Time Series Analysis of Economic Integration in Asia

Ong Sheue Li

Academic Advisor:

Professor Sato Kiyotaka

This dissertation has been submitted in partial fulfillment of the requirements
for the Degree of Doctor of Philosophy in Economics

Graduate School of International Social Sciences
Yokohama National University

September 2016

ACKNOWLEDGEMENTS

First and foremost, praises and thanks to the God, the Almighty, for His showers of blessings throughout my three years doctoral study to complete the research successfully.

With great pleasure, I would like to express my deep and sincere gratitude to my research supervisor, Professor Sato Kiyotaka, who gave me his support, encouragement and advice. Professor Sato Kiyotaka provided me with the foundation to become a researcher on Economics issue. He made extensive contributions to my research; provided great ideas, excellent error checking, and added clear instructions to improve the quality of my research. I am also grateful to him for giving me the opportunity to participate in many conferences, workshops and so on. The research facilities and equipment provided by him are definitely acknowledged. It was a great privilege and honor to study under his guidance.

I express my heartfelt gratitude to Graduate School of Social Sciences, Yokohama National University, for giving me the opportunity to further my doctoral study and providing all the facilities throughout my study. I also extend my special thanks to the Japanese government, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) for offer me the Monbukagakusho scholarship throughout my study, which enable me to focus more clearly and aggressively on my academics rather than my finances. Their kindness and generosity are greatly appreciated.

Last but not least, completion of this doctoral dissertation was not possible without the support of teachers, school officers, friends and family. Their continuous encouragement, patience and forbearance have been valuable for the successful completion of this research. I would like to express my sincere gratitude to all of them.

ABSTRACT

This dissertation consists of three research papers that study the regional economic integration in Asia. In particular, this dissertation tries to extend the existing literature by improving the methodologies. To overcome the methodological limitation of the standard VAR and dynamic factor models, three advance methods were applied. The first research paper, considers a global vector autoregressive (GVAR) model, which allows global inter-linkages between domestic and foreign variables. The first research paper analyzed whether recent regional economic growth and inflation dynamics in Asia were driven by a global (United States) shock or regional (Japanese and Chinese) shock. The second research paper, is uses a dynamic factor model (DFM) with time-varying parameters. The model allows the factor loadings of the model to change over time, so that the changes due to policies adopted by specific countries, or from structural changes, can be captured. This research paper analyzed whether the common dynamic properties of macroeconomic disturbances were influenced by global, regional, or country-specific factors. The last research paper deals with a DFM that is able to capture the spillover effects among the factors. The goal of this paper is to examine whether the co-movement results from common shocks or spillover effects. This is achieved by unrestricting the autoregressive coefficient of the factors. This research paper analyzed whether China and United States have spillover effects on the Asian countries. All results from the three research papers show a reduction in the importance of the world shock or world factor in influencing or explaining the macroeconomic movement of Asian economies. For the regional perspective, the three papers provide a distinct result. The first research paper shows that China's output and inflation shock have a significant influence on Asian economies. However, the second and third research papers indicate the regional factor plays only a minor role in explaining fluctuations in Asian economic activity. Thus, the results may explain a

noticeable importance of the Chinese economy on Asian countries, but not a significant share of regional factor on Asian economies. Moreover, the considerable co-movement of activity for Asian economies appears to be driven to a large extent by country-specific factors, indicate that Asian countries are more favorable for its own independent counter-cyclical monetary policy. Although these results show that Asian countries are not strongly integrate, to make a final conclusion, many more studies that are outside the scope of this study need to be done to examine the regional economic integration in Asia.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Asian countries have enjoyed rapid economic growth and development for the last several decades, but these countries also experienced severe economic and currency crises several times. The process of increasing effort in coordination and policy harmonization on a regional scale, plus the rising trade and financial openness of Asian countries, have raised up the question of an appropriate regional monetary arrangement. It remains unclear whether the Asian countries have shared a common business cycle. Therefore, the issue of regional integration based on the real economics perspective has received considerable critical attention in the past decade. By investigating the responses to the external shocks, researchers are interested in verifying the degree of homogeneity between the Asian countries and convergence process of their policies.

Two different approaches have been attempted to assess this issue. The first strand of research employed vector autoregressive (VAR) models to identify the nature and the impact of external shocks on Asian. Through this, they able to trace the impact of various shocks, including the internal and external shocks on every country. The second strand of research employed dynamic factor model (DFM) to decompose cycles into specific and common components. Most of the studies decompose the shocks to global shock, regional shocks, and country-specific shocks. Through this, the researchers can check the extent of each type of shock that has most significant effects on economic fluctuations.

However, there are some drawbacks of these existing studies in the application of standard VAR and conventional DFM. The standard VAR models can only deal with a relatively small number of variables and limited interactions between them. To capture the complicated international linkages between variables, the model needs to include either higher-order time lags or a large number of domestic variables; otherwise, this causes serious dimensionality problems. Furthermore, it is important to note that the standard VAR models maintain a closed economy assumption, which fails to capture international linkages of endogenous variables across countries. On the other hand, the conventional DFM with static parameters assumes that both the stochastic process driving volatility and the nature of co-movement among variables have not changed over time. Many macroeconomic datasets cannot satisfy the assumption of structural stability, although many macroeconomics data has slowly changed in a dynamic way. This is particularly important for Asia as the countries of this region have experienced dynamic changes of regional economic linkages from the year 2000 to the present.

Therefore, this Ph.D. dissertation aims to overcome the methodological limitations of the standard VAR and conventional DFM. In particular, it consists of three independent research papers, all written jointly with Professor Sato Kiyotaka. The first research paper employs the Global VAR model, and the second research paper employs the DFM with time-varying parameters, while the third research paper employs the DFM with time-varying parameters and spillover effects.

The first research paper focused on the shock term and long-term implications of global (United States) and regional (Japanese and Chinese) shocks for the Asian regional economy. The simulations clearly show that China's influence on the Asian economies is greater than the United States influence in terms of both real output and inflation shocks, although the United States still has a greater financial effect on Asian economies in terms of interest rate shocks.

While previous studies found the Chinese economy has increasing importance in the global economy, no studies have found that China's influence surpass that of the United States in the context of Asian monetary integration/union. In contrast to the responses to a Chinese real output shock, Asian economies' responses to a Japanese real output shock are far less statistically significant.

The second and third research paper examined the regional integration issue by decomposing the co-movement of international business cycles into the global, regional and country-specific level, respectively. The second research paper allowed the parameters to change over time while the third research paper allowed the factors to correlate with each other in capturing the spillover effects from the United States and China. The second research paper found that the relative contributions of the world, regional and country-specific components change over time for most of the Asian countries. Among the factors, country-specific factor still explains a noticeable fraction of output volatility in many Asian economies; but, not in Hong Kong, Malaysia and Singapore cases. The co-movement of real output fluctuation in these three countries are mainly explained by regional factor. Besides, the results show that the regional factor captures the greatest share of output fluctuations in Japan, Taiwan and Thailand since the year 2010.

After taking into account the spillover effects from China and United States, the third research paper found regional factor no longer the main component in explaining Japan, Taiwan and Thailand's economic fluctuations, but the country-specific factor instead. These results indicate that Asian countries are more favorable for its own independent counter-cyclical monetary policy.

Although the first research paper shows that China's output and inflation shock have a significant influence on Asian economies, both second and third research paper indicate the regional factor play only a minor role in explaining fluctuations in Asian economic activity. This may explains a noticeable important of China economy on Asian countries, but not the significant share of the regional factor on Asian economies.

Table 1.1 shows an overview of the three research papers.

Table 1.1: Overview of the Three Research Papers

Research Paper	First	Second	Third
Method	Global vector autoregression model	Dynamic factor model with time-varying parameters	Dynamic factor model with time-varying parameters and spillover effects
Country	**20**	**33**	**33**
Asia	China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand	China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand	China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore, Taiwan, Thailand
North America	United States	Canada, Mexico, United States	Canada, Mexico, United States
Oceania	Australia, New Zealand	Australia, New Zealand	Australia, New Zealand
Europe	Austria, Belgium, Finland, France, Germany, Italy, Netherlands, Spain, United Kingdom	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom	Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom
Sample period	1990Q1 – 2013Q4	1978 – 2015	1978 – 2015

Variables	Real Output Consumer Price Index, Interest Rate, Real Effective Exchange Rate	Real output	Real Output
Shocks/ Factors/ Spillover	Global Shock: United States Regional Shocks: China and Japan	World factor, Regional factor, Country-specific factor	Spillover effects from China and United States
Results	• China's influence on the Asian economies are greater than the U.S. influence in terms of both real output and inflation shocks, although the U.S. still has a greater financial effect on Asian economies in terms of interest rate shocks. • Asian economies' responses to a Japanese real output shock are far less statistically significant.	• The country-specific factor explains a significant fraction of the fluctuations in most of the Asia countries. • Different results are shown for Hong Kong, Malaysia and Singapore cases, where these three countries are more explained by regional factor. • The regional factor captures the greatest share of output fluctuations in Japan, Taiwan and Thailand since the year 2010.	• The country-specific factor explains a significant fraction of the fluctuations in most of the Asia countries. • Regional factor appears to explain the majority of Malaysia, Indonesia, and Singapore output volatility.

REGIONAL OR GLOBAL SHOCK?

A GLOBAL VECTOR AUTOREGRESSIVE ANALYSIS OF ASIAN MONETARY INTEGRATION

2.1 Introduction

The feasibility of forming a regional economic and monetary union in Asia has gained considerable attention over the last several decades against a backdrop of growing intra-regional trade and investment.[1] The 1997–1998 Asian financial crisis heightened calls to establish regional monetary and financial cooperation among regional economies. After the 2008 collapse of Lehman Brothers, Asian currencies substantially and asymmetrically fluctuated. While the Japanese yen appreciated sharply against almost all currencies, the Korean won began to drastically depreciate. Such large and asymmetric exchange rate responses changed export price competitiveness between Asian economies, which may inhibit region-wide steady economic growth.[2] Thus, regional exchange rate stability has been an important policy agenda for the further growth and development of regional economies.

[1] Ferrarini (2013) analyzes recent trade network development in Asia. Kwon and Ryou (2015) investigate value-added trade and vertical specialization focusing on Asia.
[2] See, for instance, Sato *et al*. (2013) and Ito and Shimizu (2015) for an analysis of export price competitiveness of Asian economies.

A large number of studies have also analyzed regional exchange rate stability and possible monetary cooperation and arrangements in Asia. These studies typically rely on the theory of optimum currency area (OCA) to investigate whether it makes economic sense for Asian economies to adopt a regional monetary arrangement. The OCA theory suggests several preconditions to forming a currency area, and existing studies have mostly investigated business cycle synchronization and symmetry in fundamental shocks as one of major OCA preconditions.[3] Most studies, such as Bayoumi *et al*. (2000), Zhang *et al*. (2004), Bacha (2008), Allegret *et al.* (2012), and Lee and Koh (2012), employ a vector autoregressive (VAR) model to analyze the degree of symmetry in shocks among Asian economies. However, this approach cannot explain whether growing similarity in real output fluctuations are driven by external shocks or self-sustaining development in Asia.

Chow and Kim (2003) examined the relative importance of global, regional, and country-specific shocks for Asian economies using variance decomposition tests based on a structural VAR analysis. If business cycle co-movements are mainly affected by regional shocks, a common monetary policy can be an effective tool for regional

[3] The OCA theory typically suggests the following preconditions: economic openness and trade integration; business cycle synchronization and symmetry of fundamental economic shocks; financial integration; and factor market integration including free labor mobility.

economies. In contrast, if country-specific shocks are prevalent in the region, regional economies need to adopt independent monetary policies. If regional output co-movements are driven largely by global shocks, global arrangements need to be considered when establishing regional monetary coordination.

Hsu (2010) extended the Chow and Kim (2003) approach by constructing weighted average macroeconomic variables as a proxy for regional variables. Sato *et al*. (2011) and Dungey and Vehbi (2015) employed the structural VAR method to compare the degree of regional influence between global and regional shocks according to an impulse response function analysis. Assuming Chinese and Japanese shocks as regional shocks, these studies found that a global (U.S.) shock has a greater regional influence on Asian economies than does regional shocks. However, these standard VAR models can only deal with a relatively small number of variables and interactions between a limited number of variables. To capture the complicated international linkages between variables, the model needs to include either higher-order time lags or a large number of domestic variables, but it then cannot avoid a serious dimensionality problem. Furthermore, it is important to note that the above VAR models maintain a closed-economy assumption, which fails to capture international linkages of endogenous variables across countries.

Recent business cycle studies, such as Lee and Azali (2012) and Hirata *et al*. (2013), employ a dynamic factor model and have found that regional factors play a more important role in Asia than global factors in explaining fluctuations in macroeconomic variables. While the estimated unobserved factors are assumed to summarize the empirical content of a large number of macroeconomic variables, Dees *et al*. (DdPS, 2007) noted that the dynamic factor model's results are subject to the identification problem of unobserved factors, especially when making economic interpretations.[4] To assess the source of macroeconomic fluctuations more rigorously, it is necessary to rely on a far more detailed global model and framework.

To overcome the methodological limitation of the standard VAR and dynamic factor models, Pesaran *et al*. (2004), thereafter modified by DdPS (2007), and Dees *et al*. (DPSS, 2014) developed a global VAR (GVAR) model. The associated GVAR model is literally a global model that allows global inter-linkages between domestic and foreign variables. The GVAR modeling approach has a number of attractive features:

[4] DdPS (2007) emphasized that "even when all such 'common' factors are taken into account, there will be important residual interdependencies due to policy and trade spillover effects that remain to be explained" (page 3).

1. This approach allows interdependence at various levels, including national and international levels, because the lags of all variables enter individual equations and the reduced-form errors can be cross-sectional dependent.
2. It allows for both long-run and short-run relationships consistent with the theory and data.
3. It solves the dimensionality problem in which both the cross-section dimension N and time-series dimension T can be relatively large as a result of estimating the country-specific error-correction models (ECMs) separately.

These features are important because they provide a global modeling framework for quantitatively analyzing the relative importance of different shocks and transmission channels. Thus, using the GVAR model offers a strong advantage in examining the feasibility of forming a regional monetary arrangement in Asia.

Various studies have applied the GVAR model to the question of forming a monetary union. DdPS (2007) applied the GVAR model to the analysis of international linkages in the Euro area. Pesaran *et al.* (2007) empirically investigated the consequences of a scenario in which the U.K. adopted the Euro in 1990. Fielding *et al.* (2012) identified the channels through which macroeconomic innovations in one country affect other countries in the West African Economic and Monetary Union (UEMOA).

The objective of this study is to investigate the feasibility of a regional monetary arrangement in Asia by using a GVAR model to evaluate whether a global or regional shock exerts greater influence on Asian economies. We compare the impulse responses of macroeconomic variables, such as real output, inflation rates, and interest rates in Asia, to both global and regional shocks. Recently, Feldkircher and Korhonen (2014) employed the GVAR model to assess the degree of China's economic influence on various regions and countries and surprisingly found little Chinese influence on Japan and the entire Asian region. In marked contrast, we demonstrate that fluctuations in macroeconomic variables are more affected by a regional (Chinese) shock than by a global (U.S.) shock.

