruptcies is difficult across countries. Furthermore, as Uhde and Heimeshoff (2009) argue, supervisory authorities may not be willing to announce the rise of instability in their countries because it may implicate weak and inefficient monetary and financial regulations. Finally, important financial intermediaries such as important banks are supported by authorities to avoid any systemic panic. Thus, this study uses the Z-score as a time variant measure for financial stability instead of time episodes of crisis.

This study follows Levine (2002) to construct an indicator of financial system structure. This indicator is defined with the activity and size of stock market as a proportion of banks activity (loans) in a country. Banks activity (banks credit) is the

ratio of banks loans to the private sector to GDP. The measure of the size of the stock market ( $MZ_t$ ) is stock market capitalization ratio which is the value of listed shares to GDP. Stock market activity ( $MA_t$ ) is measured by the total value of shares traded in the stock market to GDP in a given period. Finally, financial structure consists of two components, namely structure-size ( $SZ_t$ ) that shows size of the stock market relative to banks activity and structure-activity ( $SA_t$ ) that shows the activity of the stock market relative to banks activity. These components indicate the performance of the stock market and banks. They are computed as follow:  $SZ_t = \ln(MZ_t/banks\ credit_t)$  and  $SA_t = \ln(MA_t/banks\ credit_t)$ . Hence, when the stock market is more active in terms of size and volume of trades (compared to banks activity) the  $SZ_t$  and  $SA_t$  measures are positive, indicating a market-based financial system (Levine, 2002). The first principal component of structure-size ( $SZ_t$ ) and structure-activity ( $SA_t$ ) aggregates these two components and captures most variation of them<sup>18</sup>. Thus, the higher financial structure measure means moving towards the market-oriented (market-based) financial system.

### 3.5.1. Data

The data are quarterly, covering the period from 1990:Q1 to 2007:Q4. All variables are real and transferred to the natural logarithm except short term nominal interest rate. Definition and sources of data and correlation matrices are provided in Table 3.1 in the text and in the Appendix, respectively. Table 3.1 shows the VAR endogenous variables (Z-score, financial structure measure, bank credit, nominal interest rate and output gap) and components of the financial structure measure. In addition to financial stability and financial structure which are focal variables, bank

---

<sup>18</sup> Further details of principal components are explained in the Appendix.

credit, as a variable to control for banks activity, short term nominal interest rate and output gap are also added to the model to control macroeconomic effects. It is expected that output gap affects banks profitability since banks' investment activities may depend on business cycles (Laeven and Majoni, 2003). Hence, it is expected that banks profitability and then financial stability increases when economy is over the trend. Moreover, borrowers' solvency may be higher in a over full-capacity economy, leading to the fall in default risk and hence financial instability. The effect of short term nominal interest rate on financial stability depends on the net effect from the interest rates margin. Particularly, with an increase in nominal interest rate, lending interest rate increases, on the one hand, and cost of deposits may also increase, on the other.

*Table 3.1- Data description and sources. Note: Following Beck, Demirguc-Kunt and Levine (2009), real bank credit is calculated by  $((0.5) * (\text{private loan}/C + \text{private loan}(-1)/C(-1))) / (\text{GDP}/AC)$  where  $\text{private loan}(-1)$  denotes banks' loan to the private sector in previous period,  $C$  denotes end period CPI and  $AC$  denotes average annual CPI. The same method is used for calculating real stock market capitalization over GDP and real stock market total value traded over GDP.*

Variable	Description	Data sources
<b>Z-score(FS)</b>	Ratio of the sum of bank average return on assets (ROA) and equity capital to total assets to standard deviation of ROA	Beck, Demirguc-Kunt and Levine (2009)
<b>Bank credit(BC)</b>	The real private loans by deposit money banks to GDP	IMF's International Financial Statistics (IFS)
<b>Stock market capitalization ratio</b>	Real value of listed shares to GDP	Beck, Demirguc-Kunt and Levine (2009), Author calculation
<b>Stock market total value traded ratio</b>	Real stock market total value traded shares to GDP	Beck, Demirguc-Kunt and Levine (2009), Author calculation
<b>Structure- size</b>	The natural logarithm of stock market capitalization ratio over bank credit	Beck, Demirguc-Kunt and Levine (2009), IFS, Author calculation.
<b>Structure-activity</b>	The natural logarithm of stock market total value traded ratio over Bank credit	Beck, Demirguc-Kunt and Levine (2009), IFS, Author calculation.
<b>Financial structure(FT)</b>	First principal component of structure-size and structure- activity	Author calculation.
<b>Nominal interest rate(NI)</b>	Short term lending interest rate	IFS, World Bank, Central banks of countries.
<b>Output gap(OG)</b>	The difference between natural logarithm of real GDP and potential GDP (HP filtered GDP).	IFS, Author calculation.

Hence, the profitability of banks is affected by the net effect. Finally, bank credit is included as another control variable since the huge increase in bank credit is associated with a decrease in equity capital and hence in financial stability (Dell’Ariccia and Marquez, 2006). Furthermore, the rise of credit by banks may increase the credit risk through the rise in non-performing loans.

### ***3.5.1.1. Applying Kalman Filter technique to generate Z-score quarterly data***

The data of the Z-score ratio, from 1990 to 2007 and for each country, was obtained from the World Bank data set<sup>19</sup>. These data are annual and for the purpose of generating a quarterly series for Z-score ratio, this study used the Kalman filter technique, according to Harvey (1989)<sup>20</sup>. The Kalman filter is a recursive estimator that uses the estimated state from the previous time step and the current measurement to estimate current value of unobservable (or current state of the nature) and then uses the relationship in the next period to update the system. For this study, the relationship between the values of observable variables (annual series of Z-score) and unobserved variables (quarterly series of Z-score) is assumed known and linear. In other words, the observable values for the variable are described by the vector of unobserved variables of interest (state of the nature) as follow:

$$y_t = Fh_t + e_t \quad (5)$$

$$h_t = Th_{t-1} + CX_t + u_t \quad (6)$$

---

<sup>19</sup> This is data set on financial development and structure constructed by Beck , Demirguc-Kunt and Levine (2000) . I have used the latest revised version as at December 2009 (<http://econ.worldbank.org/external/default/main?menuPK=478071&pagePK=64168176&piPK=64168140&theSitePK=478060>).

<sup>20</sup> The application of the Kalman filter technique to generate a quarterly series is based on Shuetrim (1999).

where  $y_t$  is the observable values of the variable,  $h_t$  is unobserved values of the variable,  $X_t$  is the reference or related series and finally  $e_t$  and  $u_t$  are white noises. The relationship between  $y$  and  $h$  is described by the measurement equation (5), and equation (6) is called state equation. In other words, state equation describes the dynamics of the unobserved variable, quarterly Z-score (or  $h$ ), and measurement equation links the state to the observed variable (annual Z-score or  $y$ ).

The filter generates the new state (which contains some noise) by using a reference series (or related series),  $X_t$ . For our purpose, it is assumed that volatility of Z-score is originated from inflation and exchange rate variation because banks' profit and assets quality would change with changes in inflation and exchange rate if banks hold both domestic and foreign assets. The annual series of the Z-score was interpolated for the quarters of each year to use for filtering. Moreover, standardized exchange rate and inflation were calculated from the inflation rate and exchange rate series. The explanatory variable of the state equation of the filter ( $X_t$ ), was constructed with the weighted conditional variances of standardized inflation rate and exchange rate. To estimate the conditional variances of inflation rate and exchange rate, this study used GARCH (1, 1) (equation 7 and 8) for each and then the sum of weighted conditional variances of inflation rate and exchange rate (equation 9) was calculated as the aggregate conditional variance that can explain the variation of the Z-score

$$X_{in,t} = c + \alpha \varepsilon_{t-1}^2 + \beta X_{in,t-1} \quad (7)$$

$$X_{ex,t} = a + \varphi \omega_{t-1}^2 + \gamma X_{ex,t-1} \quad (8)$$

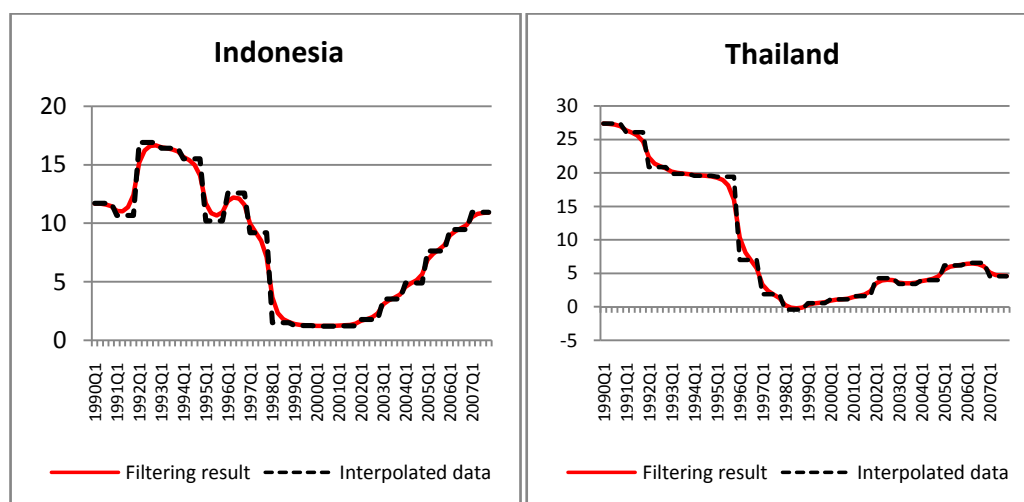
$$X_t = wX_{in,t} + (1 - w)X_{ex,t} \quad (9)$$

where  $X_{in,t}$  is conditional variance of inflation and  $X_{ex,t}$  is conditional variance of exchange rate.  $\varepsilon_{t-1}^2$  and  $\omega_{t-1}^2$  denote square of previous time period's shock to inflation and exchange rate, respectively.  $X_t$  is the sum of the weighted conditional variances where  $0 < w < 1$ . For each country weights are different because an attempt was made to make a strong relationship between the Z-score and measure of inflation rate and exchange rate. We expect an inverse relationship between the Z-score ratio and volatility of inflation rate and exchange rate since the higher the volatility of inflation rate and exchange rate, the higher the volatility of banks' profit and hence the lower Z-score ratio. Other related series could be considered since bank profitability can be correlated with some other variables such as liquid assets that can increase bank income. However, related series must be in the same frequency of unobserved variable that is quarterly observations, which limits us to choose the related variables. Thus, we found it intuitive to use inflation and exchange rate as related series since they are readily available for quarterly observations. Using the Kalman filter technique, interpolated data of Z-score is used as the state process with weighted conditional variances of inflation and exchange rate series as the related series. It is assumed that state and measurement noises are white and the nature of shocks to the system is the same for all countries. The filter is initialized using the unconditional variance of  $X_t$  and first observation of interpolated data. The output of filtering is the quarterly time series of the Z-score which is obtained for the empirical computation.

To find out whether the filtering result is desirable, a quick investigation can be done by doing comparison between the filtering results, that is the estimated quarterly Z-score (solid line in figure 3.1), and available published annual data of Z-

score (dashed line). Figure 3.1 demonstrates this comparison for two countries, for instance.

*Figure 3.1: Kalman filtering inference for Z-score*



In Figure 3.1 the annual published data is shown at the first quarter of each year and repeated for the rest of the quarters of each year. By a quick comparison of the solid and dashed lines at each quarter points, it may be found that there is no significant difference between the two series. To test this, the estimated quarterly Z-scores were averaged for each year to obtain an annual series. Then, the difference between estimated series and published series was statistically tested through the null hypothesis of no difference between the means of two annual series. The test result indicates that there is not enough evidence to reject the null hypothesis for all countries.

The alternative technique that could be used for interpolation of series is that introduced by Chow and Lin (1971). It is an econometric approach that assumes a linear relation between the series of interest and related series. It is not a very

complicated multiple regression approach and is commonly used. However, the Kalman filter technique is a dynamic framework that can be adapted for various models and hence it is more flexible. Furthermore, this technique is more desirable because it updates the first estimates of the system to use them as new information for the next period (Cuche and Hess, 1999).

### **3.6. An overview of economic situations and the financial system structure of the countries<sup>21</sup>**

Before estimating the empirical model, this section provides a brief description of economic situations and the financial system structure of the sample countries during the study period, 1990 to 2007. Indonesia is one of the large economies in Southeast Asia and a member of the G-20 economies. In the early 1990s, with some reforms in the economy, and focusing on export-oriented manufacturing sector, the Indonesian economy experienced an average growth of over 7% (Schwarz, 1994). As a response to currency crisis and depreciation, resulted from the East Asia financial crisis, Indonesia increased its domestic interest rate, floated the exchange rate and tightened its fiscal policy. The highest rate of inflation was in 1998 at about 77%. However, it decreased back to approximately 2% in 1999. It seems that the Indonesian economy is going to be a market-based economy where after the 1997 crisis, Indonesia's real value of stock market capitalization (as a percentage of GDP) has increased by 400% and the real value of traded domestic shares in the stock market has grown by nearly 196% whereas, real bank credit (as a percentage of GDP) has increased by 28% from 2000 to 2007. Table 3.2 shows after-crisis (2000-2007) stock market and banks activity for the countries. With a glance at Table 3.2, it is clear that stock markets

---

<sup>21</sup> The statistics of this section are from the World Bank and International Monetary Fund. Otherwise, references have been provided.



activity has grown more than banks activity in all countries except Korea where the growth of banks loans has been more than growth of the stock market activity.

*Table 3.2- Stock market and banks activity as the percentage of GDP. Stock market activity is measured as the real value of traded shares in the stock market in a given year divided by real GDP. Bank credit is the real value of deposit- money banks loan to the private sector as the percentage of real GDP.*

Country/year	Stock market activity (% of GDP)			Banks activity (banks loans as % of GDP)		
	2000	2007	Growth rate	2000	2007	Growth rate
<b>Indonesia</b>	8.7%	25.75%	196%	69.5%	89%	28%
<b>Korea</b>	52.25%	50.75%	-2.87%	294.5%	373.5%	27%
<b>Malaysia</b>	65%	82.75%	27.31%	126.5%	104.75%	-17.19%
<b>Philippines</b>	4.5%	29.75%	561%	154.25%	89.5%	-42%
<b>Singapore</b>	24.5%	59.5%	143%	383.75%	349.75	-8.86%
<b>Thailand</b>	19%	44%	132%	469%	359%	-23%
<b>Hong Kong</b>	224%	443%	98%	607%	576%	-5.11%
<b>Japan</b>	58%	148%	155%	197%	97%	-51%

Although the size of banks loans to the economy is greater than the size of liquidity provided to the economy by the stock markets, statistics show a rapid sharp growth of stock market activity in 2007 compared to 2000.

South Korea is classified as a high-income economy by the World Bank and a developed market by the FTSE Group and an advanced economy by International Monetary Fund (IMF). This country is known by its high-tech infrastructure where the government invests in some high-tech industries. During the Asian financial crisis the banking sector of South Korea suffered from a huge amount of non-performing loans. After the crisis banks loans was about 295% of GDP in 2000, and increased dramatically to 374% of GDP, whereas, its stock market activity has decreased by 2.87% (from 52.2% to 50.7% of GDP) in 2007 compared to year 2000 (Table 3.2). It seems that the financial system is more based on banks. In before-

crisis period (from 1990 to 1997) South Korea inflation had an average of about 6% with an average economic growth of nearly 4%. During the Asian financial crisis inflation rate increased to 9% in 1998 which is the highest rate after 11% in 1991 and real GDP growth dropped dramatically to 0.08% averagely in 1997-98. In 1999, inflation dropped sharply to about 1% and had an average rate of 3% with average real economic growth of 1.4% from 2000 to 2007. Thus, it seems that Korea has benefited from a bank-based financial system during the sample period since banking activity has risen whereas, stock market activity has fallen. This is to support high-tech industries of the Korea which need huge support of the banking system.

Malaysia is a growing economy with the average real GDP growth rate of about 2% to 3% during the period 1990-2007. However, it jumped up to 7% in the last three quarters of 2007. This country has had an average inflation rate of about 3% before the Asian financial crisis (1990 to 1997). In 1998 inflation rate was about 5.5%. After the crisis, it decreased to an average of 2% during the period of 2000 to 2007. The Central Bank of Malaysia introduced the Financial Sector Masterplan in 2001 to secure financial stability after the Asian financial crisis. The plan has an emphasis on Islamic banking. Malaysia owns a large Islamic banking sector where there are more than 2,200 branches of Islamic banks and other institutions offering Islamic banking products and services. In addition, in the capital market, Islamic debt securities and equity markets have grown rapidly (The Financial Sector Masterplan, Central bank of Malaysia). Islamic banking prohibits fixed income, interest bearing financial instrument and contracts. Thus, this system is expected to be less exposed to financial shocks such as interest rate changing.

The Philippines is known as one of the newly industrialized economies of Southeast Asia where the average growth of the real GDP was about 2% during the period 1990 to 1997 (before-crisis period) with the average inflation rate of 9.5%. In the financial crisis time inflation rate reached about 10% but after crisis the average inflation rate was about 5.5% during the period 1999 to 2007. Philippines has a variety of banks. However, banks credit to the private sector has dropped by 42% in 2007 compared to 2000, whereas stock market activity increased by 561% in 2007. However, banks credit size was much greater than the value of the stock market activity.

Singapore is a market-based economy with minimum intervention of the state in the economy. Singapore has one of the world's largest foreign exchange markets after New York, London and Tokyo (Monetary Authority of Singapore, annual report 2005/2006). Furthermore, Table 3.2 shows that the real value of the trades (as a percentage of real GDP) in the stock market has increased by 143% in 2007 compared to the stock market activity in 2000. The average real GDP growth of Singapore in the period before the crisis (1990-1996) and after the crisis (2000-2007) is about 2% and 1.8%, respectively. During the crisis period, Singapore experienced a growth rate of about 0.4%. The average inflation rate during 1990-1996, in crisis time (1997-98), and after crisis (2000-2007), was about 2.5%, 0.6% and 1%, respectively. The average growth rate of the real GDP, about 2%, over 1990-2007 with low inflation rate has made Singapore a developed economy.

Thailand is an emerging and newly industrialized economy in Southeast Asia. The average real economic growth of Thailand is about 2% during 1990-1996. Thailand suffered from the Asian financial crisis and experienced a real growth rate

about 0.4%. After the crisis the economy recovered and the average real growth rate increased to 1.5%. The inflation rate on average is 5.1%, 4.6% and 2.5% during 1990-1996, 1997-1999 and 2000-2007, respectively. The banking sector suffered from non-performing loans during the crisis time. The size of banks loans was much greater than the activity of the Thailand stock exchange. However, the stock market activity increased by 132% in 2007 compared to 2000 whereas, banks loans decreased by 23%.

Hong Kong is one of the Four Asian Tigers for its rapid economic growth and development. It was known as an industrialized economy after Second World War and then turned to a services-based economy in the 1980s (Hong Kong Government, 2010, <http://www.ceo.gov.hk/eng/press/oped.htm>). The economy of the Hong Kong is based on free transactions and market forces where the state intervention is very limited in the economy. Hong Kong has an active large Stock Exchange market that has been one of the largest centres of Initial Public Offering (IPO) in the world (<http://www.bloomberg.com>).<sup>22</sup> As Table 3.5 shows, the stock market activity has been about 443% of GDP which shows a growth of 98% compared to year 2000 whereas, the banking sector lending activity has decreased from 607% of GDP in 2000 to 576% of GDP in 2007. Hong Kong has been enjoying from low inflation rate where the average of inflation has been -0.80% during the period 2000-2007 with -3.72% inflation rate in 2000 and 2% in 2007.

Japan is most advanced Asian economy and a member of The Organisation for Economic Co-operation and Development (OECD). The economy of Japan is known with scientific research activities in technology and machinery. It is also leading in

---

<sup>22</sup> Bei H., 2009. Hong Kong IPOs may raise record \$48 Billion in 2010, <http://www.bloomberg.com>.

robotic science. Famous enterprises such as Toyota, Sony, Panasonic, Sharp, Toshiba, Honda and Canon have been founded in Japan. Tokyo Stock Exchange market is well-known for its Nikkei 225 and Topix indices. The value of traded shares in the stock market has been 58% of GDP in 2000 which it increased dramatically to 148% of GDP in 2007 whereas, banks loans was 197% and 97% of GDP in 2000 and 2007, respectively. The average of Inflation rate has been -0.14% during the period 2000-2007 and 1.21% in 1990-2000. The Japanese economy featured with huge number of banks and hence its financial system may be known as a bank-based financial system.

### **3.7. Estimating the dynamic responses**

#### ***3.7.1. Model specification***

The first step for model specification is testing the stationarity of the data to determine the variables' orders of integration. Variables with unit root (or non-stationary variables) yield non-reliable estimation results (or spurious regression results). For the unit root test, the commonly used Augmented Dickey–Fuller (ADF) and Phillips-Perron (PP) tests (Table 3.3) have been applied to test unit root hypothesis. The PP method estimates  $\Delta y_t = \rho y_{t-1} + u_t$  and tests the hypothesis of  $\rho = 0$ . The PP test addresses this issue that if the series is correlated at higher order lags of  $\Delta y_t$ , it will make  $y_{t-1}$  endogenous. Whilst ADF test also addresses this issue by adding lags of  $\Delta y_t$  as regressors in the test equation, PP test proposes alternative (non-parametric) methods for serial correlation. Furthermore, the test is robust to unspecified autocorrelation and heteroscedasticity in the disturbances of the test equation (Phillips and Perron, 1988). With the evaluation of the presence of deterministic trend in the data, the trend term is included in the ADF and PP tests

where relevant. As Table 3.3 shows, variables have unit root in levels and are stationary in first-difference values. The exception is Korea and Japan where both tests show that financial stability measure is stationary in level (in different significant levels). For the Malaysia case, ADF test suggests the stationarity of financial stability measure in level whereas, PP test shows that it has unit root. We rely on PP test and decide that financial stability measure is non-stationary in level for the case of Malaysia too. Output gap is stationary in level for all countries. Thus, in this study, country-specific augmented VAR model is estimated using the first-difference value of all variables except FS for Korea and Japan and OG for all countries<sup>23</sup>.

