MACROECONOMIC FLUCTUATIONS AND ASSET MARKETS IN KOREA

Ta Ly I

A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy

Discipline of Economics

Business School

The University of Sydney

July, 2012

Statement of Originality

This is to certify that to the best of my knowledge, the content of this thesis is my own work. This thesis has not been submitted for any degree or other purposes.

I certify that the intellectual content of this thesis is the product of my own work and that all the assistance received in preparing this thesis and sources have been acknowledged.

………………………………..

Ta Ly I

2012

ACKNOWLEDGEMENT

First and foremost, I would like to express my deepest gratitude to my supervisor, Dr David Kim. His continuing encouragement, sage advice, constructive criticisms, and outstanding guidance were indispensable not only for the completion of this thesis but also for helping me to gain insights in conducting economic research. I deeply appreciate his kindness throughout the entire process. I am also grateful to my associate supervisor, Dr Anthony Aspromourgos. He was always willing to discuss my problems and encourage me.

I would like to thank other teachers at the University of Sydney, in particular, Dr Stephen Whelan, Dr Russell Ross, Dr Mark Melatos and Dr Yunjong Eo for their hospitality and encouragement. I also wish to thank teachers at Sogang University, in particular, Dr Chae Shick Chung, Dr Hahn Shick Lee and Dr Bok Ung Kim for their kind comments and helpful words of advice.

Last but not least, I owe a debt of gratitude to all my family. If there were no endurance and support of my family, this thesis would not have been completed. I wish to thank my mother for her love and prayer, my beloved wife Jung Min for her ceaseless support and complete trust, and my only son, Joon Seo who is the reason for my happiness. Lastly, I dedicate this thesis to the memory of my late father. Father, I always remember and thank you what you have done in my life.

ABSTRACT

This thesis focuses on the dynamic interactions between macroeconomic activities and asset markets in Korea following financial liberalization in the early 1990s. Using a sequence of empirical models, I examine three key issues concerning the Korean economy characterized by an emerging and volatile capital market and a unique housing market system.

The first issue is concerned with the effects of changes in country risk and world interest rates on macroeconomic fluctuations in Korea. To examine these effects, an SVAR model of a small open economy is estimated, and a small open economy dynamic stochastic general equilibrium (DSGE) model of Uribe and Yue (2006) is calibrated to the Korean data. To check the robustness, the theoretical impulse responses from the calibrated model are compared against the impulse responses from the estimated SVAR model. Regarding the second issue of the changes in international stock market and country risk effects on changes in Korean stock market, the trivariate VAR BEKK GARCH (1,1) model is employed to estimate the presence of return and volatility spillover effects between internal and external financial markets. The third issue is related to the relationship between macroeconomic fluctuations and housing markets in Korea. In particular, three relationships are considered: between the business cycle and housing prices, between housing prices and *chonsei* prices, key feature of the unique rental system in Korea, and between monetary policy and housing prices. To investigate these three respective relationships in a single framework, a vector error correction model (VECM) is estimated and Gonzalo and Ng's (2001) two-step procedure is used to identify the structural shocks into permanent and transitory components.

The main findings of the thesis are as follows. First, there exists a countercyclical relationship between country risk and the business cycle in Korea. The U.S. interest rate shock and the Japanese interest rate shock have different effects on the business cycle in Korea. Second, there are significant return and volatility spillover effects between the Korean credit default swap (CDS) market and the Korean stock market in most cases. In addition, the return spillover effects from foreign exchange markets and the U.S. stock market to the Korean stock market, and the volatility spillover effect from the Japanese stock market to the Korean stock market are both significant. Third, housing market prices have a positive effect on output while a favourable supply shock leads housing market prices to respond positively. When the housing price rises, the *chonsei* price shows a transitory increase while the *chonsei* price rises are associated with permanent increases in housing price. A contractionary monetary policy shock leads to a significant fall in both housing and *chonsei* prices, implying that monetary policy in Korea is an effective policy tool to control housing prices.

Overall, the thesis concludes that changes in domestic and international financial and asset markets have a significant influence on the macroeconomic fluctuations in Korea. In addition, macroeconomic fluctuations also account for significant movements in Korean asset markets.

TABLE OF CONTENTS

Page No.

ACKNOWLEDGEMENT………………………………………………………...…..iii

ABSTRACT…………………………………………………………………………iv

TABLE OF CONTENTS……………………………………………………….....vi

LIST OF TABLES…………………………………………….………………….xi

LIST OF FIGURES………………………………………………………………..xiii

Chapter 1 Introduction and Overview………………………………………………1

1.1 Motivation and Objectives of the Study…………………………...…………....1

1.1.1 Macroeconomic Fluctuations and Asset Markets.…………………………....1

1.1.2 Business Cycles in Korea as a Small Open Economy………...……………6

1.1.2.1 Macroeconomic Performance and Financial Markets in Korea…...7

1.1.2.2 The Influence of the U.S. and Japan on the Korean Economy..…...8

1.1.2.3 Volatile Nature of the Korean Economy…………………...……...9

1.1.2.4 The Cyclical Properties of Output, Interest Rate, Stock Prices, and Housing Prices in Korea………….10

1.1.3 Effects of the Country Spread and World Interest Rates on the Korean Business Cycle….12

1.1.4 Return and Volatility in the Korean Stock Market and the Effects of Country Risk…....14

1.1.5 Business Cycle, Monetary Policy, and Housing Markets in Korea………16

1.2 Organization of Chapters……………………………………………..………..18

Chapter 2 Country Spread and Macroeconomic Fluctuations in Korea……...…20

2.1 Introduction…………………………………………………………...…20

2.2 Related Literature………………………………………………………...27

2.3 Data…………………………………………………………………….32

2.3.1 Data Description……….……………………………………………….33

2.3.2 Unit Root Tests..……………………………………………………..34

2.4 Empirical Analysis………………………………………………………..36

2.4.1 The Empirical Model…………………………………………...………38

2.4.2 A Structural VAR Analysis……………………………………………..43

2.4.2.1 Estimation Results………………………………………………..43

2.4.2.2 Impulse Response Functions……………………………………..46

2.4.2.3 Variance Decomposition………………………………………….57

2.5 A Theoretical Explanation………………………………………………..61

2.5.1 A Calibrated Model……………………………………………………….62

2.5.1.1 Households…………………………………………………….63

2.5.1.2 Firms…………………………………………………………...71

2.5.2 Calibration Results………...…………………………………...………75

2.5.3 Theoretical and Estimated Impulse Response Functions…………………79

2.6 Conclusion………………………………………………………………..83

Appendix for Chapter 2…………………………………………………………...86

Appendix 2A Impulse Response Functions for the Period of Post-Asian Financial…86
Crisis in the Case of Using the U.S. Interest Rate

Chapter 3 Study on Return and Volatility Spillover Effects among Stock, CDS, and Foreign Exchange Markets in Korea……………..90

3.1 Introduction……………………………………………………………90

3.2 Literature Review……………………………………………………….…..98

3.3 Descriptions of Data and Statistical Characteristics……………………...……..101

3.3.1 Unit Root and Autocorrelation Tests..…………………………………...…103

3.3.2 Cross-Correlation Test………………………………………………......106

3.3.3 Characteristics of Financial Time Series……………………...………108

3.4 Methodology…………………………………………………………….113

3.5 Empirical Results………………………………………………………...118

3.5.1 Foreign Exchange Markets, the Korean CDS market, and the Korean Stock Market………………119

3.5.2 U.S. and Japanese Stock Markets, the Korean CDS market, and the Korean Stock Market………..132

3.6 Conclusion………………………………………………………………141

Appendices for Chapter 3………………………………………………………..145

Appendix 3A The Conditional Covariance Equations……………………...………145

Appendix 3B Coefficients of Trivariate GARCH Model…………………………...146

Appendix 3C Estimates for the Pre-Global Financial Crisis Period………..………148

Chapter 4 The Business Cycle, Monetary Policy, and the Housing Market in Korea…...158

4.1 Introduction……………………………………………………………..158

4.2 Literature Review……………………………………………………….164

4.3 Methodology and Theoretical Basis...……………………………………..172

4.3.1 Cointegration Analysis………..……………………………...…….173

4.3.1.1 Money Demand…………………………………………………173

4.3.1.2 Output-House Ratio……………………………………………..174

4.3.1.3 *Chonsei*-House Ratio…………………………...…………177

4.3.1.3.1 The Arbitrage Condition Model…………………......180

4.3.1.3.2 The User Cost of Housing Model……………………181

4.3.2 Model Specification………………………………………...……183

4.3.3 Identifying Structural Shocks……………………………..…………186

4.3.3.1 The First Step: Permanent and Transitory Decompositon………187

4.3.3.2 The Second Step: Orthogonalized Shocks…………………...…188

4.4 Data and Tests……………………………………………………...………190

4.4.1 Data Description and Data Source……………………………….191

4.4.2 Unit Root Tests…..……………………………………………………193

4.4.3 Cointegration Tests…..……………………………………………..195

4.4.3.1 Johansen's Cointegration Rank Test…………………...……..195

4.4.3.2 Residuals-Based Test……………………………………………198

4.5 Empirical Results…………………………………………………………..199

4.5.1 Cointegrating Parameters…………………………………..………200

4.5.2 Estimation Output of VECM……………………………………….203

4.5.3 Impulse Responses………………………………………...……….206

4.5.3.1 Supply Shock……………………………………………………207

4.5.3.2 Inflation Shock……………………………………...……..209

4.5.3.3 *Chonsei* Price Shock…………………………………………….210

4.5.3.4 Money Demand Shock……………………………...………..212

4.5.3.5 Housing Price Shock…………………………………………213

4.5.3.6 Monetary Policy Shock………………………………………214

4.5.4 Variance Decomposition………………………………………………216

4.5.5 Historical Decomposition……………………………………………..220

4.6 Conclusion…………………………………………………………………222

Chapter 5 Conclusion…………………………………………………...227

5.1 Summary of the Thesis……………………………………………………227

5.2 Directions for Future Research………………………..……..……………….230

Bibliography……………………………………………………………………….232

LIST OF TABLES

Table 1.1: Reference Date and Duration of Korean Business Cycles..……………..….12

Table 2.1: ADF Test and PP Test………………………………………...……….36

Table 2.2: Optimal Lag Length Selection for SVAR………………………………..43

Table 2.3: Parameter Estimates of the SVAR (2) (Korea-U.S.)……………………..44

Table 2.4: Parameter Estimates of the SVAR (2) (Korea-Japan)……………………45

Table 2.5: Variance Decomposition…………………………………………………60

Table 2.6: Parameter Values……………………………………………………...…78

Table 3.1: ADF Test and PP Test……………………………………………………..105

Table 3.2: Ljung-Box Q-statistics of Returns and Changes………………………106

Table 3.3: Cross-Correlation between Two Financial Markets……………………107

Table 3.4: Descriptive Statistics for the Financial Series………...…………...…...112

Table 3.5: Estimates of Trivariate GARCH Model for Case I and Case II………..120

Table 3.6: Estimates of Trivariate GARCH Model for Case III and Case IV……..133

Table 3B.1: Coefficients of Multivariate GARCH Model for Case I and Case II….146

Table 3B.2: Coefficients of Multivariate GARCH Model for Case III and Case IV..147

Table 3C.1: Estimates of Trivariate GARCH Model for Case I and Case II …...…..150

Table 3C.2: Estimates of Trivariate GARCH Model for Case III and Case IV ...…..152

Table 3C.3: Coefficients of Multivariate GARCH Model for Case I and Case II….156

Table 3C.4: Coefficients of Multivariate GARCH Model for Case III and Case IV..157

Table 4.1: ADF Test and PP Test……………………………………………………..194

Table 4.2: Johansen Test……………………………………………...………196

Table 4.3: Residuals-Based Test…………………………………...…………198

Table 4.4: DOLS Estimates of the Cointegrating Parameters……………………..201

Table 4.5: OLS Estimates of the Cointegrating Parameters……………………….202

Table 4.6: Optimal Lag Length Selection for VECM……………….…………..203

Table 4.7: Estimates of VECM Conditional on DOLS Estimates…………………205

Table 4.8: Variance Decomposition…………………………………………..217

LIST OF FIGURES

Figure 1.1: Industrial Production, Interest Rate, Stock Prices, and……………….....11
Housing Prices in Korea

Figure 2.1: GDP and Country Interest Rates (Korea-U.S.)………..……………..…21

Figure 2.2: GDP and Country Interest Rates (Korea-Japan)………..………………22

Figure 2.3: Cross-Correlations between GDP and Country Interest Rates…………23

Figure 2.4: Impulse Responses to Country Spread Shock (Korea-U.S.)……………48

Figure 2.5: Impulse Responses to Country Spread Shock (Korea-Japan)…………..49

Figure 2.6: Impulse Responses to U.S. Interest Rate Shock………………………..51

Figure 2.7: Impulse Responses to Japanese Interest Rate Shock……...……………52

Figure 2.8: Impulse Responses to Output Shock (Korea-U.S.)……………………..55

Figure 2.9: Impulse Responses to Output Shock (Korea-Japan)……………………56

Figure 2.10: Theoretical and Estimated Impulse Response Functions……………….80
(U.S. Interest Rate Shock and Country Spread Shock)

Figure 2.11: Theoretical and Estimated Impulse Response Functions……………….82
(Japanese Interest Rate Shock and Country Spread Shock)

Figure 2A.1: Impulse Responses to Country Spread Shock………………………….87

Figure 2A.2: Impulse Responses to U.S. Interest Rate Shock……………………......88

Figure 2A.3: Impulse Responses to Output Shock…………………………………. ..89

Figure 3.1: CDS Spread Underlying Korean Government Bonds and……..………93
Korean Stock Market Index (KOSPI)

Figure 3.2: U.S. Stock Market Index (S&P 500) and Japanese Stock Market……..94
Index (NIKKEI 225)

Figure 3.3: Won/Dollar Exchange Rate and Won/Yen Exchange Rate…………..……96

Figure 3.4: Time Plots of Returns (Changes) and Squared Series…………………109

Figure 3.5: Return and Volatility Spillover Effects for Case I and Case II…..……125

Figure 3.6: Impulse Response Functions for Case I………………………………128

Figure 3.7: Impulse Response Functions for Case II………………………………129

Figure 3.8: Return and Volatility Spillover Effects for Case III and Case IV……..135

Figure 3.9: Impulse Response Functions for Case III……………………………..138

Figure 3.10: Impulse Response Functions for Case IV……………………………..139

Figure 3C.1: Return and Volatility Spillover Effects for Case I and Case II………..153

Figure 3C.2: Return and Volatility Spillover Effects for Case III and Case IV…….154

Figure 4.1: Housing Price Index and Industrial Production Index………………...175

Figure 4.2: Housing Price Indices…………………………………………………178

Figure 4.3: Housing Prices Growth………………………………………….......178

Figure 4.4: Impulse Responses to Supply Shock……………………………...…..208

Figure 4.5: Impulse Responses to Inflation Shock………………………………...210

Figure 4.6: Impulse Responses to *Chonsei* Price Shock……………………….....211

Figure 4.7: Impulse Responses to Money Demand Shock………………………...212

Figure 4.8: Impulse Responses to Housing Price Shock…………………………..213

Figure 4.9: Impulse Responses to Monetary Policy Shock……………………..….215

Figure 4.10: Historical Decomposition……………………………………………..221

Chapter 1 Introduction and Overview

1.1 Motivation and Objectives of the Study

Macroeconomic fluctuations and asset price movements have been fundamental issues of interest among macroeconomic researchers, asset market participants, and policy makers. There are important questions concerning business cycles, asset price volatilities, financial risk premiums, and fluctuations in asset markets. These issues have always been the subject of debate in macroeconomics and finance. This thesis addresses these issues empirically, concentrating on Korea with regard to three particular issues. The first issue relates to how and to what extent the macroeconomic fundamentals and business cycle in Korea can be affected by changes in country risk and international financial markets. The second issue is related to the existence of return and volatility spillover effects from changes in the country risk of Korea and larger countries' stock markets to Korea's stock market. The third issue is associated with the questions of whether housing price movements in Korea can explain the Korean business cycle and how monetary policy can affect housing market fluctuations. This thesis aims to analyse these three issues within the broad framework of macroeconomic fluctuations and asset price movements in Korea.

1.1.1 Macroeconomic Fluctuations and Asset Markets

A large body of research has focused on the relationship between asset markets and economic fluctuations. These studies invariably find that changes in asset prices, such as stock prices and housing prices, are negatively related to changes in interest rates, and these two asset markets lead the business cycle. In order to discuss the interaction of business cycle factors with financial market factors as major features in the cycle, a brief description of the relationship between asset markets and business cycles is provided from Bolten and Weigand (1998).

If an economy starts at a trough and is about to recover, expectations for positive economic growth and higher future earnings become prevalent gradually, which has a positive impact on current asset prices.[1] Interest rates are typically low during this period over the business cycle, which will positively affect stock prices and housing prices due to a decrease in the user cost of capital and an increase present value of asset payoffs. Additionally, low interest rates induce investors to transfer investment from low-yielding assets such as bonds to high-yielding assets such as stocks and housing, which influences stock prices and housing prices to increase. The combined effect causes stock prices and housing prices to rise somewhat rapidly at this stage.

As the economy continues to grow and the demand for capital increases, interest rates rise gradually due to inflationary pressure. However, expectations of future earnings still increase, stemming from the stable growth of the economy. At this stage of the business cycle, the positive effect of expectations for higher earnings dominates the negative effect of higher interest rates. Hence, the overall effect on the asset market is positive, and asset prices still tend to rise but not faster than the first stage of the

[1] Financial variables, such as the prices of financial instruments, are commonly associated with expectations of future economic events (Estrella and Mishkin. 1998). Theoretically, a link between asset prices and the real economy can be established from a consumption-smoothing argument. As investors are willing to buy assets to smooth out their future consumption paths, given current economic conditions, current asset prices should contain information about investors' expectations about the future real economy (Næs *et al.*, 2010).

economic recovery.

However, gradually, the loanable funds cannot supply enough to satisfy the increased demand for capital, and the monetary policy authority carries out tight monetary policy due to inflation, which leads to a further increase in interest rates. In addition, the rate of earnings growth shows a slowdown stemming from diminishing marginal productivity. Under these economic situations, asset prices tend to be at their peak, implying that a downward movement is imminent.

At last, prevailing negative economic expectations have a negative effect on asset prices. The decreased demand for capital and monetary policy response lead to decreasing interest rates; however, stock and housing prices will continue to decrease until interest rates decline substantially.

The above illustrates some typical cases of the relationships among the business cycle, interest rates, stock prices, and housing prices. Changes in asset prices are negatively related to changes in interest rates, whereas they are positively related to business cycle. These features inspire this study to analyse the dynamic interactions between the business cycle and asset price fluctuations.

There are several strands of literature on the relationship among the business cycle, interest rates, stock market, and housing market. One branch of the literature on the real economy and asset market linkages suggests that there exists a bilateral predictive association between the two. Several studies document that forward-looking asset markets make use of asset prices as predictors of the real economy, while others find that asset prices themselves are influenced by business cycle phases and thus can be predicted by macroeconomic variables.

Schwert (1989) examines some factors which could have potential influence on stock price volatility and finds that the level of real activity is an important determinant of the volatility of stock returns. Hamilton and Lin (1996) investigate the relationship between stock returns and industrial production. They find that economic recessions are the primary factor driving fluctuation in the volatility of stock returns. Bolten and Weigand (1998) demonstrate the relationship between stock market and business cycle dynamics, and they find that the interaction of changes in earnings and interest rates throughout economic cycles cause changes in the level of stock prices. Chauvet (1998) examines the dynamic relationship between stock market fluctuations and the business cycle, and she finds that the extracted stock market factor is a leading indicator of the state of the business cycle and can be used to predict turning points in real time. Estrella and Mishkin (1998) outline several reasons (e.g., double-checking both econometric and judgmental predictions, gathering better in-sample results, and seeking quick and simple characteristics) why policy makers and market participants should look at a few well-chosen financial indicators. They examine the performance of various financial variables as predictors, such as interest rates and spreads, stock prices, and currencies, and their results show that stock prices can be used as effective predictors. Neumeyer and Perry (2005) and Sarquis (2007) find that real interest rates are countercyclical, and lead the business cycle. Uribe and Yue (2006) find that the world interest rate and country spread shocks are useful indicators that provide a good explanation for the business cycle. Leamer (2007) finds that housing plays an important role in economic growth and that changes in the housing market are a leading indicator of the business cycle. Næs *et al*. (2010) investigate whether stock market liquidity is a good leading indicator of the real economy, and they find a strong relationship between stock market liquidity and the business cycle.

The other branch of literature on the relationship between business cycles and asset prices is concerned with dynamic analysis of the permanent and transitory components of business cycles and asset prices.

Cochrane (1994) characterizes transitory components in GNP and stock prices, and he finds evidence that substantial amounts of variation in GNP growth and stock returns are attributed to transitory shocks. Iacoviello (2002) analyses how housing prices interact with the shocks that drive economic fluctuations, and he finds that housing price inflation is highly sensitive to these forces driving economic fluctuations. Gonzalo and Lee (2008) use the common trend decomposition of King *et al*. (1991) to clarify Cochrane's results, and they find that the permanent components of GDP and stock prices are much larger than those estimates by Cochrane, although substantial variations in GDP growth and stock returns are attributed to transitory shocks. Senyuz (2011) analyses the dynamics of the permanent and transitory components of U.S. economic activity and the stock market, and she finds that both output and stock prices contain significant transitory components. She also finds the bilateral predictability of the economy and the stock market.

Along with domestic factors of financial market and asset market indicators for economic fluctuations, international factors such as changes of circumstances in international financial markets also play an important role in domestic economic fluctuations and changes in the asset market. In addition, it is often said that the business cycle in a country has a close relationship with changes in world economic conditions such as a global recession and financial crises. In line with this phenomenon, when macroeconomic volatility which comes from a certain region in the world increases or global financial crisis occurs, it tends to spread out not only through the region or country but also all over the world on this account. Consequently, there is a growing interest in the international transmission of global risk factors, especially among emerging and small developed economies, since an emerging economy or small developed economy responds sensitively to changes in international financial markets and business fluctuations in large developed economies. It is certain that an emerging economy or small developed economy experiences more serious financial crisis than an advanced economy during an unstable world economic period due to the larger volatility of an emerging economy or small developed economy than of an advanced economy.[2] Thus, international factors which affect the domestic macroeconomic fluctuations should also be considered along with domestic factors, as done in the thesis.

1.1.2 Business Cycles in Korea as a Small Open Economy

Following the Asian financial crisis in 1997 and the accompanying severe recessions in East Asia, the focus of economists' attention shifted to East Asia. While the growth prospects for East Asia are still an ongoing topic, the unprecedented scale of the macroeconomic fluctuations accompanying the financial crisis has become a motivation for research interests in understanding the sources of macroeconomic fluctuations in East Asia. Korea is a leading economy in Asia along with Japan and

[2] While business cycle fluctuations in developed markets may have moderated during recent decades, business cycles in emerging markets are characterized increasingly by their large volatility (Stock and Watson, 2005; Aguiar and Gopinath, 2007).

China. Although Korea shows rapid economic growth during a relatively short period and joins the ranks of advanced countries, Korea is still largely vulnerable to changes in international economic circumstances, especially in other advanced economies such as the U.S. and Japan. In addition, while Korea has solidified the financial and social system for decades, Korea suffered from economic damage due to several financial crises. This makes Korea particularly interesting as it is a recently developed economy with a heavy international economic dependency.

1.1.2.1 Macroeconomic Performance and Financial Markets in Korea

Korea has been achieving a high level of economic growth for decades. According to the GDP data from the World Bank, the GDP of Korea was 71 billion U.S. dollars in 1981.[3] However, after 30 years of economic growth, the GDP of Korea in 2010 was 1,014 billion U.S. dollars, representing an increase by a factor of 14. The GDP ranking of Korea has remained between 11 and 14 since 2001, and it was ranked 14th of 194 countries in 2010. For nearly three decades, Korea has experienced a very high level of economic growth, except for only one year of negative growth (1997-1998) following the Asian financial crisis.

It is easy to notice a similar pattern of high growth in Korean financial markets during the same period. Korea had maintained a state-controlled financial system until the 1970s; however, the era of deregulation in the financial sector began in the 1980s. Korea had experienced an economic boom due to low oil prices, low interest rates, and competitive exchange rates from 1986 to 1989. Since 1992, as it was possible for

[3] http://data.worldbank.org/country/korea-republic

foreigners to invest in the domestic stock market, the range of deregulation in the financial sector has extended to foreign capital. Korea became the 29th member country of the OECD in 1996.

However, there have been several economic contractions due to internal and external financial crises, to name a few, the Asian financial crisis in 1997, the SK accounting fraud and the credit card debacle in 2003, and the global financial crisis in 2007-2008. Whenever these unfavourable economic events occurred, the Korean business cycle showed an economic downturn, financial market indicators such as the country spread, interest rates, and exchange rates rose, and asset prices in the stock market and housing market fell. Nevertheless, the Korean financial market has shown robust growth in terms of volume and maturity, over these years. According to a chronological table regarding finance in Korea (2011), published by the Financial Services Commission on the basis of data provided by the Bank of Korea, aggregate financial assets in Korea have grown 90 times in size by 2010 (10298 trillion won) as compared to its size in 1980 (114 trillion won). In addition, the total market value of listed shares of the Korean stock market has become 10 times larger in scale by 2010 (1142 trillion won), as compared to the market value in 1996 (117 trillion won).

1.1.2.2 The Influence of the U.S. and Japan on the Korean Economy

Considering the Korean economy in relation to other countries, it is necessary to clarify the close connections with the U.S. and Japan. Although the U.S. and Japan account for a smaller share of total exports than before, since China is beginning to represent an increasing share in trade recently, the U.S. and Japan are still major economic partners with Korea. The combined share of trade with the U.S. and Japan represented 17% of total exports of Korea in 2010. Individually, the U.S. was the second largest trading partner (11%), and Japan was the third (6%) in 2010. According to the report from the Korea Centre for International Finance (2011), the correlation coefficient between Korea and the U.S. in terms of output growth was 0.51 in the 1980s. However, it has increased rapidly to 0.76 in the 2000s, which implies a stronger co-movement between Korea and the U.S. The correlation coefficient between Korea and Japan also remains high (0.72). Thus, there has been a strong interdependence of Korea with the U.S. and Japan.

1.1.2.3 Volatile Nature of the Korean Economy

The Korea Centre for International Finance (2011) indicates that the rate of economic growth in Korea must slow down if the low rate of economic growth in other developed countries is sustained. According to the ratio of exports and imports to GDP, which implies the dependence on exports and imports of a country's economy, this ratio in Korea was 96% in 2009, compared to the dependence ratios of the U.S. (19%), Japan (22%), and China (45%) during the same year.[4] From these values, it is recognizable that the levels of Korea's dependence on the international economy are much higher than these three other countries. This fact implies that the economic growth of Korea is largely induced by export oriented economic activities in connection with the growth of developed economies. However, beyond the positive aspect, there is the possibility for Korea to suffer from serious financial crisis when

[4] The ratio of exports and imports to GDP in Korea is published by the Bank of Korea (www.bok.or.kr).This ratio is calculated by the following equation. The ratio of exports and imports to GDP = (exports + imports)/GDP$\times$100

advanced economies enter recessionary periods. Korea is exposed to the danger of rapid increase in country risk due to high volatility when facing unfavourable international economic events, such as the current global financial crisis.

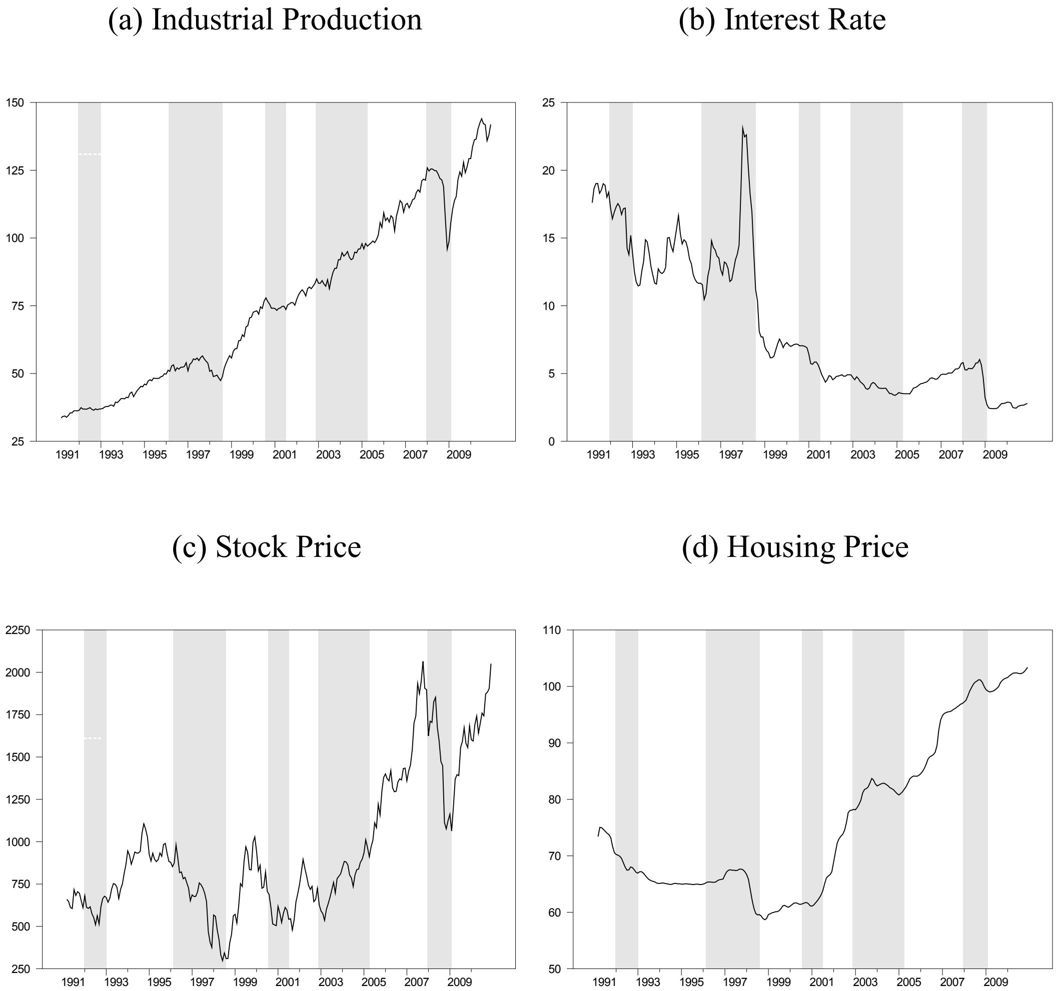
1.1.2.4 The Cyclical Properties of Output, Interest Rate, Stock Prices, and Housing Prices in Korea

Figure 1.1 depicts the time series of monthly industrial production, the three-month CD rate as a nominal interest rate, the Korea composite stock price index (KOSPI) as stock price, and a housing sale price index as the housing price in Korea.

The characteristics of changes in four time series are similar to the characteristics of interaction between business cycles and asset price fluctuations in the aforementioned summary of the relationships among the business cycle, interest rates, stock prices and housing prices. Output, stock prices, and housing prices share a common upward trend, and they show sharp decline during the grey section of the contractionary period. On the contrary, nominal interest rates in Korea demonstrate a downward path, although it shows a sharp rise during the contractionary period. Most contractionary periods in Korea are in accordance with the periods of financial crisis such as the Asian financial crisis in 1997, the SK accounting fraud and the credit card debacle in 2003, and the global financial crisis in 2008. During these periods, output, stock prices, and housing prices increased and interest rate decreased.

The range for a contractionary period in Korea is based on the reference dates of a Korean business cycle, published by Statistics Korea, a government branch in charge of officially organizing reference dates. Reference dates are the turning points, peaks,

Figure 1.1: Industrial Production, Interest Rate, Stock Prices, and Housing Prices in Korea



Note: Monthly industrial production is obtained from the Bank of Korea. Three-month CD rate is from the Bank of Korea. Korea composite stock price index (KOSPI) is from the Korea Centre for International Finance. Housing sale price index is from the Kookmin Bank. The data period is from Jan. 1991 to Dec. 2010. The grey section displays contractionary periods of the Korean business cycle based on the reference dates from Statistics Korea.

and troughs, of a business cycle. These business cycle turning points are based on the cyclical variations of the business cycle comovement index which is constructed by combining data regarding GDP, consumption, investment, surveys of professional economists, etc.[5] Table 1.1 presents the reference dates and durations of Korean business cycles on the basis of official reference material for press release from the Korean government.

Table 1.1: Reference Date and Duration of Korean Business Cycles

Cycle	Reference Date			Duration (Month)		
	Trough	Peak	Trough	Expansion	Contraction	Cycle
1st cycle	Mar. 1972	Feb. 1974	Jun. 1975	23	16	39
2nd cycle	Jun. 1975	Feb. 1979	Sep. 1980	44	19	63
3rd cycle	Sep. 1980	Feb. 1984	Sep. 1985	41	19	60
4th cycle	Sep. 1985	Jan. 1988	Jul. 1989	28	18	46
5th cycle	Jul. 1989	Jan. 1992	Jan. 1993	30	12	42
6th cycle	Jan. 1993	Mar. 1996	Aug. 1998	38	29	67
7th cycle	Aug. 1998	Aug. 2000	Jul. 2001	24	11	35
8th cycle	Jul. 2001	Dec. 2002	Apr. 2005	17	28	45
9th cycle	Apr. 2005	Jan. 2008	Feb. 2009	33	13	46
10th cycle	Feb. 2009					
Average				31	18	49

Note: Reference dates and durations are published by Statistics Korea (www.kostat.go.kr). Expansionary period is from trough to peak, and contractionary period is from peak to trough.

1.1.3 Effects of the Country Spread and World Interest Rates on the Korean Business Cycle

Country spread, the relative interest rate of a country against the world interest rate, is used as an indicator of the size of the country risk. Chapter 2 focuses on the

5 These are not the turning points in the classical sense, because the classical business cycle does not deal with any detrended series. The Statistics Korea benchmarks the procedure used by the NBER's Business Cycle Dating Committee, and then combines the procedure with other cyclical indicators of the economy, after taking into account the observation that Korea had a high growth trend and little classical recession. Although these turning points are not based on classical recessions, I use these turning points for better understanding the Korean business cycle in this thesis.

relationship between country risk and the business cycle in Korea. During a period of low country spread, a country is typically in an economic expansion stage. In contrast, during a period of high country spread, a country is in economically difficult times. Thus, the country spread has an effect on aggregate economic activity but at the same time responds to domestic macroeconomic fundamentals. In the meantime, the world interest rate has an effect on the country interest rate through the familiar no-arbitrage condition as well as country spread (Uribe and Yue, 2006). Korea is also vulnerable to external shocks, particularly world interest rate shocks, exchange rate shocks, and foreign productivity shocks, like other small open economies (Ahn and Kim, 2003). Thus, it is postulated that the Korean business cycle is largely affected by changes in interest rates in the U.S. and Japan. Shocks from these two − country spread and world interest rates − are used to examine the business cycle in a small open economy such as Korea.

Theoretical models of business cycles for a small open economy have been developed, and empirical studies have been performed to evaluate these models (Mendoza, 1991; Aguiar and Gopinath, 2007; Garcia-Cicco *et al.*, 2010). Since the work of Mendoza (1991), researchers have used dynamic stochastic models for small open economies driven by external shocks because the external shocks are postulated as important sources of macroeconomic fluctuations in small open economies (Canova, 2005; Maćkowiak, 2007; Sarquis, 2007).

In particular, researchers study the role of domestic and international interest rates in leading business cycles in emerging countries. Neumeyer and Perri (2005) and Uribe and Yue (2006) use dynamic stochastic general equilibrium (DSGE) models of emerging markets to investigate the effect of real interest rates on the business cycle. Neumeyer and Perry (2005) find that real interest rates are countercyclical and lead the business cycle. Additionally, they also find that country spread is induced by domestic fundamentals but that it amplifies the effects of fundamental shocks on business cycles at the same time. Uribe and Yue (2006) focus on separating the effects of the world real interest rate and emerging market fundamentals from those of country-specific risk. They find that the world interest rate and country spread shocks explain a sizable proportion of business cycles in emerging countries.

Therefore, the first goal of this thesis is to analyse how and to what extent international financial shocks, such as the U.S. interest rate shock as a world interest rate shock and Japanese interest rate shock as a regional interest rate shock, and country spread shock, can contribute to the fluctuations of the business cycle and macroeconomic fundamentals in Korea.

1.1.4 Return and Volatility in the Korean Stock Market and the Effects of Country Risk

Over the past few decades, economists and asset market participants have sought to determine the effect of macroeconomic variables on asset prices and investment decisions. The literature has presented many empirical studies to disclose the relationship between asset prices and macroeconomic variables such as the interest rate, inflation, the exchange rate, and money supply. However, there are few studies about the links between asset market volatility and macroeconomic volatility, despite a growing interest in understanding how shocks and volatilities are transmitted across markets over time. Schwert (1989) finds evidence that macroeconomic volatility can help to predict stock return volatility, and financial asset volatility helps to predict future macroeconomic volatility, since the prices of speculative assets should react quickly to new information about economic events.

Country risk in which economic fundamentals in a country are reflected is a good factor in explaining or forecasting the movement in asset markets. Hence, I consider the credit default swap (CDS) underlying the government bond market and use CDS spread as an indicator for country risk.[6] Together with the CDS market, I also consider the foreign exchange market, which plays a role in delivery of international risk to the domestic economy. Fluctuations in the exchange rate also reflect the variation of domestic country risk. Although there have been many studies regarding the relationship between exchange rates and stock returns in emerging economies (Bekaert and Harvey, 1995; Phylaktis and Ravazzolo, 2005; Beer and Hebein, 2008), the relationship between the CDS market and macroeconomic variables or asset markets remains a largely unexplored area. Remolona *et al*. (2008) find that each country's economic fundamentals, such as the inflation rate and foreign exchange reserves, affect the underlying asset of CDS spread itself. Longstaff *et al*. (2011) analyse that international elements such as the U.S. stock market conditions, global risk premiums and credit spreads of corporate bonds in the U.S., as well as macroeconomic conditions in a country can explain well the changes in the CDS premium. Kim (2009) studies the determinants of the Korean CDS premium underlying government bonds in a model with stock prices, short-term debt, and exchange rate shocks.

[6] CDS spread is the cost of compensation for credit risk of a specific bond. In particular, CDS spread underlying government bonds indicates the degree of sovereign risk (Kim, 2009).

Another issue exploited in the third chapter is the contagion from mature asset markets to emerging asset markets. The stock market is employed as a representative asset market to study in this issue, since every country provides reliable and accurate data for its stock market. The growing international integration of financial markets has prompted several recent empirical studies to examine the international transmission mechanism between stock markets around the world (Sun and Zhang, 2009; Sok-Gee and Karim, 2010; Beirne *et al.*, 2010). Bekaert and Harvey (1997) study how an emerging equity market is affected by the world capital market and find that the effects of the world factors are generally small. Ng (2000) assumes that there are three sources of shocks − local, regional, and world shocks − and constructs a model of volatility spillover which allows the unexpected return of Asian six emerging markets to be driven by a local idiosyncratic shock, a regional shock from Japan, and a global shock from the U.S.

The CDS, stock, and foreign exchange market data for the last decade show that Korean stock prices display opposite movements from CDS spreads and exchange rates. That is, Korean stock prices tend to be low during the period of high CDS spread and exchange rates while the stock prices tend to increase when the stock markets in the U.S. and Japan are strong.

Therefore, the second issue studied in this thesis is the return and volatility spillover effects among Korean CDS market, foreign exchange markets, and stock markets in Korea in relation to the U.S. and Japan.

1.1.5 Business Cycle, Monetary Policy, and Housing Markets in Korea

This thesis also considers the housing market as a major Korean asset market in order to examine the relationship between the housing market and macroeconomic fluctuations with reference to monetary policy. There is widespread evidence that the housing market is linked to aggregate economic activity. Carstensen *et al.* (2009) suggest that housing price fluctuations can have tremendous macroeconomic consequences. Iacoviello and Neri (2010) study sources and consequences of fluctuations in the housing market using a calibrated dynamic stochastic general equilibrium (DSGE) model. They find that, over the business cycle, housing demand and housing supply shocks explain 25% each of the volatility of housing investment and housing prices. On the other hand, monetary factors explain 20%. In many research areas related to the housing market, this thesis concentrates on the relationships between the business cycle and monetary policy for the Korean housing market, with a unique feature in housing rental markets called '*chonsei*' system, namely, the house sale and house rental markets.[7]

One branch of the literature focuses primarily on stressing the effects of fluctuations in the housing market on the business cycle (Iacoviello, 2002; Davis and Heathcote, 2005; Leamer, 2007). Leamer (2007) shows that housing makes a contribution to normal economic growth, and a change in the housing market is the best forward-looking indicator of the business cycle. He also argues that the housing market should play a more prominent role in the implementation of monetary policy.

Another branch of study of the housing market is related to the role of the channels for

---

[7] *Chonsei* is a unique dwelling system of total rent during the contract period, typically two years. In this system, the tenant pays an upfront lump sum as a deposit to the house owner for the use of the property with no additional requirement for periodic rent payments. The deposit should be returned to the tenant when the contract expires.

monetary policy transmission. The role of the housing market for the transmission of monetary policy has attracted substantial attention over the last few years, both empirically and theoretically (Mishkin, 2007). Theoretically, Iacoviello and Minetti (2003) and Iacoviello (2005) develop and estimate DSGE models featuring credit and borrowing constraints to clarify the link between housing prices and monetary policy. Empirically, Giuliodori (2005), Elbourne (2008), Vargas-Silva (2008), and Gupta and Kabundi (2010) find that housing prices are significantly affected by monetary policy shocks, and housing prices respond negatively to contractionary monetary policy shocks.

The third branch of study of the housing market is concerned with the house rental market. Himmelberg *et al*. (2005) and Otto (2007) analyse the housing and rental markets. In particular, *chonsei*, which is a unique rental system in the Korean housing market, is studied to provide meaningful information for the market value of rental housing services together with the house sale market. Although related studies about the *chonsei* system have been conducted by Son (2000) and Cho (2005), there is still no formal theory, and it lacks sufficient empirical test to make clear the relationship between housing prices and *chonsei* prices in an empirical macroeconomic framework.

Motivated by these three branches of research on housing markets, the third objective of this thesis is to examine the three relations, between the business cycle and the housing market, between monetary policy and the housing market, and between house sale markets and house rental (*chonsei*) markets, in Korea.

1.2 Organization of Chapters

This thesis is structured as follows. In Chapter 2, country risk and world interest rates are the driving force of business fluctuations in Korea. Chapter 2 is concerned with examining the changes in country spread and the world interest rates effects on fluctuations in Korean macroeconomic fundamentals. The structural vector autoregressive (SVAR) model is employed to achieve empirical results, and calibration using DSGE model for a small open economy of Uribe and Yue (2006) is conducted.

Chapter 3 is basically in line with Chapter 2 in regards to using country risk and international asset prices as shocks which affect Korean asset prices. Chapter 3 investigates the presence of return and volatility spillover effects among the CDS market, foreign exchange markets, and stock markets. To examine the changes in international stock market and the country risk effects on the domestic stock market, the trivariate vector autoregressive generalized autoregressive conditional heteroskedasticity (VAR GARCH) model is employed.

In Chapter 4, housing market prices are the driving force of business fluctuations in Korea. Chapter 4 is concerned with examining three relationships: that between the business cycle and housing markets, between housing prices and *chonsei* prices, and between monetary policy and housing market prices. To investigate these three relationships, the vector error correction model (VECM) is employed and Gonzalo and Ng's (2001) two-step procedure is adopted to identify the structural shocks to permanent and transitory components.

Chapter 5 concludes the thesis with key findings. Directions for future research as an extension of the current research are also provided in this chapter.

Chapter 2 Country Spread and Macroeconomic Fluctuations in Korea

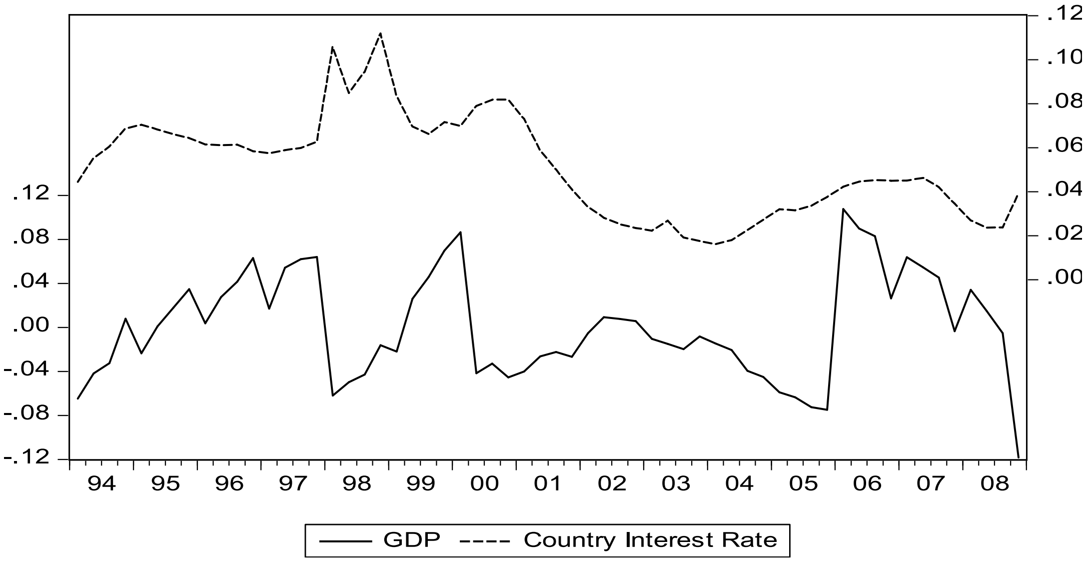
2.1 Introduction

It is well known that the business cycle of a country with an open economy is driven not only by fluctuations in domestic aggregate economic activities but also by changes in world economic conditions and international financial markets. Seeing these two internal and external aspects, country spread, which is the relative interest rate of a country against the world interest rate, is a useful indicator by which to examine the business cycle in a country. On the other hand, country spreads respond to changes in both world interest rates and domestic economic conditions simultaneously. A number of studies have emphasized the role of movements in country spreads and world interest rates in driving business cycles in small open economies (Neumeyer and Perri, 2005; Uribe and Yue, 2006). Thus, this chapter seeks to examine whether these complicated relationships are significant in Korea. In particular, since the Korean economy has close relationships with the U.S. and Japanese economies, the U.S. interest rate is used as a world interest rate, and the Japanese interest rate is used as a regional interest rate to compare the different effects from two advanced economies.

When a small country borrows capital from the international financial market, the cost of borrowing is closely related to domestic economic conditions. If the country is under conditions of higher country risk due to some unfavourable shocks such as financial crisis and business recession, the country has no choice but to sign loan agreements with high interest rates. Figures 2.1 and 2.2 illustrate relatively well the characteristics of these relationships between the country interest rate and the Korean business cycle. Figures 2.1 and 2.2 depict detrended GDP and country interest rates, the country interest rate computed with the U.S. interest rate and the country interest rate computed with the Japanese interest rate, respectively, for the period of 1994 to 2008 in Korea.

Generally, during the periods of low country interest rates, Korea is in economic expansion, while times of high country interest rates are characterized by economic contraction in the Korean business cycle. Higher interest rates cause private consumption and business investment to be depressed, which makes aggregate supply

Figure 2.1: GDP and Country Interest Rates (Korea-U.S.)



Note: GDP is seasonally adjusted and detrended using an H-P filter. The data source of GDP is *International Financial Statistics* (IFS). The country interest rate is the sum of country spread and world interest rate. Real yields on the U.S. dollar-denominated bond of Korea issued in international financial markets are used as a country spread and the three-month Treasury bill rate of U.S. is used as a world interest rate. The data source of the real yields on bonds of Korea is the Asian Development Bank's *Asian Bonds Online* and that of the three-month Treasury bill rate as the U.S. interest rate is *International Financial Statistics* (IFS). The numerical values on the right side are for the country interest rate and the numerical values on the left side are for GDP.

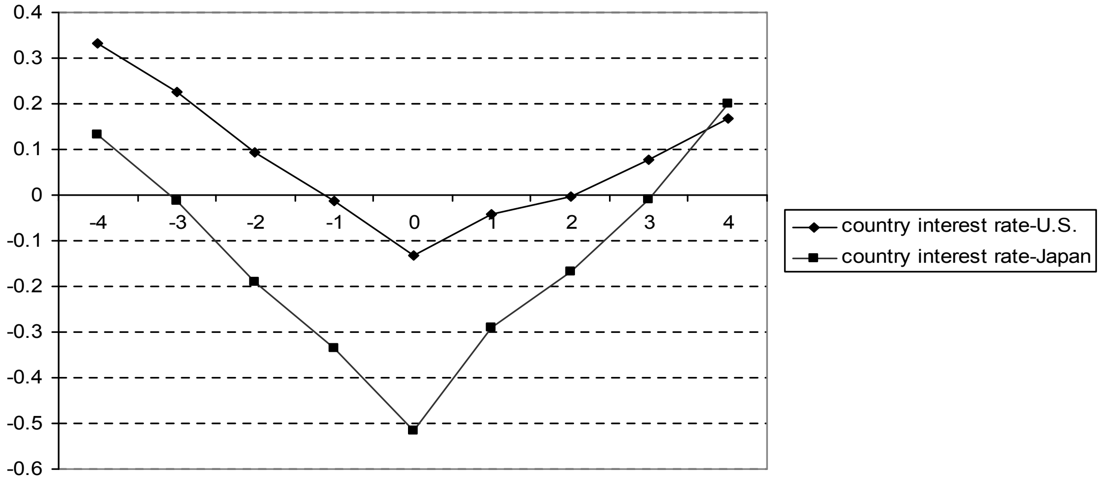
Figure 2.2: GDP and Country Interest Rates (Korea-Japan)

Note: GDP is seasonally adjusted and detrended using an H-P filter. The data source of GDP is *International Financial Statistic* (IFS). The country interest rate is the sum of country spread and regional interest rate. Real yields on the U.S. dollar-denominated bond of Korea issued in international financial markets are used as a country spread and the three-month CD rate of Japan is used as a regional interest rate. The data source of real yields on bonds of Korea is the Asian Development Bank's *Asian Bonds Online*, and that of the three-month CD rate as the Japanese interest rate is *International Financial Statistics* (IFS). The numerical values on the right side are for country interest rate and the numerical values on the left side are for GDP.

decrease. On the other hand, according to the classic school's economic theory of aggregate supply and aggregate demand model, interest rate falls off to the favourable supply shock. Thus, it can be assumed that real interest rates implying country spread in Figures 2.1 and 2.2 are decreasing functions of economic activity, and productivity shocks are also concerned with a decline in real interest rates.

In particular, for the period of the Asian financial crisis in 1997-1998, country interest rates show a rapid increase, while GDP shows a sharp decrease. That is, there exists a countercyclical relationship between country interest rates and Korean aggregate economic activity. This implies that an increase in country interest rates has a negative effect on domestic macroeconomic fundamentals but at the same time responds negatively to favourable aggregate economic activity, such as positive productivity shocks. However, during the time period of 2005 to 2008 in Figures 2.1 and 2.2, before the global financial crisis in 2008, country interest rates show acyclical patterns rather than countercyclical patterns. It is expected that the reason for this is a transitional phenomenon in Korea stemming from its joining the ranks of advanced economies recently; thus Korea reveals both two properties as a small developed economy and a developing economy throughout the whole data period.[8]

Figure 2.3: Cross-Correlations between GDP and Country Interest Rates



Note: Y axis denotes correlation coefficients between GDP and country interest rates. X axis denotes the quarters from 0 to both lags and leads directions.

Figure 2.3, which depicts the cross-correlation between GDP and country interest rates at different lags and leads, makes this point more precisely. In the Korean economy, country interest rates are countercyclical, observing that the correlation coefficients are

[8] According to the report by Neumeyer and Perri (2005), Korea is categorized as an emerging country, and Korea shows typical countercyclical characteristics of an emerging economy during their data period from 1994Q1 to 2001Q4.

-0.13 for the case of using the U.S. interest rate to compute the country interest rate, and -0.52 for the case of using the Japanese interest rate to compute the country interest rate. Figure 2.3 also shows that there is co-movement between GDP and country interest rates. The correlation between GDP and the country interest rate computed using the Japanese interest rate shows a stronger countercyclical characteristic than the correlation between output and the country interest rate computed using the U.S. interest rate by judging the scale of numerical values. The characteristics of U-shape and negative correlations between GDP and country interest rates are consistent with other emerging economies reported in Neumeyer and Perri (2005) and Uribe and Yue (2006).

Along with the country spread, another important shock to consider in this chapter is concerned with the world and regional interest rates. In theory, the world real interest rate is an important mechanism by which foreign shocks are transmitted to small open economies. Changes in the world real interest rate can affect behaviour along many margins: they affect households by generating intertemporal substitution, wealth and portfolio allocation effects, and they affect firms by altering incentives for domestic investment (Blankenau *et al*., 2001, p. 867). On the other hand, according to a number of studies concerned with the relationship between the world interest rate and country spread, they document that country spreads respond to changes in the world interest rate. That is, country spreads play a role as a transmission mechanism of world interest rates to amplify or to dampen the effect of world interest rate shocks on the domestic economy. Uribe and Yue (2006) argue that the world interest rate has an effect on the country interest rate through the familiar no-arbitrage condition as well as country spread.

In case of open economy analysis for Korea, the U.S. and Japan are inseparable economies because of close connections with the Korean economy. Since the Korean economy has been heavily dependent on foreign trade to achieve economic growth, innovations in economic conditions of major trading partners such as the U.S. and Japan have had an important influence on the Korean economy.[9] For instance, if there is an improvement in the output of the U.S. and Japanese economies, it can be expected that imports from other countries will increase due to the better economic conditions, and as a result, Korea will also have a chance to increase its exports to the U.S. and Japan. Hence, it can be expected that innovations in the economic conditions of the U.S. and Japan affect Korean economic activity. In this process, the U.S. interest rate as a world interest rate and the Japanese interest rate as a regional interest rate can be used as the transmission channels of economic conditions of these two advanced countries to the Korean economy directly or indirectly through the Korean country spread.

The main aim of this study is to examine the country spread and world interest rate effects on macroeconomic fundamental fluctuations in Korea. Country spread, which reflects world economic and international financial market conditions as well as domestic economic conditions in Korea, is used for examining the effects on Korean aggregate economic activity and vice versa. The U.S. and Japanese interest rates are used for investigating the world and regional interest rate effects on the Korean economy. Output, investment and net exports-to-output ratio are used as Korean key macroeconomic fundamental variables.

A structural vector autoregressive (SVAR) model is employed to examine the dynamic

[9] The U.S. was the second largest and Japan was the third largest trading partner of Korea in 2010. The combined share of trading with the U.S. and Japan was 17% of the total exports of Korea.

interactions between variables for the two different cases of using the U.S. and Japanese interest rates with quarterly data from 1994Q1 to 2008Q4. The restrictions for a small open economy, which implies that the changes in a small economy do not cause changes in a large economy, are applied in the SVAR model. After presenting empirical results from a SVAR framework, a dynamic stochastic general equilibrium (DSGE) model for a small open economy studied by Uribe and Yue (2006) is calibrated. To check robustness, theoretical impulse responses from the DSGE model and estimated impulse responses from the SVAR model are compared. Christiano *et al*. (2006) recommend VAR-based procedures for estimating the response of the economy to a shock since the structural VAR performs well in all of their examples and tests. The results of their paper support the view that structural VAR is a useful guide in constructing and evaluating DSGE models although evaluating DSGE models using a VAR has limitations.

To specify the interactions, the following four questions are suggested. First, how much can a country spread shock explain the movements of aggregate activity in the Korean economy? Second, how much can the U.S. and Japanese interest rate shocks explain the movements of aggregate activity in the Korean economy? Third, how does aggregate economic activity in Korea respond to increasing country spread shock? Fourth, how does Korean aggregate economic activity and country spread respond to increasing U.S. and Japanese interest shocks?

The key findings are as follows. First, innovations in country spread explains about 7% of output fluctuations in the Korean economy in the case of using the U.S. interest rate and about 0.2% of output fluctuations in the Korean economy in the case of using the

Japanese interest rate. Second, innovations in the U.S. interest rate explain about 3% of output fluctuations in the Korean economy. Innovations in the Japanese interest rate explain about 5% of output fluctuations in the Korean economy during the data period. Third, when the country spread rises by a positive one standard deviation shock, Korean GDP falls. Fourth, when the U.S. interest rate rises by a positive one standard deviation shock, Korean GDP and country spread rise. On the other hand, when the Japanese interest rate rises by a positive one standard deviation shock, Korean GDP falls and country spread rises.

The remainder of the chapter is structured as follows. In section 2.2, a brief overview of the related literature is provided. Section 2.3 describes the data employed to estimate the empirical model. Section 2.4 presents and estimates the empirical model and reports the results of the economic fluctuations in Korea driven by country spread and the U.S. and Japanese interest rates. Section 2.5 introduces and calibrates the theoretical model, and then afterwards compares the results of empirical and theoretical impulse response functions. Section 2.6 concludes the chapter.

2.2 Related Literature

Compared with the acyclical nature of real interest rates in developed countries, it has been documented that there is a negative correlation between real interest rates and overall economic activity in emerging countries (Agénor and Prasad, 2000; Neumeyer and Perri, 2005; Uribe and Yue, 2006). These studies find that the correlation between real interest rates and output is negative and show that the real interest rate lags behind the business cycle in developed countries, whereas the real interest rate leads the business cycle in developing countries. The reason that developed countries reveal this characteristic is that developed countries usually use the interest rate as a monetary policy instrument in response to output and inflation.

Empirical studies prior to Neumeyer and Perri (2005) show that interest rate shocks do not play a significant role in driving business cycles in emerging economies. Neumeyer and Perri (2005) analyse statistically the relationships between real interest rates and output in a set of five small open emerging economies, including Korea, on one hand and a set of five small open developed economies on the other hand to contrast these two different sets of economies.[10] They find that business cycles in emerging economies are more volatile than those in developed economies, and real interest rates are countercyclical and lead the business cycle in emerging economies. In their results for the Korean economy during the period from 1994Q1 to 2001Q4, Korea also shows a countercyclical and U-shape pattern of cross-correlation properties, along with the other four emerging economies. This chapter presents the relationships between country interest rates and output for an additional seven years of data for Korea, from 1994Q1 to 2008Q4, from Neumeyer and Perri (2005) through Figure 2.1 to Figure 2.3. According to these figures, a countercyclical and U-shape pattern of cross-correlation characteristics in Korea are still revealed, although an acyclical pattern is shown after 2005.

Uribe and Yue (2006) focus on examining the relationship between country spreads,

[10] Neumeyer and Perri (2005) select Argentina, Brazil, Mexico, Korea and the Philippines as small open emerging economies, and Australia, Canada, Netherlands, New Zealand and Sweden as small open developed economies.

world real interest rates, and output fluctuations in seven Latin American developing economies using a VAR framework.[11] They find a negative correlation between real interest rates and economic activity. They also find that world interest rate and country spread shocks explain a large portion of the business cycles in emerging countries, but that world interest rate shocks affect domestic variables in emerging economies mostly through their effects on country spreads. Additionally, country spreads affect aggregate activity but at the same time respond to domestic macroeconomic fundamentals, and the world interest rate has an effect on the country interest rates not only through the familiar no-arbitrage condition but also through country spreads. This chapter follows Uribe and Yue's study for Latin American emerging economies and applies their procedures to the Korean economy using updated data.

If world interest rates take a sudden upward course, this will lead to less hospitable financing conditions for emerging countries. It is most desirable for an emerging economy to achieve economic growth using domestic capital; however, emerging economies are mostly dependent on foreign capital inflow because of insufficiency of domestic capital accumulation. A small developed economy such as Korea, in which there is excess demand in domestic investment over the supply in domestic saving, needs to import foreign capital to compensate for the deficiency. When the world interest rate rises, emerging economies, which need to borrow capital from the world capital market, are placed in a disadvantageous position due to the growing cost of borrowing.