Specifically, by applying the GVAR model rigorously to the OCA question to allow global inter-linkages between domestic and foreign variables, we revealed that Asian economies tend to show significantly positive real output responses to Chinese output shock, while responses to a Japanese output shock are far less statistically significant. Such asymmetric responses are likely due to Japan's unilateral dependence on Asian economies, in that Japan does not import much from Asian economies, while Japanese exports to Asia have increased. Asian real outputs showed a significant but relatively short-lived response to the U.S. shock, which indicates China's growing influence on Asian economies compared with the U.S. influence. While strong financial linkages are still observed between the U.S. and Asian economies, China's influence in Asia surpasses that of the U.S. in terms of real output and inflation shocks, which needs to be considered when determining whether to establish a regional monetary arrangement in Asia.

The remainder of this paper is organized as follows. Section 2.2 reviews the methodology of the GVAR analysis. Section 2.3 describes the data and empirical approach. The empirical results are presented and discussed in Section 2.4. Finally, Section 2.5 concludes this study.

2.2 Methodology

The GVAR approach can be briefly summarized as a two-step approach.[5] First, individual country-specific augmented models are estimated as being conditional on the rest of the world. In this step, all domestic macroeconomic variables are related not only

[5] The following exposition of the empirical methodology is based on DdPS (2007) and Chudik and Pesaran (2015).

to corresponding foreign variables constructed to match the international trade pattern of the country under consideration but also to dominant variables that can influence the remaining variables in the model directly and indirectly, but not vice versa. The country-specific foreign variables and the dominant variable are treated as weakly exogenous (or long-run forcing) for most economies when the number of countries *N* is sufficiently large and the idiosyncratic shocks are weakly correlated. Second, the individual country models are combined in a consistent and cohesive manner to form a global model. The combined model is then used to generate forecasts or impulse response functions for all world economy variables simultaneously. Smith and Galesi (2014) provided a toolbox for constructing GVARs.

2.2.1 Country-Specific Models

Assume that there are $N+1$ countries in the global economy, indexed by $i = 0,1,2,\cdots,N$, where 0 serves as a reference country. For each country i, $k_i \times 1$ vector of domestic variables $Y_{i,t}$ are related to the $k_i^* \times 1$ vector of foreign variables $Y_{i,t}^*$, the $m_\omega \times 1$ vector of dominant unit ω_t, and the deterministic variable time trends $t = 1,2,\cdots,T$. This augmented VAR model is denoted as VARX* and expressed as

$$Y_{i,t} = \alpha_{i,0} + \alpha_{i,1}t + \sum_{\ell=1}^{p_i} \phi_{i,\ell} Y_{i,t-\ell} + \sum_{\ell=0}^{q_i} \Lambda_{i,\ell} Y_{i,t-\ell}^* + \sum_{\ell=0}^{s_i} D_{i,\ell}\omega_{t-\ell} + \epsilon_{i,t} \quad (1)$$

where $\epsilon_{i,t}$ is a $k_i \times 1$ vector of idiosyncratic country-specific shocks; $\phi_{i,\ell}$ are $k_i \times k_i$ matrices of lagged coefficients; $\Lambda_{i,\ell}$ are $k_i \times k_i^*$ matrices of coefficients associated with the foreign-specific variables; and $\mathrm{D}_{i,\ell}$ are $k_i \times m_\omega$ matrices of coefficients associated with the common variables. The lag orders p_i, q_i, and s_i of the domestic, foreign, and dominant variables, respectively, are selected using the Akaike information criterion (AIC).

The set of country-specific foreign variables $Y_{i,t}^*$ is built using fixed trade weights $w_{i,j}$, as $Y_{i,t}^* = \sum_{j=0}^{N} w_{i,j} Y_{j,t}$. Specifically, $w_{i,j}$ are calculated as the total trade between country i and country j divided by the total trade of country i with all of its trading partners, where $w_{i,i} = 0$ and $\sum_{j=0}^{N} w_{i,j} = 1$ for all i. The trade weights are important for accommodating the effects of external shocks that could pass through all countries' output via trade channels. The set of country-specific foreign variables represents the dynamics of global economic variables, which are assumed to affect and shape Asian countries' macroeconomic variables.

Assume that the idiosyncratic shocks $\epsilon_{i,t}$ are serially uncorrelated with mean 0 and nonsingular covariance matrix $\Sigma_{ii}(\sigma_{ii,\ell s})$, where $\sigma_{ii,\ell s} = cov(\epsilon_{i\ell t,} \epsilon_{ist})$. The idiosyncratic shocks are denoted as $\epsilon_{i,t} \approx iid(0, \Sigma_{ii})$.

2.2.2 Dominant Variables

In modeling the dominant variable ω_t, a possible cointegration among the elements of ω_t is first checked using the Johansen procedure. Consider the following $VAR(p_\omega)$ specification for the dominant model:

$$\omega_t = \mu_0 + \mu_1 t + \sum_{\ell=1}^{p_\omega} \phi_{\omega\ell}\, \omega_{t-\ell} + \eta_{\omega t} \qquad (2)$$

which can be equivalently written in the ECM as

$$\Delta\omega_t = c - \alpha_\omega \beta'_\omega [\omega_{t-1} - \kappa(t-1)] + \sum_{j=1}^{p_\omega - 1} \Gamma_{\omega j} \Delta\omega_{t-j} + \eta_{\omega t} \qquad (3)$$

where $\alpha_\omega \beta'_\omega = \sum_{\ell=1}^{p_\omega} \phi_{\omega\ell}$, α_ω and β_ω are $m_\omega \times r_\omega$ vectors, r_ω denotes the number of cointegrating relationships, $\Gamma_{\omega j} = -(\phi_{\omega,\ell+1} + \phi_{\omega,\ell+2} + \cdots + \phi_{\omega,\ell+p_\omega})$, and the lag length p_ω is selected by the AIC information criterion. For cases in which ω_t contains $I(1)$ variables, Eq (3) clearly allows cointegration among the dominant variables.

To allow for feedback effects from the variables included in the GVAR model back to the dominant variables via cross-section averages, Eq (2) can be augmented with lagged changes of the variables in the rest of the GVAR model, $\tilde{Y}_{\omega t} = \widetilde{W}_\omega Y_t$, where Y_t is the $k \times 1$ vector of the variables included in the models of the non-dominant variables ($k = \sum_{i=0}^{N} k_i$), and $\widetilde{W}_\omega$ is an $m_{\tilde{x}} \times k$ matrix of weights defining $m_{\tilde{x}}$ global cross-section averages:

$$\omega_t = \mu_0 + \mu_1 t + \sum_{\ell=1}^{p_\omega} \phi_{\omega\ell}\, \omega_{t-\ell} + \sum_{\ell=1}^{q_\omega} \Lambda_{\omega\ell}\, \tilde{Y}_{\omega,t-\ell} + \eta_{\omega t} \quad (4)$$

Assuming there is no cointegration among the common variables ω_t and the cross-section averages $\tilde{Y}_{\omega t-\ell}$, Eq (4) can be written as

$$\Delta\omega_t = c - \alpha_\omega \beta'_\omega [\omega_{t-1} - \kappa(t-1)] + \sum_{j=1}^{p_\omega - 1} \Gamma_{\omega j} \Delta\omega_{t-j} + \sum_{j=1}^{q_\omega - 1} \theta_{\omega j} \Delta\tilde{Y}_{\omega,t-\ell} + \eta_{\omega t} \quad (5)$$

where $\theta_{\omega j}$ is consistently estimated by least squares. Note that contemporaneous values of $\Delta\tilde{Y}_{\omega t}$ do not feature in Eq (5).

2.2.3 Building the Global Vector Autoregressive Model (GVAR)

The conditional country-specific model Eq (1) and the marginal model Eq (5) can be combined and solved as a complete global VAR model.

To construct the GVAR model from the country-specific models, first define the $(k_i + k_i^*) \times 1$ vector $Z_{i,t} = (Y_{i,t}, Y_{i,t}^*)^T$. Assuming for simple exposition that $p_i = q_i$, Eq (1) can be rewritten as

$$G_{i,0} Z_{i,t} = \alpha_{i,0} + \alpha_{i,1} t + \sum_{\ell=1}^{p_i} G_{i,\ell} Z_{i,t-\ell} + \sum_{\ell=1}^{s_i} D_{i,\ell} \omega_{i,t-\ell} + \epsilon_{i,t} \quad (6)$$

where $G_{i,0} = (I_{k_i}, -\Lambda_{i,0})$ and $G_{i,\ell} = (\phi_{i,\ell}, \Lambda_{i,\ell})$ for $\ell = 1, \cdots, p_i$. Both $G_{i,0}$ and $G_{i,\ell}$ are $k_i \times (k_i + k_i^*)$ matrices, and $G_{i,0}$ has a full row rank, namely rank $\left(G_{i,0}\right) = k_i$.

Second, collect all the country-specific variables together in the $k \times 1$ global vector $Y_t = \left(Y_{0,t}', Y_{1,t}', \cdots, Y_{N,t}'\right)'$, where $k = \sum_{i=0}^{N} k_i$ is the total number of the endogenous variables in the global model. Then, the country-specific variables can all be written in terms of Y_t, as

$$Z_{i,t} = W_i Y_t, \quad i = 0,1,2, \cdots, N \quad (7)$$

where W_i is a $(k_i + k_i^*) \times k$ matrix of fixed constants defined in terms of the country-specific weights $w_{i,j}$. The matrix W_i links all country-specific and foreign variables in the system. Because no subscript i is attached to Y_t, variables for all countries in the system are stacked in Y_t.

Third, substituting Eq (7) into Eq (6) yields:

$$G_{i,0}W_iY_t = \alpha_{i,0} + \alpha_{i,1}t + \sum_{\ell=1}^{p_i} G_{i,\ell}W_iY_{t-\ell} + \sum_{\ell=1}^{s_i} D_{i,\ell}\omega_{i,t-\ell} + \epsilon_{i,t},$$

where both $G_{i,0}W_i$ and $G_{i,\ell}W_i$ are $k_i \times k$ dimension matrices. Stacking these equations yields a "global" solution:

$$G_0Y_t = \alpha_0 + \alpha_1 t + \sum_{\ell=1}^{p} G_\ell Y_{t-\ell} + \sum_{\ell=0}^{s} D_\ell \omega_{t-\ell} + \epsilon_t \tag{8}$$

where both the contemporaneous and lagged values of ω_t now appear on the right-hand side of Eq (8) with $p = \max(p_i)$, $s = \max(s_i)$, and

$$G_0 = \begin{pmatrix} G_{00}W_0 \\ G_{10}W_1 \\ \vdots \\ G_{N0}W_N \end{pmatrix}, G_\ell = \begin{pmatrix} G_{0\ell}W_0 \\ G_{1\ell}W_1 \\ \vdots \\ G_{N\ell}W_N \end{pmatrix}, \alpha_0 = \begin{pmatrix} \alpha_{00} \\ \alpha_{10} \\ \vdots \\ \alpha_{N0} \end{pmatrix}, \alpha_1 = \begin{pmatrix} \alpha_{01} \\ \alpha_{11} \\ \vdots \\ \alpha_{N1} \end{pmatrix}, \epsilon_t = \begin{pmatrix} \epsilon_{0t} \\ \epsilon_{1t} \\ \vdots \\ \epsilon_{Nt} \end{pmatrix}.$$

Defining the $(m_\omega + k) \times 1$ vector $X_t = (\omega_t', Y_t')'$, then Eq (4) and Eq (8) for $p = p_\omega = q_\omega = s$ can be written as

$$H_0 X_t = h_0 + h_1 t + \sum_{\ell=1}^{p} H_\ell X_{t-\ell} + \zeta_t \tag{9}$$

where

$$H_0 = \begin{bmatrix} I_{m_\omega} & 0_{m_\omega \times k} \\ -D_\ell & G_0 \end{bmatrix}, h_0 = \begin{bmatrix} \mu_0 \\ \alpha_0 \end{bmatrix}, h_1 = \begin{bmatrix} \mu_1 \\ \alpha_1 \end{bmatrix}, H_\ell = \begin{bmatrix} \phi_{\omega\ell} & \Lambda_{\omega\ell}\widetilde{W}_\omega \\ D_\ell & G_\ell \end{bmatrix}, \zeta_t = \begin{bmatrix} \eta_{\omega t} \\ \epsilon_t \end{bmatrix}.$$

Finally, because H_0 is a $k \times k$ dimensional matrix and will be a full rank, it is a nonsingular matrix. Therefore, the GVAR model in all the variables can be expressed as

$$X_t = {H_0}^{-1} h_0 + {H_0}^{-1} h_1 t + H_0^{-1} \sum_{\ell=1}^{p} H_\ell X_{t-\ell} + {H_0}^{-1} \zeta_t \tag{10}$$

where

$$H_0^{-1} = \begin{bmatrix} I_{m_\omega} & 0_{m_\omega \times k} \\ G_0^{-1} D_\ell & G_0^{-1} \end{bmatrix},$$

which is a block lower triangular matrix showing the causal nature of the dominant variables ω_t. Eq (10) can be solved recursively forward to obtain the future values of X_t.

2.3 Empirical Application

2.3.1 Countries and Regions

To have a sufficiently long time series for reliable statistical inference, this study uses quarterly data over the period from 1990Q1 to 2013Q4 for 20 countries from different regions of the world (see Table 2.1). To consider the impact of external shocks on the euro area as a whole, the eight countries in the Euro area are grouped together and treated as a single economy. The following ten Asian economies are included: China, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, and Thailand.

The regional variables are constructed from country-specific variables using the following weighted averages:

$$Y_{it} = \sum_{i=1}^{N} w_{i,l}^{0} Y_{i,l,t},$$

where $Y_{i,l,t}$ indicates a variable of country l in region i, and $w_{i,l}^{0}$ is the aggregation weight.

2.3.2 Variables

The choice of variables in this study follows Pesaran *et al*. (2004) and DdPS (2007): real output measured by real gross domestic product (*RGDP*); inflation rate (*INF*) measured by $[(CPI_t - CPI_{t-4})/CPI_{t-4}] * 100$, where *CPI* is the consumer price index; money market interest rate measured by interest rate (*IR*); and real effective exchange rate (*REER*). The *RGDP* is used as a proxy for real output, *INF* is used as the proxy for the general price level, and the *IR* is used as the proxy for the monetary policy variable. The *REER* is included to capture the multi-country nature of the analysis. The price of oil is included to account for possible common factors. All these variables are expressed in natural logarithms except *IR*, which is expressed as a percentage. Seasonality is adjusted using the Census X12 method for all variables except *REER* and *IR*.

As indicated by Baxter and Kouparitsas (2004) and Imbs (2004), bilateral trade is the most important source of inter-country business cycle linkages, therefore, this study built the country-specific foreign variables by using the fixed trade weights $w_{i,j}$ based on the share of trade (exports plus imports). The regional variables are built using the aggregation weights based on the purchasing power parity's adjusted *GDP* series (*PPP-GDP*) weights. Both weights are constructed with annual data computed over the sample period of 1990–2013. The data source for each variable is reported in Table 2.2.

For country $i = 0,1,2,\cdots,N$, the country-specific domestic $Y_{i,t}$ and foreign variables, $Y_{i,t}^{*}$ are

$$Y_{i,t} = (RGDP_{i,t}, INF_{i,t}, IR_{i,t}, REER_{i,t})' \text{ and } Y_{i,t}^{*} = (RGDP_{i,t}^{*}, INF_{i,t}^{*}, IR_{i,t}^{*})'.$$

The country-specific foreign variables are defined as

$$RGDP_{i,t}^{*} = \sum_{j=0}^{N} w_{i,j}\, RGDP_{i,t},$$

$$INF_{i,t}^{*} = \sum_{j=0}^{N} w_{i,j}\, INF_{i,t} \text{ and}$$

$$IR_{i,t}^{*} = \sum_{j=0}^{N} w_{i,j}\, IR_{i,t},$$

where $w_{i,i} = 0$ and $\sum_{j=0}^{N} w_{i,j} = 1$. The matrix of the trade weights is presented in Table 2.3.