*Table 3.3: Unit root tests results. Figures imply test statistics; '\*' denotes stationarity at 1%, '\*\*' denotes stationarity at 5% and '\*\*\*' denotes stationary at 10% significance level. FS: Financial stability; FT: Financial structure; BC: Bank credit; NI: Nominal interest rate; OG: Output gap. Variables with letter 'D' imply first-difference value of variables.*

		FS	FT	BC	NI	OG	DFS	DFT	DBC	DNI
<b>Indonesia</b>	ADF	-1.52	-1.21	-1.36	-1.97	-4.25*	-2.81*	-4.92*	--4.82*	-4.81*
	PP	-1.23	-0.93	-1.16	-1.84	-4.37*	-2.11**	-4.31*	-4.91*	-4.33*
<b>Hong Kong</b>	ADF	-1.60	-0.60	-2.34	-2.23	-4.77*	-3.13*	-4.31*	-2.55*	-3.40**
	PP	-0.95	-0.44	-2.06	-1.69	-4.54*	-3.21**	-4.49*	-8.79*	-3.47**
<b>Korea</b>	ADF	-3.17**	-3.0	-0.40	-2.23	-4.29*	-9.35*	-4.94*	-1.90***	-5.04*
	PP	-3.94*	-2.05	-0.11	-1.28	-4.73*	-15.92*	-5.04*	-8.71*	-4.64*
<b>Malaysia</b>	ADF	-2.58***	-1.98	-2.87	-1.67	-3.98*	-2.52**	-6.50*	-5.40*	-4.57*
	PP	-1.47	-2.15	-1.78	-1.19	-3.66*	-1.76***	-6.58*	-5.49*	-4.56*
<b>Philippines</b>	ADF	-0.58	-1.36	-1.49	-1.91	-6.45*	-3.49*	-3.47**	-4.06*	-6.94*
	PP	-0.53	-1.10	-1.55	-1.45	-6.48*	-2.26**	-3.47**	-3.84*	-7.09*
<b>Singapore</b>	ADF	-1.80	-1.57	-1.48	-2.98**	-2.99**	-1.90***	-4.88*	-6.33*	-5.40*
	PP	-1.35	-1.65	-1.43	-1.95	-2.99**	-4.82*	-4.93*	-6.35*	-5.72*
<b>Thailand</b>	ADF	-1.90	-1.59	-1.10	-1.74	-2.99**	-3.78*	-4.0*	-5.58*	-5.22*
	PP	-1.59	-1.33	-1.69	-1.17	-3.15**	-3.83*	-4.07*	-5.56*	-5.31*
<b>Japan</b>	ADF	-3.46**	0.62	0.21	-5.08*	-3.07**	-3.84*	-15.28**	-24.16*	-4.46*
	PP	-2.79***	0.1	-1.69	-6.56*	-3.29*	-3.88*	-11.02*	-13.93*	-3.28**

As I already explained, we augment VAR models of countries with average of foreign variables across countries. The rationalization is that series might be cross-sectionally dependant. To test this statistically, Cross-section Dependence test (CD)

<sup>23</sup> The possibility of model misspecification due to co-integration is investigated in the Appendix.

which has been proposed by Pesaran (2004) was implemented. CD tests the null hypothesis of no correlation between residuals across cross-sections<sup>24</sup>. Table 3.4 reports the test statistics of CD for the panels of individual series. According to the test statistics, there exists an inter-relationship among individual panels except the panel of FS. FS is cross-sectionally dependant only for lag 1 (p=1). Thus, some variations of individual series of a country  $n$  of the sample can be explained by the corresponding series of other countries of this study. Then, I set regression (10) to regress variable  $y$  of country  $n$  to its own lags and current and lag values of the average of the same variable from other countries of this study. Given the VAR model (3) and following Chudik and Pesaran (2009), the following regression which has been augmented with star variables (cross-section averages), can be estimated consistently by least squares for each variable and each country  $n$ :

*Table 3.4- Cross-section dependence (CD) test. Under the null hypothesis of independent series across countries, the CD test is carried out at the 5% [2-sided] nominal significant level; the null is rejected if  $|CD| \geq 1.96$ .*

CD statistics				
Panel/Lag	P=1	P=2	P=3	P=4
<b>FS</b>	4.53	1.19	0.73	0.81
<b>FT</b>	7.18	8.25	8.49	8.19
<b>BC</b>	-4.05	-4.52	-4.65	-4.39
<b>OG</b>	11.48	11.02	11.52	10.77
<b>NI</b>	11.44	6.70	7.15	7.38

$$y_{nt} = \alpha_n + \sum_{\ell=1}^{p_n} a_{n\ell} y_{n,t-\ell} + \sum_{\ell=0}^{h_n} b_{n\ell} y_{n,t-\ell}^* + u_{nt} \quad (10)$$

for  $n = 1, 2, \dots, N$ ,  $N=8$ , where  $y_{n,t}^*$  denotes cross-section arithmetic average of corresponding foreign countries variables. Therefore, for each country  $n$ , 5

<sup>24</sup> Further details of CD test are explained in the Appendix.

regression models of (10) are estimated with lag order 2. Joint significance test of the coefficients of star variables in equation (10) with the Wald test can determine the significance of star variables and presence of dominant effects in the system. Changing the lag order to 1 did not change the result of the tests significantly. However, it seems that lag of 2 periods is much plausible to capture the previous effects sufficiently. According to the test results, the financial stability measure in Malaysia, Thailand and Singapore is not affected by the financial stability of other countries in the region. FT star (cross-section average of financial structure measure) is significant for Indonesia, Malaysia, Korea and Singapore. Therefore, for these countries, dominant effect should be considered. In other words, it can be concluded that there is an inter-relationship between the financial markets of these countries and the other countries of the study. The literature such as Forbes and Rigobon (2002) also provide evidence that there is interdependency between markets of East and south East Asia<sup>25</sup>. Moreover, star variables of BC are not significant for Philippines, Japan and Singapore, meaning that banks activity of these countries is not affected by banks activities of other countries. Nominal interest rate star is not significant for Indonesia, Korea and Singapore, meaning that the interest rate movement of these countries is independent of the movement of interest rate in other countries (no dominant effect for these countries). For output gap, only Singapore tends to be independent of other countries. Table 3.5 summarizes the results of the test. Letter Y in Table 3.5 denotes the significant star variables (rejection of null hypothesis of no dominant effects) and N denotes insignificant star variables in

---

<sup>25</sup> In addition to normal interdependency between Asian markets, studies such as Caporale et al. (2003), Bekaert *et al.* (2005), Bond *et al.* (2006) and Chiang *et al.* (2007), using a variety of techniques, all find evidence of spread of shocks between many markets in Asia. (See Dungey *et al.*, 2006 for more complete literature review).



equation (10). Given the result of the significance test, for each country, the VAR model (4) is estimated over the sample period to take in to account the effect of unobserved common factors and hence inter-relation between markets across countries.

Having implemented the Wald tests, the significant star variables (cross-section average of variables) were added to VAR models for all countries to capture unobserved common factors and to generate the dynamic effect of financial structure shocks. The impulse response function estimates are from the VARs with 3 lags, a constant, seasonal dummies and contemporaneous and lagged values of star variables which are included as exogenous variables. According to Hall (1989) and Johansen (1992), lag length should make the VAR residuals serially uncorrelated. For this study, lag of 3 is found to be sufficient to render the residuals serially uncorrelated.

*Table 3.5: The significance test of star variables (dominant effect) for each country, using the Wald significant test of star variables' coefficient in regression equation (10). Y denotes the significant star variable (rejection of null hypothesis) and N denotes insignificant star variables (not rejection of null hypothesis).*

Star variables					
	FS*	FT*	BC*	NI*	OG*
<b>Indonesia</b>	Y	Y	Y	N	Y
<b>Hong Kong</b>	Y	N	Y	Y	Y
<b>Malaysia</b>	N	Y	Y	Y	Y
<b>Philippines</b>	Y	N	N	Y	Y
<b>Thailand</b>	N	N	Y	Y	Y
<b>Japan</b>	Y	N	N	Y	Y
<b>Korea</b>	Y	Y	Y	N	Y
<b>Singapore</b>	N	Y	N	N	N

This study is based on generalized impulse response functions that have been developed by Koop *et al.* (1996) and Pesaran and Shin (1998). An impulse response function traces the effects of shock to an innovation on current and future values of

the endogenous variables. One of the problems with VAR estimation is contemporaneous correlation between innovations in VAR equations. This problem leads to inadequate response of a variable to innovations in other variables (Lutkepohl, 1991) because innovations are correlated. To solve this problem, Sims' (1980) strategy is commonly used by orthogonalizing the innovations using the Cholesky decomposition. Therefore, impulse response of the system is the response of the system to a particular shock given that all other shocks are zero. However, the approach depends on the ordering of variables and the impulse-responses may change with changing the order of the variables. The generalized impulse response functions (GIRF) can solve the ordering problem by making the responses unique, which are not affected by ordering the variable. More precisely, GIRF allows for the varying of other variables when one variable is shocked by averaging and integrating all other shocks. Thus, since there is no clear idea for the ordering of variables, this study applies generalized impulse responses for dynamic analysis.

Given the focus of this study, the selected generalized impulse responses are presented. Figure 3.2 presents generalized responses of the financial stability measure to a positive shock to the financial structure measure. Since variables are in first-difference value, Figure 3.2 presents that how the change of the measure of financial stability (Z-score) responds to a positive shock to the change of the financial structure measure<sup>26</sup>. On the whole, if the zero line is not within the asymptotic standard error bands, then the responses are significant (or different from zero)<sup>27</sup>. With a glance at Figure 3.2, we find that moving the financial system

---

<sup>26</sup> The financial stability measure of Korea and Japan are stationary in level (see Table 3.3). Hence, in VAR models of these two countries, the financial stability measure has been used in level and not in first difference.

<sup>27</sup> Impulse responses contain analytic (asymptotic) plus/minus two standard error bands.

towards a market-based system (or a positive shock to the financial structure measure) may support financial stability through the increase in the Z-score. However, this is not significant in some countries. Where impulse responses are insignificant statistically, it means that responses are not different statistically from zero given the plus/minus two standard error significance bands. It may look a weak result based on impulse responses. However, they still render useful information about the effect of performance of the stock market on banks' performance, given the model of estimation. The insignificant impulse responses suggest that enhancing the stock market through listing more shares and/or increasing the turnover of the market does not matter for financial soundness of banks and hence financial stability. This is unlike some of studies that were mentioned in the literature review of this chapter (in Introduction) where they have concluded that enhancing a market-based financial system can increase financial stability, estimating panel data models with using actual time episodes of banking crisis as a measure of financial instability. Using augmented VAR model for each country (or doing country-by-country analysis) and Z-score ratio instead of actual episode of banking crisis as the measure of financial (in)stability, the present study may shed a new light on this topic showing that enhancing a market-based financial system cannot enhance financial stability in all countries.

The increase in financial stability in response to the increase in the measure of financial structure is significant in Hong Kong, Japan and Malaysia for a few periods after the impulse time. The longest significant response is for Japan which lasts 5 periods (quarters). Therefore, it means that when the financial system is changed to be a market-orientated system, banks' financial soundness and hence financial

stability will increase for a short period. The rationalization is that with a positive shock to the financial structure measure, that is development in the size of the stock market and increase in turnover of total traded shares, a positive atmosphere in the market is created and hence this leads to a rise in assets price and positive returns. In such a situation, it seems that banks can benefit from upswing trend in the stock market, given that banks hold shares as liquid assets and hence they benefit from capital gain of the short-run investment in the shares. Moreover, given that investors finance some of their investments in shares from the banking system, when financial markets such as the stock market are enough developed in terms of financial instruments and is able to share risks among markets participants, the market risk is low and hence development in activity of such markets benefits the banking system through lowering the probability of loss for investors and then the probability of loan loss for the banking system will decrease for a short term. Such financial markets are able to provide enough liquidity to the economy and hence loan-financed investors can meet their financial obligations (or they can repay loans to the banking system).

In the case of Malaysia, the Financial Sector Masterplan which is aimed at financial stability has provided stability in the banking sector. Furthermore, a wide variety of Islamic banking services which are not exposed to some financial shocks have contributed to stability in the banking sector. In such banking system, enhancing activity of the stock market has not significant impact on banks' financial soundness and hence the response of financial stability measure is significant only at the shock time (Figure 3.2). The positive response of financial stability to the increase in financial structure measure is in line with Ruiz-Porrás (2008), where his

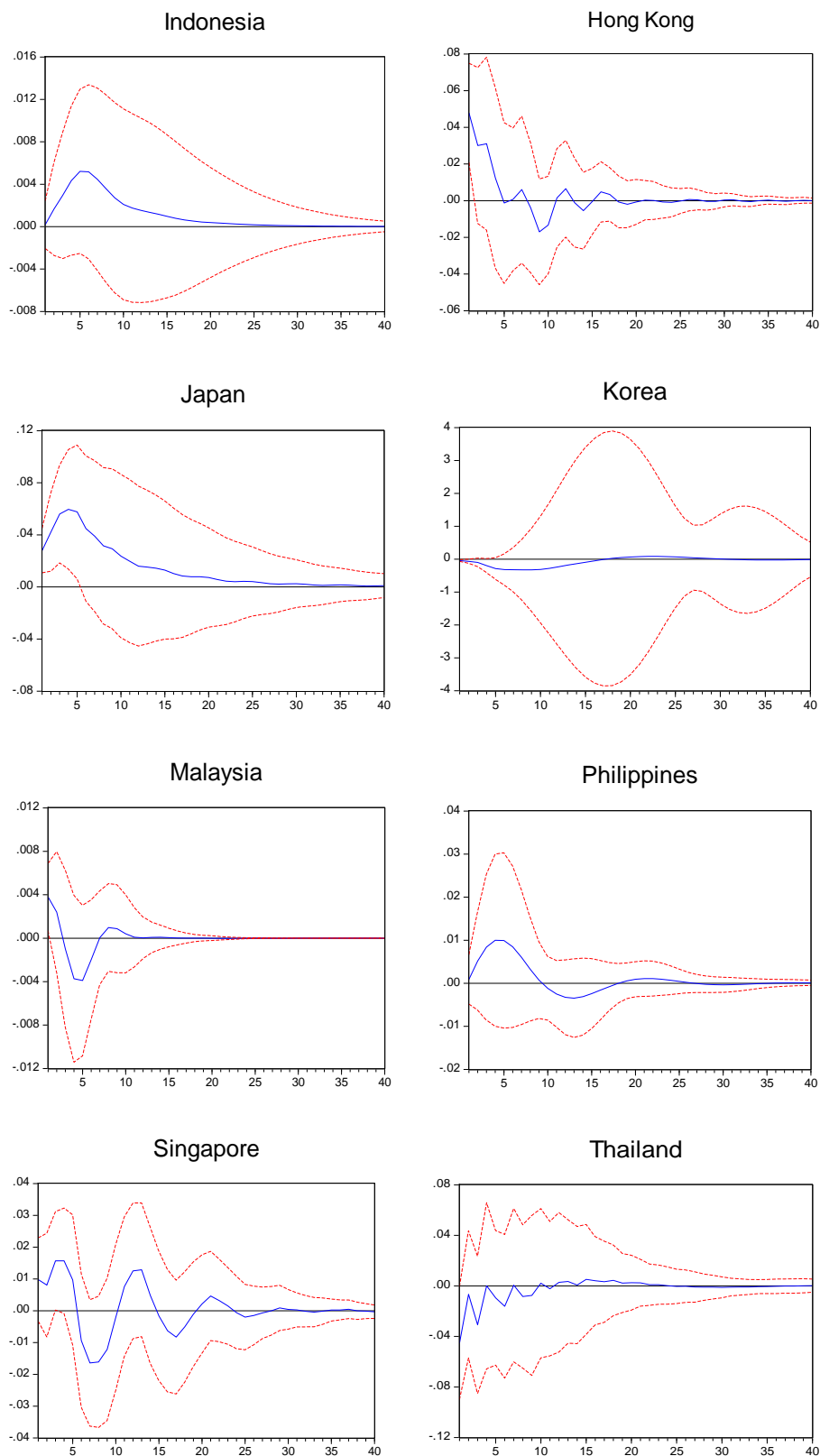
findings suggest that a market-based financial system might increase the banking system stability.

For the case of Korea, financial stability measure responds negatively to the increase in financial structure measure. However, it is not much significant since the impulse response is not significantly different from zero. On the whole, the negative response of financial stability may be because of the non-perfect financial system in terms of relationship between markets and institutions. For instance, heavy competition between banks and financial markets may cause banks to take risky activity to absorb funds when stock market is active and hence return volatility of banks increases (Allen and Gale, 2004). Furthermore, changing the upswing trend of the stock market to a downward trend leads to the fall in the value of debt-financed investors' balance sheet and hence this increases the probability of loan default in the banking sector. If the banking system cannot smooth the effect of this type of shocks, a positive shock to the financial structure measure can violate the banking system performance. For Korea, although the impulse response is not significant for a long time, it suggests that if financial shocks originating from enhancing the stock market activity and size are large enough, it may have negative impact on the financial status of banks at least for a few periods.

Figure 3.3 indicates the generalized response of financial structure to financial stability. The aim is to understand whether bidirectional causality exists between financial structure and financial stability. On the whole, there is no significant reaction from financial structure to financial stability except for Hong Kong, Japan and Malaysia for a few periods (2-3 quarters) where the increase of financial stability, through the rise of banks' financial soundness, supports the stock market

and hence leads to an increase to the activity of the stock market. This is intuitive that a stock market performs well in a situation in which systemic stability is convincing. It means that when banks' financial soundness increases through the profitability and efficient lending activity, banks can increase distance-to-default and hence do better in their intermediation activity and provide economy and hence investors with liquidity.

Besides the focal variables of this study, Figure 3.4 implies the sensitivity of financial stability to the positive shock to the change of nominal interest rate. This impulse response analysis shows the effect of monetary policy on the banking system's financial soundness and hence our financial stability measure. The impact of interest rates on banks depends on the net effect. The increase in lending interest rate acts as a tight monetary policy that limits banks lending and return on assets. On the other hand, tight monetary policy may contribute to reduce loan default rates because it provides banks an opportunity to control over loans and non-performing loans. This results in fall in return volatility and risk for banks. The net effect depends on how banks hold interest rates-sensitive assets and liabilities. Figure 3.4 shows that, on the whole, the change of financial stability respond negatively to the positive shock to the changes of nominal interest rate, meaning that tight monetary policy will decrease banks' financial soundness and hence financial stability. However, the sensitivity of financial stability to nominal interest rate is only significant statistically in Hong Kong and Korea where the measure of financial stability responds immediately to the increase in nominal interest rate, and then the effect of the shock vanishes after 2-3 periods.