Although there has been much research on the macroeconomic effects of world interest

[11] Uribe and Yue (2006) select Argentina, Brazil, Ecuador, Mexico, Peru, Philippines and South Africa as small open emerging economies.

rates, the current state of research fails to provide consistent results. Some studies find that world real interest rate movements are not important in explaining the dynamics of small open economies (Mendoza, 1991; Correia *et al*., 1995; Schmitt-Grohe, 1998), while others find that the world real interest rate is an important mechanism for transmitting international shocks to small open economies (Blankenau *et al*., 2001; Kim, 2001; Canova, 2005; Uribe and Yue, 2006; Maćkowiak, 2007).

Blankenau *et al*. (2001) examine the importance of world real interest rate shocks by assessing the Canadian economy as a small open economy and find that world real interest rate shocks play an important role in explaining the cyclical variation of the Canadian economy. Kim (2001) estimates the international transmission effects of the U.S. monetary policy shocks on the non-U.S. G-6 countries using an SVAR model. He focuses on the objective that a monetary expansion in the U.S. leads to recessions or booms in other countries and finds that U.S. monetary expansion has a positive spillover effect on output in G-6 countries. He explains that this positive spillover effect occurs through the world capital market. A monetary expansion of the large open economy decreases the world real interest rate and stimulates world aggregate demand on current goods and services of G-6 countries, which is theoretically suggested by some intertemporal models, such as those of Svensson and Van Wijnbergen (1989) and Obstfeld and Rogoff (1995).

Canova (2005) estimates the effects of the exogenous U.S. monetary policy shock identified using sign restrictions on eight Latin American emerging countries. He finds that the U.S. monetary policy shock affects the interest rates in Latin America quickly and strongly and produces significant macroeconomic fluctuations in Latin America.

Maćkowiak (2007) assumes that the emerging market is a small open economy and examines external shocks as a source of macroeconomic fluctuations in eight emerging markets using an SVAR model. He finds that a U.S. monetary policy shock is an important source of macroeconomic fluctuation and explains a larger fraction of the variance in the aggregate output in small open economies. An interesting difference between Kim's (2001) results and those of Maćkowiak (2007) is that Kim does not support the perspective that the spillover effects of U.S. monetary policy shocks on the non-U.S., G-6 countries are sizable. This finding accords well with the view that emerging markets are more vulnerable to external shocks than large and developed economies are.

The various empirical results motivate researchers to build and develop theoretical models for a small open economy. Following Kydland and Prescott (1982), the real business cycle (RBC) approach has now become a standard model in equilibrium macroeconomics. From this work, one stand of the open economy extension of the RBC research is attributable to Mendoza (1991). He develops the dynamic stochastic general equilibrium (DSGE) model for a small open economy and uses it to analyse business cycle fluctuations in Canada. Following the analysis of Mendoza (1991) for a real business cycle model of a small open economy, similar models have been used extensively in the literature. Correia *et al.* (1995), Schmitt-Grohe (1998), Blankenau *et al*. (2001), Neumeyer and Perri (2005) and Uribe and Yue (2006) use dynamic small open economy models in evaluating the role of different types of shocks. In particular, Uribe and Yue (2006) feed the estimated processes for the shocks into a DSGE model in which working capital and a one-period gestation lag in production play a key role in the transmission of interest rate innovations to economic activity. They find that the country spreads drive business cycles in emerging economies, and vice versa. Their standard neoclassical growth model of the small open economy yields theoretical impulse response functions that are broadly consistent with empirical impulse responses implied by the VAR model.

2.3 Data

A business cycle involves fluctuations of aggregate economic activity. Real GDP is generally used to estimate aggregate economic activity as an approximate indicator. However, when examining a country's business cycle, it is necessary to contain not only real macroeconomic variables but also financial market variables in a model. This chapter uses GDP as a representative measure of aggregate economic activity, investment and net exports-to-GDP ratio as real macroeconomic variables, and the world interest rate and country spread as financial market variables to investigate the dynamic interactions between variables.

In them, since this chapter is about the role of country spreads in Korean economy business cycles, I need to explain the meaning of the country spread specifically. On the one hand, country spreads are by definition a component of the costs of foreign borrowing by emerging economies, and present with considerable correlation in both sovereign and private borrowings (see Mendoza and Yue, 2008). On the other hand, they work as a credit mechanism or contract by which international financial markets impose a credit constraint on these economies. Higher spreads can result from weaker fundamentals and propagate further, aggravating the macroeconomic downturn, while impairing the country's access to foreign credits (see Sarquis, 2008). Thus, in this chapter, country spread is used as a measure of credit risk in an economy external to Korea.

2.3.1 Data Description

The data consists of quarterly real GDP, investment, net exports-to-GDP ratio, country spread and interest rates of the U.S. and Japan over the period of 1994Q1 to 2008Q4. The U.S. three-month Treasury bill rate is used as a world interest rate, and the Japanese three-month CD rate is used as a regional interest rate. All interest rates are deflated using each country's GDP deflator. There are several bond market indicators for the Korean economy, and 'credit spread–Major USD issues vs. U.S. treasuries' is used as a country spread for computing the country interest rate in this chapter.[12]

The quarterly series for GDP, investment, imports, exports and three-month Treasury bill rate as the U.S. interest rate are obtained from *International Financial Statistics* (IFS) of the International Monetary Fund (IMF). The data source of the three-month CD rate as the Japanese interest rate is Datastream. The 'credit spread–Major USD issues vs. U.S. treasuries' used as a country spread for computing the country interest rate is obtained from *Asian Bonds Online* (ABO) of the Asian Development Bank (ADB). Output, investment and the net exports-to-GDP ratio are deflated using the GDP deflator and seasonally adjusted. The detrended macroeconomic fundamental

[12] 'Credit spread–Major USD issues vs. U.S. treasuries' measures the difference between a U.S. Dollar-denominated bond's yield and an equivalent U.S. Treasury benchmark bond. For *Asia Bond Indicators*, the credit spreads of major U.S. Dollar -denominated issues by ASEAN+3 issuers are compared with the interpolated yields of the U.S. Treasury of equivalent tenor. Credit spreads represent the pricing adjustment for the credit risk associated with these securities over risk-free U.S. Treasury securities.

variables and interest rates for three countries are used for empirical analysis.[13]

2.3.2 Unit Root Tests

Many economic and financial time series show trending behaviour or non-stationary property in the mean. Thus, these time series data are required to remove trends or to transform to a stationary form prior to analysis. Unit root tests can be used to determine if trending data should be first differenced or regressed on deterministic functions of time to render the data stationary. There are several methods to test unit roots, including the Dickey-Fuller (DF) test, Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test. The ADF test and PP test for unit root are used, and results from the two tests are presented.[14]

The way to test unit root using ADF is to add augmented terms (ΔY_{t-j}, j=1,..., p) to each of the three basic models to remove the effect of autocorrelation and then the following three models for ADF test are verified through F-statistics:

---

[13] The Hodrick-Prescott (HP) filter, which decomposes a given time series into a trend component and a cyclical component by solving an optimization problem, is used to detrend the data although it is often remarked that the HP filter may generate spurious cyclical patterns. The figure 1,600 is applied for λ because quarterly data are used in this chapter (see Hodrick and Prescott (1980) and Fisher *et al.* (1996)). When the variables are I(1), detrending the data is appropriate. In this case, detrending with a linear time trend may be better since it is often remarked that the HP filter may introduce spurious patterns in the data. However, Korean time series data have the characteristics of dynamic growth patterns comparing with the characteristics of developed countries' time series data. Thus, in detrending the Korean data, detrending with the HP filter, which is a flexible detrend method, may be more useful than detrending with a linear time trend, which is a fixed filter.

[14] The reason that two types of test are used in this chapter is that each has demerits as well as merits. The ADF test is the widely used method to test the unit root because it is convenient to apply. However, the ADF test has come into the focus of criticism due to the weakness of power of the test. That is, the ADF test has a significant weak point that the probability of Type-II error is considerably high despite the low probability of Type-I error. On the other hand, Schwert (1989) also indicates that the PP test has a similar weakness that the probability of Type-I error is high in the case of serial autocorrelation, although the probability of Type-II error is low. Thus, the results of two tests are reported to compare.

Model I : $\Delta Y_t = \hat{\gamma}\hat{Y}_{t-1} + \sum_{i=1}^{p}\delta_i \Delta Y_{t-i} + \varepsilon_t$

Model II : $\Delta Y_t = \alpha + \tilde{\gamma}\tilde{Y}_{t-1} + \sum_{i=1}^{p}\delta_i \Delta Y_{t-i} + \varepsilon_t$

Model III : $\Delta Y_t = \alpha + \beta T + \bar{\gamma}\bar{Y}_{t-1} + \sum_{i=1}^{p}\delta_i \Delta Y_{t-i} + \varepsilon_t$

The null hypothesis is $H_0 : \gamma\,(\hat{\gamma}, \tilde{\gamma}, \bar{\gamma}) = 0$, which means there is a unit root in the data.

With regard to the other comparable method to test the unit root, Phillips and Perron (1988) proposed the PP test, which is a nonparametric unit root test method used in the case of weakly dependent of stochastic error term or heteroschedasticity. The null hypothesis is examined by Z statistics which are calculated using basic models. The corresponding Phillips-Perron statistics are as follows:

Model I : $Z(t_{\hat{\gamma}})$ for $H_0 : \hat{\gamma} = 1$

Model II : $Z(t_{\tilde{\gamma}})$ for $H_0 : \tilde{\gamma} = 1$

Model III : $Z(t_{\bar{\gamma}})$ for $H_0 : \bar{\gamma} = 1$

In particular, cases of model II and model III are considered in general. Model II is appropriate when the alternative hypothesis is that the series is stationary around a fixed mean, and model III is appropriate when the alternative hypothesis is that the series is stationary around a trend. The results of ADF test and the PP test are reported in Table 2.1.

Results from the two tests are similar. In the majority of cases, the data have unit roots at the 5% level of critical value. Parentheses located on the second line of each data group indicate the statistics of the ADF and PP tests after performing the first difference with level variable. Most first differenced variables are stationary.

Table 2.1: ADF Test and PP Test

	Model I		Model II		Model III	
	ADF	PP	ADF	PP	ADF	PP
Country Spread	-2.82*	-2.93	-2.79*	-2.90*	-1.61*	-1.50*
	(-8.83)	(-8.85)	(-8.75)	(-8.76)	(-8.90)	(-8.91)
GDP	0.67*	-0.31*	-1.64*	-6.04	2.68*	6.00*
	(-3.49)	(-23.84)	(-4.04)	(-26.79)	(-1.46)*	(-12.49)
Investment	0.28*	-3.08*	-2.23*	-8.04	1.64*	1.71*
	(-2.51)*	(-29.83)	(-2.66)*	(-33.38)	(-1.88)	(-18.01)
Net Exports /GDP	-2.48*	-2.61*	-2.43*	-2.56*	-2.13	-2.23
	(-7.94)	(-7.94)	(-7.87)	(-7.87)	(-8.01)	(-8.01)
U.S. Interest Rate	-1.45*	-1.41*	-3.09*	-2.26*	-1.40*	-0.97*
	(-3.09)	(-3.04)	(-3.18)*	(-3.18)*	(-3.04)	(-3.02)
Japanese Interest Rate	-3.16	-3.09	-2.22*	-2.20*	-3.03	-2.89
	(-5.62)	(-5.57)	(-6.01)	(-5.90)	(-5.60)	(-5.56)

Note: * denotes significant statistics at the 5% critical value. Statistics in parentheses located on the second line are for the first difference of each variable.

2.4 Empirical Analysis

This section assesses differences and draws similarities of the effects of the world interest rate and country spread on aggregate activity of the Korean economy under the small open economy analysis. An open economy may be a large open economy, which implies that the country interest rate is decided individually by its own domestic economic factors, or a small open economy, which implies that the country interest rate is affected exogenously by the world interest rate. Supposing that a small open economy can borrow as much as it wants under the given world interest rate from the international financial market, the economy is similar to a perfectly competitive firm in microeconomic theory. A small competitive firm does not affect the sales volume and labour employment of the whole market. Hence, a perfect competitive small firm has to make a decision for purchasing goods and hiring employees under the given price of good and wage level. Similarly, a small open economy is so small that it cannot affect the movement of the world interest rate and borrows capital under the given world interest rate from the international financial market.

The Korean economy has grown rapidly due to sufficient foreign capital inflow and growth in exports for decades. The World Trade Organization (WTO), which can enforce free trade over almost all possible fields, was founded in 1995. Korea joined the Organization of Economic Cooperation and Development (OECD), which pursues capital liberalization, in 1996. As a result of free trading and financial liberalization, the Korean economy has been successfully transformed to an open economy in the global economic era, although its scale is too small to have an effect on the change in world economy.

The main aim of the empirical analysis is to examine how, how much, and how long the U.S. and Japanese interest rate shocks and country spread shock have a dynamic effect on macroeconomic fluctuations in the Korean economy. An analysis of country spread and the U.S. interest rate as a world interest rate is performed at first, and an analysis with country spread and Japanese interest rate as a regional interest rate is performed next using the structural VAR model.

2.4.1 The Empirical Model

The VAR approach is a suitable methodology to make a model considering interdependency or endogeneity among economic and financial variables. In particular, although the VAR approach assumes a simple structure, users can make a flexible time series model which has an autocorrelation structure of object variables and estimate the movement of variables on the basis of the process of variables without economic theory-based knowledge. Despite the convenience of making a model, there are several problems with the VAR approach, such as the restricted role of economic theory, the recursive form of economic structure and openness of the results to a variety of interpretations.

To overcome these weak points in the VAR approach, Sims (1986) and Bernanke (1986) present the structural VAR (SVAR) model to identify the structural stochastic deviation using economic theory. Above all, the main purpose of the SVAR estimation is to obtain non-recursive orthogonalization of the error terms for impulse response analysis. This alternative to the recursive Cholesky orthogonalization can enable the researcher to impose enough restrictions to identify the orthogonal structural components of the error terms.

The empirical model used for empirical estimation in this chapter takes the form of a second-order SVAR system with five variables:[15]

---

[15] The SVAR (2) equation used in this chapter takes a form of equation (2.1). However, if A^{-1} is taken on both sides of equation (2.1), the original equation is changed to

$$AX_t = BX_{t-1} + CX_{t-2} + \varepsilon_t \quad (2.1)$$

where X_t is a 5×1 matrix composed of five variables, and ε_t is a 5×1 matrix of innovations for each variable in time *t*. *A*, *B* and *C* are 5×5 parameter matrices. The equation (2.1) can be re-written with equations (2.2) and (2.3) for convenience.

$$A \begin{bmatrix} \hat{y}_t \\ \hat{i}_t \\ nxy_t \\ \hat{R}_t^w \\ \hat{R}_t^c \end{bmatrix} = B \begin{bmatrix} \hat{y}_{t-1} \\ \hat{i}_{t-1} \\ nxy_{t-1} \\ \hat{R}_{t-1}^w \\ \hat{R}_{t-1}^c \end{bmatrix} + C \begin{bmatrix} \hat{y}_{t-2} \\ \hat{i}_{t-2} \\ nxy_{t-2} \\ \hat{R}_{t-2}^w \\ \hat{R}_{t-2}^c \end{bmatrix} + \begin{bmatrix} \varepsilon_t^y \\ \varepsilon_t^i \\ \varepsilon_t^{nxy} \\ \varepsilon_t^{rw} \\ \varepsilon_t^{rc} \end{bmatrix} \quad (2.2)$$

where y_t denotes real gross domestic output, i_t denotes real gross domestic investment, nxy_t denotes net exports-to-output ratio, R_t^w denotes the gross real interest rate of advanced economies such as the U.S. and Japan and R_t^c denotes the gross real country interest rate which is computed following the definition of country spread. The definition of the country interest rate comes from the definition of country spread, $\hat{S}_t \equiv \hat{R}_t^c - \hat{R}_t^w$. That is, the newly defined country interest rate, $\hat{R}_t^c = \hat{R}_t^w + \hat{S}_t$, is used as a new endogenous interest rate variable. More often than not, a country interest rate shock (ε_t^{rc}) is equally interpreted as a country spread shock in this chapter, since the country interest rate can reflect the risk premium of a country (Uribe and Yue,

---

$X_t = A^{-1}BX_{t-1} + A^{-1}CX_{t-2} + A^{-1}\varepsilon_t$. This form is equal to the general reduced form equation; thus, there is no significant distortion between the two equations. There is an important reason that the equation (2.1) type of SVAR form is used in this chapter. The equation (2.1) type of SVAR (2) form can contain the restriction that the world interest rate cannot be affected by the other four domestic variables by inserting 0 into the corresponding row of matrix *A* as well as matrices *B* and *C*. This means that the equation (2.1) type of SVAR (2) form can apply short-run restrictions to matrix *A* and long-run restrictions to matrices *B* and *C* simultaneously.

2006). For such reasons, the country interest rate is used as an important standard to borrow or to lend among nations in the international financial market. A hat on top of y_t and i_t denotes log deviations from a log-linear trend, on the contrary, a hat on R_t^w and R_t^c denotes simply the log.

Parameter matrices of the SVAR (2) model are specified below.

$$A = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ a_{51} & a_{52} & a_{53} & a_{54} & 1 \end{bmatrix}, \quad B = \begin{bmatrix} b_{11} & b_{12} & b_{13} & b_{14} & b_{15} \\ b_{21} & b_{22} & b_{23} & b_{24} & b_{25} \\ b_{31} & b_{32} & b_{33} & b_{34} & b_{35} \\ 0 & 0 & 0 & b_{44} & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & b_{55} \end{bmatrix}$$

$$C = \begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} & C_{15} \\ C_{21} & C_{22} & C_{23} & C_{24} & C_{25} \\ C_{31} & C_{32} & C_{33} & C_{34} & C_{35} \\ 0 & 0 & 0 & C_{44} & 0 \\ C_{51} & C_{52} & C_{53} & C_{54} & C_{55} \end{bmatrix} \qquad (2.3)$$

I compose the SVAR model by using the restriction that matrix *A* has lower triangular with unit diagonal elements. In most SVAR models, the equation with respect to the world real interest rate would be placed first in the ordering, allowing the world interest rate variable to have a contemporaneous effect on the domestic variables. However, in this chapter, the world interest rate and country interest rate are located at the bottom of the system since a formation of this type can help domestic real macroeconomic variables to absorb each innovation of the world interest rate (ε_t^{rw}) and innovation of the country interest rate (ε_t^{rc}) with a one-period lag. At the same time, three real domestic shocks ($\varepsilon_t^y, \varepsilon_t^i, and\, \varepsilon_t^{nxy}$) are organized to affect the financial market contemporaneously at the upper position of the system because financial markets are to react quickly to news about the state of the economic fluctuations in small open economies. There is another reason to arrange the three real domestic macroeconomic variables in the upper position of the SVAR system. From this arrangement, the order of these three variables ($\hat{y}_t, \hat{i}_t, and\, nxy_t$) does not cause any problem to estimate the world interest rate shock (ε_t^{rw}) and country interest rate shock (ε_t^{rc}) as well as impulse responses of the three variables ($\hat{y}_t, \hat{i}_t, and\, nxy_t$) to innovations in two sources of aggregate fluctuation (ε_t^{rw} and ε_t^{rc}).

Restriction in the fourth equation implies that the world interest rate is decided only by domestic variables of a large economy, thus, macroeconomic variables of a small open economy cannot affect the movement of the world interest rate, since a small open economy is in a price-taker position in the international financial market. Reflecting this idea, the factor that can influence the world interest rate in the SVAR system is only its own past value as shown in *A*, *B* and *C* matrices. As a result, the fourth equation of $\hat{R}_t^w$ is a simple AR (2) process by restricting $a_{jk} = b_{jk} = c_{jk} = 0$ (*j*, *k* = 1, 2, 3, 4, 5), for all *j*=4 and *k*≠4.

The SVAR (2) is estimated equation by equation using an instrumental variable method for each variable. One way of identifying models that cannot be estimated by using multiple regression is through the use of instrumental variables. For multiple regression to be used, the endogenous variable's disturbance must be uncorrelated with each of the causal variables. There are three reasons why such a correlation might exist: omitted variable, reverse causation, or measurement error. In this situation, ordinary linear regression generally produces biased and inconsistent estimates since one or more causal variable is correlated with the disturbance of the endogenous variable. However, if an instrument is available, consistent estimates may still be obtained. An instrument is a variable that does not itself belong in the explanatory equation and is correlated with the endogenous explanatory variables, conditional on the other covariates. Thus, instrumental variable estimation can possibly be used to identify the model. In this chapter, model is estimated using an instrumental variable method with lagged levels serving as instrumental variables.

The results of the optimal lag length selection criteria such as the Akaike information criterion (AIC), the Schwarz information criterion (SIC), and likelihood ratio (LR) test are reported in Table 2.2. Although the selected lag length is one for four models out of six different models in Table 2.2, I include two lags in the SVAR model as presented in equation (2.1). The first reason is that this study focuses more on the effect of U.S. interest rate as a world interest rate on the Korean economy than on the effect of Japan interest rate as a regional interest rate. Since the selected lag length for the case of Korea-U.S. is two for two models out of three different models, I choose two as an optimal lag length. On the other hand, although one is selected as an optimal lag length for the case of Korea-Japan, I employ the same SVAR (2) model for this case for maintaining consistency. The second reason is that the SVAR (2) model is more useful to capture the short-run dynamics of macroeconomic variables fluctuation than a single lag of the SVAR model. However, adding longer lags such as three or four does not improve the fit of the model.

Table 2.2: Optimal Lag Length Selection for SVAR

Lag Length	Korea-U.S.			Korea-Japan		
	LR	AIC	SIC	LR	AIC	SIC
SVAR(1)	262.05	-27.31	-26.23*	221.51*	-29.19*	-28.11*
SVAR(2)	49.86*	-27.51*	-25.54	28.89	-28.94	-26.97
SVAR(3)	30.87	-27.39	-24.52	14.76	-28.42	-25.56

Note: * denotes the selected lag length.

2.4.2 A Structural VAR Analysis

Using the impulse response function and variance decomposition of the SVAR (2) framework, the empirical analysis focuses on examining the dynamic effects of world interest rate shocks and country spread shocks on the real domestic macroeconomic variables and how country spread responds to innovations in domestic macroeconomic fundamentals. Two kinds of international interest rates, U.S. and Japanese interest rates, and country interest rate computed using country spread for Korea are used in the analysis to compare each case. Each case provides similar but different outcomes.

2.4.2.1 Estimation Results

Parameters of the SVAR (2) estimation are reported in Tables 2.3 and 2.4 for using country spread with the U.S. interest rate and Japanese interest rate, respectively. Overall results of parameter estimation from two cases of the SVAR (2) model have almost the same characteristics, although there are some small differences. Summarizing the significant relationships among variables in Tables 2.3 and 2.4 in common, output is positively related to the previous own past value, and investment has a positive relationship with the current output. The net exports-to-output ratio is negatively related to current investment and positively related to the previous own past value. The U.S. and Japanese interest rates have positive relationships with their own

Table 2.3: Parameter Estimates of the SVAR (2) (Korea-U.S.)

Independent Variable	Dependent Variable				
	$\hat{y}_t$	$\hat{i}_t$	nxy_t	$\hat{R}_t^{us}$	$\hat{R}_t^{c}$
$\hat{y}_t$	—	0.7861 (6.28)*	0.0181 (0.20)	—	-0.0469 (-1.40)
$\hat{y}_{t-1}$	0.4998 (2.43)*	-0.0480 (-0.25)	0.0976 (0.98)	—	0.0028 (0.08)
$\hat{y}_{t-2}$	0.0939 (0.45)	0.1656 (0.90)	-0.0154 (-0.16)	—	-0.0163 (-0.46)
$\hat{i}_t$	—	—	-0.2782 (-3.64)*	—	0.0019 (0.06)
$\hat{i}_{t-1}$	0.1386 (0.74)	-0.0153 (-0.09)	0.0372 (0.43)	—	0.0278 (0.89)
$\hat{i}_{t-2}$	-0.2708 (-1.55)	0.0450 (0.29)	0.1238 (1.51)	—	0.0067 (0.22)
nxy_t	—	—	—	—	0.2274 (4.26)*
nxy_{t-1}	0.2705 (0.77)	-0.6071 (-1.98)*	0.7665 (4.58)*	—	-0.1879 (-2.57)*
nxy_{t-2}	-0.2125 (-0.61)	-0.1098 (-0.36)	-0.1151 (-0.72)	—	0.0948 (1.63)
$\hat{R}_t^{us}$	—	—	—	—	0.2134 (0.77)
$\hat{R}_{t-1}^{us}$	0.0998 (0.08)	2.4309 (2.12)*	0.8925 (1.42)	1.6531 (16.18)*	0.5144 (1.02)
$\hat{R}_{t-2}^{us}$	1.1860 (0.76)	-1.9960 (-1.47)	-0.8715 (-1.19)	-0.6687 (-6.58)*	-0.3476 (-1.02)
$\hat{R}_t^{c}$	—	—	—	—	—
$\hat{R}_{t-1}^{c}$	-0.9100 (-1.04)	-0.7805 (-1.01)	-0.4543 (-1.11)	—	0.6498 (4.28)*
$\hat{R}_{t-2}^{c}$	-0.0064 (-0.01)	0.4895 (0.71)	0.4453 (1.22)	—	0.0636 (0.47)
R^2	0.3978	0.7453	0.7422	0.9650	0.9383
S.E.	0.0401	0.0348	0.0183	0.0035	0.0066

Note: *t*-statistics are presented in parentheses. * denotes the significance under the 5% critical value of *t* statistics.

Table 2.4: Parameter Estimates of the SVAR (2) (Korea-Japan)

Independent Variable	Dependent Variable				
	$\hat{y}_t$	$\hat{i}_t$	nxy_t	$\hat{R}_t^{us}$	$\hat{R}_t^{c}$
$\hat{y}_t$	—	0.7718 (6.14)*	0.0119 (0.14)	—	-0.0634 (-1.71)*
$\hat{y}_{t-1}$	0.5594 (2.63)*	-0.0173 (-0.09)	0.0919 (0.90)	—	-0.0014 (-0.03)
$\hat{y}_{t-2}$	0.0607 (0.29)	0.1070 (0.58)	-0.0279 (-0.29)	—	-0.0150 (-0.37)
$\hat{i}_t$	—	—	-0.2721 (-3.61)*	—	0.0114 (0.32)
$\hat{i}_{t-1}$	0.1626 (0.88)	0.0135 (0.08)	0.4461 (0.53)	—	0.0372 (1.04)
$\hat{i}_{t-2}$	-0.1905 (-1.06)	0.1129 (0.71)	0.1336 (1.62)	—	0.0151 (0.42)
nxy_t	—	—	—	—	0.2290 (3.72)*
nxy_{t-1}	0.1490 (0.43)	-0.5390 (-1.78)*	0.8011 (4.96)*	—	-0.2094 (-2.49)*
nxy_{t-2}	-0.1920 (-0.54)	-0.0964 (-0.31)	-0.1147 (-0.72)	—	0.0990 (1.46)
$\hat{R}_t^{us}$	—	—	—	—	1.7343 (2.60)*
$\hat{R}_{t-1}^{us}$	-3.6858 (-1.06)	-2.0850 (-0.68)	0.5703 (0.36)	1.1648 (9.07)*	-0.8028 (-0.78)
$\hat{R}_{t-2}^{us}$	3.4696 (1.05)	2.7195 (0.94)	-0.1736 (-0.11)	-0.2495 (-2.06)*	-0.4443 (-0.67)
$\hat{R}_t^{c}$	—	—	—	—	—
$\hat{R}_{t-1}^{c}$	-0.1864 (-0.24)	-0.8859 (-1.33)	-0.5533 (-1.57)	—	0.7213 (4.80)*
$\hat{R}_{t-2}^{c}$	0.1434 (0.19)	0.6629 (1.01)	0.4720 (1.38)	—	0.1658 (1.14)
R^2	0.3866	0.7386	0.7428	0.8822	0.7769
S.E.	0.0405	0.0353	0.0182	0.0017	0.0076

Note: *t*-statistics are presented in parentheses. * denotes the significance under the 5% critical value of *t* statistics.

one-period-ahead values and a negative relationship with their two-period-ahead values. Country spread has a positive relationship with the current net exports-to-output ratio and a negative relationship with the one-period-ahead values of net exports-to-output ratio. It is positively related to their own one-period-ahead values.

2.4.2.2 Impulse Response Functions

The VAR models are commonly used for forecasting systems of interrelated time series and for analysing the dynamic impact of random disturbances on the system of variables. To analyse the correlations of variables and spillover effects from innovations of variables, an impulse response function verifies the results of time varying response of all variables after constant impulse to a specific variable in the model. The impulse response function is defined as a moving average representation of the VAR system in equation (2.4).

$$X_t = [I - B(L)]^{-1}\varepsilon_t = M(L)\varepsilon_t = M_0\varepsilon_t + M_1\varepsilon_{t-1} + M_2\varepsilon_{t-2} + ... \quad (2.4)$$

The moving average representation of X_t is defined using parameter matrix, M_k, and it is possible to be correlated between ε_{it} and ε_{jt}, where ε_{it} is the error term of element *i* in time *t*, and ε_{jt} is the error term of element *j* in time *t*. To overcome this appearance, the Cholesky factorization can be applied as a matrix decomposition.[16]

$$X_t = M(L)G^{-1}G\varepsilon_t \quad (2.5)$$

That is, to induce $G\varepsilon_t$ to be a diagonal matrix of the covariance matrix, the original matrix is decomposed using a *G* matrix by Cholesky Decomposition, which deduces the covariance matrix through the following process.

$$G^{-1}(G^{-1})' = V = E[\varepsilon_t(\varepsilon_t)'] \quad (2.6)$$

[16] There is a theorem that symmetric and positive matrix (*P*) is composed of a lower triangular matrix (*L*) and an upper triangular matrix (*U*), which is *L*'s transpose matrix (*U*= *L'*). This matrix is equal to the multiplication of *L* and *U*. This factorization is the so-called Cholesky Decomposition. *P=LU=LL'*

If we let $M(L)G^{-1} = C(L)$, and $G\varepsilon_t = W_t$, equation (2.5) can be rewritten as follows.

$$X_t = C(L)W_t = \sum_{k=0}^{\infty} C_k W_{t-k} \qquad (2.7)$$

Then one of the elements C_k^{ij} in C_k can be interpreted as the amount of response in variable *j* due to a change in variable *i*. Since no more correlations exist among W_{t-k} elements in the equation (2.7), C_k^{ij} in C_k represents the pure amount of response in terms of a change of variable *j* to variable *i*.

Figures 2.4 and 2.5 display the impulse response functions implied by the SVAR (2) to a positive one standard deviation country spread shock (ε_t^{rc}) for each case of using the U.S. interest rate and Japanese interest rate, respectively.[17] Confidence band is obtained through a standard bootstrapping procedure.[18] Two standard error band as a confidence interval, which is used to indicate the reliability of an estimate, is adopted to cover the insignificant estimates of theoretical impulse responses computed in the next section from the confidence intervals of estimated impulse responses. I follow the procedure of Uribe and Yue (2006).

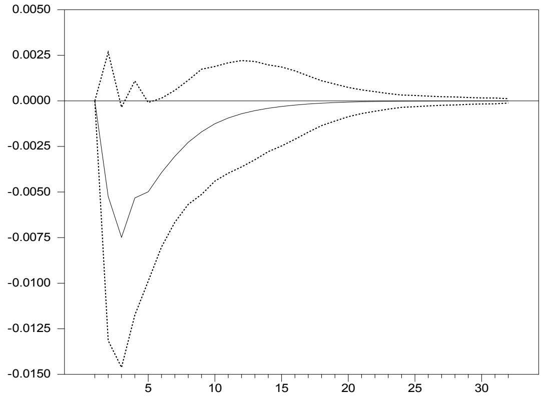
---

[17] A horizon of eight years is chosen for the variance of the forecasting error of the Korean business cycle fluctuation. Since between two peaks of the Korean business cycle is an estimated average 50 months (approximately 16 quarters), 32 quarters, which is a doubled average Korean business cycle period, are applied as a basic period for impulse response analysis. Researchers usually set frequencies of business cycles ranging from 6 quarters to 32 quarters (Stock and Watson, 1999).

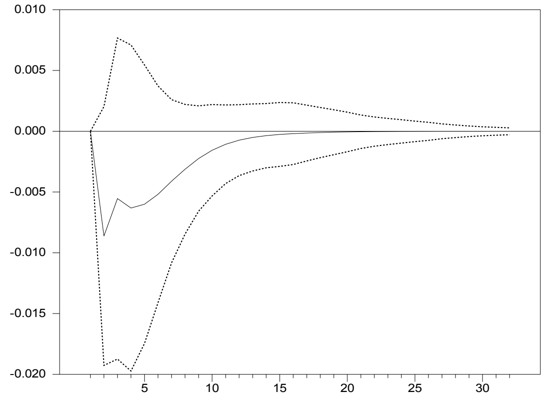
[18] I used RATS as a statistical software to estimate the SVAR (2) model. When using RATS, there are three principal methods proposed for computing confidence bands for impulse responses: Monte Carlo integration, Delta method and Bootstrapping. In them, bootstrapping method is widely used because of its simplicity. It is straightforward way to derive estimates of confidence intervals for complex estimators of complex parameters of the distribution. In addition, bootstrapping method is a suitable way to control and check the stability of the results.

Figure 2.4: Impulse Responses to Country Spread Shock (Korea-U.S.)

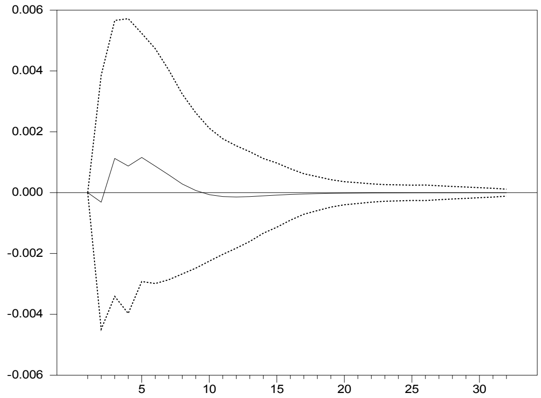
(a) Output



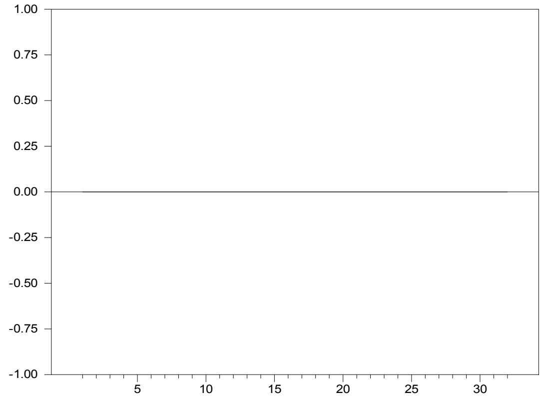
(b) Investment



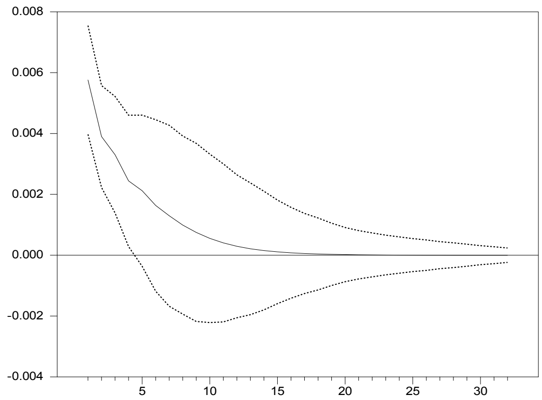
(c) Net exports-to-output ratio



(d) U.S. interest rate

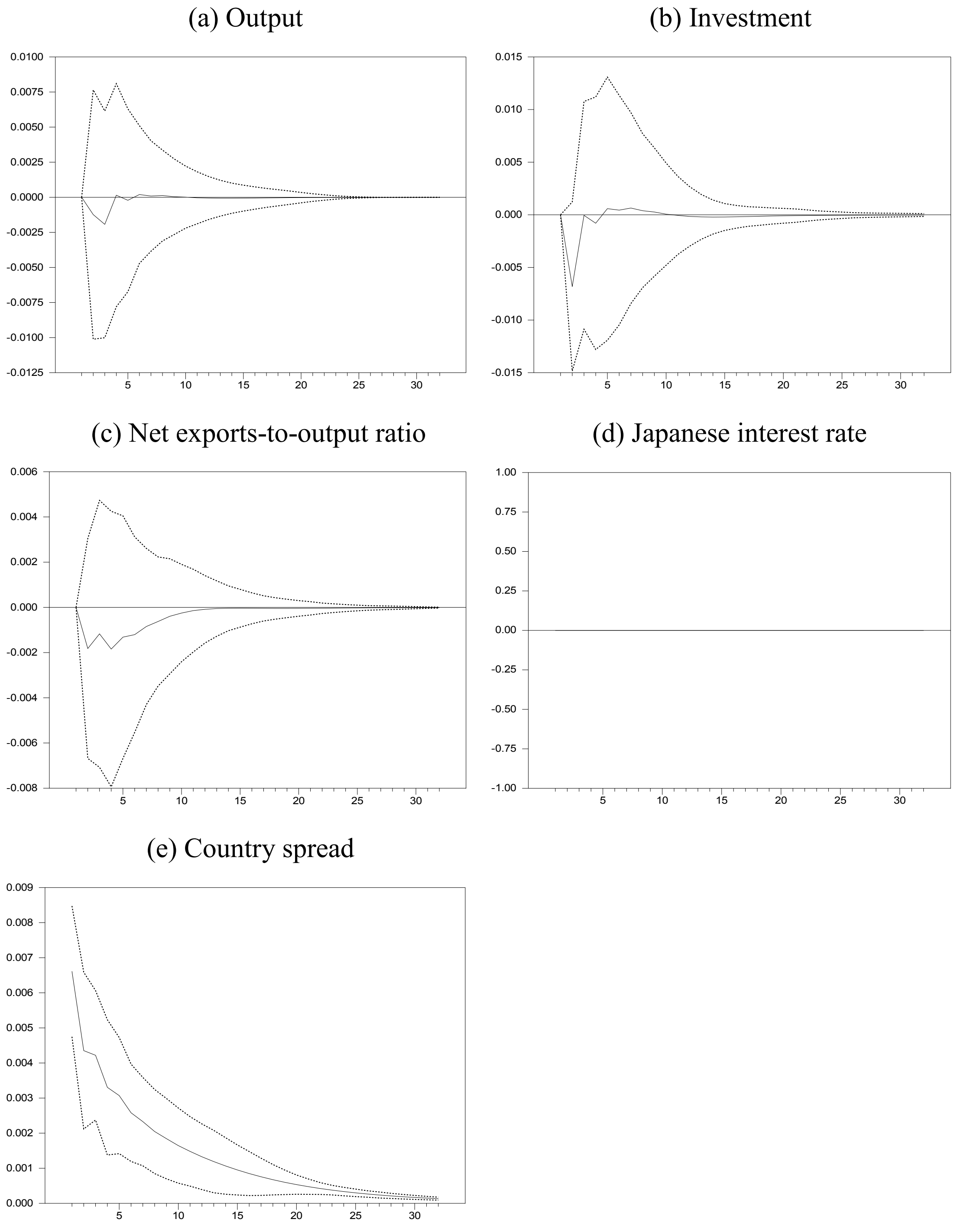


(e) Country spread



Note: Solid lines depict point estimates of impulse responses to a one standard deviation country spread shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

Figure 2.5: Impulse Responses to Country Spread Shock (Korea-Japan)



Note: Solid lines depict point estimates of impulse responses to a one standard deviation country spread shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

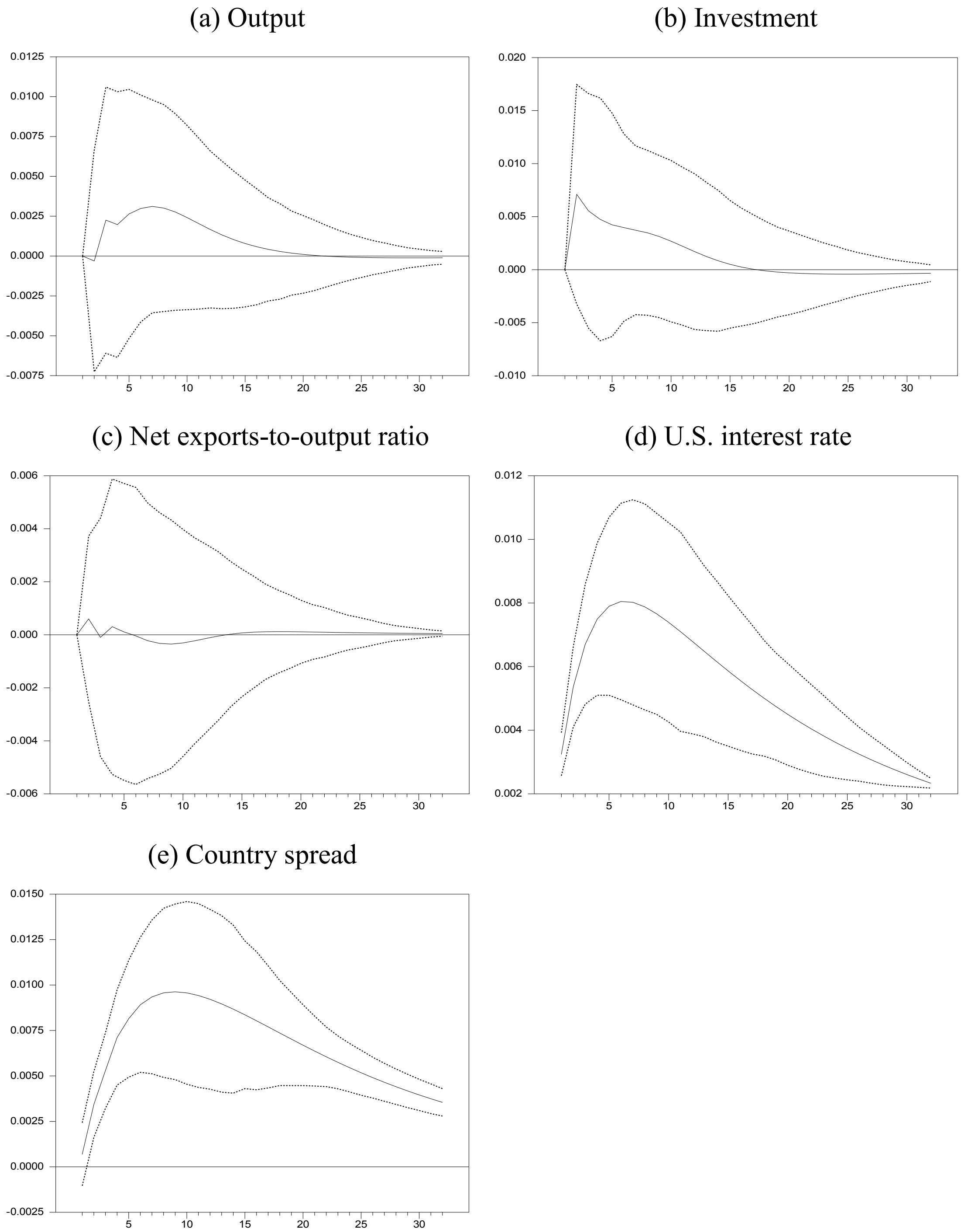
Output, investment and the net exports-to-output ratio do not change at the initial time of the shocks and then shift positively or negatively after one period, because external financial shocks spend one period affecting production and absorption in the domestic economy. In the early stage, GDP and investment fall in response to the increasing country spread shock; however, they gradually return to pre-shock level. After a short and slight decrease, the net exports-to-output ratio increases and then gradually recovers to pre-shock level in response to country spread shock. An increase in country spread shock causes a larger contraction in aggregate domestic absorption than that in aggregate output, and then, the net exports-to-output ratio increases as a result. The U.S. interest rate is not affected by country spread shock. Country spread responds immediately and positively to its own shock and then declines quickly to the steady-state level. These results are consistent with the results of Uribe and Yue (2006).

In the case of using the Japanese interest rate as a regional interest rate, shapes and figures of recovery to the pre-shock level look similar to the case of using the U.S. interest rate, although the size of response is different. The only different feature is the response of net exports-to-output to the country spread shock.

Figures 2.6 and 2.7 display the responses of the variables in the SVAR (2) to the positive U.S. interest rate (ε_t^{rus}) and Japanese interest rate (ε_t^{rj}) shocks, respectively.

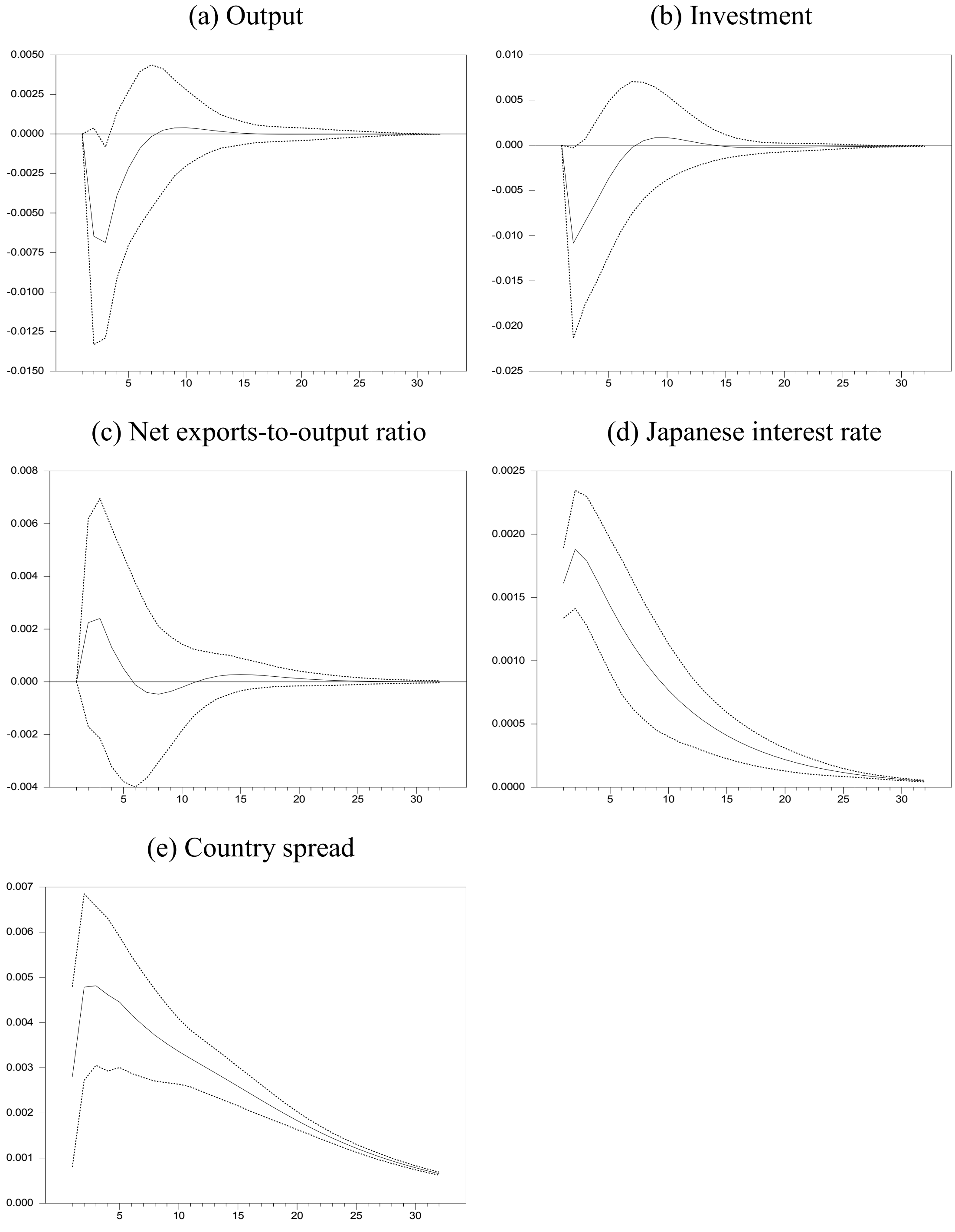
In Figure 2.6, while output, investment and the net exports-to-output ratio do not respond at the moment of shock, they start to respond positively from the next. In comparison to the case of country spread shock, responses of Korean domestic macroeconomic variables to the U.S. interest rate shock are, on the whole, qualitatively

Figure 2.6: Impulse Responses to U.S. Interest Rate Shock



Note: Solid lines depict point estimates of impulse responses to a one standard deviation U.S. interest rate shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

Figure 2.7: Impulse Responses to Japanese Interest Rate Shock



Note: Solid lines depict point estimates of impulse responses to a one standard deviation Japanese interest rate shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

adverse. In particular, results of output and investment are inconsistent with the results of Uribe and Yue (2006), which show decreasing responses of output and investment. The response of the U.S. interest rate to its own shock shows delayed increase before converging to the pre-shock level. The country spread responds positively at the initial time to the increasing U.S. interest rate shock, and then afterwards, delayed overshooting follows. To summarize synthetically, the U.S. interest rate shock transmits to the Korean macroeconomic variables with delay. Impulse responses presented in Figure 2.6 are on the opposite side of generally well-known empirical results related to the responses of emerging markets to the increasing U.S. interest rate shock as a world interest rate shock (Ahn and Kim, 2003; Uribe and Yue, 2006). The responses of Korean macroeconomic variables to the increasing U.S. interest rate shock reported in Figure 2.6 are rather in line with the responses of developed economies (Kim and Roubini, 2000; Favero, 2001; Miniane and Rogers, 2003; Maćkowiak, 2007). In the previous section, I mentioned that the Korean economy demonstrates both characteristics of a small developed economy and of an emerging economy. These characteristics of the Korean economy make it possible to provide a reasonable explanation about those responses of Korean macroeconomic variables. According to the explanation of Kim and Roubini (2000) about these phenomena, the response of output to increasing U.S. interest rate shock is mixed, since the two effects are contrary to each other. On one side, as the real exchange rate depreciates, aggregate demand is stimulated and then output should increase. On the other side, the higher interest rate dampens aggregate demand and tends to reduce output. As a result, output of emerging countries usually decreases and output of developed countries generally increases after an increasing world interest rate shock. Although Korea was commonly classified in the emerging country group in past literature, Korea is a developed country, especially in terms of aggregate economic scale.[19]

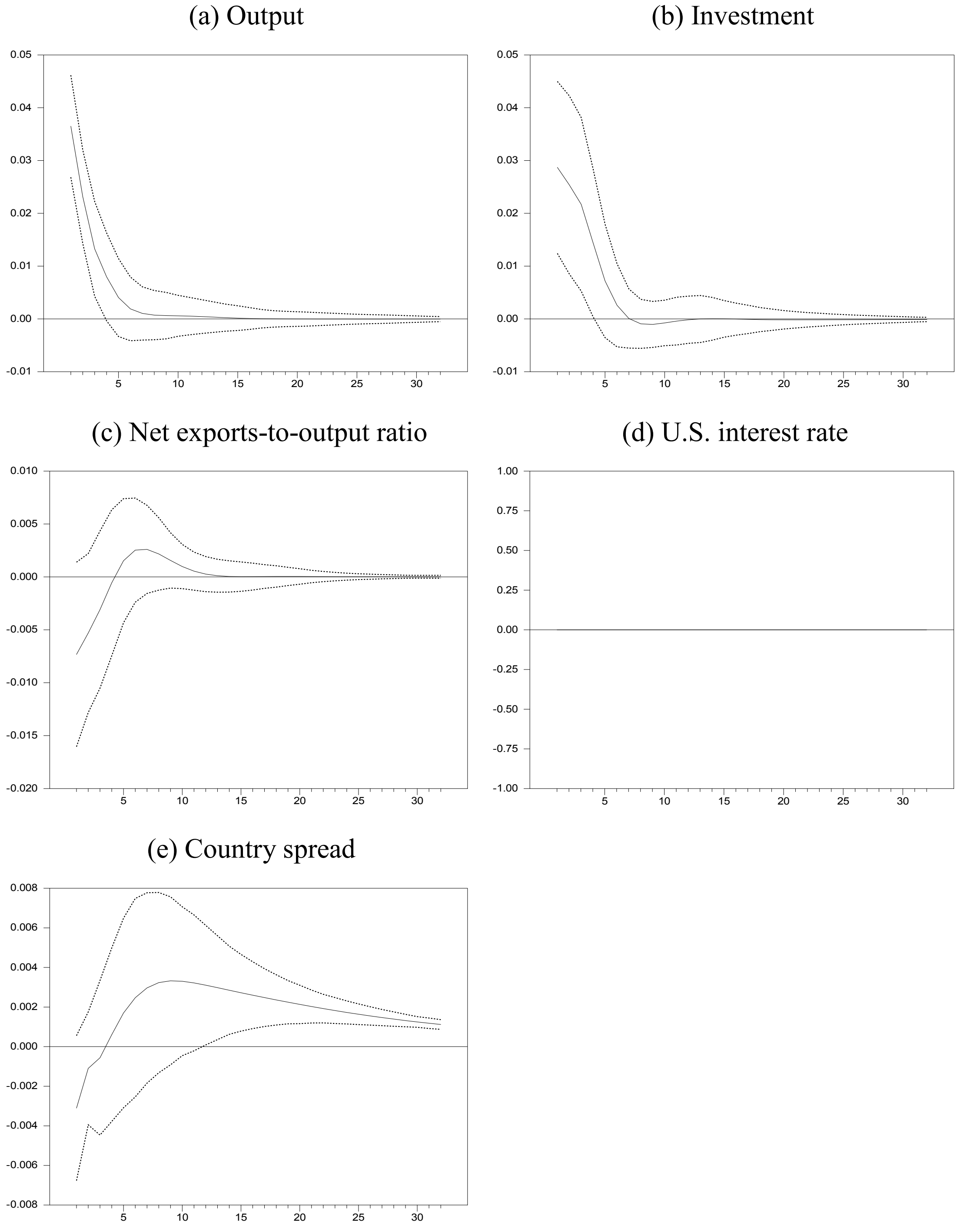
Impulse responses of Korean macroeconomic variables to an increasing Japanese interest rate shock as a regional interest rate shock in Figure 2.7 are rather close to the well-known results related to emerging economies than impulse responses to the U.S. interest rate shock. Output, investment and the net exports-to-output ratio start to respond after one period in comparison to the lack of initial movement. Output and investment contract, while the net exports-to-output ratio improves when the Japanese interest rate rises. The response of country spread shows delayed overshooting to the increasing Japanese interest rate shock. In contrast to the impulse response to the increasing country spread shock in Figure 2.5, the responses of output and investment are qualitatively similar, but the net exports-to-output ratio to country spread shock responds in the opposite direction compared with the increasing Japanese interest rate shock. These responses of Korean real macroeconomic variables to an increasing Japanese interest rate shock are rather consistent with those of emerging economies in the Uribe and Yue (2006) study.

Responses of the variables in the SVAR (2) to the favourable output shock (ε_t^y), reflecting variations in total factor productivity, are reported in Figures 2.8 and 2.9.

Owing to the one standard deviation increasing output shock, output itself and investment respond positively and immediately in the period of impact and gradually converge on the steady-state level. In contrast, the first reaction of the net exports-to-output ratio is a negative response and gradually recovers to the pre-shock level. The

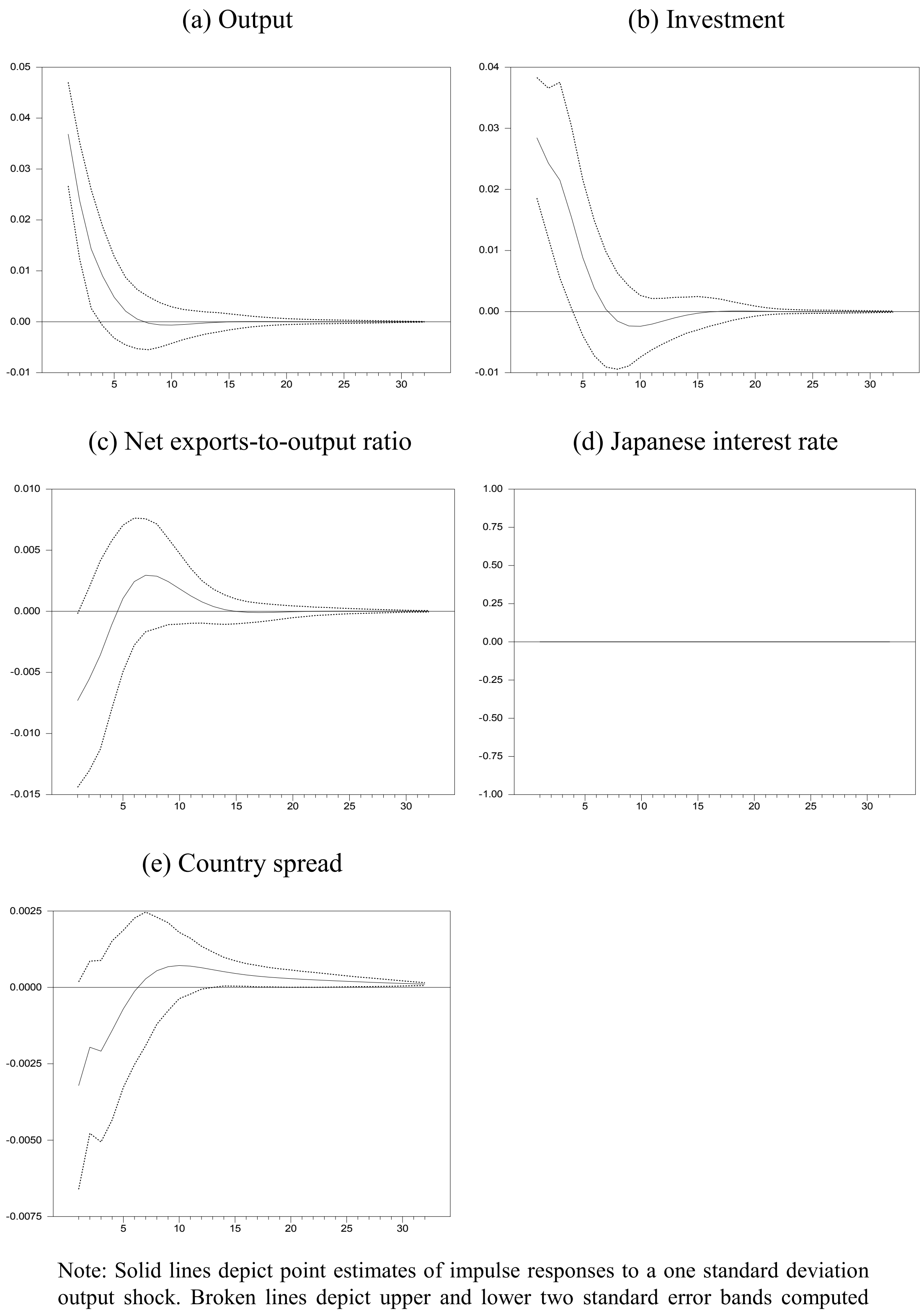
[19] The World Bank pronounced that nominal GDP of Korea was 929 billion U.S. dollars, and the economic scale of Korea is ranked 15 of 188 countries in the world in 2008. Korean economy has ranked from 11 to 14 since 2001.

Figure 2.8: Impulse Responses to Output Shock (Korea-U.S.)



Note: Solid lines depict point estimates of impulse responses to a one standard deviation output shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

Figure 2.9: Impulse Responses to Output Shock (Korea-Japan)



Note: Solid lines depict point estimates of impulse responses to a one standard deviation output shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

countercyclical feature of the net exports-to-output ratio to increasing output shock is in line with the result of Neumeyer and Perri (2005). These responses of output, investment and the net exports-to-output ratio are consistent with the impulse responses to a positive productivity shock implied by the small open economy RBC model (Schmitt-Grohe and Uribe, 2003; Uribe and Yue, 2006). An increasing output shock causes country spread to decrease immediately, and recovery of half life takes four quarters. The countercyclical behaviour of country spread in response to an output shock implies that country spread behaves in ways that exacerbate the business cycle effects of a favourable output shock.