This study treats the oil price as the globally dominant variable. The global dominance of the oil price implies that idiosyncratic shocks to the oil price would have a non-negligible effect on potentially any country in the world while the effect of a small economy on the oil price is negligible. Therefore, oil price effectively becomes a dynamic common factor for other economies. In this study, *RGDP* and *INF* are the two feedback variables selected to enter the augmented ECM.

2.3.3 Estimation of the Country Models

The GVAR model assumes foreign and dominant variables are weakly exogenous and the parameters are stable over time. Under weak exogeneity, the parameters of the country-specific models can be estimated consistently using the reduced-rank estimation procedure. However, the Johansen (1988, 1995) reduced-rank estimation procedure treats all the variables in the model as endogenous $I(1)$. Thus, this study estimates the individual VARX* models using the modified technique developed by Harbo *et al.* (1998) and Pesaran *et al.* (2000). Following the estimation procedure, we first conduct the cointegration test and then estimate the individual country models subject to the reduced rank restrictions. We then derive the corresponding ECM and, finally, use the ECM to conduct weak exogeneity tests.

2.3.3.1 Integration Properties of the Series

To select appropriate transformations of the domestic and foreign variables for inclusion in the country-specific cointegrating VAR models, the integration properties of the individual series under consideration are examined. Because the traditional Dickey-

Fuller (DF) test has poor power performance in small samples, this study employs the Weighted Symmetric Augmented Dickey-Fuller (WS-ADF) test introduced by Park and Fuller (1995). The WS-ADF unit root test uses the time reversibility of stationary autoregressive processes to increase their power performance (Leybourne *et al.*, 2005; Pantula *et al.*, 1994). The lag length employed by the WS-ADF unit root test is selected using the Akaike Information Criterion (AIC). Because quarterly data is employed, this study sets the maximum lag length to four.

The WS-ADF test results for the level and first differences of all country-specific domestic, foreign, and global variables in the GVAR model are reported in Table 2.4, which shows that most of the variables are integrated with order 1 or $I(1)$. To avoid over-differencing and efficiency loss in the remaining countries, all the variables are treated approximately as $I(1)$.

2.3.3.2 Rank of Cointegration Space

For each country model, the corresponding cointegrating VAR model is estimated and the rank of the cointegrating space is identified. Initially, the order of the individual country VARX$^*(p_i, q_i)$ models are selected, where p_i is the domestic variables' lag order and q_i is that of the foreign variables in the VARX* models. The variables' lag order is selected according to the AIC. Due to data limitations, the domestic variables have a maximum lag order of two, while that for foreign variables is set to one.

Then, the cointegration rank is derived by employing the trace test and the asymptotic 5% critical values taken from MacKinnon *et al.* (1999). The deterministics of the VARX* models were unrestricted intercept and restricted trend. Table 2.5 provides the orders of the VARX* models and the number of cointegrating relationships. The cointegrating relationships can be interpreted as long-run relationships among the domestic variables and between the domestic and foreign variables.

2.3.3.3 Weak Exogeneity Test

The weak exogeneity of variables is tested using weak exogeneity tests from Johansen (1992) and Harbo *et al.* (1998). The *F*-statistics for testing the weak exogeneity of all country-specific foreign and global variables are summarized in Table 2.6. No weak exogeneity assumptions can be rejected for most variables, where only 5 of 52 exogeneity tests were statistically significant. Thus, the analysis was re-estimated by assuming those five variables as endogenous, which showed that it did not affect the number of cointegrating relationships in the model. Therefore, the variables are treated as exogenous throughout the GVAR model.

2.4 Empirical Results

In this section, we study the dynamic properties of the GVAR model to assess the time profile of the effects following various shocks. This can be achieved through the impulse response function, which characterizes the possible response of the system at different future periods to the effect of shocking one of the variables in the model. In the traditional VAR literature, the Orthogonalized Impulse Responses (OIR) of Sims (1980) was extensively used. The OIR approach requires the impulse responses to be computed with respect to a set of orthogonalized shocks, which depend critically on the ordering of the variables and the countries in the model. However, as a natural ordering generally does not exist, the more recent study widely used the structural VAR methodology to identify the shocks, by imposing a priori restrictions on the covariance matrix of the shocks. This could have been hardly implemented in the case of GVAR model. In the GVAR model with $N + 1$ countries and k_i endogenous variables per country, exact identification of the shocks will require $\sum_{i=0}^{N} k_i\,(k_i - 1)$ restrictions. Therefore, considering the inadequate of the OIR application in the GVAR model, this study employs the generalized impulse response function (GIRF), which is invariant to the variables' order and to the countries in the model, is clearly can provide better results in a large macroeconomic system.

The purpose of this empirical analysis is to evaluate the extent to which the Asian integration process has been driven by external or regional shocks. In this study, the U.S. is considered as a possible source of the global shock, while Japan and China are considered as possible regional shock sources for Asian economies. To get a robust result, we try to examine the responses of the Asian economies in various perspectives, we consider the following one standard error positive shocks: (1) real output shock, (2) inflation shock, (3) interest rate shock, and (4) oil price shock of the U.S., Japan and China.

We display the results of GIRF analysis over 20 quarters (i.e., 5 years), with the bootstrap estimates of the GIRF and their associated 90% confidence bounds.

2.4.1 Real Output Shocks

We first analyze the impulse responses of real outputs to a one standard error positive real output shock originating from China (Figure 2.1), Japan (Figure 2.2), and the U.S. (Figure 2.3), which are equivalent to a positive rise in the real output of China, Japan, and the U.S., respectively.

First, in Figure 2.1, all Asian economies exhibit positive and significant real output responses to the Chinese real output shock except the Philippines, where the impulse response is significantly positive only for the first few periods. This result indicates that most Asian economies tend to be positively affected by a shock from China, likely reflecting China's role as a regional production hub and the growing regional trade between China and neighboring economies. It is interesting to note that not only the U.S. but also the Euro area shows a significantly positive response of real outputs to Chinese real output shock. This result is consistent with the findings of Sato and Shrestha (2014) and Amador *et al*. (2015), which demonstrate China's strong participation in global value chains and the growing dependence of the U.S. and European countries on China for their intermediate input imports.

Second, all Asian economies show positive and significant real output responses to a Japanese real output shock only for an initial period. Subsequently, these countries' impulse responses rapidly become small and insignificant. The impulse responses of the U.S. and Euro area are not statistically significant at all. Thus, Japan's real output shock has a surprisingly small effect on Asian economies, likely because Japan is not a major export market for Asian economies compared to China. Sato and Shrestha (2014) empirically investigated trade and production linkages based on a globally linked input–

output table and demonstrated that Japan' import-dependence on Asian economies for intermediate inputs is far smaller than the degree of Asian import-dependence on Japan, whereas Asian economies have a substantially high import dependence on Japanese intermediate goods.

Third, as found in the previous studies, a U.S. real output shock has significantly positive influences on Asian economies. In Figure 2.3, all Asian economies can be seen to respond positively to the U.S. real output shock for at least the first two years. A comparison between Figures 2.1 (Chinese real output shock) and 2.3 (U.S. real output shock) shows that the degrees of impulse response by real outputs are mostly similar in all Asian economies except the Philippines. However, the period of statistically significant response to Chinese real output shock is clearly longer than the corresponding responses to the U.S. real output shock. In terms of a real output shock, China's regional influence becomes comparable to, or even stronger than, the U.S. influence, which contrasts markedly with the findings of Sato *et al*. (2011), Feldkircher and Korhonen (2014), and Dungey and Vehbi (2015).

2.4.2 Inflation Shocks

To further assess the degree of China's economic influence on Asian economies in comparison with the U.S. influence, we generated two additional shocks: a one standard error positive inflation shock from China (Figure 2.4) and the U.S. (Figure 2.5) to inflation, respectively.

In Figure 2.4, Hong Kong, Taiwan, Malaysia, and Korea can be seen to exhibit positive and significant responses to Chinese inflation shock over the five-year time horizon. Indonesia, Singapore, and Thailand also show significantly positive responses to Chinese inflation shock for at least the first few quarters, but the responses of Japan and the Philippines are not statistically significant at all. Although not reported in this study, we also attempted to estimate the impulse responses of Asian economies' price inflation to a Japanese inflation shock, which indicates that the response of Asian economies' price inflation is not statistically significant in most cases.

Figure 2.5 shows the impulse responses of Asian economies to a U.S. inflation shock. It is interesting to note that the U.S. shock has a significantly positive effect on Asian inflation only for the first one or two quarters in Hong Kong, Korea, Malaysia, Thailand, and Taiwan. For other Asian economies, the U.S. shock has no significant influences on domestic price inflation. In terms of the inflation shock, China has far stronger influences than the U.S. on Asian regional economies.

2.4.3 Interest Rate Shocks

In addition to the real output and price linkages, it is necessary to assess the degree of financial linkages. Under the GVAR framework, we investigate the degree of interest rate shock transmission. Figure 2.6 shows that nominal interest rates of all Asian economies respond positively and significantly to the U.S. interest rate shock at least for the first several periods. In contrast, although not presented in this study, an interest rate shock from either China or Japan has no significant effect on the nominal interest rates in Asian economies, likely due to the China's capital controls and Japan's near-zero interest rate policy since the end of the 1990s. In terms of financial linkages, Asian economies are subject not to regional shocks but to global shocks originating from the U.S.

2.4.4 Oil Price Shocks

Lastly, to assess the effects of an oil price shock, another possible source of global shock, on Asian economies, a one standard error positive shock to oil prices is generated, and the effects of an oil price shock on real output (Figure 2.7) and inflation (Figure 2.8) are investigated. A one standard error positive shock results in a 0.1% increase in the price of oil. Most real output of Asian economies first shows a positive response but soon decreases sharply. The above responses are not statistically significant for most Asian economies. On the other hand, although short-lived, an oil price shock has a positive and significant effect on inflation in Asian economies. Compared to its effects on real output, an oil price shock has stronger effects on Asian economies by causing inflationary pressure. Furthermore, the short-lived responses to inflation support the finding of Galesi and Lombardi (2009) that inflationary effects of oil price shocks are felt mostly in advanced countries, with less sizeable effects felt in emerging economies.

2.5 Concluding Remarks

This study has examined the issues involved in the feasibility of forming a regional monetary arrangement in the Asian region. These issues are illustrated in a global macroeconomic modeling approach that allows global inter-linkages between domestic and foreign variables, i.e. a GVAR model estimated for 20 economies from all over the world over the period 1990Q1 – 2013Q4. Then later, we have focused on the shock-term and long-term implications of global (U.S.) and regional (Japanese and Chinese) shocks for the Asian region economy. We investigated whether recent regional economic growth and inflation dynamics are driven by external shocks or self-sustaining development in Asia and present the time profiles of these shocks using generalized impulse response function.

We found that Asian economies tend to show significantly positive and longer responses to a Chinese real output shock than to a U.S. shock. While previous studies found the Chinese economy has increasing importance in the global economy (Cesa-Bianchi *et al*., 2012; Feldkircher and Korhonen, 2014; Dreger and Zhang, 2014), no studies have found that China's influence surpass that of the U.S. in the context of Asian monetary integration/union. The simulations clearly show that China's influence on the Asian economies are greater than the U.S. influence in terms of both real output and inflation shocks, although the U.S. still has a greater financial effect on Asian economies in terms of interest rate shocks. In contrast to the responses to a Chinese real output shock, Asian economies' responses to a Japanese real output shock are far less statistically significant. This is likely due to Japan's unilateral dependence on the Asian economies, in that Japan does not import much from Asian economies.

From a policy analysis perspective, a number of interesting results emerge. The rising role of regional (Chinese) shocks in driving business cycles and inflation indicates that Asian economies meet some of the key preconditions in establishing a regional monetary union. However, Asian economies are financially affected by the U.S., in that nominal interest rates of Asian economies are significantly influenced by a U.S. interest rate shock. To facilitate regional monetary arrangements, China needs further financial liberalization and removal of capital controls to strengthen its financial linkages with other Asian economies.

References

Allegret, J., Couharde, C. and Guillaumin, C. (2012). The Impact of External Shocks in East Asia: Lessons from a Structural VAR Model with Block Exogeneity. *International Economics*, 132, 35–89.

Amador, J., Cappariello, R. and Stehrer, R. (2015). Global Value Chains: A View from the Euro Area. *Asian Economic Journal*, 29(2), 99–120.

Bacha, O. L. (2008). A Common Currency Area for ASEAN? Issues and Feasibility. *Applied Economics*, 40(4), 515–529.

Baxter, M. and Kouparitsas, M. A. (2004). Determinants of Business Cycle Comovement: A Robust Analysis. *Journal of Monetary Economics*, 52(1), 113–157.

Bayoumi, T., Eichengreen, B. and Mauro, P. (2000). On Regional Monetary Arrangements for ASEAN. *Journal of the Japanese and International Economies*, 14, 121–148.

Cesa-Bianchi, A., Pesaran, M. H., Rebucci, A. and Xu, T. (2012). China's Emergence in the World Economy and Business Cycles in Latin America. *Journal of LACEA Economia*, 12, 1–75.

Chow, H. K. and Kim, Y. (2003). A Common Currency Peg in East Asia? Perspectives from Western Europe. *Journal of Macroeconomics*, 25(3), 331–350.

Chudik, A. and Pesaran, M. H. (2015). Theory and Practice of GVAR Modelling. *Journal of Economic Surveys*, forthcoming (DOI: 10.1111/joes.12095).

Dees, S., di Mauro, F., Pesaran, M. H. and Smith, L. V. (2007). Exploring the International Linkages of the Euro Area: A Global VAR Analysis. *Journal of Applied Econometrics*, 22(1), 1–38.

Dees, S., Pesaran, M. H., Smith, L. V. and Smith, R. P. (2014). Constructing Multi-Country Rational Expectations Models. *Oxford Bulletin of Economics and Statistics*, 76(6), 812–840.

Dreger, C. and Zhang, Y. (2014). Does the Economic Integration of China Affect Growth and Inflation in Industrial Countries? *Economic Modelling*, 38, 184–189.

Dungey, M. and Vehbi, T. (2015). The Influences of International Output Shocks from the US and China on ASEAN Economies. *Journal of Asian Economics*, 39. 59–71.

Feldkircher, M. and Korhonen, I. (2014). The Rise of China and Its Implications for the Global Economy: Evidence from a Global Vector Autoregressive Model. *Pacific Economic Review*, 19(1), 61–89.

Ferrarini, B. (2013). Vertical Trade Maps. *Asian Economic Journal*, 27(2), 105–123.

Fielding, D., Lee, K. and Shields, K. (2012). Does One Size Fit All? Modelling Macroeconomic Linkages in the West African Economic and Monetary Union. *Economic Change and Restructuring*, 45(1–2), 45–70.

Galesi, A. and Lombardi, M. J. (2009). External Shocks and International Inflation Linkages: A Global VAR Analysis. *Working Paper Series 1062, European Central bank*.

Harbo, I, Johansen, S., Nielsen, B., Rahbek, A. (1998). Asymptotic Inference on Cointegrating Rank in Partial Systems. *Journal of Business and Economics Statistics*, 16(4), 388–399.

Hirata, H., Kose, M.A., Otrok, C. (2013). Regionalization v.s. Globalization. IMF Working Paper, WP/13/19.