*Figure 3.2: Generalized response of financial stability to financial structure*

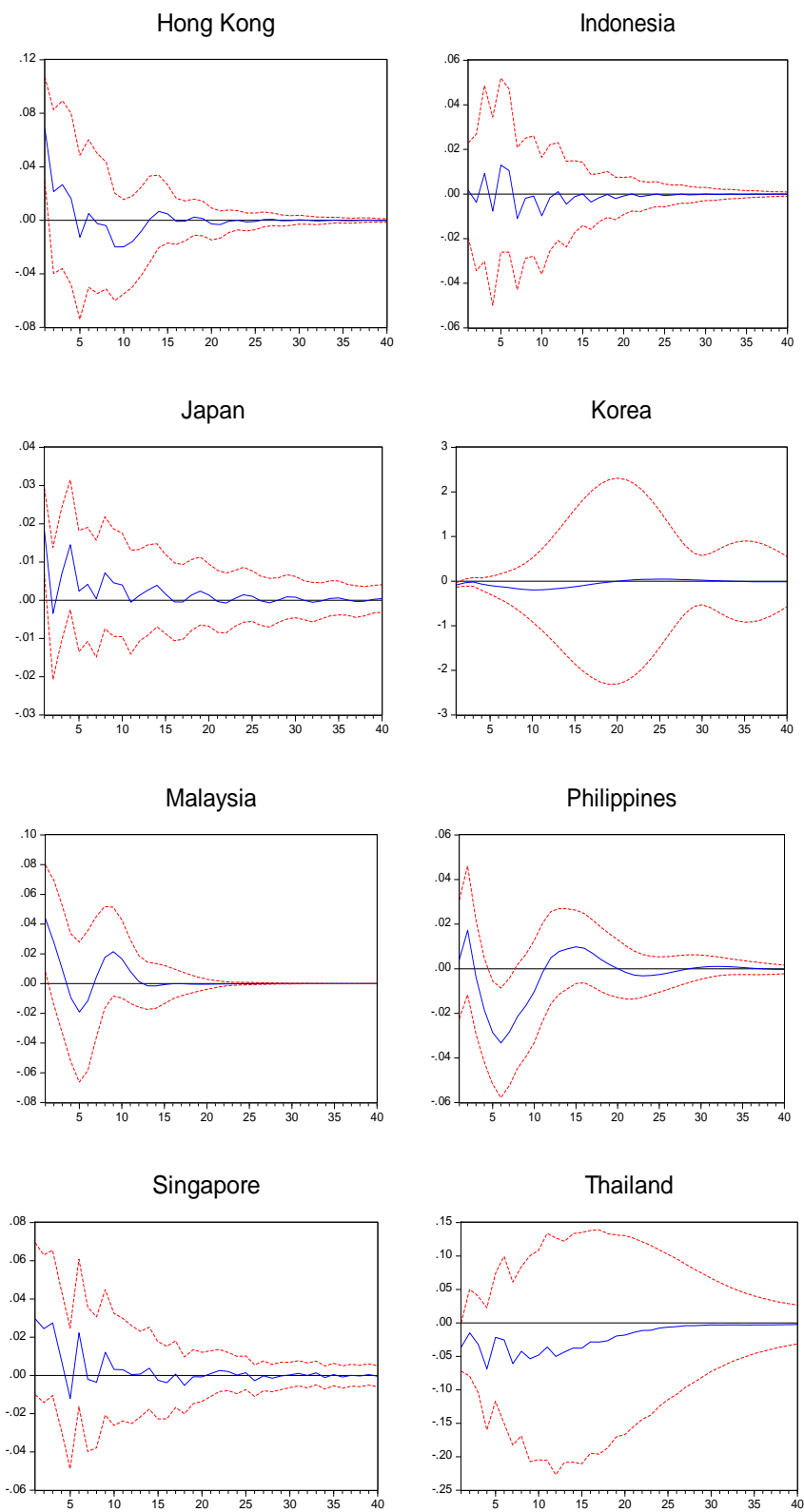
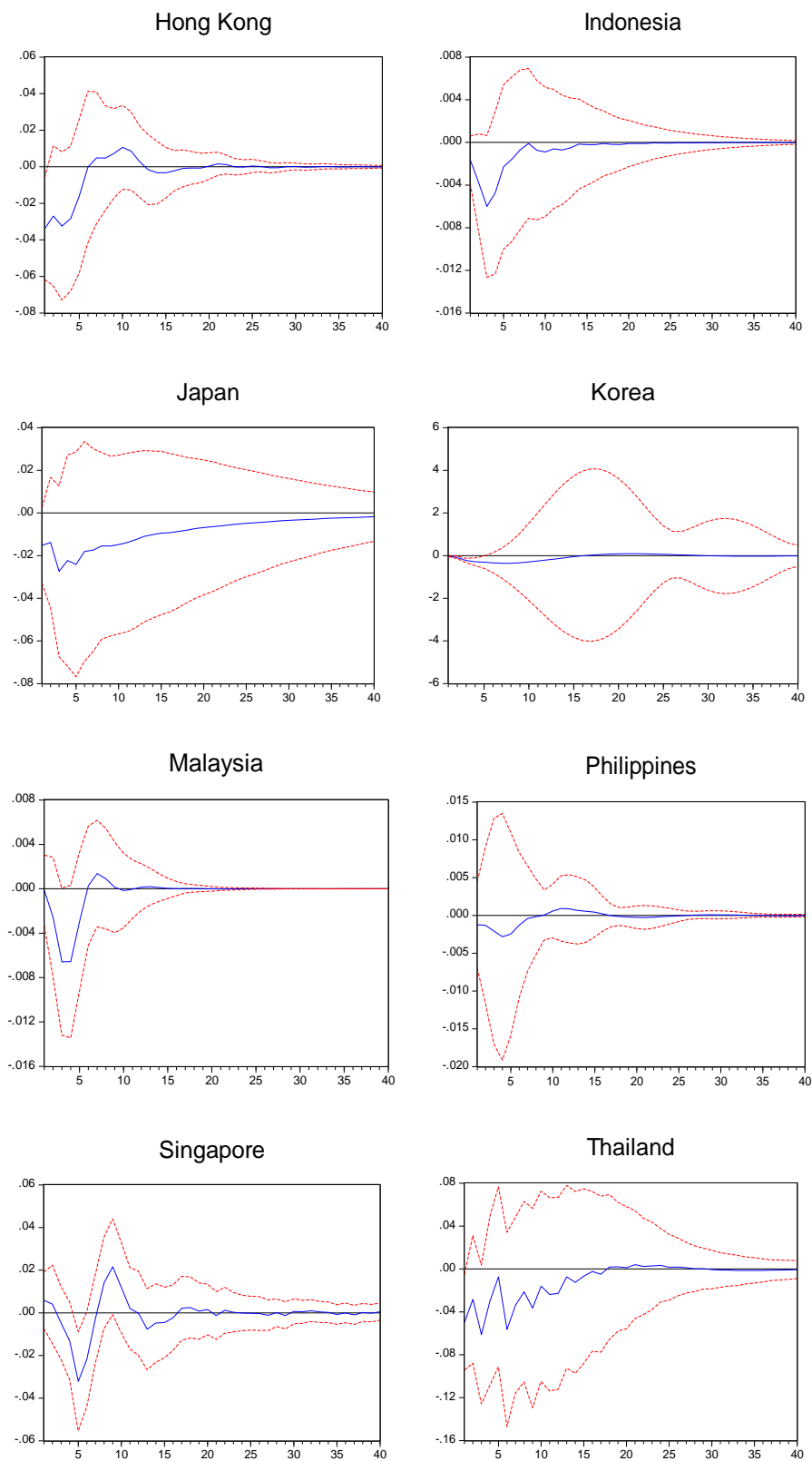
*Figure 3.3: Generalized response of financial structure to financial stability*



Figure 3.4: Generalized responses of financial stability to nominal interest rate



Financial stability also seems to respond immediately to the positive shock to nominal interest rate only at the impact time in Thailand.

### **3.8. Conclusion**

By estimating cross-sectional augmented country-specific VAR models that is estimating country-by-country VARs augmented by cross-sectional averages of endogenous variables (based on the global VAR model) for Indonesia, South Korea, Malaysia, the Philippines, Singapore, Thailand, Hong Kong and Japan, the evidence suggests that moving away from a bank-based towards a market-based financial system will support stability through the increase in banks' financial soundness in Hong Kong, Japan and Malaysia only. Immediate and short significant impulse responses suggest that enhancing a market-based financial system can be seen as a short run policy to increase banks' financial soundness and hence financial stability in Hong Kong and Japan and even for Malaysia. Financial stability measure does not seem to respond significantly to financial structure measure in other countries. However, insignificant responses still have important information where they suggest that moving towards the market-based financial system does not matter for financial stability of banking system and hence policy makers should be aware of this issue.

The different response of financial stability to the positive shock to the financial structure measure is because of different features of the financial system in each economy. The important point is that in order to enhancing a market-based financial system, developed financial risk management techniques (such as using financial derivatives) need to be applied to share risks among investors (see for instance, Allen and Gale, 2004 and Demirguc-Kunt and Huzinga, 2000). Enhancing (or developing)

the financial market (that is, moving towards a market-based financial system) causes banks to shrink their activity and their holdings of long-term assets, especially when markets are liquid (Diamond, 2004). Moreover, in such a system, banks may be more exposed to market risk, especially when risks cannot be hedged due to a lack of risk management tools. Hence, banks' balance sheets may be damaged by sudden changes in market prices, which might not be beneficial for banks and the economy that is fed mainly with liquidity provided by banks. For example, in South Korea, the financial system is a bank-based one where banks are more active than the stock market and provide credit for high-tech industries. Table 3.2 confirms the huge activity of the banking sector in South Korea where banks loans have increased by 27% in the 2000s accounting for 373.5% of GDP in 2007, whereas stock market activity has been about 51% of GDP in 2007 which is about 3% less than that in 2000. Thus, shrinking the activity of the banking system may decrease capabilities of the economy.

For the cases (such as Japan and Hong Kong) where the financial stability measure responds positively to the financial structure measure, financial markets are relatively more advanced than other countries of the study and hence the stock market activity shows a huge rise during the study-period (Table 3.2). This would increase liquidity in the economy and help the banking system to be less vulnerable to market risk. Moreover, moving towards a market-based financial system is associated with a rise in asset prices and credit expansion (Allen, 2001). This will help banks to make well diversified loan portfolios and hence have less return volatility.

This study additionally reveals that there is a bidirectional relation between stock market activity and financial soundness of banks in Hong Kong, Japan and Malaysia. Good financial status of banks increases financial soundness and hence this supports financial stability. This can instil confidence in the stock market and hence leads to promotion of activity in the stock market. One explanation is that when banks' profitability and equity capital increase this would support stock markets by expansion in banks' credit and by an increase in confidence in the financial system.

The banking system has been always sensitive to interest rates changes. Since our financial stability measure is based on banks' financial status, the changes of nominal interest rate then affect financial stability. This effect depends on the amount of interest rates-sensitive items that banks hold in their balance sheets. On the whole, tight monetary policy through an increase in lending interest rate means that monetary authorities want to control and decrease borrowing. Hence, this policy limits lending activity of the banking system where it may have a negative effect on return on assets of banks. This is the case for almost all countries (with significant and insignificant responses). Thus, a monetary authority should be aware that if it applies a tight monetary policy, the banking system will suffer as a result and may lose their financial soundness at least for a short period.

I am aware of this fact, that the structure of a financial system may be more complex than that which is defined by the size and activity of stock markets in relation to banks loans. However, the information of this chapter is useful for the policy makers who want to analyse the changes in the performance and financial status of the banking system in a situation where a sufficiently large enhancement occurs in the size and activity of the stock market. This is important because this

chapter discusses how financial soundness of banks is important for financial stability.

## **CHAPTER 4: Stress-test of loan loss of banks in some members of the EMEAP**

#### 4.1. Introduction

For the analysis of the financial system, many attempts are made to assess the vulnerability of the financial system to exceptional but plausible macroeconomic shocks. This type of analysis is called macroeconomic stress testing (Blaschke *et al.*, 2001; Sorge, 2004). ‘Stress’ is an extreme bad shock that is usually defined by the authorities of an economy based on the economy structure and historical economic events such as a huge downward change in the real Gross Domestic Product (GDP) of an economy. A ‘stress scenario’ consists of a presumed particular stress as defined by public authorities being implemented within the financial system during a given period. Therefore, in ‘stress-testing’ a group of financial institutions is subjected to stress scenarios to assess the resistance of the system to extreme shocks of each scenario. Thus, macroeconomic stress testing is an important tool for risk management and analysing financial stability (Sorge, 2004; Lopez, 2005). The public authorities are interested in stress-testing of the financial system, especially the banking system, because stress-testing allows one to analyse the financial system in relation to the macroeconomy to investigate the effects of macroeconomic conditions on the financial system during a specified time period. According to the related literature (for example, Gavin and Hausmann, 1995, among others), the deterioration of the macroeconomic environment is mostly the cause of financial weakness of single banks and hence the resulting panic within the banking system. Thus, it is in the interest of central banks to study the interactions between the macroeconomy and the financial system to analyse how the financial system, especially the banking system, is resistant to serious changes in economic conditions.

Stress-testing is one of the useful tools to analyse vulnerability of the financial system to macroeconomic deterioration.

Macroeconomic stress-testing is rather new in the academic field (Dovern *et al.*, 2010), and a number of different approaches have been taken. Initial approaches, used, for instance, by the International Monetary Fund (IMF) in its Financial System Assessment Programmes, look at the impact of a single macroeconomic variable on banks' balance sheets (Hoggarth *et al.*, 2005a, 2005b). The drawback of this approach is that it does not allow for interaction between macroeconomic variables. Therefore, later studies such as Hoggarth *et al.* (2005b) used VAR approaches to do a stress test of the banking system in the UK.

The objective of this chapter is to analyse the effects of macroeconomic stresses on the loan loss of banks to test the strength of the banking system in eight members of the EMEAP<sup>28</sup>; Indonesia, Malaysia, Singapore, the Philippines, Thailand, Hong Kong, South Korea, and Japan. In the present study, loan default rates are obtained as the measure of likely loan loss of banks and then as a factor that may affect financial soundness of a bank. The countries of the study have suffered from the same extreme phenomenon that is the Asian financial crisis of 1997/8. The Asian financial crisis emerged from the financial collapse of the Thailand currency (Thai baht) beginning in July 1997. The crisis increased unemployment, poverty and private debt in Thailand and other countries of the region (Lane, 1999). The crisis spread and most of Southeast Asia<sup>29</sup> and Japan suffered from devalued stock market, currency devaluation and rising private debt<sup>30</sup>. To define plausible stresses,

---

<sup>28</sup> The Executives' Meeting of East Asia-Pacific Central Banks.

<sup>29</sup> Indonesia, South Korea and Thailand were the most affected countries. Hong Kong, Malaysia, the Philippines and Singapore were also hurt by the crisis and the slump.

<sup>30</sup> See Kaufman *et al.* (1999) page 195, among others, for more details.



therefore, this study defines stress scenarios similar to the large shocks that happened during the Asian financial crisis and then implements stresses over macroeconomic variables to analyse the possible responses of loan default rates to the stresses. Indeed, the objective is to demonstrate how banks remain strong against some crisis-like extreme events. This is done by estimating an empirical model and then simulating banks' loan default rates using a stochastic simulation technique. The results yield probability distribution of banks' loan default rates and hence banks' possible loss which might have originated from the lending activity of banks conditional on some predefined stress scenarios.

In this chapter a stochastic simulation technique is used for stress-testing of the banking system. In this technique, after estimating an empirical model (a VAR model) and defining some scenarios, the value of a particular variable is forecasted under a specific condition (or scenario), allowing stochastic components (error terms) of equations to be non-zero. Therefore, one has to deal with non-zero error terms in the forecast. Assuming error terms to be randomly distributed, a random variable needs to be generated from a presumed statistical distribution to represent a realization of error terms. Here, random variables are used to calculate the frequency distribution of loan default rates (or to forecast possible paths of the default rates) based on an empirical macroeconomic model. This is not the case in the deterministic stress-testing where error terms are assumed to be zero and the stochastic component is absent. Hence, only one path of evolution of a variable is computed under a scenario in a deterministic approach.

In the macroeconomic studies, it is normal to assume that variables (error terms) are normally distributed and hence random variables are generated by the normal

distribution, and then these random variables correspond to error terms of the system in the simulation. However, the normal distribution cannot accurately predict the probability of extreme values occurring because the normal distribution is characterised by thin tails. Hence, for data with fat tails (or a lot of extreme value), non-normal distributions should be used to model the tail events (Rachev and Mittnik, 2000). Among non-normal distributions, alpha-stable distribution (which is also called stable distributions) is a distribution that has been proposed for modelling the distribution of data with fat-tail properties. However, with  $\alpha < 2$  ( $\alpha$  is the stability index in the characteristic function of a stable random variable), stable distributions obtain infinite second moments that make tails too fat. Tempered stable distributions were proposed to overcome this problem of stable distributions (see Rosinski, 2007, for more details). In the tempered stable distribution, fat tails of a stable distribution are tempered to obtain all moment finite along with the desirable properties of stable distributions such as infinitely divisibility. This study therefore, uses the tempered stable distribution to generate the random variable and simulate the distribution of some macroeconomic variables such as inflation and real interest rate<sup>31</sup>. Therefore, the tempered stable distribution would be able to capture the extreme values or outliers since it has fatter tails than the normal distribution. Moreover, this study considers the effect of the neighbouring economies in the estimation of the empirical model for each country because the countries are interrelated and constitute a block of economies in East and Southeast Asia which represent the economic conditions of the region. This is also useful to capture

---

<sup>31</sup> For instance, Charemza *et al.* (2010a) indicate that fitting the tempered stable distribution for error terms of a two-variable VAR model (Inflation and output gap) can generate a series for inflation that more satisfactorily resembles the series of inflation with outlier values than using the normal distribution for Indonesia, Malaysia and Pakistan.

indirectly the effect of the world economy since the economies of the region, especially Japan and South Korea are affected by the rest of the world (i.e. US economy). Thus, assuming the existence of common effects and dominant economies among the countries, this study uses the global vector autoregressive model (VAR) proposed by Pesaran *et al.* (2004) and Chudik and Pesaran (2009) to capture the interrelations between markets and economies.

For the remainder of this study, section 4.2 explains the tempered stable distribution. Section 4.3 presents the empirical model. Section 4.4 provides the results of estimation of the model that is defined in section 4.3. Section 4.5 develops a stress-test framework. Section 4.6 provides the simulation results and section 4.7 concludes.

## 4.2. Tempered stable distribution

The extreme events are observed in some macroeconomic data, especially financial variables. Therefore, ‘fat tails’ is a well known feature of some probability distributions. Given the normal distribution as a reference for comparing tails of distributions, a distribution is said have fatter tails than the normal distribution if there exist a lot of events and values that wander away from the average and receive higher frequency than those in the normal distribution (Allen *et al.*, 2004). The normal distribution is a probability distribution which is known as an example of a thin tail distribution. The normal distribution is defined by the following probability density function:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-(x-\mu)^2/(2\sigma^2)}, \text{ where } \sigma \text{ is the variance and } \mu \text{ is the mean. } \pi \text{ is}$$

approximately 3.14 and  $e$  is approximately 2.72.  $x$  denotes a normal random variable. The assumption of normality cannot accurately model fat tail events and

hence is not suitable for forecasting empirical distributions of some variables because the probability of outsized events is higher than what is predicted by the normal distribution. For data with fat tails, non normal distribution are required to model the tail events and hence the empirical distribution (see, for example, Rachev and Mittnik, 2000). The stable distribution (which is also called alpha stable distribution) is one of the various non-normal distributions that were proposed to model the distributions with skewness and fat tail properties. Random variable  $X$  is said to be stable if there is a positive number  $B$  and a real number  $D$  such that  $X_1 + X_2$  has the same distribution as  $B.X + D$ .  $X_1$  and  $X_2$  are independent copies of  $X$ . This is referred to the feature of infinitely divisible (Samorodnitsky and Taqqu, 1994).  $X$  would be called stable if its characteristic function is defined by:

$$\exp \left[ -\delta^\alpha |\lambda|^\alpha \left( 1 - i\beta \left( \operatorname{sgn}(\lambda) \tan\left(\frac{\pi\alpha}{2}\right) \right) + i\mu\lambda \right) \right] \text{ for } \alpha \neq 1$$

and  $\exp \left[ -\delta |\lambda| \left( 1 - i\beta \frac{2}{\pi} (\operatorname{sgn}(\lambda)) \ln|\lambda| \right) + i\lambda\mu \right] \text{ for } \alpha = 1$ <sup>32</sup>.

$\alpha \in (0,2)$  is the stability index that specifies asymptotic behaviour of the distribution.  $\delta$  is either zero or positive and is called scale parameter that determines the width of the distribution. The location parameter is  $\mu \in R$ . Skewness of the distribution is determined by  $\beta \in [-1,1]$ .

The probability densities of stable random variables exist. However, they are not known in closed form (Samorodnitsky and Taqqu ,1994). There are some exceptions with particular parameters value such as Gaussian distribution from setting  $\alpha = 2$  and  $\beta = 0$ . With setting  $\alpha = 1$  and  $\beta = 1$  Levy distribution is yielded as:

$$\exp \left[ -\frac{\delta}{2(x-\mu)} \right] \frac{1}{(x-\mu)^{3/2}} \left( \frac{\delta}{2\pi} \right)^{1/2}.$$

---

<sup>32</sup> See, for example, Samorodnitsky and Taqqu (1994) and Nolan (2009) for more details.

Hence,  $\alpha = 2$  yields the standard normal distribution. Therefore, the normal distribution is a special case of the stable distributions. All stable distributions are infinitely divisible, meaning that there exists a distribution function  $f_n$  such that  $F$  is the sum of  $n$  copies ( $n$ -fold collection) of  $f_n$ . In other words, with this property, a random variable can be defined as a sum of  $n$  independent identically-distributed random variables. In this case,  $F$  is infinitely divisible. Every infinitely divisible distribution corresponds to a stochastic process, meaning that there is indeterminacy in the future evolution of the process under time and hence one has not to stick on only one possible way to interpret the evolution of the process. This is described by probability distributions.

For all  $\alpha < 2$ , stable distributions have infinite second moments. To overcome this limit, Tempered stable (TS) distributions were proposed to have all moments finite and, at the same time, desirable properties of stable distributions such as infinitely divisible property is kept (Rosinski, 2007). The TS distribution was introduced in finance by Boyarchenko and Levendorskiy (2000) as a class of infinitely divisible distributions that are able to combine some properties of stable and Gaussian distributions (Charemza *et al.*, 2010b). It implies a fatter tail than the standard normal distribution and seems to be more suitable to capture the extreme events observed in inflation with time episodes of considerable high inflation and real interest rate. Hence, in this chapter, TS distributions with the density function of  $g(x) = \frac{\exp(-\theta x) f_s(x)}{f^*(\theta)}$  are used (Rosinski, 2007); where  $\theta > 0$ .  $f_s(x)$  is a density functions of the  $\alpha$ -stable distribution and  $f^*(\theta)$  denotes its Laplace transformation:

$$f^*(s) = \exp(-\xi\{(\theta + |s|)\alpha - \theta^\alpha\}) \text{ where } \xi = \frac{\delta^\alpha}{\cos\left(\frac{\pi\alpha}{2}\right)} \text{ (Charemza et al., 2010a).}$$

$\alpha$  determines the tail fatness of the distribution.  $\delta$  is the coefficient of scale of the  $\alpha$ -stable distribution.  $\beta$  represents the skewness of the distribution. Positive  $\beta$  means that the distribution is skewed positively (to the right).  $\theta$  is the parameter of exponential tilting to temper jumps and hence fat tails of the probability density function of  $\alpha$ -stable distribution in such a way that yields finite moments and also, at the same time, keeps desirable properties of  $\alpha$ -stable distribution.