Basically, results of the Korea-Japan case to increasing output shock in Figure 2.9 are the same as those of the Korea-U.S. case of an increasing output shock in Figure 2.8 quantitatively and qualitatively except for responses in country spread. Although the response of country spread in the case of using the U.S. interest rate rises more positively after a first negative response than the response of country spread in the case of using the Japanese interest rate, the positive output shock yields negative country spread in both cases.

2.4.2.3 Variance Decomposition

Variance decomposition is useful in explaining the dynamic characteristics of the system and examining the relationships among economic variables. Variance decomposition determines how much of the forecast error variance of each of the variables can be explained by shocks to the other variables. Thus, variance decomposition can provide a way to measure the relative significance of each stochastic error to variables in the VAR framework.

If l-step forecasting value is written as in equation (2.8), l-step forecasting error can be written like equation (2.9), which implies the difference between the actual value and forecasting value.

$$E_{t-1}X_t = \sum_{k=l}^{\infty} C_k W_{t-k} \tag{2.8}$$

$$X_t - E_{t-1}X_t = \sum_{k=0}^{\infty} C_k W_{t-k} - \sum_{k=l}^{\infty} C_k W_{t-k} = \sum_{k=0}^{l-1} C_k W_{t-k} \tag{2.9}$$

If V_l is assumed to be a covariance matrix, V_l can be noted as follows:

$$V_l = \sum C_k V(W_{t-k}) C_k^T \tag{2.10}$$

where $V(W_{t-k})$ is a diagonal matrix. Supposing that V_l^i means the variance of the forecasting error after l period of X_t^i, which is the i_{th} variable of X_t, V_l^i can be interpreted as i_{th} one of diagonal elements of V_l vector and defined as the following equation (2.11).

$$V_l^i = \sum [(C_k^{i1})^2 \sigma_1^2 + (C_k^{i2})^2 \sigma_2^2 + ... + (C_k^{in})^2 \sigma_n^2] \tag{2.11}$$

According to equation (2.11), variance of forecasting error of X^i can be expressed by the sum of variance to forecasting error of every variable in the model. Thus, by virtue of the following percentage, which is called variance decomposition or innovation accounting, influence from i innovation to j innovation can be calculated.

$$\frac{\sum_{k=0}^{l-1}(C_k^{ij})^2\sigma_j^2}{V_l^i}\times 100 \tag{2.12}$$

Table 2.5 presents the results of variance decomposition for the variables contained in the SVAR (2) model at different horizons to compose the fraction of the variance on the basis of the explanatory power of country spread and world or regional interest rate to the Korean economy. The results in Table 2.5 are categorized by two cases considering Korea-U.S. and Korea-Japan.

Innovations in the U.S. interest rate (ε_t^{rus}) account for about 3% of movements in output in the Korean business cycle frequency. In contrast, innovations in the country spread (ε_t^{rc}) explain about 7% of movements in output in the Korean business cycle frequency. Thus, disturbances in external financial variables, combined U.S. interest rate and country spread, explain about 10% of movements in output in the Korean business cycle frequency. However, combined innovations of U.S. interest rate shock and country spread shock are not effective to elucidate the movement of the net exports-to-GDP ratio (below 1%). Fluctuations in country spread are mainly explained by innovations in the U.S. interest rate and country spread itself. These two kinds of combined financial uncertainties account for about 88% of the fluctuation in country spread. The explanatory power of innovations in the U.S. interest rate increases gradually and that of innovations in country spread decreases in the long run.

The Japanese interest rate shock (ε_t^{rj}) explains about 5% of movements in output in the Korean business cycle frequency. On the other hand, country spread shock (ε_t^{rc})

explains only about 0.2% of movements in output in the Korean business cycle frequency. Thus, disturbances in external financial variables, combined Japanese

Table 2.5: Variance Decomposition

Case	Variable	Shock	Horizons 1	4	8	12	16	20	24	28	32
Korea - U.S.	Y	CS	0	4.86	6.80	6.94	6.95	6.95	6.95	6.95	6.95
		UIR	0	0.40	1.79	2.58	2.73	2.74	2.74	2.74	2.74
		SUM	0	5.26	8.59	9.52	9.68	9.69	9.69	9.69	9.69
	I	CS	0	3.69	5.34	5.48	5.49	5.49	5.49	5.49	5.49
		UIR	0	2.64	3.72	4.23	4.28	4.29	4.30	4.31	4.33
		SUM	0	6.33	9.06	9.71	9.77	9.78	9.79	9.80	9.82
	NX/Y	CS	0	0.23	0.46	0.46	0.47	0.47	0.47	0.47	0.47
		UIR	0	0.05	0.06	0.09	0.09	0.10	0.10	0.10	0.10
		SUM	0	0.28	0.52	0.55	0.56	0.57	0.57	0.57	0.57
	R^{us}	CS	0	0	0	0	0	0	0	0	0
		UIR	91	91	91	91	91	91	91	91	91
		SUM	91	91	91	91	91	91	91	91	91
	R^{c}	CS	54.5	30.6	12.6	7.6	5.77	4.92	4.47	4.22	4.08
		UIR	0.79	42.7	69.8	77.4	80.5	81.9	82.7	83.2	83.5
		SUM	55.3	73.3	82.4	85.0	86.3	86.8	87.2	87.4	87.6
Korea - Japan	Y	CS	0	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.23
		JIR	0	4.44	4.59	4.61	4.61	4.61	4.61	4.61	4.61
		SUM	0	4.66	4.82	4.84	4.84	4.84	4.84	4.84	4.84
	I	CS	0	1.22	1.16	1.16	1.16	1.16	1.16	1.16	1.16
		JIR	0	5.87	5.88	5.90	5.90	5.90	5.90	5.90	5.90
		SUM	0	7.09	7.04	7.06	7.06	7.06	7.06	7.06	7.06
	NX/Y	CS	0	0.88	1.24	1.25	1.25	1.25	1.25	1.25	1.25
		JIR	0	1.36	1.32	1.32	1.34	1.36	1.36	1.36	1.36
		SUM	0	2.24	2.56	2.57	2.59	2.61	2.61	2.61	2.61
	R^{j}	CS	0	0	0	0	0	0	0	0	0
		JIR	96	96	96	96	96	96	96	96	96
		SUM	96	96	96	96	96	96	96	96	96
	R^{c}	CS	56.3	41.2	35.1	32.4	30.7	29.8	29.3	29.0	28.9
		JIR	10.1	33.9	42.5	47.1	50.0	51.6	52.5	52.9	53.1
		SUM	66.4	75.1	77.6	79.5	80.7	81.4	81.8	81.9	82.0

Note: CS denotes the fraction of the variable's movement in country spread shock. UIR denotes the fraction of variable's movement in the U.S. interest rate shock. JIR denotes the fraction of variable's movement in Japanese interest rate shock. SUM denotes the Sum of fraction of variable's movement in world or regional interest rate shock and country spread shock. Each number is a percentage of variance decomposition.

interest rate and country spread explain only about 5% of movements in output in the Korean business cycle frequency. Combined innovations in the Japanese interest rate shock and country spread shock account for the movement of the net exports-to-GDP ratio about 3%. Fluctuations in country spread are mostly explained by the Japanese interest rate shock and country spread shock itself. The combined two financial uncertainties explain about 82% of fluctuation in country spread. The explanatory power of innovations in the Japanese interest rate increases gradually, and that of innovations in country spread decreases in the long run, although the effect of Japanese interest rate to country spread is weaker than that of U.S. interest rate to country spread.

The results are comparatively less significant than the results of other research, which investigates the relationship between country spread and business cycle of a small open economy from a quantitative perspective. This is because Korea is a small developed economy, which has a relatively big economic size and a well-organized financial system, though it still has characteristics of an emerging economy. Thus, fluctuations in the external (world) financial market can affect emerging economies, which are the research objectives of previous studies, more seriously than the Korean economy.

2.5. A Theoretical Explanation

This section presents and calibrates a structural model for the Korean economy with the aim of providing a theoretical framework and checking the plausibility of the model by comparing it with the results from the empirical analysis. A small open economy is vulnerable to external shocks such as world interest rate shocks. Many researchers have analysed the effects of world interest rate shocks empirically on domestic macroeconomic variables using various econometric methodologies, including the VAR model. However, the empirical estimation can only provide ad-hoc economic interpretations in terms of the results. Thus, along with the empirical study, demand for a theory-based analysis has increased to compensate for the weakness of empirical analysis. In the previous section, although the SVAR (2) model includes several restrictions to explain the relationships among variables, there is no clear evidence that the results of the SVAR (2) model reflects well the economic implications. Supposing that an appropriate theoretical model can be built up and impulse responses driven by the theoretical model are similar to impulse responses driven by the SVAR (2), outcomes will be able to be accepted as plausible results.

Thus, I pass through three stages to substantiate the plausibility of measured innovations. In the first stage, I specify the business cycle model for small open economy from Uribe and Yue (2006). In the second stage, a calibration for the structural parameters is performed using the specified theoretical model. In the final stage, I draw the impulse response functions from the theoretical model and compare them with the impulse response functions from the SVAR (2) model in section 2.4 to check the plausibility. Through the processes, the effects of the U.S. interest rate shock, Japanese interest rate shock and country spread shock are reconsidered in terms of how to influence theoretically the Korean macroeconomic variables using the DSGE model.

2.5.1 A Calibrated Model

DSGE modelling is gradually influential in contemporary macroeconomics. DSGE models attempt to explain various aggregate economic phenomena such as economic growth, business cycles and the effects of policies on the basis of macroeconomic models derived from microeconomic principles. In particular, these models are powerful tools that provide a coherent framework for analysis of economic fluctuations and the business cycle. The reason that macroeconomists use the DSGE models is that they can help to identify sources of fluctuations, to answer questions about structural changes, to forecast the effect of macroeconomic fluctuations and to perform counterfactual experiments (Tovar, 2008). The DSGE model as a theoretical model presented in this chapter is on the basis of the standard neoclassical growth model for a small open economy developed by Uribe and Yue (2006). The implication of the model is simple. Households choose how much to consume and decide how much labour to supply. On the other hand, firms produce enough goods to meet demand. The maximization problems of these sectors that households desire utility maximization and firms aspire to gain maximized profit under each budget constraint can be solved under the microeconomic foundations of the DSGE model.

2.5.1.1 Households

A typical open economy is composed of households who own capital. Households rent capital to domestic firms and provide labour in exchange for wage income. They are usually satisfied with leisure and consuming commodities which are composed of domestic products and imported goods. In each period, a representative household decides how much to spend on consumption within his or her income and how much labour to supply for his or her income to obtain the maximized utility under the budget constraint. For a small open economy populated by a large number of households, the following utility function describes the representative household's maximization of the expected lifetime utility from consumption and hours worked.

$$E_0 \sum_{t=0}^{\infty} \beta^t U(c_t - \mu \tilde{c}_{t-1}, h_t) \tag{2.13}$$

where c_t denotes consumption in period *t*, $\tilde{c}_t$ denotes average consumption by all individuals in the economy in period *t*−1, and h_t denotes the fraction of time devoted to work in period *t*. Households take as given the process for $\tilde{c}_t$. There are two parameters in this utility function. One is β ($0<\beta<1$), which indicates the subjective discount factor, and the other is μ, which denotes the degree of external habit formation. Preferences are assumed to have a feature of external habit formation in which an individual's habit level depends on the history of aggregate consumption rather than on the individual's own past consumption. This feature improves the predictions of the standard model by preventing an excessive contraction in private non-business absorption in response to external financial shocks. If μ is equal to 0, it indicates time separability in preferences. The larger the μ, the stronger the degree of external habit formation.[20]

Since labour is not what households want to do spontaneously, marginal utility of labour is negative. Consumption, which has positive marginal utility, compensates for households of marginal disutility of labour stemming from their increased work. For each individual, a household has 24 hours per day, and this means that the individual should decide how much time a household allocates to work in a day. Hence, a household necessarily faces a maximization problem between adequate time of labour and appropriate consumption, and a rational household is able to solve the selection

[20] The term external habit is widely accepted since it was first used by Campbell and Cochrane (1999), although the idea of "catching up with the Joneses" (namely, external habit formation) was first developed by Abel (1990). Habit formation has played a role in helping researchers to explain asset prices and business fluctuations in both developed economies (e.g., Boldrin *et al.*, 2001) and emerging countries (e.g., Uribe, 2002).

problem through utility maximization. That is, when disutility from increasing labour and utility from increasing consumption are balanced, a household can achieve the maximized utility. The utility function in equation (2.13) involves this implication.

It is assumed that households can hold two types of assets. One is physical capital, which is owned by domestic residents, and the other is a bond, which can be traded internationally. There are three kinds of income sources for households. The first source is wages, which is compensation for labour as opposed to sacrifice of their leisure. The second source is capital rents from holding the physical capital. The third source is interest income from holding financial assets, such as a bond. Households purchase newly the consumption goods, investment goods, and financial goods with their incomes which they obtain in each period. Considering incomes and consumption in period *t*, a household's budget constraint is written by the following:

$$d_t - R_{t-1} d_{t-1} = c_t + i_t + \Psi(d_t) - w_t h_t - u_t k_t \qquad (2.14)$$

where d_t denotes the household's debt position in period *t*, R_t denotes the interest rate in the financial market, c_t denotes the gross domestic consumption, i_t denotes gross domestic investment, w_t denotes the wage rate, h_t denotes the allocated time to labour, u_t denotes the rental rate of capital, and k_t denotes the stock of physical capital. The equation (2.14), which is a budget constraint, implies that newly increased net debt, which is set on the basis of time *t*, is measured by the subtracted total revenue, such as wages and capital rents from the total expenditure such as consumption, investment, and adjustment cost.

The unique item, $\Psi(d_t)$, in the part of expenditure is the function of incidental expenses to adjust various conditions when households borrow assets from abroad in period *t*. The debt-adjustment cost function ($\Psi(d_t)$) is assumed to be convex and to satisfy $\Psi(\bar{d}) = \Psi'(\bar{d}) = 0$, for some $\bar{d} > 0$. To maximize profit, this kind of cost function has an increasing convex shape relative to the volume of intermediation (d_t). It is necessary to include the financial intermediation of a domestic institution such as a bank, since it is difficult to transact financial assets directly between domestic residents and foreign residents. Domestic financial institutions capture funds from the international financial market at the world interest rate (R_t) and lends to domestic consumers at the domestic interest rate (R_t^d). Following the process, the domestic financial institution should pay extra costs, such as operation costs ($\Psi(d_t)$). Profit can be inferred from a difference between the total volume of intermediation-applied domestic interest rate ($R_t^d d_t$) and the sum of the total borrowed investment principal from abroad ($R_t d_t$) and the adjustment cost ($R_t^d \Psi(d_t)$).

$$R_t^d d_t - [R_t d_t + R_t^d \Psi(d_t)] \tag{2.15}$$

In order to maximize profit, domestic financial institutions should decide the optimal volume of d_t. The equation associated with the maximized profit written by means of domestic interest rate from the first-order condition in terms of d_t is given by

$$R_t^d = \frac{R_t}{1 - \Psi'(d_t)} \tag{2.16}$$

This optimal profit of domestic financial institutions is assumed to be portioned out to households in a lump-sum method. All non-financial domestic residents can borrow at this interest rate (R_t^d).

In the process of modelling associated with investment, capital adjustment costs in the form of gestation lags are considered in this chapter.[21] Introducing capital adjustment costs is common in models for a small open economy. Involvement of the capital adjustment costs in the model provides a convenient and plausible way to avoid excessive investment volatility in response to changes in interest rate faced by the country in international markets (Uribe, 1997; Uribe and Yue, 2006). Since previous models concerned with investment typically have assumed that capital becomes productive almost immediately after purchase, there is no need for the presence of gestation lags. However, the timing of investment and capital stock accumulation are different due to the time to build as well as delivery lags. Jorgenson (1963) states that a new project is initiated in each period until the backlog of uncompleted projects is equal to the difference between desired stock and actual capital stock. Hence, it is necessary to impose the adjustment costs associated with the installation of capital goods of period t.[22] It is assumed that to produce one unit of capital good requires investing 1/2 units of goods for two consecutive periods in this chapter. Then investment in period t is given by

[21] There is some history to build and to plan the gestation lags in the real business cycle literature. The remarkable research was performed by Kydland and Prescott (1982), which added a time to build lag for capital to a calibrated RBC model. On the basis of their setup, Christiano and Todd (1995) added a planning phase. These models suggest that capital gestation lags can capture some empirical features of the business cycle more effectively than standard models with one building period or models with convex capital adjustment costs. They also emphasized that a combined building and planning lag can account for the persistent effects of technological shocks, the tendency for business and structures investment to lag movements in output and the leading relationship of productivity to hours worked.

[22] Introducing adjustment costs yields a well-defined investment decision (Blanchard and Fisher, 1989, p. 58).

$$i_t = \frac{1}{2}\sum_{i=0}^{1} p_{it} \qquad (2.17)$$

where p_{it} denotes the number of investment projects started in period *t-i* for *i* =0, 1. This implies that capital expenditure occurs immediately after the investment decision, and the purchased capital becomes productive with one period delay.[23] In turn, the evolution of p_{it} (i = 0, 1) is given by

$$p_{i+1t+1} = p_{it} \qquad (2.18)$$

The capital stock obeys the following law of motion

$$k_{t+1} = (1-\delta)k_t + k_t\Phi(\frac{p_{1t}}{k_t}) \qquad (2.19)$$

where δ ($0<\delta<1$) denotes the depreciation rate of physical capital. The process of capital accumulation is assumed to be on the condition of capital adjustment costs function (Φ), which is assumed to be strictly increasing, concave, and to satisfy $\Phi(\delta) = \delta$ and $\Phi'(\delta) = 1$. These last two assumptions ensure the absence of adjustment costs in the steady-state (Uribe and Yue, 2006).

The last constraint to solve the optimization problem for households is the borrowing constraint, which prevents the possibility of Ponzi schemes. In formulating a consumer's problem in the model, researchers should include some constraint on debt; otherwise the consumer would never pay back his or her debt. The no-Ponzi condition implies that the individual cannot keep borrowing forever. Any debt that has been

[23] Uriebe and Yue (2006) set up four periods for gestation lags in their paper, maybe because they use quarterly data. However, the model used in this chapter sets two periods of gestation lags, because no significant difference is found from the tests for appropriate gestation lags with examinations from two to four periods of gestation lags.

accumulated eventually has to be paid off.[24] A borrowing constraint of this form is as follows:

$$\lim_{j\to\infty} E_t \frac{d_{t+j+1}}{\Pi_{s=0}^{j} R_{t+s}} \leq 0 \tag{2.20}$$

Since all preparations are ready to solve the problem, then households decide contingent plans of c_{t+1}, h_{t+1}, d_t, i_{t+1}, k_{t+1} to maximize the utility function (2.13) subject to the budget constraint (2.14), which includes the debt adjustment costs (2.16) and investment divided by projects (2.17), the evolution of investment projects (2.18), the law of motion of the capital stock (2.19) and a borrowing constraint which includes the idea of no-Ponzi schemes (2.20). The Lagrangian related to the households' optimization problem can be written as:

$$\text{£} = E_0 \sum_{t=o}^{\infty} \beta^t \{U(c_t - \mu \widetilde{c}_{t-1}, h_t) + \lambda_t [d_t - R_{t-1} d_{t-1} - \Psi(d_t) + w_t h_t + u_t k_t - \frac{1}{2}\sum_{i=0}^{1} p_{it} - c_t]$$
$$+ \lambda_t v_{0t}(p_{it} - p_{i+1t+1}) + \lambda_t q_t [(1-\delta)k_t + k_t \Phi(\frac{p_{1t}}{k_t}) - k_{t+1}]\} \tag{2.21}$$

where λ_t, $\lambda_t v_{0t}$ and $\lambda_t q_t$ are the Lagrange multipliers associated with each constraint of (2.14), (2.18) and (2.19).

The first-order conditions in terms of c_{t+1}, h_{t+1}, d_t, p_{it+1}(i =0, 1) and k_{t+1} follow respectively.

$$E_t \lambda_{t+1} = U_c(c_{t+1} - \mu \widetilde{c}_t, h_{t+1}) \tag{2.22}$$

[24] A no-Ponzi game condition is a constraint that prevents over-accumulation of debt. One way to rule out this behaviour is to prohibit debt entirely, for example, to require wealth to be always nonnegative. A more lenient way is to require only the present discounted value of wealth at infinity to be nonnegative. This type of condition is known as a no-Ponzi condition (Blanchard and Fisher, 1989, p.49).

$$E_t[w_{t+1}\lambda_{t+1}] = -U_h(c_{t+1} - \mu\widetilde{c}_t, h_{t+1}) \tag{2.23}$$

$$\lambda_t[1 - \Psi'(d_t)] = \beta R_t E_t \lambda_{t+1} \tag{2.24}$$

$$E_t \lambda_{t+1} v_{0t+1} = \frac{1}{2} E_t \lambda_{t+1} \tag{2.25}$$

$$\beta E_t[\lambda_{t+1} q_{t+1} \Phi'(\frac{p_{1t+1}}{k_{t+1}})] = \frac{\beta}{2} E_t \lambda_{t+1} + \lambda_t v_{0t} \tag{2.26}$$

$$\lambda_t q_t = \beta E_t\{\lambda_{t+1} q_{t+1}[1 - \delta + \Phi(\frac{p_{1t+1}}{k_{t+1}}) - \frac{p_{1t+1}}{k_{t+1}} \Phi'(\frac{p_{1t+1}}{k_{t+1}})] + \lambda_{t+1} u_{t+1}\} \tag{2.27}$$

Equation (2.22), derived from partial differentiation in terms of c_{t+1} (∂£ / ∂c_{t+1}), shows the way in which households decide how much they consume several kinds of goods and have leisure for period *t*+1 in period *t.* To make such decisions, they typically choose the point which equates the marginal utility of consumption in period *t* + 1 to the expected marginal utility of wealth in that period. Equation (2.23) derived from partial differentiation in terms of h_{t+1} (∂£ / ∂h_{t+1}) states the household's labour supply plan by equating the marginal disutility of labour in period *t* + 1 to the expected utility value of the wage rate in that period. Equation (2.24) derived from partial differentiation in terms of d_t (∂£ / ∂d_t) is an asset pricing equation related to the intertemporal marginal rate of substitution in consumption and the rate of return on financial assets. The rate of return induced in this chapter ($R_t /[1 - \Psi'(d_t)]$) looks different compared to the market rate of return generally shown (R_t) in the Euler equation. I already mentioned this rate of return and showed the generating process in equation (2.16). Equation (2.25) derived from partial differentiation in terms of $p_{0\,t+1}$ (∂£ / ∂p_{0t+1}) shows the price of an investment project at the first stage. Equation (2.26) derived from partial differentiation in terms of p_{1t+1} $(\partial £ / \partial p_{1t+1})$ implies that the cost of producing a unit of capital to the shadow price of installed capital, or Tobin's Q (q_t) equals the price of a project in the *i*-1 half of gestation plus 1/2 units of goods. Equation (2.27) derived from partial differentiation in terms of k_{t+1} $(\partial £ / \partial k_{t+1})$ is a pricing condition for physical capital. This equates the revenue from selling one unit of capital today (q_t) to the discounted value of renting the unit of capital for one period and then selling it $(u_{t+1} + q_{t+1})$ net of depreciation and adjustment costs.

2.5.1.2 Firms

Firms' profit maximization process seeks to find and determine the best association of inputs which can yield the greatest output. There are several approaches to solve this problem. The total revenue/total cost approach depends on the fact that profit equals revenue minus cost, and the marginal revenue-marginal cost approach relies on the fact that the maximum profit can be achieved when marginal revenue equals marginal cost under the circumstances of a perfectly competitive market. In some cases, a marginal revenue approach in which marginal revenue equals zero when the marginal revenue curve reaches its maximum value is used. In other words, the profit maximizing inputs can be determined by setting marginal revenue equal to zero. In this chapter, the revenue part and the cost part are arranged to compute the firm's profit, and then maximized profit can be calculated using the condition that the marginal profit equals zero.

In the production function, the output of a firm is related to the amount of inputs, typically capital and labour. Firms rent capital and hire labour services from perfectly competitive markets to produce final goods according to the following production function.

$$y_t = F(k_t, h_t) \tag{2.28}$$

y_t denotes the output from the production function, which has two basic assumptions. First, increasing capital input (k_t) and labour input (h_t) influence the increasing output (y_t). This assumption is concerned with the fact that the slope of production function is marginal productivity of input, and it is over 0. The second assumption is that the law of diminishing marginal productivity works in this production function. That is, the ratio of increasing output to increasing input is gradually decreased. Synthetically, the production function shows the increasing and concave shape of the curve under the two assumptions. Additionally, one more assumption is added. The production function is to be homogeneous of degree one, which implies the constant returns to scale like the Cobb-Douglas production function.

Firms' production process is subject to a working capital in advance constraint that firms are required to hold non-interest-bearing assets, which corresponds to a fraction of the wage bill for each period. This constraint introduces a direct supply side effect of changes in the cost of borrowing in international financial markets and allows the model to predict a more realistic response of domestic output to external financial shocks (Uribe and Yue, 2006). The working capital in advance constraint takes the form of equation (2.29).

$$\kappa_t \geq \eta w_t h_t; \quad \eta \geq 0 \tag{2.29}$$

where κ_t denotes the amount of working capital that the representative firm should hold in advance in period *t*. That is to say, expression (2.29) implies that the representative firm is under the constraint of reserving some portion (η) of the total wages in period *t* ($w_t h_t$).

The equation of a representative firm's profit in period *t* is composed in part of revenue and in part of cost. The revenue part consists of output coming from labour and capital input and net debt in period *t*. The cost part consists of wage cost for labour, rental cost for capital, and net working capital that should be accumulated in period *t*. The firm's profit in period *t* (π_t) is expressed by the following equation (2.30):

$$\pi_t = \{F(k_t, h_t) + (d_t^f - R_{t-1}^f d_{t-1}^f)\} - \{w_t h_t + u_t k_t + (\kappa_t - \kappa_{t-1})\} \qquad (2.30)$$

where R_t^d is the interest rate at which domestic residents borrow and is given by equation (2.16).

The representative firm's total net liabilities at the end of period *t* is defined as $l_t = R_t^d d_t^f - \kappa_t$. Then, equation (2.30) can be rewritten with l_t as

$$\pi_t = F(k_t, h_t) - w_t h_t - u_t k_t + \frac{l_t}{R_t^d} - l_{t-1} - (1 - \frac{1}{R_t^d})\kappa_t \qquad (2.31)$$

The working capital in advance constraint is used holding with equality to eliminate κ_t using expression (2.29). This is because the representative firm can achieve the maximum profit when the working capital in advance constraint is an equation.

$$\pi_t = F(k_t, h_t) - [1 + \eta(1 - \frac{1}{R_t^d})] w_t h_t - u_t k_t + \frac{l_t}{R_t^d} - l_{t-1} \qquad (2.32)$$

Equation (2.32) implies that, if the working capital in advance constraint increases due to increasing interest rate (R_t^d), labour cost will increase by a fraction $\eta(1-1/R_t^d)$.

The representative firm's purpose is to maximize the present discounted value of the profit, which should be distributed to the domestic residents who own it. Expression (2.33) denotes the firm's objective function using the household's marginal utility of wealth as the stochastic discount factor.

$$E_0\sum_{t=0}^{\infty}\beta^t\frac{\lambda_t}{\lambda_0}\pi_t \tag{2.33}$$

Using equation (2.32) to substitute for π_t in the firm's objective function (2.33), the process to solve the firm's maximization problem can be interpreted as choosing appropriate l_t, h_t and k_t.

$$E_0\sum_{t=0}^{\infty}\beta^t\frac{\lambda_t}{\lambda_0}\{\,F(k_t,h_t)-[1+\eta(1-\frac{1}{R_t^d})]w_t h_t-u_t k_t+\frac{l_t}{R_t^d}-l_{t-1}\,\} \tag{2.34}$$

The new firm's objective function of expression (2.34) is subject to a no-Ponzi game borrowing constraint of the form in equation (2.35).

$$\lim_{j\to\infty}E_t\frac{l_{t+j}}{\Pi_{s=0}^{j}R_{t+s}^d}\le 0 \tag{2.35}$$

The representative firm chooses the optimal demand for labour and capital to maximize its profit. The first-order conditions associated with the firm's maximization problem are driven as equations (2.36) and (2.37).

$$F_h(k_t,h_t)=[1+\eta(1-\frac{1}{R_t^d})]w_t \tag{2.36}$$

$$F_k(k_t,h_t)=u_t \tag{2.37}$$

It is clear from the first-order conditions in equations (2.36) and (2.37) that the conditions for maximum profit can be achieved when marginal products of labour and capital equal each real cost, respectively. Although there is a particular appearance in part of the real wage rate, which is due to the working capital in advance constraint, it is also an expected result that the working capital in advance constraint distorts the labour market by introducing a wedge between the marginal product of labour and the real wage rate. The larger the opportunity cost of holding working capital $(1-(1/R_t^d))$ or the higher the intensity of the working capital constraint (η), the larger the distortion.

2.5.2 Calibration Results

Following two well-known early papers by Shoven and Whalley (1972) and Kydland and Prescott (1982), so-called "calibrated" models have become mainstream in empirical investigation in macroeconomics.[25] The calibration method is conceptually similar to the typical estimation method in the aspect that the choice of parameter values is subject to a goodness of fit criterion with respect to data. However, researchers recognize that empirical investigation using conventional econometric methodologies is often insufficient to specify their theoretical models and seldom appear to produce conclusive results. Hence, researchers have begun using calibrated models more than conventional econometric models, since calibrated models are convenient in that they stay close to the particular theoretical model that researchers want to investigate and are applicable to cases that are hard to estimate, not estimated, or even unestimable (See Dawkins *et al*., 2001).

[25] Gregory and Smith (1991) affirm that calibrated models are the predominant tool in contemporary macroeconomics for empirical investigation.

It is assumed that all households consume identical quantities in equilibrium. Therefore, each household consumes equally at the average consumption level ($\tilde{c}_t$).

$$c_t = \tilde{c}_t; \quad t \geq -1 \tag{2.38}$$

The process to find an equilibrium set of $c_{t+1}, \tilde{c}_{t+1}, h_{t+1}, d_t, i_t, k_{t+1}, p_{it+1}$ for *i*= 0, 1, $R_t, R_t^d, w_t, u_t, y_t, nx_t, \lambda_t, q_t$ and v_{0t} can be obtained when they are satisfied with all conditions in the model. The following standard utility function, production function, capital adjustment cost function and debt adjustment cost function are adopted to obtain the equilibrium set.

$$U(c - \mu\tilde{c}, h) = \frac{[c - \mu\tilde{c} - \omega^{-1}h^{\omega}]^{1-\gamma} - 1}{1-\gamma} \tag{2.39}$$

$$F(k, h) = k^{\alpha} h^{1-\alpha} \tag{2.40}$$

$$\Phi(x) = x - \frac{\phi}{2}(x - \delta)^2; \quad \phi > 0 \tag{2.41}$$

$$\Psi(d) = \frac{\varphi}{2}(d - \bar{d})^2 \tag{2.42}$$

In calibrating the model, the time unit is meant to be one quarter.

When calibrating an economic model, researchers need to set the specified parameters to replicate a benchmark data set as a model solution. In particular, in calibrating a general equilibrium model, the numerical values of some model parameters are typically set exogenously, while others, the calibrated parameters, are endogenously determined so as to reproduce the benchmark data as an equilibrium of the model (dawkins *et al*., 2001). Thus, to select parameters and the stochastic processes driving the theoretical model, at first, I choose parameters such that the deterministic steady state for the endogenous variables replicates the time series averages of the actual economy. And then, the exogenously specified parameters are set on the basis of estimates drawn from the literature since some parameters cannot be obtained by the deterministic steady state of the model. In this chapter, these parameter values are drawn from Mendoza's (1991) paper, which are standard in the international business cycle literature.

I set $\gamma = 2$, $\omega = 1.455$ and $\alpha = 0.32$, where γ means the inverse of intertemporal elasticity of substitution, $1/(\omega-1)$ is labour supply elasticity, and α denotes capital elasticity of output. The depreciation rate is set at 10% per year, which is also a standard value in business cycle studies (Uribe and Yue, 2006). The steady-state level of the U.S. real interest rate at 6% and that of the Japanese real interest rate at 2.5% are set per year faced by the Korean economy in the international financial market. These values are calculated by the average U.S. interest rate of about 4%, the Japanese interest rate of about 0.5%, and an average country premium of 2%, which result from the time series data used in the empirical test.

There still remain four parameters to assign values to: φ, ϕ, η and μ. There are no available estimates known to the academic world for these four parameters. Therefore, to estimate these parameters, I follow the procedures which are used by Boldrin *et al.* (2001) and Uribe and Yue (2006). They choose the values of the parameters that have the minimized distance between the empirically estimated impulse response functions and the theoretical impulse response functions stemming from the calibrated model. Table 2.6 summarizes the parameter values and descriptions.

Table 2.6: Parameter Values

	φ	ϕ	η	μ
Case I	0.41	45.52	0.83	0.06
Case II	0.14	20.48	0.67	0.15

Description: φ, Debt adjustment cost parameter; ϕ, Capital adjustment cost parameter; η, Fraction of wage bill subject to working capital in advance constraint; μ, Habit formation parameter.
Note: Case I; the case of using the U.S. interest rate as a world interest rate, Case II; the case of using the Japanese interest rate as a regional interest rate.

The debt adjustment cost parameter (φ) of Case II is smaller than that of Case I. This implies that, if a certain amount of debt (d_t) increases over its steady-state value ($\bar{d}$), debt adjustment cost in Case I will increase with much higher increasing rate than debt adjustment cost in Case II, because of assumed debt adjustment cost's increasing and convex characteristics of function. That is, the increasing rate of the debt adjustment cost on the basis of the U.S. interest rate is higher than that of the Japanese interest rate, when domestic residents borrow foreign assets from the international financial market. The capital adjustment costs may seem very significant in both cases. In particular, the capital adjustment cost parameter (ϕ) of Case I is much larger than that of Case II − more than double. This implies that, if there is a certain amount of increase in investment from the steady-state condition, capital adjustment cost in Case I will increase with higher decreasing rate than capital adjustment cost in Case II, because of assumed capital adjustment cost's increasing and concave properties of function. Although the two fractions of the wage bill that are subject to a working capital in advance constraint (η) have a gap more or less, there is no serious difference between the two cases. Based on the results, firms maintain a level of working capital equivalent to about two and half months of wage payments for Case I and about two months of wage payments for Case II. Lastly, although the intensity of external habit formation (μ) in Case II is larger than that in Case I, both estimated degrees of habit formation are modest compared with the typically used values to explain asset price regularities in closed economies such as Mehra and Prescott (1985) and Constantinides (1990).

2.5.3 Theoretical and Estimated Impulse Response Functions

The plausibility of the theoretical model can be examined by comparing the theoretical impulse response functions with the estimated impulse response functions. The theoretical impulse response functions of four variables − output, investment, net exports-to-output ratio and the country interest rate − to two shocks − the U.S. or Japanese interest rate shock and the country spread shock − are displayed in Figures 2.10 and 2.11, respectively. There are eight graphs for each case associated with the U.S. interest rate and the Japanese interest rate. In each case, the left column shows the impulse responses of output, investment, net exports-to-output ratio, and country spread to a U.S. interest rate shock (ε_t^{rus}) and Japanese interest rate shock (ε_t^{rj}). The right column shows impulse responses of four variables to a country spread shock (ε_t^{rc}).

Comparing two kinds of impulse response functions, the theoretical model replicates the data relatively well with the exception of the impulse response of the net exports-to-GDP ratio to country spread shock (ε_t^{rc}) in the case of using the Japanese interest rate. However, according to economic theory and the results of previous research such as that of Neumeyer and Perri (2005) and Uribe and Yue (2006), net exports are countercyclical. Thus, the positive theoretical impulse response of the net exports-to-output ratio to increasing country spread shock is more reasonable than the estimated impulse response of the net exports-to-output ratio to country spread shock. Almost every part of each theoretical impulse response except for some last parts of the several responses lies inside the estimated two standard error bands. However, the impulse response functions are actually not directly comparable because one is from a theoretical economy while the other is from data. What matters is the qualitative response, rather than actual magnitudes.

The model also replicates key qualitative features of the estimated impulse responses similarly. First, output and investment contract in response to the increasing Japanese interest rate shock, whereas responses of output and investment to increasing U.S. interest rate shock expand. Although two macroeconomic variables to two foreign

Figure 2.10: Theoretical and Estimated Impulse Response Functions

(U.S. Interest Rate Shock and Country Spread Shock)

(a) Response of output to ε_t^{rus} (b) Response of output to ε_t^{rc}

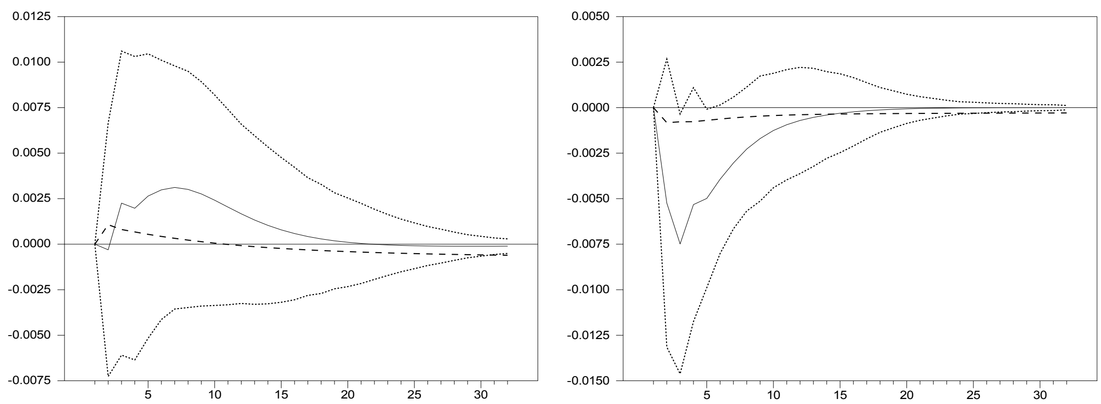
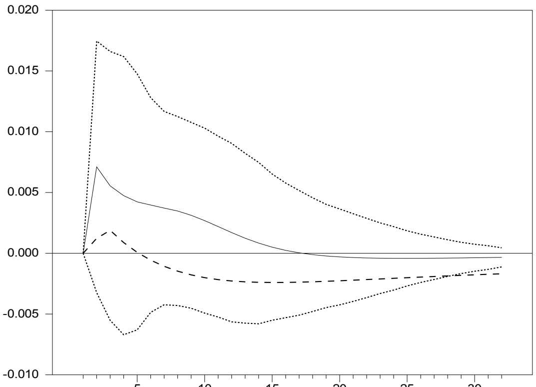
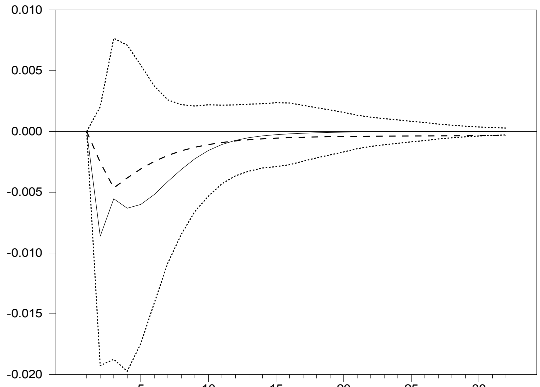


Figure 2.10 (continued)

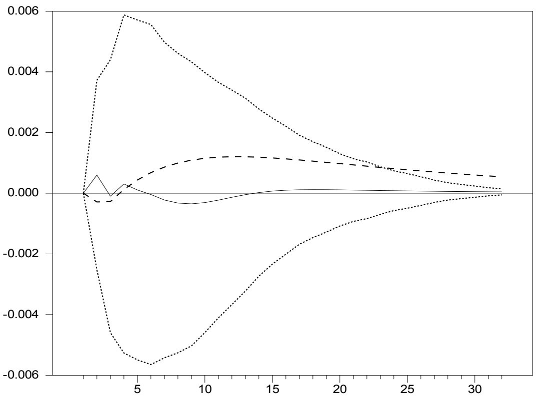
(c) Response of investment to ε_t^{rus}



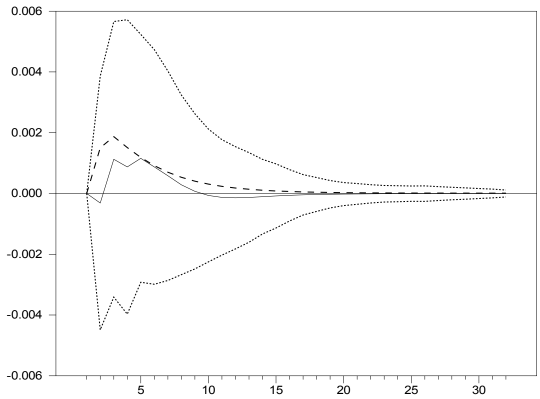
(d) Response of investment to ε_t^{rc}



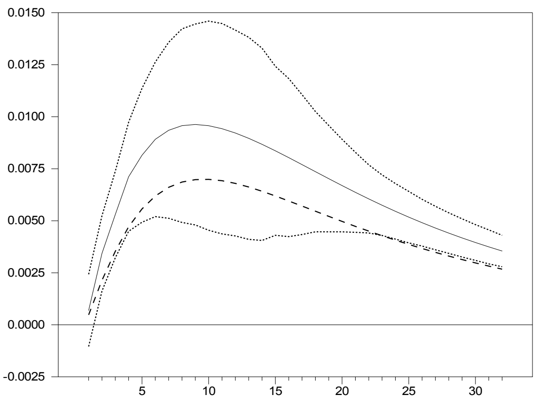
(e) Response of net exports to ε_t^{rus}



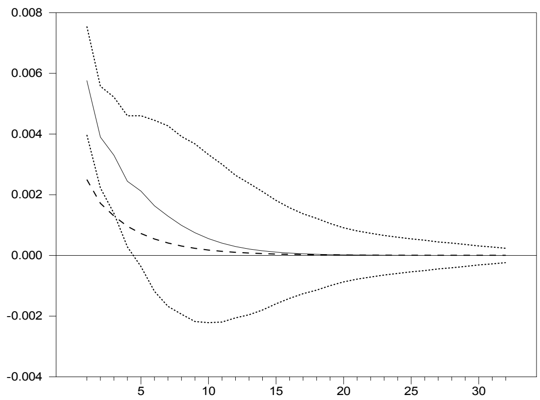
(f) Response of net exports to ε_t^{rc}



(g) Response of country spread to ε_t^{rus}



(h) Response of country spread to ε_t^{rc}

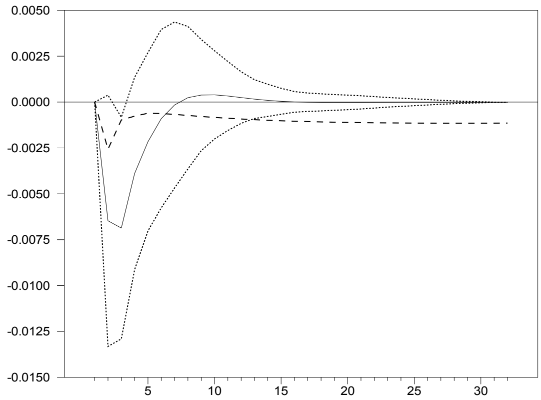


Note: – – – – Theoretical impulse responses
—— Estimated impulse responses
- - - - - - Upper and lower two standard error bands around estimated impulse responses

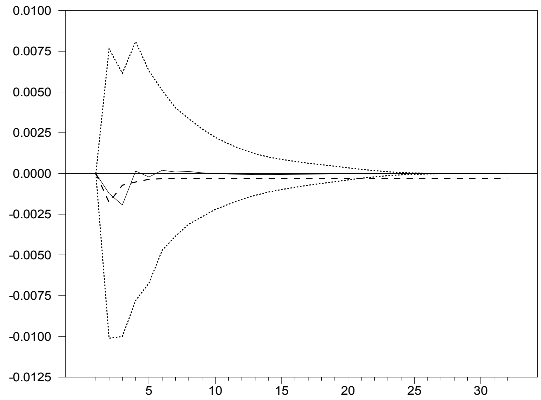
Figure 2.11: Theoretical and Estimated Impulse Response Functions

(Japanese Interest Rate Shock and Country Spread Shock)

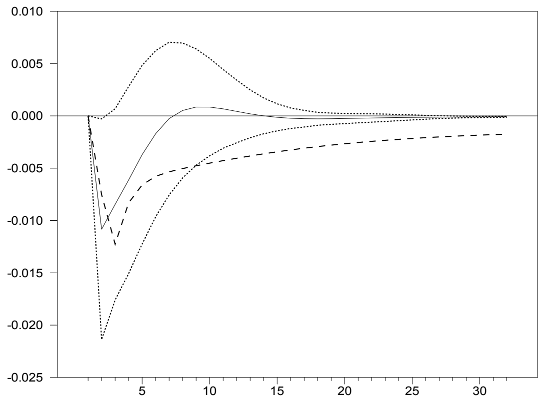
(a) Response of output to ε_t^{rj}



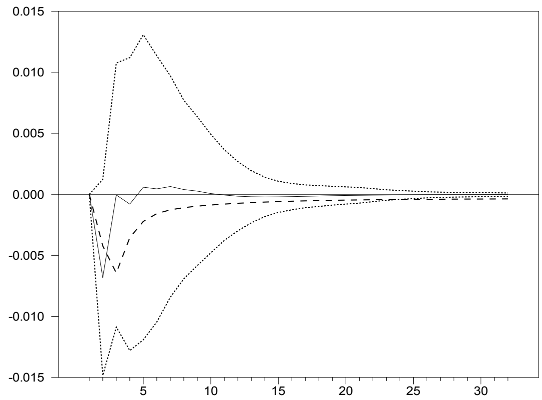
(b) Response of output to ε_t^{rc}



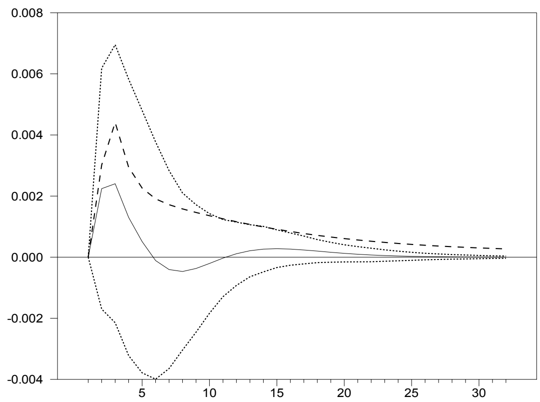
(c) Response of investment to ε_t^{rj}



(d) Response of investment to ε_t^{rc}



(e) Response of net exports to ε_t^{rj}



(f) Response of net exports to ε_t^{rc}

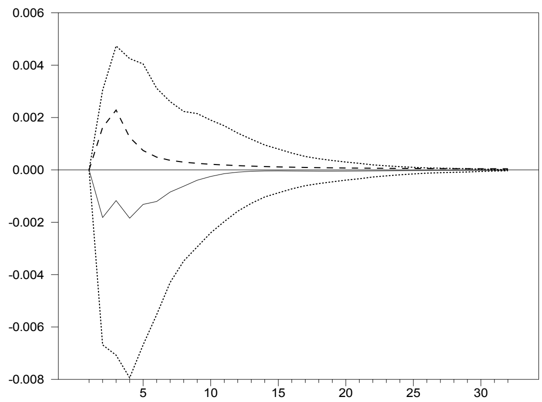
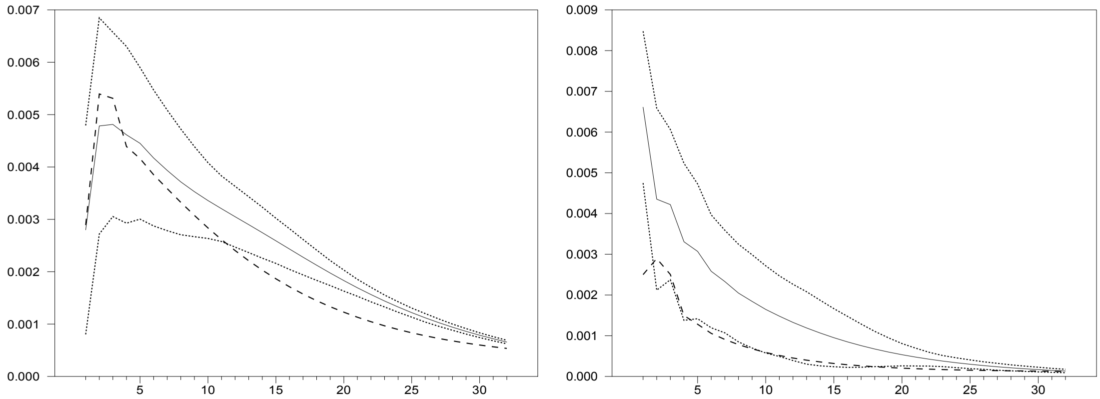


Figure 2.11 (continued)

(g) Response of country spread to ε_t^{rj} (h) Response of country spread to ε_t^{rc}



Note: – – – – Theoretical impulse responses
——— Estimated impulse responses
- - - - - - Upper and lower two standard error bands around estimated impulse responses

financial shocks show different responses, increasing country spread shocks in both cases lead to the same contractive responses. Second, the net exports-to-output ratio improves in response to increasing shocks of the U.S. interest rate and Japanese interest rate, which are the same results of both the theoretical model and empirical model. On the other hand, two impulse responses of the net exports-to-output ratio to increasing country spread shock in the case of using the Japanese interest rate move in the opposite direction. Third, the country interest rate displays a hump-shaped response to increasing U.S. and Japanese interest rate shocks and monotonically decreasing response to country spread shock in both the empirical and theoretical models.

2.6 Conclusion

Macroeconomic fundamentals are the basic indicators that can represent the macroeconomic conditions in a country. At the same time, circulating market for bond provides the objective index that can represent the conditions of underlying asset. In this chapter, GDP, investment and the net exports-to-GDP ratio are used as macroeconomic fundamental variables, and a credit spread as a bond market indicator is used to estimate the country spread effect. In addition, the U.S. and Japanese interest rates are used to specify world and regional interest rate effects on the Korean economy.

To examine the dynamic interactions among variables, the SVAR (2) model is employed. Summarized results of impulse responses to country spread, world and regional interest rates and output are as follows. First, when the country spread rises, these shocks have negative effects on the movement of output and investment. In contrast, responses of the net exports-to-GDP ratio to increasing country spread shock are positive except for the response of the net exports-to-GDP ratio to increasing country spread shock using the Japanese interest rate case. Second, a positive U.S. interest rate shock causes Korean macroeconomic variables to increase temporarily, whereas a positive Japanese interest rate shock causes Korean macroeconomic variables, except for the net exports-to-GDP ratio, to decrease. Third, the impulse response of country spread to increasing output shock shows immediate negative response and converges to the steady-state level.

Synthetically, country spread and the business cycle in Korea have a countercyclical relationship. An increase in the U.S. interest rate affects positively Korean macroeconomic fluctuations, whereas increasing Japanese interest rate shock affects negatively aggregate economic activity in Korea. These different responses are due to the distinctive characteristics of the Korean economy that Korea is a small developed economy, but it still has developing economy features.

The variance decompositions show that domestic variables are responsible for about 13 and 18% of the variance of country spread at business cycle frequency in the case with the U.S. and the case with Japan, respectively. This means that most innovations in country spread are explained by the sum of their own innovations and innovations in the U.S or Japanese interest rate. Another result from variance decomposition is that about 10% of the movements of Korean business cycle frequency can be explained by the sum of disturbances of the U.S. interest rate and country spread, whereas about 5% of output can be explained by the sum of disturbances of the Japanese interest rate and country spread.

A DSGE model for a small open economy of Uribe and Yue (2006) is employed as a theoretical model to test how closely the model solution approximates the estimated results from time series data. The theoretical model is capable of capturing the observed macroeconomic dynamics induced by the U.S. and Japanese interest rate shocks and country spread shock relatively well since almost every part of each theoretical impulse response lies inside the estimated two standard error bands.

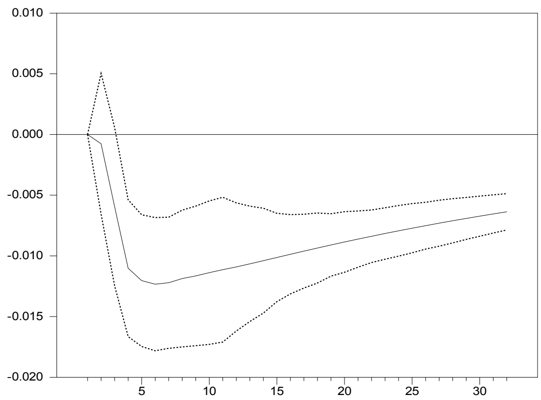
In this chapter, the fluctuations in country spread and world and regional interest rates are investigated as important indicators to explain the business cycle of small open economies such as Korea. In conclusion, the chapter finds evidence that country spread drives macroeconomic fluctuations in Korea and vice versa to a certain degree. Another meaningful finding is that the U.S. and Japanese interest rates also affect macroeconomic fluctuations in Korea, although the effects are not larger than expected.

Appendix 2A Impulse Response Functions for the Period of Post-Asian Financial Crisis in the Case of Using the U.S. Interest Rate

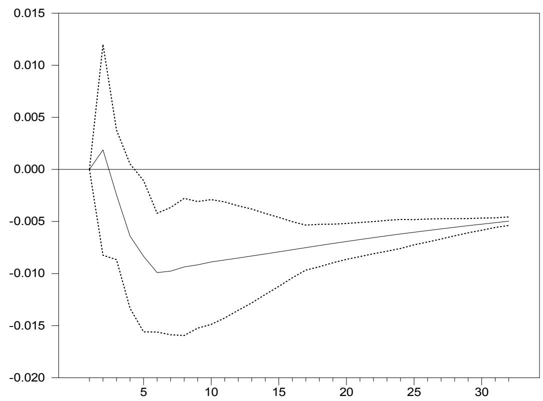
Quarterly data from 1994Q1 to 2008Q4 are used to estimate the empirical model in the main body. However, this data period includes the period of the Asian financial crisis in 1997. Thus, there is a possibility that this structural break may cause distortion of the statistics. Estimation for the period of 1999Q2 to 2008Q4 is performed in this Appendix 2A by following the same estimation process using the same empirical model. Kim and Tsurumi (2000) investigate the beginning and ending period of the Asian financial crisis in Korea using the multivariate generalized autoregressive conditional heteroskedasticity (GARCH) model. They find that the structure of Korean currency movement began to change in early August 1997, and many statistical significant breaks were observed prior to November 1997. The ending period of the structural break due to the Asian financial crisis was in April 1998 on the basis of their examination, since volatilities of country spread and other variables became lower than the previous period after this time. Hence, the second quarter of 1999 is set as a beginning period of the post-Asian financial crisis in this test. The impulse response functions of using the U.S. interest rate case are reported in Figures 2A.1, 2A.2 and 2A.3 for the country spread shock, U.S. interest rate shock, and output shock, respectively. Overall, the features are in accordance with the important characteristics of impulse responses presented in the main body, although there are only differences in the sizes of responses, required time to converge to steady-state level and the more uneven shape of the graph.