Hsu, H.-F. (2010). Is a Common Currency Area Feasible for East Asia? A Multivariate Structural Vector Autoregressive Approach. *Asian Economic Journal*, 24(4), 391–411.

Imbs, J. (2004). Trade, Finance, Specialization and Synchronization. *Review of Economics and Statistics*, 86(3), 723–734.

Ito, K. and Shimizu, J. (2015). Industry-Level Competitiveness, Productivity and Effective Exchange Rates in East Asia. *Asian Economic Journal*, 29(2), 181–214

Johansen, S. (1988). Statistical Analysis of Cointegration Vectors. *Journal of Economic Dynamics and Control*, 12(2–3), 231–254.

Johansen, S. (1992). Cointegration in Partial Systems and the Efficiency of Single-equation Analysis. *Journal of Econometrics*, 52(3), 231–254.

Johansen, S. (1995). *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press, Oxford.

Kwon, T. and Ryou, J.-W. (2015). Global Value Chains of East Asia: Trade in Value Added and Vertical Specialization. *Asian Economic Journal*, 29(2), 121–143.

Lee, G. H. Y. and Azali, M. (2012). Is East Asia an Optimum Currency Area? *Economic Modelling*, 29(2), 87–95.

Lee, G. H. Y. and Koh, S. G. M. (2012). The Prospects of a Monetary Union in East Asia. *Economic Modelling*, 29(2), 96–102.

Leybourne, S., Kim, T. H. and Newbold, P. (2005). Examination of Some More Powerful Modifications of the Dickey-Fuller test. *Journal of Time Series Analysis*, 26(3), 355–369.

MacKinnon, J. G., Haug, A. A. and Michelis, L. (1999). Numerical Distribution Functions of Likelihood Ratio Tests for Cointegration. *Journal of Applied Econometrics*, 14, 563–577.

Pantula, S. G., Gonzalez-Farias, G. and Fuller, W. A. (1994). A Comparison of Unit Root Test Criteria. *Journal of Business & Economic Statistics*, 12(4), 449–459.

Park, H. and Fuller, W. (1995). Alternative Estimators and Unit Root Tests for the Autoregressive Process. *Journal of Time Series Analysis*, 16(4), 415–429.

Pesaran, M. H., Shin, Y. and Smith, R. (2000). Structural Analysis of Vector Error Correction Models with Exogenous *I*(1) Variables. *Journal of Econometrics*, 97(2), 293–343.

Pesaran, M. H., Schuermann, T. and Weiner, S. M. (2004). Modeling Regional Interdependencies Using a Global Error-Correcting Macroeconometric Model. *Journal of Business & Economic Statistics*, 22(2), 129–162.

Pesaran, M. H., Smith, L. V. and Smith, R. P. (2007). What if the UK or Sweden had joined the Euro in 1997? An Empirical Evaluation using a Global VAR. *International Journal of Finance and Economics*, 12, 55–87.

Sato, K., Shimizu, J., Shrestha, N. and Zhang, S. (2013). Industry-specific Real Effective Exchange Rates and Export Price Competitiveness: The Case of Japan, China, and Korea. *Asian Economic Policy Review*, 8(2), 298–321.

Sato, K. and Shrestha, N. (2014). Global and Regional Shock Transmission: An Asian Perspective. CESSA Working Paper, 2014–04.

http://www.econ.ynu.ac.jp/cessa/publication/pdf/CESSA%20WP%202014-04.pdf

Sato, K., Zhang, Z. and McAleer, M. (2011). Identifying Shocks in Regionally Integrated Asian Economies with Structural VAR and Block Exogeneity. *Mathematics and Computers in Simulation*, 81(7), 1353–1364.

Smith, L. V. and Galesi, A. (2014). GVAR Toolbox 2.0.

https://sites.google.com/site/gvarmodelling/gvar-toolbox.

Zhang, Z., Sato, K. and McAleer, M. (2004). Is a Monetary Union Feasible for East Asia? *Applied Economics*, 36, 1031–1043.

Table 2.1: Countries and Regions in the Global VAR Model

Regions	Countries	Regions	Countries
Asian countries	China	Euro area	Austria
	Hong Kong		Belgium
	Indonesia		Finland
	Japan		France
	Korea		Germany
	Malaysia		Italy
	Philippines		Netherlands
	Singapore		Spain
	Taiwan	Developed countries	U.K.
	Thailand		U.S.

Table 2.2: Data Sources

Country	RGDP	CPI	IR	REER	Oil Price	Imports	Exports	PPP-GDP
Austria	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Belgium	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
China	CEIC	CEIC	CEIC	IFS	IFS	DOT	DOT	WB
Finland	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
France	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Germany	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Hong Kong	CEIC	IFS	CEIC	BIS	IFS	DOT	DOT	WB
Indonesia	CEIC	IFS	CEIC	BIS	IFS	DOT	DOT	WB
Italy	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Japan	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Korea	CEIC	IFS	CEIC	BIS	IFS	DOT	DOT	WB
Malaysia	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Netherlands	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Philippines	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Singapore	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Spain	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
Taiwan	CEIC	CEIC	CEIC	CEIC	IFS	DOT	DOT	WB
Thailand	CEIC	IFS	CEIC	CEIC	IFS	DOT	DOT	WB
U.K.	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB
U.S.	CEIC	IFS	CEIC	IFS	IFS	DOT	DOT	WB

Note: CEIC is the CEIC Global Database; IFS is the International Monetary Fund, International Financial Statistics (IMF, IFS) CD-ROM edition; BIS is the Bank of International Settlements; DOT is the IMF Direction of Trade; and WB is the World Development Indicator database of the World Bank.

Table 2.3: Trade Weights (w_{ij}) Based on Direction of Trade Statistics

Country	China	Euro	Hong Kong	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Taiwan	Thailand	U.K.	U.S.
China	0	0.1574	0.4943	0.1225	0.2026	0.2457	0.1095	0.0783	0.1105	0.2377	0.1285	0.0537	0.2182
Euro	0.1645	0	0.0847	0.1156	0.1297	0.1142	0.1053	0.1138	0.1091	0.0963	0.1149	0.6425	0.2671
Hong Kong	0.1424	0.0227	0	0.0202	0.0441	0.0503	0.0454	0.0628	0.0798	0.0877	0.0458	0.0245	0.0256
Indonesia	0.0209	0.0145	0.0068	0	0.0399	0.0362	0.0391	0.0223	0.0345	0.0160	0.0403	0.0049	0.0149
Japan	0.1650	0.0903	0.0895	0.2208	0	0.1847	0.1609	0.1887	0.1090	0.1740	0.2384	0.0420	0.1792
Korea	0.1026	0.0351	0.0350	0.0838	0.0817	0	0.0489	0.0603	0.0561	0.0506	0.0398	0.0138	0.0617
Malaysia	0.0333	0.0187	0.0176	0.0616	0.0389	0.0288	0	0.0428	0.1791	0.0312	0.0721	0.0103	0.0313
Philippines	0.0145	0.0071	0.0111	0.0141	0.0198	0.0161	0.0182	0	0.0248	0.0145	0.0214	0.0036	0.0149
Singapore	0.0301	0.0241	0.0446	0.1399	0.0350	0.0407	0.1733	0.0857	0	0.0611	0.0771	0.0160	0.0349
Taiwan	0.0779	0.0270	0.0546	0.0389	0.0693	0.0445	0.0489	0.0666	0.0610	0	0.0419	0.0115	0.0525
Thailand	0.0240	0.0167	0.0165	0.0449	0.0463	0.0179	0.0584	0.0414	0.0519	0.0217	0	0.0084	0.0229
U.K.	0.0255	0.3136	0.0240	0.0177	0.0279	0.0218	0.0233	0.0182	0.0285	0.0187	0.0265	0	0.0768
U.S.	0.1993	0.2727	0.1214	0.1201	0.2649	0.1990	0.1689	0.2191	0.1558	0.1907	0.1533	0.1689	0

Note: Trade weights are computed as shares of exports and imports, displayed in columns by region (such that a column, but not a row, total 1).

Table 2.4: WS-ADF Unit Root Test for Domestic, Foreign, and Global Variables

	China	Euro	Hong Kong	Indonesia	Japan	Korea	Malaysia	Philippines	Singapore	Taiwan	Thailand	U.K.	U.S.
<u>Domestic</u>													
RGDP	-2.70	-1.37	-2.95	-1.85	-2.57	-0.91	-0.79	-0.19	-2.19	-0.82	-1.77	-1.02	-1.61
∆RGDP	-2.61*	-4.41*	-4.71*	-5.58*	-5.38*	-5.67*	-5.48*	-4.19*	-6.04*	-6.46*	-6.07*	-3.60*	-3.74*
INF	-2.07	-2.75	-1.14	-6.82*	-1.19	-2.67	-3.09	-1.44	-1.74	-2.49	-2.67	-3.00	-2.10
∆INF	-3.80*	-8.61*	-4.48*	-4.57*	-7.15*	-7.89*	-8.81*	-4.55*	-5.20*	-7.28*	-8.61*	-3.55*	-5.00*
REER	-2.03	-2.46	-1.31	-1.88	-2.66	-3.22	-2.27	-1.88	-0.65	-3.10	-2.95	-2.52	-1.72
∆REER	-6.35*	-6.08*	-3.69*	-6.87*	-4.38*	-5.30*	-7.17*	-5.22*	-5.23*	-5.21*	-7.59*	-4.53*	-7.84*
IR	-1.92	-2.46	-3.32*	-4.64*	-1.81	-2.85	-3.55*	-2.96	-3.31*	-2.24	-3.48*	-2.21	-4.40*
∆IR	-5.41*	-5.27*	-4.72*	-6.40*	-3.61*	-8.73*	-4.86*	-5.41*	-5.29*	-3.87*	-6.16*	-5.42*	-4.15*
<u>Foreign</u>													
RGDP*	-1.86	-1.51	-0.99	-1.31	-1.13	-1.35	-1.96	-1.50	-0.96	-1.44	-1.24	-1.29	-1.16
∆RGDP*	-4.99*	-4.41*	-3.85*	-5.37*	-4.93*	-4.67*	-5.44*	-5.26*	-4.74*	-4.69*	-5.12*	-4.98*	-4.68*
INF*	-1.57	-2.13	-2.05	-2.00	-2.12	-2.01	-2.13	-1.99	-2.09	-1.91	-2.12	-2.37	-1.97
∆INF*	-5.11*	-7.04*	-4.04*	-7.53*	-4.82*	-6.89*	-7.96*	-8.12*	-8.16*	-4.63*	-7.87*	-8.19*	-6.32*
IR*	-3.60*	-2.95	-2.30	-3.24	-2.87	-2.71	-3.00	-3.26*	-2.63	-2.66	-2.50	-3.05	-2.59
∆IR*	-5.33*	-4.59*	-4.78*	-5.54*	-5.60*	-5.13*	-5.46*	-4.95*	-5.87*	-5.04*	-5.55*	-4.64*	-5.08*
<u>Dominant</u>													
Oil Price	-2.29												
∆Oil Price	-6.01*												

Note: * indicates significance at a 5% level of significance.

Table 2.5: VARX* Order and Cointegrating Relationship in Country-Specific Models

	Lag order of domestic variables	Lag order of foreign variables	Number of cointegrating relations
China	2	1	1
Euro	2	1	2
Hong Kong	1	1	1
Indonesia	2	1	3
Japan	2	1	2
Korea	2	1	2
Malaysia	2	1	1
Philippines	2	1	3
Singapore	1	1	2
Taiwan	1	1	2
Thailand	1	1	2
U.K.	2	1	2
U.S.	2	1	2

Note: The rank of the cointegrating orders for each country/region is computed using Johansen's trace statistics at the 95% critical value level.

Table 2.6: Weak Exogeneity Tests of Country-Specific Foreign and Global Variables

Country	F test	Critical values	Country-specific foreign and global variables			
			RGDP	INF	IR	Oil Price
China	F(1,77)	3.97	5.96	0.03	0.62	0.11
Euro	F(2,76)	3.12	0.33	0.58	1.89	0.17
Hong Kong	F(1,73)	3.97	0.80	0.86	0.46	0.19
Indonesia	F(3,81)	2.72	1.49	0.18	1.54	0.92
Japan	F(2,82)	3.11	0.70	0.78	0.20	0.69
Korea	F(2,82)	3.11	1.53	2.73	0.10	4.73
Malaysia	F(1,73)	3.97	0.51	0.02	0.81	1.55
Philippines	F(3,75)	2.73	0.67	1.87	2.52	1.98
Singapore	F(2,76)	3.12	0.80	0.23	0.52	1.28
Taiwan	F(2,82)	3.11	0.10	0.65	0.14	2.64
Thailand	F(2,82)	3.11	3.27	1.24	3.55	0.89
U.K.	F(2,82)	3.11	0.11	0.63	0.02	6.47
U.S.	F(2,72)	3.12	0.22	1.12	0.77	2.58

Note: Critical values are at the 5% level of significance.