In order to comparison between tails of the normal distribution and a TS distribution, I generated a TS distribution with  $\alpha = 1.5, \beta = 0$  and  $\theta = 1$  and then I compared it with the normal distribution. More precisely, the goal was comparing the probability of occurring tail events in these two distributions. For this, I considered the number of values of the distribution (in absolute value) that are greater than three standard deviation of the distribution as tail events. For the normal distribution, this accounts for about  $1 - 0.997 = 0.003$  (or % 0.3) of the rest of the distribution. For the generated TS distribution, about % 0.5 of numbers are greater than three standard deviation of the distribution. It means that the probability of outsized events in the TS distribution is greater than what the normal distribution can predict. Hence, the assumption of normality may be incorrect for the data with fat tail (outsized) events. Here, the TS distribution would be the process that generates disturbances of equations of inflation and real interest rate in the simulation of future path of the variables.

In this chapter, estimating a five-equation VAR model (for loan default rate, real bank credit growth, real GDP growth, inflation and real interest rate), future possible paths of variables are simulated to describe the behaviour of banks loan default rates conditional to artificial stresses in a given forecast period in the future. Stresses are

defined by stress scenarios and implemented over the variables through changing corresponding generated disturbances with stresses in the simulation (see section 4.5 of this chapter). This study uses the TS distribution to generate disturbances of inflation and real interest rate. For the rest of variables, disturbances are assumed to be normally distributed. This is done in such a way that the simulation results resemble the data of inflation and interest rate (that have outsized observations as exists in most countries of the study) to have more accurate forecast of future paths of variables.

### **4.3. The empirical model**

In this study, the aim of the simulation of future paths of variables is computing the possible values that loans default rate may obtain in the future when macroeconomic conditions change based on presumed stress scenarios. The simulation of default rates involves two steps: First, estimating an empirical model that links the default rates to the macroeconomic variables. This would determine how macroeconomic variables can explain the variation of default rates in a dynamic system. For this, a system of equations for default rate and macroeconomic dynamics are constructed through a VAR model in the light of the global VAR model proposed by Pesaran *et al.* (2004) and Chudik and Pesaran (2009). Second, using the estimated equations, possible default rates of banks' loans (or credit risk) are calculated with a simulation technique.

To define the loan default rate, this chapter uses, among the items of banks' balance sheet, the amount of non-performing loans (NPLs) at time  $t$ . Since the Asian financial crisis, NPLs have been increasingly considered by academicians and practitioners as one of the suspects of the Asian crisis (Collyns and Senhadji, 2002;

Dovern *et al.*, 2010; Kawack, 2000; Quingley, 2001). Therefore, one of the indicators that might be a threat to the financial strength of banks is NPL. NPLs are loans that are in default or very close to being in default. Mostly, it reflects the loans that are more than 3 months overdue. This study uses this variable to analyse banks likely loan loss. One of the popular measures (in relation to NPL) is loan default rate which is defined as the ratio of NPLs to the total amount of loans. As default rate ( $p_t$ ) is bound between zero and 1, it was transformed to  $FI_t$  by using the formula  $FI_t = \ln(\frac{1-p_t}{p_t})$  and hence it yields  $-\infty < FI_t < +\infty$ . In this way,  $FI_t$  is not bound in a particular range of values and hence can be estimated over macroeconomic variables. Obviously,  $FI_t$  and  $p_t$  are negatively related. In the present study, therefore, transformed loan default rate ( $FI$ ) and loans to the private sector are added to the standard macroeconomic VAR model. Accepting that macroeconomic conditions have significant impact on individual banks and hence on the banking system, this study constructs a VAR model that links the macroeconomy to the banking system (this approach has been widely accepted in the literature. See for example, Dovern *et al.*, 2010). The macroeconomic variables that were chosen (for the present study) are real GDP growth, inflation rate, real interest rate and domestic real credit growth. The first three variables are variables that are used to analyse the macroeconomic condition of an economy. For this study, real growth of loans to the private sector (real credit growth) is added since it may reflect the risk of private sector default in repayment of loans and its effect on the rise of banks loan default rate. Here, it is assumed that loans to government or to government-owned sectors cannot significantly raise the risk of loan defaults as government usually bails out its troubled institutions. Additionally, assuming presence of dominant and unobserved



common effects among countries of the study, weighted average of real GDP growth and weighted average of FI of the countries (as exogenous variables) are added to the system (where they are significant i.e. where dominant effects exists). For the present study, weight was determined according to the trade (sum of imports and exports) between the countries<sup>33</sup>. The exogenous variables can capture unobserved common factors and the interrelations between economies and markets (Chudik and Pesaran, 2009) since economic performance of countries of the study may be correlated since they are neighbouring countries in the region of East and South East Asia. Table 4.1 shows the data and their descriptions.

*Table 4.1- Data description and sources. Note: Following Beck, Demircuc-Kunt and Levine (2009), real bank credit is calculated by  $(0.5) * (\text{private loan}/C + \text{private loan}(-1)/C(-1))$  where private loan(-1) denotes banks' loan to the private sector in previous period, C denotes end period CPI. Real interest rate is calculated by  $(1+i/1+if)-1$ , where i denotes nominal lending interest rate and if denotes inflation rate (percentage change in CPI). '\*\*' denotes exogenous variables which were added to the estimation model only where they are significant (see the text for details).*

Variable	Description	Data sources
<b>Default rate (P)</b>	Ratio of banks non-performing loans to total loans	National statistics, The World Bank (WDI).
<b>Transformed default rate (FI)</b>	Logit-transformed of default rate through $FI_t = \ln\left(\frac{1-p_t}{p_t}\right)$	Author calculation.
<b>Bank real credit growth (BC)</b>	First difference value of log of real loans to private sector by banks	IMF's International Financial Statistics (IFS), Author calculation.
<b>Real GDP growth (GDP)</b>	First difference value of log of real Gross Domestic Product (GDP)	IFS, Author calculation.
<b>Inflation (IF)</b>	Percentage change of consumer Price Index (CPI)	IFS, Author calculation.
<b>Real interest rate(IN)</b>	The real short term lending interest rate	IFS, World Bank, Central banks of countries.
<b>Average of GDP of the countries* (GDP*)</b>	Weighted average of GDPs of the neighboring countries of the study.	Author calculation.
<b>Average of FI of the countries* (FI*)</b>	Weighted average of FIs of the neighboring countries of the study.	Author calculation.

<sup>33</sup> Here, for country  $n$ , weights were defined as the trade of country  $n$  with country  $m$  divided by total trade of country  $n$ .

The empirical model that is used for this chapter is the same as that in chapter 3. The model is explained briefly below:

Let  $\mathbf{z}_{nt} = (FI_{nt}, BC_{nt}, GDP_{nt}, IF_{nt}, IN_{nt})'$  be the vector of five endogenous variables for country  $n$ ,  $n = 1, 2, \dots, N$  and  $N=8$ , at time  $t$ . Then, suppose that all the variables in  $\mathbf{Z}_t = (\mathbf{z}'_{1t}, \mathbf{z}'_{2t}, \dots, \mathbf{z}'_{Nt})'$  are endogenously determined within a  $NK \times NK$  panel VAR model:

$$\mathbf{Z}_t = \boldsymbol{\alpha} + \boldsymbol{\Phi}(\mathbf{L})\mathbf{Z}_{t-1} + \boldsymbol{\varepsilon}_t \quad (1)$$

where  $k=1, 2, \dots, K$ , and  $K=5$  is the number of endogenous variables.

$\boldsymbol{\alpha} = (\boldsymbol{\alpha}'_1, \boldsymbol{\alpha}'_2, \dots, \boldsymbol{\alpha}'_N)'$  is  $NK \times 1$  vector of fixed effects,  $\boldsymbol{\alpha}_n = (\alpha_{n1}, \dots, \alpha_{nk})'$ ,  $\boldsymbol{\Phi}(\mathbf{L})$  is a lag polynomial ( $\rho$  lags) with the VAR coefficients;  $\boldsymbol{\varepsilon}_t = (\boldsymbol{\varepsilon}'_{1t}, \boldsymbol{\varepsilon}'_{2t}, \dots, \boldsymbol{\varepsilon}'_{Nt})'$ ,  $\boldsymbol{\varepsilon}_{nt} = (\varepsilon_{n1t}, \dots, \varepsilon_{nkt})'$ , is the vector of disturbances.

Equation (1), with one lag, can be presented in the following form

$$\begin{pmatrix} \mathbf{z}_{1t} \\ \mathbf{z}_{2t} \\ \vdots \\ \mathbf{z}_{Nt} \end{pmatrix} = \begin{pmatrix} \boldsymbol{\alpha}_1 \\ \boldsymbol{\alpha}_2 \\ \vdots \\ \boldsymbol{\alpha}_N \end{pmatrix} + \begin{pmatrix} \boldsymbol{\Phi}_{11} & \dots & \boldsymbol{\Phi}_{1N} \\ \vdots & \ddots & \vdots \\ \boldsymbol{\Phi}_{N1} & \dots & \boldsymbol{\Phi}_{NN} \end{pmatrix} \begin{pmatrix} \mathbf{z}_{1t-1} \\ \mathbf{z}_{2t-1} \\ \vdots \\ \mathbf{z}_{Nt-1} \end{pmatrix} + \begin{pmatrix} \boldsymbol{\varepsilon}_{1t} \\ \boldsymbol{\varepsilon}_{2t} \\ \vdots \\ \boldsymbol{\varepsilon}_{Nt} \end{pmatrix} \quad (2)$$

where  $\boldsymbol{\Phi}$  has been partitioned to  $K \times K$  dimensional sub-matrices  $\boldsymbol{\Phi}_{ij}$ . In (2) there are cross-section lagged interdependencies whenever  $\boldsymbol{\Phi}_{ij} \neq \mathbf{0}$  for any  $i \neq j$ . Obviously, if countries are cross-sectionally interdependent, it would make the system of parameters larger. Adding some exogenous variables to the system to capture the effect of the global economy will also increase the number of parameters for the estimation. Thus, this leads to a large dimensional model that the “curse of

dimensionality” may cause one to omit some important variables to solve the dimensionality problem.

Assuming that there are dominant effects from the countries of the region and they affect significantly on other countries of the study, Chudik and Pesaran (2009) propose a method to estimate this system. In this case, if the country-specific VAR model is augmented with cross-sectional averages of variables of other countries’ of the study (equation 3), the model can capture the effect of local dominant and unobserved common factors without the problem of dimensionality. For this, let  $\mathbf{z}_t^* = \mathbf{W}' \cdot \mathbf{z}_t$  where  $\mathbf{W} = (\mathbf{W}_1, \dots, \mathbf{W}_N)'$  is any matrix of predetermined weights. Then, the following augmented VAR model should be estimated for each country  $n$

$$\mathbf{z}_{nt} = \alpha_n + \sum_{\ell=1}^{p_n} \Phi_{\ell ii} \mathbf{z}_{n,t-\ell} + \sum_{\ell=0}^{q_n} \Omega_{\ell n} \mathbf{z}_{n,t-\ell}^* + \varepsilon_{nt} \quad (3)$$

where  $\mathbf{z}_n^*$  is the vector of cross-sectional weighted averages of the variables of the countries other than country  $n$ :  $\mathbf{z}_n^* = \sum_{m=1}^{n-1} w_{nm} \mathbf{z}_m$ ;  $w_{nm}$  denotes the weight assigned for country  $n$  according to the trade volume (sum of imports and exports) between country  $n$  and country  $m$ ,  $n \neq m$ <sup>34</sup>. It implies the relation between country  $n$  and  $m$  and the effect of country  $m$  on country  $n$ . Since the model assumes that the number of unobserved common factors is lower than the number of endogenous variables per country ( $k$ ), full augmentation of the VAR model by averages of all endogenous variables across countries is not necessary for consistent estimation of VAR coefficients (Chudik and Pesaran ,2009). Thus, a system of equations to be estimated for each country  $n$  is ( $n$  has been removed for convenience):

---

<sup>34</sup> Here, weights were defined as the trade of country  $n$  with country  $m$  divided by total trade of country  $n$ .

$$FI_t = c_1 + \gamma_1 FI_{t-1} + \dots + \gamma_q FI_{t-q} + b_1 x_{t-1} + \dots + b_q x_{t-q} + d_1 x_{t-1}^* + \dots + d_r x_{t-r}^* + \varepsilon_{1t} \quad (4)$$

$$x_t = c_2 + \alpha_1 x_{t-1} + \dots + \alpha_q x_{t-q} + \delta_1 FI_{t-1} + \dots + \delta_q FI_{t-q} + \psi_1 x_{t-1}^* + \dots + \psi_r x_{t-r}^* + v_t \quad (5)$$

where  $c_1$  and  $c_2 = (c_{12}, c_{22}, c_{32}, c_{42})'$  are constant,  $x_t$  is the vector of macro-economic variables,  $x_t = (BC_t, GDP_t, IF_t, IN_t)'$  and  $x_t^*$  is the vector of weighted average of transformed default rates and real GDP growth of other countries of the study to capture the interrelationship between economies<sup>35</sup>.

$\varepsilon_{1t}$  and  $v_t = (\varepsilon_{2t}, \varepsilon_{3t}, \varepsilon_{4t}, \varepsilon_{5t})'$  are the disturbances which I assume that they are serially uncorrelated. For the simulation, this study assumes that  $\varepsilon_{4t}$  and  $\varepsilon_{5t}$  are generated by a TS distribution, (as already explained)<sup>36</sup>, and the rest of disturbances in the system of equations (4) and (5) are generated from the normal distribution with mean being zero and variance-covariance matrix being  $\Sigma$ . Furthermore, let  $e_t = \begin{pmatrix} \varepsilon_{1t} \\ v_t \end{pmatrix}$  then this study assumes that all disturbances are correlated with variance-covariance matrix  $\Sigma_e$ . Therefore, for the purpose of this study, I allow off-diagonal elements of  $\Sigma_e$  to be non-zero. This system indicates the link of our indicator of possible banks' loss to its own lags and lags of each macroeconomic variable where macroeconomic condition possesses a dynamic process.  $x_t^*$  is the vector of exogenous variables. Finally, this system allows the feedback effect of banks activity on economy by letting  $x_t$  depends on past values of transformed loans default rate.

Before estimating the empirical model the variables' orders of integration should be determined. The existence of unit root leads to invalid estimates (spurious regression results) which show high goodness of fit and high  $t$ -ratios. The raw data

---

<sup>35</sup> See the Appendix for details.

<sup>36</sup>  $\varepsilon_{4t}$  and  $\varepsilon_{5t}$  correspond to equations of inflation and real interest rate, respectively, in the VAR model.

have been transformed to natural logarithm values (except inflation and interest rate) and the growth rate of GDP and banks credit calculated as the first difference of the log of the data. Therefore, we expect a stationary process for real GDP and bank credit growth. For the unit root test, potential structural breaks in the time series should be considered because breaks may lead to biased results toward non-stationarity (Vogelsang and Perron (VP), 1998). Therefore, the present study uses the model of a unit root test with structural breaks from VP. This model has been called the additive outlier (AO) model in VP. This model assumes that breaks occur suddenly and the constant term in the equation of the model would change after breaks. This refers to Model 1 in VP:  $y_t = \mu + \beta t + \theta DU_t^c + z_t$ , where  $y_t$  is a time series,  $\mu$  is the intercept,  $t$  is the time trend,  $DU_t^c = 1(t > T_b^c)$  and  $1(.)$  is the indicator function,  $T_b^c$  denotes the date of the breaks and superscript “c” denotes the correct date of break.  $z_t$  is the error term that follows an ARMA(p+1,q) process. When the time series has a unit root, the intercept of  $y_t$  is  $y_0$  (that is a fixed constant), up to time  $T_b^c$  and  $y_0 + \theta$  after that time. In stationary series, the intercept is  $\mu$  up to time  $T_b^c$  and  $\mu + \theta$  after that time. The unit root test in the AO model is done in two steps: first, estimating the following regression with OLS to de-trend the series:  $y_t = \mu + \beta t + \theta DU_t + \hat{y}_t$  where  $DU_t = 1(t > T_b)$ . Second, the null hypothesis of a unit root is tested using the  $t$ -statistic for testing  $\alpha = 1$  in the regression:

$$\hat{y}_t = \sum_{i=0}^k \omega_i D(T_b)_{t-i} + \alpha \hat{y}_{t-1} + \sum_{i=1}^k c_i \Delta \hat{y}_{t-i} + \xi_t$$

$k$  denotes the lag length,  $D(T_b)_t = 1(t = T_b + 1)$  is the dummy variable and  $\xi_t$  denotes the part that cannot be explained by the regression. The critical values of

the t-statistics for testing  $\alpha = 1$  have been provided in Table 1 of VP for different sample sizes. Table 4.2 shows the unit root test results, using the AO model over all time series. According to the test results, the banks' financial soundness indicator has a unit root. Thus, non-stationary time series were transformed to the first-difference value (they are stationary at the first difference values) and then were used for the estimation of country specific VAR models.

*Table 4.2. Unit root test results, using the AO framework. Figures imply test statistics. According to VP, critical value of the test statistic is -5.20 at 5% significance level. '\*', therefore, denotes stationarity at 5% significance level.*

	FI	BC	GDP	IF	IN
<b>Hong Kong</b>	-2.68	-4.50	-5.88*	-4.33	-4.14
<b>Indonesia</b>	-5.01	-5.38*	-5.72*	-3.98	-3.85
<b>Japan</b>	-2.55	-3.79	-4.95	-5.00	-5.23*
<b>S. Korea</b>	-3.41	-3.04	-7.08*	-3.70	-3.53
<b>Malaysia</b>	-2.75	-27.81*	-3.90	-4.01	-4.23
<b>Philippines</b>	-5.20	-4.25	-5.26*	-4.62	-5.24*
<b>Singapore</b>	-3.27	-4.61	-4.83	-6.09*	-6.39*
<b>Thailand</b>	-5.00	-2.74	-5.64*	-4.23	-4.17

#### 4.4. Estimation results

This section provides the information about the estimation of the empirical model. For the purpose of this chapter, only the estimated equation of FI (for each country) has been presented in the Appendix B. It is expected that the increase in real GDP growth leads to a drop in default rates through the increase in the level of income. For the Hong Kong case, the result is in the line with this expectation (see Table 1A in the Appendix B). In Thailand, it seems that more activated economy (or the rise in

real GDP growth) requires more support from the banking system and hence banks lending activity will be developed in such situations. The development in loans along with the week risk management and supervisory controls might increase the level of NPLs and hence the level of loans defaults. Default rate also responds positively to its lagged values. It means that there is a positive autocorrelation in default rates; suggesting that an artificial shock (stress) to a macroeconomic variable can produce a longer impact on default rates. Thus, the analysis of default rates development is possible during a time horizon which is a significant element to investigate the future behaviour of default rates.

As VAR model is a model under the normality assumption, here, VAR residuals were checked for normality by Jarque-Bera (JB) test. This test investigates to see whether skewness and kurtosis of data mach a normal distribution. Hence, it shows how the data are well modelled, given the model of estimation and the normality assumption. If the data come from the normal distribution, the JB statistic has asymptotically chi-squared distribution with two degree of freedom. The test was done country-by-country over all equations of the VAR of each country for all countries (for 8 countries where each country's VAR has 5 endogenous variables). The JB test results are given in the Appendix (Table 4.2B). Each country has a VAR model which consists of 5 endogenous variables. Therefore, Table 4.2B indicates five results for each country which are corresponding to the normality test of residuals of 5 equations of the country's VAR. The 5 results of each country (in Table 4.2B) correspond to the equations where dependent variables are  $FI_t, BC_t, GDP_t, IF_t, IN_t$  (that are transformed loans default rate, real growth of banks credit, real growth of GDP, inflation rate, and real interest rate, respectively).

The bold numbers in Table 4.2B in the Appendix highlights the non-normal residuals (at 5% significance level) of the corresponding equations in each country. Considering the system of equations for all countries (40 equations), JB test shows that 11 equations have non-normal residuals (see Table 4.2B). In non-normal cases, the parameter estimates and standard deviations are still valid. However,  $t$ -tests are less reliable. Lutkepohl (2006, p. 491) discuss that “[a]lthough normality is not a necessary condition for the validity of many of the statistical procedures related to VAR models, deviations from the normality assumption may indicate that model improvements are possible”.

#### 4.5. Stress-test framework

Given estimated equation (4) and (5) and defining macroeconomic stress scenarios, one may analyse the effect of the artificial shocks (or stresses) on banks by substituting the values of macroeconomic variables given by the scenarios into the estimated equations (4) and (5) and computing the predict of  $FI_t$  and hence  $p_t$ , assuming disturbances are zero. The drawback of this approach is that macroeconomic stress scenarios impact on banks in a deterministic way, meaning that how likely it is that a chosen scenario occurs is not an issue in this approach. Furthermore, based on this approach, if a specific scenario does not impact significantly on loan default rates, it might be concluded that the risk, originated from the scenario, is low. Such a conclusion however is misleading because a large deviation from the average, with a high probability of occurrence, can also generate some sorts of risks.