Figure 2A.1: Impulse Responses to Country Spread Shock

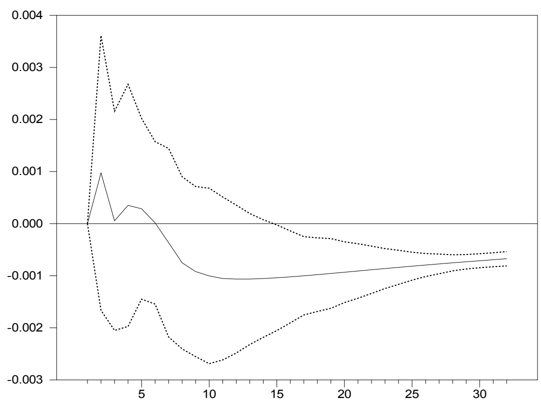
(a) Output



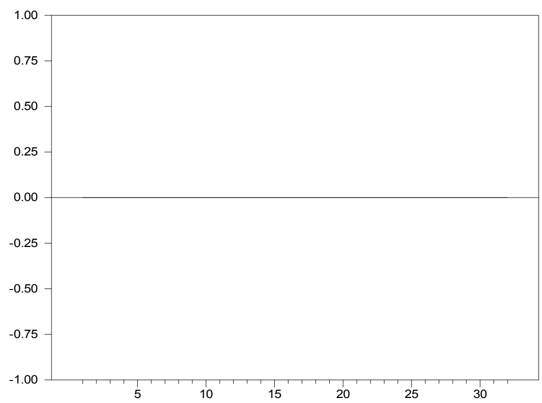
(b) Investment



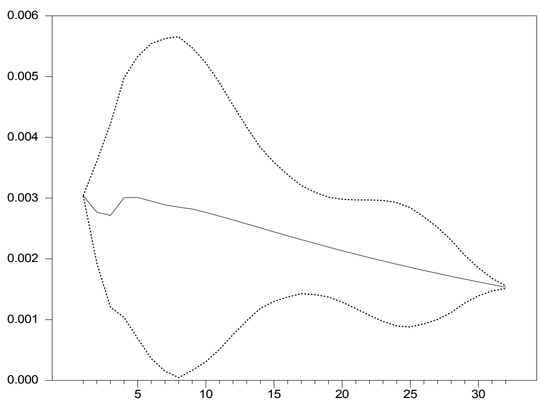
(c) Net exports-to-output ratio



(d) U.S. interest rate

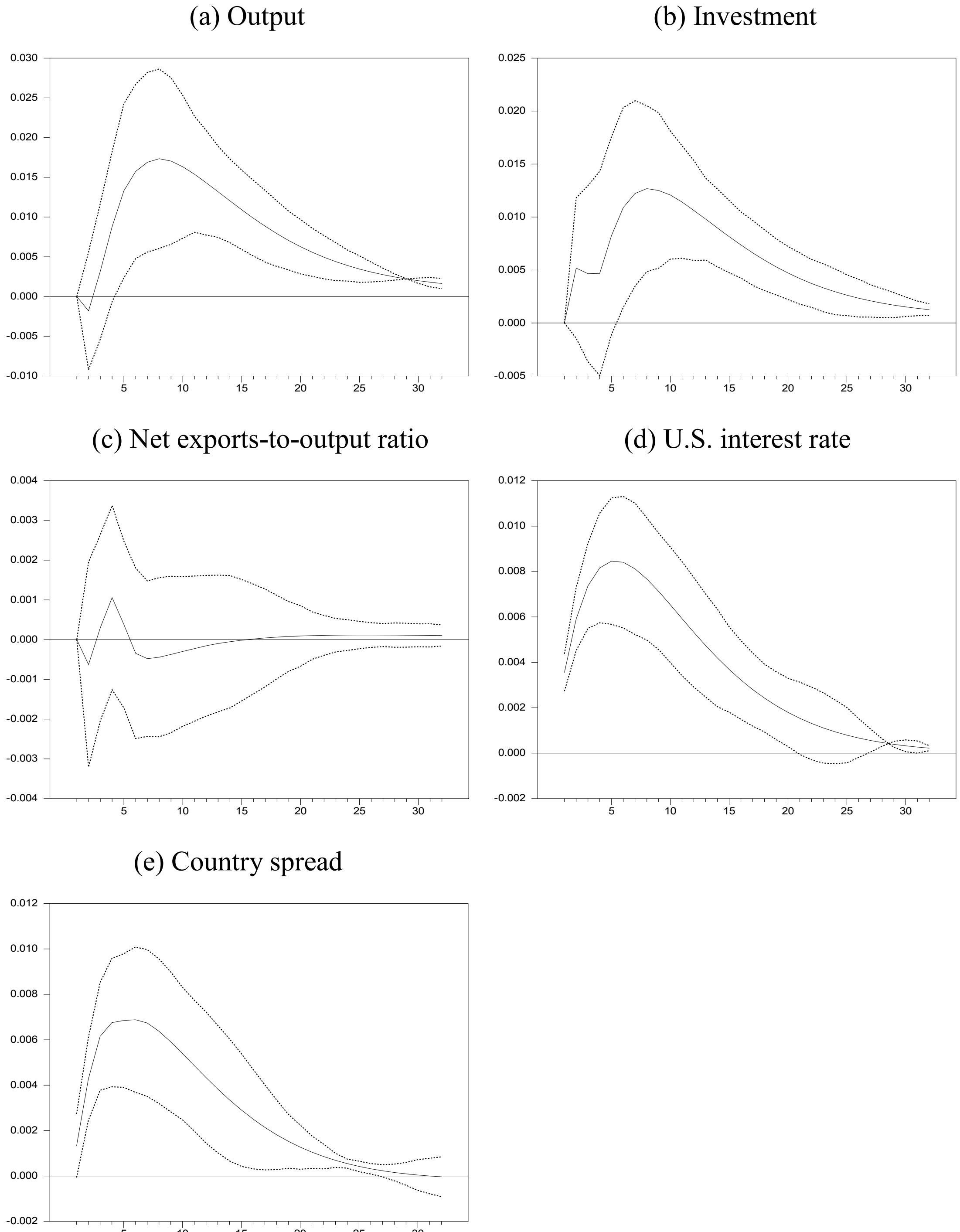


(e) Country spread



Note: Solid lines depict point estimates of impulse responses of one standard deviation country spread shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

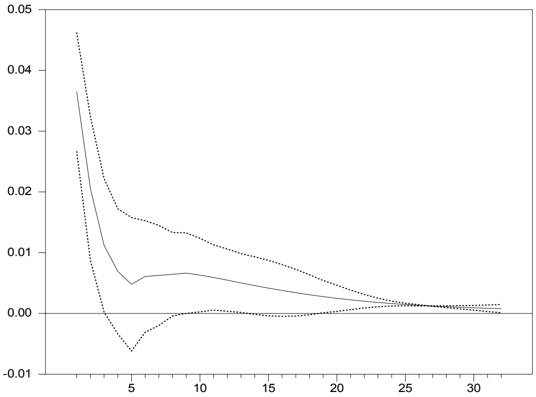
Figure 2A.2: Impulse Responses to U.S. Interest Rate Shock



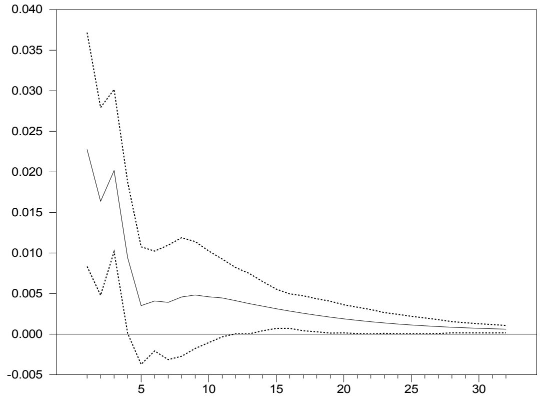
Note: Solid lines depict point estimates of impulse responses of one standard deviation U.S. interest rate shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

Figure 2A.3: Impulse Responses to Output Shock

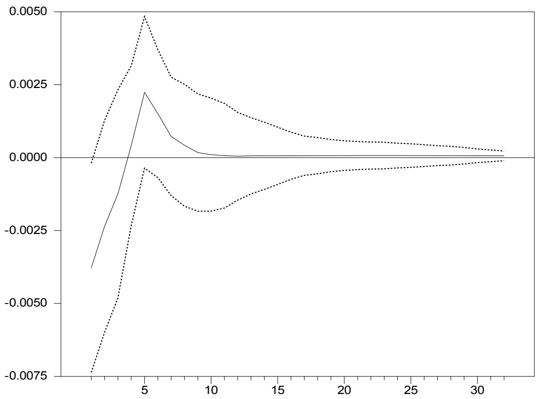
(a) Output



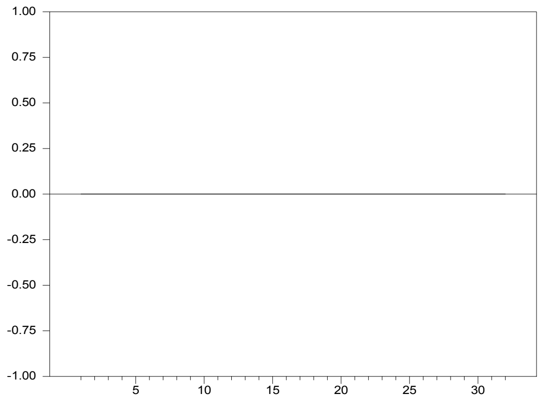
(b) Investment



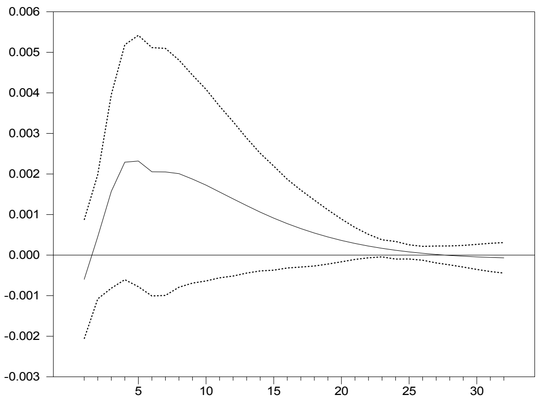
(c) Net exports-to-output ratio



(d) U.S. interest rate



(e) Country spread



Note: Solid lines depict point estimates of impulse responses of one standard deviation output shock. Broken lines depict upper and lower two standard error bands computed using bootstrapping.

Chapter 3 Study on Return and Volatility Spillover Effects among Stock, CDS, and Foreign Exchange Markets in Korea

3.1 Introduction

A number of studies have examined the effect of macroeconomic variables on financial asset returns. Since the work of Ross (1976), various macroeconomic variables such as GDP, inflation, and the trade balance as well as financial market variables such as interest rates and exchange rates have been tested to identify the influential factors for the expected return of a financial asset. However, few studies have been conducted about the relationships between macroeconomic volatility and asset market volatility. Schwert (1989) states that volatility in macroeconomic fundamentals and financial market factors are helpful in predicting stock return volatility, and vice versa.

The key objective of this chapter is to investigate the return and volatility spillover effects between domestic and international financial and asset markets focused on the Korean economy. In particular, the presence of return and volatility spillover effects from country risk and advanced economy asset markets to Korean asset markets is the primary interest in this chapter. Before approaching the main subject, it is necessary to specify the concept of country risk and advanced economy asset market.

It is known that some indicators represent the credit risk of a country, which evaluates the country's economic condition synthetically. Typically, JP Morgan's emerging market bond indices such as the EMBI+ and EMBI global, several bond indices announced by the Asian Development Bank (ADB), the foreign exchange stabilization bond spread underlying government bonds, and credit default swap (CDS) spreads underlying government bonds are widely used indicators to assess a country's credit risk as a proxy of the economic condition of a country. Among these indices, the CDS spread underlying government bonds is used as a measure of country risk in this chapter.

A credit default swap (CDS) is a swap contract between two parties, a protection buyer, and a protection seller. A protection buyer who wants to transfer the credit risk pays a premium (spread) to the protection seller in exchange for a payment if a credit event occurs with a reference entity.[26] As a bond holder buys a CDS to hedge the default risk, the characteristics of a CDS are similar to that of credit insurance. Another characteristic of a CDS is that it is a financial good which can be bought and sold by investors. Although the CDS market is unfamiliar among individual investors, CDS are widely traded to cover the default risk of financial transactions in the international financial market. The CDS premium, which a protection seller pays to a protection buyer as transfer cost of credit risk on the contract, generally rises when credit risk of the underlying asset increases. That is, the higher the default probability of underlying asset, the more payment is needed to cover the risk. Hence, the CDS premium is interpreted as a measure of credit rating of the authorities or the institutions which issue the underlying asset. For this reason, the CDS premium which is on the basis of bond in foreign money issued by the each country's government is used well as an indicator which reflects the country's credit rating.

[26] The CDS premium is often referred to as the CDS spread. I also use CDS premium and CDS spread interchangeably in this chapter.

Previous research related to the CDS market has made little progress, because the history of the credit derivatives market is not long enough, and there is limited data collection for empirical test due to the characteristic of over-the-counter transactions. Thus, the mainstream focus of research about country credit risk was not based on the CDS spread underlying government bonds but on the government bond spread, on the underlying asset itself. However, recently, by virtue of accumulated time series data and quantitative development in the CDS market, further research on the stock market is being carried out to obtain meaningful information (Cossin and Hricko, 2001; Kim, 2009; Elmahadaoui and Dugas, 2009; Baum and Wan, 2010; Longstaff *et al*., 2011).[27]

Figure 3.1 shows the time series of the CDS spread underlying Korean government bonds and the Korean stock market index (KOSPI) from the first week of January 2002 to the fourth week of February 2010.

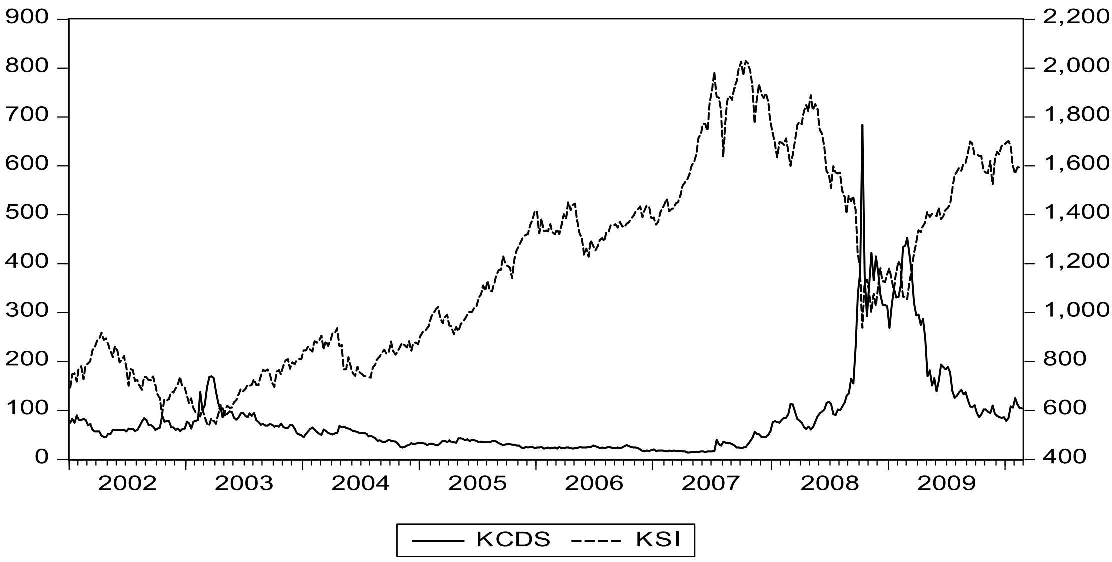
With the exception of the moment that CDS spread rose rapidly due to the SK accounting fraud and the credit card debacle in March 2003, the CDS spread maintained its downward stability for several years due to some favourable factors such as reduced risk of North Korea's nuclear problem and the prospect of upgrading Korea's sovereign credit rating since 2004. However, the CDS spread was affected by the sub-prime mortgage crisis in the U.S. in July 2007, and since then the trend had been changed to upward. In particular, the highest point of the CDS spread was recorded at the time of the Lehman Brothers' collapse in September 2008, and

---

[27] Since JP Morgan's first transaction of CDS in 1995, the Asian financial crisis provided momentum to develop the CDS market by increasing demand to hedge credit risk. According to the market survey of the International Swap and Derivatives Association (ISDA), the CDS contract balance at the end of 2001 was \$0.9 trillion, but the market increased tremendously by the end of 2007; the outstanding amount was \$62.2 trillion, falling to \$30.4 trillion of outstanding CDS trades by the end of 2009 due to the effect of the global financial crisis (www2.isda.org).

thereafter, it showed a sharp decline due to the currency swap contract between the U.S. and Korea in November 2008. Following that time, the CDS spread has fluctuated according to the changes in international and domestic financial markets as well as domestic economic conditions. Although the CDS spread has been stabilizing by degrees, it has still remained at a high level since the beginning of the global financial crisis in 2008. In this way, increase in the CDS spread underlying government bonds implies increasing sovereign risk and, in contrast, decrease in the CDS spread means decreasing sovereign risk.

Figure 3.1: CDS Spread Underlying Korean Government Bonds and Korean Stock Market Index (KOSPI)



Note: Solid line of KCDS denotes the CDS spread underlying Korean government bonds. Dotted line of KSI denotes the Korean stock market index (KOSPI). Numerical values on the left side are KCDS, and numerical values on the right side are KSI. The data period is from Jan. 2002 W1 to Feb. 2010 W4. The data source is the Korea Centre for International Finance (KCIF).

For the Korean stock market index, Korea composite stock price index (KOSPI) is used to represent the asset market condition as well as the general Korean economic condition. The time path of Korean stock market index illustrated in Figure 3.1 shows negative process compared to the time path of CDS spread. This implies that the Korean stock market booms during economically stable periods of low country risk. Figure 3.1 displays the gradual increase in the Korean stock market index to more than double when the CDS spread was low during the stable period from 2004 to 2007. However, the Korean stock market index dropped immediately when the CDS spread soared in 2008. Hence, it is expected that there might be a negative relationship between Korean stock price and country risk.

Another interesting issue, which is one of the main objectives for this chapter, is the

Figure 3.2: U.S. Stock Market Index (S&P 500) and Japanese Stock Market Index (NIKKEI 225)

Note: Solid line of USI denotes the U.S. stock market index (S&P 500). Dotted line of JSI denotes the Japanese stock market index (NIKKEI 225). Numerical values on the left side are USI, and numerical values on the right side are JSI. The data period is from Jan. 2002 W1 to Feb. 2010 W4. The data source is the Korea Centre for International Finance (KCIF).

identification of the contagion from the advanced asset market to the Korean asset market. Many international investors have taken interest in the Korean stock market for diversification to explore higher returns due to its rapid economic growth and its increased link with international capital markets over the past decades. Figure 3.2 shows the time series of stock market indices for the U.S. and Japan.

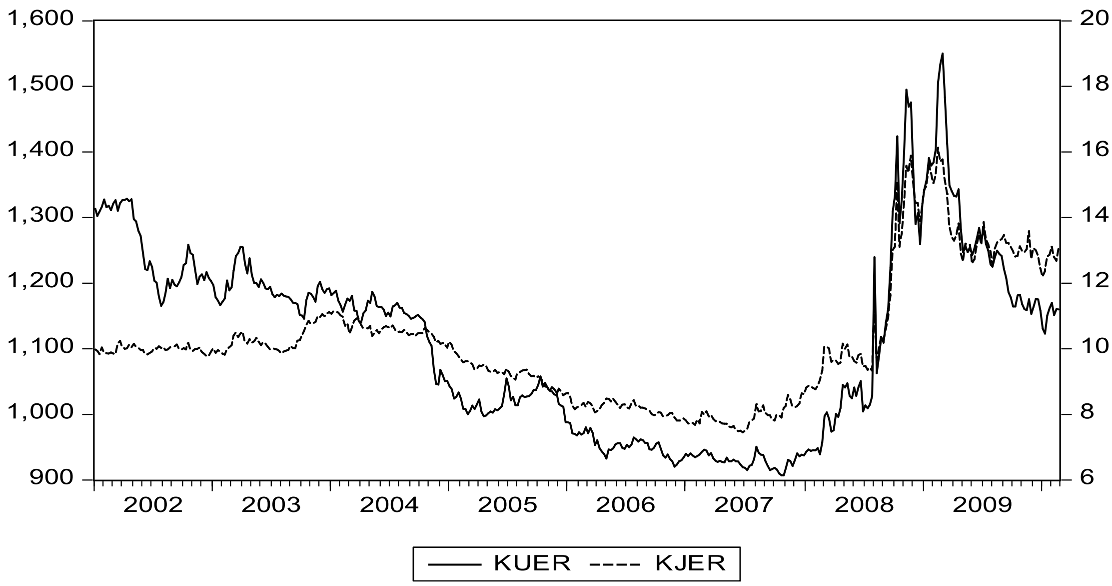
The stock market is employed in this chapter as a representative asset market for three countries: Korea, the U.S., and Japan. The U.S. stock price is adopted as a global stock price, and the Japanese stock price is adopted as a regional stock price. The time paths of these two indices look very similar to that of the Korean stock market index in Figure 3.1. From these figures, it is also expected that the Korean stock market has a close relationship with the U.S. and Japanese stock market.[28]

Along with the CDS spread, fluctuations in the exchange rate also reflect variation of domestic country risk since the exchange rate generally shows a sensitive response to the credit status of the country. In addition, the foreign exchange market delivers international risk to the domestic economy, serving the role of a bridge. The foreign exchange market plays a role in establishing the first contact from the variation in international financial markets through the exchange rate, and it spreads the effect to the domestic economy. For instance, due to the sharp rise of the credit risk in Korea at the time of the Asian financial crisis in 1997, the Korean won depreciated more than double in an instant. This is a good example of the exchange rate as a typical macroeconomic indicator which is closely associated with the sovereign credit rating.

[28] Chung (2002) finds that the influence of the U.S. stock price on the Korean stock price has grown more since the Asian financial crisis in 1997, and the Japanese stock price also has been closely connected with the Korean stock price.

The time series of the Korea won/U.S. dollar exchange rate and Korea won/Japanese yen exchange rate are illustrated in Figure 3.3 from the first week of January 2002 to the fourth week of February 2010.

Figure 3.3: Won/Dollar Exchange Rate and Won/Yen Exchange Rate



Note: Solid line of KUER denotes the won/dollar exchange rate. Dotted line of KJER denotes the won/yen exchange rate. Numerical values on the left side are KUER, and numerical values on the right side are KJER. The data period is from Jan. 2002 W1 to Feb. 2010 W4. The data source is the Bank of Korea.

The two time series of exchange rates show similar fluctuations through the time path, and their fluctuations are also similar to the CDS spread variation in Figure 3.1. Hence, it is expected that there is a positive relationship between the CDS spread underlying Korean government bonds and exchange rates. Two financial market indicators show the same increasing responses to the historical unfavourable economic shocks. In addition, time paths of two exchange rates show a negative process in comparison to the time path of the Korean stock market index illustrated in Figure 3.1. Thus, it is expected that exchange rates might have a negative relationship with the Korean stock price.

This chapter examines the contagions among three financial markets by estimating the within-country and cross-country return and volatility spillover effects from market to market. To specify the relationships, the following four questions are suggested. First, are there return and volatility spillover effects among foreign exchange markets, the Korean CDS market, and the Korean stock market? Second, are there return and volatility spillover effects from U.S. and Japanese stock markets to the Korean stock market and Korean CDS market? Third, how do the Korean CDS spread change, exchange rate change, and Korean stock return respond to each increasing return (change) shock? Fourth, how do the Korean stock return and Korean CDS spread change respond to increasing shocks in U.S. and Japanese stock returns? To answer these questions, weekly data of CDS spread, foreign exchange rates, and stock prices for three countries are used over the period of 2002 to 2010 using a multivariate GARCH model.

The main results for these questions can be briefly summarized as follows. First, there are significant return spillover effects from the two foreign exchange markets to the Korean CDS market and Korean stock market and unidirectional volatility spillover effects from foreign exchange markets to the Korean CDS market. Second, return spillover effects from the U.S. stock market to the Korean CDS market and the Korean stock market are significant, whereas volatility spillover effects from the Japanese stock market to the Korean CDS market and the Korean stock market are significant. In most cases, there are bidirectional return and volatility spillover effects between the Korean CDS market and Korean stock market. Third, increase in exchange rate changes leads to increase in Korean CDS spread change and decrease in Korean stock return. Fourth, increase in U.S. and Japanese stock returns lead to decrease in Korean CDS spread change and increase in Korean stock return.

The rest of this chapter is organized as follows. Section 3.2 provides an overview of the related theoretical and empirical literature. Section 3.3 presents descriptive statistics and results of the tests on data. Section 3.4 lays out the econometric methodology. The main results are presented in section 3.5, and section 3.6 summarizes the main findings and offers some concluding remarks.

3.2 Literature Review

The CDS spread underlying government bonds is an efficient indicator as a dynamic market-based measure of sovereign risk. Thus, when external or internal economic and financial shocks affect the country's economy, the CDS market reacts sensitively and shows the current state through its index, called the CDS spread. Remolona *et al*. (2008) find that the macroeconomic fundamental variables of a country, such as inflation and foreign exchange reserves, affect the credit event itself, and the sovereign risk premium (CDS spread) is more highly correlated than sovereign risk (credit risk) itself in emerging markets. Longstaff *et al*. (2011) assert that the external components such as the U.S. stock and high-yield bond markets, global risk premium, and international trading and liquidity patterns together with domestic macroeconomic conditions are well explainable factors to illustrate the variation of the CDS premium. Baum and Wan (2010) empirically investigate the impact of macroeconomic uncertainty on the CDS spread. They find that the second moments of macroeconomic factors (macroeconomic uncertainty) such as GDP, index of industrial production, and stock index have excellent explanatory power over and above that of traditional macroeconomic factors such as the risk-free rate and the Treasury term spread.

There have been few studies on the relationship between the CDS market and stock market. Only a few earlier studies related to the CDS market demonstrate the close relationship with the stock market by showing that the stock price is significant as a principal determinant of the CDS premium. Cossin and Hricko (2001) find that the CDS premium is determined by credit rating, yield curve, stock price, and debt ratio, which are similar to the determinants of the credit spread in the bond market. Elmahadaoui and Dugas (2009) study the significance of the correlation between variations in CDS spread and the underlying stock. They argue that variations in the CDS spread can be used efficiently as a signal to trade the underlying stock.

Compared with the substantial amount of empirical and theoretical studies on the foreign CDS market since 2000, most studies related to credit risk in Korea have focused on the credit premium in the bond market because of immature market conditions and deficiency of data for the Korean CDS market. Recently, several pioneering works for the Korean CDS spread are in progress. Nam and Byun (2006) conduct empirical analysis to find deterministic elements of the Korean CDS spread. They find that variations of the Korean CDS spread is affected by the variations of past value of CDS spread itself, domestic macroeconomic fundamentals, and financial variables such as yields on government bonds, stock prices, and the won/dollar exchange rate. They also find that the CDS market is more efficient in reflecting the change of credit status in the underlying asset to the change of credit risk spread than is the bond market. Considering the determinants of the CDS premium underlying Korean government bonds, Kim (2009) finds that increase in stigma effect and capital mobility causes the CDS premium to rise. Another of his findings is that the CDS premium of the country which experienced financial crisis in the past like Korea increases more than that of the country which did not experience financial crisis when the short-term debt ratio and exchange rate rise. In addition, typically well-known determinants of the CDS premium such as the short-term foreign debt ratio, exchange rate, and stock prices are ascertained to be also statistically significant in the Korean CDS market. That is, he finds that the CDS premium decreases when stock prices increase and the exchange rate decreases.

Early studies on the relationship between CDS spread and other macroeconomic or financial market variables usually focus on the link between the levels of the series without considering the link between the returns or volatilities of the series. However, examining the relationship between returns or volatilities of the series, not levels of series, reflects the current trend of studies on the analysis for the relationship between financial markets. In a study on the relationship between CDS spread change and stock return, Norden and Weber (2004) analyse the relationship among CDS, bond and stock markets empirically. They find that stock returns affect CDS and bond spread changes, and the CDS market is significantly more sensitive to the stock market than the bond market is.

It has become clear that globalization of financial markets requires advanced econometric models capturing the correlation between the financial markets in the aspect of return and volatility. Hamilton (2008) argues that correctly modelling the conditional variance is important in order to capture the characteristics of time series, although macroeconomists' interest is in the conditional mean. Following the initial GARCH model of Bollerslev (1986), various extensions from the original model have been proposed under different motivations and assumptions to overcome some limits. The multivariate GARCH (MGARCH) model, which is used in this chapter as a methodology, has been commonly used to estimate the relationships between the volatilities of several financial markets since the studies by Bollerslev *et al*. (1988) and Engle and Kroner (1995). The latest trend of research using the MGARCH model focuses on the persistence and transmission of volatility from one market to other markets, and now it is widely accepted that financial volatilities move together over time and across assets and markets (Bauwens *et al*., 2006).

Recent study using the MGARCH model to examine the volatility spillover effect between CDS market and other financial markets is performed by Meng *et al*. (2009). They investigate the volatility transmission among CDS, equity, and bond markets, and they find that volatility in any of the three markets is commonly transmitted to the other two markets. In a recent study on volatility spillover effects for Korean financial markets, Kim (2007) investigates the return and volatility spillover effects among stock, bond, and foreign exchange markets using the MGARCH model. He finds that the volatility spillover effect from the stock market to the foreign exchange market is statistically significant.

3.3 Descriptions of Data and Statistical Characteristics

Weekly data for Korean, U.S., and Japanese stock returns, Korean CDS spread change, and Korean-U.S. and Korean-Japanese exchange rate changes are used to compose financial and asset market variables for the MGARCH model. KOSPI, S&P 500, and NIKKEI 225 are used for Korean, U.S. and Japanese stock market indices, respectively, which are obtained from the Korea Centre for International Finance (KCIF). The CDS spread underlying the five-year maturity Korean government bond is used, because the five-year is not only the most common liquid maturity in the swap market but it is also widely announced to the public. The Korean CDS spread data are obtained from the KCIF. The data source of the two exchange rates is the Bank of Korea. The data period starts from the first week of January 2002 and ends at the fourth week of February 2010. All weekly data are composed on the basis of Friday's observation. When there is no observation on Friday due to reasons such as public holiday, observation of the day before (Thursday) is used as a replacement.

Weekly data provide a number of advantages compared to the use of daily data in a multinational analysis. First, the use of weekly data can help avoid the interference due to the different trading days and public holidays between countries. Second, the use of weekly data can help avoid the time zones associated with different opening and closing times (Karunanayake *et al*., 2009). Third, the use of weekly data in this study is justified, since high frequency data (e.g., daily or intradaily) may contain too much noise, while low frequency data (e.g., monthly or quarterly) may present the possibility of not capturing the information about changes in financial variables. Thus, weekly data can provide a balance between information and noise (So, 2001).

The first difference of the log of stock prices, exchange rates, and CDS spread are used for computing stock returns and changes in exchanges rates and CDS spread. Let p_t be the price of each market at time *t*. The returns and changes in financial markets at time *t* (y_t) can be calculated as follows:

$$y_t = \ln(\frac{p_t}{p_{t-1}}) \tag{3.1}$$

When using the first difference variables, some information regarding a possible linear combination between the levels of the variables may be lost. However, relationships between financial markets are analysed using the first difference of the log of returns and changes instead of using the original level series of financial data in this chapter. We concentrate on returns because financial time series usually do not satisfy the basic assumption of the stationary process required to avoid spurious inferences based on regression analysis. Thus, before performing the main analysis, it is necessary to test the unit roots for each return and change as well as level of each financial variable.

3.3.1 Unit Root and Autocorrelation Tests

To check whether the return series of data is stationary, two standard unit-root tests − the augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test − are performed.

The following three models are used for ADF test.

Model I : $\Delta Y_t = \hat{\gamma}\hat{Y}_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \varepsilon_t$

Model II : $\Delta Y_t = \alpha + \tilde{\gamma}\tilde{Y}_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \varepsilon_t$

Model III : $\Delta Y_t = \alpha + \beta T + \bar{\gamma} \bar{Y}_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \varepsilon_t$

The null hypothesis is $H_0 : \gamma(\hat{\gamma}, \tilde{\gamma}, \bar{\gamma}) = 0$, which implies that there is a unit root in data.

On the other comparable method to test unit-root, PP test is conducted. The corresponding Phillips-Perron statistics are as follows.

Model I : $Z(t_{\hat{\gamma}})$ for $H_0 : \hat{\gamma} = 1$

Model II : $Z(t_{\tilde{\gamma}})$ for $H_0 : \tilde{\gamma} = 1$

Model III : $Z(t_{\bar{\gamma}})$ for $H_0 : \bar{\gamma} = 1$

Null hypotheses of this test are examined with *Z* statistics calculated using basic models. The results of ADF test and the PP test are reported in Table 3.1.

Table 3.1 shows that there is no unit root in the returns and changes at the 5% level of critical value without exception, although every level variable has unit root. Thus, it is indisputable that returns and changes in all financial and asset markets used in this chapter are of stationary process.

The Ljung-Box *Q*-test is commonly used to test the quality of the fit of a time series. If significant autocorrelation is not found in the residuals from the series, then the series is declared to pass the test. The Ljung-Box *Q*-statistics are used to test for independence of higher relationships as manifested in volatility clustering by the MGARCH model (Huang and Yang, 2000, pp. 329). The Ljung-Box *Q*-statistics and their *p* values by 20 lags and leads are reported in Table 3.2. The null hypothesis is that several autocorrelation coefficients are 0 at the same time.

Table 3.1: ADF Test and PP Test

Prices and Rates	Model I		Model II		Model III	
	ADF	PP	ADF	PP	ADF	PP
Korean CDS Spread	-2.61* (-20.63)	-2.68* (-20.63)	-2.87* (-20.63)	-2.96* (-20.62)	-1.87* (-20.65)	-1.73* (-20.65)
Korean-U.S. Exchange Rate	-2.00* (-22.65)	-1.91* (-22.64)	-1.88* (-22.68)	-1.73* (-22.75)	-0.56* (-22.67)	-0.59* (-22.66)
U.S. Stock	-1.45* (-20.23)	-1.47* (-20.23)	-1.46* (-20.21)	-1.48* (-20.21)	-0.32* (-20.26)	-0.32* (-20.26)
Korean-Japanese Exchange Rate	-0.88* (-24.74)	-1.01* (-24.62)	-1.24* (-24.77)	-1.37* (-24.62)	0.44* (-24.75)	0.36* (-24.62)
Japanese Stock	-1.27* (-21.45)	-1.30* (-21.45)	-1.11* (-21.45)	-1.14* (-21.45)	-0.35* (-21.48)	-0.36* (-21.48)
Korean Stock	-1.20* (-22.59)	-1.19* (-22.59)	-1.90* (-22.56)	-1.91* (-22.57)	0.59* (-22.55)	0.62* (-22.55)

Note: Model I represents the case of no constant and trend. The case with constant is in Model II, and the case with both constant and trend is in Model III. * denotes that there is a unit root in the data under the 5% level of critical value. Parentheses located on the second line denote the statistics of ADF test and PP test for returns and changes corresponding to each level series of variables.

According to the Ljung-Box *Q*-statistics and *P*-values in Table 3.2, there exist autocorrelations in won/dollar exchange rate and won/yen exchange rate changes and U.S. stock return by rejecting the hypothesis. On the other hand, the hypothesis of no autocorrelation up to order 20 is accepted in the CDS spread change and Japanese and

Table 3.2: Ljung-Box *Q*-statistics of returns and changes

Returns and changes	1	2	3	5	10	15	20
Korean CDS Spread	0.001 (0.98)	0.024 (0.99)	1.488 (0.69)	3.635 (0.60)	5.016 (0.89)	15.17 (0.44)	18.86 (0.53)
Korean-U.S. Exchange rate	4.021 (0.04)	5.082 (0.07)	5.448 (0.14)	10.06 (0.07)	17.47 (0.06)	65.86 (0.00)	86.24 (0.00)
U.S. Stock	0.100 (0.75)	1.616 (0.44)	6.212 (0.10)	8.723 (0.12)	21.50 (0.01)	33.10 (0.00)	49.40 (0.00)
Korean-Japanese Exchange rate	14.59 (0.00)	18.95 (0.00)	19.14 (0.00)	19.68 (0.00)	43.91 (0.00)	80.53 (0.00)	92.93 (0.00)
Japanese Stock	0.791 (0.37)	2.074 (0.36)	2.282 (0.51)	2.316 (0.80)	3.091 (0.97)	6.345 (0.97)	11.81 (0.92)
Korean Stock	3.493 (0.06)	3.634 (0.16)	5.301 (0.15)	5.748 (0.33)	14.22 (0.16)	22.77 (0.08)	24.80 (0.20)

Note: The numbers in parentheses denote *P*-value.

Korean stock returns; thus, there are no autocorrelations in these change and returns. The significance of the Ljung-Box *Q*-statistics for the return and change series indicate linear dependencies due to the strong conditional heteroskedasticity (Higgs and Worthington, 2004).

3.3.2 Cross-Correlation Test

The cross-correlation test is used to estimate the degree to which two time series are correlated. This test helps to identify which return (change) is a leading indicator of the other return (change) or how much of one return (change) can be predicted by movement in the other return (change). The cross-correlation test between two financial market returns (changes) involves many calculated coefficients through the time shifts of the one return (change) relative to the other return (change). Thus, the result of typical cross-correlation shows enough lags and leads in both negative and positive directions to denote the cyclical relationship of the two sets of data.

The results from the cross-correlation test for Korean CDS spread change and the Korean stock return series relative to the other financial market variables by 20 lags and leads are reported in Table 3.3.

Table 3.3: Cross-Correlation between Two Financial Markets

(A)	(B)	Shift	0	1	2	5	10	15	20
Korean CDS Spread	Won/ Dollar	Lag	0.374	0.007	-0.019	0.086	-0.087	0.005	0.105
		lead	0.374	0.092	0.042	0.031	0.164	-0.083	0.024
	U.S. Stock	Lag	-0.439	0.023	0.031	0.030	0.069	-0.074	-0.187
		lead	-0.439	-0.106	-0.143	-0.009	0.044	-0.062	-0.053
	Won/ Yen	Lag	0.445	-0.010	-0.000	0.020	-0.064	-0.002	0.071
		lead	0.445	0.045	0.041	0.007	0.147	-0.057	0.034
	Japanese Stock	Lag	-0.489	-0.032	-0.029	0.021	-0.004	-0.014	-0.093
		lead	-0.489	-0.013	-0.099	-0.028	-0.005	-0.052	-0.000
	Korean Stock	Lag	-0.558	0.025	-0.025	-0.015	0.037	-0.012	-0.003
		lead	-0.558	0.035	-0.080	0.023	-0.012	0.018	-0.108
Korean Stock Return	Won/ Dollar	Lag	-0.373	-0.056	-0.024	0.010	-0.208	0.039	-0.056
		lead	-0.373	0.068	-0.028	-0.058	0.123	-0.016	-0.078
	U.S. Stock	Lag	0.537	0.099	0.220	-0.031	-0.030	0.090	0.056
		lead	0.537	-0.114	-0.034	-0.008	-0.043	0.022	0.156
	Won/ Yen	Lag	-0.417	-0.037	-0.058	0.023	-0.146	0.034	-0.096
		lead	-0.417	0.082	-0.036	-0.012	0.084	0.020	-0.061
	Japanese Stock	Lag	0.686	-0.045	0.147	0.007	-0.015	0.045	0.069
		lead	0.686	-0.069	-0.024	-0.015	0.016	0.043	0.076

Note: (A) and (B) are target returns or changes to be tested for cross-correlation.

Positive cross-correlation implies that when one return (change) series in (A) rises, the other return (change) series in (B) can be predicted to rise at a rate of coefficient value. In the same sense, negative cross-correlation means that, when one return (change) series in (A) rises, the other return (change) series in (B) falls. The strength of the relationship between two returns (changes) is perfect when the numerical value is at ±1, and it gradually decreases to the minimum value of 0 as lags and leads increase. The coefficient value at 0 lag and lead is usually used to interpret as an ordinary correlation.[29] The Korean CDS spread change is positively correlated with two exchange rate changes (0.374, 0.445) and negatively correlated with three domestic and foreign stock returns (-0.439, -0.489, -0.558). In particular, the correlation between the Korean CDS spread change and Korean stock return is the highest (-0.558). On the other hand, Korean stock return is negatively correlated with two exchange rate changes (-0.373, -0.417) and positively correlated with the other two foreign stock returns (0.537, 0.686). Additionally, the Korean stock return looks more correlated with two foreign stock returns (0.537, 0.686) than two exchange rate changes (-0.373, -0.417). These results of cross-correlation between domestic and foreign financial market returns and changes are consistent with the observations for each time series presented in Figures 3.1, 3.2, and 3.3, although they are not return or change series but level variables.

3.3.3 Characteristics of Financial Time Series

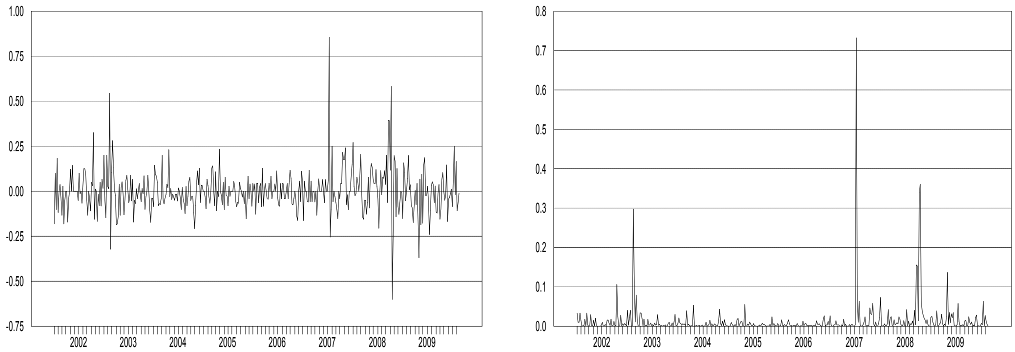
Although volatility is not directly observable, it has some characteristics that become

[29] Although covariance can be used to measure the movement between two variables, it has a problem in terms of which unit is applied to measure the scale of variable. Hence, correlation is generally used to investigate the relationship between two variables, as it is an unrelated indicator with data measurement scale. That is, the problem of unit to measure can be solved in the case of dividing covariance with two standard deviations.

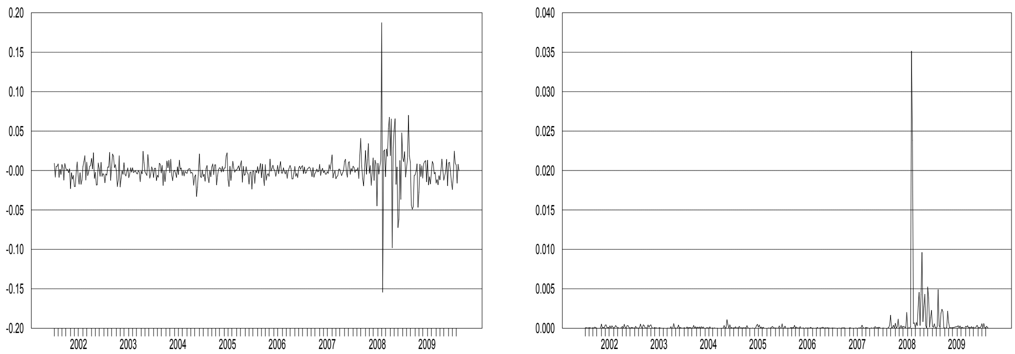
known empirically and are commonly seen in financial market returns (changes) as cases of "stylized fact."[30] First, financial market returns exhibit volatility clustering,

Figure 3.4: Time Plots of Returns (Changes) and Squared Series

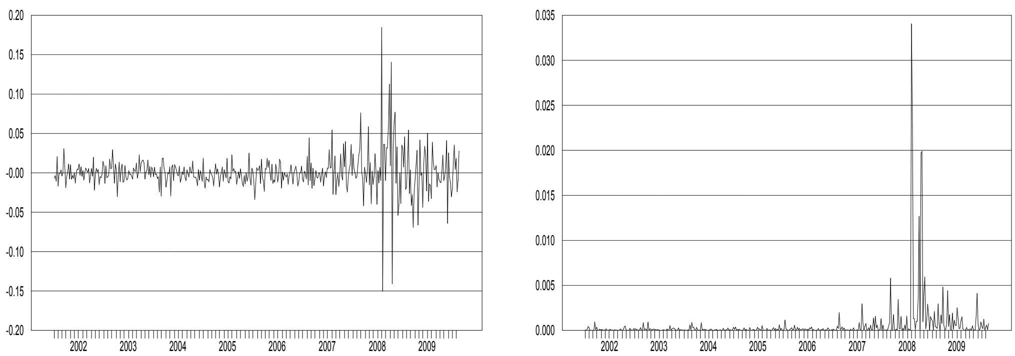
(a) Korean CDS Spread Change



(b) Won/Dollar Exchange Rate Change



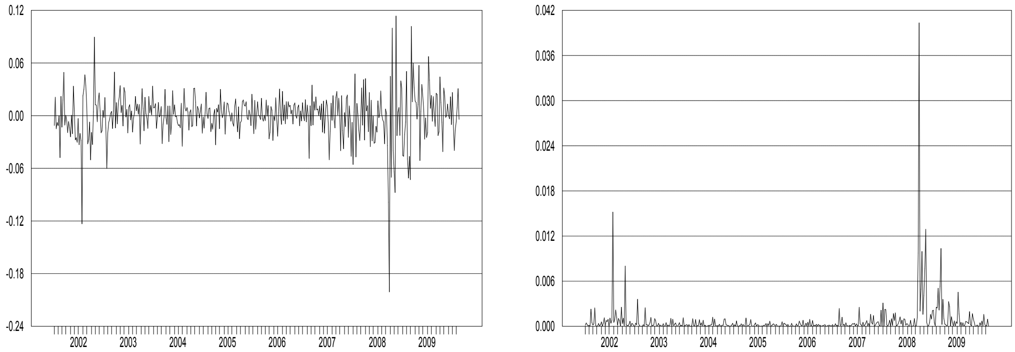
(c) Won/Yen Exchange Rate Change



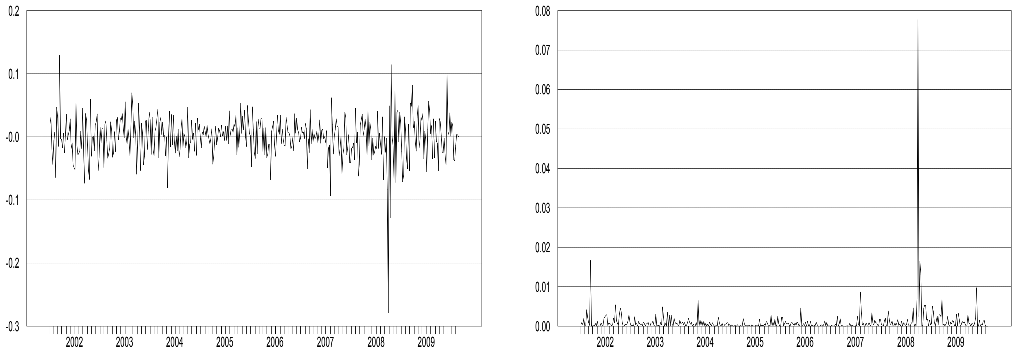
[30] Here volatility refers to the conditional variance of the underlying financial market return. Volatility can be applied to measurement of uncertainty as well as measurement of risk.

Figure 3.4 (continued)

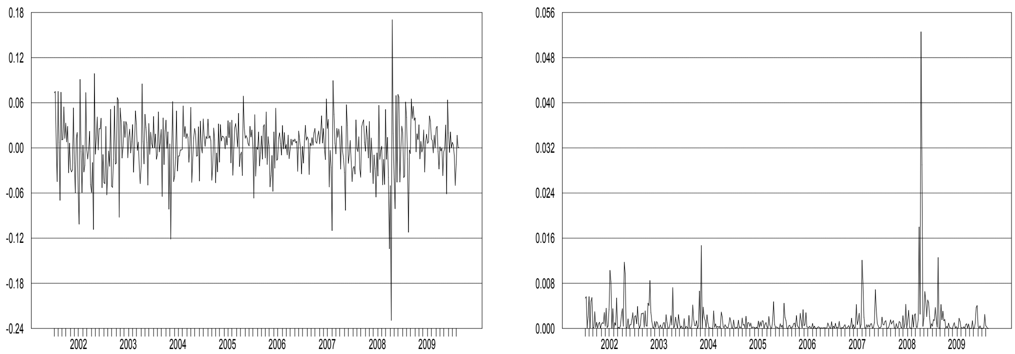
(d) U.S. Stock Return



(e) Japanese Stock Return



(f) Korean Stock Return



Note: Left column displays the time plots of returns and changes. Right column displays the squared series from original returns and changes. The data period is from Jan. 2002 W1 to Feb. 2010 W4.

which means that large volatilities tend to be followed by large volatilities and small volatilities tend to be followed by small volatilities. Second, volatility does not diverge to infinity. This means that volatility varies within some fixed range over time. Third, the empirical distribution of financial market returns shows characteristics of non-normal distribution such as leptokurtic, skew, and fat tail. Before modelling and estimating the spillover effects, investigation regarding the presence of these stylized facts in three asset market returns and three financial market changes is performed.

In Figure 3.4, the left column displays the time plots of returns and changes in each financial market (y_t), and the right column illustrates the squared series from the original returns and changes (y_t^2) for the period from Jan. 2002 W1 to Feb. 2010 W4.[31]

According to the right columns in Figure 3.4, the volatility clustering is observed in six asset market returns and financial market changes. Figures show that large returns (changes) tend to be followed by large returns (changes). Moreover, the fact that volatility varies within some fixed range over time is also observed.

To examine another characteristic of non-normal distribution, Table 3.4 provides a summary of the descriptive statistics of each asset market return and financial market change.

According to the Jarque-Bera statistic, which is used to test the normality of data, in Table 3.4, the null hypothesis that return (change) is a normal distribution is rejected, because probability is 0. On the other hand, leptokurtic and fat tail can be

---

[31] y_t^2 is regarded as a proxy of variance because variance is a mean of y_t^2 (Kim and Jang, 2006).

Table 3.4: Descriptive Statistics for the Financial Series

Statistics	CDS Spread	Won /Dollar	U.S. Stock	Won /Yen	Japanese Stock	Korean Stock
Mean	0.001	-0.001	-0.001	0.001	-0.001	0.002
Maximum	0.856	0.187	0.114	0.185	0.129	0.170
Minimum	-0.601	-0.154	-0.201	-0.151	-0.279	-0.229
Std.Dev.	0.118	0.019	0.027	0.024	0.034	0.037
Skewness	1.284	0.863	-1.037	0.843	-1.372	-0.713
Kurtosis	13.056	34.894	12.522	20.01	14.358	7.489
Jarque-Bera	1907.5	18066.1	1681.9	5173.9	2417.9	392.8
Probability	0.000	0.000	0.000	0.000	0.000	0.000

acknowledged by observing statistics for skewness and kurtosis. U.S., Japanese, and Korean stock returns show left-skewed tails (-1.037, -1.372, and -0.713, respectively), and changes in the CDS spread and two exchange rates have right-skewed tails (1.284, 0.863, and 0.843, respectively). Since kurtosis of normal distribution is theoretically 3, all returns and changes are leptokurtic due to excess kurtosis over 3. Summarizing the results in a sentence, returns and changes in the six asset and financial markets are non-normal distributions, because returns and changes show leptokurtic and fat tail characteristics.

Under this circumstance, the assumption of constant variance (homoskedasticity) is inappropriate. When modelling with non-constant variance (heteroskedasticity), there is a way to model the changing variance due to the characteristics of leptokurtic and fat tail in data. ARCH- and GARCH-related models are useful in this case. In particular, the empirical success of GARCH-related models shows that they are able to estimate the model composed of asset market returns and financial market changes involving the large extent of the volatility clustering and the excess kurtosis. With three stock returns and changes in Korean CDS spread and two exchange rates, this study provides additional evidence for the relationship among three financial markets in three countries by investigating the significance and degree of return and volatility of within-country and cross-country spillover effects using the MGARCH model.

3.4 Methodology

In the case of modelling volatility in financial time series, the presence of a conditional variance within a conditional mean equation makes linear econometric models inappropriate for capturing time varying shocks. To overcome this problem, ARCH and GARCH models have been considered to capture the nonlinearity that exists in financial data. In particular, the MGARCH model is widely employed for modelling the volatility of returns, because it is efficient in explaining the volatility co-movements and spillover effects between different financial market returns. Namely, the MGARCH model is flexible enough to represent the dynamics of the conditional variances and covariances in several financial markets simultaneously by incorporating lagged returns, innovations, volatilities, or a combination of these variables from one single market as explanatory variables of the other market (Silvennoinen and Terasvirta, 2008; Karunanayake *et al*., 2009).

In this chapter, the trivariate GARCH model is constructed to provide an insight into the nature of interaction among domestic and foreign financial markets on the basis of the Korean CDS market and the Korean stock market. There is a reason that the trivariate GARCH model is employed; MGARCH models have a well-known weak point that the number of parameters to estimate increases very rapidly as the number of variables increases. This weak point causes difficulties in the estimation of the model and interpretation of the results. Thus, a trivariate GARCH model is suitable to analyse the return and volatility spillover effects among the Korean CDS market, Korean stock market, and one other financial market such as a foreign exchange market or another country's stock market.

The autoregressive stochastic process of financial market returns (changes) is given in the following conditional mean equation (3.2).

$$y_{i,t} = \mu_i + \sum_{j=1}^{3} \gamma_{ij} y_{j,t-1} + \varepsilon_{i,t} \quad \text{(For all } i = 1, 2, 3\text{)} \tag{3.2}$$

where $y_{i,t}$ is the return (change) of financial market *i* between time *t*-1 and *t*, μ_i is a long-term drift coefficient of financial market *i*, γ_{ij} indicates the coefficients for lagged own market returns (changes) and other financial market returns (changes), and $\varepsilon_{i,t}$ is the error term for the return (change) of financial market *i* at time *t*. Returns (changes) of each financial market ($y_{i,t}$) are specified as a function of their own innovations ($\varepsilon_{i,t}$), the lagged own return (change) ($y_{j,t-1}$, for all *j*=1,2,3 in case of $i = j$), and lagged other financial market returns (changes) ($y_{j,t-1}$, for all *j*=1,2,3 in case of $i \neq j$). Four cases of trivariate GARCH models are estimated for different asset and financial markets. In each case, $i = j = 1$ indicates won/dollar exchange rate change, U.S. stock return, won/yen exchange rate change, and Japanese stock return.

These returns and changes are used one after another in order to consider four different cases in empirical tests along with the Korean CDS spread change ($i = j = 2$) and the Korean stock return ($i = j = 3$).

The following matrix form of conditional mean equation (3.3) has the same implication as equation (3.2).

$$\begin{bmatrix} y_{1,t} \\ y_{2,t} \\ y_{3,t} \end{bmatrix} = \begin{bmatrix} \mu_1 \\ \mu_2 \\ \mu_3 \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix} \begin{bmatrix} y_{1,t-1} \\ y_{2,t-1} \\ y_{3,t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} \tag{3.3}$$

The reason that this type of mean equation (3.3) is considered is that it is convenient to analyse the return spillover effects and dynamic relationships using the impulse response function between financial market returns and changes.[32]

The two common parameterizations for the MGARCH model used in previous research are the VECH model and BEKK model.[33] The traditional VECH model is introduced by Bollerslev *et al*. (1988), given as follows:

$$\text{vech}\,(H_t) = A_0 + \sum_{j=1}^{q} B_j vech(H_{t-j}) + \sum_{j=1}^{p} A_j vech(\varepsilon_{t-j}\varepsilon'_{t-j}) \tag{3.4}$$

where $\varepsilon_t = H_t^{1/2}\eta_t$, η_t ~*iid* N(0,I) and H_t is the conditional variance and covariance matrix. The *vech* (H_t) denotes the (n(n+1))/2$\times$1 vector of the individual elements in H_t which is obtained by stacking the lower triangle of H_t. The VECH model,

[32] The vector form of the mean equation presented in equation (3.3) is equal to the three-variable unrestricted VAR (1) model. To be specific, the VAR (1) form of conditional mean equation is used to examine the return spillover effects between financial markets in this chapter.

[33] The acronym BEKK model is used in the literature to refer to earlier unpublished work of Baba, Engle, Kraft, and Kroner (1990).

however, does not ensure a positive semi-definite H_t matrix, although it is necessary for the estimated variance to be greater than or equal to zero.

A more practicable alternative is the BEKK model from Engle and Kroner (1995). Most studies have used the BEKK model to overcome the difficulties associated with the VECH parameterization (Kearney and Patton, 2000; Hassan and Malik, 2007). This model is designed in such a way that the estimated covariance matrix will be positive semi-definite, which is a requirement needed to guarantee non-negative estimated variances. The BEKK parameterization for the MGARCH model is written as follows:[34]

$$H_t = C'C + A'\varepsilon_{t-1}\varepsilon'_{t-1}A + B'H_{t-1}B \qquad (3.5)$$

The individual elements for *C*, *A*, *B*, H_t and ε_t matrices in equation (3.5) are given as follows:

$$C = \begin{bmatrix} \omega_{11} & 0 & 0 \\ \omega_{21} & \omega_{22} & 0 \\ \omega_{31} & \omega_{32} & \omega_{33} \end{bmatrix}, \quad A = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{bmatrix}, \quad B = \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \\ \beta_{31} & \beta_{32} & \beta_{33} \end{bmatrix}$$

$$H_t = \begin{bmatrix} \sigma^2_{1,t} & \sigma_{12,t} & \sigma_{13,t} \\ \sigma_{21,t} & \sigma^2_{2,t} & \sigma_{23,t} \\ \sigma_{31,t} & \sigma_{32,t} & \sigma^2_{3,t} \end{bmatrix} = \begin{bmatrix} h_{11,t} & h_{12,t} & h_{13,t} \\ h_{21,t} & h_{22,t} & h_{23,t} \\ h_{31,t} & h_{32,t} & h_{33,t} \end{bmatrix}, \quad \varepsilon_t = \begin{bmatrix} \varepsilon_{1,t} \\ \varepsilon_{2,t} \\ \varepsilon_{3,t} \end{bmatrix} \qquad (3.6)$$

where ω_{ij} are elements of a 3×3 lower triangular matrix with six parameters of constants *C*. *A* is a 3×3 square matrix of parameters and shows how conditional variances are correlated with past squared errors. The elements (α_{ij}) of matrix *A*

[34] According to the naming way of Dark *et al*. (2005), the multivariate GARCH model used in this chapter is named as trivariate VAR BEKK GARCH (1,1) model.

measure the degree of innovation from financial market i to another financial market j. B is also a 3×3 square matrix of parameters, and its elements (β_{ij}) indicate the persistence in conditional volatility between financial market i and market j. H_t is the 3×3 matrix composed of conditional variances ($\sigma_{i,t}^2$) and covariances ($\sigma_{ij,t}$). Hence, the total number of elements that should be estimated for variance equations of the trivariate GARCH model is 24.

The conditional variance for each equation can be expanded for the trivariate GARCH (1,1) as:

$$h_{11,t} = \omega_{11}^2 + \omega_{21}^2 + \omega_{31}^2 + \alpha_{11}^2\varepsilon_{1,t-1}^2 + \alpha_{21}^2\varepsilon_{2,t-1}^2 + \alpha_{31}^2\varepsilon_{3,t-1}^2 + \beta_{11}^2 h_{11,t-1} + \beta_{21}^2 h_{22,t-1} + \beta_{31}^2 h_{33,t-1}$$
$$+ 2(\alpha_{11}\alpha_{21}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{11}\alpha_{31}\varepsilon_{1,t-1}\varepsilon_{3,t-1} + \alpha_{21}\alpha_{31}\varepsilon_{2,t-1}\varepsilon_{3,t-1} + \beta_{11}\beta_{21}h_{12,t-1} + \beta_{11}\beta_{31}h_{13,t-1}$$
$$+ \beta_{21}\beta_{31}h_{23,t-1}) \tag{3.7}$$

$$h_{22,t} = \omega_{22}^2 + \omega_{32}^2 + \alpha_{12}^2\varepsilon_{1,t-1}^2 + \alpha_{22}^2\varepsilon_{2,t-1}^2 + \alpha_{32}^2\varepsilon_{3,t-1}^2 + \beta_{12}^2 h_{11,t-1} + \beta_{22}^2 h_{22,t-1} + \beta_{32}^2 h_{33,t-1}$$
$$+ 2(\alpha_{12}\alpha_{22}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{12}\alpha_{32}\varepsilon_{1,t-1}\varepsilon_{3,t-1} + \alpha_{22}\alpha_{32}\varepsilon_{2,t-1}\varepsilon_{3,t-1} + \beta_{12}\beta_{22}h_{12,t-1} + \beta_{12}\beta_{32}h_{13,t-1}$$
$$+ \beta_{22}\beta_{32}h_{23,t-1}) \tag{3.8}$$

$$h_{33,t} = \omega_{33}^2 + \alpha_{13}^2\varepsilon_{1,t-1}^2 + \alpha_{23}^2\varepsilon_{2,t-1}^2 + \alpha_{33}^2\varepsilon_{3,t-1}^2 + \beta_{13}^2 h_{11,t-1} + \beta_{23}^2 h_{22,t-1} + \beta_{33}^2 h_{33,t-1}$$
$$+ 2(\alpha_{13}\alpha_{23}\varepsilon_{1,t-1}\varepsilon_{2,t-1} + \alpha_{13}\alpha_{33}\varepsilon_{1,t-1}\varepsilon_{3,t-1} + \alpha_{23}\alpha_{33}\varepsilon_{2,t-1}\varepsilon_{3,t-1} + \beta_{13}\beta_{23}h_{12,t-1} + \beta_{13}\beta_{33}h_{13,t-1}$$
$$+ \beta_{23}\beta_{33}h_{23,t-1}) \tag{3.9}$$

Equations (3.7), (3.8), and (3.9) show how volatilities are transmitted across financial markets over time. The conditional covariance equations used to program together with conditional variance equations are presented in Appendix 3A.

The following log-likelihood function is maximized for the trivariate GARCH model with the assumption that errors are normally distributed:

$$L(\theta) = -\frac{TN}{2}\ln(2\pi) - \frac{1}{2}\sum_{t=1}^{T}(\ln|H_t| + \varepsilon'_t H_t^{-1}\varepsilon_t) \qquad (3.10)$$

where θ is the vector of parameters to be estimated, N is the number of financial markets in the system being estimated, and T is the number of observations. Since the log-likelihood function in this case is non-linear, the Marquardt algorithm is used as an iterative algorithm to estimate the parameters.[35]

The next section of empirical analysis proceeds using a trivatiate GARCH model with conditional mean equations for return spillover effects and conditional variance equations of the BEKK model for volatility spillover effects between international and domestic financial market returns and changes.

3.5 Empirical Results

In this section, the results of return and volatility spillover effects among the CDS market, stock markets and foreign exchange markets for the U.S., Japan, and Korea are reported. To examine the return and volatility spillover effects between change in CDS spread underlying Korean government bonds, which implies country risk in Korea, and

[35] The Berndt, Hall, Hall, and Hausman (BHHH) (1974) algorithm has been used in most previous studies. However, the Marquardt algorithm is used in this chapter because of its better performance than the BHHH algorithm, which does not converge.

the Korean stock return, which is the index of the representative Korean asset market mainly, these return and change are commonly included in all four cases. In addition, the won/dollar exchange rate change, won/yen exchange rate change, U.S. stock return, and Japanese stock return are used one after another for the third financial market return or change in each case to investigate another spillover effect from the third financial market return or change to the Korean stock return and Korean CDS spread change.

Estimation for return and volatility spillover effects is conducted using a trivariate GARCH model, and analysis for dynamic interactions between returns and changes are performed using impulse response functions obtained from the unrestricted VAR (1) framework of conditional mean equation (3.3). The structure of the four cases is organized as follows:

Case I : Won/dollar exchange rate change – CDS spread change – Korean stock return

Case II : Won/yen exchange rate change – CDS spread change – Korean stock return

Case III : U.S. stock return – CDS spread change – Korean stock return

Case IV : Japanese stock return – CDS spread change – Korean stock return

3.5.1 Foreign Exchange Markets, the Korean CDS market, and the Korean Stock Market

The estimated coefficients and standard errors of the conditional mean equations and conditional variance equations for Case I and Case II, which include foreign exchange markets as a third financial market, are reported in Table 3.5. Estimated coefficients of equations (3.3) and (3.6) which are based on computing the coefficients of ARCH term and GARCH term in Table 3.5 are also reported in Appendix 3B.1.