Figure 2.1: GIRFs of Real Output to a Positive Chinese Real Output Shock

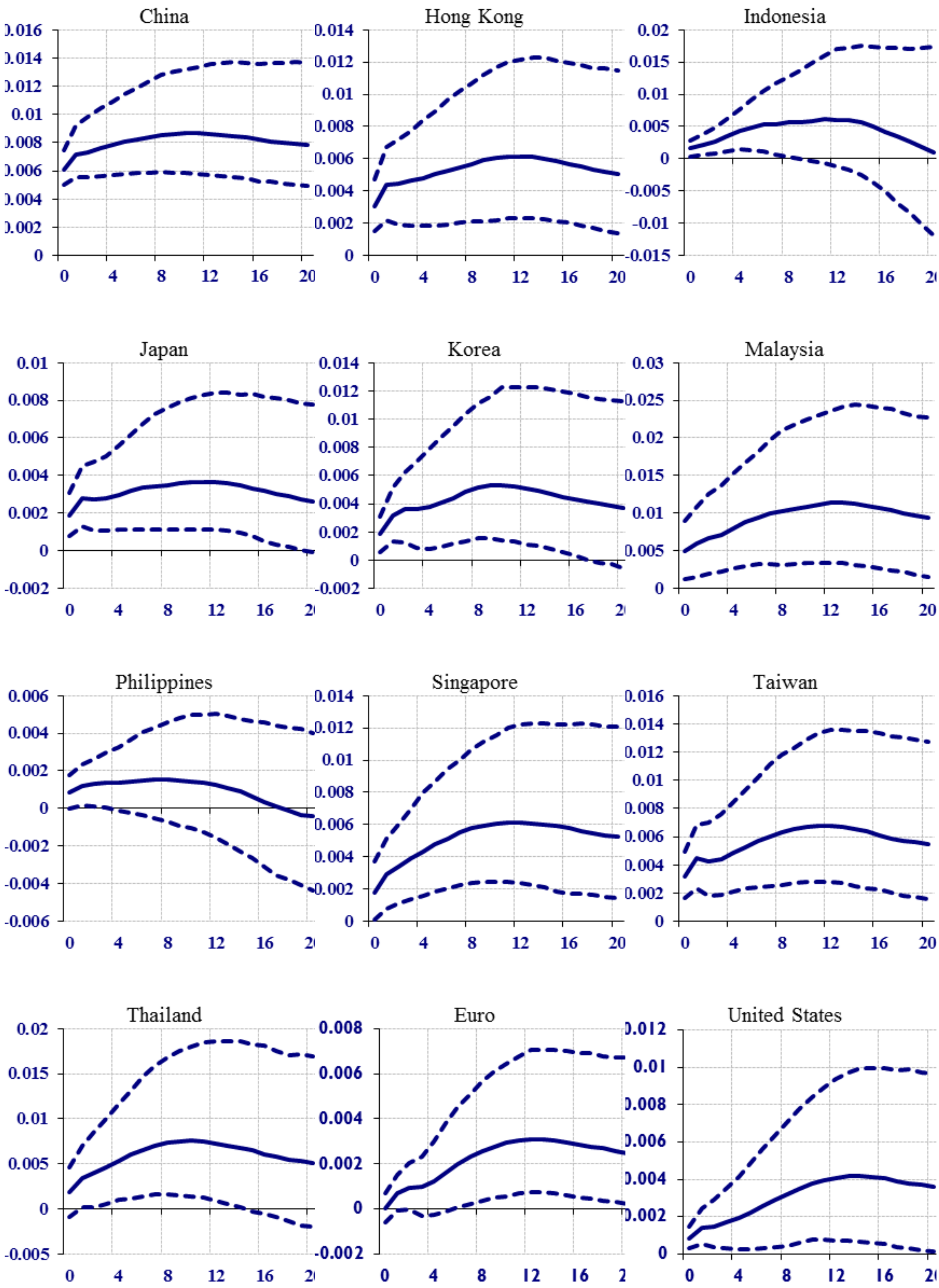


Figure 2.2: GIRFs of Real Output to a Positive Japanese Real Output Shock

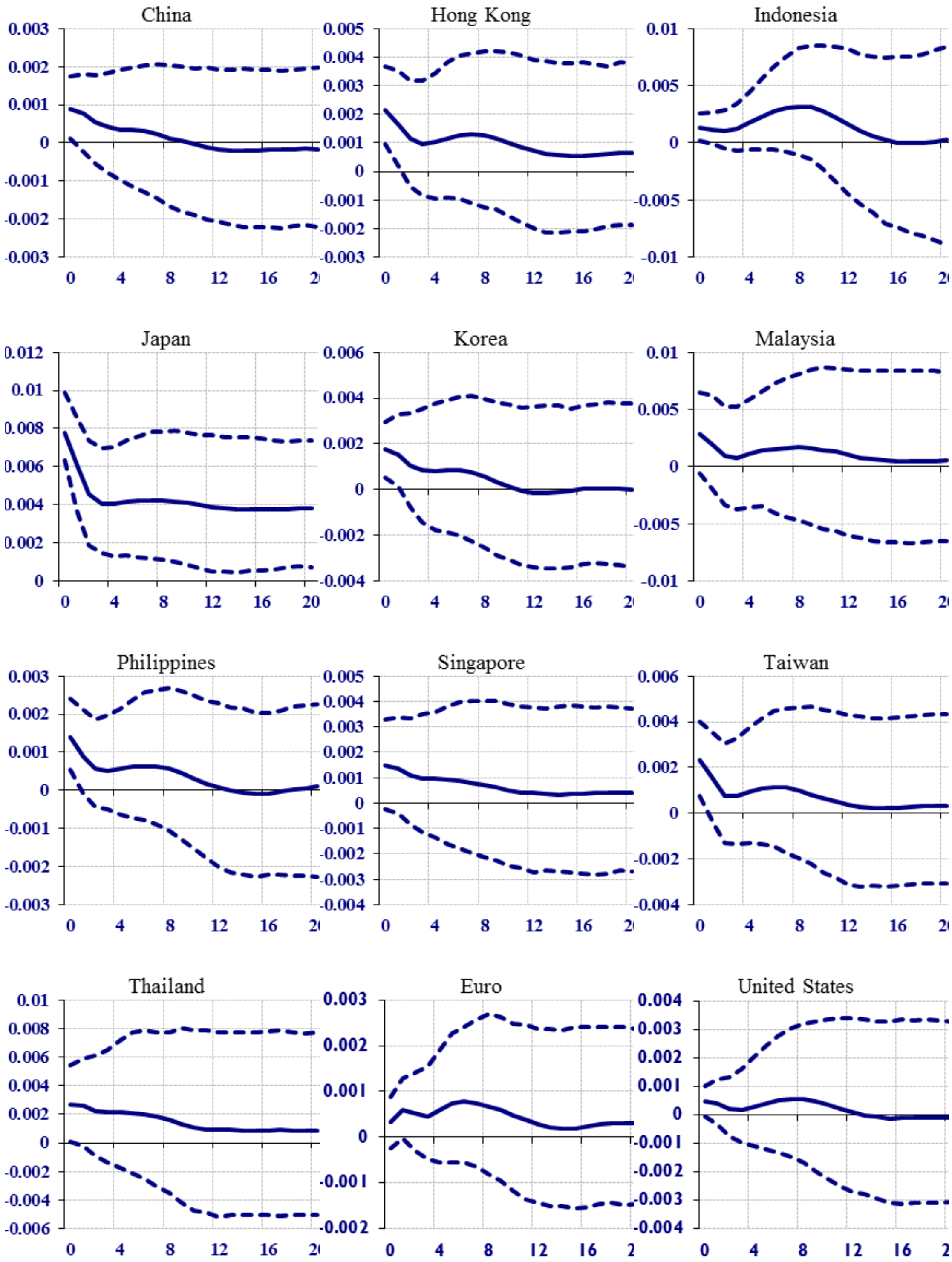


Figure 2.3: GIRFs of Real Output to a Positive U.S. Real Output Shock

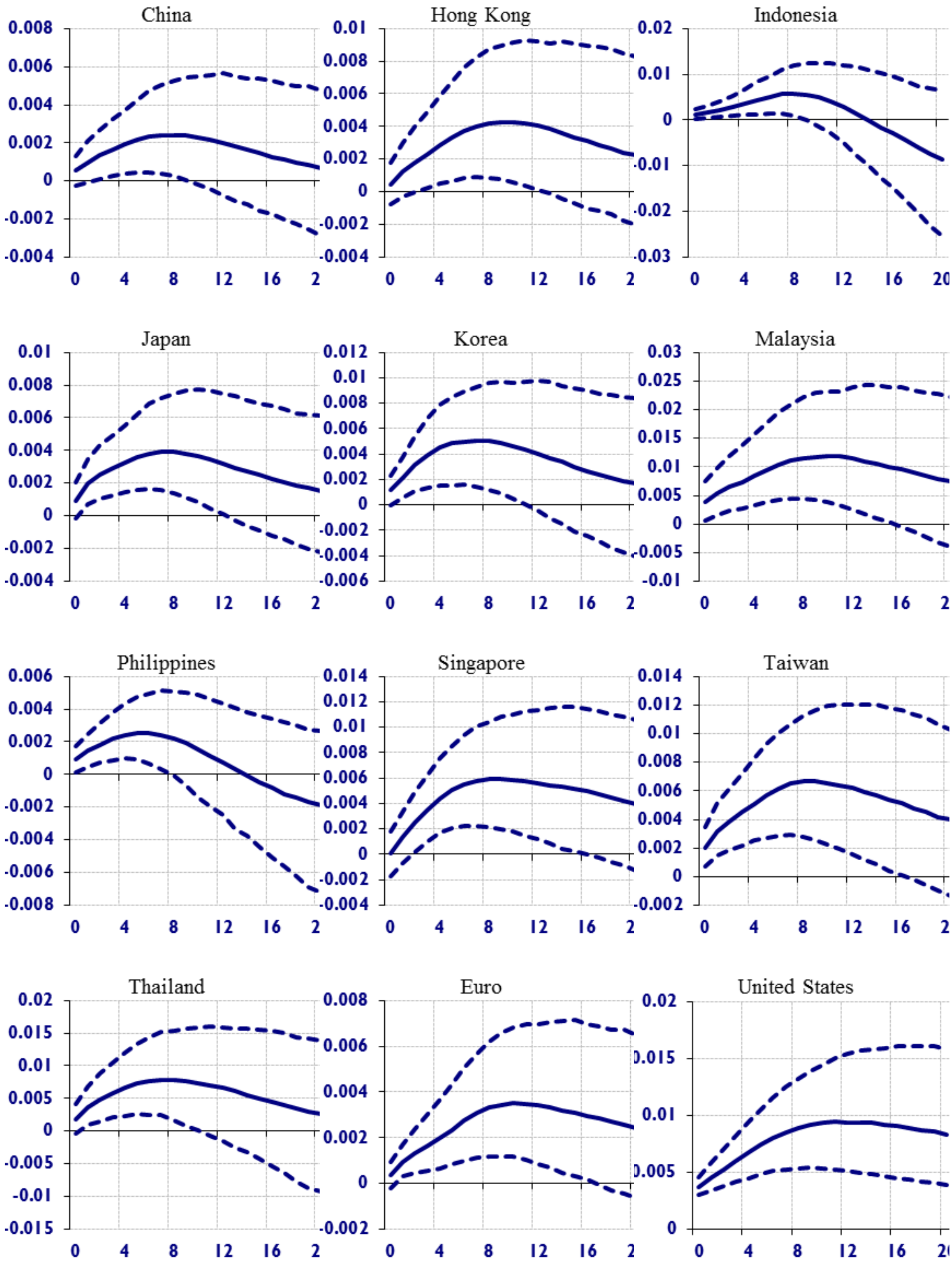


Figure 2.4: GIRFs of Inflation Rates to a Positive Chinese Inflation Shock

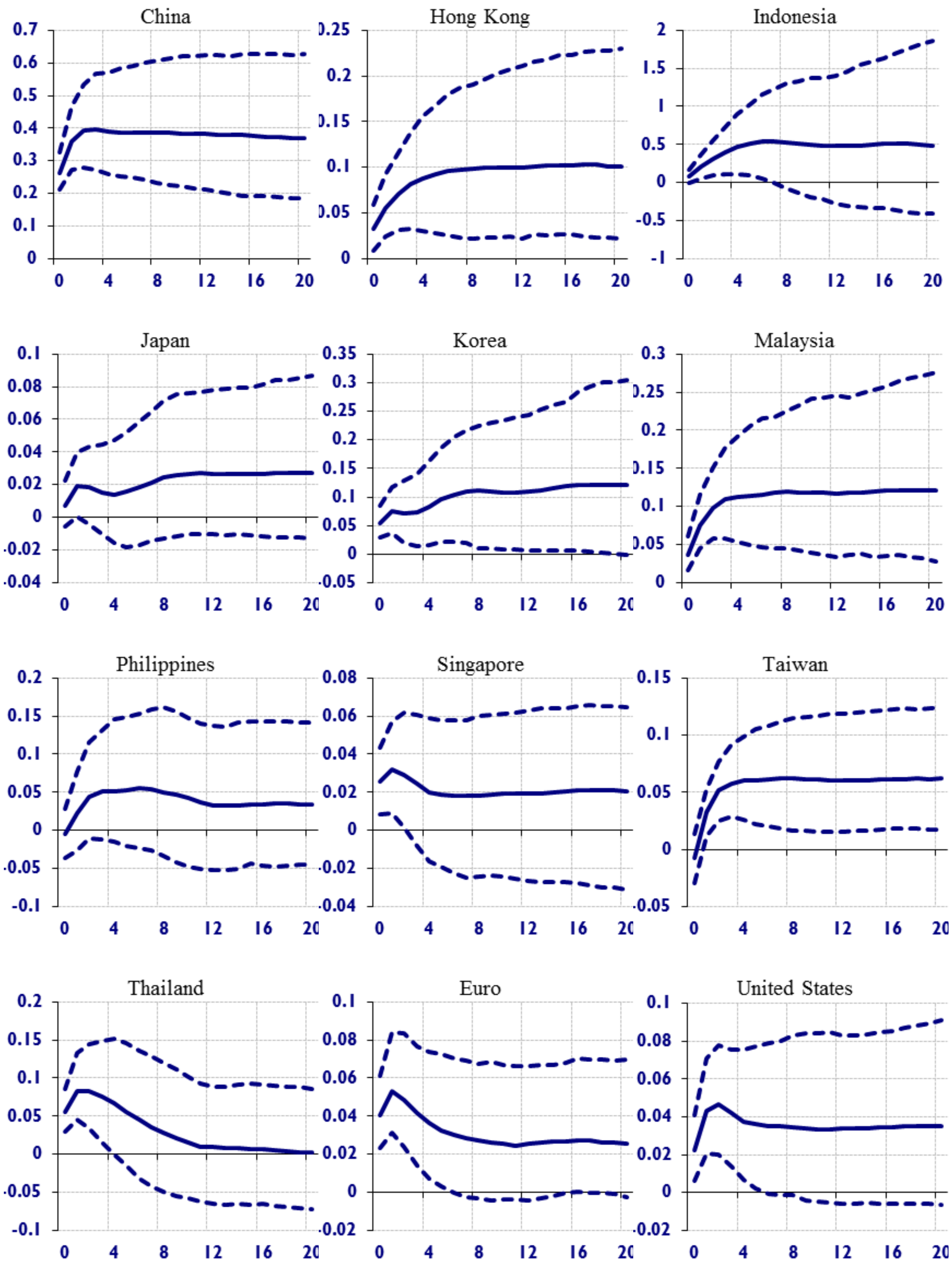


Figure 2.5: GIRFs of Inflation Rates to a Positive U.S. Inflation Shock

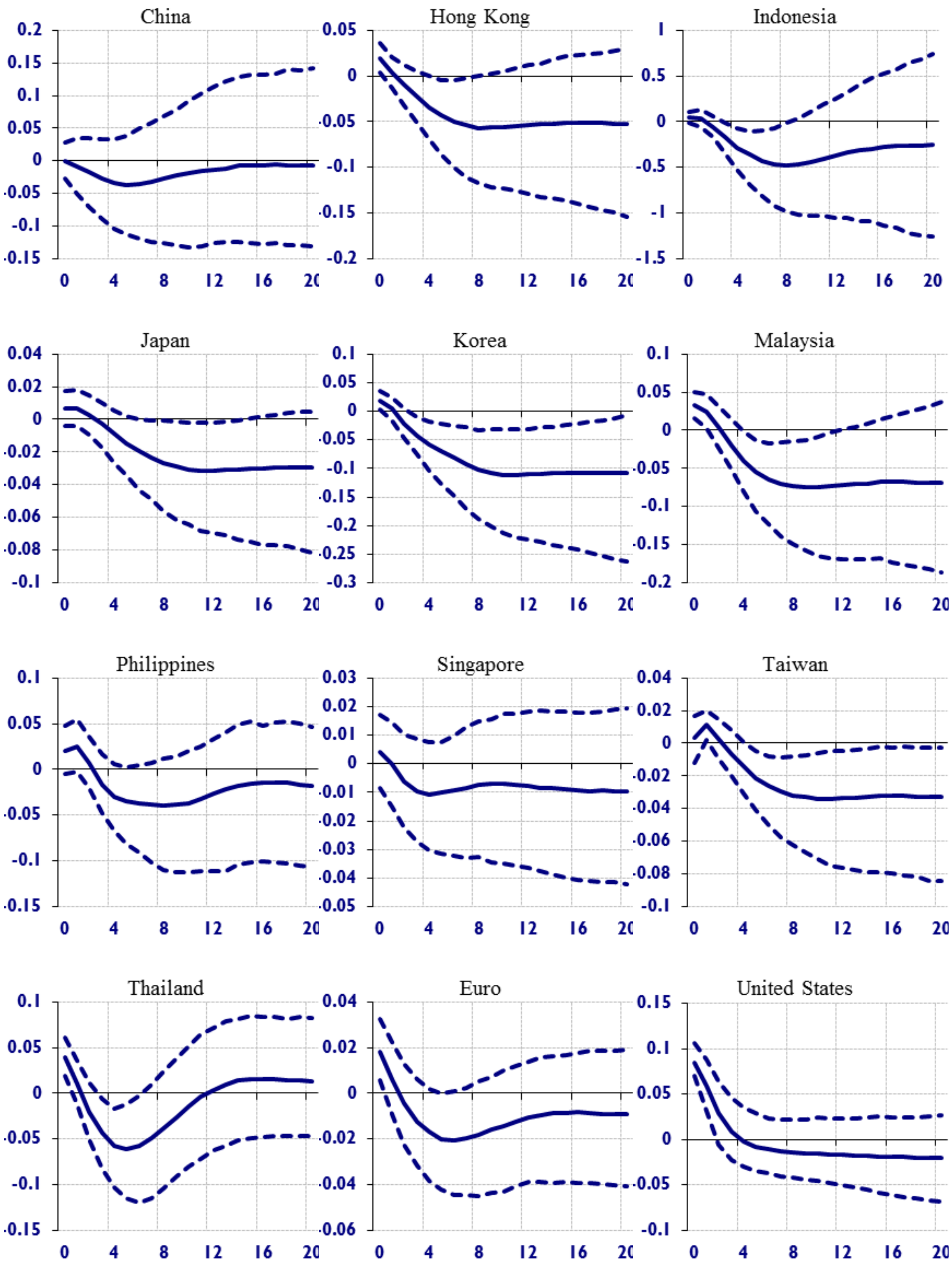


Figure 2.6: GIRFs of Interest Rates to a Positive U.S. Interest Rate Shock

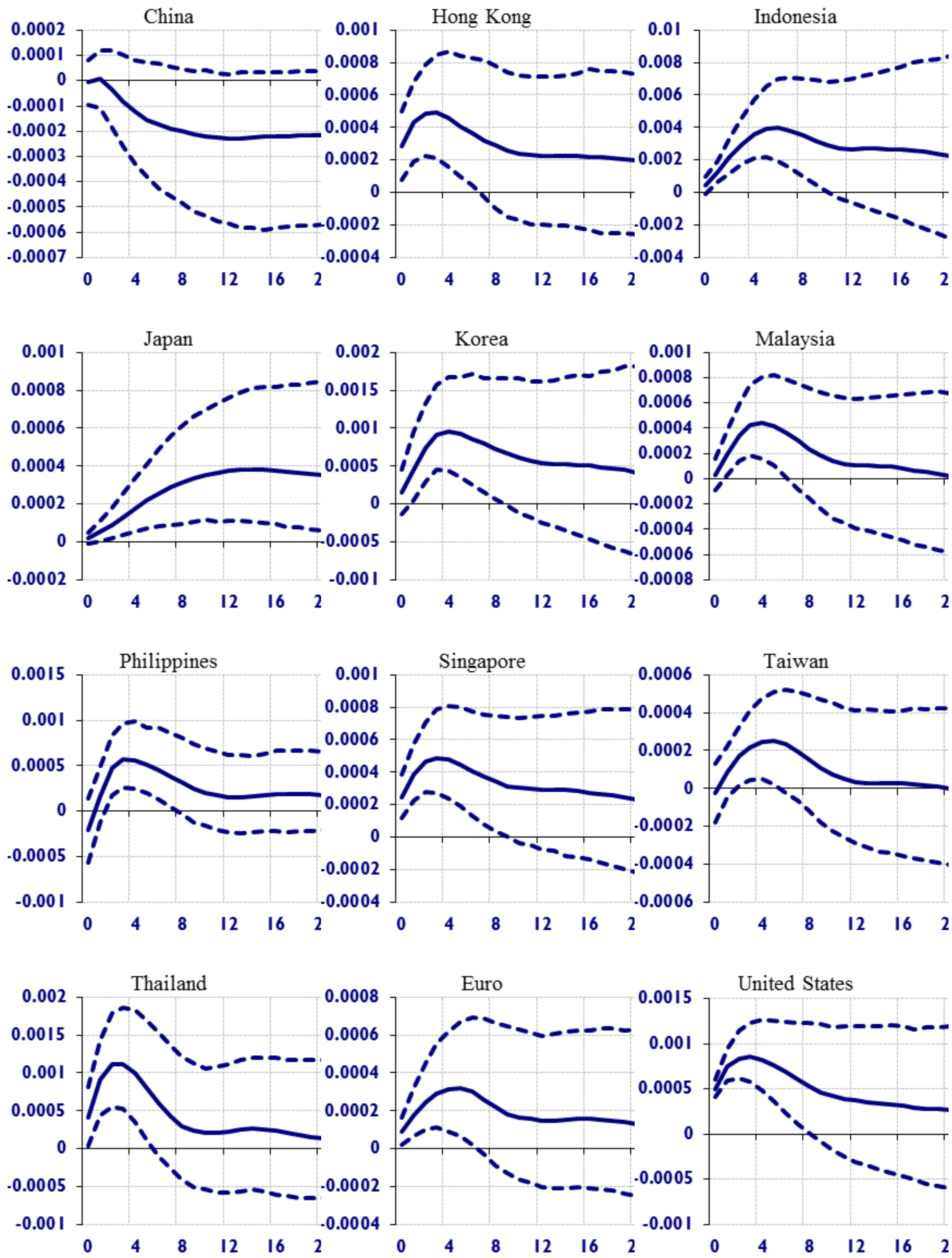


Figure 2.7: GIRFs of Real Output to a Positive Oil Price Shock

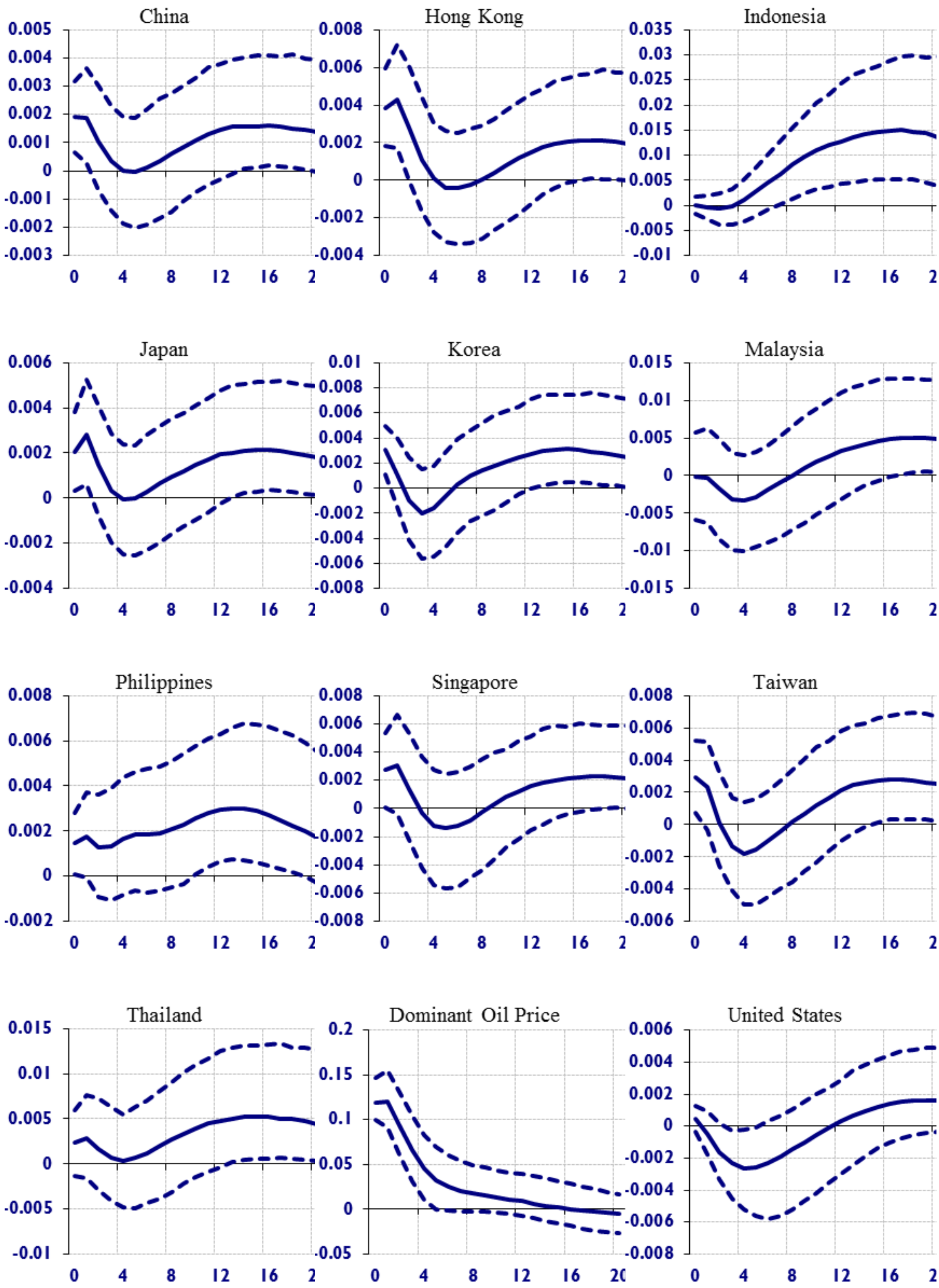
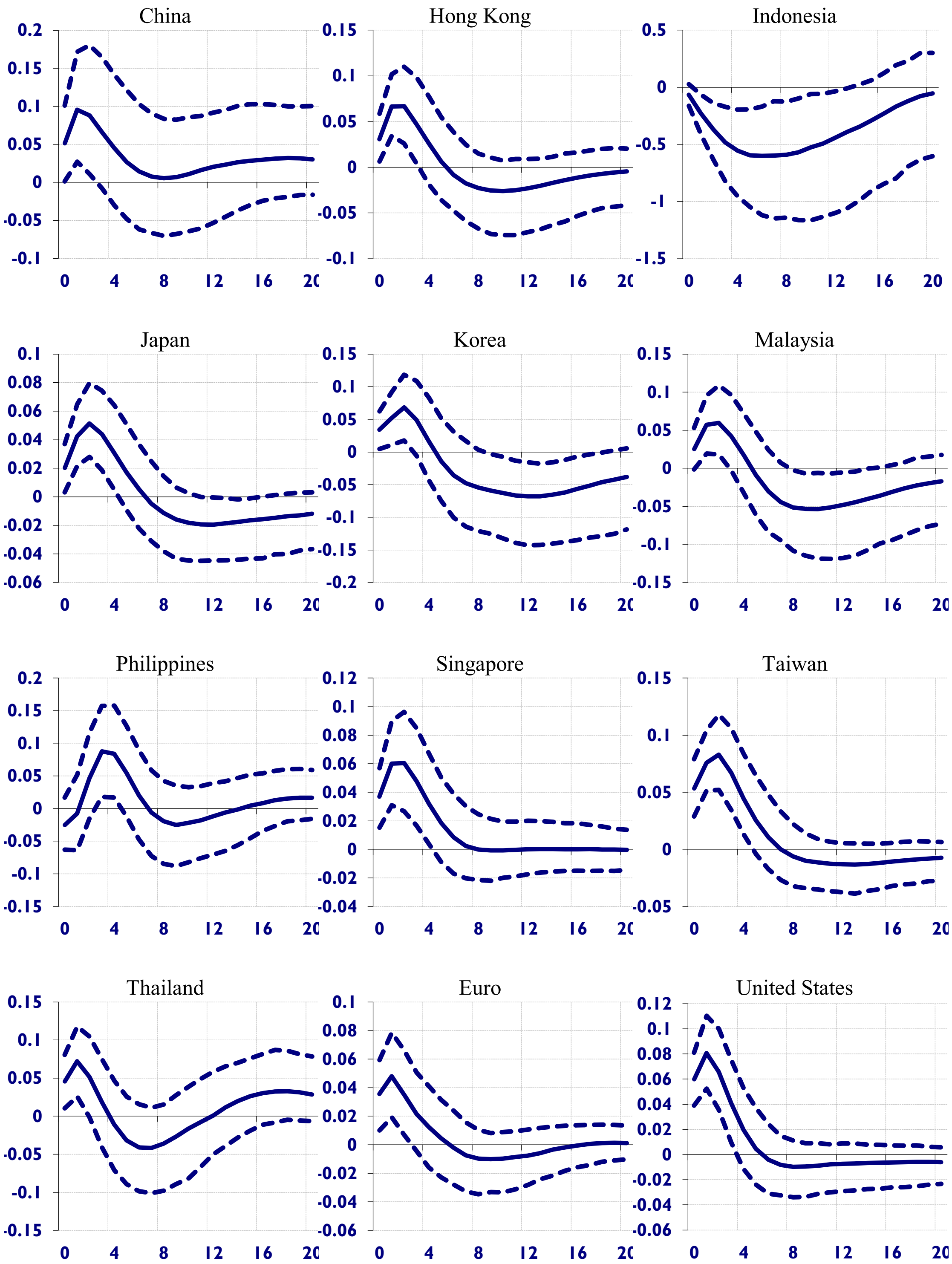


Figure 2.8: GIRFs of Inflation Rates to a Positive Oil Price Shock



BUSINESS CYCLES SYNCHRONIZATION IN ASIA: DYNAMIC FACTOR MODEL WITH TIME-VARYING PARAMETERS

3.1 Introduction

In the history of business cycles fluctuations, it has been long observed that many countries experienced similar fluctuations in macroeconomic aggregates. These fluctuations revealed substantial synchronization across countries. This view is supported by Backus *et al*. (1993) and Baxter (1995), where they found business cycles in major industrialized economies are quite similar. Since then, a large number of studies have analyzed the degree of business cycles similarities between different countries, using numerous empirical methods. Among others, a dynamic factor model has been widely used to extract common dynamic components in macroeconomic aggregates, such as a dynamic factor that is common to all aggregates, sectors, regions or world (Long and Plosser, 1987; Gregory *et al*., 1997; Kose *et al*., 2003; Foerster *et al*., 2011; Kabundi and Simone, 2011; Karadimitropoulou and León-Ledesma, 2013).