Allowing disturbances being non-zero and assuming that there is randomness in the behaviour of macroeconomic variables, this study follows Wong (2008) to



simulate the future banks' loan default rates under macroeconomic scenarios. As already mentioned, we also set up the system in a way that all disturbances are not Gaussian. More precisely, in this study, the randomness in the behaviour of two macroeconomic variables, inflation and real interest rate, is originated from the TS distribution.

After estimating the VAR model for each country the simulation was done according to the following steps for the baseline model. The baseline model is a simulation in which no stress is introduced to the system. Therefore, only the randomness of the disturbances of the model creates risk through the probability distribution:

1. A  $(K \times 1)$  vector of random variables was generated from the standard normal and the TS distributions (according to the assumptions that were already explained for the distributions of disturbances in the empirical model). This drawn vector represents a realization of the vector of disturbances for time  $t+1$ , that is  $\mathbf{e}_{t+1}$ <sup>37</sup>. Computing the  $K \times K$  matrix of the Cholesky decomposition ( $\mathbf{C}$ ) of the variance-covariance matrix  $\mathbf{\Sigma}$ , where  $\mathbf{\Sigma} = \mathbf{C}\mathbf{C}'$ , and pre-multiplying  $\mathbf{e}_{t+1}$  by  $\mathbf{C}$  yields the  $(K \times 1)$  vector  $\mathbf{u}_{t+1}$ . Then, I scaled  $\mathbf{u}_{t+1}$  with standard deviations of VAR residuals for each equation of VAR for each country. With this, shocks within the generated residuals (or  $\mathbf{U}$ ) after scaling; obtain the magnitude very close to those exists within VARs residuals<sup>38</sup>.

---

<sup>37</sup> For this study,  $\alpha$ ,  $\beta$  and  $\theta$  (parameters of the TS distribution) were set equal to 1.5, 0.5 and 2, respectively based on Charemza *et al.* (2010a). The possible changes in results due to the change in the parameters value are checked in the Appendix. The program of TS random number generator has been written by Charemza and Makarova (2010) in Gauss.

<sup>38</sup> For example, for Thailand, the standard deviations of generated residuals or  $\mathbf{U}$  (after scaling) are 0.045, 0.011, 0.009, 0.009, and 0.010 (corresponding to 5 equations of VAR) which are almost the same as standard deviation of VAR residuals for this country.

2. For the simulation, the initial condition must be defined. Here, the last observations of the data are taken as the initial values (condition) of the forecast. Using the generated disturbances  $\mathbf{u}_{t+1}$ , current and past values of macroeconomic data and equations (4) and (5), one-period ahead variables (the forecast for time  $t+1$ ) can be calculated. For the forecast of two-period ahead default rates, another vector of random numbers ( $\mathbf{e}_{t+2}$ ) was independently drawn from the same random number generators as the step 1 and with calculating  $\mathbf{u}_{t+2}$  and using calculated one-period ahead values in step 1, two-period ahead values were calculated. We can repeat the above steps to calculate more periods ahead up to four periods as the time horizon for this study is four periods (quarters) or one year. With simulating such paths 10,000 times, a frequency distribution of default rates can be constructed. This frequency indicates future behaviour of loan default rates under the baseline model.

In the simulation steps above, no stress (artificial shocks) was implemented over the system and hence it is called the baseline model. Frequency distributions in the base line model are the result of different evolutions of macroeconomic variables due to the random numbers ( $\mathbf{U}$ ) in each period. In such a model risk is not zero because outsized values that show deviations from the average may occur with a considerable probability although the system has not been affected by artificial shocks or stresses.

After the baseline model, the banks' loan default rates were calculated under some macroeconomic stress scenarios which are the origin of artificial shocks. On the whole, in the stress testing analysis, stress scenarios should be rational and plausible. In other words, it is crucial that artificial shocks of the stress scenarios be suitable in terms of the economic structure of a country. One of the approaches to define artificial shocks (stresses) is to investigate the history of an economy and

choose historical extreme events as the origin of shocks. Although these events are extreme and might have low possibility to happen again, they are plausible because the macroeconomic variables were affected by these shocks in the past and then the economy had suffered (at least once) from them. For this study, since the countries of the study have suffered from the Asian Financial crisis in 1997/8, stress scenarios are defined similar to extreme changes that occurred during the crisis. Thus, stress scenarios were defined from the changes in two main macroeconomic variables during the Asian financial crisis in 1997/8 (Table 4.3). As the forecast horizon in this study is 4 quarters (1 year), 4 largest changes during the crisis were chosen to construct the scenarios.

*Table 4.3- Stress scenarios. Scenarios were defined based on changes of variables during the Asian Financial Crisis in 1997/8.*

Time horizon	Change in real GDP growth				Change in real interest rate			
	Quarter 1	Quarter 2	Quarter 3	Quarter 4	Quarter 1	Quarter 2	Quarter 3	Quarter 4
<b>Hong Kong</b>	-1.2%	3%	-3.3%	-4.7%	8.7%	30%	4.3%	69.5%
<b>Indonesia</b>	-14.5%	-19%	-15%	-14.8%	11%	6%	31%	29%
<b>Japan</b>	-0.4%	-2.1%	-1.6%	-0.6%	26%	-12%	17%	21%
<b>S. Korea</b>	-14%	-7.5%	-3.4%	-2%	5%	18%	18%	34%
<b>Malaysia</b>	-13%	-11%	-8%	-9.5%	0	13%	21%	22%
<b>Philippines</b>	-5%	-0.5%	0	-1.7%	12%	8.6%	57%	71%
<b>Singapore</b>	-2.9%	-5%	-6.4%	-5%	55%	18%	13%	-6%
<b>Thailand</b>	-3.2%	-4.7%	-9.3%	-8.7%	-21%	3%	20%	25%

Nevertheless, simulation can be done for more than 4 periods ahead, assuming more scenarios or even assuming no more stresses take place after the simulation time horizon. The stresses defined in Table 4.3 are used to stress real GDP growth and real interest rate through impacting on the vector  $\mathbf{u}$  that was defined in the baseline model above. The objective is to describe responses of banks loan default rates in the situation in which real GDP growth or real interest rate are stressed by

stresses in Table 4.3. For calculation of default rates under the stress scenarios, starting with the current values of variables, the forecast of variables was done with the following steps:

1. To introduce artificial shocks (or stresses of Table 4.3) over the macroeconomic variables (real GDP and real interest rate), corresponding element of vector  $\mathbf{u}_{t+1}$  was affected by stresses in such a way that  $\mathbf{u}_{t+1}^s = \mathbf{u}_{t+1} + s$ , where  $\mathbf{u}_{t+1}^s$  is the vector of disturbances used in the baseline model above but now affected by artificial shocks or stresses ( $s$ ) from Table 4.3.  $\mathbf{u}_{t+1}^s$ , thus, represents the stressed vector of disturbances for the forecast of one-period ahead.

2. To compute the value of variables after implementing stresses, the same method as in the step two of the baseline model was applied but instead of  $\mathbf{u}_{t+1}$ , we used  $\mathbf{u}_{t+1}^s$  in the calculation.

When one element of the vector  $\mathbf{u}$  is stressed (e.g. stressing real GDP growth), it impacts on other variables since off-diagonal elements of  $\Sigma_e$  are not zero. Similar to the baseline model, a large number of future paths of variables and then loan default rates were constructed through doing 10,000 times simulation to make a frequency distribution of default rates.

#### 4.6. Simulation results

The main statistics of simulated distributions are given in Table 4.4. This Table shows 10,000 simulated default rates of period 4 of the simulation (2009q4), its mean and 95% and 99% confidence levels. Precisely, they are 95<sup>th</sup> and 99<sup>th</sup> percentiles of 10,000 simulated default rates. In the baseline scenario, the default rate that is expected to occur in 2009q4 in Hong Kong, for instance, is about 0.39%. Introducing the artificial shocks over GDP growth from 2009q1 to 2009q4 increases

expected default rate (or the mean default rate) to 0.393%. Table 4.4 also represents the tail information of the distributions. This has been done by the two percentiles, 95<sup>th</sup> and 99<sup>th</sup> percentiles. They indicate the expected maximum default rate at the corresponding confidence level. For example, for the Hong Kong case, the expected maximum default rates at 99% confidence level are 0.411%, 0.412%, 0.414% in the baseline, stressed real GDP growth and stressed real interest rate, respectively. It means that, for example in stressed real GDP growth, there is 1% chance that default rate obtain a value greater than 0.412%.

Figure 4.1 presents simulated distribution of default rates. On the whole, graphs indicate that with the stress to real GDP growth (based on table 4.3), distribution of default rates shifts to the right. That is the occurrence of higher banks' loan default rate with higher probability, compared to the baseline model. There are two exceptions, Indonesia and Thailand in which the decrease in real GDP growth leads to the occurrence of lower default rate with higher probability.

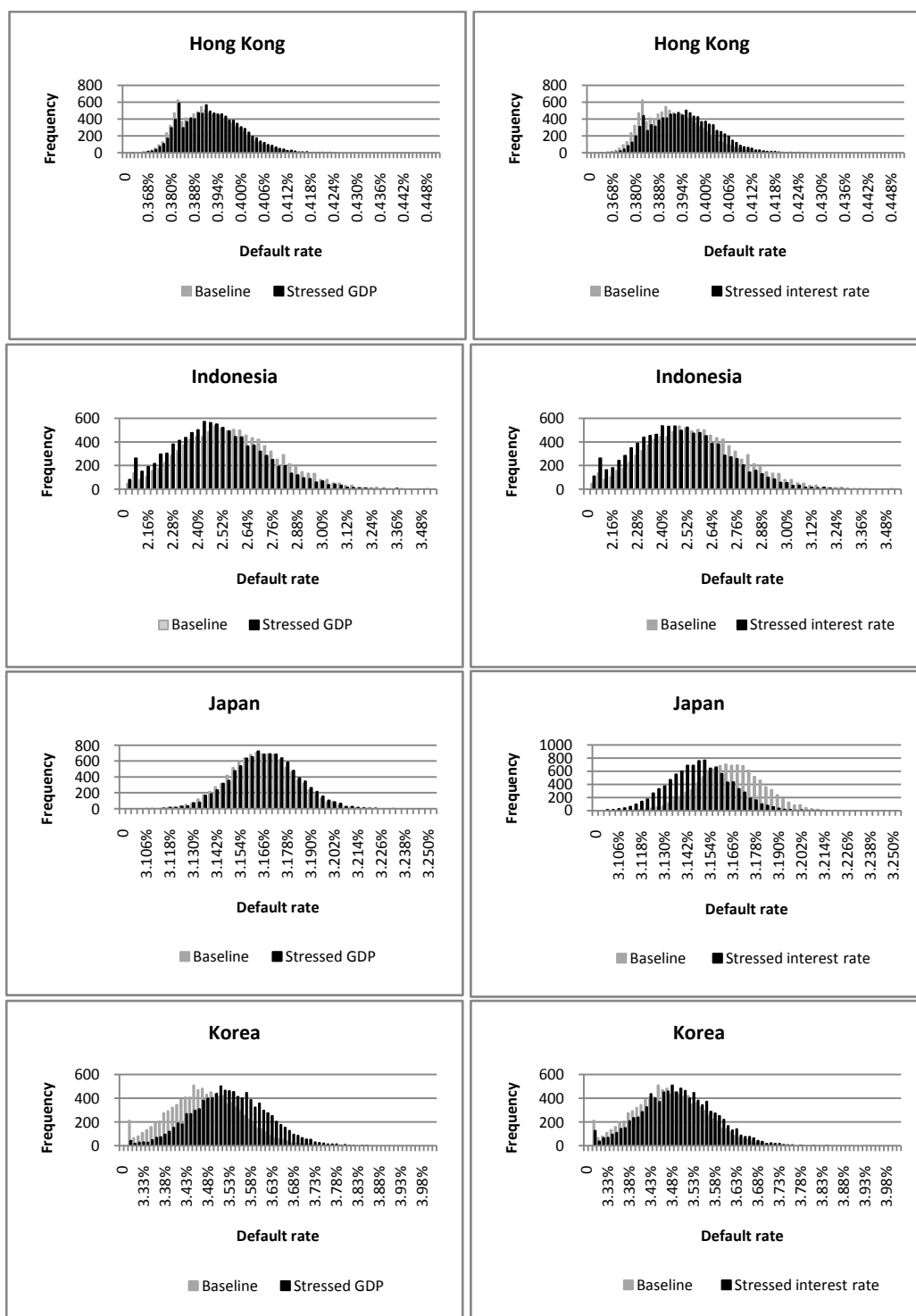
*Table 4.4- Main statistics of 10,000 simulated default rates. nth% confidence level indicates the nth percentiles of 10,000 simulated default rates.*

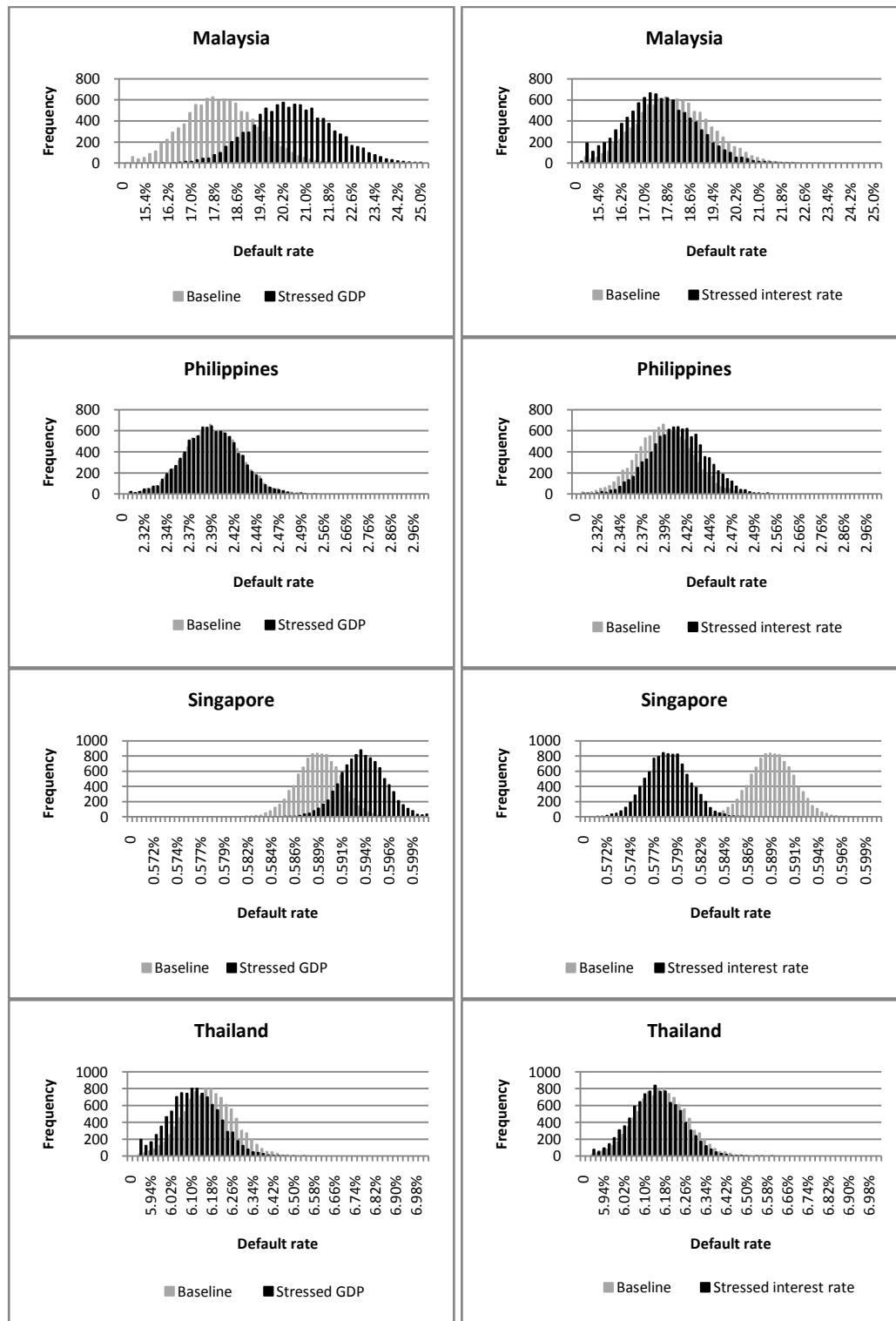
	Baseline			Shock to real GDP			Shock to real interest rate		
	Mean	95% Confidence level	99% confidence level	Mean	95% confidence level	99% confidence level	Mean	95% confidence level	99% confidence level
<b>Hong Kong</b>	0.391%	0.405%	0.411%	0.393%	0.406%	0.412%	0.395%	0.407%	0.414%
<b>S. Korea</b>	3.47%	3.6%	3.7%	3.5%	3.67%	3.73%	3.48%	3.63%	3.7%
<b>Japan</b>	3.16%	3.19%	3.2%	3.17%	3.19%	3.2%	3.15%	3.17%	3.19%
<b>Indonesia</b>	2.55%	2.94%	3.13%	2.48%	2.88%	3.06%	2.47%	2.86%	3.04%
<b>Malaysia</b>	18%	20%	21%	20%	23%	24%	17%	19.5%	20%
<b>Singapore</b>	0.580%	0.593%	0.594%	0.590%	0.597%	0.6%	0.570%	0.581%	0.583%
<b>Philippines</b>	2.38%	2.44%	2.46%	2.38%	2.43%	2.46%	2.40%	2.45%	2.48%
<b>Thailand</b>	6.16%	6.33%	6.4%	6.09%	6.26%	6.33%	6.13%	6.30%	6.36%

In these two countries, most economic sectors are credited by banks. The decrease in real economic growth means that economic sectors produce services and products less than before and, as a result, their demand for operational and supporting credits has declined. In this situation banks' lending decreases. The decrease in the level of banks' loans can be one of the ways of control of the level of NPLs and then credit risk. On the other hand, in such a situation, the level of income decreases and hence borrowers' defaults may rise through the increase in the level of NPLs. However, the speed of emergence of new NPLs might be less than the decrease of income level and hence banks benefit from the fall in level of economic activity (in short term) rather than suffer from the increase in the level of NPLs due to the fall in income level. Thus, the simulation results show how the future behaviour of banks loan default rate and hence the banking systems likely loss due to the banks' lending activity are different across countries of the study and suggest how strong the banking systems are against shocks in different countries.

As Table 4.3 indicates, since the overall change of real interest rate during the simulation period can be read as a positive shock to real interest rate, the stress scenarios of real interest rate can be interpreted as applying a tight monetary policy. Thus, the movement of distributions due to shocks to real interest rate can be read as the result of applying a tight monetary policy. Accepting this, in most countries, the rise of real interest rate can protect the banking systems from the increase in the probability of higher default rates (compared to the baseline scenario).

Figure 4.1- Frequency distribution of banks' loans default rate under the baseline scenario and two stress scenarios





The tight monetary policy is applied to control lending activity of banks and decrease the level of borrowing in the economy. This leads to the decrease in banks



loans. In this situation the authority can categorise loans and manage credit risk. As a result, the level of NPLs decreases and hence probability of loans default decreases.

In contrast, in Hong Kong, Korea and Philippines the frequency of higher default rates would increase when real interest rates rise, meaning that the expected loan default rate is higher compared to that in the baseline scenario. Thus, tightening the monetary policy may worsen banks financial status through the increase in borrowers' default in these countries.

Table 4.5 indicates the number of periods that the effect of stresses on loans default rate remains alive after the last period of the forecast. To find when the effects of stresses vanish, the simulation was continued after the 1 year forecast period and again two types of frequency distributions were generated for time steps after the last period of the forecast ( or after  $t + 4$  or 2009q4). Repeating the steps of simulation for the baseline model, the first type distribution was simulated (for time  $t + 5$ ) using the values of the last period of the forecast (that is,  $t + 4$  from the base line model) as the initial condition. The same method was used to simulate the second type of distribution (for time  $t + 5$ ) but computed values of the last period of the forecast (or time  $t + 4$ ) from the stress scenarios used as the initial condition of this simulation. There are no more stresses in this step. However, this type of distribution has been affected by the stress scenarios of Table 4.3 that were implicated over variables during the forecast period. Then, means of these two types of distributions were statistically compared by the two-sample T-test with the null hypothesis of no difference between means of the two distributions. The hypothesis was tested for each time step at 5% significance level. I repeated the simulations for more time steps after the forecast period (i.e. for  $t + 6$ ,  $t + 7$ , ...) until time that the difference

between means of the distributions were not statistically significant at 5% significance level. For example, if at time  $t + 10$  the means are statistically same, it can be concluded that 5 periods after the forecast period (or after first 4 period) the effect of stresses remains alive and hence at  $t + 10$  (or 6 periods after the forecast period) the effect of stresses will vanish. The time of vanishing (shown in Table 4.5), then, is the time that two types of distributions are expected to have the same statistics. Table 4.5 shows that the life of the effect of stresses to real GDP growth is longer than the life of effects of stresses to real interest rate. Obviously, the persistency of a shock's effect depends on the magnitude of the stress. As already mentioned, my method to define stress scenarios is based on the real historical stresses that occurred during the East Asia Financial Crisis in 1997/8.