First, seeing the results of the conditional mean equation in Case I, which considers the

Table 3.5: Estimates of Trivariate GARCH Model for Case I and Case II

	Case I			Case II		
Return Spillover Effect (Mean Equation)						
γ_{ij}	$i=1$	$i=2$	$i=3$	$i=1$	$i=2$	$i=3$
γ_{i1}	0.187**	1.003***	-0.193**	-0.279***	0.244***	-0.134***
	(0.076)	(0.267)	(0.095)	(0.069)	(0.035)	(0.022)
γ_{i2}	0.004	-0.041	0.027**	0.036	0.013	-0.017***
	(0.007)	(0.052)	(0.013)	(0.027)	(0.014)	(0.005)
γ_{i3}	0.018	0.090	-0.051	0.039	0.074***	-0.185***
	(0.021)	(0.116)	(0.045)	(0.085)	(0.023)	(0.021)
Volatility Spillover Effect (Variance Equation)						
h_{ij}	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$
$\varepsilon^2_{1,t-1}$	0.248***	0.902***	0.021	0.005*	0.004*	8.21e-5
	(0.073)	(0.268)	(0.095)	(0.040)	(0.035)	(0.025)
$\varepsilon^2_{2,t-1}$	2.44e-6	0.173***	0.004***	1.06e-4	0.215***	2.79e-5
	(0.011)	(0.054)	(0.018)	(0.023)	(0.012)	(0.007)
$\varepsilon^2_{3,t-1}$	0.002	0.135**	0.279***	0.020*	0.024***	0.652***
	(0.042)	(0.148)	(0.065)	(0.079)	(0.024)	(0.026)
$h_{11,t-1}$	0.835***	0.017	0.003	0.997***	0.001	2.02e-4
	(0.031)	(0.140)	(0.078)	(0.009)	(0.059)	(0.036)
$h_{22,t-1}$	8.98e-5	0.799***	0.003*	7.24e-5	0.487***	5.47e-5
	(0.013)	(0.056)	(0.032)	(0.022)	(0.008)	(0.005)
$h_{33,t-1}$	0.005	0.044	0.228***	0.003	0.005***	0.522***
	(0.054)	(0.245)	(0.123)	(0.038)	(0.014)	(0.009)

Note: (Case I) i=1: Won/dollar exchange rate change, i=2: Korean CDS spread change, i=3: Korean stock return. (Case II) i=1: Won/yen exchange rate change, i=2: Korean CDS spread change, i=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Korean-U.S. foreign exchange market, Korean CDS market, and Korean stock market, all return spillover effects from the lagged change of the won/dollar exchange rate to the current own-market-change, current Korean CDS spread change, and current Korean stock return are significant. Each coefficient is 0.187(γ_{11}), 1.003(γ_{21}), and -0.193(γ_{31}), respectively, and they are significant at the 5%, 1%, and 5% levels, respectively. In particular, a positive cross-market return spillover effect exists from the Korean-U.S. foreign exchange market to the Korean CDS market. In contrast, a negative cross-market-return spillover effect exists from the Korean-U.S. foreign exchange market to the Korean stock market. Positive cross-market return spillover effect from the lagged Korean CDS spread change to the current Korean stock return is significant at the 5% level (0.027, γ_{32}). Conditional return spillover effects from the lagged Korean stock return to the current own-market-return and cross-market return do not exist, because the results are statistically insignificant. Thus, during the data period, conditional return spillover effect from the Korean-U.S. foreign exchange market to the Korean CDS market exists, and return spillover effects from the Korean-U.S. foreign exchange market and the Korean CDS market to the Korean stock market are significant.

Second, seeing the result of the conditional variance equation in Case I, each persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all *i*=*j*) for the Korean-U.S. foreign exchange market, the Korean CDS market, and the Korean stock market is 0.835, 0.799 and 0.228, respectively, and all of these coefficients are strongly significant at the 1% level. According to the size of each coefficient, the won/dollar exchange rate change has the highest volatility persistence. The volatility persistence of the Korean CDS spread change and Korean stock return follows in order. All three financial market returns and changes are significant at the 1% level of critical value in terms of own-market-volatility spillover effects (0.248, 0.173, and 0.279, respectively). Examining the cross-market volatility spillover effect, there are no significant volatility spillover effects from the Korean CDS spread change and the Korean stock return to the won/dollar exchange rate change. However, volatility spillover effects from the won/dollar exchange rate change and the Korean stock return to the Korean CDS spread change are significant at 0.902 (1%) and 0.135 (5%), respectively. On the other hand, the volatility spillover effect from the Korean CDS spread change to the Korean stock return is significant at 0.004 (1%). Thus, during the data period, there are bidirectional significant volatility spillover effects between the Korean CDS market and the Korean stock market, and there is a significant unidirectional volatility spillover effect from the Korean-U.S. foreign exchange market to the Korean CDS market.

Third, in comparison to Case I, seeing the result of the conditional mean equation in Case II, which considers the Korean-Japanese foreign exchange market, the Korean CDS market and the Korean stock market, return spillover effects from the lagged change of the won/yen exchange rate to the current own-market-return, the current Korean CDS spread change, and the current Korean stock return are -0.279 (γ_{11}), 0.244 (γ_{21}) and -0.134 (γ_{31}), respectively. They are all statistically significant at the 1% level. In particular, a positive cross-market return spillover effect exists from the won/yen exchange rate change to the Korean CDS spread change, and a negative cross-market return spillover effect exists from the won/yen exchange rate change to the Korean stock return. As these results are consistent with the results of Case I, it can be concluded that there exist significant cross-market return spillover effects from both foreign exchange markets to the Korean CDS market and the Korean stock market. The lagged change of the Korean CDS spread has a negative conditional return spillover effect to the current Korean stock return at the 1% level of critical value, with the coefficient value of -0.017 (γ_{32}). The lagged Korean stock return has a conditional return spillover effect to the current Korean CDS spread change and current return of own market at the 1% level with coefficient values of 0.074 (γ_{23}) and -0.185 (γ_{33}), respectively. Thus, during the data period, there are bidirectional return spillover effects between the Korean CDS market and the Korean stock market, and there are unidirectional return spillover effects from the Korean-Japanese foreign exchange market to the Korean CDS market and the Korean stock market.

Fourth, seeing the result of the conditional variance equation in Case II, the persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all *i*=*j*) for the Korean-Japanese foreign exchange market, the Korean CDS market, and the Korean stock market is 0.997, 0.487, and 0.522, respectively, and all of these coefficients are strongly significant at the 1% level. According to the size of each coefficient, the won/yen exchange rate change has the highest volatility persistence. The volatility persistence of the Korean stock returns and the Korean CDS spread change follows in order. All three financial market return and changes are significant at the 10%, 1% and 1% levels of critical value in terms of own-market-volatility spillover effects, respectively, and those estimates are 0.005, 0.215, and 0.652, respectively. Examining the cross-market volatility spillover effect, three significant volatility spillover effects, from the Korean stock return to the Won/Yen exchange rate change (0.020, 10%), from the won/yen exchange rate change to the Korean CDS spread change (0.004, 10%), and from the Korean stock return to the Korean CDS spread return (0.024, 1%), are statistically significant. Thus, during the data period, there are significant unidirectional volatility spillover effects from the Korean-Japanese foreign exchange market and the Korean stock market to the Korean CDS market. Another significant unidirectional volatility spillover effect is from the Korean stock market to the Korean-Japanese foreign exchange market.

For better understanding, simple figures for the results of return and volatility spillover effects for Case I and Case II are presented in Figure 3.5.

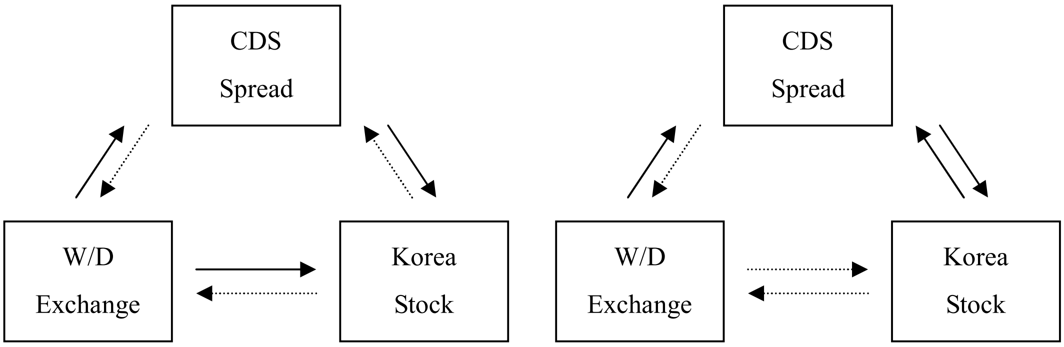
Some empirical research provides evidence of return spillover effects between the stock market and the foreign exchange market (Roll, 1992; Dumas and Solnik, 1995; Choi *et al*., 1998; Phylaktis and Ravazzolo, 2005). They find the presence of bidirectional return spillover effects between the foreign exchange market and the stock market. In contrast to these results, during the data period for Korea, there is a unidirectional return spillover effect from foreign exchange markets to the Korean stock market.

In the meantime, although there are significant unidirectional volatility spillover effects from two foreign exchange markets to the Korean CDS market, there is no significant volatility spillover effect from two foreign exchange markets to the Korean stock market. Some empirical research provides different results of volatility spillover effects between the stock market and the foreign exchange market. Francis *et al*. (2002) and Wu (2005) find significant bidirectional volatility spillovers between the

Figure 3.5: Return and Volatility Spillover Effects for Case I and Case II

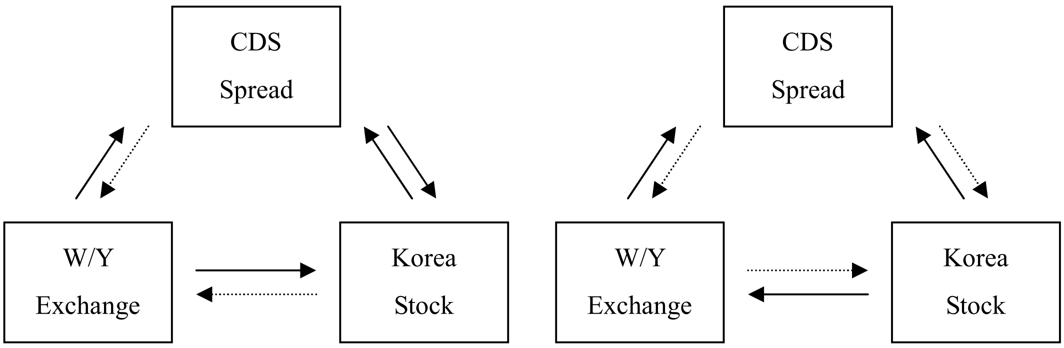
(Case I) Won/dollar exchange rate change – CDS spread change – Korean stock return

(a) Return Spillover Effect (b)Volatility Spillover Effect



(Case II) Won/yen exchange rate change – CDS spread change – Korean stock return

(a) Return Spillover Effect (b)Volatility Spillover Effect



Note: —— denotes significant spillover effect, and ········ denotes insignificant spillover effect

stock market and the foreign exchange market. Beer and Hebein (2008) find significant volatility spillovers from the foreign exchange market to the stock market for several countries. To the contrary, Kanas (2000) and Kim (2001) find the presence of unidirectional volatility spillover from the stock market to the foreign exchange market. Although there are no volatility spillover effects between the Korean-U.S. foreign exchange market and the Korean stock market, the significant unidirectional volatility spillover effect from the Korean stock market to the Korean-Japanese foreign exchange market is in line with the results of Kanas (2000) and Kim (2001).

In terms of the relationship among the CDS, foreign exchange, and stock markets, Nam and Byun (2006) claim a significant effect from the variations of stock prices and the exchange rate to the variation of the Korean CDS spread. Elmahadaoui and Dugas (2009) emphasize the effect from variations in the CDS spread to the variations in stock prices. Baum and Wan (2010) indicate the significant effect from the second moment of the stock index to the CDS spread. The results of this study are consistent with those of foregoing studies that there is a significant return spillover effect from the foreign exchange market to the CDS market, a return spillover effect from the CDS market to the stock market, and a volatility spillover effect from the stock market to the CDS market.

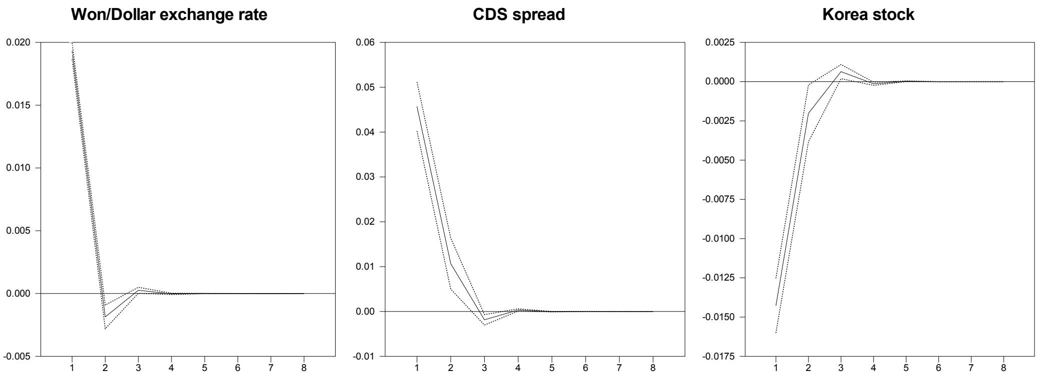
Considering the relationships in mean equations from a different angle, time varying impulse responses to positive one standard deviation of each return (change) shock are provided to illustrate the dynamics of the trivariate GARCH system for the conditional mean returns (changes) of financial markets. Impulse response functions are reported based on the mean equation (3.3). The errors ($\varepsilon_{i,t}$) are orthogonalized and then shocked to generate the impulse response functions. To observe the distinct response patterns of the system, the errors are transformed to orthogonalize the innovations using a Cholesky factorization. The impulse response functions for the trivariate GARCH process apply the same procedures to their standardized residuals series, which have been corrected for time varying conditional heteroskedasticity (Karolyi, 1995). Although the errors are conditionally heteroskedastic, it is valid to perform impulse response function analysis since this is a stationary GARCH which has unconditionally constant variance. The impulse responses of the return and change series to each positive financial market return and change shock with one standard error bands are presented in Figure 3.6 for Case I and in Figure 3.7 for Case II.

Figures 3.6 and 3.7 show similar impulse responses for each case. First, carrying out a thorough inspection of the results, the Korean CDS spread change increases immediately and returns to a steady-state level in one month to one standard deviation increasing shocks of the two exchange rate changes. Since increase in the exchange rate, which implies an increasing risk premium in foreign exchange market, is related to increasing country risk, the result of the increasing Korean CDS spread change is reasonable. This result is consistent with that of Kim (2009). To the contrary, the Korean stock return shows negative response immediately and recovers to the pre-shock level within one month to increasing shocks of the two exchange rate changes. This result is the same as previous research that draws the conclusion of a negative relationship between foreign exchange rate change and the Korean stock return (Chung, 2002).

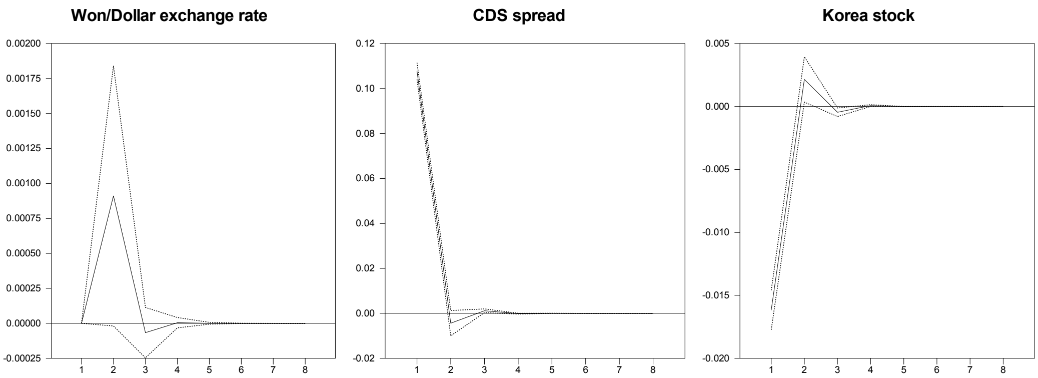
The flow approach of Dornbusch and Fischer (1980) affirms that currency movements affect international competitiveness and the balance of trade position. As a result, the real output of the country is changed, and then this changed economic activity affects current and future cash flows of companies and stock prices. From this perspective, a depreciation in the Korean currency leads to increasing Korean exports, and consequently this will cause an increase in Korean stock prices due to increased output. In contrast, when the Korea currency is depreciated, prices rise because of increased

Figure 3.6: Impulse Response Functions for Case I

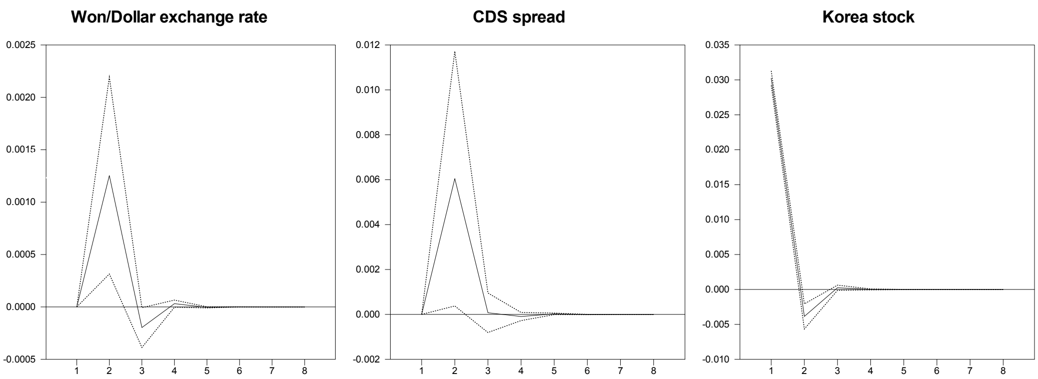
(a) Responses to Won/Dollar Exchange Rate Change Shock



(b) Responses to CDS Spread Change Shock



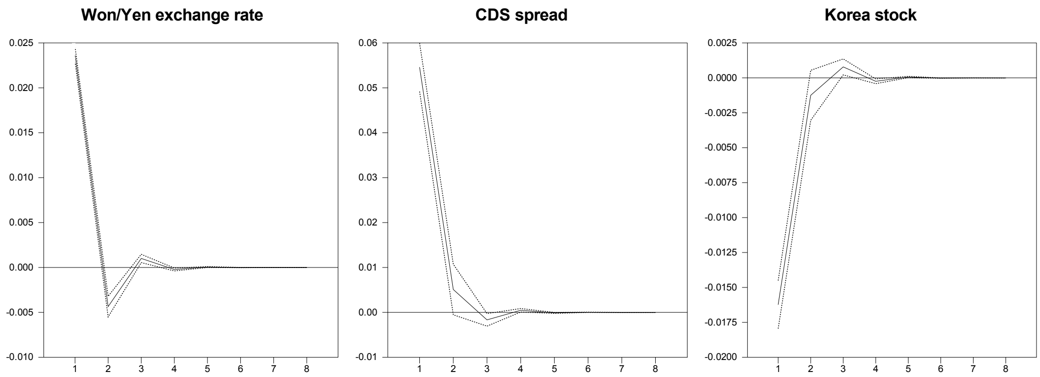
(c) Responses to Korean Stock Return Shock



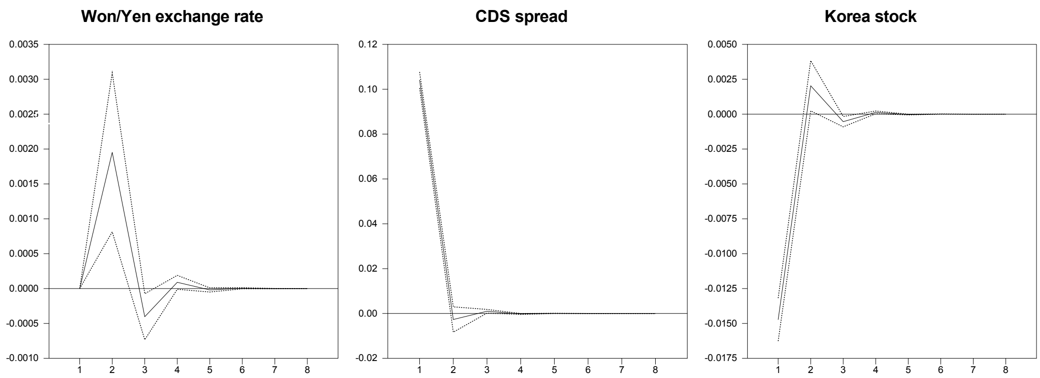
Note: Solid lines depict impulse responses of each one standard deviation increasing shock, and broken lines depict the upper and lower one standard error bands.

Figure 3.7: Impulse Response Functions for Case II

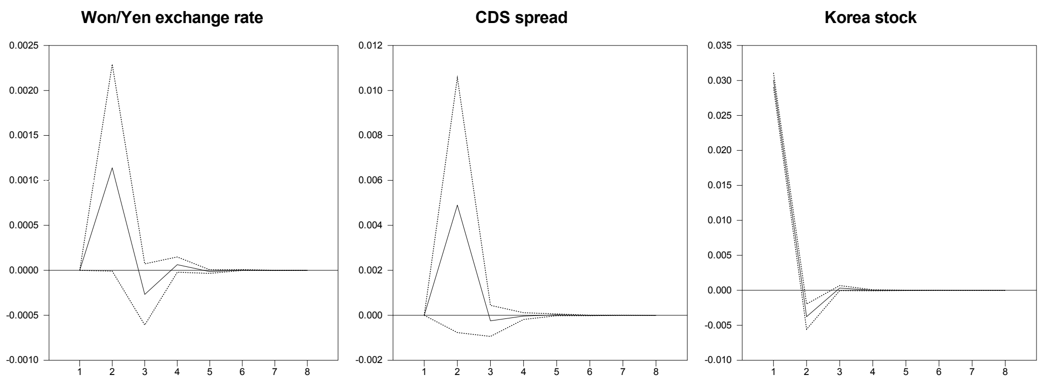
(a) Responses to Won/Yen Exchange Rate Change Shock



(b) Responses to CDS Spread Change Shock



(c) Responses to a Korean Stock Return Shock



Note: Solid lines depict impulse responses of each one standard deviation increasing shock, and broken lines depict the upper and lower one standard error bands.

import prices, and this will cause domestic interest rates to rise. The stock prices will fall because of higher interest rates. In addition, because of expected foreign-exchange loss stemming from the sudden rise in exchange rate, investment of foreign capital in the Korean asset market will not increase. Consequently, for the Korean economy during the data period, the Korean stock return responds negatively to the increasing exchange rate change shock.

Second, two exchange rate changes do not respond at first to the increasing Korean CDS spread change shock. However, they show delayed overshooting after the initial stage and return to the steady-state level in one month. The reason that the Korean currency depreciates is due to the increased country credit risk reflected by the increased CDS spread underlying Korean government bonds. In comparison to the exchange rate change responses, the impulse response in the Korean stock return to the increasing Korean CDS spread change shock displays immediate falling, and then afterward, the Korean stock return goes back to the pre-shock level in one month. Since investment is sensitively affected by the risk in assets, increased country risk due to increasing country credit spread causes decreasing foreign investment in the Korean asset market. It goes without saying that this condition makes the Korean stock return fall. This response pattern is very similar to the case of an increasing exchange rate change shock.

Third, impulse responses in the two exchange rate changes and the Korean CDS spread change to the increasing Korean stock return shock look similar. There are no responses at the initial stage, but they show delayed overshooting and return to the pre-shock level in one month. According to economic theory and previous empirical results, the change in the stock market has an influence on the change in the foreign exchange market negatively or positively (see Aggarwal (1981), Branson (1983), Phylaktis and Ravazzolo (2005), Pan *et al*. (2007), and Rahman and Uddin (2009)).

These conflicting results are explained by several economic theories related to the determinants of the exchange rate. According to the perspective of the flow approach, an increase in the Korean stock market conveys information about improved performance in the Korean economy, and it can be expected that imports in Korea will increase due to the better economic state. For this reason, demand for foreign currency leads to a depreciation in Korean currency. On the other hand, according to the monetary approach and portfolio balance approach, agents allocate their wealth among alternative assets such as foreign stocks and domestic money, bonds, and stocks. The role of the exchange rate is to balance the foreign and domestic asset demands and supplies. Hence, if there is a change in the demand and supply of Korean stock, this will change the equilibrium exchange rate. If the Korean stock price rises, it will persuade foreign investors to buy more Korean stock by selling foreign assets to obtain Korean currency. Increase in demand for Korean currency will lead to appreciation of the Korean currency (see Frankel, 1983). In addition, if the Korean stock price rises, this will lead to the growth of wealth, which will increase the demand for money. The excess demand for money will cause interest rates in Korea to rise, and in this situation, more foreign capital will be attracted and increase the foreign demand for the Korean currency (see Gavin, 1989). As a result, the Korean currency will appreciate. Thus, the overall effect on the exchange rate will depend on the relative strength of the various competing effects (Phylaktis and Ravazzolo, 2005). For the Korean economy during the data period, increase in the Korean stock return shock has a positive influence on exchange rate changes.

3.5.2 U.S. and Japanese Stock Markets, the Korean CDS market, and the Korean Stock Market

The empirical results for Case III and Case IV, which include two large countries' stock returns, the Korean CDS spread change and the Korean stock return are reported in Table 3.6. Estimated coefficients of equations (3.3) and (3.6), which are based on computing the coefficients of ARCH term and GARCH term to examine the volatility spillover effect in Table 3.6, are also reported in Appendix 3B.2.

First, seeing the results of the conditional mean equation in Case III which considers the U.S. stock market, the Korean CDS market, and the Korean stock market, return spillover effects from the lagged U.S. stock return to the current CDS spread change and the current Korean stock return are -0.774 (γ_{21}) and 0.402 (γ_{31}), respectively, and they are both significant at the 1% level of critical value. In particular, a negative cross-market return spillover effect exists from the U.S. stock market to the Korean CDS market. In contrast, a positive cross-market return spillover effect exists from the U.S. stock market to the Korean stock market. Thus, it can be concluded that the U.S. stock market has a significant effect on the Korean CDS market and the Korean stock market during the data period. Although there is no significant return spillover effects from the lagged change of the Korean CDS spread to the current returns of the other two stock returns, the lagged return of the Korean stock market has a significant return spillover effect on the current Korean CDS spread change (0.565, γ_{23}) and its own market (-0.347, γ_{33}) under the 5% and 1% levels of critical value, respectively.

Table 3.6: Estimates of Trivariate GARCH Model for Case III and Case IV

	Case III			Case IV		
Return Spillover Effect (Mean Equation)						
γ_{ij}	$i=1$	$i=2$	$i=3$	$i=1$	$i=2$	$i=3$
γ_{i1}	0.094 (0.199)	-0.774*** (0.299)	0.402*** (0.080)	0.032 (0.068)	-0.021 (0.235)	-0.003 (0.058)
γ_{i2}	-0.001 (0.057)	0.061 (0.090)	-0.012 (0.027)	-0.037* (0.021)	0.128** (0.054)	-0.033 (0.023)
γ_{i3}	-0.236 (0.153)	0.565** (0.237)	-0.347*** (0.069)	-0.101 (0.068)	0.166 (0.286)	-0.116 (0.071)
Volatility Spillover Effect (Variance Equation)						
h_{ij}	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$
$\varepsilon^2_{1,t-1}$	0.079 (0.255)	0.002 (0.523)	0.004 (0.122)	0.006 (0.069)	1.007*** (0.266)	0.085*** (0.064)
$\varepsilon^2_{2,t-1}$	0.053*** (0.073)	0.379*** (0.141)	0.013*** (0.053)	0.002*** (0.012)	0.008* (0.050)	0.003*** (0.019)
$\varepsilon^2_{3,t-1}$	0.003 (0.228)	0.376* (0.341)	0.011 (0.112)	0.033** (0.072)	2.251*** (0.180)	0.163*** (0.069)
$h_{11,t-1}$	0.223 (0.812)	0.248 (1.331)	0.001 (0.351)	1.056*** (0.042)	0.005 (0.179)	0.033*** (0.058)
$h_{22,t-1}$	0.012 (0.135)	0.728*** (0.228)	1.52e-4 (0.053)	0.001*** (0.015)	0.505*** (0.059)	0.012*** (0.016)
$h_{33,t-1}$	0.061 (1.117)	1.455 (2.108)	0.259 (0.529)	0.004 (0.064)	0.518*** (0.241)	0.880*** (0.085)

Note: (Case III) i=1: U.S. stock return, i=2: Korean CDS spread change, i=3: Korean stock return. (Case IV) i=1: Japanese stock return, i=2: Korean CDS spread change, i=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Second, seeing the result of the conditional variance equation in Case III, the only significant persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all i=j)

is the Korean CDS spread change (0.728, 1%). Only the Korean CDS spread change is also significant at the 1% level in terms of the own-market-volatility spillover effect (0.379). Examining the cross-market volatility spillover effect, volatility spillover effects from the Korean CDS spread change to the other two stock returns (0.053, 0.013) are significant at the 1% level. Additionally, the volatility spillover effect from the Korean stock return to the Korean CDS spread change is significant at the 10% level of critical value (0.376).

Third, in comparison with Case III, the result of the conditional mean equation in Case IV, which considers the Japanese stock market, the Korean CDS market, and the Korean stock market, indicates that there is no meaningful return spillover effect among the three financial markets.

Fourth, as indicated by the result of the conditional variance equation in Case IV, the persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all i=j) for the Japanese stock market, the Korean CDS market, and the Korean stock market are 1.056, 0.505, and 0.880, respectively. All of these coefficients are strongly significant at the 1% level. According to the size of each coefficient, the Japanese stock return has the highest volatility persistence. The volatility persistence of the Korean stock return and the Korean CDS spread change follow in order. The Korean CDS spread change and the Korean stock return are significant at the 10% and 1% levels of critical value in terms of own-market-volatility spillover effect, respectively (0.008 and 0.163, respectively). Examining the cross-market volatility spillover effect, all three financial markets have significant bidirectional volatility spillover effects between markets in this case. The volatility spillover effects from the Japanese stock market and the

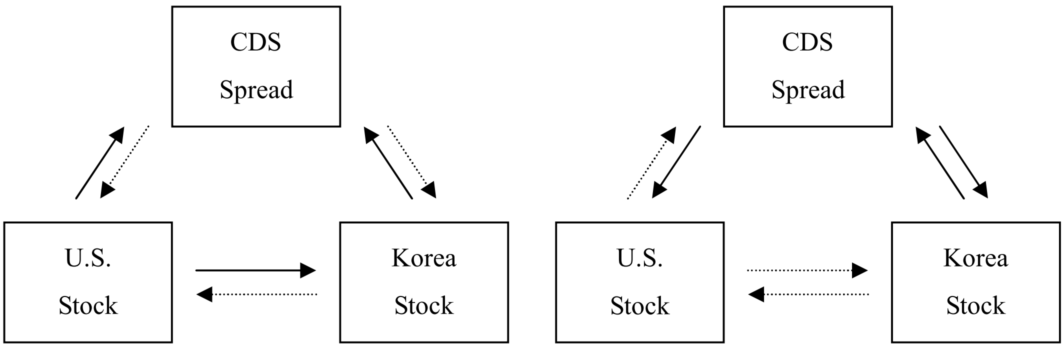
Korean stock market to the Korean CDS market are statistically significant at 1.007 and 2.251, respectively, at the 1% significance level. The volatility spillover effects from the Japanese stock market and the Korean CDS market to the Korean stock market are significant at 0.085 and 0.003, respectively, at the 1% level.

For better understanding, simple figures for the results of return and volatility spillover effects for Case III and Case IV are presented in Figure 3.8.

Figure 3.8: Return and Volatility Spillover Effects for Case III and Case IV

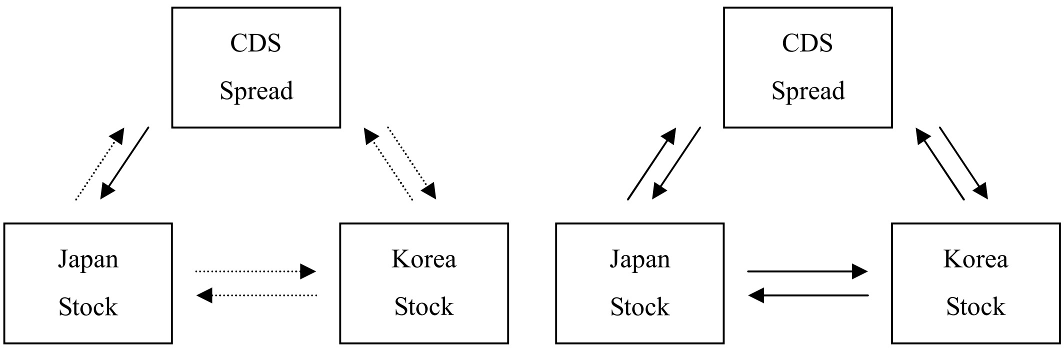
(Case III) U.S. stock return – CDS spread change – Korean stock return

(a) Return Spillover Effect (b) Volatility Spillover Effect



(Case IV) Japanese stock return – CDS spread change – Korean stock return

(a) Return Spillover Effect (b) Volatility Spillover Effect



Note: —— denotes significant spillover effect, and ········ denotes insignificant spillover effect

Considering synthetically Case IV together with Case III examining the return and volatility spillover effects among the Korean CDS market, the Korean stock market, and the U.S. or Japanese stock markets, there are significant cross-market return spillover effects from the U.S. stock market to the Korean CDS market and the Korean stock market. In contrast, there are significant cross-market volatility spillover effects from the Japanese stock market to the Korean CDS market and the Korean stock market. This result is consistent with Scheicher (2001), who shows that the regional influences are the cause of volatility in the markets, whereas international volatility has no impact on small stock markets. Beirne *et al*. (2010) conclude that return and volatility spillover effects exist from global or regional stock markets to local emerging markets. Studies by Karolyi (1995), Chou *et al*., (1999), Worthington and Higgs (2004), Harris and Pisedtasalasai (2006), and Sun and Zhang (2009) are also in line with this result. They show that there are return and volatility spillover effects from the advanced stock market to the smaller stock market.

Commonly in these two cases, although there is no significant bidirectional cross-return-spillover effect between the Korean CDS market and the Korean stock market besides the significant effect from the Korean stock market to the Korean CDS market in Case III, bidirectional cross-market volatility spillover effects between two Korean financial markets are significant. Through the results of volatility spillover effects between the Korean CDS market and the Korean stock market from Case I to Case IV, there are significant bidirectional volatility spillover effects between two Korean financial markets except only one unidirectional effect. This can be interpreted that a decrease in the Korean CDS spread uncertainty, which implies that the country state is stable, leads to a decrease in the Korean stock market uncertainty and, as a result, there is a decrease in volatility and persistence in the Korean stock market. On the other hand, a decline in the Korean stock return uncertainty, which implies the stable state of asset markets, causes the volatility and persistence in the Korean CDS market to decrease because of the decreased Korean CDS spread uncertainty.

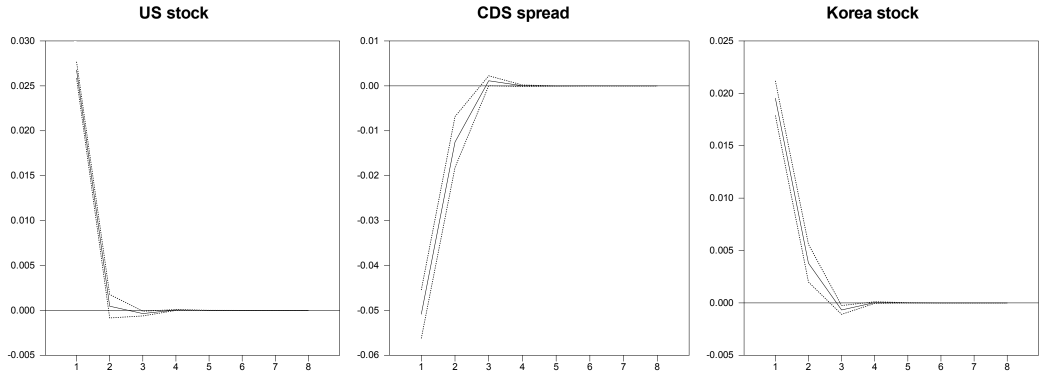
Although a study by Bala and Premaratne (2003) shows that the volatility spillover effect from the smaller stock market to the dominant stock market is plausible, most of the other earlier research concludes that spillover effects are significant only from the dominant market to the smaller market. Because the Korean stock market is relatively small, it is plausible that the influence from the Korean stock market and the Korean CDS market to global stock market such as that of the U.S. and a regional stock market such as that of Japan is insignificant, although some statistics indicate significance. Hence, only results are reported without further explanation.

To observe the time varying impulse responses of return and change series to positive financial market return and change shocks in the unrestricted VAR(1) model reported in equation (3.3), the results with one standard error bands are presented in Figure 3.9 for Case III and in Figure 3.10 for Case IV.

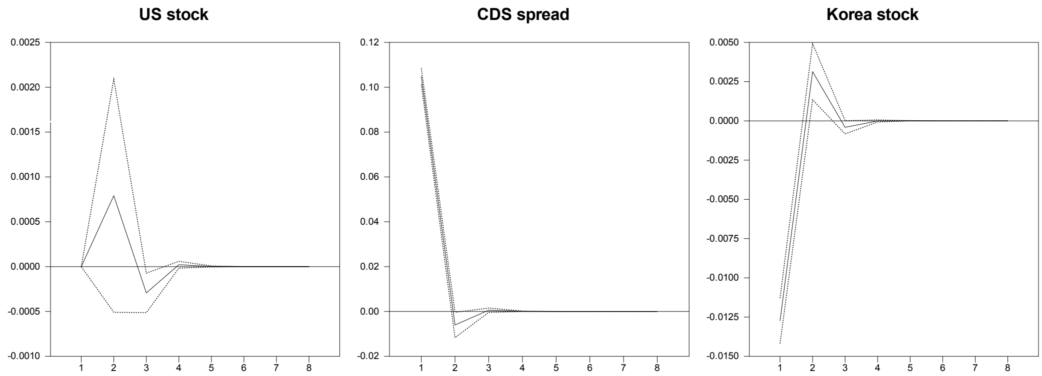
Figures 3.9 and 3.10 illustrate the impulse response functions of Case III and Case IV including U.S. and Japanese stock markets along with the Korean CDS market and the Korean stock market, which show similar responses in each case. Basically, impulse responses of the Korean CDS spread change and the Korean stock return to one standard deviation increasing U.S. and Japanese stock return shocks show similarities except for the different numerical values and the required periods to return to the steady-state level.

Figure 3.9: Impulse Response Functions for Case III

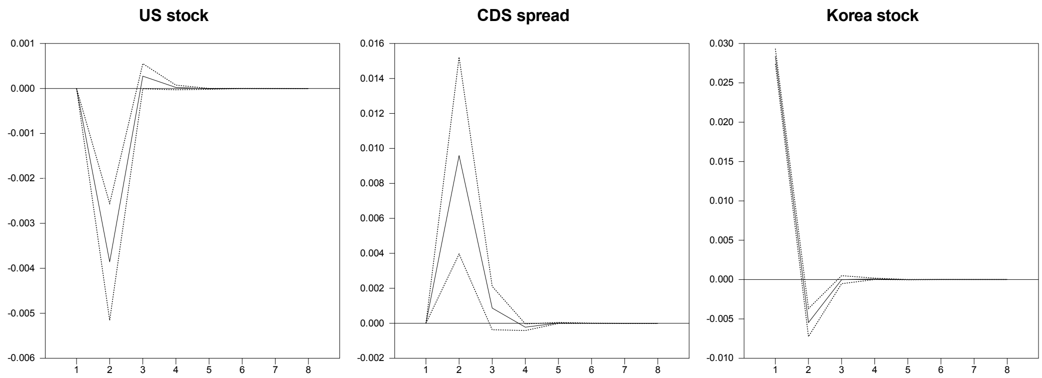
(a) Responses to U.S. Stock Return Shock



(b) Responses to CDS Spread Change Shock



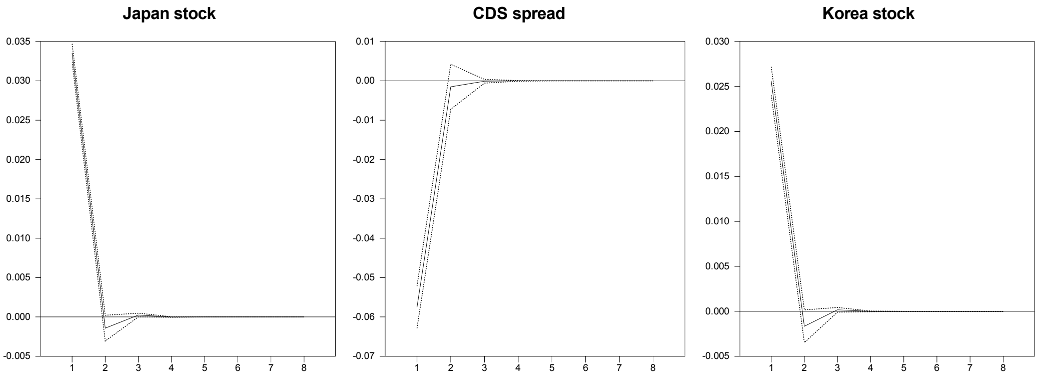
(c) Responses to Korean Stock Return Shock



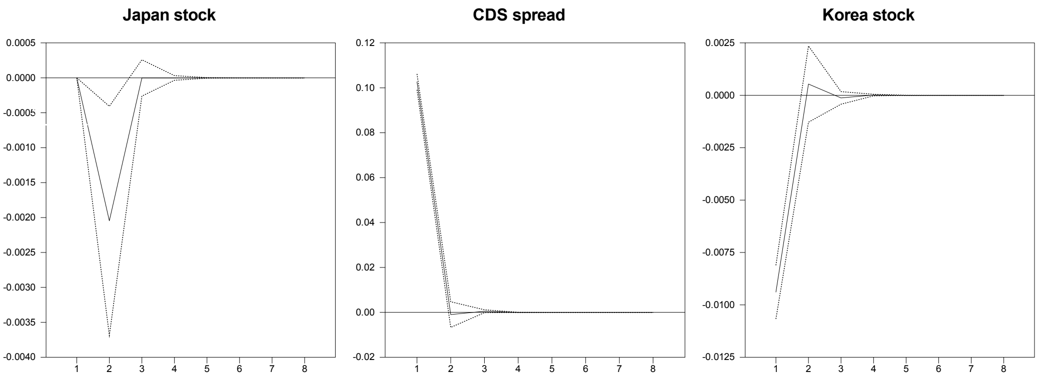
Note: Solid lines depict impulse responses of each one standard deviation increasing shock, and broken lines depict the upper and lower one standard error bands.

Figure 3.10: Impulse Response Functions for Case IV

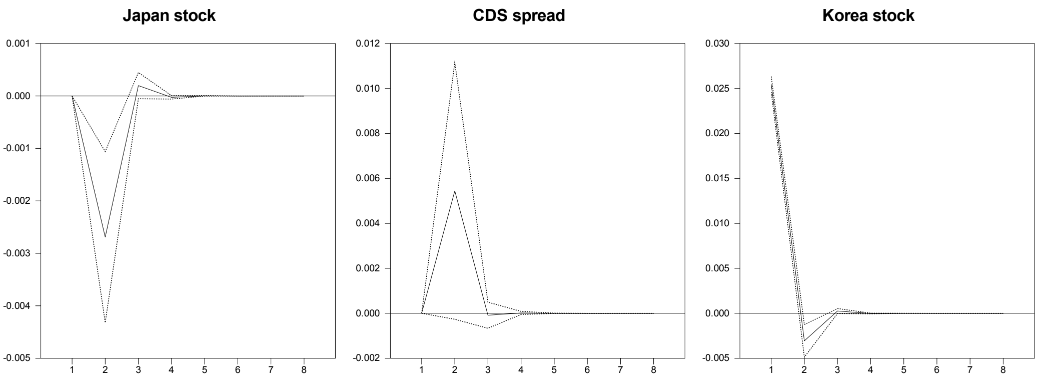
(a) Responses to Japanese Stock Return Shock



(b) Responses to CDS Spread Change Shock



(c) Responses to Korean Stock Return Shock



Note: Solid lines depict impulse responses of each one standard deviation increasing shock, and broken lines depict the upper and lower one standard error bands.

Describing the detailed results, the Korean CDS spread change falls immediately and returns to the pre-shock level to increasing U.S. and Japanese stock return shocks. In contrast, the Korean stock return rises immediately and returns to the pre-shock level to the same shocks. This result is consistent with the findings of Phylaktis and Ravazzolo (2005), who argue that an increase in the U.S. stock market causes the local stock market to rise as a result of the greater integration between Pacific Basin countries' markets and world markets. Compared to the required period to return to the steady-state level, responses in the Korean CDS spread change and the Korean stock return to increasing Japanese stock return shock are shorter by about one period (week) than responses in the Korean CDS spread change and the Korean stock return to the increasing U.S. stock return shock. This implies that change in the U.S. stock market has a longer effect on the movement in the Korean CDS market and the Korean stock market than change in the Japanese stock market does.

Since the characteristics of CDS spread underlying government bonds is an indicator of country risk, the global financial crisis period is included in the data period. However, since the financial crisis has a temporary effect on the long-run co-movement of financial markets generally, there is a possibility that the trivariate GARCH model induces distorted results if the estimation process undergoes the data period which includes a structural break like a financial crisis (Phylaktis and Ravazzolo, 2005). Hence, I also conduct the empirical test under the same conditions with a different data period, which excludes the global financial crisis period.[36] In comparison with the results for the whole period, there is no remarkable difference between the two without the fact

[36] I segment the pre-global financial crisis period on the basis of the collapse of Lehman Brothers in September 2008 (37^{th} week of 2008) from the whole data period used in the main text.

that more significant return and volatility spillover effects exist in the case of the whole period than that of pre-global financial crisis period. It can be expected that risk transmission during the global financial crisis period works more strongly than usual. The results from the test with data for the pre-global financial crisis period are reported in Appendix 3C.

3.6 Conclusion

This chapter examines the return and volatility spillover effects among several domestic and foreign financial markets in Korea for the period from the first week of January 2002 to the fourth week of February 2010. In particular, the relationship between the CDS underlying the Korean government bond market, which uses CDS spread as an indicator implying country risk, and the Korean stock market, which is a representative domestic asset market, is the main focus. Two kinds of financial markets − foreign exchange markets and global and regional stock markets − are added to investigate the relationships along with the Korean stock market and the Korean CDS market in a model. This study employs the trivariate GARCH model to capture the return and volatility transmission mechanism. In addition, to account for the dynamic interactions among financial market returns and changes, impulse response analysis is conducted.

The answers to questions presented in the introductory section 3.1 can be summarized as follows. First, the return spillover effects from the two foreign exchange markets, Korean-U.S. and Korean-Japanese foreign exchange markets, to the Korean stock market and the Korean CDS market are significant. In the case of including the Korean-U.S. foreign exchange market in the model, there is a significant unidirectional return spillover effect from the Korean CDS market to the Korean stock market. On the other hand, there is a significant bidirectional return spillover effect between the Korean CDS market and the Korean stock market in the case of including the Korean-Japanese foreign exchange market in the model. In the meantime, a significant unidirectional volatility spillover effect from the Korean-U.S. foreign exchange market to the Korean CDS market and a bidirectional volatility spillover effect between the Korean CDS market and the Korean stock market. On the other hand, there are three significant unidirectional volatility spillover effects: that from the Korean-Japanese foreign exchange market to the Korean CDS market, from the Korean stock market to the Korean CDS market, and from the Korean stock market to the Korean-Japanese foreign exchange market.

Second, the return spillover effects from the U.S. stock market to the Korean stock market and the Korean CDS market are significant. In the case of including the U.S. stock market in the model, there is a significant unidirectional return spillover effect from the Korean stock market to the Korean CDS market. Meanwhile, a significant bidirectional volatility spillover effect exists between the Korean CDS market and the Korean stock market in the case of including the U.S. stock market in the model. On the other hand, the volatility spillover effects from the Japanese stock market to the Korean stock market and the Korean CDS market are significant. Additionally, there is a significant bidirectional volatility spillover effect between the Korean CDS market and the Korean stock market in the case of including the Japanese stock market in the model.

Third, the Korean stock return responds negatively, and the Korean CDS spread changes positively to increasing the two exchange rate change shocks. The Korean stock return responds negatively and the two exchange rate changes respond positively to the increasing Korean CDS spread change shock. Both the Korean CDS spread change and the two exchange rate changes respond positively to the increasing Korean stock return shock. Although there are some exceptions, it can generally be supposed that there is a negative relationship between the Korean CDS spread change and the Korean stock return, a positive relationship between exchange rate changes and the Korean CDS spread change, and a negative relationship between exchange rate changes and the Korean stock return.

Fourth, the Korean stock return responds positively and the Korean CDS spread change responds negatively to increasing U.S. and Japanese stock returns.

This study on return and volatility spillover effects among the CDS market, stock market, and foreign exchange market can provide useful information for risk analysis to domestic and foreign financial market participants. There is evidence that volatility transmission exists among these financial markets with some exceptions, increasing volatility in one financial market is a clear signal of increasing volatility in other financial markets. In particular, investors, financial market managers, and policy makers need to monitor the movements in CDS spread underlying government bonds, because this is an indicator of country risk. Stock market participants also need to observe exchange rate movements and dominant stock price movements, because they may have an impact on the cost of capital and stock market performance. Managers who deal with foreign exchange risk may also need to monitor developments in stock markets and movements in CDS markets.

Appendix 3A The Conditional Covariance Equations

$$h_{12,t} = \omega_{21}\omega_{22} + \omega_{31}\omega_{32} + \alpha_{11}\alpha_{12}\varepsilon_{1,t-1}^2 + \alpha_{21}\alpha_{22}\varepsilon_{2,t-1}^2 + \alpha_{31}\alpha_{32}\varepsilon_{3,t-1}^2 + (\alpha_{12}\alpha_{21} + \alpha_{11}\alpha_{22})\varepsilon_{1,t-1}\varepsilon_{2,t-1}$$

$$+(\alpha_{12}\alpha_{31} + \alpha_{11}\alpha_{32})\varepsilon_{1,t-1}\varepsilon_{3,t-1} + (\alpha_{22}\alpha_{31} + \alpha_{21}\alpha_{32})\varepsilon_{2,t-1}\varepsilon_{3,t-1} + \beta_{11}\beta_{12}h_{11,t-1} + \beta_{21}\beta_{22}h_{22,t-1}$$

$$+\beta_{31}\beta_{32}h_{33,t-1} + (\beta_{21}\beta_{12} + \beta_{11}\beta_{22})h_{12,t-1} + (\beta_{31}\beta_{12} + \beta_{11}\beta_{32})h_{13,t-1} + (\beta_{31}\beta_{22} + \beta_{21}\beta_{32})h_{23,t-1}$$

$$h_{13,t} = \omega_{31}\omega_{33} + \alpha_{11}\alpha_{13}\varepsilon_{1,t-1}^2 + \alpha_{21}\alpha_{23}\varepsilon_{2,t-1}^2 + \alpha_{31}\alpha_{33}\varepsilon_{3,t-1}^2 + (\alpha_{13}\alpha_{21} + \alpha_{11}\alpha_{23})\varepsilon_{1,t-1}\varepsilon_{2,t-1}$$

$$+(\alpha_{13}\alpha_{31} + \alpha_{11}\alpha_{33})\varepsilon_{1,t-1}\varepsilon_{3,t-1} + (\alpha_{23}\alpha_{31} + \alpha_{21}\alpha_{33})\varepsilon_{2,t-1}\varepsilon_{3,t-1} + \beta_{11}\beta_{13}h_{11,t-1} + \beta_{21}\beta_{23}h_{22,t-1}$$

$$+\beta_{31}\beta_{33}h_{33,t-1} + (\beta_{21}\beta_{13} + \beta_{11}\beta_{23})h_{12,t-1} + (\beta_{31}\beta_{13} + \beta_{11}\beta_{33})h_{13,t-1} + (\beta_{31}\beta_{23} + \beta_{21}\beta_{33})h_{23,t-1}$$

$$h_{23,t} = \omega_{32}\omega_{33} + \alpha_{12}\alpha_{13}\varepsilon_{1,t-1}^2 + \alpha_{22}\alpha_{23}\varepsilon_{2,t-1}^2 + \alpha_{32}\alpha_{33}\varepsilon_{3,t-1}^2 + (\alpha_{13}\alpha_{22} + \alpha_{12}\alpha_{23})\varepsilon_{1,t-1}\varepsilon_{2,t-1}$$

$$+(\alpha_{13}\alpha_{32} + \alpha_{12}\alpha_{33})\varepsilon_{1,t-1}\varepsilon_{3,t-1} + (\alpha_{23}\alpha_{32} + \alpha_{22}\alpha_{33})\varepsilon_{2,t-1}\varepsilon_{3,t-1} + \beta_{12}\beta_{13}h_{11,t-1} + \beta_{22}\beta_{23}h_{22,t-1}$$

$$+\beta_{32}\beta_{33}h_{33,t-1} + (\beta_{22}\beta_{13} + \beta_{12}\beta_{23})h_{12,t-1} + (\beta_{32}\beta_{13} + \beta_{12}\beta_{33})h_{13,t-1} + (\beta_{32}\beta_{23} + \beta_{22}\beta_{33})h_{23,t-1}$$

Appendix 3B Coefficients of Trivariate GARCH Model

Table 3B.1: Coefficients of Multivariate GARCH Model for Case I and Case II

	Case I			Case II		
	$i = 1$	$i = 2$	$i = 3$	$i = 1$	$i = 2$	$i = 3$
μ_i	-0.002***	-0.008**	0.005***	0.002	-0.005***	0.006***
	(-2.710)	(-2.362)	(4.247)	(0.734)	(-7.346)	(16.31)
γ_{i1}	0.187**	1.003***	-0.193**	-0.279***	0.244***	-0.134***
	(2.470)	(3.761)	(-2.031)	(-4.068)	(6.869)	(-6.194)
γ_{i2}	0.004	-0.041	0.027**	0.036	0.013	-0.017***
	(0.649)	(-0.793)	(2.024)	(1.306)	(0.939)	(-3.586)
γ_{i3}	0.018	0.090	-0.051	0.039	0.074***	-0.185***
	(0.862)	(0.775)	(-1.134)	(0.460)	(3.165)	(-8.652)
ω_{1i}	-0.000			0.000		
	(-0.000)			(0.000)		
ω_{2i}	0.002	-0.008		0.001	0.006	
	(0.222)	(-0.341)		(0.014)	(0.142)	
ω_{3i}	-0.001	0.012	0.018***	0.000	0.012	-0.001
	(-1.458)	(1.611)	(10.12)	(0.014)	(0.620)	(-0.637)
α_{1i}	0.498***	0.950***	-0.145	0.068*	0.062*	-0.009
	(6.852)	(3.545)	(-1.529)	(1.684)	(1.763)	(-0.367)
α_{2i}	0.002	0.416***	-0.064***	0.010	0.463***	0.005
	(0.142)	(7.747)	(-3.573)	(0.442)	(39.78)	(0.740)
α_{3i}	-0.047	-0.367**	0.528***	-0.143*	-0.154***	0.807***
	(-1.118)	(-2.482)	(8.127)	(-1.793)	(-6.539)	(30.88)
β_{1i}	0.914***	-0.130	-0.055	0.998***	0.023	0.014
	(29.78)	(-0.932)	(-0.707)	(107.6)	(0.383)	(0.392)
β_{2i}	0.009	0.894***	-0.058*	-0.009	0.698***	-0.007
	(0.739)	(15.94)	(-1.838)	(-0.385)	(86.47)	(-1.484)
β_{3i}	0.070	0.210	0.477***	0.055	0.069***	0.723***
	1.295)	0.857)	(3.869)	(1.471)	(5.067)	(80.77)

Note: (Case I) i=1: Won/dollar exchange rate change, i=2: Korean CDS spread change, i=3: Korean stock return. (Case II) i=1: Won/yen exchange rate change, i=2: Korean CDS spread change, i=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Table 3B.2: Coefficients of Multivariate GARCH Model for Case III and Case IV

	Case III			Case IV		
	$i = 1$	$i = 2$	$i = 3$	$i = 1$	$i = 2$	$i = 3$
μ_i	-0.005 (-0.928)	-0.004 (-0.549)	0.002 (1.026)	0.001 (0.587)	-0.001 (-0.201)	0.003 (1.498)
γ_{i1}	0.094 (0.473)	-0.774*** (-2.588)	0.402*** (5.002)	0.032 (0.469)	-0.021 (-0.088)	-0.003 (-0.053)
γ_{i2}	-0.001 (-0.012)	0.061 (0.678)	-0.012 (-0.464)	-0.037* (-1.759)	0.128** (2.382)	-0.033 (-1.428)
γ_{i3}	-0.236 (-1.537)	0.565** (2.380)	-0.347*** (-5.019)	-0.101 (-1.487)	0.166 (0.580)	-0.116 (-1.627)
ω_{1i}	0.000 (0.000)			0.000 (0.000)		
ω_{2i}	-0.036 (-0.203)	0.027 (0.193)		-0.003 (-0.061)	-0.025 (-0.180)	
ω_{3i}	-0.006 (-0.285)	-0.044 (-1.151)	0.024*** (2.623)	0.004 (0.342)	-0.031 (-0.277)	0.003 (0.211)
α_{1i}	0.281 (1.102)	0.047 (0.090)	0.060 (0.496)	0.078 (1.136)	1.003*** (3.774)	-0.291*** (-4.513)
α_{2i}	-0.231*** (-3.145)	0.615*** (4.355)	-0.145*** (-2.715)	-0.045*** (-3.691)	0.090* (1.813)	-0.057*** (-3.038)
α_{3i}	-0.054 (-0.236)	0.613* (1.800)	0.103 (0.918)	0.182** (2.550)	-1.500*** (-8.345)	0.404*** (5.823)
β_{1i}	0.473 (0.582)	-0.498 (-0.374)	0.037 (0.105)	1.207*** (24.45)	-0.070 (-0.391)	0.180*** (3.099)
β_{2i}	0.111 (0.818)	0.853*** (3.750)	-0.012 (-0.233)	0.038*** (2.609)	0.711*** (12.14)	0.108*** (6.867)
β_{3i}	0.246 (0.221)	1.206 (0.572)	0.509 (0.963)	-0.064 (-0.985)	-0.720*** (-2.987)	0.938*** (11.07)

Note: (Case III) i=1: U.S. stock return, i=2: Korean CDS spread change, i=3: Korean stock return. (Case IV) i=1: Japanese stock return, i=2: Korean CDS spread change, i=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level and * indicates significance at the 10% level.

Appendix 3C Estimates for the Pre-Global Financial Crisis Period

The estimated coefficients and standard errors of the conditional mean equations and conditional variance equations for Case I and Case II, which include foreign exchange markets as a third financial market, are reported in Table 3C.1. Estimated coefficients of equations (3.3) and (3.6), which are based on computing the coefficients of ARCH term and GARCH term in Table 3C.1, are reported in Appendix 3C.3. The data period is from the first week of January 2002 to the second week of September 2008.

First, seeing the result of the conditional mean equation in Case I, the return spillover effect from the lagged change of the won/dollar exchange rate to the current own-market-change is significant. The coefficient is 0.147 (γ_{11}), and it is significant at the 5% level. There is no return spillover effect from the lagged change of the Korean CDS spread to the current own-market-return and cross-market return. Conditional return spillover effects from the lagged Korean stock return to the current own-market-return and current Korean-U.S. foreign exchange market change are significant (-0.125 (γ_{33}, 5%) and 0.035 (γ_{13}, 10%), respectively).