According to the theory of optimal currency areas developed by Mundell (1961), business cycles synchronization is one of the major preconditions to form a common currency area. The more synchronized business cycles across countries, the more suitable the countries are to establishing a full-fledged monetary union. Understanding the source of business cycles similarities is important for making policy decisions. If business cycles are indeed a worldwide phenomenon, a domestic policy may not be as responsive as thought. On the other hand, if business cycles are largely driven by regional factors, regional monetary and exchange rate coordination will be feasible among the countries in question.

In Asia, the process of increasing intra-regional integration, as well as the Asian currency crisis of 1997, have raised up a question of an appropriate regional monetary arrangement for Asian countries. It remains unclear whether increasing intra-regional integration has translated into the emergence of a common business cycle. To answer this, previous studies used a dynamic factor model in the study of business cycles synchronization in Asia region (Moneta and Rüffer, 2009; Nguyen, 2010; Lee and Azali, 2012; He and Liao, 2012). The existing studies applied the dynamic factor model in a multi-level factor structure approach, which allows characterizing the co-movements of business cycles on the global level, regional level, and country level, respectively. This allows the regional and country-specific cycles been examined simultaneously with the world business cycles. According to the explanation given by Kose *et al.* (2003), the importance of studying all three in one model is that studying a subset of countries can lead one to believe that observed co-movements are particular to the subset of countries when it, in fact, is common to a much larger group of countries. Through this, a better understanding of the sources of international economic fluctuations can be achieved, and further applied to developing business cycle models and making policy decisions.