*Table 4. 5- Number of periods that stresses' effect still exists after the stress period.  
After these periods shown in the Table the effect of shocks will vanish.*

	Shock to real GDP	Shock to real interest rate
<b>Hong Kong</b>	13	15
<b>S. Korea</b>	64	9
<b>Japan</b>	14	19
<b>Indonesia</b>	11	10
<b>Malaysia</b>	12	7
<b>Philippines</b>	4	22
<b>Singapore</b>	13	8
<b>Thailand</b>	10	14

The information of Table 4.4 is simulated loan default rates under different scenarios. Using this information, the likely loan losses of the entire banking system can be calculated if the amount of provided credit by the entire banking system is

available. This study assumes that the amount of loans will not change and it is the same as the current level (or as in 2008q4). Therefore, possible loans loss (credit loss) of the entire banking sector was calculated for each country, multiplying the default rate to the given amount of loans. The results are showed by Table 4.6. In addition to average response of variables to stresses, Table 4.6 also shows the tail statistics of the distributions with Value at Risk (VaR) at different confidence levels. VaR has been one technique that banks authorities use to calculate risk (the worse situation that may occur under different scenarios) since VaR concentrates on downside risk and losses of a portfolio. In other words, VaR indicates the expected maximum loss at the certain confidence level (e.g. 99%) (Jorion, 2007). This provides an idea for bank managers or supervisory authorities about future losses and hence they can manage the risk through holding enough capital. Among VaR methods, Monte Carlo simulation is a powerful and flexible method for computing VaR (see Jorion, 2007). In this method, simulations are used for the random behaviour of a variable and to generate a probability distribution of the changes in the variable. Then VaR is calculated as a percentile of the developed probability distribution (See for instance, Allen *et al.*, 2004; Jorion, 2007; Nocetti, 2006). Based on this method, for this study, VaR was calculated as the percentile of generated probability distributions of default rates in different scenarios. More precisely, VaR was calculated as the product of corresponding percentiles (in Table 4.4) and the amount of loans (in Table 4.6). For instance, for Hong Kong, the loan loss will not exceed \$2.187 and \$2.192 billion with 99% confidence under the baseline and stressed real GDP growth scenarios, respectively. It means that the probability that loss exceeds \$2.192 billion is 1% in the stressed GDP growth scenario. When real

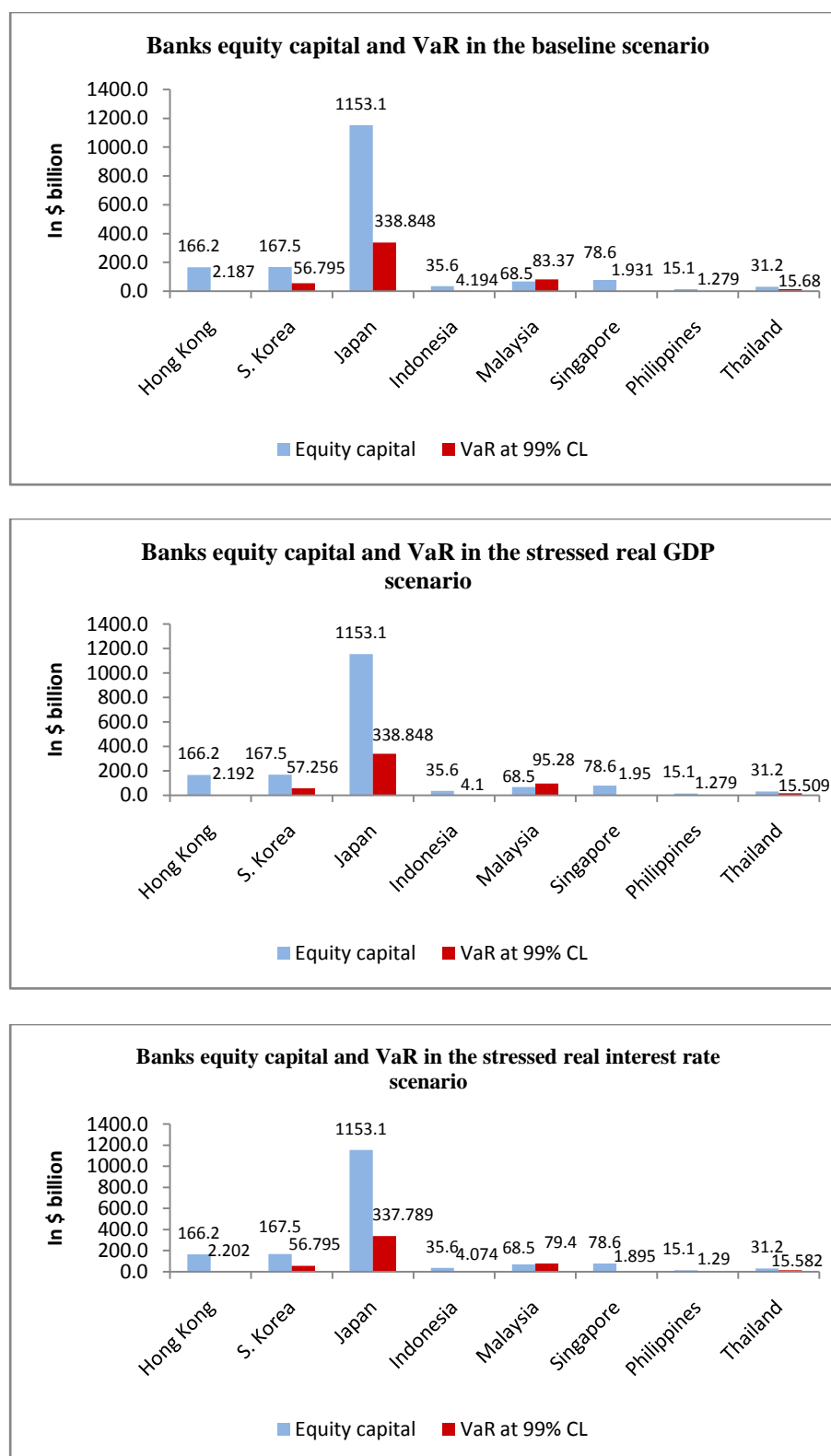
interest rate is stressed, the expected maximum loss would be \$2.202 billion at 99% confidence level. However, such extreme events that result in maximum losses and beyond will occur with rather small probability of 1%. At 99% confidence level, the lowest amount of possible loan loss is for the Philippines and then Singapore and the largest amount of possible loss is for Japan and then Malaysia in both stressed scenarios.

*Table 4. 6- Mean and VaR statistics of simulated distribution of likely loan loss of entire banking system, compared to equity capital of the banking system in 2008 (in \$ billion).*

			Baseline			Shock to real GDP			Shock to real interest rate		
	Loan	Equity capital	Mean	VaR (95%)	VaR (99%)	Mean	VaR (95%)	VaR (99%)	Mean	VaR (95%)	VaR (99%)
<b>Hong Kong</b>	532	166.17	2.080	2.155	2.187	2.091	2.160	2.192	2.101	2.165	2.202
<b>S. Korea</b>	1,535	167.55	53.265	55.260	56.795	53.725	56.335	57.256	53.418	55.721	56.795
<b>Japan</b>	10,589	1153.12	334.612	337.789	338.848	335.671	337.789	338.848	333.554	335.671	337.789
<b>Indonesia</b>	134	35.64	3.417	3.940	4.194	3.323	3.859	4.100	3.310	3.832	4.074
<b>Malaysia</b>	397	68.50	71.460	79.400	83.370	79.400	91.310	95.280	67.490	77.415	79.400
<b>Singapore</b>	325	78.63	1.885	1.927	1.931	1.918	1.940	1.950	1.853	1.888	1.895
<b>Philippines</b>	52	15.14	1.238	1.269	1.279	1.238	1.264	1.279	1.248	1.274	1.290
<b>Thailand</b>	245	31.25	15.092	15.509	15.680	14.921	15.337	15.509	15.019	15.435	15.582

Capital adequacy has been an important item to retain banks financial strength and manage risks, especially credit risk and smooth the effect of financial shocks to the banking system. Therefore, the regulatory scheme of the Basel Accords considers this issue to supervise banks for their financial risk management plans. Hence, it would be useful if expected losses (the VaR information) are compared to the capital of banks to see how strong the banking system is against the possible losses. Figure 4.2 compares VaR at 99% confidence level (which shows the expected maximum loss due to banks lending activity) with the equity capital of the entire banking system in different scenarios.

Figure 4.2- Comparison of expected maximum loan loss (VaR at 99% confidence level) and equity capital (observed in 2008) in the banking system across the countries.



The comparison suggests that in most countries equity capital is enough to cover the maximum possible loss. For the Malaysia case, although the probability of occurrence of implied losses and beyond is quite low (1%), the equity capital is lower than the likely loss, meaning that losses would deplete the capital and hence weaken financial soundness of banks. Thus, the exposure of the banking system to credit risk in this country would be more than others. Thailand is the second country after Malaysia that is most exposed to credit risk since the expected maximum loss of the banking system in Thailand would be almost half of total equity capital. South Korea is the third country (after Malaysia and Thailand) where the maximum loss is expected to reach about half of the total equity capital.

Although likely loss of the banking system is less than total capital (except the Malaysia case), it does not mean that all individual capitalized banks are safe against the damages of shocks. It means that when VaR is less than the total capital of the banking system, we can conclude that banks loan loss does not lead to a systemic failure and panic. However, some individual banks may fail in such a situation.

#### **4.7. Conclusion**

This study developed a stress-test framework to assess the vulnerability of the banking system to two stress scenarios, extreme shocks (stresses) to real GDP growth and to real interest rate. The assumed shocks are similar to those that occurred during the East Asia financial crisis during 1997/8 and which were introduced in Table 4.3. Simulated results suggest that the banking system in most countries in the study will suffer from negative shocks to real GDP growth through the increase in probability of higher bank loan default rates occurring. The response of the banking system to the tight monetary policy (positive artificial shocks to real

interest rates) differs across countries. For instance, in most cases, results suggest that tightening monetary policy might be profitable for the banking system through the increase in frequency of lower default rates in comparison with the baseline scenario where no stresses are introduced over real interest rate. In a tight situation, there usually exist tough regulations along with tight monetary policy to control over-enhancement of credit and NPLs. For example, in Japan, The Financial Services Agency (formed in 2000) undertakes special audits on banks' performance including classification of loans to borrowers to control the level of NPLs and hence credit risk. This system can smooth the effect of shocks, and hence leads to the decrease in default rates rather than violating borrowers' balance sheets due to the rise in interest rates. In contrast, the banking systems in some countries such as Hong Kong, Korea and the Philippines are vulnerable to the increase in real interest rate where tight monetary policy will increase the probability of higher loan default rates. In Hong Kong, net interest margin and NPLs are two important determinants of profitability of banks, but interest rates are not tools for the immediate control of the Hong Kong Monetary Authority (HKMA)<sup>39</sup>. In particular, interest rates are used to adjust exchange rate (the relation between the Hong Kong dollar and the US dollar) and hence cannot be used to control the state of the banking system. Therefore, regulatory policy is applied over the banking system for supervision purposes. Increasing interest rates may protect the national currency but weaken the financial state of borrowers and increase NPLs. This has been confirmed by the HKMA. Thus, authorities should be aware of sensitivity of borrowers' balance sheets to the changes of interest rates.

---

<sup>39</sup> [www.info.gov.hk/hkma/eng/research/RM\\_macro\\_and\\_banking.pdf](http://www.info.gov.hk/hkma/eng/research/RM_macro_and_banking.pdf).

According to the Bank of Korea, in Korea, household loans have less credit risk for banks in comparison to other types of loans such as industrial or small and medium size enterprise loans. Therefore, there is a type of competition among banks to lend to households and hence households' debt has shown a continuing upward trend. This leads to over-borrowing of low income households who are more likely to default. Furthermore, in Korea, only interest, not principal, is paid for home mortgage loans, and this makes households more sensitive to interest rates and hinders deleveraging of households debts when interest rate dramatically increases<sup>40</sup>.

For the Philippines case, the increase in real interest rate poses a higher burden on borrowers' debt and hence the probability of loan defaults increases. In particular, borrowers are affected directly by changes in interest rates where, according to the Philippines Central Bank, rising interest rate causes trading profits to fall and hence shareholders' earning decreases<sup>41</sup>. This may hamper debt repayment of borrowers.

For Indonesia and Thailand, loan default rates fall after the adverse shock to real GDP growth. Although the shock decreases the overall level of income due to the decrease in economic activities, it does not lead to default of banks' borrowers and hence loans default in the short-term because downward movement of economic growth may provide an opportunity for banks to decrease their lending activities, and as a result of which the rate of emergence of new NPLs falls.

The VaR analysis shows that the banking system in most countries of the sample has been buffered enough against the expected maximum loss. However, exposure of the banking system to credit risk is different across countries. This type of analysis is very important because it shows how banks capital would be depleted by loss if a

---

<sup>40</sup> Financial stability report (April 2011), the Bank of Korea.

<sup>41</sup> A status report on the Philippine financial system (first semester 2008), the Central Bank of the Philippines.



particular stress scenario occurs. For instance, VaR analysis suggests that Malaysian authorities should exert control over NPLs and ensure that banks are adequately secure with much more capital. In both stress scenarios the maximum expected loss will exceed total equity capital of banks. This increases the probability of insolvency and may result in financial instability of the banking system in Malaysia.

## **Chapter 5: Conclusion**

### 5.1. Summary

This thesis aimed to study financial stability and its opposite concepts (financial instability or financial imbalances) in EMEAP countries. Considering accumulated outstanding debt as a factor that increases financial pressures on the economic agents and hence financial imbalances that monetary authority or central bank should care about it, chapter 2 has designed a new optimal monetary policy rule for the central bank to exert control over financial imbalances and secure financial stability. In this chapter, a DSGE-type new Keynesian model for a small open economy was expanded to show the effects of financial imbalances on the economy. This chapter contributes to the literature with guidance that shows how the central bank should deal with outstanding debt as well as exchange rate movements under the optimal monetary policy rule in a small open economy.

Chapters 3 and 4 discussed financial stability in the light of financial stability of the banking sector. Chapter 3 investigated the effects of the financial system structure (whether this is bank- or market-based) on banks' financial soundness which is a measure of financial stability in this chapter. This chapter aimed to analyse the impact of moving towards a market-based financial system on the financial stability measure in Hong Kong, Indonesia, Japan, South Korea, Malaysia, the Philippines, Singapore and Thailand (eight members of EMEAP countries) since there is a lack of studies explicitly analysing this issue for the above countries.

Chapter 4 analysed the resistance of the banking systems of the countries to artificial macroeconomic extreme shocks (stresses). This chapter undertook stress-testing in a different way. Fat tails are observed in some macroeconomic data, especially financial variables. Hence, in the simulation, unlike some empirical

studies where disturbances are assumed to be Gaussian, a Tempered Stable (TS) distribution was used to generate the distribution of disturbances. TS distributions have fatter tails and hence can present tail events (or extreme events) better than the normal distribution. In other words, applying heavy-tailed distributions enables quantifications of the probability of default in a more precise way. Hence, the forecast of default rates is more precise. Stress scenarios were defined based on the extreme changes in the macroeconomic variables that occurred during the Asian financial crisis in 1997/8.

## **5.2. Conclusions**

Chapter 2 indicated two key points: first, that financial imbalances arising from the accumulated outstanding debt of firms can reduce the capabilities of the economy through decreasing the total factor productivity and then production level, and second, that exchange rate plays a significant role in the economy and affects domestic inflation, real marginal cost and, aggregate demand. Exchange rate also has a positive effect on capital accumulation of firms; that is, the origin of debt creation. Chapter 2 concluded that when financial imbalances arise in the economy through increasing debt and the economy comes out of the normal situation because of the financial pressures on the economy agents, the central bank should react to financial imbalances under the optimal policy rule in this chapter. Moreover, the optimal monetary policy showed that the response of the monetary authority to real exchange rate movements should be indirect where the policy maker reacts to exchange rate indirectly through domestic inflation and output gap.

The generalised impulse response analysis in chapter 3 showed that enhancing a market-based financial system can increase banks' financial soundness and hence

financial stability in some countries. However, the significant impulse responses are immediate and short. It seems that in countries where banks are the main financial institutions in the payment system and provide credit and liquidity, the economy cannot benefit from the market-based financial system. This would be the case if financial markets are not developed enough in terms of risk-sharing mechanism. For example, the economies of both Japan and South Korea are known for their bank-based financial system. Banks supports high-tech and science-based industries in these countries. Nevertheless, impulse response analysis in chapter 3 showed that enhancing a market-oriented financial system can increase financial stability in Japan through increasing banks' financial soundness, but it decreases financial stability in South Korea. One explanation is that the stock market in Japan with its well known index (Nikkei) is relatively more developed than the stock market in South Korea where stock market activity has had a decreasing trend and bank lending has had an increasing trend over a seven year period during the 2000s. In contrast, the stock market activity in Japan has seen a huge growth, which is greater than banks lending activity in the same period. Thus, developed financial markets would be beneficial for the economy and impact positively on the financial soundness of banks.

Stress-testing of loan default rates of the banking system indicated that probability distribution of default rates moves to the right in response to the stress to real GDP growth in most countries. This means that a fall in real GDP growth (similar to that which occurred during the Asian financial crisis in 1997/8) increases the probability of the occurrence of higher default rates in these countries and hence the banking system will be exposed to credit risk. One explanation is that when economic growth decreases, it leads to a fall in the level of income in the economy and hence this

increases NPLs rather than facilitating control over banks' lending and control of NPLs in such a situation. In this chapter, stress to real interest rate (or extreme rise in real interest rate) was also defined. The results show that this type of stress (that can be read as a tight monetary policy) can secure financial stability in the banking system through shifting the probability distribution to the left (that is, decreasing the frequency of higher default rates) in most countries, in comparison with the baseline model where frequency distribution of default rates was generated without the effects of stresses. Given the frequency distribution of default rates and the amount of aggregate loans and equity capital of the banking system, the Value at Risk (VaR) measure was calculated for the banking system for each country. For example, VaR at 99% confidence level suggested that the banking systems of all countries are sufficiently buffered by capital against the expected maximum loss under the stress scenarios, except the banking system in Malaysia. There are many banks (Islamic and non Islamic) in the banking system of Malaysia which has led to the huge expansion of credit by banks. This can increase the level of NPLs. Thus, the Malaysian authority should exercise control over the lending activity of banks to control the level of NPLs because with occurring stress scenarios, the bank loss would deplete total equity capital and hence the banking system may fail. Although the probability of incurring this amount of loss and beyond is quite low (for example, 1%), it shows that the banking system in this country is more exposed to credit risk than others.

Different response of default rate to the same stress (such as rise in interest rate) in different countries is a result of the different features of the financial systems and channels of the effects of stresses in these countries. For example, in Hong Kong,

interest rates are tools to adjust exchange rate rather than control lending and borrowing activities. Hence, the monetary authority of Hong Kong may raise interest rates to adjust exchange rate but this increases financial pressures on borrowers.

This thesis may have some limitations in the method of analysing financial stability. In chapter 2, the central bank acts as an authority to bring inflation close to the target and stabilize the economy. There is no financial institution in the model and hence to construct the model it was simply assumed that borrowers contact lenders and, therefore, households and firms directly undertake lending and borrowing activities.

In chapters 3 and 4, I am aware of the fact that the analysis provided by this thesis is at the aggregate level. For example, VaR information suggested how possible loss of banks at the aggregate level may damage the banking system and hence create panic. It is worth noting that some individual banks may become insolvent in the case of occurring adverse large shocks. The contagion effect in the banking system may lead to spread of the effects of shocks within banks. Hence, failure of a single bank with sufficiently large effects threatens other banks. This issue has not been studied in this thesis since I assumed that the monetary authority would prefer to analyse the banking system at the aggregate level.

For future studies, it would be interesting if different measures of financial stability are used. It might be possible to construct an index that contains different measures of financial stability (based on dominant definitions of the financial stability). In the context of chapter 2, further extension can be done by adding the financial sector into the model. Financial intermediation of financial institutions can control financial imbalances in the economy. For further research on the topic investigated in chapter

3, one can include some other measures of the financial system structure to the model; for example, adding measures of the development of the financial markets and/or measures of the financial liberalisation. For chapter 4, one may be able to show how inter-bank mechanisms such as the inter-bank market facilitate the spread of the stresses throughout the system and hence makes the system more vulnerable to these stresses.