Second, seeing the result of the conditional variance equation in Case I, the persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all *i*=*j*) for the Korean-U.S. foreign exchange market, the Korean CDS market, and the Korean stock market are 0.659, 0.704, and 0.973, respectively, and all of these coefficients are significant at the 1% level. All three financial market return and changes are significant at the 1% level of critical value in terms of own-market-volatility spillover effects (0.073, 0.076, and 0.011, respectively). Examining the cross-market volatility spillover effect, there are no significant volatility spillover effects from the won/dollar exchange rate change to the Korean CDS spread change and the Korean stock return. However, volatility spillover effects from the Korean stock return to the won/dollar exchange rate change and the Korean CDS spread change are significant at 0.002 (1%) and 0.079 (10%), respectively. On the other hand, the volatility spillover effect from the Korean CDS spread change to the Korean stock return is significant at 0.003 (5%).

Third, seeing the result of the conditional mean equation in Case II, return spillover effects from the lagged change of the won/yen exchange rate to the current Korean CDS spread change and the current Korean stock return are 0.124 (γ_{21}) and -0.134 (γ_{31}), respectively. They are statistically significant at the 1% and 10% levels, respectively. The lagged change of the Korean CDS spread has conditional return spillover effects on the current own-market-return and the current Korean stock return at the 1% level of critical value, with coefficient values of 0.110 (γ_{22}) and 0.014 (γ_{32}), respectively. The lagged Korean stock return has a conditional return spillover effect on the current Korean CDS spread change and current return of own market at the 1% level with coefficient values of 0.077 (γ_{23}) and -0.115 (γ_{33}), respectively.

Fourth, seeing the result of the conditional variance equation in Case II, the persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all i=j) for the Korean-Japanese foreign exchange market, the Korean CDS market, and the Korean stock market are 1.018, 0.487, and 0.608, respectively, and all of these coefficients are significant at the 1% level. The Korean CDS spread change and the Korean stock return are significant at the 1% level in terms of own-market-volatility spillover effect, and those estimates are 0.065 and 0.245, respectively. Examining the cross-market volatility spillover effect, that from the Korean CDS spread change to the Korean stock return (2.59e-5, 1%) is statistically significant.

Table 3C.1: Estimates of Trivariate GARCH Model for Case I and Case II

	Case I			Case II		
Return Spillover Effect (Mean Equation)						
γ_{ij}	$i=1$	$i=2$	$i=3$	$i=1$	$i=2$	$i=3$
γ_{i1}	0.147** (0.071)	-0.011 (0.724)	0.062 (0.224)	-0.090 (0.338)	0.124*** (0.013)	-0.021* (0.011)
γ_{i2}	0.004 (0.007)	0.047 (0.079)	-0.018 (0.023)	-0.009 (0.046)	0.110*** (0.005)	0.014*** (0.003)
γ_{i3}	0.035* (0.019)	0.022 (0.239)	-0.125** (0.062)	-0.004 (0.140)	0.077*** (0.007)	-0.115*** (0.008)
Volatility Spillover Effect (Variance Equation)						
h_{ij}	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$
$\varepsilon^2_{1,t-1}$	0.073*** (0.065)	0.575 (0.794)	0.012 (0.243)	2.96 e-5 (0.141)	2.05 e-5 (0.006)	1.58e-5 (0.007)
$\varepsilon^2_{2,t-1}$	1.17e-5 (0.009)	0.076*** (0.080)	0.003** (0.020)	9.28e-6 (0.019)	0.065*** (0.002)	2.59e-5*** (0.002)
$\varepsilon^2_{3,t-1}$	0.002*** (0.018)	0.079* (0.168)	0.011** (0.051)	1.37e-4 (0.113)	5.40e-6 (0.406)	0.245*** (0.008)
$h_{11,t-1}$	0.659*** (0.085)	0.041 (0.666)	1.461*** (0.270)	1.018*** (0.002)	4.41e-5 (0.008)	3.02e-5 (0.006)
$h_{22,t-1}$	2.68e-4 (0.012)	0.704*** (0.072)	0.001 (0.039)	6.72e-5 (0.030)	0.487*** (0.002)	2.74e-5** (0.003)
$h_{33,t-1}$	0.016*** (0.024)	0.074 (0.173)	0.973*** (0.081)	8.03e-5 (0.063)	2.49e-5** (0.002)	0.608*** (0.003)

Note: (Case I) i=1: Won/dollar exchange rate change, i=2: CDS spread change, i=3: Korean stock return. (Case II) i=1: Won/yen exchange rate change, i=2: CDS spread change, i=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

The estimated coefficients and standard errors of the conditional mean equations and conditional variance equations for Case III and Case IV, which include advanced economy stock markets as the third financial market, are reported in Table 3C.2. Estimated coefficients of equations (3.3) and (3.6), which are based on computing the coefficients of the ARCH term and GARCH term in Table 3C.2, are reported in Appendix 3C.4. The data period is from the first week of January 2002 to the second week of September 2008.

First, the result of the conditional mean equation in Case III indicates that return spillover effects from the lagged U.S. stock return to the current Korean CDS spread change is significant. The coefficient is -0.923 (γ_{21}), and it is significant at the 5% level. The conditional return spillover effect from the lagged Korean stock return to the current own-market-return is significant (-0.191 (γ_{33}, 5%)).

Second, the result of the conditional variance equation in Case III indicates that the persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all *i*=*j*) for the U.S. stock market, the Korean CDS market, and the Korean stock market are 0.810 (1%), 0.831 (1%), and 0.354 (10%), respectively. The Korean CDS spread change and the Korean stock return are significant at the 1% level of critical value in terms of own-market-volatility spillover effects (0.033 and 0.111, respectively).

Third, the result of the conditional mean equation in Case IV indicates that the lagged return of Korean stock has a conditional return spillover effect on the current own-market return at the 10% significance level with a coefficient value of -0.127 (γ_{33}).

Fourth, the result of the conditional variance equation in Case IV indicates that the persistence of volatility (see the significance of $h_{ij,t}$ and $h_{ij,t-1}$ for all *i*=*j*) for the

Table 3C.2: Estimates of Trivariate GARCH Model for Case III and Case IV

	Case III			Case IV		
Return Spillover Effect (Mean Equation)						
γ_{ij}	$i = 1$	$i = 2$	$i = 3$	$i = 1$	$i = 2$	$i = 3$
γ_{i1}	0.010 (0.088)	-0.923** (0.467)	0.162 (0.140)	0.023 (0.081)	-0.067 (0.300)	0.025 (0.088)
γ_{i2}	-0.004 (0.017)	0.055 (0.087)	0.043 (0.027)	-0.022 (0.022)	0.042 (0.061)	-0.003 (0.024)
γ_{i3}	-0.058 (0.058)	0.416 (0.299)	-0.191** (0.085)	-0.070 (0.068)	0.068 (0.290)	-0.127* (0.077)
Volatility Spillover Effect (Variance Equation)						
h_{ij}	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$	$h_{11,t}$	$h_{22,t}$	$h_{33,t}$
$\varepsilon^2_{1,t-1}$	0.032 (0.176)	0.673 (0.922)	0.281 (0.344)	6.78e-5 (0.136)	0.494* (0.380)	0.018 (0.127)
$\varepsilon^2_{2,t-1}$	3.40e-6 (0.025)	0.033*** (0.064)	2.73e-4 (0.030)	0.002*** (0.018)	0.012* (0.064)	0.002*** (0.014)
$\varepsilon^2_{3,t-1}$	0.064*** (0.072)	0.020 (0.332)	0.111*** (0.117)	0.024* (0.083)	0.369*** (0.230)	0.008 (0.085)
$h_{11,t-1}$	0.810*** (0.144)	1.171* (0.642)	0.035 (0.303)	0.901*** (0.055)	0.001 (0.233)	4.46e-5 (0.054)
$h_{22,t-1}$	0.001 (0.050)	0.831*** (0.207)	0.015 (0.086)	4.89e-4 (0.020)	0.780*** (0.075)	4.51e-4 (0.018)
$h_{33,t-1}$	0.001 (0.186)	0.956 (0.659)	0.354* (0.317)	0.001 (0.054)	0.062 (0.196)	1.024*** (0.048)

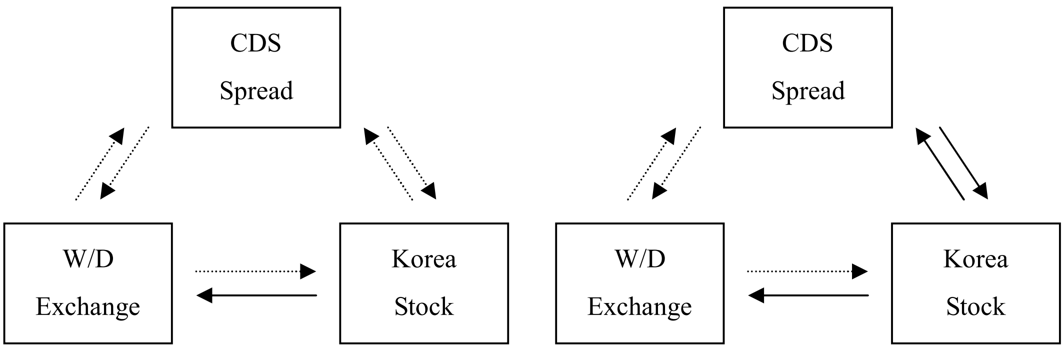
Note: (Case III) *i*=1: U.S. stock return, *i*=2: Korean CDS spread change, *i*=3: Korean stock return. (Case IV) *i*=1: Japanese stock return, *i*=2: Korean CDS spread change, *i*=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Japanese stock market, the Korean CDS market, and the Korean stock market are 0.901, 0.780, and 1.024, respectively, and all of these coefficients are strongly significant at the 1% level. Examining the cross-market volatility spillover effect, there are three significant and meaningful spillover effects: from the Japanese stock return to the Korean CDS spread change (0.494, 10%), from the Korean CDS spread change to the Korean stock return (0.002, 1%), and from the Korean stock return to the Korean CDS spread change (0.369, 1%).

Figure 3C.1: Return and Volatility Spillover Effects for Case I and Case II

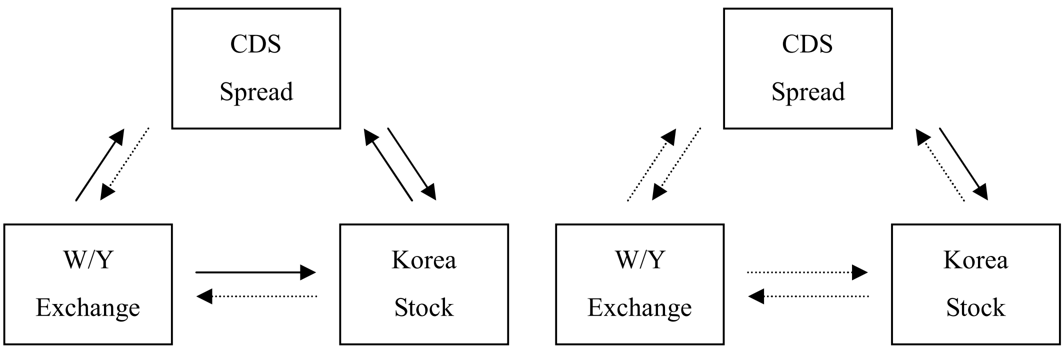
(Case I) Won/dollar exchange rate change – CDS spread change – Korean stock return

(a) Return Spillover Effect (b) Volatility Spillover Effect



(Case II) Won/yen exchange rate change – CDS spread change – Korean stock return

(a) Return Spillover Effect (b) Volatility Spillover Effect



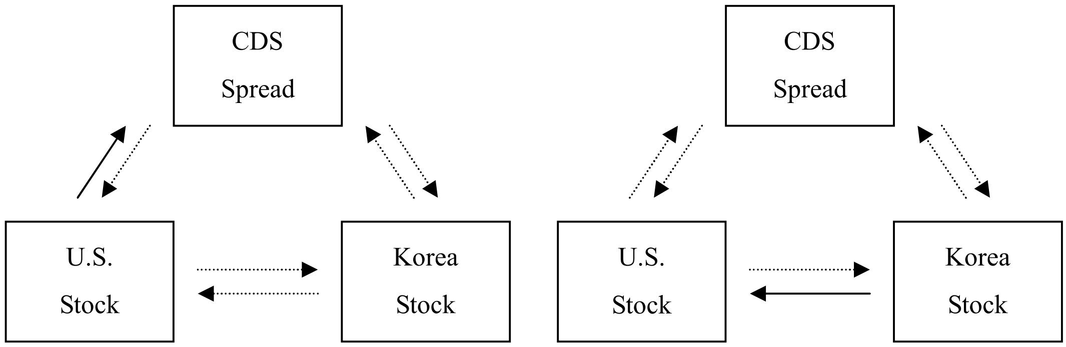
Note: —— denotes significant spillover effect, and ········ denotes insignificant spillover effect

For better understanding, simple figures for the results of return and volatility spillover effects for Case I and Case II are presented in Figure 3C.1 and for Case III and Case IV are presented in Figure 3C.2.

Figure 3C.2: Return and Volatility Spillover Effects for Case III and Case IV

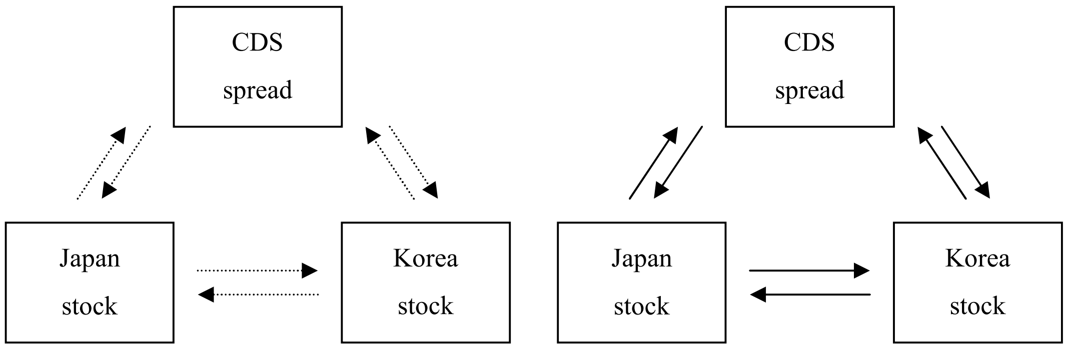
(Case III) U.S. stock return – CDS spread change – Korean stock return

(a) Return Spillover Effect (b) Volatility Spillover Effect



(Case IV) Japanese stock return – CDS spread change – Korean stock return

(a) Return spillover effect (b) Volatility spillover effect



Note: —— denotes significant spillover effect, and ┈┈ denotes insignificant spillover effect

Upon comparison of the results in Figure 3C.1 with those of Figure 3.5, two remarkable differences appear. One is the significant return spillover effect from the

Korean-U.S. foreign exchange market on the two Korean financial markets, and another is the significant volatility spillover effect from the two foreign exchange markets on the Korean CDS market. This implies that amplified economic and financial market uncertainty in the world during the global financial crisis was transmitted to the Korean economy through the foreign exchange market.

Comparison of the results in Figure 3C.2 with those of Figure 3.8 reveals a difference; that is, a significant return spillover effect from the U.S. stock market on the Korean stock market. This finding is in line with the finding of Angkinand *et al*. (2009), who indicate that the degree of interdependence and spillover effects between the U.S. stock market and advanced economy stock markets are greatest after the collapse of Lehman Brothers in September 2008.

Table 3C.3: Coefficients of Multivariate GARCH Model for Case I and Case II

	Case I			Case II		
	$i=1$	$i=2$	$i=3$	$i=1$	$i=2$	$i=3$
μ_i	-0.001 (-0.919)	-0.003 (-0.478)	0.003* (1.787)	0.000 (0.096)	0.001*** (2.838)	0.005*** (31.52)
γ_{i1}	0.147** (2.080)	-0.011 (-0.015)	0.062 (0.276)	-0.090 (-0.267)	0.124*** (9.338)	-0.021* (-1.822)
γ_{i2}	0.004 (0.595)	0.047 (0.592)	-0.018 (-0.769)	-0.009 (-0.203)	0.110*** (24.47)	0.014*** (5.086)
γ_{i3}	0.035* (1.840)	0.022 (0.093)	-0.125** (-2.034)	-0.004 (-0.028)	0.077*** (11.44)	-0.115*** (-14.89)
ω_{1i}	-0.000 (-0.000)			-0.000 (-0.000)		
ω_{2i}	0.000 (0.015)	0.030 (0.065)		0.000 (0.004)	0.005*** (17.40)	
ω_{3i}	0.000 (0.007)	0.024 (0.042)	0.002 (0.050)	-0.002 (-0.013)	0.000 (0.051)	0.000 (0.064)
α_{1i}	0.270*** (4.144)	-0.758 (-0.954)	-0.110 (-0.453)	-0.005 (-0.039)	0.005 (0.797)	0.004 (0.531)
α_{2i}	0.003 (0.391)	0.276*** (3.430)	-0.051** (-2.487)	0.003 (0.163)	0.255*** (132.3)	0.005*** (2.668)
α_{3i}	0.046*** (2.575)	0.280* (1.665)	0.105** (2.039)	0.012 (0.104)	0.002 (0.406)	0.495*** (58.22)
β_{1i}	0.812*** (9.506)	0.204 (0.305)	1.209*** (4.474)	1.009*** (436.8)	0.007 (0.852)	0.005 (0.912)
β_{2i}	-0.016 (-1.392)	0.839*** (11.71)	-0.028 (-0.698)	-0.008 (-0.276)	0.698*** (301.9)	0.005** (2.032)
β_{3i}	-0.125*** (-5.247)	-0.272 (-1.571)	0.986*** (12.17)	-0.009 (-0.143)	0.005** (2.326)	0.780*** (230.5)

Note: (Case I) i=1: Won/dollar exchange rate change, i=2: Korean CDS spread change, i=3: Korean stock return. (Case II) i=1: Won/yen exchange rate change, i=2: Korean CDS spread change, i=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Table 3C.4: Coefficients of Multivariate GARCH Model for Case III and Case IV

	Case III			Case IV		
	$i = 1$	$i = 2$	$i = 3$	$i = 1$	$i = 2$	$i = 3$
μ_i	0.000	-0.003	0.003	0.002	-0.001	0.004**
	(0.361)	(-0.386)	(1.586)	(1.272)	(-0.116)	(2.323)
γ_{i1}	0.010	-0.923**	0.162	0.023	-0.067	0.025
	(0.115)	(-1.977)	(1.158)	(0.285)	(-0.224)	(0.289)
γ_{i2}	-0.004	0.055	0.043	-0.022	0.042	-0.003
	(-0.252)	(0.634)	(1.576)	(-1.005)	(0.676)	(-0.134)
γ_{i3}	-0.058	0.416	-0.191**	-0.070	0.068	-0.127*
	(-0.998)	(1.390)	(-2.237)	(-1.025)	(0.234)	(-1.645)
ω_{1i}	0.000			0.000		
	(0.000)			(0.000)		
ω_{2i}	-0.007	0.039		-0.001	0.017	
	(-0.577)	(0.561)		(-0.033)	(0.274)	
ω_{3i}	-0.000	0.014	0.012	0.006	-0.029	0.003
	(-0.016)	(0.169)	(0.908)	(1.085)	(-0.645)	(0.709)
α_{1i}	0.178	0.820	0.530	-0.008	0.703*	0.132
	(1.009)	(0.890)	(1.543)	(-0.060)	(1.849)	(1.042)
α_{2i}	0.002	0.183***	-0.017	-0.046***	0.107*	-0.041***
	(0.075)	(2.869)	(-0.557)	(-2.588)	(1.680)	(-2.964)
α_{3i}	-0.253***	0.140	-0.333***	-0.155*	-0.608***	-0.089
	(-3.527)	(0.422)	(-2.834)	(-1.873)	(-2.639)	(-1.055)
β_{1i}	0.900***	-1.082*	0.188	0.949***	0.037	-0.007
	(6.266)	(-1.684)	(0.620)	(17.23)	(0.157)	(-0.124)
β_{2i}	0.029	0.911***	-0.123	0.022	0.883***	0.021
	(0.575)	(4.410)	(-1.423)	(1.105)	(11.84)	(1.177)
β_{3i}	0.026	0.978	0.595*	0.037	-0.248	1.012***
	(0.139)	(1.484)	(1.877)	(0.695)	(-1.266)	(21.12)

Note: (Case III) i=1: U.S. stock return, i=2: Korean CDS spread change, i=3: Korean stock return. (Case IV) i=1: Japanese stock return, i=2: Korean CDS spread change, i=3: Korean stock return. The values in parentheses are standard errors. *** indicates significance at the 1% level, ** indicates significance at the 5% level, and * indicates significance at the 10% level.

Ch.4 The Business Cycle, Monetary Policy, and the Housing Market in Korea

4.1 Introduction

During the last three decades, many industrialized and emerging countries have experienced fluctuations in housing prices (Iacoviello, 2002). Korea is no exception to this trend. These fluctuations in housing prices have been closely connected with the fluctuations in macroeconomic and financial market variables in general. Since housing investment and imputed rent of homeowners play a significant role in the economy, the housing market forms a critical part of the domestic economy in scale and ripple effect.[37] In addition, housing prices, as a tangible variable of housing market fluctuations, can have a significant effect on household consumption and saving, business investment, and cost of production. In contrast, macroeconomic variables have a decisive effect on the housing business cycle and housing prices. As such, the housing market is one of the more notable asset markets which has attracted a number of researchers with its intriguing relationships with various aspects, including the business cycle, monetary policy, and the transmission mechanism. Thus, examining the relationships between movements in housing prices and macroeconomic fluctuations in

[37] Housing investment is the sum of the cost of building new houses on residential premises (net of land value) and the additional value from extending or remodelling existing houses. World Bank (1993, p. 103) reported that the average housing investment of several countries in the world accounts for 2 to 8% of GDP and 10 to 30% of gross fixed capital formation. In the case of Korea, the ratio of housing investment to GDP was on average 5%, and the ratio of housing investment to gross fixed capital formation was around 18% during the period 1970 to 2009. Although the housing investment rate was 3% in Korea in the early 1970s and remained at 4 to 5% until 1988, it rose sharply in 1989, due to the implementation of the two million housing unit construction plan. For this reason, the housing investment rate peaked at 9% in 1991. Since then, the ratio gradually decreased to 7% in 1997, and to 4% in 2000, and it has stabilized around 4 to 5% until 2009.

Korea is the main objective in this chapter. In particular, this chapter focuses on three relationships: between housing prices and the business cycle, between housing prices and monetary policy, and between housing prices and rental prices.

Housing market fluctuations exert strong and broad influence on the business cycle of a country, as housing investment has a significant effect on production, employment, and income. Leamer (2007) notes the close relationship between the housing market and the business cycle. He refers to the fact that housing starts and the change in housing starts are the best forward-looking indicator of the business cycle, since residential investment provides the best early warning sign of an oncoming recession in the components of GDP. In support of this, housing investment has been empirically identified as a significant factor of the business cycle. Green (1997) reports that housing investment causes change in GDP, but innovation in GDP does not cause housing investment, according to the Granger causality test. However, the case of Korea shows a result in contrast to Green's claim. According to Kim's (2004) analysis of the causality between housing investment and GDP, change in GDP causes a change in housing investment, but innovation in housing investment does not cause change in GDP.

Assuming that the housing market plays a significant role in the domestic economy, if output and price levels are determined by aggregate demand and aggregate supply, it is necessary to examine how housing prices affect aggregate demand and aggregate supply. For instance, an increase in housing prices can have a positive influence on GDP and prices through its effect on aggregate demand and aggregate supply. On the other hand, an increase in real GDP will drive up the demand for housing. In addition, when the general level of prices rises, the price of real estate including houses rises, which stems from increased demand for assets, like real estate, to hedge the risk of inflation and increasing cost of production for houses and other buildings. Hence, housing market fluctuations and changes in output and prices affect each other. This is also consistent with Kim and Son's (2010) analysis of the correlation between housing prices and several macroeconomic variables in Korea for the period 1975-2009. Their analysis indicates that there are strong correlations between nominal GDP and housing prices and between the consumer price index and housing prices.

Along with output and prices, as with other assets, housing prices are affected by changes in money supply and interest rates. Since the interest rate reflects the state of capital supply and demand in the economy, it is closely related to each financial institution's policy and attitude toward granting loans. In particular, monetary policy typically uses money supply or the interest rate to define an intermediate goal and stable economic growth with price stabilisation to define a long-term goal.[38] When money supply is increased, interest rates fall, which then leads to an increase in output following a rise in private consumption and investment demand. In contrast, a decline in money supply and a rise in interest rates have a function to suppress excessive inflation. Adding to this, Elbourne (2008) contends that the interest rate has an indirect effect on the consumption level through housing prices. That is, a higher interest rate leads to lower housing prices and lower household consumption, because the real value

---

[38] Korea adopted monetary targeting which set M2 as an intermediate goal and had enforced it from 1979 to 1997. However, in the late 1990s, usefulness of monetary indicators has been outlived because of structural shifts in the relation between monetary aggregates, GDP and inflation. For this reason, inflation targeting was adopted on an amendment of the bank law of Korea in late 1997, and the Bank of Korea has operated a new system to achieve the established target for prices using call rate as an operational goal since 1998.

of household assets is reduced.[39]

There is an ongoing argument about whether and how the monetary authority should respond to housing market fluctuations. This argument is related to the question whether pre-emptive intervention by the central bank is necessary to prevent violent fluctuations in asset prices, including housing prices. Bernanke (2010) and Mishkin (2008) suggest an asymmetric monetary policy response to asset price fluctuations. More specifically, they argue that the central bank should lower the interest rate when asset prices fall, whereas there is no need to increase interest rate in the case of a rise in asset price. On the other hand, Roubini (2006) disputes that pre-emptive monetary policy is necessary for stabilisation of the financial system. Taylor (2009) suggests that, if the central bank implements monetary policy under the Taylor rule, the range of fluctuation in the housing market will become smaller.[40] Although there are varying views on the topic, this argument serves as evidence that it is generally felt that housing price inflation and deflation should be considered when formulating monetary policy because of significant effects of the housing market on the economy.

This chapter seeks to analyse the contribution of the housing market to the business cycle and study the effect of monetary policy on the housing market. It does so by examining how changes in two housing market prices − housing prices and rental prices − interact with key macroeconomic fluctuations in Korea by specifying the characteristics of the relationships between variables. The key variables used in this analysis for the Korean housing market are two primary housing market indices:

[39] Private consumption, which accounts for the largest portion of aggregate demand, is a function of real disposable income. But if the real value of assets possessed by private sector increases, private consumption grows due to the wealth effect.

[40] The Taylor rule is a monetary policy rule that stipulates how much the central bank should change the nominal interest rate in response to changes in inflation, output, or other economic conditions.

housing sale price index and housing *chonsei* price index.

Chonsei is a unique dwelling system of total rent during the contract period. In this system, the tenant pays an upfront lump sum as a deposit to the house owner for the use of the property with no additional requirement for periodic rent payments. The interest earned on this lump sum deposit, therefore, provides the house owner with income during the contract period, typically two years. The deposit should be returned to the tenant when the contract expires. If the house owner does not return the *chonsei* deposit at maturity, the Korean legal system grants the tenant the right of full control over the property until the house owner returns the deposit. Therefore, the deposit money of the tenant is legally protected as an asset that can be claimed against the collateral value of the property. The *chonsei* system has been widely adopted with the rapid urbanisation that has occurred during the last few decades in Korea. Housing prices have increased because of the limited supply of housing in spite of the growing demand for housing due to expansion of city size during this period. *Chonsei* was an excellent alternative for those who could not afford to purchase a house and could not make the high interest payment. According to the Population and Housing Census Reports published in 2000 and 2010, the total number of households in Korea was 14.31 million in 2000 and 17.34 million in 2010.[41] Out of this total number of households, homeowners accounted for 7.75 million (54%) in 2000 and 9.39 million (54%) in 2010. Those who were under *chonsei* contracts accounted for 4.04 million (28%) in 2000 and 3.77 million (22%) in 2010. The remaining households were under monthly rent arrangement. Although the *chonsei* residential ratio to the entire ordinary households has fallen by as much as 6% over the course of 10 years, *chonsei* still

[41] www.census.go.kr

represents a significant portion of the overall dwelling system in Korea. Therefore, the *chonsei* price can provide a very meaningful indicator of the market value of housing services in Korea, together with housing prices.[42]

Along with these two housing market prices − housing price and *chonsei* price, four key macroeconomic variables − output, inflation, money demand, and the nominal interest rate − are used to construct a model for analysis of the Korean economy. These four macroeconomic variables were chosen not only because they have been empirically found to have close relationships with housing prices as introduced above, but also because these variables are used as key components of theory for housing market analysis. Since it is expected that there would be some cointegrating relationships between variables, a cointegrated VAR model is deemed to be a useful specification for their dynamics. This chapter follows the procedure of King, Plosser, Stock, and Watson (1991) (hereafter KPSW), and for the construction of cointegrating relationships to obtain economic restrictions, I refer to Gali (1992), Iacoviello (2002), Cho (2005), and Otto (2007). The approach by Gonzalo and Ng (2001) is then used to identify the structural shocks to the permanent and transitory components.

The main questions of this chapter are related to three relationships between variables. These are the relationship between the housing market and business cycle, the relationship between housing price and *chonsei* price within the housing market, and the relationship between monetary policy and the housing market in Korea. This chapter seeks to address the following questions. First, what characteristics are manifested in the relationships between housing market fluctuation and the business

[42] Hereafter, in order to prevent confusion in terminology, the term housing price is used in place of housing sale price, and *chonsei* price in place of housing *chonsei* price.

cycle in Korea? Does the business cycle effectively account for housing market fluctuations? Second, what characteristics of the two housing markets are shown, and how do they affect each other? Third, should the monetary authority take into consideration fluctuations in the housing market when establishing monetary policy? If they should, what effects on housing market fluctuations are brought about by changes in monetary policy? In response to these questions, the research findings in this chapter suggest the following relationships: a positive relationship between housing market fluctuation and the business cycle, a strong positive relationship between housing price and *chonsei* price, and a negative relationship between monetary policy and real housing prices, where tight monetary policy leads to a decrease in real housing prices.

The remainder of this chapter is organised as follows. Section 4.2 provides a brief overview of the literature on business cycles, monetary policy, and the housing market. Section 4.3 outlines the methodology and theoretical background to the investigation of the relationships among variables. Section 4.4 provides a description of the data and reports the results of basic tests for data. Section 4.5 discusses the empirical results which are followed by conclusions presented in section 4.6.

4.2 Literature Review

Housing plays an important role in macroeconomic fluctuations, not only because housing investment is a very volatile component of demand (Bernanke and Gertler, 1995), but also because changes in housing prices can have important wealth effects on consumption (IMF, 2000) and investment (Topel and Rosen, 1988). As awareness of the importance of the housing market from both a macroeconomic point of view and an asset point of view is growing, quite significant research findings have been accumulating.

Following the real business cycle model of Kydland and Prescot (1982), the home production models are the first papers to specify explicitly a different purpose for residential investment rather than investment in market capital to examine the role of housing in the business cycle.[43] On the other hand, Davis and Heathcote (2005) investigate the ability of a multi-sector growth model to overcome the weak points of assumptions about housing in the home production model and to replicate three facts: residential investment is more than twice as volatile as business investment; consumption, residential, and non-residential investment co-move positively; and residential investment leads the business cycle, whereas non-residential investment lags. They succeed in accounting for the first two of three facts using their model, but they fail to explain the third fact, that residential investment leads the business cycle.

Regarding the third fact presented by Davis and Heathcote (2005), although not an analysis which uses a special method, Leamer (2007) extracts the essence of relationships among the business cycle, housing, and monetary policy and describes the overall economic trends of the U.S. He finds that, of the components of GDP, residential investment offers by far the best early warning sign of an oncoming recession, and housing plays an important role in the conduct of monetary policy. Since he acknowledges the fact that housing is the forward-looking indicator of the

[43] Examples of the neoclassical growth model augmented with home production are Benhhabib et al. (1991) and Greenwood and Hercowitz (1991). Chang and Hornstein (2006) also provide summaries about the home production model.

cycle, he argues that a preemptive anti-inflation monetary policy should be conducted in the middle of the expansions when housing is not so sensitive to interest rates to make recessions less frequent and/or less severe.

Recently, Iacoviello and Neri (2010) develop a dynamic stochastic general equilibrium (DSGE) model which employs Bayesian methods to examine the housing market spillovers using U.S. data. Their model explains well the facts that housing prices and housing investment are strongly procyclical, volatile, and sensitive to monetary shocks. They also find that monetary factors play an important role in explaining the housing market cycle. They conclude that the spillovers from the housing market to the economy are non-negligible and have become more important over time.

Along with the housing market relationship to the business cycle, another area of interest among researchers regarding housing market fluctuation is the monetary policy effect on the housing market. As Maclennan *et al*. (2000) and Elbourne (2008) note, there are both direct and indirect ways in which monetary policy may be transmitted through the housing market. The direct effect is an income or cash flow effect. When the interest rate rises, the interest burden of any outstanding debt rises and after-housing-costs disposable income falls. The indirect effects are wealth effects and credit channel effects. Increases in real housing prices give individuals more assets to spend throughout their lifetimes. Hence, they can increase their consumption because of this increase in wealth. A credit channel of monetary transmission works as follows. Higher interest rates reduce housing wealth and households' access to credit through lower collateral levels. Credit-constrained households must reduce their consumption spending following a fall in housing prices (see Bernanke and Blinder, 1988, and

Bernanke and Gertler, 1995, for more on the credit channel).

Iacoviello (2002) finds that monetary policy has a significant effect on housing prices for six countries in Europe with five variables: GDP, money, housing price, interest rate, and inflation, using a VAR analysis with the common trend approach of KPSW (1991) to identify structural shocks. An extension of this study, Iacoviello and Minetti (2007), analyses the credit channel, or bank lending channel, which is one of the monetary policy transmission channels, of the household's demand side focusing on the housing market for four countries in Europe using the VAR model. They show an evident relationship between the presence of the credit channel, efficiency of housing finance, and type of institutions active in mortgage provision.

Mishkin (2007) examines the role of housing in the monetary transmission mechanism and explores the implications of knowledge for the conduct of monetary policy. To examine how monetary policy affects the housing market and overall economy by raising or lowering short-term interest rates, he reviews the theoretical and empirical housing-related six channels of the monetary transmission mechanism. By raising or lowering short-term interest rates, monetary policy has a direct influence on the user cost of capital, expectations of future housing price movements, and housing supply, and indirectly influences the standard wealth effects from housing prices, balance sheet credit channel effects on consumer spending, and balance sheet credit channel effects on housing demand. He shows that housing is important in the monetary transmission mechanism.

Some empirical studies suggest evidence that housing plays an important role in the transmission of monetary policy. To explore the response of housing prices to a monetary policy shock, Iacoviello (2002), Iacoviello and Minetti (2003), Giuliodori (2005), and Elbourne (2008) employ a single-country VAR model. They report the great role of housing in the transmission of monetary policy, although housing prices across countries respond differently to changes in interest rates due to the country-specific characteristics of national mortgage markets. Iacoviello (2005) develops a monetary business cycle model with nominal loans and collateral constraints tied to housing values, and he evaluates the model by comparing the results of estimation with U.S. data. Bjornland and Jacobsen (2008) also use U.S. data to analyse the role of housing prices in the monetary policy transmission mechanism using the structural VAR (SVAR) model. They find that real housing prices fall immediately following a monetary policy shock, which raises the interest rate and interest rates respond systematically to housing price shocks. Vargas-Silva (2008) examines the impact of monetary policy shocks on the U.S. housing market using an identification procedure which imposes sign restrictions on the response of some variables. Their results indicate that housing starts and residential investment respond negatively to contractionary monetary policy shocks.

Goodhart and Hofmann (2008) suggest using a panel VAR model to increase the power and the efficiency of the analysis. They assess the link between real output, monetary variables, and housing prices for a panel of 17 OECD countries, and they find a significant relationship between these variables. Similarly, Carstensen et al. (2009) use a panel VAR model to explore empirically the role of housing for the transmission of monetary policy in a panel of 12 European countries, and they achieve evidence for the importance of the housing market in the transmission of monetary policy. Gupta and Kabundi (2010) assess the impact of monetary policy on housing price inflation for the nine census divisions of the U.S. economy using a factor-augmented VAR (FAVAR). They reach the result that housing price inflation responds negatively to a positive monetary policy shock.

Korean people typically have a strong desire to own their own homes. Even though they do not have their own houses, they demonstrate strong preference for leading a life independent from landlords. *Chonsei* is the most independent dwelling system apart from home ownership, because it offers residents every right without interference from landlords during the contract period. Additionally, Korean people think of the *chonsei* deposit as a kind of savings or asset without loss in nominal wealth, although no interest income is generated. That is why the trend of housing price and *chonsei* price are primary issues to individual housing decisions and, furthermore, these housing market fluctuations can have a significant impact on the domestic economy in Korea. Therefore, when analyzing the relationship between the housing market and macroeconomic variables in Korea, it is desirable to include the two housing prices at a time in a model in order to improve the accuracy of analysis.

Cho and Ma (2006) study the long-term relationship between housing values and interest rates in the Korean housing market using the cointegration test, Granger causality test, and spectral analysis. Their results show a long-term negative equilibrium relationship between housing values and interest rates and one-way causality from interest rate to the growth rate of housing values. Song (2008) examines the effects of monetary policy shocks on housing price, employing a structural VAR model with a sign restriction method to identify monetary shocks in Korea. He finds that technology shocks increase the housing price and decrease the interest rate, and contractionary monetary shocks affect housing price negatively. His study concludes that the change in housing price is affected more by other macroeconomic variables such as CPI inflation and real GDP than by autonomous monetary shocks. Kim and Lee (2009) note that the housing price is influenced by fluctuations in income and prices, and the change in housing price has an important effect on the movement of consumption and investment in Korea. To examine these relationships, they estimate correlations between the housing price and the key economic indicators. They report some findings that movement in GDP has the highest correlation with housing price, and the rate of housing price growth demonstrates slightly more volatility than the rate of economic growth and is pro-cyclical. Kim and Son (2010) indicate that change in housing investment has a significant influence on the overall business cycle and that there are strong correlations between GDP, CPI, and the housing price in Korea.

Few studies have been conducted about the *chonsei* system, although the *chonsei* is a common residential system in Korea. Son (2000) sets the model to explain the relationship between housing price and *chonsei* price using a no-arbitrage condition between asset markets including the real asset market. He carries out the regression analysis on the basis of a function in which the ratio of *chonsei* price to housing price can be explained by expected returns and every kind of cost associated with real estate. Cho (2005) insists that the ratio of housing price to *chonsei* price depends on the ratio of inflation to the real interest rate using an arbitrage condition between the housing price and *chonsei* price. From this fact, he draws a policy implication that, even when the monetary authority maintains a pre-announced target level of inflation rate, the relative rate of housing price to *chonsei* price rises if the real interest rate declines.

Previous research about the relationship between the housing market and macroeconomic variables in Korea mainly focuses on the investigation of each segmentalized issue. Many studies on the relationship between the housing market and the business cycle (Kim and Lee, 2009; Kim and Son, 2010), the relationship between housing price and monetary policy (Cho and Ma, 2006; Song, 2008), and the relationship between the house sale market and house *chonsei* market (Son, 2000; Cho, 2005) have been carried out sufficiently with various methods. This study is the first attempt to examine the dynamic effects between business cycle, monetary policy, and divided housing markets into house sale market and house *chonsei* market in a model for the Korean economy. Even the most similar study of Iacoviello (2002) on six European countries does not aim to investigate the relationship between housing price and rental price.

Following the findings of cointegration by Engle and Granger (1987), a vector error correction model (VECM) has been used to estimate the long-run equilibrium relationship between variables, and several methods have been developed for identification of structural shocks (KPSW, 1991; Cochrane, 1994; Gonzalo and Ng, 2001; Pagan and Pesaran, 2008). In particular, Gonzalo and Ng (2001) propose a systematic framework for analyzing the dynamic effects of permanent and transitory shocks on a VECM system of economic variables to recover the structural shocks with permanent and transitory effects.

To evaluate the fact that housing market shocks can explain macroeconomic fluctuations and vice versa, the stochastic trend properties of housing prices and macroeconomic variables in Korea are used in this chapter. Thus, in the next section, the model composed of cointegrating vectors on the basis of economic theory is set up, and the approach of Gonzalo and Ng (2001) as a methodology for identification of structural shocks to the permanent and transitory components is introduced.

4.3 Methodology and Theoretical Basis

Over the past decades, the Korean economy has witnessed a growth process in housing prices, and these housing prices have fluctuated according to typical business cycle frequencies (see Figures 4.2 and 4.3). To examine housing market fluctuation with other variables, appropriate methodology should be employed to estimate dynamic interactions between variables. Vector autoregression (VAR) analysis has become a popular tool in empirical macroeconomics and finance. An important element in these VAR-related models is the identification of structural shocks. In particular, when there are cointegrating relationships in variables, the VECM is appropriate in order to apply the cointegration restrictions reflecting economic theory and to separate permanent innovations, which are the source of the upward trend in real variables, from the transitory innovations.[44] In this section, I introduce several economic theories and ideas from previous related research and set up the expected cointegrating equations, which are interpreted as long-run equilibriums, to specify the VECM framework. To identify the structural shocks to permanent and transitory components, I also introduce Gonzalo and Ng's two-step approach.

[44] Kim and Lee (2005) argue that VECM is the most efficient method in various econometric methodologies to forecast the fluctuations in housing prices with macroeconomic factors in Korea. Their claim is based on their empirical results that the forecast error of VECM shows the smallest value compared with other methods such as the Autoregressive Distributed Lag (ADL) model and VAR model.

4.3.1 Cointegration Analysis

The VECM is modelled with six variables comprising two housing market prices and four macroeconomic variables. Three cointegrating relationships − between housing price and output, between housing price and *chonsei* price, and between inflation and the nominal interest rate − are explored on the basis of previous studies.[45] The choice of cointegration rank is critical to VECMs. Three is chosen as a cointegration rank based on the result of tests. In order to recover the structural shocks with permanent and transitory effects in the model, Johansen and Juselius (1992) suggest using restrictions which are derived from economic hypotheses about equilibrium relationships between the variables. Thus, the following three cointegrating equations are based on standard economic theories: the money demand equation, the ratio of output:housing price (hereafter output-house ratio) equation, and the ratio of *chonsei* price:house price (hereafter *chonsei*-house ratio) equation. These three cointegrating equations are used as cointegrating vectors in the VECM framework.

4.3.1.1 Money Demand

In theory, money demand has a positive relationship with output and a negative relationship with nominal interest rates. In particular, KPSW (1991) uses this relationship in terms of real money balances. This relationship can be written as follows:

[45] There is theoretical evidence that the real interest rate has stationary behaviour, called the Fisher equation. Fisher (1930) argues that the real interest rate does not change, since the nominal interest rate increases at the same time inflation increases. Kaldor (1961) notes that the real interest rate does not show a particular trend but is generally constant, which is one of six organized stylized facts of economic growth about long-run regularity in the growth process of the capitalist economy.

$$m_t - p_t = \mu_y y_t - \mu_i i_t + \nu_{1,t} \quad (4.1)$$

where $m_t - p_t$ is the logarithm of real money balances, y_t is the logarithm of real output, i_t is the nominal interest rate, and $\nu_{1,t}$ is the money-demand disturbance.[46] The secular rise in the price level in most countries suggests the possibility of a stochastic trend associated with the design of monetary policy; as suggested by Gali (1992), the central bank's desire to avoid output fluctuations may result in nominal instability, leading to a common trend between nominal rates, money balances, and output. Generally, the nominal demand for money increases with the level of nominal output (price level times real output) and decreases with the nominal interest rate. If real balances, output, and nominal interest rate are I(1), while the money-demand disturbance in equation (4.1) is I(0), then real balance, output, and nominal interest rate are cointegrated. Equation (4.1) is used as the first cointegrating equation in this chapter.

4.3.1.2 Output-House Ratio

To examine the question on the existence of a long-run relationship between housing price and output, Iacoviello (2002) adopts a suggestion from Poterba (1984) and uses the cointegrating relationship between the real housing price and GDP stemming from the idea of the same logarithm characteristics of trend.[47] Figure 4.1 shows the monthly

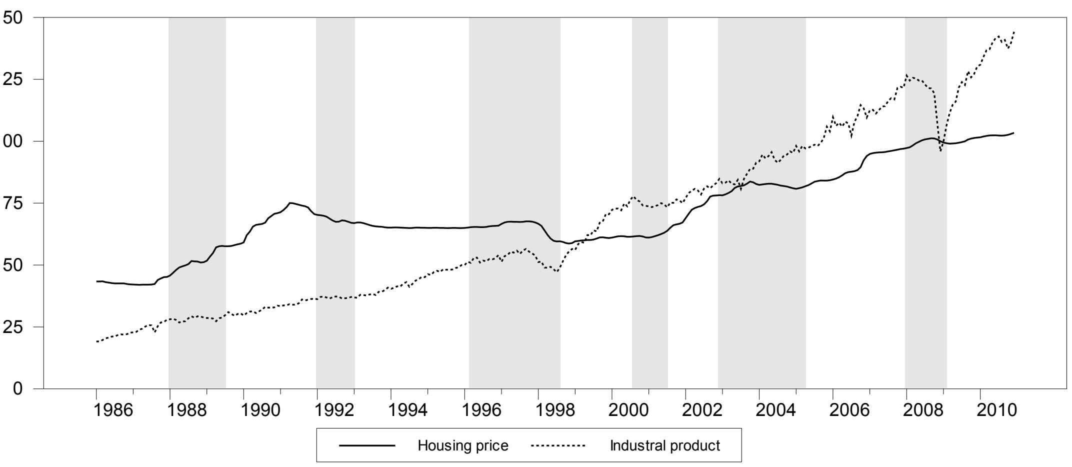
---

[46] Hereafter, lowercase letters denote the natural logarithm of each variable. The only exceptions are the nominal interest rate (i_t) and real interest rate (r_t).

[47] According to Poterba (1984), if the long-run housing supply curve and the supply curve for all the other goods were perfectly elastic, the steady-state price of structures would depend on construction costs. However, if any determining factor of real estate supply, such as land, construction materials, or construction workers, is available in fixed supply, it can be expected that the production possibility frontier between houses and other goods does not have perfect elasticity anymore and shows an upward

time series of the housing price index and industrial production index of Korea from 1986 to 2010 with contractionary periods to provide a glance at the dense changes in housing price and output; industrial production index is used as a representative output in this part. The most often-used representative index for domestic total productivity is, of course, GDP. Actually, GDP is used as output in the main empirical test. However, since the estimation for accurate GDP statistics takes a long time (at least two or three months after the quarter), sometimes it is difficult to judge the current economic situation quickly or to forecast the future economic trend precisely using the GDP process. Hence, by means of a replaceable indicator to make up for GDP's shortcoming, the monthly industrial production index can be used to grasp the trend of economic performance more quickly. The reason for setting January 1986 as a starting

Figure 4.1: Housing Price Index and Industrial Production Index



Note: The period represented is from January 1986 to December 2010 regarding monthly index data. The grey sections display contractionary periods of the Korean business cycle based on the reference dates from Statistics Korea.

---

trend in real housing prices over time. Combining this suggestion and the fact that output gives a measure of how the production possibilities frontier is shifting out over time, Iacoviello (2002) considers the possibility of the existence of a cointegrating relationship between the real housing price and output.

point of the considered period is the availability of reliable accumulated time series data for the housing market in Korea since that date. The time series of the housing price index in Korea displays a smoothly growing pattern and seems to be closely associated with the business cycle.

The housing price in Korea displayed an increasing trend consistently in the early 1990s as a result of steady economic growth. Since then, although housing prices fell dramatically during the economic recessionary period due to two financial crises − the Asian financial crisis in 1997 and the credit card debacle in 2003 − the regime of housing price switched to an upward trend with economic recovery. Although the Korean housing market met another recession stemming from the global financial crisis in 2008, recovery of the real economic sector made housing prices turn around again to experience an increasing trend after 2009. Through this history, it is recognizable that housing prices in Korea react sensitively to the business cycle fluctuation of the whole economy.

Iacoviello (2002) and Iacoviello and Minetti (2007) set up the cointegrating vector as $h_t = \tau y_t$ from the cointegrating relationship between the real housing price and output.[48] h_t is the real housing price, and τ is the proportion of the real housing price to output. This candidate cointegrating relationship with the real interest rate is used to construct the cointegrating vector as in KPSW (1991), who compose the cointegrating vector using the real ratios (consumption:output ratio and investment:output ratio) and real interest rate. This cointegrating vector is similar to the

[48] KPSW (1991) construct two great ratios (consumption:output and investment:output) as a cointegrating relationship, and they use the cointegrating vector as (1,-1). However, in this chapter, Iacoviello's (2002) idea of the cointegrating vector as (1, - τ) is considered, since housing investment is a constant fraction of GDP in the long run.

generally used IS equation of the Keynesian model.[49] The considered relationship can be expressed in the following equation (4.2), which is composed of output-house ratio and real interest rate:

$$\alpha_h h_t - y_t = \alpha_r r_t \tag{4.2}$$

where r_t is real interest rate. This implies that r_t is stationary for h_t and y_t, and they are cointegrated. From equation (4.2), the second cointegrating equation can be drawn, presented in the following equation (4.3):

$$y_t = \alpha_h h_t - \alpha_r r_t + v_{2,t} \tag{4.3}$$

where $v_{2,t}$ is the structural disturbance to the second cointegrating equation.

4.3.1.3 *Chonsei*-House Ratio

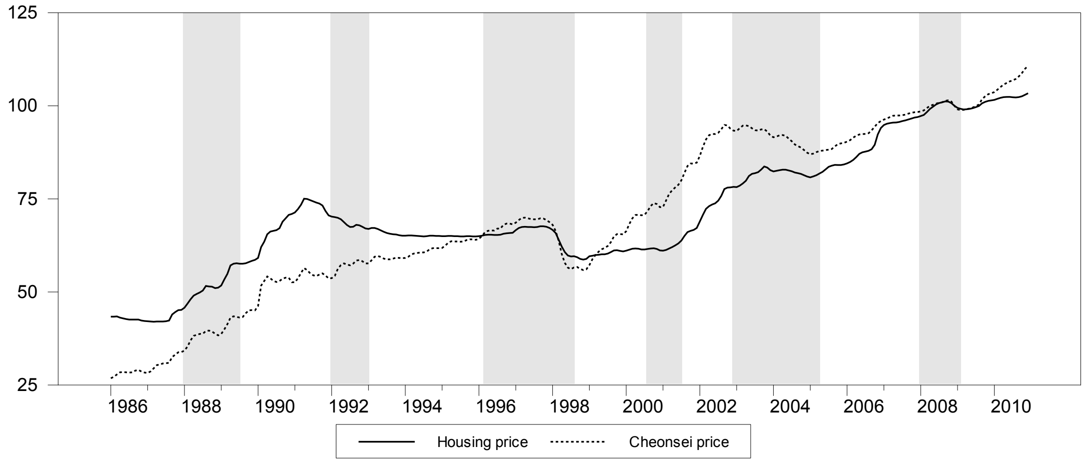
Along with the house sale market, the *chonsei* market is an important housing market feature which is distinctive in Korea. *Chonsei* price shows an upward growing path as does housing price.

Figure 4.2 shows the process of the housing price index and *chonsei* price index, and Figure 4.3 displays the growth of the housing price index and *chonsei* price index from January 1986 to December 2010 for monthly data. In the late 1980s, Korea experienced a rapid housing price increase, which was a major social issue at that time.

[49] Gali (1992) introduces a textbook-like version of the IS equation as $y = \alpha + u_s - \sigma(i - E\Delta p_{+t}) + u_{is}$ to identify disturbances. The output in this equation is composed of positive stochastic processes of supply (u_s) spending driving forces (u_{is}) and, negative processes of real interest rate ($i - E\Delta p_{+t}$). Linkages between two great ratios and the real interest rate in KPSW (1992), which is similar in form to equation (2), having common components in the IS equation of Gali (1992).

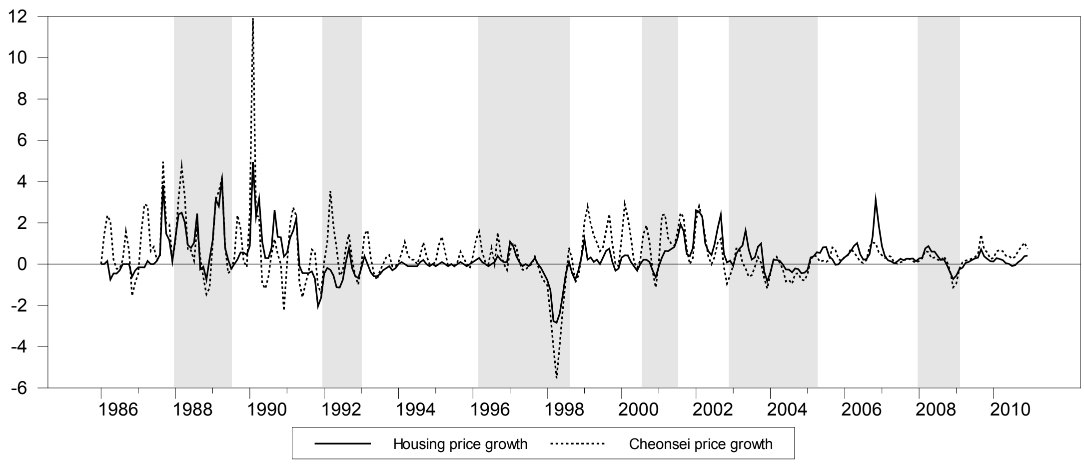
To prevent over-heating in the housing market and to stabilize housing market fluctuations, the Korean government implemented a strong tax policy in the short run

Figure 4.2: Housing Price Indices



Note: The period represented is from January 1986 to December 2010 for monthly index data. The grey sections display the contractionary periods of the Korean business cycle based on the reference dates from Statistics Korea.

Figure 4.3: Housing Prices Growth



Note: The period represented is from January 1986 to December 2010 for monthly index data. The grey sections display the contractionary periods of the Korean business cycle based on the reference dates from Statistics Korea.

and established a policy for expanding the housing supply, such as having two million housing units constructed over the long run. As a result of these housing market stabilization policies, the Korean housing market had been declining or has remained stable from the early 1990s to the Asian financial crisis period in the late 1990s. These characteristics of the housing market in Korea can be seen in the increasing housing price in the 1980s, stable or decreasing housing price in the 1990s, and increasing housing prices in the 2000s as shown in Figure 4.2. Additionally, the variation in housing price in Figure 4.3 is also consistent with the features of the Korean housing market during almost three decades. There were large fluctuations in the 1980s, whereas volatility decreased in the 1990s. After a big negative spike during the Asian financial crisis period in the late 1990s, the volatility in housing prices increased in the 2000s. Although *chonsei* price looks more volatile than housing price, changes in *chonsei* price seem to demonstrate similar fluctuation with changes in housing price, and in particular, change in *chonsei* price precedes change in housing price. Two housing price indices in Korea demonstrate an upward trend and show similar rise and fall with the shift of the business cycle.

Two models are considered as evidence that there is a close relationship between housing price and *chonsei*, or rental, price. One is the arbitrage condition model developed by Cho (2005), which considers that the house owner can make a profit by investing *chonsei* deposits from renting out as well as from the expected capital gains from the housing price increase. The other model is the user cost model presented by Otto (2007), which is based on the idea of equilibrium between the total costs to own and maintain a house and rent a house. The difference between the two models is that the arbitrage condition model is constructed from the side of capital gains by owning a house, and the user cost model is based on the costs of owning a house. However, the fact that the real interest rate is an important factor that can affect both housing price and *chonsei*, or rental, price is common in both models.

4.3.1.3.1 The Arbitrage Condition Model

Cho (2005) proposes a meaningful theoretical framework for investigating the linkage among housing price, *chonsei* price, and interest rates. According to the arbitrage condition model, focusing on the side of expected capital gain, the arbitrage condition between the housing price and *chonsei* price can be written as:

$$H_t = \frac{i_t C_t + E_t(H_{t+1})}{1 + i_t} \tag{4.4}$$

where H_t is the housing price at time *t*, C_t is *chonsei* price at time *t*, i_t is the nominal interest rate, and $E_t(H_{t+1})$ is the housing price at time *t*+1 expected at time *t*. That is, housing price at time *t* is the discounted sum of the return from managing *chonsei* deposit or the opportunity cost of dwelling in the house rather than leasing the house on a *chonsei* contract ($i_t C_t$) and the expected housing price at time *t*+1 ($E_t(H_{t+1})$).

This arbitrage condition can be recursively solved forward, and the solution will be a complicated function of the expectations about future *chonsei* prices and interest rates. If the interest rate is assumed to be constant and the *chonsei* price increases at a constant inflation rate of π, a simple and intuitive result can be produced from equation (4.4).

$$\frac{H_t}{C_t} = \frac{i_t}{i_t - \pi_t} = \frac{i_t}{r_t} \tag{4.5}$$

Equation (4.5) implies that the ratio of the housing price to *chonsei* price is equal to the ratio of nominal interest rate to real interest rate.

4.3.1.3.2 The User Cost of Housing Model

Himmelberg *et al*. (2005) suggest a user cost of housing model to identify the influential factors on housing prices. They take into account the following equilibrium condition:

$$F_t = H_t u_t \tag{4.6}$$

where F_t is rent per period, and u_t is the user cost of owner occupied housing. A no-arbitrage condition is satisfied in equation (4.6), since the cost of renting a house (F_t) is equivalent to the cost per period of owning a house ($H_t u_t$). The function of user cost of housing (u_t) is composed of cost-related factors such as the real interest rate, property tax rates, subsidies to housing, the cost of maintenance or depreciation, expected capital gains, and any risk premium associated with owning a house rather than renting a house.

On the basis of this theoretical framework, Otto (2007) focuses on two of these factors, the real interest rate and expected capital gains by owning a house, and assumes that the other variables are constant over time. The equation (4.6) can be re-written as follows:

$$\frac{H_t}{F_t} = \frac{1}{u(r_t, E_t \Delta \log H_{t+1})} \tag{4.7}$$

Equation (4.7) implies that the housing price-to-rent ratio equals the inverse of the user cost of housing, where the user cost of housing (u_t) is a function of the real interest rate (r_t) and expected capital gains from owning a house ($E_t \Delta \log H_{t+1}$). The user cost of housing will increase when the real interest rate rises and expected capital gains falls.

Seeing above two models, although they adopt different approaches to the equilibrium in the housing market, profit or cost, and set up the model with different dwelling systems, *chonsei* or rent, and housing price, there is a common factor that both models consider the real interest rate as an important factor affecting the two housing markets. As a matter of fact, both models show the same formation of equation in the end. As noted in equation (4.4), $i_t C_t$ implies the return from managing *chonsei* deposit, or the opportunity cost of dwelling in the house rather than leasing the house on a *chonsei* contract. Thus $i_t C_t$ in equation (4.4) is equal to F_t in equation (4.6). With substitution of this relation, $F_t = i_t C_t$, in equation (4.7), the re-arranged equation, $\frac{H_t}{C_t} = \frac{i_t}{u(r_t, E_t \Delta \log H_{t+1})}$, can be obtained. This equation shows the same form with equation (4.5). Therefore, I show the possibility that the *chonsei* price and housing price ratio might exhibit permanent shifts resulting from permanent shifts in the real interest rate. The idea that *chonsei* price, housing price, and the real interest rate are cointegrated is in alignment with the sense of Klyuev (2008).[50] The linkage between three variables, which connotes this cointegrating relation, can be arranged as the following equation (4.8).

---

[50] Klyuev (2008) indicates the existence of a cointegrating relationship between the log of real housing price, the log of real rent, and the real interest rate from the statistical test for U.S. data from 1972Q1 through 2008Q1. To compute the extent of overvaluation of housing price, they estimate this cointegrating vector with dynamic OLS (DOLS).

$$c_t - \beta_h h_t = \beta_r r_t \quad (4.8)$$

where c_t is the real *chonsei* price. From the implication of equation (4.8), the following the third cointegrating equation (4.9) can be derived.

$$c_t = \beta_h h_t + \beta_r r_t + v_{3,t} \quad (4.9)$$

where $v_{3,t}$ is the disturbance to the third cointegrating equation.