One major drawback of these existing studies is the application of dynamic factor model with the static parameter, assuming that both the stochastic process driving volatility and the nature of co-movements among variables has not changed over time. However, several studies have revealed the assumption of structural stability is invalid for many macroeconomic datasets, indicating that models with fixed parameters may not do well in describing macroeconomic data (McConnell and Perez-Quiros, 2000; Del Negro and Otrok, 2008). The belief that changes in the factor loadings over time may stem from policies adopted by specific countries, or from structural changes such as increased trade or economic integration of a country with the rest of the world. This is particularly important in Asia issue where Asian countries have experienced dynamic changes of regional economic linkages from the year 2000 to the present.

Therefore, this study addresses the inadequacy of dynamic factor model with the static parameter in contributing to the literature of Asian regional monetary arrangements by applying a dynamic factor model with time-varying parameters. The similar model has been applied by Del Negro and Otrok (2008) in measuring the evolution of international business cycles in the post-Bretton Woods period, mainly focused on Group of Seven (G-7) countries and European countries. However, based on our knowledge, to date, the existing research has not yet applied this approach to examining the symmetry in business cycles for Asian countries as the preconditions for forming a regional monetary arrangement.

This paper proposes to employ the Bayesian dynamic factor model with time-varying parameters in a multilevel form to analyze the business cycles of 33-countries, covering four regions. Specifically, with annual data from 1979 to 2015, this paper decompose fluctuations in real aggregate output for these countries into three components: (i) a world factor that is common to all countries; (ii) four regional factors that are common across countries belonging to the same region; (iii) the idiosyncratic terms that can be interpreted as the combination of two effects: country-specific shocks and potentially measurement error. The goal of this paper is to identify the sources of the economic fluctuations for each country so that the composition of the shocks in Asian countries will be identified and appropriate policy actions can be undertaken accordingly.

The remainder of the paper is organized as follows. Section 3.2 describes the dynamic factor model with static and time-varying parameters respectively, the identifications, the estimation procedure and the variance decomposition test. Section 3.3 presents the data and Section 3.4 presents the empirical findings. Section 3.5 discusses the findings and concludes the study.

3.2 Model

3.2.1 Multilevel Factor Model with Static Parameters

Let N denote the number of countries and T the length of the time series. Observable variables are denoted $Y_{i,t}$, for $i = 1, \dots, N$, $t = 1, \dots, T$. There are three types of unobservable factors: single world factor (f_t^{world}), R regional factors ($f_{r,t}^{region}$, $r = 1, \cdots, R$) and N idiosyncratic error terms ($e_{i,t}$, $i = 1, \cdots, N$). The observable variable $Y_{i,t}$ for each country is modeled as being affected by a world factor f_t^{world}, a regional factor $f_{r,t}^{region}$ and an idiosyncratic error term $e_{i,t}$. All factors being latent,

$$Y_{i,t} = \beta_i^{world} f_t^{world} + \beta_i^{region} f_{r,t}^{region} + e_{i,t} \qquad (1)$$

where the free parameters β_i^{world} and β_i^{region} are the matrices of factor loadings on factors f_t^{world} and $f_{r,t}^{region}$ reflecting the degree to which variation in $Y_{i,t}$ can be explained by each factor, with *r* denotes the region that country *n* belongs to. The idiosyncratic error term $e_{i,t}$ are assumed to be normally distributed.

The data generating process for factors and idiosyncratic error term are given by a vector autoregression (VAR) with diagonal autoregressive coefficient matrix and independent error terms. A VAR(1) specification of each factor and idiosyncratic error term are:

$$f_t^{world} = \alpha^{world} f_{t-1}^{world} + u_t^{world}$$

$$f_{r,t}^{region} = \alpha_r^{region} f_{r,t-1}^{region} + u_t^{region} \quad (2)$$

$$e_{i,t} = \gamma_i e_{i,t-1} + v_{i,t} \quad (3)$$

where $\{\alpha^{world}, \alpha_r^{region}\}$ are the diagonal matrices conformable to the dimension of corresponding factors; $\{u_t^{world}, u_t^{region}\} \sim i.i.d. N(0,1)$ and $v_{i,t} \sim i.i.d. N(0, \sigma_i^2)$ are independent of one another at all leads and lags. This special VAR specification allows one to separately identify the factors at different levels up to a scale normalization when some sign restriction is given.

3.2.2 Multilevel Factor Model with Time-Varying Parameters

To allow the changes in the sensitivity of individual series to common factors, the factor loadings of standard multilevel factor model in Equation (1) are allowed to vary over time. The measurement equation then becomes:

$$Y_{i,t} = \beta_{i,t}^{world} f_t^{world} + \beta_{i,t}^{region} f_{r,t}^{region} + e_{i,t} \quad (4)$$

And the dynamics of the factor loadings are assumed to follow a random walk without drift process:

$$\beta_{i,t}^{k} = \beta_{i,t-1}^{k} + \sigma_{\eta_i}\eta_{i,t}$$

where $k = \{world, region\}$ and the last term is an i.i.d. innovation $\eta_{i,t} \sim N(0,1)$, with σ_{η_i} is the standard deviation of $\eta_{i,t}$. The innovations in the factor loadings for the k factors are independent from each other.

The evolution of the factors and idiosyncratic error term are likewise governed by the autoregressive Equation (2) and Equation (3).

$$f_t^{world} = \alpha^{world} f_{t-1}^{world} + u_t^{world}$$

$$f_{r,t}^{region} = \alpha_r^{region} f_{r,t-1}^{region} + u_t^{region} \quad (5)$$

$$e_{i,t} = \gamma_i e_{i,t-1} + v_{i,t} \quad (6)$$

3.2.3 Identifications

There are two related identification problems in the model (1) – (3), as well as model (4) – (6). The signs and the scales of the factors and the factor loadings are identified together.

Identification 1: Signs are identified by requiring one of the factor loadings to be positive for each of the factors. In particular, β_1^{world} and $\{\beta_i^{region}\}_{r_{i=1}}$ are all lower-triangular matrices with strictly positive diagonal terms, where the factor loading for the world factor is required to be positive for China output; the regional factors are identified by positive loadings for the output of the first country listed for each region in the Table 3.1.

Identification 2: Scales are identified by assuming each σ_i^2 is equal to a constant. It is sufficient to assume σ_i^2 is an identity matrix.

3.2.4 Bayesian Estimation Using Gibbs Sampling

This study employs the Bayesian Gibbs-sampling approach in estimating the unobserved factors and the parameters. Instead of sampling based on the joint posterior distribution of the unobserved factors and the parameters, the literature provides an easier solution to implement the Bayesian inference in the state-space model by sampling based on the conditional distributions for a subset of the parameters conditional on all the other parameters.

Therefore, this study implements the Gibbs sampling by successive iteration of the following steps, given appropriate prior distributions and arbitrary starting values for the model's parameters:

Step 1: Conditional on data $\{Y_{i,t}\}$ and all the parameters of the model, generate the unobserved factors $\{f_t^{world}, f_{r,t}^{region}\}$, and idiosyncratic error terms $\{e_{i,t}\}$.

Step 2: Conditional on the idiosyncratic error terms $\{e_{i,t}\}$, generate the parameters $\{\gamma_i\}$.

Step 3: Conditional on the unobserved factors $\{f_t^{world}, f_{r,t}^{region}\}$, generate the parameters $\{\alpha^{world}, \alpha_r^{region}\}$.

Step 4: Conditional on the data, idiosyncratic error terms and the unobserved factors, generate the parameters $\{\beta_{i,t}^{world}, \beta_{i,t}^{region}\}$.

Step 5: Conditional on data and the model's generated parameters, calculate δ_i^k (the mean of unobserved factors) and calculate the standardized unobserved factors.

3.2.5 Variance Decomposition

As the factors are by construction orthogonal to each other, hence it is possible to perform variance decomposition for these three components in the dynamics of $Y_{i,t}$ based on Equation (4):

$$VAR(Y_{i,t}) = (\beta_{i,t}^{world})^2 VAR(f_t^{world}) + (\beta_{i,t}^{region})^2 VAR(f_{r,t}^{region}) + VAR(e_{i,t}).$$

The share of the variance $Y_{i,t}$ for country *n* accounted for by variation in the factor $k =$ {*world*, *region*} can be written as:

$$\frac{(\beta_{i,t}^{k})^2 VAR(f_t^k)}{VAR(Y_{i,t})},$$

and all these measures can be calculated at each pass of the Markov Chain. The estimates of the shares accounted for these three factors are important to evaluate whether the countries belong to the same region are eligible to form a regional monetary arrangement. In addition, the value of the share accounted for the region common factor, also able to capture how co-movement of business cycles are symmetric within a region.

3.3 Empirical Application

3.3.1 Data

The source for the data is the CEIC Global database.

In order to uncover worldwide co-movement, this study estimates common dynamic components in macroeconomic aggregate (real output) in a 33-country sample, covering four regions of the world (see Table 3.1). The data are annual and cover the sample period from 1978 to 2015. The sample of 33-countries from 1978 to 2015 included in this analysis represents one of the longest sample period evaluated in the Asian economies literature[6]. Hence all the 33 countries are treated as the "world" economy in this study. Thus this study uses real output series for $N = 33$ countries, with $T = 38$ time series observations for each.

Following Otrok and Whiteman (1998), each series was log first-differenced and demeaned. Working in growth rates can avoid the problem that the size of the country can drive the world component and direct impact on the measurement of the world business cycles.

The priors for all the parameters are normal with mean zero and precision equal to one. As the data are growth rates, this prior embodies the notion that growth is not serially correlated. This study uses 15000 draws, and discards the first 2000 in the actual implementation of the Gibbs sampler. Estima RATS program is used in the estimation.

[6] For example, Kose *et al*. (2003) used the annual data for 60 countries from 1960 to 1990; Lee and Azali (2012) used the annual data for 28 countries from 1970 to 2007.

3.4 Results

3.4.1 The Dynamic Factors

Figure 3.1 presents the posterior distribution of the world factor. The fluctuations in the factor reflect the major economic events of the last 37 years: the recession of the early 1980's (associated with the debt crisis and the tight monetary policies of major industrialized nations), the European Monetary System crisis in 1992 – 93, the financial crisis in East Asia after the 1997 baht crisis, early 2000s recession, and the European debt crisis since the end of 2009.

As the factor is unobservable, and it is merely extracted based on the hypothesized relationships to observed time series, it is hard to judge what the world factor represents. It is common that world factor is often treated as a stand-in for oil price. Indeed, when there was a sudden increase in the price of oil, the factor displays troughs. To be more specific, when the oil price data extracted from CEIC Global database increase more than 2%, on year the 1982, 1987, 1993 and 2001, the world factor displays troughs around the stated year too. However, the correlation between the oil price and the world factor is only -0.22. Thus, as suggested by Kose *et al.* (2003), oil prices may be an important source of international shocks, understanding world business cycles will likely require going beyond oil price alone.

Figure 3.2 presents the posterior distribution of the regional factors: Asian region factor, North American region factor, Oceania region factor and European region factor.

In order to gain some insights for how the various factors interact, Figures 3.3 to Figure 3.6 present the relationships between the world factor, regional factors, country-specific factors and real output for all the studied countries.

3.4.2 The Variance Decomposition

To measure the relative contribution of the world, region and country-specific factors to variations in real outputs in each country, the share of the variance of each real output due to each factor is estimated. The results are presented in two tables. Table 3.2 and Table 3.3 present variance shares attributable to the common factors and idiosyncratic term for Asia and the other countries, respectively. Each table contains seven snapshots of the magnitudes: 1980, 1990, 1995, 2000, 2005, 2010 and 2015. The overall variance is 100, computed as the sum of the variances attributed to each component. Besides, the results from three selected literature have been presented in Table 3.2, while four selected literature have been displayed in Table 3.3 in order to compare the obtained results.

3.4.2.1 Asian Countries

Table 3.2 demonstrates the variance decompositions for the Asian countries over the time from 1979 to 2015. As Table 3.2 shows, the relative contributions of the components change over time for most of the countries. The results show that the country-specific factor captures the greatest share of output fluctuations for most of the Asian countries, consistent with the findings of Kose *et al*. (2003), Nguyen (2010) and Lee and Azali (2012) studies. However, this study finds that the regional factor is important in inducing variations in real output from Hong Kong, Malaysia and Singapore cases. It explains more than 50% of real output volatility. Besides, the results show that the shares of variances attributable to the regional factor are increased in the recent years. This finding is consistent with previous works by Moneta and Ruffer (2009) and Lee and Azali (2012) who found the increased importance of the regional factor that could be due possibly to the contagion effect of the financial crisis. As the immediate creation of the ASEAN Surveillance Process (ASP) by the ASEAN in maintaining regional macroeconomic and financial stability after the Asian Financial Crisis, this may lead to the integration among the Asian countries.

By contrast, the result for Indonesia case shows opposite way, where the movement of real output in Indonesia is highly explained by the regional factor from 1980 to 2000, but later highly explained by the country-specific factor. For China, Korea, and the Philippines cases, the country-specific factors explain a significant fraction of the fluctuations.

3.4.2.2 Other Countries

Table 3.3 demonstrates the variance decompositions attributable to the world, regional and country-specific factors for the countries in North America, Oceania, and Europe regions.

For countries in North America region, the results show the regional factor is explaining the majority of the real output fluctuation for Canada and the United States, while the country-specific factor is explaining the majority of the real output fluctuation for Mexico. As this study only includes Canada, Mexico and the United States in the case of the North America region, so the unobserved regional factor is mainly constructed based on these three countries. Consider that Canada and the United States have the largest trade relationship in the world, their economics should be largely affected by each other and hence it is not surprisingly to see that both countries' real output fluctuations are mainly explained by the regional factor.

Empirical results comparing the Australia and New Zealand indicate that the share of output volatility for these two countries are quite different. For Australia case, the regional factor explains a significant fraction of the fluctuations before the year 2005 but country-specific factor explains a significant fraction of the fluctuations after the year 2005. While for New Zealand case, the result suggests that the country-specific factor explains a significant fraction of the real output fluctuations since the year 2000.

The variance decompositions for the European countries show that the regional factor explains more in most of the countries, including Belgium, Finland, France, Ireland, Luxembourg, Netherlands, Spain, and Sweden. All these countries except for Sweden are adopting the euro since the year 1999. This is different with Kose *et al*. (2003) and Lee and Azali (2012) study, where they show that world factor explains more in European countries. One of the explanations for this difference is due to the different sample periods have been employed. Both studies were employed the sample period before the European debt crisis. Kose *et al*. (2003) study is cover the sample period started from 1960 till 1990 while Lee and Azali (2012) cover the sample period started from 1970 till 2007. The crisis experience might reduce the share of world factor and raise the share of region factor, especially in Europe case.

3.5 Conclusion

This study employ a Bayesian dynamic factor model to examine the symmetry in business cycles for Asian countries as satisfying one of the preconditions for forming a regional monetary arrangement. This study makes a contribution on extend the existing literature by improving the methodology through a dynamic factor model with time-varying factor loadings to the common factors. Hence, this study considers a dynamic factor model that decomposes the movement of output growth over time into components attributable to world, regional and country-specific factors.

As Asian countries have experienced dynamic changes of regional economic linkages, it is not surprise to see that the relative contributions of the components change over time for most of the countries. Although results show a reducing importance of the country-specific factor in explaining the output, this factor still explains a noticeable fraction of output volatility in the Asian economies, compared with North America and Europe. The regional factor, on the other hand, explains a noticeable fraction of aggregate output volatility for Europe countries, might explain why the Europe countries' economies appear to have been relatively more affected by the global financial crisis in 2009 compared to the Asia.