## **Appendices**

### **Chapter A: Correlation Matrix, CD test and robustness check (for chapter 3)**

Table 3.1A- Correlation matrix (Z-score: Financial stability measure). ‘\*’ denotes significant correlation at 1% or 5% and ‘\*\*’ denotes significant correlation at 10% significance level

		Nominal interest rate	Bank credit	Output gap	Financial structure measure	Z-score
Indonesia	Z-score	-0.20	0.58*	0.08	-0.46*	1.0000
Hong Kong	Z-score	0.37*	0.44*	-0.10	-0.18	1.0000
Korea	Z-score	0.33*	-0.17	0.47*	0.15	1.0000
Malaysia	Z-score	-0.09	-0.32*	0.22**	0.54*	1.0000
Philippines	Z-score	0.49*	0.06	0.03	-0.11	1.0000
Singapore	Z-score	0.38*	-0.88*	-0.006	-0.15	1.0000
Thailand	Z-score	0.24**	-0.67*	0.43*	0.67*	1.0000
Japan	Z-score	0.41*	-0.39*	-0.21	0.36*	1.0000

### 3.1A. Principal components

Principal components analysis models the variance structure of a set of observed variables using linear combinations of the variables, or components, to re-express multivariate data. Components can be used in subsequent analysis, and the combination coefficients, or loadings, may be used in interpreting the components. Principal components explain total variance of original variables in such a way that first principal components explain the maximum possible of the total variances and remaining variances are explained by subsequent principal components. It means that the first principal component is the best summary of a set of correlated variables. The principal component analysis determines the coefficients  $a_{ij}$  for the following system:

$$y_1 = a_{11}x_1 + a_{12}x_2 + \dots + a_{p1}x_p$$

$$y_2 = a_{12}x_1 + a_{22}x_2 + \dots + a_{p2}x_p$$

·  
·  
·

$$y_p = a_{1p}x_1 + a_{2p}x_2 + \dots + a_{pp}x_p$$

where  $(x_1, \dots, x_p)$  is the former set of correlated variables and  $(y_1, \dots, y_p)$  is the set of principal component variables. Analytically, the solution to the principal components problem is achieved by performing an eigenvalue decomposition of the correlation matrix. Thus, the solution is to find the eigenvalue vector and eigenvectors of the correlation matrix. This study applies symmetric weights to eigenvalues in the variables and loadings (observation scores). Moreover, for this study, the scores  $(a_{ij})$  are scaled so that their variance matches the desired value. Here, the sample variances of the component scores will equal 1.

### 3.2A. Pesaran's cross-section dependence (CD) test

Pesaran (2004) has proposed the following test statistic for cross-sectional dependence test:

$$CD = \sqrt{\frac{2T}{N(N-1)}} \left( \sum_{i=1}^{N-1} \sum_{j=i+1}^N \hat{\rho}_{ij} \right)$$

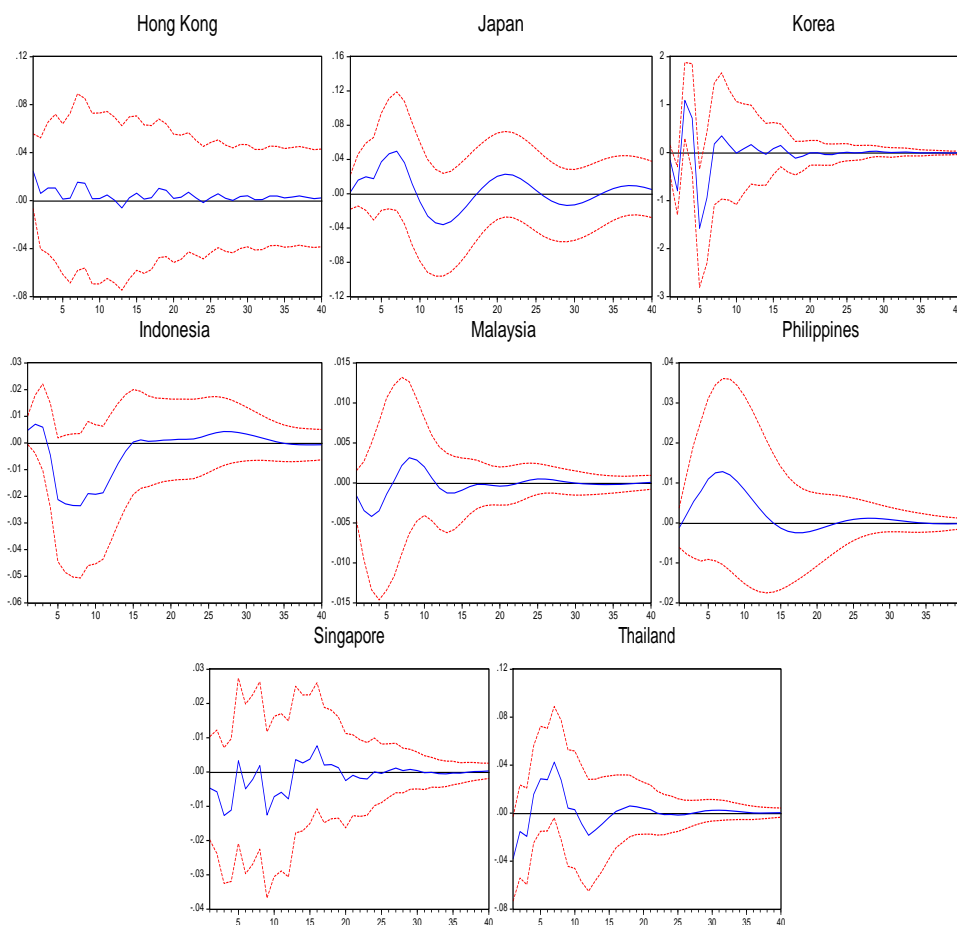
where  $\hat{\rho}_{ij}$  denotes the sample estimate of the pair wise correlation of the residuals from individual AR(3) regressions. More precisely, for each country, OLS residuals from an auto-regressive (AR) equation of each variable were computed and then using these residuals, CD statistic was computed. Under the null hypothesis of zero cross-section dependence, CD is distributed as  $N(0, 1)$  for sufficiently large  $N$  (number of cross-sections) and  $T$  (number of time periods). CD statistic has zero mean for the fixed value of  $N$  and  $T$  and it works properly for different panel-data models, including non-stationary models. Under the null hypothesis of zero cross

dependence the CD test is carried out at the 5% 2-sided nominal significance level and the null is rejected if  $|CD| \geq 1.96$ .

### **3.3A. Estimating country-specific VARs without cross-section averages (or neighbouring effect)**

This section shows how import is the average of foreign variables (star variables in VAR model (4) in chapter 3) to explain the variation of endogenous variables, especially financial stability measure. For this, VAR model (4) was re-estimated without star variables. Generalized impulse response of financial stability resulted from this estimation is following. As figure 3.1A indicates, the common effect of other countries is significant for Hong Kong, Japan and Malaysia where when cross-section averages of variables were removed from the estimation, financial stability was insensitive ( unlike to Figure 3.2 in the text) to a positive shock in the changes of financial structure for these three countries (Figure 3.1A). For Thailand, financial stability tends to show significant negative response whereas, when common effect of neighbouring countries were taken into account, financial stability was insensitive to financial structure changes. Korea still shows a negative response with more severe response than that in Figure 3.2 in the text. Impulse response of Thailand has changed after removing the effect of common factors where it shows a negative response unlike to Figure 3.2 in the text where the impulse response was insignificant.

*Figure 3.1A: Generalized response of financial stability to financial structure without the effect of common factors among countries*



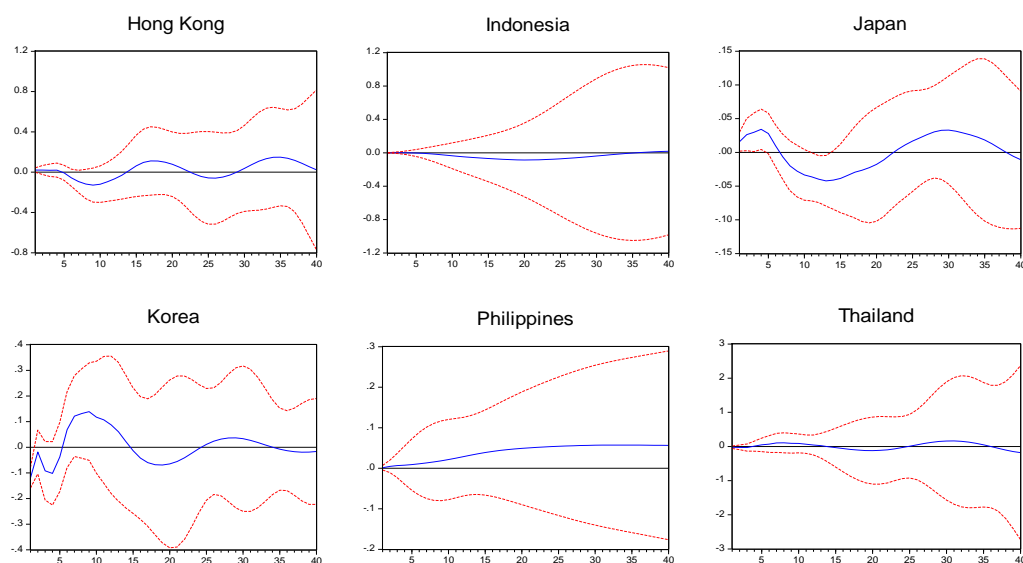
### 3.4A. Co- integration and impulse responses

For the model specification, some endogenous variables in first-difference value were used for estimating impulse responses. This section deals with possible misspecification of VARs due to co-integration between variables. Therefore, Johansen's maximum eigenvalue and Trace tests are applied to check the existence of co-integrations amongst variables. As Reinsel and Ahn (1992) suggest, with a limited number of observations, the co-integration tests tend to be biased towards finding evidence for co-integration. Following Reisel and Ahn (1992) the Trace and

maximum eigenvalue statistics should be adjusted by factor  $(D-KP)/D$ , where  $D$  is the number of observations,  $K$  is number of variables and  $P$  is the order of VAR.

Given implemented co-integration tests, a reasonable case can be made for a single co-integrating vector for Hong Kong, Indonesia, Japan, Philippines and Thailand. Therefore, the co-integrated VAR model should be applied for these countries. Since Vector Error Correction Model (VECM) can also be presented as a VAR model it seems that it is valid when variables in level are used in the VAR model for the countries that have co-integrating vectors. Ramaswamy and Slock (1998) suggest that the VAR model with variables in level should be estimated for co-integrated series if there is no prior interpretation about co-integrating vectors. Therefore, given all of these, by using the variables in level, the cross-section augmented VAR model is re-estimated for Hong Kong, Indonesia, Japan, Philippines and Thailand to see whether the impulse responses of financial stability tend to change due to existence of co-integration among variables (Figure 3.2A). Thus, allowing for co-integration for Japan, Figure 3.2A shows that the response of financial stability to the increase in financial structure measure is still significant and the same (i.e. positive response) as in Figure 3.2 in the text. However, it implies a smoother sensitivity to the shock to the financial structure measure. For the case of Korea, the response is still negative with more severe response than that in Figure 3.2 in the text. In Hong Kong the response of financial stability turns to an insignificant response.

Figure 3.2A: Generalized response of financial stability to financial structure resulting from the estimation of co-integrated VARs.



For the other countries, financial stability response remains insignificant. Thus, re-estimating the VAR model by using variables in level, which is equivalent to the Vector Error Correction model, only changes the impulse response of financial stability for Hong Kong.

## **Chapter B: Estimation results and robustness check (for chapter 4)**



*Table 4.1B- Estimation results for endogenous variables. Dependent variable is  $\Delta FI_t$ . The rest of variables are either in first-difference or in level based on the unit root test. ‘\*’, ‘\*\*’, ‘\*\*\*’ indicate that parameters are significant in 1%, 5% and 10%, respectively. Numbers in brackets implies respective standard errors.*

	Hong Kong	Korea	Japan	Indonesia	Malaysia	Singapore	Philippines	Thailand
$\Delta FI_{t-1}$	0.13 (0.22)	0.60* (0.18)	0.63* (0.21)	0.46** (0.20)	0.70* (0.23)	0.26* (0.05)	0.44*** (0.22)	0.55** (0.24)
$\Delta FI_{t-2}$	1.49 (1.31)	-0.67 (1.62)	0.09 (0.35)	0.10 (1.34)	0.02 (0.02)	0.43 (0.47)	0.02 (0.77)	0.09 (0.99)
$BC_{t-1}$	1.24 (1.06)	0.29 (0.66)	0.58 (1.07)	0.31 (1.60)	0.05 (0.16)	0.11 (0.23)	0.57 (0.77)	1.52 (1.68)
$BC_{t-2}$	-2.22 (6.14)	-4.32 (4.42)	-20.35 (23.09)	9.14 (7.51)	3.37 (4.42)	-17.18 (14.99)	-0.04 (1.83)	-11.18** (6.06)
$GDP_{t-1}$	-4.81 (4.75)	-4.99 (4.04)	-21.18 (22.92)	10.79 (9.10)	2.24 (4.41)	-14.72 (15.14)	-0.44 (1.79)	-12.79** (5.95)
$GDP_{t-2}$	0.40*** (0.20)	0.30 (0.20)	0.14 (0.18)	0.15 (0.21)	0.20 (0.21)	0.07 (0.05)	0.07 (0.20)	0.09 (0.20)
$IF_{t-1}$	-3.09** (1.25)	-0.99 (1.76)	-0.15 (0.37)	-1.07 (1.19)	-0.002 (-0.03)	0.33 (0.44)	0.30 (0.71)	0.16 (0.86)
$IF_{t-2}$	-1.25 (1.08)	0.46 (6.60)	-0.44 (1.00)	0.009 (0.91)	-0.04 (0.15)	0.22 (0.21)	-0.45 (0.70)	0.76 (1.18)
$IN_{t-1}$	-0.24 (5.28)	-1.12 (8.70)	2.27 (2.66)	-1.10 (1.34)	4.03 (5.47)	10.73 (14.29)	-0.30 (1.18)	8.96*** (6.18)
$IN_{t-2}$	2.66 (4.64)	-5.38 (9.07)	23.29 (22.14)	-10.06 (8.17)	5.72 (5.29)	8.99 (14.35)	-0.26 (1.97)	7.36 (6.47)

Table 4.2B. The results of normality test (Jarque-Bera test) of VARs residuals. The bold p-values indicate the rejection of null hypothesis of normality at 5% significance level.

	Test statistics	P-value
<b>Hong Kong</b>	2.415	0.299
	1.282	0.527
	1.808	0.405
	0.485	0.785
	1.253	0.535
<b>Indonesia</b>	28.073	<b>0.000</b>
	0.087	0.957
	0.176	0.916
	48.229	<b>0.000</b>
	47.870	<b>0.000</b>
<b>Japan</b>	8.407	<b>0.015</b>
	16.419	<b>0.000</b>
	0.402	0.818
	4.978	0.083
	5.204	0.074
<b>South Korea</b>	9.661	<b>0.008</b>
	1.753	0.416
	6.966	<b>0.031</b>
	0.988	0.610
	2.965	0.227
<b>Malaysia</b>	2.603	0.272
	131.712	<b>0.000</b>
	1.926	0.382
	0.064	0.968
	0.099	0.952
<b>Philippines</b>	62.640	<b>0.000</b>
	13.896	<b>0.001</b>
	2.795	0.247
	0.953	0.621
	4.542	0.103
<b>Singapore</b>	87.388	<b>0.000</b>
	0.522	0.770
	0.392	0.822
	0.426	0.808
	0.327	0.849
<b>Thailand</b>	3.9363	0.1397
	0.6803	0.7117
	1.0931	0.5790
	0.1235	0.9401
	0.4485	0.7991

#### 4.1B. Robustness check

In this section the robustness of the simulation results to the changes of TS distribution parameters is checked. To generate random numbers as the representative for the error terms of the model, we fixed the parameters of TS distribution. The parameters were assigned  $\alpha = 1.5, \beta = 0.5$  and  $\theta = 2$  in the text. In this section, for the robustness check to some changes, we changed the value of parameters to 1.4, -0.5 and 1, respectively and then did the simulation with the new values of these three parameters. The value of  $\beta$  changed to -0.5 to see the effect of changing of positive skewness of the distribution to a negative skewness. The statistics of the new simulation then was compared to the statistics of Table 4.4 in the text and we found that simulation with new parameters makes trivial changes in some statistics and cannot change probability distributions and hence future behaviour of default rates. Thus, the results of the new simulation were not presented again in this section since they do not show significant differences.

#### 4.2B. Common (neighbouring) effects among countries

Following Chudik and Pesaran (2009), I assumed that there are common factors and dominant effect among countries of the study that have significant impact on country-specific VAR models. For this, cross-section weighted averages of foreign variables (marked by ‘star’ and called star variables) were calculated and then following regression was done for two variables  $FI_t$  and  $GDP_t$  for each country  $n$  :

$$y_{nt} = \alpha_n + \sum_{\ell=1}^{p_n} a_{n\ell} y_{n,t-\ell} + \sum_{\ell=0}^{h_n} b_{n\ell} y_{n,t-\ell}^* + u_{nt}$$

We did this regression for variable FI and real GDP growth to capture the effect of the economic performance and the banking system condition of other countries on

country  $n$ .  $y_{nt}^*$  is the weighted average of corresponding foreign variables (i.e. weighted average of real GDP growth and FI of the sample countries other than country  $n$ ). The weight for averaging was determined according to the amount of trades that country  $n$  has had with the other countries of the sample during the period. Then, the significance of coefficient  $b_{n\ell}$  was tested with the Wald test and the significant star variables were added to the VAR model of the country  $n$ . Following Chudik and Pesaran (2009), I also assume that the number of common factors is less than endogenous variables for each country and, therefore, it is not necessary to augment VAR of a given country with the average of all endogenous variables of foreign country.

## References

- Adjemian, S., Bastani,H., Juillard,M., Mihoubi,F., Perendia,G., Ratto, M., Villemot, S.,  
2011. Dynare: Reference Manual, Version 4, Dynare Working Papers, 1, CEPREMAP.
- Akhter, S., Daly, K., 2009. Bank health in varying macroeconomic conditions: A panel study. *International Review of Financial Analysis* 18, 285–293.
- Akram, Q.F., Ba°rdsen,G., Lindquist, K.G., 2007. Perusing financial stability under an inflation-targeting regime. *Annals of Finance* 3, 131-153.
- Akram, Q.F., Eitrheim, Q., 2008. Flexible inflation targeting and financial stability: Is it enough to stabilize inflation and output? *Journal of Banking and Finance* 32, 1242-1254.
- Allen, W., Wood, G., 2006. Defining and achieving financial stability. *Journal of Financial Stability* 2, 152–172.
- Allen, F., 2001. Financial structure and financial crisis. *International Review of Finance* 2, 1-19.
- Allen, F., Gale, D., 2004. Comparative financial systems: A discussion. In: S. Bhattacharya,S., Boot, A., and Thakor, A. V. (eds.), *Credit Intermediation and the Macroeconomy: Models and Perspectives*. Oxford University Press, Oxford, 699-770.
- Allen, F., Gale, D., 2000. *Comparing Financial Systems*, Cambridge. US,MIT Press.
- Allen, F, Gale, D., 2001. Financial contagion. *Journal of Political Economy*,108 (1), 1–33.
- Allen, F., Carletti, E., 2006. Credit risk transfer and contagion. *Journal of Monetary Economics*, 53 (1), 89–111.
- Allen, F., Carletti, E., Gale, D., 2009. Interbank market liquidity and central bank intervention. *Journal of Monetary Economics*,56 (5), 639–652.
- Allen, L., Boudoukh, J., Saunders, A., 2004. *Understanding market, credit, and operational risk. The Value at Risk approach*. Blackwell publishing.

- Alexander, C., Sheedy, E., 2008. Developing a stress testing framework based on market risk models. *Journal of banking and Finance* 32, 2220-2236.
- Aspachs, O., Goodhart, C., A., E., Tsomocos, D., P., Zicchino, L., 2007. Towards a measure of financial fragility. *Annals of Finance* 3, 37–74.
- Basurto, M., A., S., Goodhart, C., Hofmann, B., 2006. Default, Credit Growth, and Asset Prices. International Monetary Fund (IMF). Working paper WP/06/223.
- Baum, F., C., Schäfer, D., Talavera, O., 2011. The impact of the financial system's structure on firms' financial constraints. *Journal of International Money and Finance* 30, 678–691.
- Bean, C. 2004. Asset prices, financial imbalances and monetary policy. *American Economic review* 94, Issue 2.
- Bean, C. 2003. Asset prices, financial imbalances and monetary policy: Are inflation target enough? In A. Reichard and T. Robinson eds., *Asset prices and monetary policy*. Sydney: Reserve Bank of Australia., pp.48-76.
- Beck, T., Levine, R., 2004. Stock markets, banks and growth: panel evidence. *Journal of Banking and Finance* 28, 423–442
- Beck, T., Demirgüç-Kunt, A., Levine, R., (2000), *A New Database on Financial Development and Structure* (Updated December 2009). *World Bank Economic Review* 14, 597-605.
- Bei, H., 2009. Hong Kong IPOs may raise record \$48 Billion in 2010, <http://www.bloomberg.com>.
- Bekaert, G., Harvey, C., Ng, A., 2005. Market integration and contagion. *Journal of Business*, 78(1), 39-69.
- Benigno, P., 2004. Optimal monetary policy in a currency area. *Journal of International Economics* 63, 293-320.