4.3.2 Model Specification

There is the possibility of losing important information related to the long-run relationship between variables when estimating the VAR models with first difference variables to avoid spurious regression despite the integrated and cointegration properties of the time series in system. In this case, since the VAR analysis ignoring the cointegrating relationships between variables leads to a possible specification error, the vector error correction model (VECM) is suitable to examine the dynamic interactions among the variables in the system. In addition, modelling the VECM system with appropriate cointegration restrictions can reduce the bias. Abadir *et al*. (1999) find that the bias of estimated VAR parameters is asymptotically proportional to the sum of the system's characteristic roots. Vlaar (2004) notes that if cointegration properties in the data are considered properly, this can help to reduce the bias in the impulse responses. Another benefit of the VECM is that the cointegration restrictions imply a decomposition of the model's innovations into common trend components and cyclical components using the connection between the system's long-run behaviour and its cointegration properties. Common trend components have permanent effects on the levels of the variables, and cyclical components have only transitory effects. This information can be used for the identification of structural permanent and transitory shocks. However, VECM has a weakness in that it loses the information which the level variable has when the model is set up with first difference variables.

Let X_t be an *n*-dimensional real valued vector time series generated by the unrestricted vector autoregression of finite order *k*:

$$A(L)X_t = e_t \tag{4.10}$$

where $A(L)$ is an $n \times n$ matrix polynomial of order k in the lag operator $A(L) = I_n - \sum_{i=1}^{k} A_i L^i$ with I_n an $n \times n$ identity matrix: e_t is an $n \times 1$ vector of innovations satisfying with mean zero, $E(e_t) = 0$, and covariance matrix, $E(e_t e_t') = \Omega$.

Moreover, X_t is assumed to be cointegrated of order (1, 1) with cointegration rank equal to *r* (Johansen, 1991). It then follows that X_t has a vector error correction model (VECM) representation (Engle and Granger, 1987).

$$\Delta X_t = \alpha\beta' X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + e_t \tag{4.11}$$

where $\Delta = 1 - L$ is the first difference operator, $\Gamma_i = -\sum_{j=i+1}^{k} A_j$ is the matrix of coefficients on the ith lagged change in X_t, and α and β are $n \times r$ matrices of full column rank such that $\alpha\beta' = A(1)$. As seen in the equation (4.11), the VECM has properties of including level variables and difference variables in the same equation simultaneously. Typically, dependent variables are stationary first difference variables

(ΔX_t), and explanatory variables are composed of lagged stationary first difference variables (ΔX_{t-i}) and equilibrium error of the previous period which takes the form of level variables (X_{t-1}). The columns of β are the coefficients in the cointegrating relationships, and the rows of α are the loadings on the error correction terms ($\beta' X_{t-1}$). The term $\beta' X_{t-1}$ provides the last period's equilibrium error, or cointegrating residual; α is the vector of "adjustment" coefficients that imply which variables subsequently adjust to restore the common trend when a deviation occurs. The Granger Representation theorem states that, if a vector X_t is cointegrated, at least one of the adjustment parameters must be nonzero in the error-correction representation. Estimation of the reduced-form VECM of equation (4.11) can provide a statistically meaningful description of the dynamic interrelations between the variables in X_t.

From the Granger representation theorem, it follows that ΔX_t can also be expressed in terms of past disturbances. A multivariate Wold moving-average representation takes the form.

$$\Delta X_t = C(L)e_t \tag{4.12}$$

The matrix polynomial, or distributed lag operator, $C(L) = C(1) + (1-L)C^*(L)$ has the property that $C_0 = I_n$, $C(z)$ is 1-summable, and $C^*(z)$ is full rank everywhere on $|z| \leq 1$ (Blanchard and Quah, 1989; Lippi and Reichlin, 1993; Gonzalo and Ng, 2001). Following the above process, the matrix of long-run multipliers C(1) can be estimated consistently, and this is a necessary precondition for imposing reliable long-run restrictions to identify the impulse response functions (Faust and Leeper, 1997). If enough and proper parameter restrictions are placed to identify structural shocks, it is possible to interpret the estimated cointegrating vectors and the results from VECM.

4.3.3 Identifying Structural Shocks

Since the influential work of Engle and Granger (1987) was performed, it is well known that the shocks in a cointegrated system can be decomposed into shocks with permanent effects and shocks with transitory effects on the levels of the series. KPSW (1991) propose a distinction between structural shocks with permanent effects on the level of the variables from those with only temporary effects. The permanent shocks produce the common stochastic trends across the variables, and the number of these shocks equals the difference between the number of variables in the system and the number of cointegrating relationships. On the other hand, the number of transitory innovations equals the number of cointegrating relationships. Intuitively, since a cointegrating vector identifies a linear combination of the variables that is stationary, shocks to it do not eliminate the steady-state in the system.

To identify the structural shocks into the permanent (or trend) elements and transitory (or cyclical) elements, several methods have been developed to apply the identifying restrictions. Among them, I follow Gonzalo and Ng's procedure for isolating the permanent and the transitory shocks from a VECM system.[51] The moving average representation of the VECM in equation (4.12) can be used to decompose the time series of each variable into a permanent component, which is the stochastic trend, and a transitory component, which is the time series of the deviations from the stochastic

[51] More detailed descriptions of the methodology are found in Gonzalo and Ng (2001).

trend. When some of the variables share common stochastic trends, these variables can be bound together to impose cointegration restrictions. Thus, identification is possible because cointegration imposes restrictions on the long-run multipliers of the shocks in a structural model where innovations are distinguished by their degree of persistence (KPSW, 1991; Gonzalo and Granger, 1995). Gonzalo and Ng's two-step approach shows that information on these linear relationships can be used to decompose shocks into permanent and transitory components. The point of their approach is that, once the permanent and transitory shocks are isolated, standard VAR identification tools can be used to make them mutually uncorrelated. Thus, the procedure consists of two steps. The first step distinguishes innovations that have permanent effects from those that have transitory effects only. This is able to be accomplished with a transformation of the residuals using information that is readily available from the VECM for the cointegrated system. The second step uses the Choleski decomposition to obtain a set of permanent and transitory shocks that are mutually orthogonal. A summary of this methodology is provided as follows.

4.3.3.1 The First Step: Permanent and Transitory Decomposition

In the first step, transitory and permanent components in each time series are computed using the results of the cointegration analysis. The purpose of this step is to find the set of unorthogonalized permanent and transitory shocks (u_t) by transformation using the G matrix. The G matrix is defined as follows:

$$G = \begin{bmatrix} \alpha'_{\perp} \\ \beta' \end{bmatrix} \qquad (4.13)$$

where $\alpha'_{\perp}\alpha = 0$. The G matrix is an $n \times n$ matrix composed of $\alpha'_{\perp}$, $(n-r)\times n$ matrix, and β', $r \times n$ matrix. Using this G matrix, the $(n-r)\times 1$ vector of permanent shocks, $u_t^P = \alpha'_{\perp} e_t$, and the $r \times 1$ vector of transitory shocks, $u_t^T = \beta' e_t$, can be separated. This permanent and transitory decomposition exists given the non-singularity condition of $(\alpha_{\perp}, \beta)'$. The variance-covariance matrix of the permanent and transitory shocks is $G\Omega G'$. The shocks, u_t^P and u_t^T, are the innovations related to the permanent and the transitory components of X_t, respectively. Therefore, identification of the trend and cycle of X_t as well as underlying innovations can be completed using the G matrix. An implication of the permanent and transitory decomposition is arranged in equation (4.14) as follows:

$$\Delta X_t = C(L)G^{-1}Ge_t = D(L)u_t = \begin{bmatrix} D_{11}(L) & D_{12}(L) \\ D_{21}(L) & D_{22}(L) \end{bmatrix} \begin{bmatrix} u_t^P \\ u_t^T \end{bmatrix} \tag{4.14}$$

The point that should be considered to compose equation (4.14) is that $D(1)$ must be characterized by $(n-r)\times r$ matrix of $D_{12}(1) = 0$ and $r \times r$ matrix of $D_{22}(1) = 0$. This is because the last *r* columns of the polynomial matrix $D(L)$ are the responses of ΔX_t to the transitory shocks, and they have no long-term effects on the first difference or the level of X_t. As a result of this step, each element of ΔX_t can be decomposed into a function of $(n-r)$ permanent shocks and *r* transitory shocks.

4.3.3.2 The Second Step: Orthogonalized Shocks

Although u_t is decomposed by two terms of u_t^P and u_t^T from e_t using the G matrix at the first step, u_t^P and u_t^T are still mutually correlated with each other. Thus, in order to achieve mutually uncorrelated shocks ($\widetilde{\eta}_t$), another transformation from $\Delta X_t = D(L)u_t$ to $\Delta X_t = \widetilde{D}(L)\widetilde{\eta}_t$ is conducted using the H matrix at the second step. The H matrix is the lower block triangular matrix, which can be obtained by applying Choleski decomposition to covariance of $u_t\,(u_t = Ge_t)$, satisfying $HH' = G\Omega G'$.[52] Therefore, orthogonalized permanent and transitory shocks can be obtained using the H matrix. An implication of the mutually uncorrelated permanent and transitory shocks is summarized in the following equation (4.15).

$$\Delta X_t = D(L)HH^{-1}u_t = \widetilde{D}(L)\widetilde{\eta}_t \qquad (4.15)$$

Since the Choleski decomposition produces a lower triangular matrix, it presents the exact number of zero restrictions, and $\widetilde{\eta}_t = H^{-1}u_t$ can be generated, which has the characteristic of unit variance and mutually uncorrelated shocks.

Gonzalo and Ng's approach consists of two steps to obtain uncorrelated identified shocks. On the other hand, KPSW's common trend method is a one-step approach which implements the identification with an orthogonalized cointegrating vector imposing economic theory and the lower triangular to make uncorrelated structural shocks at one time. Another difference between these two approaches is that KPSW (1991) use economic theory to fix α and β, whereas Gonzalo and Ng (2001) impose long-run restrictions which are implied by the data rather than economic theory. Instead, the Gonzalo and Ng approach can impose economic restrictions on the cointegrating vectors. Additionally, KPSW (1991) do not study the dynamic effects of

[52] Gonzalo and Ng (2001) choose the Choleski decomposition, as it is convenient to use, although this brings about the usual limitation of how to order the variables.

the transitory shocks, whereas this can be accommodated in Gonzalo and Ng (2001). These two methods are frequently employed to identify structural shocks using a slightly different method with different economic theory or different data, since they have an almost identical as well as simple process (Iacoviello, 2002; Bruggemann, 2003; Lettau and Ludvigson, 2004; Jang, 2008; Fisher et al., 2010).

In this chapter, I employ the VECM composed of six variables ordered as $X_t = [y_t, \pi_t, c_t, mp_t, h_t, i_t]'$ using the Gonzalo and Ng approach to identify structural shocks with the three cointegrating equations of (4.1), (4.3), and (4.9). Thus, three permanent innovations and three shocks which have only transitory effects on X_t can be isolated.

4.4 Data and Tests

The basic assumption of time series analysis is that time series are stationary processes which have properties of finite variance and consistent mean and correlation function over time. However, it is known that most macroeconomic and financial time series are non-stationary processes. Although each individual variable is non-stationary, a regression model imposing stationary linear combination between variables can yield meaningful regression results. In this section, a detailed description of the data for empirical testing and the data source is provided. Then, as a preliminary step, unit root tests for each time series are performed and the results of the test are reported to verify the stationarity of variables. To specify the model correctly, the long-run properties of the time series, which implies the presence of cointegrating relationships, are also tested.

4.4.1 Data Description and Data Source

I set up the model to investigate the dynamic effects of housing market and macroeconomic fluctuations using two housing market price indices and four key macroeconomic variables. Two housing market price indices are the housing sale price index and the housing *chonsei* price index as capturing housing market prices. Four key macroeconomic indicators are gross domestic product (GDP) without net exports, consumer price index (CPI), M1, and the Bank of Korea's call rate.

To examine the unadulterated effect of domestic macroeconomic and housing market variables, net exports which represent the foreign component of GDP are excluded. Hereafter the term GDP in this chapter indicates GDP without net exports.

The call rate and certificate of deposit (CD) rate for three-months (hereafter referred to as CD3) are representative short-run interest rates in Korea. The difference between these two interest rates is that the former is used as a monetary policy interest rate and the latter is a market interest rate used as a base rate. An appropriate one of two interest rates can be chosen by standard of purpose of study, since these two short-run interest rates have their own advantages for different usage. As most commercial banks in Korea adopt 'CD rate + spread' as a floating rate type of mortgage rate, the change in CD rate has a large impact on the floating rate type of mortgage rate. Although CD3 looks desirable for analysis of the housing market, call rate is chosen as a short-run nominal interest rate in this chapter, because one of the main purposes of this chapter is to examine the relationship between monetary policy and the housing market. Additionally, it may safely be said that the call rate is as effective as CD3 to analyse housing market fluctuations, since changes in the call rate can affect the mortgage rate through changes in CD3 indirectly. It is known that changes in the call rate lead to changes in CD3 sensitively in one direction in Korea.

Quarterly data are used and the sample period is from 1991Q1 to 2010Q4 for the Korean economy. The data period is decided by considering the obtainability of six variables, and this is the maximum period which satisfies all six variables. During this period, although there might exist two structural breaks − the Asian financial crisis of 1997-98 and the global financial crisis of 2007-08 − there does not seem to be good reason to separate or exclude these structural breaks from the whole data period to avoid distortion. Both expansion and contraction periods of the Korean business cycle should be considered at the same time in order to examine the relationship between housing market changes and the business cycle as shown in the Figure 4.1.

The time series for all data are seasonally adjusted and logged, except for the nominal interest rate. GDP, GDP deflator, CPI, M1, and call rate are obtained from the *Economic Statistics System* of the Bank of Korea, and the housing sale price index and the housing *chonsei* price index are obtained from the Kookmin Bank.[53] The housing sale price index and the housing *chonsei* price index of the Kookmin Bank are the only reliable long-term time series data associated with housing markets in Korea.

The six-variable VECM is then specified with real output (y_t) derived from nominal

---

[53] The Housing and Commercial Bank had made these indices since 1986 until it merged with the Kookmin Bank, and since then the Kookmin Bank has announced these indices continuously every month through the investigation of the contract prices of every type of housing in Korea (www.kbstar.com).

GDP divided by the implicit price deflator, inflation (π_t) from the growth of the consumer price index, real *chonsei* price index (c_t) from the nominal housing *chonsei* price index deflated by GDP deflator, real money balances (mp_t) derived from the difference between money supply (M1) and inflation, real housing price index (h_t) from the nominal housing sale price index deflated by GDP deflator, and short-term nominal interest rate (i_t).

4.4.2 Unit Root Tests

Unit-root tests are performed to examine the non-stationary property of macroeconomic and financial time series before proceeding with empirical analysis. Two well-known unit-root tests − the Augmented Dickey-Fuller (ADF) test and Phillips-Perron (PP) test − are used and the results are reported.

The way to test unit-root using ADF is to add augmented terms (ΔY_{t-j}, *j*=1,..., p) to each three basic models to remove the effect of autocorrelation. Then the following three models for ADF testing through *F*-statistics are used to verify the results.

Model I : $\Delta Y_t = \hat{\gamma}\hat{Y}_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \varepsilon_t$

Model II : $\Delta Y_t = \alpha + \tilde{\gamma}\tilde{Y}_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \varepsilon_t$

Model III : $\Delta Y_t = \alpha + \beta T + \bar{\gamma}\bar{Y}_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-i} + \varepsilon_t$

The null hypothesis is $H_0 : \gamma(\hat{\gamma}, \tilde{\gamma}, \bar{\gamma}) = 0$, which means there is a unit root in the data.

The other comparable method to test unit-root, the PP test is conducted (Phillips and Perron, 1988). The corresponding PP statistics are as follows.

Model I : $Z(t_{\hat{\gamma}})$ for $H_0 : \hat{\gamma} = 1$

Model II : $Z(t_{\tilde{\gamma}})$ for $H_0 : \tilde{\gamma} = 1$

Model III : $Z(t_{\bar{\gamma}})$ for $H_0 : \bar{\gamma} = 1$

The null hypotheses of this test are examined by Z statistics calculated using basic models. The results of the ADF test and the PP test are reported in Table 4.1.

Table 4.1: ADF Test and PP Test

	Model I		Model II		Model III	
	ADF	PP	ADF	PP	ADF	PP
GDP	1.3150 (-6.2771)	1.6081 (-6.2447)	-1.3818 (-6.5023)	-1.1178 (-6.2050)	4.4756 (-4.0075)	6.9446 (-3.8628)
CPI	-0.1237 (-7.7923)	-0.1363 (-7.7838)	-2.2418 (-7.7391)	-2.5477 (-7.7300)	12.9738* (-1.3622)	10.6829 (-3.0738)
Housing Price	0.4617 (-4.7941)	0.6151 (-4.9266)	-2.6107 (-5.4632)	-1.9538 (-5.6314)	1.2573 (-4.6312)	1.5668 (-4.7524)
Chonsei Price	-0.3707 (-3.6455)	-0.1499 (-3.7458)	-3.0847 (-3.6669)	-2.2398 (-3.7705)	1.5217 (-3.2236)	2.2036 (-3.3006)
M1	0.4794 (-7.5602)	0.3701 (-7.5554)	-1.7747 (-7.5790)	-1.9927 (-7.5756)	3.9330 (-6.3288)	3.3876 (-6.4455)
Call Rate	-1.9689 (-7.5509)	-1.3764 (-7.4427)	-4.2868† (-7.5347)	-2.8622 (-8.2760)	-1.9374 (-7.4771)	-1.5882 (-6.7178)
Real Money Balance	-1.3711 (-7.7322)	-1.3945 (-7.7322)	-1.3944 (-7.7306)	-1.5501 (-7.7306)	1.2200 (-7.6000)	3.5896 (-7.6682)

Note: Non-marking statistics denote I(1) process of time series at the 5% critical value. * denotes second difference stationary series and † denotes no-unit root at the 5% critical value. Parentheses located on the second line of each data indicate the statistics of ADF test and PP test after performing first difference.

The results from the two tests are similar. All of the data have unit root at the 5% level except for two cases, * (second difference stationary series) and † (no-unit root in the level). Parentheses located on the second line of each group of data indicate the statistics of ADF test and PP test after performing the first difference with level variable. Evidence from the tests suggests that most of the variables are stationary after the first difference. Considering the theory of previous related research, since non-stationary process of inflation can be driven from the first difference of CPI, CPI is rather I(2) process than I(1). At this point, the result of model III, which implies that CPI is a second difference stationary process, is economically significant. Most of these results except for two cases are consistent with the unit root properties of the macroeconomic and financial time series.

4.4.3 Cointegration Tests

Since the result from regression is not spurious in the case of being a cointegrating relationship between variables despite the existence of unit root in individual time series, typical *t*-value and *F*-value are still valid in this case. Thus cointegration test performs a role of pre-inspection to avoid spurious regression. To obtain a correctly specified error correction model, I begin by testing for both the presence and number of cointegrating relationships in X_t. I examine the number of existing cointegrating relationships in variables and the stationarity of the expected cointegrating vectors which are suggested by equations (4.1), (4.3), and (4.9). The Johansen cointegration test is used to test the former, while, for the latter, ADF and PP tests are used to test the stationarity of residuals of cointegrating equations.

4.4.3.1 Johansen's Cointegration Rank Test

Johansen (1988) and Johansen and Juselius (1991) suggest the method with which to test the number of cointegrating relationships and to determine whether a group of non-stationary time series are cointegrated or not. In particular, the Johansen cointegration test is widely used in the case of multivariate analysis, since this test is the extended version of the Dickey-Fuller unit root test to the multivariate case. Table 4.2 reports the results of two types of cointegration rank test statistics − trace statistics and maximum eigenvalue statistics − using procedures developed by Johansen.

In panel A, the trace statistics for testing the number of cointegrating relationships are reported, and in panel B, maximum eigenvalue statistics for rank test are reported. In

Table 4.2: Johansen Test

A. Trace Test				
Number of Cointegration (*r*)	Eigenvalue	Trace Statistic	5% Critical Value	*P*-value
A.1. Intercept Included				
0*	0.5604	152.31	95.754	0.0000
1*	0.4114	89.019	69.819	0.0007
2*	0.3273	48.205	47.856	0.0463
3	0.0916	17.677	29.797	0.5900
4	0.0792	10.275	15.495	0.2601
5	0.0497	3.9251	3.8415	0.0576
A.2. Intercept and Time Trend Included				
0*	0.5616	172.15	117.71	0.0000
1*	0.4114	108.66	88.804	0.0009
2*	0.3496	67.843	63.876	0.0223
3	0.2421	34.716	42.915	0.2569
4	0.0907	13.369	25.872	0.7090
5	0.0755	6.0466	12.518	0.4544

Table 4.2 (continued)

B. Maximum Eigenvalue Test				
Number of Cointegration (*r*)	Eigenvalue	Trace Statistic	5% Critical Value	*P*-value
B.1. Intercept Included				
0*	0.5604	63.291	40.078	0.0000
1*	0.4114	40.813	33.877	0.0064
2*	0.3273	30.529	27.584	0.0203
3	0.0916	7.4012	21.132	0.9364
4	0.0792	6.3502	14.265	0.5687
5	0.0497	3.9251	3.8415	0.0576
B.2. Intercept and Time Trend Included				
0*	0.5616	63.495	44.497	0.0002
1*	0.4114	40.813	38.331	0.0254
2*	0.3496	33.126	32.118	0.0375
3	0.2421	21.347	25.823	0.1749
4	0.0907	7.3229	19.387	0.8776
5	0.1023	6.0466	12.518	0.4544

Note: The phrase 'intercept included' indicates cases in which the level data have linear trends but the cointegrating equations have only intercepts. 'Intercept and time trend included' indicates cases in which the level data and the cointegrating equations have linear trends. The null hypothesis of test is 'cointegration rank = *r*'. * denotes rejection of the hypothesis at the 5% critical value.

detail, the first part of each panel reports the results of the case of 'intercept included,' and in the second part, the results of the case 'intercept and time trend included' are reported. To determine the number of cointegrating relations, the procedure is tested sequentially from r=0 to r=n-1 until the test fails to reject the hypothesis. The trace test indicates that there are three cointegrating relationships between variables at the 5% level, since the hypothesis of two existing cointegrating relationships is rejected. Similarly, the maximum eigenvalue test also indicates that there are three cointegrating relationships between variables at the 5% level. As both the trace statistic and the maximum eigenvalue statistic yield the same results, residuals of each cointegrating equation is examined to test the existence of cointegration in the next part regarding residuals-based test.

4.4.3.2 Residuals-Based Test

Table 4.3 presents the results of cointegration properties from the ADF and PP unit root

Table 4.3: Residuals-Based Test

	Model I		Model II		Model III	
	ADF	PP	ADF	PP	ADF	PP
A. Cointegrating Relationships						
$y_t - h_t$	-2.637*	-2.749*	-2.754	-2.443	-2.527**	-2.694**
	(-2.899)	(-2.898)	(-3.469)	(-3.468)	(-1.945)	(-1.945)
$c_t - h_t$	-3.607**	-2.644*	-3.092	-1.950	-3.449**	-2.609**
	(-2.899)	(-2.898)	(-3.468)	(-3.468)	(-1.945)	(-1.944)
$i_t - \pi_t$	-1.906	-6.772**	-8.959**	-8.991**	-2.031**	-6.612**
(r_t)[54]	(-2.900)	(-2.899)	(-3.468)	(-3.468)	(-1.945)	(-1.945)
B. Cointegrating Equations						
Money	-2.049	-2.049	-2.052	-2.053	-2.065**	-2.065**
Demand	(-2.899)	(-2.898)	(-3.468)	(-3.467)	(-1.945)	(-1.944)
Output-	-3.006**	-2.322	-3.870**	-2.894	-3.030**	-2.345**
House Ratio	(-2.899)	(-2.899)	(-3.469)	(-3.468)	(-1.945)	(-1.945)
Chonsei-	-3.108**	-2.373	-3.089	-2.364	-3.126**	-2.382**
House Ratio	(-2.900)	(-2.899)	(-3.469)	(-3.468)	(-1.945)	(-1.945)

Note: The null hypothesis is no cointegration. ** denotes that the result is significant at the 5% level and * denotes that the result is significant at the 10% level. The statistics in parentheses denote the 5% critical value.

[54] Real interest rate can be calculated by marginal productivity of capital minus rate of depreciation, or nominal interest rate minus inflation. The latter of the two is generally used because of the issue of available data for the empirical test. The conventional Fisher relation is $i_t = r_t + E_t \Delta p_{t+1}$ where i_t is nominal interest rate, r_t is real interest rate, and $E_t \Delta p_{t+1}$ denotes the expected rate of inflation between t and t+1. Although the original Fisher relationship links nominal interest rates and expected inflation, $r_t = i_t - \pi_t$ is generally used, since using inflation in period t+1 as a proxy for inflation expectations and modelling the system with π_{t+1} instead of π_t produces almost similar results.

tests applied to the residuals from an ordinary least squares (OLS) regression of three cointegrating relationships and three cointegrating equations for the sample period of 1991Q1 to 2010Q4.

If results show that the series does not have a unit root through the ADF and PP unit root tests, this means that there is evidence for existence of a cointegrating relationship between variables since the linear combination is stationary. Results reported in Table 4.3 indicate that most of the residuals of cointegrating equations are stationary. These facts suggest the existence of cointegrating relationships. Thus, I use these three cointegrating equations as cointegrating vectors in the VECM specification for empirical analysis.

4.5 Empirical Results

The VECM carries out a two-step estimation. In the first step, three cointegrating equations, which are linear combinations of level variables to impose economic theory, are estimated using a typical regression method. To compute cointegrating parameters, dynamic ordinary least squares (DOLS) for three cointegrating equations in section 4.4 on the ground of economic theory in section 4.3 is employed. These estimated parameters of variables can explain the long-run relationship of equations. In the second step, the lagged residuals from the regressions in the first step are added as one part of the explanatory variable to estimate the VECM system. With residuals from DOLS as the error-correction terms implied by the cointegrating equations, the six-variable VECM is estimated. After these two steps, typically well-used empirical analysis methods of VAR-related models, such as impulse response function, variance decomposition, and historical decomposition, are used to analyse the dynamic interactions between variables.

4.5.1 Cointegrating Parameters

The cointegrating parameters of each cointegrating equation should be estimated. To estimate parameters of the three cointegrating equations (μ_y, μ_i, α_h, α_r, β_h, β_r), Stock and Watson's (1993) DOLS is employed, which is an appropriate method to generate optimal estimates of the cointegrating parameters in a multivariate setting. In the following single equations (4.16) ~ (4.18), which take the form of DOLS, each cointegrating vector is specified.

(Money demand)

$$m_t - p_t = \mu_y y_t + \mu_i i_t + \sum_{i=-k}^{k} m_y \Delta y_{t-i} + \sum_{i=-k}^{k} m_i \Delta i_{t-i} + \xi_{1,t} \tag{4.16}$$

(Output-house ratio)

$$y_t = \alpha_h h_t + \alpha_r r_t + \sum_{i=-k}^{k} a_h \Delta h_{t-i} + \sum_{i=-k}^{k} a_r \Delta r_{t-i} + \xi_{2,t} \tag{4.17}$$

(*Chonsei*-house ratio)

$$c_t = \beta_h h_t + \beta_r r_t + \sum_{i=-k}^{k} b_h \Delta h_{t-i} + \sum_{i=-k}^{k} b_r \Delta r_{t-i} + \xi_{3,t} \tag{4.18}$$

I choose one lead and lag for the money demand equation (k=1), seven leads and lags for the output-house ratio equation (k=7), and five leads and lags for the *chonsei*-house ratio equation (k=5) as the lag length in the DOLS. Since the choice of k is somewhat arbitrary, a range of values from 1 to 7 is applied. KPSW (1991) choose five lags and leads and apply them to three cointegrating vectors identically in their study. However, when k is over two, output shows a negative relationship with money demand in this case. Thus, I choose one lag and lead for the money demand equation to use this equation as a cointegrating vector, which is not against economic theory. On the other hand, parameter estimates of the other two cointegrating equations are broadly similar from k=1 to k=7 except for the little numerical difference. Lettau and Ludvigson (2004) present that the DOLS procedure can be made more precise with larger lag lengths. Hence, I select the optimal lead and lag under the standard that cointegrating equations should not contradict economic theory. The DOLS regression augments the OLS regression with k leads and lags of the first difference of the right-hand side variables in equations (4.16), (4.17), and (4.18).

Table 4.4 reports the DOLS estimates of the coefficients in three cointegrating equations. From the first cointegrating equation, money demand has a positive relationship with output and a negative relationship with the nominal interest rate. These results are consistent with economic theory, although only a negative relationship between money

Table 4.4: DOLS Estimates of the Cointegrating Parameters

Cointegrating Vectors	Money Demand		Output-House Ratio		*Chonsei*-House Ratio	
Parameters	μ_y	μ_i	α_h	α_r	β_h	β_r
Estimates	0.1108 (0.5810)	-0.0495 (-4.7759)**	0.0679 (0.2733)	-0.0545 (-5.6062)**	0.6492 (5.6237)**	0.0023 (0.4667)

Note: The table reports the estimated coefficients from DOLS. The Newey-West corrected t-statistics are reported in parentheses. The DOLS standard errors are corrected for heteroskedasticity and serial correlation using the Newey and West (1987) procedure. ** denotes that statistics are significant at the 5% level.

Table 4.5: OLS Estimates of the Cointegrating Parameters

Cointegrating Vectors	Money Demand		Output-House Ratio		*Chonsei*-House Ratio	
Parameters	μ_y	μ_i	α_h	α_r	β_h	β_r
Estimates	0.4807 (5.5441)**	-0.0283 (-6.1379)**	0.0456 (0.1213)	-0.0445 (-12.362)**	0.5431 (10.229)**	-0.0101 (-6.7823)**

Note: The table reports the estimated coefficients from OLS. The *t*-statistics are reported in parentheses. ** denotes that statistics are significant at the 5% level.

demand and nominal interest rate is significant at the 5% level. Thus, OLS regression, which is the case of k=0 in equations (4.16) ~ (4.18), is also carried out to compare the corresponding results and they are presented in Table 4.5. In the case of using OLS, money demand has also a positive relationship with output, and this parameter value is significant at the 5% level. In the second cointegrating equation in Table 4.4, output shows a non-significant positive relationship with the housing price and a significant negative relationship with the real interest rate. In this case, the OLS estimates in Table 4.5 also demonstrate that there is a positive relationship between output and the housing price. In the third cointegrating equation in Table 4.4, there is a strongly significant positive relationship between *chonsei* price and housing price. This result is identical to the case of using OLS regression in Table 4.5. As housing price increases, the *chonsei* demand curve would move to the right in the *chonsei* market, because a household that plans to purchase a house should be then more inclined to lease a house instead of buying it due to the higher price of the house. In addition, the *chonsei* supply curve moves to the left in the *chonsei* market, because a landlord wants to receive higher *chonsei* deposits as housing price rises. Synthetically, as the housing price increases, both *chonsei* demand curve and *chonsei* supply curve move upward together, and this leads *chonsei* price to increase. Hence, there is a positive relationship between housing price and *chonsei* price. In the meantime, there is a non-significant positive relationship between *chonsei* price and the real interest rate in applying the DOLS case. However, in using the OLS case, the result shows that there is a negative relationship between *chonsei* price and the real interest rate.

4.5.2 Estimation Output of VECM

For the modelling of economic and financial time series, which have cointegrating relationships, the VECM became a standard tool over the last few decades. In particular, the VECM is widely used for forecasting and for analyzing the effects of structural shocks. A critical element in the specification of the VECM is the determination of the lag length of the system. The lag length is frequently selected using explicit statistical criteria such as the Akaike's information criterion (AIC) and Schwarz's information criterion (SIC). AIC and SIC are considered to select optimal lag length, and results are reported in Table 4.6.

Table 4.6: Optimal Lag Length Selection for VECM

Lag Length	AIC	SIC
VEC (1)	-23.585*	-21.941*
VEC (2)	-23.546	-20.786
VEC (3)	-23.493	-19.599

Note: * denotes the minimum value of the information criteria.

Both information criteria select one as an optimal lag length of the VEC system. Based on the selection criteria, the VEC (1) specification is chosen.

Let X_t be a 6×1 vector of variables, $X_t = [y_t, \pi_t, c_t, mp_t, h_t, i_t]'$, and assume without loss of generality that it follows a VAR (2) process of the following form.[55]

$$X_t = \delta + \Pi_1 X_{t-1} + \Pi_2 X_{t-2} + e_t \qquad (4.19)$$

where $E(e_t e_t') = \Omega$. When there are three cointegrating relationships among the variables, there exists a VEC (1) model of the form

$$\Delta X_t = \delta + \alpha\beta' X_{t-1} + \Gamma(L)\Delta X_{t-1} + e_t \qquad (4.20)$$

where α and β are both 6×3 matrices. The results of the estimated coefficients from the VEC (1) model of equation (4.20) are presented in Table 4.7.

The growth of inflation and the nominal interest rate are predictable by lagged own growth, and the growth of output, *chonsei* price, and money demand are relatively well predictable based on the cointegrating residuals. The lagged growth of inflation predicts well not only the own growth but also the growth of *chonsei* price, money demand, and nominal interest rate. The growth of nominal interest rate is predictable from the change of the lagged money demand, and the change of the lagged nominal interest rate also affects the growth of money demand significantly. In addition, the change of inflation can be predictable from the change of money demand, and the change of *chonsei* price can be predictable from the change of housing price. Based on

[55] In the chapter, two of the cointegrating relations are developed in terms of the real interest rate (r_t). However, in the empirical test using VEC framework, there are only six variables in the model since $r_t = i_t - \pi_t$.

all of these facts, a summary of the points about the relationships among inflation, money demand, and nominal interest rate include that changes in past inflation and

Table 4.7: Estimates of VECM Conditional on DOLS Estimates

Dependent Variable	Equations Δy_t	$\Delta \pi_t$	Δc_t	Δmp_t	Δh_t	Δi_t
Constant	0.5251	0.0179	0.5144	0.6746	0.3524	3.0506
	(4.0212)**	(0.4790)	(3.7509)**	(2.8567)**	(2.5399)**	(0.4301)
Δy_{t-1}	0.03449	-0.0046	0.0613	0.4257	-0.0498	2.3521
	(0.1963)	(-0.0913)	(0.3324)	(1.3396)	(-0.2669)	(0.2464)
$\Delta \pi_{t-1}$	-0.3493	-0.4435	-0.8048	-1.6952	-0.3987	61.529
	(-0.8939)	(-3.9636)**	(-1.9609)*	(-2.3985)**	(-0.9603)	(2.8987)**
Δc_{t-1}	-0.0663	0.0101	0.3819	-0.0133	-0.0508	9.8255
	(-0.2693)	(0.1434)	(1.4773)	(-0.0299)	(-0.1941)	(0.7348)
Δmp_{t-1}	-0.0661	0.0378	-0.0529	-0.1135	-0.0757	7.4671
	(-0.8384)	(1.6757)*	(-0.6396)	(-0.7961)	(-0.9034)	(1.7438)*
Δh_{t-1}	-0.07200	-0.0063	-0.4433	-0.6412	0.0133	-15.540
	(-0.3097)	(-0.0942)	(-1.8155)*	(-1.5249)	(0.0539)	(-1.2307)
Δi_{t-1}	-0.0003	0.0011	-0.0022	-0.0099	-0.0027	0.3701
	(-0.1410)	(1.6114)	(-0.8677)	(-2.2527)**	(-1.0407)	(2.7943)**
$EC1_{t-1}$	-0.1128	0.0066	0.0286	0.1417	0.1072	5.1195
	(-1.5946)	(0.3279)	(0.3847)	(1.1078)	(1.4253)	(1.3322)
$EC2_{t-1}$	-0.0631	-0.0007	-0.0478	-0.0256	-0.0332	0.0494
	(-3.1199)**	(-0.1279)	(-2.2499)**	(-0.7006)	(-0.5428)	(0.0450)
$EC3_{t-1}$	-0.0031	-0.0044	-0.0480	-0.1695	-0.0315	-1.3114
	(-0.0801)	(-0.3888)	(-1.1660)	(-2.3917)**	(-0.7554)	(-0.6160)
s.e.	0.0245	0.0070	0.0257	0.0442	0.0260	1.3281

Note: *t*-statistics are in parentheses. The sample spans the first quarter of 1991 to the fourth quarter of 2010. ** denotes that the estimated coefficients are significant at the 5% level, and * denotes that the estimated coefficients are significant at the 10% level. There are three cointegrating vectors in the VEC framework. Thus, the terms of $EC1_{t-1}$, $EC2_{t-1}$, and $EC3_{t-1}$ denote estimated cointegrating residuals from each cointegrating vector. In detail, $EC1_{t-1}$ is for money demand equation, $EC2_{t-1}$ is for output-house ratio equation, and $EC3_{t-1}$ is for *chonsei*-house ratio equation.

money demand have a significant influence on the change in the nominal interest rate, and changes in past inflation and the nominal interest rate have also a significant influence on the change in money demand.

4.5.3 Impulse Responses

In this part, in order to analyse the inter-relationship and transmission effect between macroeconomic and housing market variables, impulse response functions, which are a method to examine the response of every variable through the time path to a specific variable shock, are used.[56] The only difference in impulse responses used in this chapter is that instead of applying Choleski decomposition to the residual of the general VEC system, it is applied to a set of transformed residuals in equation (4.15) (Gonzalo and Ng, 2001). Through the responses of each variable to one standard deviation shocks, it will be clear how dynamic impulse responses can trace out the propagating mechanism of the permanent and the transitory shocks. As outlined in the previous section, six structural shocks are identified into three permanent shocks and three transitory shocks. Identification of the permanent shocks can be achieved by imposing enough restrictions to the shocks, and their long-run effects may be given an economic interpretation. In contrast, transitory shocks, which are assumed orthogonal to the permanent shocks and to each other, have no long-run effects on the variables. Generally, the three variables with structural shocks known to have permanent effects must be specified *a priori*. In the Gonzalo and Ng (2001) approach, this is achieved by

[56] Phillips (1998) demonstrates that impulse responses for long-run horizons are not consistently estimated in the case of unit roots. He also shows that the VEC specification with consistently estimated cointegration rank significantly improves estimated impulse responses even for short horizons compared to the unrestricted VAR specification.

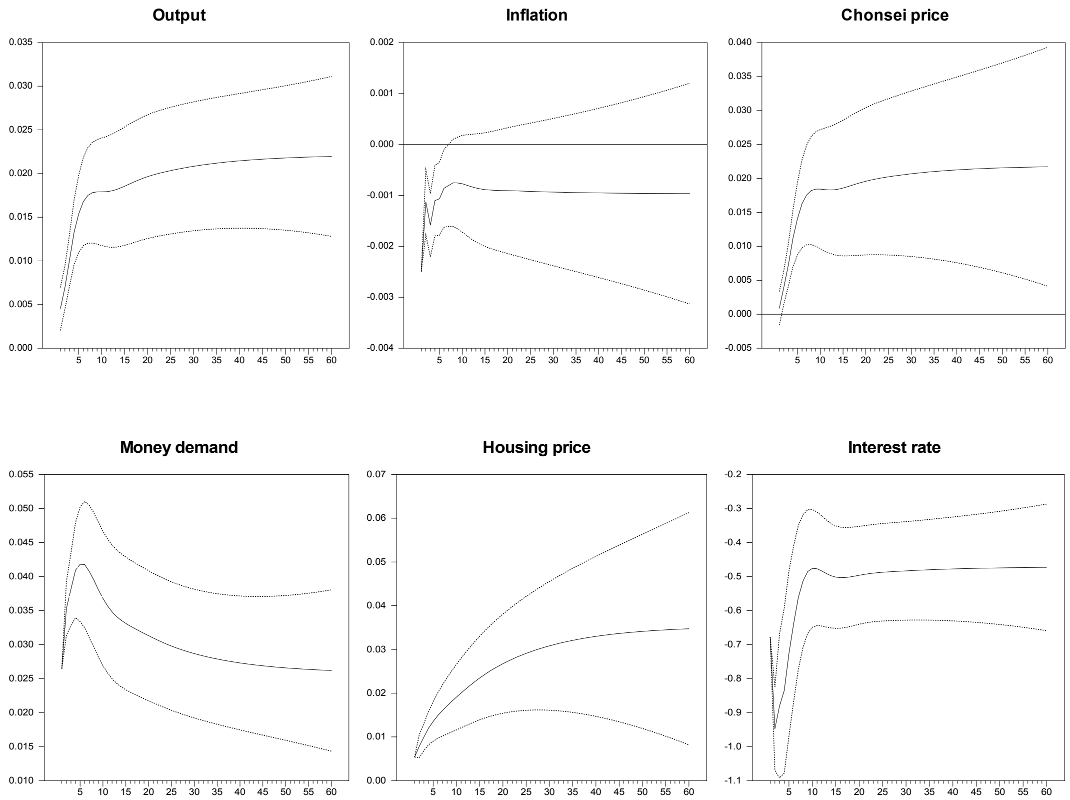
ordering these variables first in X_t. The order of the series chosen here is $X_t = [y_t, \pi_t, c_t, mp_t, h_t, i_t]'$.[57] Thus, supply, inflation, and *chonsei* price shocks have permanent effects, and money demand, housing price, and monetary policy shocks have transitory effects. From the model, since the latter group of three shocks do not have a lasting impact on the variables, the responses to these shocks all converge to zero in the long run. Mostly, the responses of variables to each structural shock are just as expected with some exceptions. Introducing important findings from impulse response analysis briefly, first, housing market prices show increased response to the favourable supply shock, and in the reverse direction, output also responds positively to the increasing housing market price shocks. Second, increasing *chonsei* price shock, which has a permanent effect, induces increasing housing price response, and increasing housing price shock which has a transitory effect also induces increasing *chonsei* price response. As responses of *chonsei* price and housing price to every structural innovation show similar descriptions, it can be concluded that the relationship between the two housing market prices is strongly connected when compared to other interactions with other macroeconomic variables. Third, contractionary monetary policy leads to a decrease in real housing prices.

4.5.3.1 Supply Shock

[57] In table 4.7, inflation(π_t), The real house price index(h_t) and the nominal interest rate(i_t) are weakly exogenous. However, for the ordering of the variables in this chapter, the orthogonal permanent shocks are associated with the first three variables and are given the interpretation of an aggregate supply shock, an inflation shock, and a *chonsei* price shock, respectively. Thus, to check the robustness on the results for the ordering considered in the chapter, I carried out the empirical model with various orderings including the case of permanent housing price shock and transitory *chonsei* price shock. In this case, there is only one difference comparing with the results of the chapter, which is a positive response of housing price to the contractionary monetary policy shock. Consequently, in every case of ordering, only the current ordering in the chapter can provide reasonable explanations in every response to each structural shock with well known economic theories and identify the structural shocks into three permanent shocks and three transitory shocks exactly.

Figure 4.4 shows the estimated responses to a one standard deviation favourable supply shock, along with one standard error bands, which are computed by bootstrapping method.[58] All responses have long-run response properties, since they do not die out in the long run. According to many works of research, such as KPSW (1991), Gali (1992), Iacoviello (2002) and Jang (2008), the supply shock, which is classified as one of the permanent shocks in this chapter, is a structural shock that has an important effect throughout the economy. The initial effect on GDP is positive but

Figure 4.4: Impulse Responses to Supply Shock



Note: ——— Estimated impulse response
- - - - - - Upper and lower one standard error bands

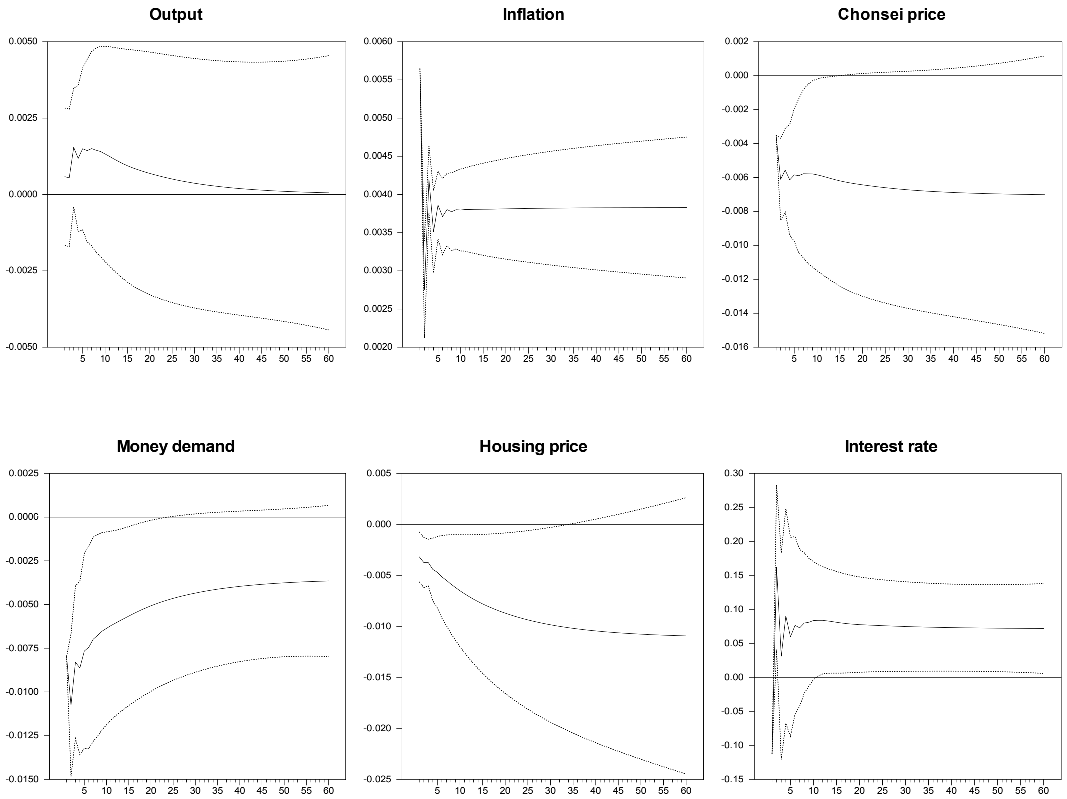
[58] The impulse response functions depend on the parameters of the model in a complex way, and constructing confidence bands are of little use (Gonzalo and Ng, 2001). However, I attach the confidence bands computed to the transformed residuals by bootstrapping with impulse responses.

small, and thereafter it shows a growing trend. The permanent supply innovation raises the two housing market prices in the long run. This implies that economic fundamentals such as productivity increases are important long-run determinants of the housing market prices. Inflation and the interest rate show negative response to the positive supply shock. These features follow the classic school's aggregate supply and aggregate demand model that the prices and interest rate fall off in response to favourable supply shocks. Positive response of money demand is in line with this. During the prosperity period of increasing output, there is an increase in consumption as a result of a rise in national income, and this makes money demand increase. These impulse response properties coincide with the results of Gali's (1992) study of the U.S. and Iacoviello's (2002) study of six countries in Europe.

4.5.3.2 Inflation Shock

Figure 4.5 shows the responses of each variable to the inflation shock, which is identified as the second permanent structural innovation. Output responds positively to this shock but is insignificant. According to economic theory, housing price may be expected to rise due to persistent inflation because of increasing demand for real assets as a hedge against inflation. Nevertheless, the two housing market prices show negative responses in the long run. Analysis indicates that housing market participants expect a rise in the interest rate and a fall in real money demand following inflation. Thus, housing market prices fall because of the higher interest rate. Indeed, although the first response of the monetary policy interest rate is negative, after rapid rise of the next period, nominal interest rate stabilizes at its higher steady-state level, consistent with a permanent inflation shock. Money demand shows a corresponding negative response, which is consistent with economic theory.

Figure 4.5: Impulse Responses to Inflation Shock

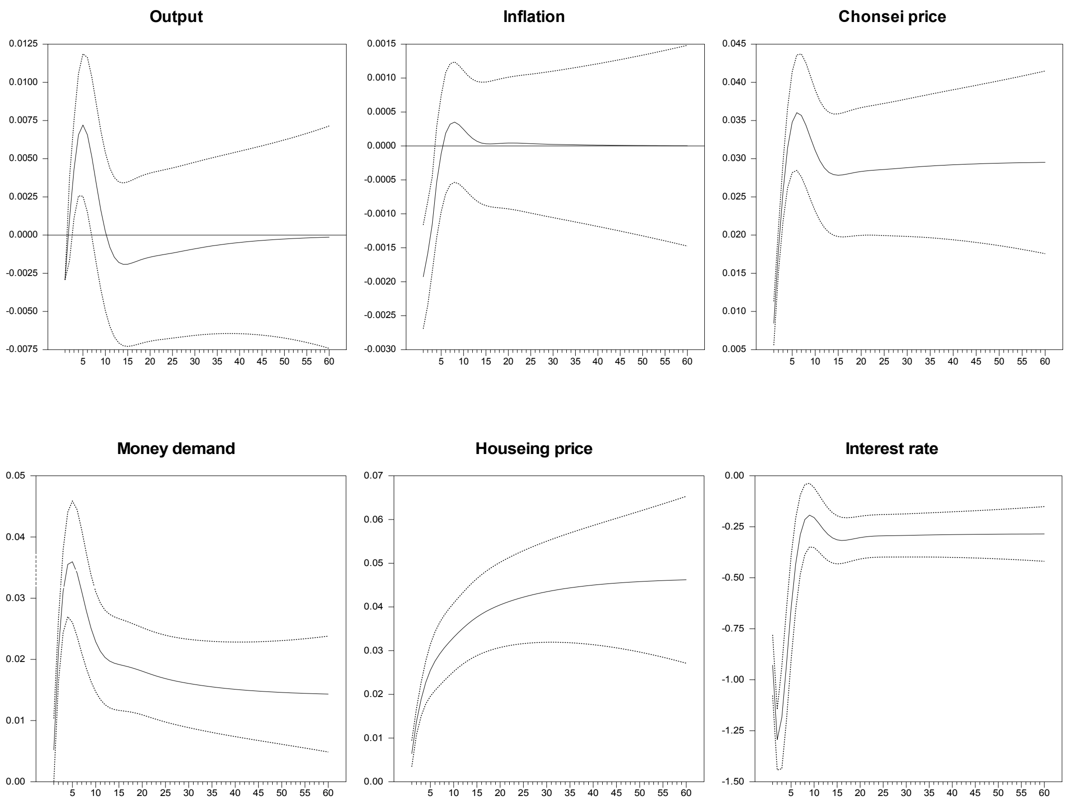


Note: ______ Estimated impulse response
- - - - - - Upper and lower one standard error bands

4.5.3.3 *Chonsei* Price Shock

Chonsei price shock as a third permanent shock is identified, and the responses of each variable to this shock are reported in Figure 4.6. The housing price may have a transitory effect from volatile movement due to speculative demand. However, *chonsei* price has a permanent effect reflecting long-run movement in proportion to economic fundamentals, because this price is driven by non-speculative demand with residential purposes. Increase in *chonsei* price shock, as with increase in housing price shock, leads to increased output response. Housing price also shows positive response to the increasing *chonsei* price shock. The reason is that people are generally aware of this situation as a signal that there will be an increase in housing price in the near future. This explanation is confirmed by examination of the flow of two actual housing market prices in Figure 4.2, which shows the fact that housing price rises after an increase in *chonsei* price, although a delay in time exists. On the other hand, increasing *chonsei*

Figure 4.6: Impulse Responses to *Chonsei* Price Shock



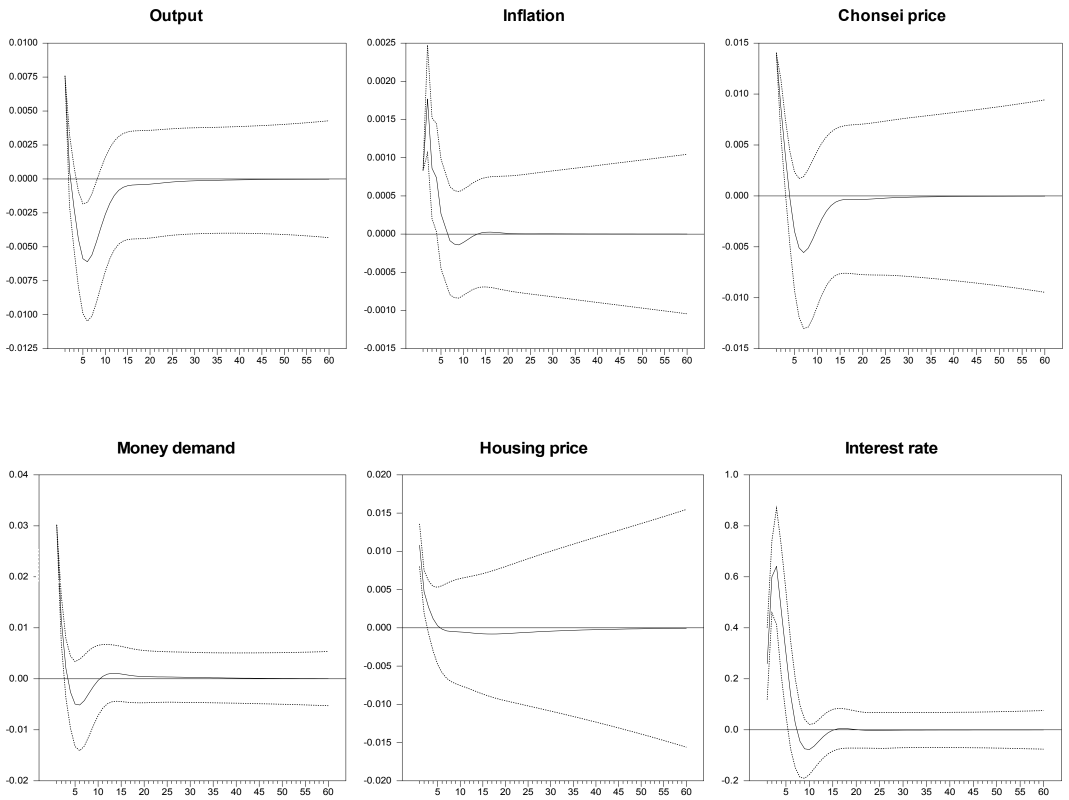
Note: ——— Estimated impulse response
- - - - - - Upper and lower one standard error bands

price leads to a decrease in inflation, and this leads to a decrease in interest rate and an increase in money demand. When *chonsei* price rises, loanable funds increase since house owners keep the increased *chonsei* deposit in the bank. This causes interest rate to decrease.

4.5.3.4 Money Demand Shock

Money demand shock is identified as a transitory shock, and impulse responses of each variable are reported in Figure 4.7. Increasing money demand shock yields responses

Figure 4.7: Impulse Responses to Money Demand Shock



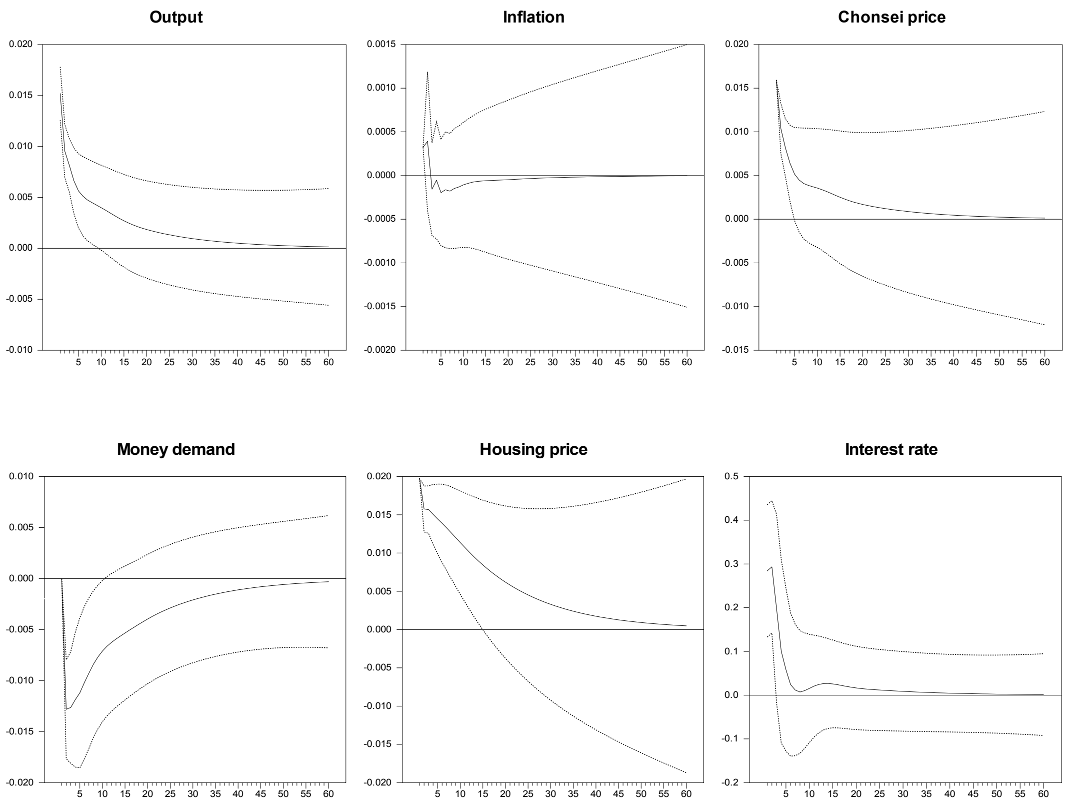
Note: ——— Estimated impulse response
- - - - - - Upper and lower one standard error bands

of increasing housing market prices initially, and these responses converge to the steady-state level over time, although the pace of convergence to the steady-state level of *chonsei* price is faster than that of housing price. In contrast, higher demand for money due to higher output leads to an increase in the interest rate, which restores money demand back to the equilibrium level and reduces inflation stemming from the increasing money demand.

4.5.3.5 Housing Price Shock

Housing price shock, identified as a second transitory shock, is reported in Figure 4.8. Output and inflation immediately rise at first to an increasing house innovation and

Figure 4.8: Impulse Responses to Housing Price Shock



Note: ——— Estimated impulse response
- - - - - - Upper and lower one standard error bands

gradually fall over time. Appreciation in the housing price leads to a growing consumption because of increased household wealth due to a rise in this asset price. This is an important factor in causing prices to increase.[59] This asset-price inflation must have been a contributing factor in the rise in the interest rate. The monetary policy maker implements tight monetary policy by increasing the nominal interest rate in order to stabilize the housing price and to keep inflation down. Decreasing money demand response, on the other hand, is related to the increased interest rate. The result showing that the housing price shock increases the price level and interest rate is consistent with the study of Elbourne (2008). When housing price rises, *chonsei* price also rises. If the house supply cannot meet the house demand, housing price will increase. If housing price rises, a *chonsei* tenant who was prepared to purchase a house may postpone such a purchase and may extend the lease or find a new *chonsei* contract instead of purchasing a house. Hence, an increase in *chonsei* demand causes *chonsei* price to increase. Responses of *chonsei* price and housing price to other macroeconomic shocks and other housing market price shock appear to be consistent. This is because these two housing market prices react sensitively to the change in the counterpart housing market price rather than change in other macroeconomic factors. This feature is in line with the result from variance decomposition of the next part that housing price and *chonsei* price explain the greatest change in each other.

4.5.3.6 Monetary Policy Shock

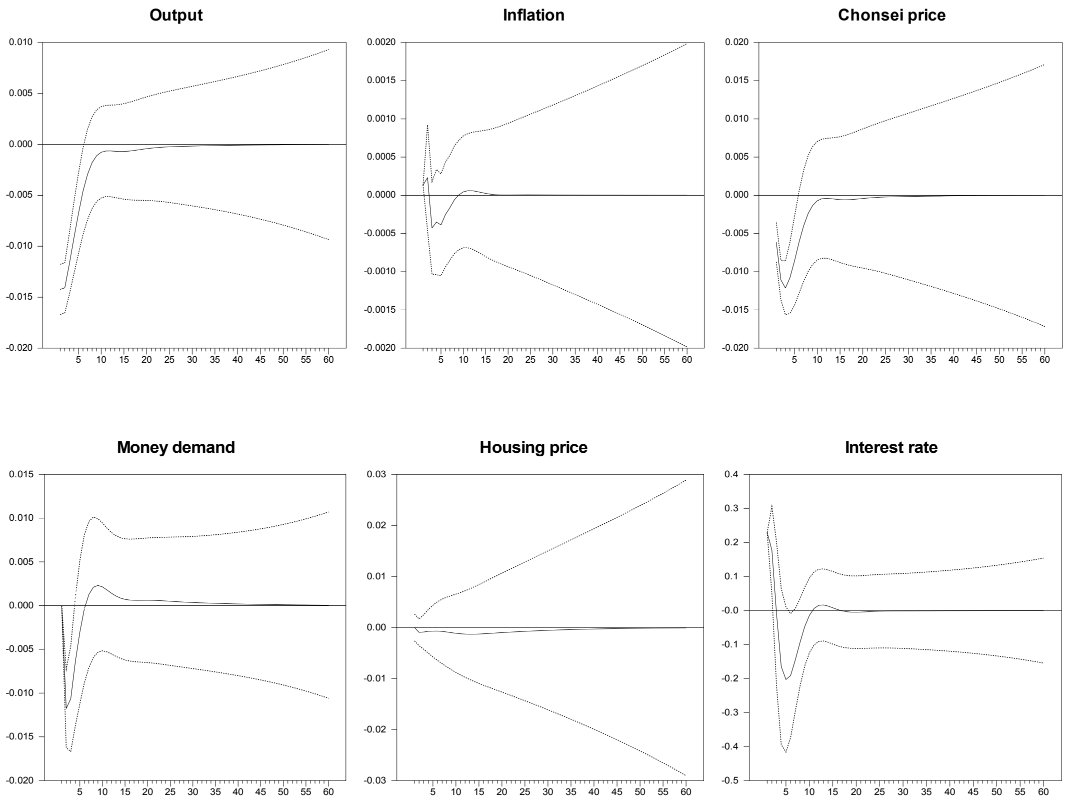
Figure 4.9, indicating monetary policy shock, which is used to determine the monetary

---

[59] Housing price accounts for 10% of CPI in Korea. On the other hand, *chonsei* price makes up 6.6% of CPI in Korea. Since the time at which *chonsei* price is generally applied to the CPI is the time that renewed *chonsei* contract is made biennially, recent increase in *chonsei* price is reflected in the CPI with a lag of two years.

policy effect on change in housing markets and macroeconomic fluctuation, shows characteristics of transitory shock. Increase in the interest rate, which is the contractionary monetary policy shock, elicits downward pressure in every other variable, and these responses are in line with the predictions of economic theory. Contractionary monetary policy leads to an immediate decrease in output, since increasing interest rate causes private consumption and business investment to be depressed, and this situation makes the aggregate supply decrease. Although inflation responds positively to the increasing nominal interest rate shock at an early stage, the effect is on the gradual decrease and converges with the steady-state level after staying

Figure 4.9: Impulse Responses to Monetary Policy Shock



Note: ——— Estimated impulse response
- - - - - - Upper and lower one standard error bands

in the minus zone for a while. Judging from this, there is a slight price puzzle, a rise in the aggregate price level in response to a contractionary innovation to monetary policy. At the early stage, the price puzzle is very short lived. Money demand response to the tight monetary policy shock is negative. Because money is an unprofitable financial asset, the higher interest rate requires the higher opportunity cost and requests more cost for money demand. Two housing market prices also show negative responses to the contractionary monetary policy shock because of higher cost. The response of *chonsei* price is sensitive to monetary policy shock, while the response of housing price is not, because housing price responds more sensitively to fundamental factors. The fact that contractionary monetary policy leads to a fall in real housing price has traditionally been found in the conventional literature, although methodologies differ (Iacoviello, 2002; Iacoviello and Minetti, 2003; Elbourne, 2008; Vargas-Silva, 2008; Gupta and Kabundi, 2010).

4.5.4 Variance Decomposition

Decomposition of the forecast error variance is examined to ascertain that the variable's change has relatively important influence on a certain variable in attempting forecast. Table 4.8 presents the percentage contribution of the structural shocks to the forecast error variance in the growth rates of the variables in the model.[60] In

[60] Results from variance decomposition should be interpreted with care when the variance decomposition is performed for the levels of the series. When each of the variables contains a unit root component, the variance of the forecast error becomes very large as the forecast horizon becomes large. The variance of the forecast error is in the denominator of the expression that is used to obtain the contribution of a particular shock to the forecast error variance for a particular variable. For a similar reason the numerator will also become large as the forecast horizon increases. In essence the calculation becomes unreliable as the forecast horizon increases when each of the variables is an I(1) process. To get around this problem, the forecast error variances for the growth rate of the series at various horizons are often reported instead.

accordance with the results from impulse response function in section 4.5.3, the results from variance decomposition indicate that three permanent shocks and three transitory shocks are identified well from six structural shocks, and the characteristics of each shock are well represented.

Upon seeing the plots of the fraction of the *k*-step ahead forecast error variance for six variables explained by the different structural shocks, first, output can be explained by the change of combined housing price shocks of about 46% and by contractionary monetary shock of about 39% in the short run. However, because of the nature of

Table 4.8: Variance Decomposition

Variables	Shocks	Periods(*k*)							
		1	2	3	6	10	20	40	60
Output	Supply	3.88	7.95	14.3	36.4	55.3	75.4	88.3	92.6
	Inflation	0.07	0.07	0.25	0.37	0.44	0.35	0.18	0.11
	Chonsei Price	1.65	1.13	2.36	7.01	5.35	3.11	1.55	0.98
	Money Demand	11.1	6.75	5.25	6.48	5.89	3.13	1.45	0.91
	Housing Price	44.4	37.5	32.6	20.6	14.7	8.59	4.11	2.60
	Monetary Policy	38.9	46.6	45.3	29.1	18.3	9.48	4.39	2.77
Inflation	Supply	14.6	13.1	12.5	10.5	8.34	6.84	6.27	6.15
	Inflation	74.8	68.9	71.6	78.3	83.8	88.8	91.5	92.3
	Chonsei Price	8.71	10.8	9.48	6.30	4.45	2.46	1.29	0.87
	Money Demand	1.63	6.67	5.73	4.15	2.83	1.55	0.81	0.55
	Housing Price	0.25	0.45	0.35	0.28	0.23	0.14	0.08	0.05
	Monetary Policy	0.04	0.12	0.32	0.47	0.33	0.19	0.10	0.07
chonsei Price	Supply	0.13	1.34	3.16	9.76	15.4	22.2	27.5	29.7
	Inflation	2.14	3.95	3.62	2.77	2.50	2.84	3.16	3.28
	Chonsei Price	12.5	31.4	47.2	67.1	70.1	68.5	66.1	64.9
	Money Demand	34.4	21.8	12.9	4.82	3.20	1.69	0.83	0.54
	Housing Price	44.2	28.8	19.3	7.63	4.46	2.57	1.29	0.84
	Monetary Policy	6.59	12.8	13.8	7.90	4.34	2.26	1.10	0.72

Table 4.8 (continued)

Variables	Shocks	Periods(*k*)							
		1	2	3	6	10	20	40	60
Money Demand	Supply	41.1	49.1	50.5	52.6	56.8	62.4	66.6	68.6
	Inflation	3.73	4.52	3.69	2.68	2.39	2.27	2.08	1.95
	Chonsei Price	1.60	12.3	21.6	31.8	31.4	28.8	26.9	26.0
	Money Demand	53.4	26.5	15.6	6.82	4.43	2.79	1.81	1.40
	Housing Price	0.00	4.14	4.81	4.26	3.74	3.03	2.13	1.65
	Monetary Policy	0.00	3.49	3.74	1.86	1.24	0.80	0.52	0.40
Housing Price	Supply	4.96	8.08	10.3	14.7	18.1	23.7	29.1	31.4
	Inflation	1.72	2.15	2.07	2.11	2.30	2.70	3.08	3.23
	Chonsei Price	7.04	20.5	31.7	50.0	58.7	64.3	64.2	63.3
	Money Demand	19.9	12.4	7.92	2.94	1.36	0.48	0.18	0.10
	Housing Price	66.4	56.8	47.9	30.1	19.4	8.80	3.41	1.97
	Monetary Policy	0.00	0.08	0.09	0.07	0.06	0.07	0.03	0.02
Nominal Interest Rate	Supply	29.9	29.4	29.4	34.8	39.6	46.7	54.2	58.1
	Inflation	0.82	0.84	0.55	0.53	0.68	0.95	1.18	1.29
	Chonsei Price	56.2	55.0	54.4	50.1	46.3	41.8	37.2	34.8
	Money Demand	4.39	9.27	11.6	10.8	9.74	7.65	5.39	4.20
	Housing Price	5.26	3.62	2.85	2.04	1.82	1.45	1.03	0.81
	Monetary Policy	3.42	1.82	1.16	1.75	1.83	1.43	1.01	0.79

Note: Each number is a percentage of variance decomposition.

permanent shock, most output fluctuation can be explained by supply shock as time transitions to the long run (93%).

Second, not only in the short run (75%) but also in the long run (92%), volatility in inflation comes from the inflation shock, which is an unquestionable piece of evidence that inflation shocks are a permanent shock. However, in the early period, the variance of inflation is attributable to supply innovation (15%) and combined housing market price innovations (9%).

Third, although housing price shock, monetary shock, and monetary policy shock playa major role in determining *chonsei* price fluctuation with 44%, 34%, and 7%, respectively, in the short run, explanatory power by supply shock increases steadily to 30% in the long run. However, variance of *chonsei* price is mostly related to the *chonsei* price innovation in the long run (65%), and this is also proof that *chonsei* price shocks are a permanent shock.

Fourth, variance of money demand can be explained by supply shock of about 41% in the short run and about 69% in the long run. Thus, the dominant shock to explain the variance of money demand is supply innovation. Additionally, variance of money demand is attributable to the combined housing market price innovations of about 28% in the long run.

Fifth, the most attributable shock to explain the housing price fluctuation is housing price shock (66%) in the short run and *chonsei* price shock (63%) in the long run. From this result, it is confirmed that variation in housing price is strongly related to the change in *chonsei* price. Other major factors to explain the variance in housing price are money demand innovation (20%) in the short run and supply shock (31%) in the long run.

Sixth, the variability of the short-term nominal interest rate is in large part due to supply shocks and combined housing market price shocks of about 30% and 61%, respectively, in the short run. These shocks still maintain their strong influence in the long run of about 58% and 36%, respectively.

Summarizing the results from variance decomposition, output is explained well by the housing market shocks and monetary policy shock in the short run; on the other hand, most of the variability of the two housing market prices is explained by supply shock and two housing market price shocks. Hence, the two housing market prices have a large influence on each other with supply shock and other housing market prices. In addition, supply shocks and the two housing market price shocks play a major role in explaining the variance of two monetary market variables: money demand and the short-term nominal interest rate.

4.5.5 Historical Decomposition

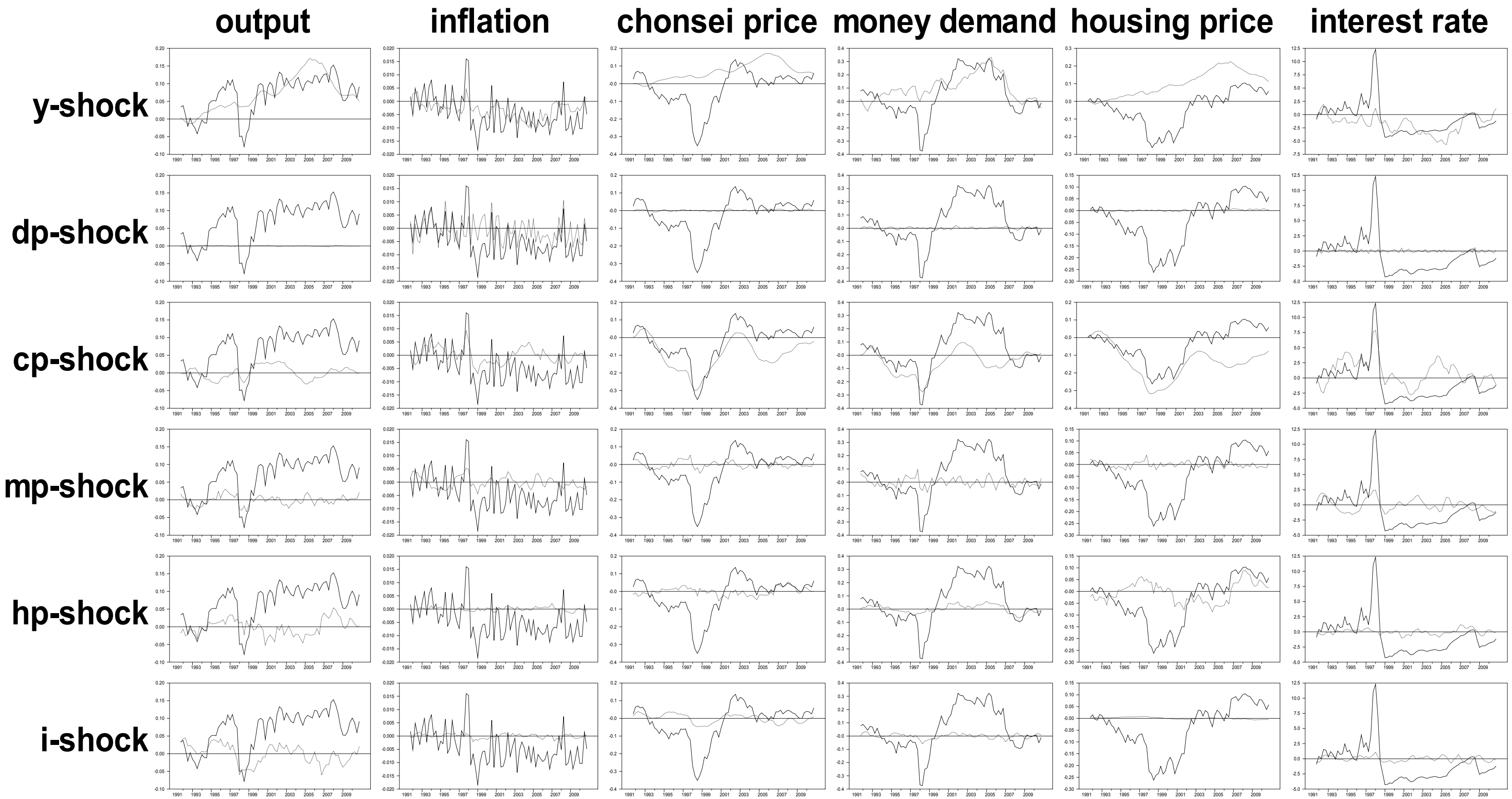
The historical decomposition has been a part of the VAR-related methodology since the early 1980s.[61] This method is useful to examine how much other variables affect the change of a specific variable (Zhu, 1996). The historical decomposition is based on the following reorganization of the moving average representation for a vector time series X_t.

$$X_{t+k} = \sum_{s=0}^{k-1} \Psi_s v_{t+k-s} + \left[\hat{X}_{t+k} + \sum_{s=k}^{\infty} \Psi_s v_{t+k-s} \right] \qquad (4.21)$$

Where X_t is a 6×1 column vector, $X_t = [y_t, \pi_t, c_t, mp_t, h_t, i_t]'$, and v_t is vector of innovations, which is the non-forecastable components of X_t. In equation (4.21), the first term ($\sum_{s=0}^{k-1} \Psi_s v_{t+k-s}$) represents the part of the historical time series attributable to innovations since *t*, and can be further examined to establish the role of the innovations of each variable separately (Burbidge and Harrison, 1985). On the other hand, the term

[61] The historical decomposition is first developed in the work on Sims (1980). However, the first paper based on historical decomposition is Burbidge and Harrison (1985).

Figure 4.10: Historical Decomposition



Note: The solid line denotes the total effect of the shock, and the dotted line denotes the contribution of each shock.

in brackets ($\hat{X}_{t+k} + \sum_{s=k}^{\infty} \Psi_s e_{t+k-s}$) is the forecast of X_{t+k} based on the information available at time *t*. In this way, the equation (4.21) for historical decomposition divides the role into two. One is the actual series among the innovations of the variables in the first term, and the other is the base projection in the second term. Thus, history decomposes the historical values of a set of time series into the accumulated effects of current and past innovations and a base projection. From equation (4.21), it is clear that the introduction of innovations since *t* in all variables yields the actual series. Hence the importance of a particular variable can be determined by examining the extent to which the introduction of the innovations since *t* in that variable closes the gap between the base projection and the actual series (Burbidge and Harrison, 1985).

Figure 4.10 shows the result of historical decomposition. The solid line denotes the total effect of all the shocks, and the dotted line denotes the contribution of each shock. The historical decomposition of output indicates that variations in supply shock are a relatively good driving force of the forecast error variance of cyclical output, money demand, and nominal interest rate. It also shows that the *chonsei* price shock has a good explanatory ability to make clear the variance of inflation, housing market price, money demand, and the nominal interest rate than other shocks. Monetary policy shock explains the output fluctuation relatively well.

4.6 Conclusion

In this chapter, a structural shock from a change in the housing market is considered as a source to generate the business cycle in Korea. Additionally, the contagion mechanism between housing market prices and key macroeconomic variables is also examined. In particular, in company with housing sale price, housing *chonsei* price is introduced independently as a representative rental housing price in Korea to examine the relationship between two segmentalized housing markets. The relationship between monetary policy and housing market prices is another important issue to study in this chapter.

To investigate these three relationships, two housing market prices, housing price and *chonsei* price, and four key macroeconomic variables − output, inflation, money demand, and the short-run nominal interest rate − are used to compose the VECM framework as a methodology. In the VECM framework, there are three cointegrating relationships − money demand, output-house ratio, and *chonsei*-house ratio − between six variables on the basis of economic theories. Since the cointegration restrictions imply a particular shape of the long-run covariance matrix, this information can be used to distinguish structural innovations into permanent and transitory innovations in the estimated system. The two-step procedure from Gonzalo and Ng (2001) is employed to identify the permanent and transitory shocks with quarterly data from 1991Q1 to 2010Q4. Impulse response functions, variance decomposition, and historical decomposition from a cointegrated VAR model using DOLS to compute cointegrating estimates provide meaningful results. Identification for six structural shocks into three permanent components and three transitory components is relatively well done. Supply, inflation, and *chonsei* price shocks are identified as permanent components, and money demand, housing price, and monetary policy shocks are identified as transitory components.

A summary of the main results are as follows. First, the findings for the first issue about the relationship between the business cycle and housing market indicate a positive relationship between the two. From the time series path, housing price shows decrease or stagnation during the recessionary period of the Korean economy. This simple visible figure corresponds to the results from impulse response functions. Two housing market prices respond positively to the favourable supply shock, and increase in two housing market prices leads to increase in output. According to the results from variance decomposition, variance of output can be explained by two housing market price shocks of about 46% in the short run, and variability of two housing market prices are in large part due to supply shock of around 30% in the long run. Historical decomposition shows that *chonsei* price shock explains output fluctuation well.

Second, the answer to the issue about the relationship between housing price and *chonsei* price is that there is a strong positive relationship between two housing market prices. Thus, change in one housing market price can provide good information to predict the movement in the other housing market price. The response of *chonsei* price is positive to increasing housing price shock, and housing price also responds positively to increasing *chonsei* price shock. In addition, the fact that the responses of these two housing market prices show the same direction of fluctuation to every individual shock in the VECM framework supports the conclusion that there is a strong positive relationship between the two housing market prices. This strong relationship is also found in the result from variance decomposition. Variance in *chonsei* prices can be explained by housing price shock of about 7% in the short run, whereas it grows more in the long run to about 63%. On the other hand, housing price innovation explains the variance in *chonsei* price of about 44% in the short run, whereas it has little effect in the long run. With these results, the flow of *chonsei* price can be recognizable by seeing the flow of housing price, and the flow of housing price can also be predictable by looking at the flow of *chonsei* price.

Third, the answer to the third issue about the relationship between monetary policy and housing market is that the contractionary monetary policy leads to a fall in housing market prices. On the other hand, an increase in housing price is a contributing factor for monetary policy makers to formulate tight monetary policy for implementation by increasing the interest rate.

As fluctuation in housing price has a growing influence on the domestic economy, study regarding the relationship between the housing market and macroeconomic fundamentals is being carried out to obtain more conclusive information. This chapter is a part of this stream, but this study is differentiated in the respect that this is the first attempt to consider not only a house sale market but also a rental housing market at the same time in one model. The results of this study suggest some policy implications to monetary policy makers that monetary policy decisions made without considering the housing market fluctuation may have the possibility to cause the domestic economy to proceed in an unintended direction. Hence, to make timely policy decisions, policy makers should observe constantly and accurately the change in the housing market together with macroeconomic fundamentals. Additionally, the results of this study also provide housing market participants, such as investors and customers, who want to buy a house to inhabit or want to make a *chonsei* contract with valuable information.

Thus far, since few economic theories and empirical results for rental housing market such as *chonsei* market are studied, consolidated theory is absent. After developing the undisputed theory for the housing market along with the rental housing market, it is expected that empirical study to support this theory can be carried out positively. In addition, when identifying the structural shocks to permanent and transitory components, it does not matter whether it is another well-known method or a newly developed method; it is necessary to examine complementarily the relationship between the housing market and macroeconomic fundamental considering short-run restrictions as well as long-run restrictions based on economic theory.

Chapter 5 Conclusion

5.1 Summary of the Thesis

The thesis has examined the dynamic interactions between monetary and financial sectors and the real economy in Korea following financial liberalization in the early 1990s. Using quantitative and empirical models, I examined key issues concerning the Korean economy characterized by an emerging and volatile capital market and a unique housing market system. The thesis identified and focused on three interrelated issues. The first issue is the extent to which changes in international borrowing costs, reflected in shocks to country risk and world interest rates, drive macroeconomic fluctuations in Korea. The second related issue is how changes in country risk and international asset returns transmit to returns and volatility in Korean asset markets. The third issue is whether and to what extent the changes in housing market prices explain short-term economic fluctuations in Korea. These three issues have been examined in each of the main chapters of the thesis.

Chapter 1 motivates the thesis in the context of the relationship between macroeconomic fluctuations and asset market movements in Korea by introducing related literature and denoting the characteristics of the Korean economy.

Chapter 2 examines the effects of changes in country spread and world interest rates on macroeconomic fluctuations in Korea. I estimate an SVAR model of a small open economy comprising output, investment, and net exports along with country spread and the world interest rate with quarterly data from 1994Q1 to 2008Q4. I find that there exists a countercyclical relationship between country spread and the business cycle in Korea. U.S. interest rate shocks affect macroeconomic fluctuations in Korea positively, whereas Japanese interest rate shocks have a negative influence on the business cycle in Korea during the period. Combined shocks in the country spread and the U.S. interest rate explain about 10% of the variability of the Korean business cycle. The explanatory ability is reduced to 5% when Japan replaces the U.S. as the world interest rate setter. I also calibrate a small open economy DSGE model of Uribe and Yue (2006) to the Korean data. To check for robustness, the theoretical impulse responses from the calibrated model are compared against the impulse responses form the estimated SVAR model. Broadly consistent with the empirical results from the SVAR model, the DSGE model captures the observed macroeconomic dynamics induced by country spread and the two external financial market shocks relatively well.

Chapter 3 investigates the presence of return and volatility spillover effects between foreign exchange markets and stock markets and Korean stock and credit default swap markets. To examine the changes in international asset market and country risk effects on change in domestic asset markets, four categorized cases are estimated case by case. In each case, the Korean stock market and the CDS market for Korean government bonds are included. In addition, Korean-U.S. and Korean-Japanese foreign exchange markets, and U.S. and Japan stock markets are also included in each case as a third financial market. The trivariate VAR BEKK GARCH (1,1) model is employed to estimate spillover effects with weekly data from the first week of January 2002 through to the fourth week of February 2010. Economic theories such as the flow approach, the portfolio balance approach, and the arbitrage pricing theory (APT) are considered in order to understand the relationships between these variables. The results show that there are significant return spillover effects from foreign exchange markets to the Korean stock and CDS markets, whereas there is a significant volatility spillover effect from foreign exchange markets to the Korean CDS market. On the other hand, there are significant return spillover effects from the U.S. stock market to the Korean stock and CDS markets, whereas there is a significant volatility spillover effects from the Japanese stock market to the Korean stock and CDS markets. In most cases, there is unidirectional or bidirectional return spillover effect between the Korean CDS market and the Korean stock market, whereas there is a bidirectional volatility spillover effect between the two Korean financial markets.

Chapter 4 explores the relationship between macroeconomic fluctuations and housing markets in Korea. In particular, three relationships are considered: the relationship between the business cycle and housing markets, the relationship between housing price and *chonsei* price, and finally the relationship between monetary policy and housing market prices. To investigate these three relationships, a six-variable vector error correction model (VECM) is estimated using quarterly data from 1991Q1 to 2010Q4 by making use of the three cointegrating relationships implied by the three relationships outlined above. In this VECM, I use Gonzalo and Ng's (2001) two-step procedure to identify the structural shocks to permanent and transitory components. The following are the main results concerning the three relationships. First, when housing market prices rise, output increases. On the other hand, when there is a favourable supply shock, housing market prices respond positively. Second, when the housing price rises, the *chonsei* price undergoes a rise transitory. In contrast, when the *chonsei* price rises, the housing price rises permanently. Third, a contractionary monetary policy shock leads to a fall in both housing and *chonsei* prices.

Overall, the results confirm that changes in domestic and international financial and asset markets have a significant influence on macroeconomic fluctuations in Korea. In addition, macroeconomic fluctuations also play an important role in movements in Korean asset markets. Thus, it is necessary for policy makers and asset market participants to consider financial and asset market movements along with macroeconomic fluctuations when formulating policies and investing in assets because of the close connection between two.

5.2 Directions for Future Research

The ideas of each chapter and the main aim of the thesis can be extended in a number of directions. For example, it is possible to construct a single unified framework that incorporates both the stock market and the housing market, in identifying structural shocks between asset markets and macroeconomic variables, whereas traditionally these two asset markets have been studied separately (see Cochrane (1994), Gonzalo and Lee (2007) and Senyuz (2011) for stock market and Iacoviello (2002) for housing market). This combined model may be constructed using variables such as GDP, consumption, investment, interest rates, stock prices and house prices.

Another direction for extension of this research concerns the volatility transmission between asset markets and macroeconomic factors such as GDP growth, inflation and interest rates. Diebold and Yilmaz (2008) find a clear link between macroeconomic fundamentals and stock market volatilities, with volatile fundamentals translating into volatile stock markets. However, since conventional GARCH or stochastic volatility models cannot permit unconditional volatility to change over time, the spline GARCH model proposed by Engle and Rangel (2008) may be useful to overcome this problem. The spline GARCH model allows high frequency financial data to be linked with low frequency macroeconomic data. Thus, volatility transmission between macroeconomic variables such as GDP and interest rates and asset markets such as the stock market and housing market can be analyzed.

Bibliography

Abadir, K. M., Hardi, K., and Tzavalisi, E., 1999, "The Influence of VAR Dimensions on Estimated Biases," *Econometrica*, vol. 67, pp. 163-181.

Abel, A. B., 1990, "Asset Prices under Habit Formation and Catching up with the Joneses," *American Economic Review Papers and Proceedings*, vol. 80, pp. 38-42.

Aggarwal, R., 1981, "Exchange Rates and Stock Prices: a Study of the US Capital Markets under Floating Exchange Rates," *Akron Business and Economic Review*, Fall, pp. 7-12.

Agénor, P.-R., J. M., and Prasad, E., 2000, "Macroeconomic Fluctuations in Developing Countries: Some Stylized Facts. *The World Bank Economic Review*, vol. 14(2), pp. 251-285.

Aguiar, M., and Gopinath, G., 2007, "Emerging Market Business Cycles: The Cycle is the Trend," *Journal of Political Economy*, vol. 115, no, 1, pp. 69-102.

Ahn, H. D., and Kim, S. H., 2003, "Dynamics of Open Economy Business Cycle Models: The Case of Korea," *Korea Institute for International Economic Policy (KIEP) Working Paper*, 03-04.

Angkinand, A. P., Barth, J. R., and Kim, H. W., 2009, "Spillover Effects from the US Financial Crisis: Some Time-Series Evidence from National Stock Return," The Financial and Economic Crises: An International Perspective Benton Gup, Editor Edward Elgar Publishing.

Baba, Y., Engle, R. F., Kraft, D., and Kroner, K., 1990, "Multivariate Simultaneous Generalized ARCH," unpublished manuscript, *University of California-San Diego*.

Bala, L. and Premaratne, G.., 2003, "Stock Market Volatility: Examining North America, Europe and Asia," *National University of Singapore, Economics working paper*.

Baum C. F., and Wan, C., 2010, "Macroeconomic Uncertainty and Credit Default Swap

Spreads," *Boston College Working Paper*. 724.

Bauwens, L., Laurent, S., and Rombouts, J. V. K., 2006, " Multivariate GARCH Models: a Survey," *Journal of Applied Econometrics*, vol. 21, pp. 79–109.

Beer, F., and Hebein, F., 2008, "An Assessment of the Stock Market And Exchange Rate Dynamics in Industrialized and Emerging Markets," *International Business & Economics Research Journal*, vol. 7, no. 8, pp. 59-70.

Beirne, J., Caporale, G. M., Schulze-Ghattas, M., and Spagnolo, N., 2009, "Volatility Spillovers and Contagion from Mature to Emerging Stock Markets," *European Central Bank. Working Paper Series*, no. 1113.

Beirne, J., Caporale, G. M., Schulze-Ghattas, M., and Spagnolo, N., 2010, "Global and Regional Spillovers in Emerging Stock Markets: a Multivariate GARCH-in-Mean Analysis," *Emerging Markets Review*, vol. 11, pp. 250-260.

Bekaert, G., and Harvey, C. R., 1995, "Time-Varying World Market Integration," *Journal of Finance*, American Finance Association, vol. 50(2), pp. 403-444, June.

Bekaert, G., and Harvey, C. R., 1997, "Emerging Equity Market Volatility," *Journal of Financial Economics*, vol. 43(1), pp. 29-77, January.

Benhabib, J., Rogerson, R., and Wright, R., 1991, "Homework in Macroeconomics: Household production and Aggregate Fluctuation," *Journal of Political Economy*, University of Chicago Press, vol. 99(6), pp. 1168-1187, December.

Bernanke, B. S., 1986, "Alternative Explanations of the Money-Income Correlation," *Carnegie-Rochester Conference Series on Public Policy*, vol. 25, pp. 49-100.

Bernanke, B. S., 2010, "Monetary Policy and the Housing Bubble," Paper presented at the annual meeting of American Economic Association, January.

Bernanke, B. S., and Blinder, A., 1988, "Credit, Money, and Aggregate Demand," *American Economic Review*, vol. 78, pp. 435-439.

Bernanke, B. S., and Gertler, M., 1995, “Inside the Black Box: The Credit Channel of Monetary Transmission,” *Journal of Economic Perspectives*, vol. 9, pp. 27-48.

Berndt, E., Hall, B., Hall, R., and Hausman, J., 1974, “Estimation and Inference in Nonlinear Structural Models,” *Annals of Economic and Social Measurement*, vol. 3, pp. 653-665.

Bjornland, H. C., and Jacobsen, D. H., 2008, “The Role of House Prices in the Monetary Policy Transmission Mechanism in the U.S.,” *Norges Bank Working paper*, 2008/24.

Blanchard, O. J., and Fisher, S., 1989, “Lectures on Macroeconomics,” *MIT Press*, Cambridge Massachusetts.

Blanchard, O. J., and Quah, D., 1989, “The Dynamic Effects of Aggregate Supply and Demand Disturbances,” *American Economic Review*, vol. 79, pp. 655-673.

Blankenau, W., Kose, M. A., and Yi, K., 2001, “Can World Real Interest Rates Explain Business Cycles in a Small Open Economy?” *Journal of Economic Dynamics and Control*, vol. 25(6-7), pp. 867-889.

Boldrin, M., Christiano, L. J., and Fisher, J., 2001, “Asset Pricing Lessons for Modeling Business Cycles,” *American Economic Review*, vol. 91 (1), pp. 149-166.

Bollerslev, T., 1986, “Generalized Autoregressive Conditional Heteroskedasticity,” *Journal of Econometrics*, vol. 31, pp. 307-327.

Bollerslev, T., Engle, R. F. and Wooldridge, J. M., 1988, “A Capital Asset Pricing Model with Time-Varying Covariances,” *Journal of Political Economy*, vol. 96(1), pp. 116-131.

Bolten, S. E., and Weigand, R. A., 1998, “The Generation of Stock Market Cycles,” *The Financial Review*, vol. 33, pp. 77-84.

Branson, W. H., 1983, “Macroeconomic Determinants of Real Exchange Rate Risk,” In: Herring, R. J., (Ed.), Managing Foreign Exchange Rate Risk, *Cambridge University*

Press, Cambridge, MA.

Bruggemann, I., 2003, “Measuring Monetary Policy in Germany: A Structural Vector Error Correction Approach,” *German Economic Review*, vol. 4, no. 3, pp. 307-339.

Burbidge, J., and Harrison, A., 1985, “A Historical Decomposition of the Great Depression to Determine the Role of Money,” *Journal of Monetary Economics*, vol. 16, no. 1, pp. 45-54.

Carstensen, K., Hulsewig, O., and Wollmershauser, T., 2009, “Monetary Policy Transmission and House Prices: European Cross-country Evidence,” *CESIFO Working paper,* No.2750.

Campbell, J., and Cochrane, J., 1999, “By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior,” *Journal of Political Economy*, vol. 107 (2), pp. 205-251.

Canova, F., 2005, “The Transmission of US Shocks to Latin America,” *Journal of Applied Econometrics*, vol. 20, pp. 229-251.

Chang, Y. S., and Hornstein, A., 2006, “Home Production,” *Federal Reserve Bank of Richmond Working paper* 06-04.

Chauvet, M., 1998, “Stock Market Fluctuations and the Business Cycle,” *Journal of Economic and Social Measurement*, vol. 25, pp. 235-257.

Cho, D. H., and Ma, S. R., 2006, “Dynamic Relationship between Housing Values and Interest Rates in the Korean Housing Market,” *The Journal of Real Estate Finance and Economics*, vol. 32, no. 2, pp. 169-184.

Cho, D. C., 2005, “Interest Rate, Inflation, and House Price with an Emphasis on *Chonsei* Price in Korea,” *NBER Working paper*, 11054.

Choi, J. J., Hiraki, T., and Takezawa, N., 1998, “Is Foreign Exchange Risk Priced in the Japanese Stock Market?” *Journal of Financial and Quantitative Analysis*, vol. 33, pp. 361-382.

Chou, R. Y., Lin, J., and Wu, C., 1999, "Modeling the Taiwan Stock Market and International Linkages," *Pacific Economic Review*, vol. 4, pp. 305-320.

Christiano, L. J., and Todd, R. M., 1995, "Time to Plan and Aggregate Fluctuations," *Federal Reserve Bank of Minneapolis Quarterly review*, vol. 20 (1), pp. 14-27.

Christiano, L. J., Eichenbaum, M., and Vigfusson, R., 2006, "Assessing Structural VARs," *NBER Working Paper*, no. 12353.

Chung, J. S., 2002, "Analysis of Connectivity between Korea Financial Market and Major Countries' Financial Market around Asian Financial Crisis," Economic Research Institute in Sogang University, *Sogang economic review*, vol. 31-1, pp. 73-99.

Cochrane, J. H., 1994, "Permanent and Transitory Components of GNP and Stock Prices," *Quarterly Journal of Economics* CIX, pp. 241-266.

Constantinides, G. M., 1990, "Habit Persistence: A Resolution of the Equity Premium Puzzle," *Journal of Political Economy*, vol. 98, pp. 519-543.

Correia, I., Neves, J. C., and Rebelo, S., 1995, "Business Cycles in a Small Open Economy," *European Economic Review*, vol. 39 (6), pp. 1089-1113.

Cossin, D., and Hricko, T., 2001, "Exploring for the Determinants of Credit Risk in Credit Default Swap Transaction Data," working paper.

Dark, J., Raghavan, M. and Kamepalli, A., 2005, "Return & Volatility Spillovers between the Foreign Exchange Market and the Australian All Ordinaries Index," unpublished manuscript, Monash University.

Davis, M. A., and Heathcote, J., 2005, "Housing and the Business Cycle," *International Economic Review*, vol. 46, pp.751-784.

Dawkins, C., Srinivasan, T. N., and Whalley, J., 2001, "Calibration," *Handbook of Econometrics*, vol. 5, pp. 3653-3703.

Diebold, F. X., and Yilmaz, K., 2008, "Macroeconomic Volatility and Stock Market Volatility, Worldwide," *NBER Working Paper*, w14269.

Dornbusch, R., and Fischer, S., 1980, "Exchange Rates and the Current Account," *American Economic Review*, vol. 15, pp. 369-386.

Dumas, B., and Solnik, B., 1995, "The World Price of Foreign Exchange Risk," *Journal of Finance*, vol. 50, pp. 445-477.

Elbourne, A., 2008, "The UK Housing Market and the Monetary Policy Transmission Mechanism: An SVAR Approach," *Journal of Housing Economics*, vol. 17, pp. 65-87.

Elmahadaoui, A. R., and Dugas, C., 2009, "Using Credit Default Swaps Information in Stock Trading" unpublished manuscript.

Engle, R. F., and Granger, C. W. J., 1987, "Cointegration and Error-correction: Representation, Estimation, and Testing," *Econometrica*, vol. 55, pp.251-276.

Engle, R. F., and Kroner, K. F., 1995, "Multivariate Simultaneous Generalized ARCH, *Econometric theory*, vol. 11, pp. 122-150.

Engle, R. F., and Rangel, J. G.., 2008, "The Spline-GARCH Model for Low Frequency Volatility and its Global Macroeconomic Causes," *The Review of Financial Studies*, vol. 21, pp. 1187-1222.

Estrella, A., and Mishkin, F. S., 1998, "Predicting U.S. Recessions: Financial Variables as Leading Indicators," *The Review of Economics and Statistics*, vol. 80(1), pp. 45-61.

Faust, J., and Leeper, E. M., 1997, "When Do Long-run Identifying Restrictions Give Reliable Results?," *American Statistical Association*, vol. 15, pp. 345-353.

Favero, C. A., 2001, "Applied Macroeconomics," *Oxford University Press*, pp. 183-238.

Financial Services Commission, 2011, "Chronological Table Regarding Finance in Korea".

Fisher, I., 1930, “The Theory of Interest”.

Fisher, L. A., Otto, G., and Voss, G. M., 1996, “Australian Business Cycle Facts,” *Australian Economic Papers*, vol. 35(67), pp. 300-320.

Fisher, L. A., Otto, G., and Voss, G. M., 2010, “The Response of Australian Consumption to Housing Wealth,” *Journal of Macroeconomics*, vol. 32, pp. 284-299.

Francis, B. B., Iftekhar H., and Delroy, M. H., 2002, “Return Volatility Linkages in International Equity and Currency Markets,” *Bank of Finland Discussion Paper*, no. 9-2002.

Frankel, J. A., 1983, “Monetary and Portfolio Balance Models of Exchange Rate Determination,” In: Bhandari, J. S., Putnam, B. H (Eds.), Economic interdependence and flexible exchange rates, *MIT Press*, Cambridge, MA.

Gali, J., 1992, “How Well Does the IS-LM Model Fit Postwar U.S. Data?,” *Quarterly Journal of Economics*, vol. 107, no. 2, pp.709-738.

Garcia-Cicco, J., and Pancrazi, R., 2010, “Real Business Cycles in Emerging countries?” *American Economic Review*, vol. 100, pp. 2510-2531.

Gavin, M., 1989. “The Stock Market and Exchange Rate Dynamics,” *Journal of International Money and Finance*, vol. 8, pp. 181-200.

Giuliodori, M., 2005, “Monetary Policy Shocks and the Role of House Prices across European Countries,” *Scottish Journal of Political Economy*, vol. 52, pp. 519-543.

Gonzalo, J., and Granger, C., 1995, “Estimation of Common Long-Memory Components in Cointegrated Systems,” *Journal of Business and Economic Statistics*, vol. 13(1), pp. 27-35.

Gonzalo, J., and Ng, S., 2001, “A Systemic Framework for Analysing the Dynamic Effects of Permanent and Transitory Shocks,” *Journal of Economic Dynamics and Control*, vol. 25, pp. 1527-1546.

Gonzalo, J., and Lee, T. H., 2008, "Permanent and Transitory Components of GDP and Stock Prices: Further Analysis," *Macroeconomics and Finance in Emerging Market Economies*, pp. 105-120.

Goodhart, C., and Hofmann, B., 2008, "House Prices, Money, Credit, and the Macroeconomy," *Oxford Review of Economic Policy*, vol. 24, pp. 180-205.

Green, R. K., 1997, "Follow the Leader: How Changes in Residential and Non-residential Investment Predicts Changes in GDP", *Real Estate Economics*, vol. 25.

Greenwood, J., and Hercowitz, Z., 1991, "The Allocation of Capital and Time over the Business cycle," *Journal of Political Economy*, University of Chicago Press, vol. 99(6), pp. 1188-1214, December.

Gregory, A. W., and Smith, G. W., 1991, "Calibration as Testing: Inference in Simulated Macroeconomic Models," *Journal of Business and Economic Statistics*, vol. 9, pp. 297-303.

Gupta, R., and Kabundi, A., 2010, "The Effect of Monetary Policy on House Price Inflation: A Factor Augmented Vector Autoregression (FAVAR) Approach," *Journal of Economic Studies*, vol. 37, issue. 6, pp. 616-626.

Hamilton, J. D., 2008, "Macroeconomics and ARCH," *NBER Working Paper*, no. 14151.

Hamilton, J. D., and Lin, G., 1996, "Stock Market Volatility and the Business Cycle," *Journal of Applied Econometrics*, vol. 11, pp. 573-593.

Harberger, A. C., 1962, "The Incidence of the Corporation Income Tax," *Journal of Political Economy*, vol.70, pp. 215-240.

Harris, R. D. F., and Pisedtasalasai, A., 2006, "Return and Volatility Spillovers between Large and Small Stocks in the UK," *Journal of Business Finance and Accounting*, vol. 33, pp. 1-16.

Hassan, S. A. and Malik, F., 2007, "Multivariate GARCH Modeling of Sector Volatility

Transmission," *The Quarterly Review of Economics and Finance*, vol. 47, pp. 470-480.

Higgs, H., and Worthington, A., 2004, "Transmission of Returns and Volatility in Art Markets: a Multivariate GARCH Analysis," *Applied Economics Letters*, vol. 11(4), pp. 217-222.

Himmelberg, C., Mayer, C., and Sinai, T., 2005, "Assessing High House Prices: Bubbles, Fundamentals and Misperceptions," *Journal of Economic Perspectives*, vol. 19, no. 4, pp.67-92.

Hodrick, R. J., and Prescott, E. C., 1980, "Post-war US Business Cycles: An Empirical Investigation," *Carnegie-Mellon University, Discussion Paper*, no. 451.

Huang, B. N., and Yang. C. W., 2000, "The Impact of Financial Liberalization on Stock Price Volatility in Emerging Markets," *Journal of Comparative Economics*, vol. 28, pp. 321-339.

Iacoviello, M., 2002, "House Prices and Business Cycles in Europe: A VAR Analysis," *Boston College Working papers in Economics*, 540.

Iacoviello, M., 2005, "House Prices, Borrowing Constraints, and Monetary Policy in the Business Cycle," *American Economic Review*, vol. 95, pp. 739-764.

Iacoviello, M., and Minetti, R., 2003, "Financial Liberalization and the Sensitivity of House Prices to Monetary Policy: Theory and Evidence," *The Manchester School*, vol.71, no.1, pp.20-34.

Iacoviello, M., and Minetti, R., 2007, "The Credit Channel of Monetary Policy: Evidence from the Housing Market," *Journal of Macroeconomics*, vol.30, no.1 (March), pp.69-96.

Iacoviello, M., and Neri, S., 2010, "Housing Market Spillovers: Evidence from an Estimated DSGE Model," *American Economic Journal: Macroeconomics*, vol. 2, no. 2, April, pp. 125-164.

International Monetary Fund, 2000, “World economic outlook: Asset prices and the business cycle,” May.

Jang, K. H., 2008, “A Structural Vector Error Correction Model with Short-run and Lon-run Restrictions,” *The Korean Economic Review*, vol. 24, no. 11, pp. 199-232.

Johansen, S., 1988, “Statistical Analysis of Cointegration Vectors,” *Journal of Economic Dynamics and Control*, vol. 12, pp. 231-254.

Johansen, S., 1991, “Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models,” *Econometrica*, vol. 59, pp. 1551-1580.

Johansen, S., and Juselius, K., 1992, “Testing Structural Hypothesis in a Multivariate Cointegration Analysis of the PPP and UIP for the UK,” *Journal of Econometrics*, vol. 53, pp. 211-244.

Jorgensen, D. W., 1963, “Capital Theory and Investment Behavior,” *American Economic Review*, vol. 53, pp. 47- 56.

Kaldor, N., 1961, “Capital Accumulation and Economic Growth,” in F. Lutz and D. Hague, eds., *The Theory of Capital, New York*, pp. 177-222.

Kanas, A., 2000, “Volatility Spillovers between Stock Returns and Exchange Rate Changes: International Evidence,” *Journal of Business Finance & Accounting*, vol. 27, pp. 447-467.

Karolyi, G. A., 1995, “A Multivariate GARCH Model of International Transmissions of Stock returns and Volatility: The Case of the United States and Canada?” *Journal of Business and Economic Statistics*, vol. 13, pp 11-25.

Karunanayake, I., Valadkhani, A., and O’Brien, M., 2009, “Modelling Australian Stock Market Volatility: A Multivariate GARCH Approach,” *University of Wollongong, Economics Working Paper*, no. 09-11.

Kearney, C., and Patton, A. J., 2000, “Multivariate GARCH Modeling of Exchange Rate Volatility Transmission in The European Monetary System,” *The Financial*

Reviwe, vol. 41, pp. 29-48.

King, R. G., Plosser, C., Stock, J., and Watson, M., 1991, "Stochastic Trends and Economic Fluctuations," *American Economic Review*, vol. 81(4), pp. 819-840.

Kim, J. S., 2001, "Study on the Cause of Won/Dollar Exchange Rate Volatility," *The Bank of Korea, Economic Analysis*, vol.7-1, pp. 92-120.

Kim, K. H., 2004, "Housing and the Korean Economy," *Journal of Housing Economics*, vol. 13, issue 4, pp. 321-341.

Kim, K. H., and Lee, H. S., 2005, "Housing Cycle Forecast Model II," *Korea Housing Institute*.

Kim, K. H., and Lee, H. S., 2009, "Housing Cycle Forecast Model VI," *Korea Housing Institute*.

Kim, K. H., and Son, J. Y., 2010, "Real Asset Economics" ch11. Real Asset and Macroeconomics, *KonKuk University Press*.

Kim, K. S., 2007, "A Study on Spillover Effects Across Volatility of Stock Returns, Interest rate and Exchange rate," *Korea International Accounting Review*, vol. 19, pp. 83-107.

Kim, M. J., and Jang, K. H., 2006, "Financial Time Series Analysis," 2nd ed., *KyungMoonSa*.

Kim, S. D., and Tsurumi, H., 2000, "Korean Currency Crisis and Regime Change: A Multivariate GARCH Model with Bayesian Approach," *Asia-Pacific Financial Markets*, vol. 7, pp. 31-44.

Kim, S. Y., 2001, "International Transmission of U.S. Monetary Policy Shocks: Evidence from VAR's," *Journal of Monetary Economics*, vol. 48, pp. 339-372.

Kim, S. Y., and Roubini, N., 2000, "Exchange Rate Anomalies in the Industrial Countries: A Solution with a Structural VAR Approach," *Journal of Monetary Economics*, vol. 45, pp. 561-586.

Kim, Y. B., 2009, "Effect from Stigma Effect and Capital Mobility to CDS Premium Underlying Government Bond," Institute for Monetary and Economic Research in the Bank of Korea, *Monetary and Economic Research*, 2009-7, working paper-388

Klyuev, V., 2008, "What Goes up Must Come down? House Price Dynamics in the United States," *IMF Working Paper*, WP/08/187.

Korea Centre for International Finance (Choi, H. S.), 2011, "Reinforcement and Effect of Comovement in the World Economy".

Kydland, F. E., and Prescott, E. C., 1982, "Time to Build and Aggregate Fluctuations," *Econometrica*, Econometric Society, vol. 50(6), pp. 1345-1370, November.

Leamer, E. E., 2007, "Housing is the business cycle," *NBER Working paper*, no. 13428.

Lettau, M., and Ludvigson, S. C., 2004, "Understanding Trend and Cycle in Asset Values: Reevaluating the Wealth Effect on Consumption," *American Economic Review*, vol. 94, pp. 276-299.

Lippi, M., and Reichlin, L., 1993, "The Dynamic Effects of Aggregate Demand and Supply Disturbances: Comment," *American Economic Review*, vol. 83, pp. 644-652.

Longstaff, F. A., Pan, J., Pederson, L. H., and Singleton, K. J., 2011, "How Sovereign is Sovereign Credit Risk?," *American Economic Journal: Macroeconomic*, vol. 3, pp. 75-103.

Maćkowiak, B., 2007, "External Shocks, U.S. Monetary Policy and Macroeconomic Fluctuations in Emerging Markets," *Journal of Monetary Economics*, vol. 54, pp. 2512-2520.

Maclennan, D., Muellbauer, J., and Stephens, M., 2000, "Asymmetries in Housing and Financial Market Institutions and EMU," *Oxford Review of Economic Policy*, vol. 14, issue. 3, pp. 54-80.

Mehra, R., and Prescott, C., 1985, "The Equity Premium: A Puzzle," *Journal of*

Monetary Economics, vol. 15, March, pp. 145-61.

Mendoza, E. G., 1991, "Real Business Cycles in a Small Open Economy," *American Economic Review*, vol. 81, pp. 798-818.

Mendoza, E. G., and Yue, V. Z., 2008, "A Solution to the Disconnect Between Country Risk and Business Cycle Theories," *NBER Working Paper*. No. 13861.

Meng, M., Gwilym, O., and Varas, J., 2009, "Volatility Transmission Among the CDS, Equity and Bond Markets," *The Journal of Fixed Income*, vol. 18, no. 3, pp. 33-46.

Miniane, J., and Rogers, J. H., 2003, "Capital Controls and the International Transmission of U.S. Money Shocks," *Board of Governors of the Federal Reserve System International Finance Discussion Paper*, no. 778.

Mishkin, F. S., 2007, "Housing and the Monetary Transmission Mechanism," *NBER Working paper*, no. 13518.

Mishkin, F. S., 2008, "How Should We Respond to Asset Price Bubbles?" speech on May 15.

Nam J. W. and Byun S. J., 2006, "Study on the Investment of National Pension Services in Credit Derivatives," *Institute for National Pension Research, Working Paper*, 2006-08.

Næs, R., Skjeltorp J. A., and Ødegaard, B. A., 2010, "Stock Market Liquidity and the Business Cycle," *The Journal of Finance Forthcoming Article*.

Neumeyer, P. A., and Perri, F., 2005, "Business Cycles in Emerging Markets: The Role of Interest rates," *Journal of Monetary Economics*, vol. 52, pp. 345-380.

Newey, W. K., and West, K. D., 1987, "A Simple Positive Semi-definite Heteroskedasticity and Autocorrelation Consistent Covariance Matrix," *Econometrica*, vol. 55, pp. 703-708.

Ng, A., 2000, "Volatility Spillover Effects from Japan and the US to the Pacific-Basin," *Journal of International Money and Finance*, Vol. 19, pp.207-233.

Norden, L., and Weber, M., 2004, "The Co-movement of Credit Default Swap, Bond and Stock Markets: An Empirical Analysis," *Centre for Financial Studies, Working Paper*, no. 2004/20.

Obstfeld, M., and Rogoff, K., 1995, "Exchange rate Dynamics Redux," *Journal of Political Economy*, vol. 103(3), pp.624-660.

Otto, G., 2007, "The Growth of House Prices in Australian Capital Cities: What Do Economic Fundamentals Explain?" *The Australian Economic Review*, vol. 40, no. 3, pp. 225-238.

Pagan, A. R., and Pesaran, M. H., 2008, "Econometric Analysis of Structural Systems with Permanent and Transitory Shocks," *Journal of Economic Dynamics and Control*, vol. 32, pp. 3376-3395.

Pan, M. S., Fok, R. C., and Liu, Y. A., 2007, "Dynamic Linkages between Exchange Rates and Stock Prices: Evidence from East Asian Markets," *International Review of Economics and Finance*, vol. 16, pp. 503-520.

Phillips, P. C. B., 1998, "Impulse Responses and Forecast Error Variance Asymptotics in Nonstationary VARs," *Journal of Econometrices*, vol. 83, pp.21-56.

Phillips, P. C. B., and Perron, P., 1988, "Testing for a Unit Root in Time Series Regression," *Biometrika*, vol. 75, no. 2, pp. 335-336.

Phylaktis, K., and Ravazzolo, F., 2005, "Stock Prices and Exchange Rate Dynamics," *Journal of International Money and Finance*, vol. 24, iss. 7(November), pp. 1031-1053.

Poterba, J., 1984, "Tax Subsides to Owner-occupied Housing: And Asset Market Approach," *Quarterly Journal of Economics*, vol. 99, pp.729-752.

Rahman, M. L., and Uddin, J., 2009, "Dynamic Relationship between Stock Prices and Exchange Rates: Evidence from Three South Asian countries," *International Business Research*, vol.2, no. 2, pp.167-174.

Remolona, E., Scatigna, M., and Wu, E., 2008, "The Dynamic Pricing of Sovereign Risk in Emerging Markets: Fundamentals and Risk Aversion," *The Journal of Fixed Income*, spring, vol. 17, no. 4, pp. 57-71.

Roll, R., 1992, "Industrial Structure and the Comparative Cointegration," *Statistical Papers*, vol. 33, pp. 335-346.

Ross, S., 1976, "The Arbitrage Pricing Theory of Capital Asset Pricing", *Journal of Econometric Theory*, vol. 13, pp. 341-360.

Roubini, N., 2006, "Why Central Banks Should burst bubbles," *International Finance*, vol. 9, issue. 1, pp. 87-107.

Sarquis, S. J. B., 2007, "Business Cycles in a Credit Constrained Small Open Economy," *Mimeo, London School of Economics*.

Sarquis, S. J. B., 2008, "Country Spreads as Credit Constraints in Emerging Economy Business Cycles," *Mimeo, London School of Economics*.

Scheicher, M., 2001, "The Comovements of Stock Markets in Hungary, Poland and the Czech republic," *International Journal of Finance and Economics*, vol. 6, pp. 27-39.

Schmitt-Grohe, S., 1998, "The International Transmission of Economic Fluctuations: Effects of U.S. Business Cycles on the Canadian Economy," *Journal of International Economics*, vol. 44, pp. 257-287.

Schmitt-Grohe, S., and Uribe, M., 2003, "Closing Small Open Economy Models," *Journal of International Economics*, vol. 61, October, pp. 163-185.

Schwert, G. W., 1989, "Tests for Unit Roots: A Monte Carlo Investigation," *Journal of Business & Economic Statistics*, vol. 7, pp. 147-159.

Senyuz, Z., "Factor Analysis of Permanent and Transitory Dynamics of the US Economy and the Stock Market," *Journal of Applied Econometrics*, vol. 26, pp. 975-998.

Shoven, J. B., and Whalley, J., 1972, “A General Equilibrium Calculation of the Effects of Differential Taxation of Income from Capital in the US,” *Journal of Public Economics*, vol. 1, pp. 281-322.

Silvennoinen, A., and Terasvirta, T., 2008, “Multivariate GARCH Models,” *SSE/EFI Working Paper Series in Economics and Finance*, no. 669.

Sims, C., 1980, “Comparison of interwar and postwar business cycles: Monetarism Reconsidered,” *American Economic Review*, vol. 70, no. 2, pp. 250-257.

Sims, C. A., 1986, “Are Forecasting Models Usable for Policy Analysis?,” *Federal Reserve Bank of Minneapolis Quarterly Review*, pp.3-16.

So, R. W., 2001, “Price and Volatility Spillovers between Interest Rate and Exchange Value of the US Dollar,” *Global Finance Journal*, vol. 12, pp. 95-107.

Sok-Gee, C., and Karim, M. Z. A., 2010, “Volatility Spillovers of the Major Stock Markets in ASEAN-5 with the U.S. and Japanese Stock Markets,” *International Research Journal of Finance and Economics*, iss. 44, pp. 156-167.

Son, J. Y., 2000, “Correlation between House Price and *Chonsei* Price”, *Social Science Research Institute*, *KonKuk University Press*, vol. 24.

Song, J. H., 2008, “House Prices and Monetary Policy: A Dynamic Factor Model for Korea,” *The Journal of the Korean Economy*, vol. 9, no. 3, pp.467-496.

Stock, J. H., and Watson, M. S., 1993, “A Simple Estimator of Cointegrating Vectors in Higher Order Integrated Systems,” *Econometrica*, vol. 61, pp. 783-820.

Stock, J. H., and Watson, M. W., 1999, “Business Cycle Fluctuations in US Macroeconomic Time Series,” in Taylor, J. B. and Woodford, M., eds., *Handbook of Macroeconomics*, Amsterdam, The Netherlands: Elsevier Science, pp. 3-64.

Stock, J. H., and Watson, M. W., 2005, “Understanding Changes in International Business Cycle Dynamics,” *Journal of the European Economic Association*, vol. 3, no. 5, pp. 966-1006, September.

Sun, T., and Zhang, X., 2009, "Spillovers of the U.S. Subprime Financial Turmoil to Mainland China and Hong Kong SAR: Evidence from Stock Market," *IMF Working Paper*, no. 166.

Svensson, L. E. O., and Van Wijnbergen, S., 1989, "Excess Capacity, Monopolistic Competition, and International Transmission of Monetary Disturbances," *Economic Journal, Royal Economic Society*, vol. 99(397), pp. 785-805.

Taylor, J. B., 2009, "The Financial Crisis and the Policy Responses: An Empirical Analysis of What Went Wrong," *NBER Working Paper*. No. 14631.

Topel, R. H., and Rosen, S., 1988, "Housing Investment in the United States," *Journal of Political Economy*, vol. 96, pp. 718-740.

Tovar, C., 2008, "DSGE Models and Central Banks," *Bank for International Settlements working paper*, no. 258.

Uribe, M., 1997, "Exchange Rate Based Inflation Stabilization: The Initial Real Effects of Credible Plans," *Journal of Monetary Economics*, vol. 39, June, pp. 179-221.

Uribe, M., 2002, "The Price Consumption Puzzle of Currency Pegs," *Journal of Monetary Economics*, vol. 49, April, pp. 533-569.

Uribe, M., and Yue, V. Z., 2006, "Country Spreads and Emerging Countries: Who Drives Whom?" *Journal of International Economics*, vol. 69, pp. 6-36.

Vargas-Silva, C., 2008, "Monetary Policy and the U.S. Housing Market: A VAR analysis imposing sign restrictions," *Journal of Macroeconomics*, vol. 30, issue. 3, pp. 977-990.

Vlaar, P. J. G., 2004, "On the Asymptotic Distribution of Impulse Response Functions with Long-run Restrictions," *Econometric Theory*, vol. 20, pp. 891-903.

Worthington, A., and Higgs, H., 2004, "Transmission of Equity Returns and Volatility in Asian Developed and Emerging Markets: A Multivariate GARCH Analysis," *International Journal of Finance and Economics*, vol. 9, pp. 71-80.

Wu, R., 2005, "International Transmission Effect of Volatility between the Financial Markets during the Asian Financial Crisis," *Transition Studies Review*, vol. 15, pp. 19-35.

Zhu, Z., 1996, "US Real Wages and Imports," *Applied Economics*, vol. 28, pp. 1435-1450.