- Black, F., Scholes, M., 1973. The pricing of Options and Corporate Liabilities. *Journal of Political Economy* 81, 637-659.
- Blaschke, W., Jones, M.T., Majnoni, G., Martinez Peria, S., 2001. Stress testing of financial systems: An overview of issues, methodologies and FSAP experiences. Working Paper 88, International Monetary Fund.
- Bond, S., Dungey, M., Fry, R., 2006. A web of shocks: crises across Asian real estate markets. *Journal of Real Estate Finance and Economics*, 32(3), 253-274.
- Borio, C. and Lowe, P. 2002, Asset prices, financial and monetary stability: exploring the nexus, mimeo, BIS, Basle.
- Boss, M., 2002. A Macroeconomic credit risk model for stress testing the Austrian credit portfolio. *Financial Stability Report 4*, Oesterreichische Nationalbank. *Statistics*, 22, 129-162.
- Boyarchenko, S., Levendorskiy, 2000. Option pricing for truncated Levy processes. *International Journal of Theoretical and Applied Finance* 3, 549-552.
- Brissimis, N., S., Skotida, I., 2008. Optimal monetary policy in the Euro area in the presence of heterogeneity. *Journal of International Money and Finance* 27, 209-226.
- Brousseau., V., Detken, C., 2001. Monetary policy and fears of financial instability. European central bank, working paper 89.
- Calvo, G., 1983. Staggered prices in a utility maximizing framework. *Journal of Monetary Economics* 12, 383–398.
- Canbas, S., Cabuk, A., Kilic, S., B., 2005. Prediction of commercial bank failure via multivariate statistical analysis of financial structures: The Turkish case. *European Journal of Operational Research* 166, 528–546.
- Caporale, G., Cipollini, A., Spagnolo, N., 2003. Testing for contagion: a conditional correlation analysis. *Journal of Empirical Finance*, 12, 476-489.

- Charemza, W.,W., Makarova, S., Shah, I., 2010a. Periods of high inflation and real effects: some empirical evidence. University of Leicester/UCL, mimeo.
- Charemza, W.,W., Makarova, S., Jelonek, P., 2010b. An application of the choleskized multivariate distributions for constructing inflation Fan Charts. University of Leicester/UCL, mimeo.
- Chari, V., Kehoe, P.J., McGrattan, E.R., 1997. Monetary Shocks and Real Exchange Rates in Sticky Price Models of International Real Business Cycles. NBER Working Paper n° 5876.
- Chari, V., Kehoe, P.J., McGrattan, E.R., 2002. Can sticky price models generate volatile and persistent real exchange rates? *Review of Economic Studies* 69, 533–563.
- Chiang, T.C., Jeon, B.N., Li, H., 2007. Dynamic correlation analysis of financial contagion: evidence from Asian markets. *Journal of International Money and Finance*, 26, 1206-1228.
- Chow, G.C., Lin, A., 1971. Best linear unbiased interpolation, distribution, and extrapolation of time series by related series. *The review Economics and statistics* 53, 372-375.
- Chudik A., Pesaran, MH., 2009. Infinite dimensional VARs and factor models. IZA discussion paper 3207.
- Clarida, R., Gali, J., and Gertler, M. (1999). The science of monetary policy: A new Keynesian perspective. *Journal of Economic Literature* 37, 1661-1707.
- Clarida, R., Gali, J., Gertler, M., 2001. Optimal monetary policy in closed versus open economies: an integrated approach. *American Economic Review Papers and Proceedings* 91 (2), 248–252.
- Clark, B., P., Goodhart A.E., C., Huang, H., 1999. Optimal monetary policy rules in a rational expectations model of Phillips curve. *Journal of Monetary Economics* 43, 497-520.
- Collard, F., Juillard, M., 2003. Stochastic simulations with DYNARE. A practical guide. Mimeo, University of Toulouse/Paris.



- Collyns, C., Senhadji, A., 2002. Lending Booms, Real Estate Bubbles, and The Asian Crisis, IMF Working Paper, 02/20.
- Crockett, A., 1997. Maintaining financial stability in a global economy. In: Federal Reserve Bank of Kansas City's Symposium, Jackson Hole, Wyoming, 28–30.
- Cuche, N.A., Hess, M.K., 1999. A monthly time series of Swiss GDP: Business cycle indicator and research tool. Working paper, university of Lausanne and university of Bern.
- De Graeve, F., Kick, T., Koetter, M., 2008. Monetary policy and financial (in)stability: An integrated micro–macro approach. *Journal of Financial Stability* 4, 205–231.
- De Hoyos, R.E., Sarafidis, V., 2006. Testing for cross-sectional dependence in panel-data models. *The Stata Journal* 6(4), 482–496.
- Dell'Ariccia, G., Marquez, R.S., 2006. Lending booms and lending standards. *Journal of Finance* 61, 1045–1066.
- Demirgüç-Kunt, A., Detragiache, E., 2005. Cross-country empirical studies of systemic bank distress: A survey. *National Institute Economic Review* 192, 68–83.
- Demirgüç-Kunt, A., Detragiache, E., 1998. The determinants of banking crises in developing and developed countries. IMF staff paper 45, 81–109.
- Demirgüç-Kunt, A., Levine, R., 2001. Financial structure and economic growth: A cross-country comparison of banks, markets, and development. MIT press, Cambridge, 243–262.
- Demirgüç-Kunt, A., Huizinga, H., 2000. Financial structure and bank profitability. Policy research working paper 2430, Development research group, The World bank.
- De Nicro, G., 2000. Size, charter value and risk in banking: An international perspective. International Finance Discussion Paper No. 689, Board of Governors of the Federal Reserve System.

- Devereux, M., 2004. Monetary policy rules and exchange rate flexibility in a simple dynamic general equilibrium model. *Journal of Macroeconomics* 26, 287-308.
- Diamond, D., W., 2004. Liquidity, banks, and markets. In: S. Bhattacharya, S., Boot, A., and Thakor, A. V. (eds.), *Credit Intermediation and the Macroeconomy: Models and Perspectives*. Oxford University Press, Oxford, 136-160.
- Dickey, D.A. and Fuller, W.A., 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association* 74, 427-431.
- Disyatat P., 2005. Inflation targeting, asset prices and financial imbalances: Conceptualizing the debate. BIS working paper no. 168, monetary and economic department.
- Divino, A., J., 2009. Optimal monetary policy for a small open economy. *Economic Modelling* 26, 352-358.
- Domac, I., Peria, M., S., 2003. Banking crises and exchange rate regimes: is there a link? *Journal of International Economics* 61, 41-72.
- Dovern, J., Meier, C., P., Vilsmeier, J., 2010. How resilient is the German banking system to macroeconomic shock? *Journal of Banking and Finance* 34, 1839-1848.
- Drehmann, M., Sorensen, S., Stringa, M., 2010. The integrated impact of credit and interest rate risk on banks: A dynamic framework and stress testing application. *Journal of Banking and Finance* 34, 713-729.
- Driffill, J., Rotondi, Z., Savona, P., Zazzara, C., 2006. Monetary policy and financial stability: What role for the futures market? *Journal of Financial stability* 2, 95-112.
- Dungey, M., Fry, R., Martin, V., 2006. Correlation, contagion and Asian evidence. *Asian Economic Papers* 5(2), 32-72.
- Ergungor, O., E., 2008. Financial system structure and economic growth: Structure matters. *International Review of Economics and Finance* 17, 292-305.
- Evrensel, A.Y., 2008. Banking crisis and financial structure: A survival-time analysis. *International Review of Economics and Finance* 17, 589-602.

- Filardo, A., 2008. Household debt, monetary policy and financial stability: still searching for a unifying model. Bank for International Settlements.
- Flavin T.J., Panopoulou E., Unalmis, D., 2008. On the stability of domestic financial market linkages in the presence of time-varying volatility. *Emerging Markets review* 9, 280-301.
- Flavin, T., Panopoulou, E., 2008. Detecting shift and pure contagion in East Asian equity markets: a unified approach. *Economics Department Working Papers Series N1890208*. NUI Maynooth.
- Forbes, K.J., Rigobon, R.J., 2002. No contagion, only interdependence: measuring stock market co-movements. *Journal of Finance*, 57 (5), 2223-61.
- Froyland, E., Larsen, K., 2002. How vulnerable are financial institutions to macroeconomic changes? An analysis based on stress testing. *Economic Bulletin* (October), Norges Bank.
- Gai, P., Kapadia, S., 2010. Contagion in financial networks. Bank of England, working Paper No. 383.
- Gali, J., Monacelli, T., 2005. Monetary policy and exchange rate volatility in a small open economy. *Review of Economic Studies* 72, 707–734.
- Gali, J., 2002. New perspectives on monetary policy, inflation, and the business cycle. NBER working paper, NO. 8767. <http://www.nber.org/papers/w8767>.
- Gavin, M., Hausmann, H., 1995. Will the Mexican stabilization program allow the banks to survive? Inter-American development Bank, Mimeo.
- Goodhart, C.A.E., Sunirand, P., Tsomocos, D.P., 2006. A model to analyse financial fragility. *Econ Theory* 27, 107–142.
- Gunsel, N., 2008. Micro and macro determinants of bank fragility in North Cyprus economy. *International Research Journal of Finance and Economics* 22, 66-82.
- Hall, S.G., 1989. Maximum likelihood estimation of cointegrating vectors: An example of Johansen's procedure. *Oxford bulletin of Economics and Statistics* 51, 213-218.

- Harvey, A.C., 1989. Forecasting, structural time series models and the Kalman filter. Cambridge University Press, 100-232.
- Hoggarth, G., Sorensen, S., Zicchino, L., 2005a. Macro stress tests of UK banks. In: Investigating the Relationship between the Financial and the Real Economy. BIS Papers No. 22, Bank for International Settlements, pp. 392–408.
- Hoggarth, G., Sorensen, S., Zicchino, L., 2005b. Stress tests of UK banks using a VAR approach. Bank of England, Working paper No. 282.
- Hoggarth, G., Whitley, J., 2003. Assessing the strength of UK banks through macroeconomic stress tests. Financial stability review (June), Bank of England.
- Ibrahim, M.H., 2006. Stock prices and bank loan dynamics in a developing country: The case of Malaysia. *Journal of Applied Economics* 1, 71-89.
- Im, K., Pesaran, H., Shin, Y., 1995. Testing for unit roots in heterogeneous panels. DAE working papers Amalgamated series NO. 9526, university of Cambridge.
- Im, K., Pesaran, H., Shin, Y., 2003. Testing for unit roots in heterogeneous panels. *Journal of Econometrics* 115, 53-74.
- Imai, J., Kawai, R., 2010. Quasi-Monte Carlo method for infinitely divisible random vectors via series representations. *Siam Journal on Scientific Computing* 32 (4), 1879–1897.
- Johansen, S., 1992. Testing weak exogeneity and the order of Co-integration in UK money demand data. *Journal of policy modelling* 14, 313-334.
- Jorion, P., 2007. Value at Risk. The new benchmark for managing financial risk. McGraw-Hill, London.
- Kalirai, H., Scheicher, M., 2002. Macroeconomic stress testing: preliminary evidence for Austria. Austrian National Bank financial stability report no. 3.
- Kaufman, G.G., Krueger, T.H., Hunter, W.C., 1999. The Asian Financial Crisis: Origins, Implications and Solutions. Springer.

- Khalid, A., M., Kawai, M., 2003. Was financial market contagion the source of economic crisis in Asia? Evidence using a multivariate VAR model. *Journal of Asian Economics* 14, 131–156.
- Kontonikas A., Montagnoli, A., 2006. Optimal monetary policy and asset price misalignments. *Scottish Journal of Political Economy* 53, No. 5.
- Kontonikas, A., Ioannidis, C., 2005. Should monetary policy respond to asset price misalignments? *Economic Modelling* 22, 1105– 1121.
- Kunt, A., D., Detragiache, E., Gupta, P., 2006. Inside the crisis: An empirical analysis of banking systems in distress. *Journal of International Money and Finance* 25, 702-718.
- Kunt, A., D., Detragiache, E., 1998. The determinants of banking crisis in developing and developed countries. *International Monetary Fund* 45:1.
- Kunt, A., D., Detragiache, E., 2005. Cross-country empirical studies of systemic bank distress: A survey. *National Institute Economic Review* 192.
- Kunt, A., D., Huizinga, H., Financial structure and bank profitability. The World Bank working paper 2430.
- Koop, G., Pesaran, MH., Potter, S., M., 1996. Impulse response analysis in non-linear multivariate models. *Journal of Econometrics* 74, 119-147.
- Kwack, S.Y., 2000. An empirical analysis of the factors determining the financial crisis in Asia, *Journal of Asian Economics*, 11, 195-206.
- Ladley, D., 2011. Contagion and risk-sharing on the inter-bank market. University of Leicester, Working Paper No. 11/10.
- Laeven, L., Majoni, G., 2003. Loan loss provisioning and economic slowdowns: Too much, Too late? *Journal of Financial Intermediation* 12, 178-197.
- Lane, T., 1999. The Asian financial crisis. What have we learned? *International Monetary Fund, Finance & Development* (36) 3.
- Lastrapes, W., D., McMillin, W., D., 2004. Cross-country variation in the liquidity effect: The role of financial markets. *The Economic Journal* 114, 890-915.

- Levine R., 2002. Bank-based or Market-based financial systems: Which is better? *Journal of Financial Intermediation* 11, 398-428.
- Liao, E., A., Teng, C., H., 2008. The effects of monetary policy: DSGE model analysis of Taiwan. *Applied Economics*, 40, 1043–1051.
- Lopez, J., 2005. Stress tests: Useful complements to financial risk models. *FRBSF Economic Letter*, 119-124.
- Luintel, K.B., Khan, M., Arestis, P., Theodoridis, K., 2008. Financial structure and economic growth. *Journal of Development Economics* 86, 181-200.
- Lutkepohl, H., 2006. Vector Autoregressive Models. In *Palgrave Handbook of Econometrics. Volume 1. Econometric Theory*. Palgrave Macmillan
- Lutkepohl, H., 1991. *Introduction to multiple time series analysis*. Berlin, Springer-Verlag.
- Merton, R., 1974. On the pricing of corporate Debt: The risk structure of interest rates. *The Journal of Finance* 29, 449-470.
- Monacelli, T., 2005. Monetary policy in a low pass-through environment. *Journal of Money, Credit and Banking* 37, 1047–1066.
- Moons, C., Garretsen, H., Aarle B., Fornero, J., 2007. Monetary policy in the New Keynesian model: An application to the Euro Area. *Journal of Policy Modeling* 29, 879–902.
- Nier, E., Zicchino, L., 2008. Bank losses, monetary policy, and financial stability: evidence on the interplay from panel data. *IMF Working Paper* 232.
- Nimark, K., P., 2009. A structural model of Australia as a small open economy. *The Australian Economic Review* 42, pp. 24–41.
- Nocetti, D., 2006. Central bank's value at risk and financial crisis: an application to the 2001 Argentine crisis. *Journal of Applied Economics (IX)* 2, 381-402.
- Nolan, P., J., 2009. *Stable distributions: Models for heavy tailed data*. Birkhauser, Boston.

- Otani., A., *et al*, 2009. Macro stress-testing on loan portfolio of Japanese Banks. Bank of Japan, Working paper No. 09-E-1.
- Pesaran, MH., 2007. A simple panel unit root test in the presence of cross-section dependence. *Journal of Applied Economics* 22, 265-312.
- Pesaran, M.H. and Smith, R. 2006. Macro econometric modelling with a global perspective. *The Manchester School, Supplement*, 24-49.
- Pesaran, M.H., Schuermann, T., Weiner, S.M. 2004. Modelling Regional Interdependencies Using A Global Error-Correcting Macro econometric Model. *Journal of Business and Economics Statistics*, 22, 129-162.
- Pesaran, MH., 2004. General diagnostic tests for cross section dependence in panels. University of Cambridge, Faculty of Economics, Cambridge working paper No. 0435.
- Pesaran MH., Shin, Y., 1998. Generalized impulse response analysis in linear multivariate models. *Econometrics Letters* 58, 17-29.
- Pesaran, M.H., Schuermann, T., Smith, L.V., 2009. Forecasting economic and financial variables with global VARs. *International Journal of Forecasting* 25, 642-675.
- Peura, S., Jokivuolle, E., 2004. Simulation based stress tests of banks' regulatory capital adequacy. *Journal of Banking and Finance* 28, 1801-1824.
- Phillips, P.C.B., Perron, P., 1988. Testing for a Unit Root in Time Series Regression. *Biometrika* 75, 335-346.
- Quigley, J.M., 2001. Real Estate and the Asian Crisis, *Journal of Housing Economics*, 10, 129-161.
- Rachev, S., T., Mitnik, S., 2000. *Stable Paretian models in finance*. John Wiley & Sons, Chichester.
- Rahman, S., Tan, T., 2004. Identifying financial distress indicators of selected banks in Asia. *Asian Economic Journal* 18, 45-57.

- Ramaswamy R., Slock T., 1998. The real effects of monetary policy in the European Union: What are the differences? IMF staff paper 45, 374-369.
- Reinsel G.C., Ahn, S.K., 1989. Vector autoregressive models with unit roots and reduced rank structure: Estimation, likelihood ratio test, and forecasting. *Journal of time Series Analysis* 13, 353-375.
- Reynolds, S., E., Ratanakomut, S., Gander, J., 2000. Bank financial structure in pre-crisis East and Southeast Asia. *Journal of Asian Economics* 11, 319–331.
- Rosinski, J., 2007. Tempering stable processes. *Stochastic Processes and their Applications* 117, 677–707.
- Rotemberg, J., Woodford, M., 1998. An Optimization-Based Econometric Framework for the evaluation of Monetary Policy: Expanded Version. NBER Working Paper n.233.
- Rotemberg, J., Woodford, M., 1999. Interest rate rules in a estimated sticky price model. In: Taylor, J. (Ed.), *Monetary Policy Rules*. The University of Chicago Press, Chicago, pp. 57–126.
- Roy, A. D., 1952. Safety First and the Holding of Assets. *Econometrica* 20, issue 3, 431-449.
- Ruiz-Porras, A., 2009. Financial Structure, Financial Development and Banking Fragility: International Evidence. *Análisis Económico* 56, vol. XXIV.
- Ruiz-Porras, A., 2008. Banking competition and financial fragility: Evidence from panel-data. *Estudios Economicos* 23, 49-87.
- Ruiz-Porras, A., 2006. Financial system and banking crisis: An assessment. *Revista Mexicana de Economía y Finanzas* 5, 13-27.
- Safdar U. K., Adnan, H., 2008. A small Open Economy DSGE Model for Pakistan. [http://mpira.ub.uni-muenchen.de/1297/MPRA paper NO.12977](http://mpira.ub.uni-muenchen.de/1297/MPRA%20paper%20NO.12977).
- Samorodnitsky, G., Taqqu, M., 1994. Stable non-Gaussian random processes: stochastic models with infinite variance. Chapman and Hall.



- Schwarz, A. 1994. *A Nation in Waiting: Indonesia in the 1990s*. Westview Press.
- Schwartz, A., 1986. Real and pseudo financial crises. In: *Financial Crises and the World Banking System*. Capie, F.H., Wood, G.E., (eds.) Macmillan, London.
- Sedghi-Khorasgani, H., 2010. Financial instability and optimal monetary policy rule. FIW Working Paper N° 42.
- Shuetrim, G., 1999. Multivariate Kalman Filtering Gauss Code (Handling Missing Observations), Programs and Software cd0002, Australian Prudential Regulation Authority.
- Sims, C.A., 1980. Comparison of interwar and post-war business cycles: monetarism reconsidered. *American Economic Review: papers and proceedings* 70, 250-257.
- Smith R., T., Eghtern, V., H., 2005. Interest rate smoothing and financial stability. *Review of financial economics* 14, 147-171.
- Soderlind, P., 2008. Monetary policy effects on Financial risk premia. *The Manchester School* (76) No.6, 690-707.
- Sorge, M., 2004. Stress-testing financial systems: an overview of current methodologies. BIS working paper No. 165.
- Sorge, M., Virolainen, K., 2006. A comparative analysis of macro stress-testing methodologies with application to Finland. *Journal of Financial Stability* 2, 113–151.
- Svensson, L., 2000. Open-economy inflation targeting. *Journal of International Economics* 50, 155-183.
- Taylor, J.B., 2001. The role of the exchange rate in monetary policy rules. *American Economics review* 91, 263-267.
- Tsomocos, D.P., 2003. Equilibrium analysis, banking, and financial instability. *J Math Econ* 39, 619–655.

- Uhde, A., Heimeshoff, U., 2009. Consolidation in banking and financial stability in Europe: Empirical evidence. *Journal of Banking & Finance* 33, 1299-1311.
- Violi, R., 2006. Asset prices and monetary policy rules: Should we forsake financial markets stabilization? Banca d' Italia, research Department, Rome, Italy.
- Vogelsang, T., J., Perron, P., 1998. Additional tests for a unit root allowing for a break in the trend function at an unknown time. *International Economic Review* 39, No. 4.
- White, R., W., 2008. Past financial crises, the current financial turmoil, and the need for a new macro financial stability framework. *Journal of financial stability* 4, 307-312.
- Wicksell, Knut. 1936. *Interest and Prices* (tr. of 1898 edition by R.F. Kahn). London: Macmillan.
- Wong, J.H.u. 2008. A framework for stress-testing banks' credit risk. *The Journal of Risk Model Validation*, 3–23.
- Wong, J., Wong, T., Leung, P., 2010. Predicting banking distress in the EMEAP economies. *Journal of Financial Stability* 6, 169-179.
- Wong, J., Wong, E., Leung P., 2007. A leading indicator model of banking distress-developing and early warning system for Hong Kong and other EMEAP economies. Hong Kong Monetary Authority, working paper 22.
- Woodford, M., 2003. *Interest and Prices: Foundations of a Theory of Monetary Policy*. Princeton: Princeton University Press.
- Wu, W., C., Chang, C., Selvili, Z., 2003. Banking system, real estate markets, and nonperforming loans. *International Real Estate Review* 6, 43-62.
- Xafa, M., 2007. Global imbalances and financial stability. *Journal of Policy Modeling* 29, 783–796.