In summary, the significant share of country-specific factor indicate that Asian countries are more favorable for its own independent counter-cyclical monetary policy. However, to make a final conclusion, many more studies that are outside the scope of this study need to be done to examine the suitability of Asian countries to form a regional monetary arrangement.

References:

Backus, D. K., Kehoe, P. J. and Kydland, F. E. (1993). International business cycles: Theory and evidence. *NBER Working Paper Series*, No. 4493.

Baxter, M. (1995). International trade and business cycles. *NBER Working Paper Series*, No. 5025.

Del Negro, M. and Otrok, C. (2008). Dynamic factor models with time-varying parameters: measuring changes in international business cycles. *Federal Reserve Bank of New York Staff Reports*, no. 326.

Foerster, A. T., Sarte, P. G. and Watson, M. W. (2011). Sectoral versus aggregate shocks: A structural factor analysis of industrial production. *Journal of Political Economy*, 119(1): 1 – 38.

Gregory, A. W., Head, A. C. and Raynauld, J. (1997). Measuring world business cycles. *International Economic Review*, 38(3): 677 – 701.

He, D. and Liao, W. (2012). Asian business cycle synchronization. *Pacific Economic Review*, 17(1): 106 – 135.

Kabundi, A. and Simone, F. N. D. (2011). France in the global economy: a structural approximate dynamic factor model analysis. *Empirical Economics*, 41: 311 – 342.

Karadimitropoulou, A. and León-Ledesma, M. (2013). World, country, and sector factors in international business cycles. *Journal of Economic Dynamics & Control*, 37: 2913 – 2927.

Kose, M. A., Otrok, C. and Whiteman, C. H. (2003). International business cycles: world, region, and country-specific factors. *The American Economic Review*, 93(4): 1216 – 1239.

Lee, G. H. Y. and Azali, M. (2012). Is East Asia an optimum currency area? *Economic Modelling*, 29: 87 – 95.

Long, J. B. and Plosser, J. C. I. (1987). Sectoral vs aggregate shocks in the business cycle. *The American Economic Review*, 77(2): 333 – 336.

McConnell, M. M. and Perez-Quiros, G. (2000). Output fluctuations in the United States: What has changed since the early 1980's? *American Economic Review*, 90(5): 1464 – 76.

Moneta, F. and Rüffer, R. (2009). Business cycle synchronisation in East Asia. *Journal of Asian Economics*, 20: 1 – 12.

Mundell, R. (1961). A theory of optimum currency area. *American Economic Review*, 60: 657 – 665.

Nguyen, T. (2010). An analysis of East Asian currency area: Bayesian dynamic factor model approach. *International Review of Applied Economics*, 24(1): 103 – 117.

Otrok, C. and Whiteman, C. H. (1998). Bayesian Leading Indicators: Measuring and Predicting Economic Conditions in Iowa. *International Economic Review*, 39(4): 997 – 1014.

Table 3.1: Countries and Regions

Regions		Countries	Regions		Countries
Asia	*c1*	China	Europe	*c16*	Austria
	c2	Hong Kong		*c17*	Belgium
	c3	Indonesia		*c18*	Denmark
	c4	Japan		*c19*	Finland
	c5	Korea		*c20*	France
	c6	Malaysia		*c21*	Germany
	c7	Philippines		*c22*	Greece
	c8	Singapore		*c23*	Iceland
	c9	Taiwan		*c24*	Ireland
	c10	Thailand		*c25*	Italy
North America	*c11*	Canada		*c26*	Luxembourg
	c12	Mexico		*c27*	Netherlands
	c13	United States		*c28*	Norway
Oceania	*c14*	Australia		*c29*	Portugal
	c15	New Zealand		*c30*	Spain
				c31	Sweden
				c32	Switzerland
				c33	United Kingdom

Table 3.2: Variance Attributable to World, Region, Country-Specific and Idiosyncratic Shocks – Asia Region

		Kose *et al.* (2003)	Nguyen (2010)	Lee and Azali (2012)		This Study						
		3 North America 2 Oceania 18 Latin America 18 Europe 7 Africa 12 Asia	10 East Asia 12 Europe 3 North America 9 South America	8 East Asia 17 Europe 3 North America		10 Asia 3 North America 2 Oceania 18 Europe						
Country	**Factor**	**1960 - 1990**	**1960 – 2002**	**1970 - 2000**	**1970 - 2007**	**1980**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**
China	World		0.02	12.47	9.98	0.80	68.52	0.50	21.85	12.91	0.15	6.34
	Region		0.00	2.2	0.61	27.30	13.17	47.72	26.01	25.28	28.85	29.13
	Country		99.98	63.58	68.79	71.90	18.32	51.78	52.14	61.81	71.00	64.53
	Idiosyncratic											
Hong Kong	World	14.9	14.24			0.86	53.78	15.53	18.00	1.12	16.74	19.67
	Region	1.5	31.85			92.97	36.03	65.79	62.05	75.23	62.21	59.74
	Country	62.9	53.91			6.17	10.19	18.68	19.95	23.65	21.05	20.58
	Idiosyncratic	18.4										
Indonesia	World	6	0.06	0.23	1.89	0.04	4.92	21.93	30.94	7.99	5.67	0.67
	Region	1.3	45.92	2.73	21.04	99.01	16.05	57.31	60.79	26.11	7.01	7.89
	Country	73	54.02	78.82	51.52	0.95	79.03	20.76	8.27	65.90	87.32	91.44
	Idiosyncratic	17.7										
Japan	World	38.2	7.13	35.99	17.79	0.31	10.14	23.59	1.34	0.14	17.22	30.59
	Region	4.1	5.15	7.05	8.28	96.60	0.37	32.93	32.96	20.14	68.48	54.78
	Country	47.7	87.72	43.62	65.01	3.09	89.49	43.49	65.70	79.72	14.30	14.63

	Idiosyncratic	7.8										
Korea	World	6.1	0.07	2.65	2.58	0.08	30.11	3.76	27.00	25.63	20.84	18.63
	Region	4.2	48.11	6.98	38.27	99.70	7.13	0.03	30.39	23.47	31.90	36.48
	Country	69	51.81	81.61	55.08	0.22	62.75	96.21	42.61	50.90	47.26	44.89
	Idiosyncratic	16.9										
Malaysia	World	6.4	1.44	10.19	8.02	0.27	10.36	13.60	17.87	22.06	20.62	25.72
	Region	2.2	67.15	1.05	27.53	98.05	80.05	78.22	73.32	67.58	67.58	60.32
	Country	86	31.41	58.04	41.78	1.68	9.60	8.18	8.80	10.36	11.80	13.96
	Idiosyncratic	4.2										
Philippines	World	4.1	0.41	13.6	7.93	0.41	10.29	3.13	5.17	5.71	5.59	6.96
	Region	1	14.82	1.3	6.65	51.29	14.42	5.96	13.02	13.95	18.66	17.49
	Country	82.1	84.78	66.09	47.65	48.30	75.29	90.91	81.81	80.34	75.75	75.54
	Idiosyncratic	11.4										
Singapore	World	2	1.36	5.95	5.16	0.19	21.33	21.03	19.48	18.99	22.00	19.88
	Region	0.8	37.84	6.69	37.56	82.06	70.50	69.35	65.46	67.87	66.84	69.06
	Country	81.6	60.80	58.02	36.24	17.74	8.17	9.62	15.06	13.14	11.16	11.07
	Idiosyncratic	14.2										
Taiwan	World		17.92			0.06	12.80	4.94	34.95	53.80	6.96	20.43
	Region		16.02			60.02	16.90	18.60	32.56	21.01	49.12	42.93
	Country		66.05			39.92	70.30	76.46	32.49	25.20	43.92	36.64
	Idiosyncratic											
Thailand	World	12.2	0.00	3	0.43	0.54	42.03	18.47	15.80	14.84	12.29	10.93
	Region	3.3	54.99	3.49	28.79	81.74	18.38	7.13	6.42	29.11	58.64	63.09
	Country	67.5	45.01	81.66	40.14	17.72	39.59	74.40	77.78	56.05	29.07	25.98
	Idiosyncratic	13.8										

Table 3.3: Variance Attributable to World, Region, Country-Specific and Idiosyncratic Shocks – Other Region

		Kose *et al.* (2003)	Nguyen (2010)	Lee and Azali (2012)	Del Negro and Otrok (2008)						This Study						
		3 North America 2 Oceania 18 Latin America 18 Europe 7 Africa 12 Asia	10 East Asia 12 Europe 3 North America 9 South America	8 East Asia 17 Europe 3 North America	1 Asia 2 North America 2 Oceania 14 Europe						10 Asia 3 North America 2 Oceania 18 Europe						
Country	**F**	**1960 – 1990**	**1960 - 2002**	**1970 - 2007**	**70Q2**	**80Q1**	**85Q1**	**90Q1**	**95Q1**	**05Q4**	**1980**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**
Canada	W	35.8		23.79	11.3	8.5	7.2	5.3	3.7	2.6	0.06	1.33	0.83	1.56	2.34	5.74	12.54
	R	36.1		58.15							66.72	87.30	88.70	88.29	82.84	76.89	69.16
	C	19.8		3.27	9.8	7.3	5.8	4.0	3.0	2.3	33.22	11.37	10.47	10.14	14.83	17.37	18.30
	I	7.1															
Mexico	W	16.2		3.38							6.54	39.64	37.25	30.33	25.20	16.17	6.49
	R	1.5		2.55							3.33	0.31	5.15	10.74	20.85	22.97	29.60
	C	77.8		88.72							90.13	60.05	57.60	58.93	53.96	60.86	63.91
	I	3.2															
United States	W	35.1		18.98	12.0	12.1	5.8	2.6	1.8	1.9	0.92	1.12	2.36	1.83	2.52	1.49	0.34
	R	27.3		29.56							94.12	91.06	88.84	88.68	88.63	89.85	91.18
	C	28.2		44.25	8.7	7.7	5.1	3.7	3.2	2.8	4.96	7.82	8.81	9.50	8.85	8.66	8.48
	I	7.9															
Australia	W	19.3			2.6	3.2	3.8	2.7	1.6	0.6	0.01	21.51	10.57	6.96	7.50	11.14	11.30

	R	3.8									69.38	42.26	67.66	69.50	51.78	25.46	1.57
	C	65			19.6	18.5	12.7	8.5	6.8	5.6	30.61	36.23	21.76	23.55	40.72	63.40	87.13
	I	9.9															
New Zealand	W	10.9			4.0	3.0	2.5	2.1	1.6	1.2	0.26	43.70	6.83	36.02	35.45	0.05	0.01
	R	2.3									58.11	0.27	73.52	8.38	1.11	32.54	1.77
	C	72.4			204	151	108	58.8	35.3	21.7	41.62	56.03	19.65	55.60	63.45	67.41	98.22
	I	12.3															
Austria	W	51.3	4.49	42.55	1.5	0.4	0.2	0.1	0.1	0.4	1.44	41.64	48.87	46.58	43.88	26.85	35.93
	R	3.7	48.23	0.55	8.3	5.3	4.7	2.8	1.3	1.1	90.81	4.81	2.23	0.66	2.26	32.95	27.14
	C	23.6	47.28	42.73	17.5	11.4	6.6	3.4	2.2	1.6	7.75	53.54	48.90	52.75	53.86	40.20	36.94
	I	19.9															
Belgium	W	59.1	8.75	78.25	0.3	0.1	0.0	0.0	0.1	0.5	0.07	1.63	0.93	0.03	0.09	1.33	1.79
	R	6.3	64.84	1.26	2.4	1.1	0.1	0.1	0.1	0.4	88.04	78.81	82.11	77.55	75.88	72.29	72.85
	C	14.7	26.41	7.64	3.2	2.7	2.2	2.1	2.3	2.2	11.90	19.56	16.95	22.42	24.03	26.38	25.36
	I	17.4															
Denmark	W	22.2		24.61	3.7	2.8	1.8	1.5	1.7	1.5	0.00	2.13	33.34	0.18	2.01	5.26	85.46
	R	1.2		7.08	0.8	1.8	1.0	0.6	0.5	0.5	14.90	0.71	1.92	0.06	4.09	3.66	6.64
	C	65.6		59.48	8.0	13.4	15.9	17.5	12.8	9.7	85.09	97.16	64.73	99.76	93.90	91.09	7.91
	I	9.6															
Finland	W	14.6	2.71	20.99	0.7	0.4	1.1	3.2	3.2	3.0	0.03	0.03	4.51	0.71	0.69	0.12	0.72
	R	2.3	8.19	3.43	0.5	0.3	0.2	0.2	0.3	0.4	79.94	26.71	68.43	52.20	47.63	59.83	56.03
	C	67.4	89.10	68.51	13.0	15.5	13.5	13.1	11.5	10.6	20.03	73.27	27.06	47.08	51.68	40.05	43.25
	I	13.3															
France	W	68.2	5.89	81.6	2.4	0.6	0.1	0.6	0.3	0.5	0.40	6.78	4.62	0.01	0.00	0.50	0.13
	R	4	71.52	1.28	3.8	1.3	1.8	1.7	2.3	0.9	24.11	23.89	58.50	77.10	72.09	66.22	64.08
	C	13.8	22.60	6.57	2.4	2.3	2.2	2.1	2	2.2	75.49	69.33	36.88	22.88	27.91	33.28	35.79
	I	12.6															

Germany	W	55	15.73	44.29	4.3	2.7	1.3	0.3	0.2	0.3	0.41	9.16	39.36	26.26	26.00	18.48	12.39
	R	1.3	83.10	0.61	4.3	3.3	4.3	6.4	3.5	2.6	72.69	16.98	0.57	0.52	2.32	10.69	13.48
	C	35.8	1.17	40.39	8.1	8.0	7.9	7.6	5.8	3.5	26.89	73.86	60.07	73.22	71.68	70.83	74.12
	I	6.2															
Greece	W	37	6.63	12.80							0.53	33.41	26.46	6.46	5.41	5.48	0.21
	R	1.1	19.71	8.58							48.38	0.14	0.01	6.12	0.70	2.71	2.90
	C	49.9	73.66	63.92							51.09	66.45	73.53	87.42	93.89	91.81	96.89
	I	10															
Iceland	W	3.6									1.09	26.53	13.63	1.72	0.01	1.59	0.32
	R	1.0									24.90	28.54	23.27	32.71	32.94	40.61	40.15
	C	77.5									74.01	44.93	63.11	65.57	67.05	57.80	59.53
	I	16.8															
Ireland	W	16.7	0.26	21.6	0.2	0.1	0.3	0.4	0.5	0.5	0.85	4.09	2.08	1.19	1.71	4.01	4.15
	R	0.7	0.23	3.16	0.8	0.7	0.3	0.2	0.5	1.0	0.00	9.29	56.64	56.56	58.08	65.30	66.84
	C	54.2	99.51	63.88	4.3	6.2	9.2	15.1	30.5	94.4	99.15	86.62	41.28	42.26	40.22	30.70	29.01
	I	27															
Italy	W	36.6	6.16	64.38	0.7	0.8	1.0	0.8	0.4	0.2	4.09	4.27	5.90	6.25	6.07	1.51	0.88
	R	2.8	46.35	2.14	5.2	3.9	2.2	1.6	2.5	2.9	70.27	24.41	29.64	24.71	27.05	49.05	53.96
	C	50.4	47.50	20.97	8.4	8.0	6.3	5.9	5.2	3.3	25.63	71.32	64.46	69.04	66.88	49.43	45.16
	I	9															
Luxembourg	W	12.7	3.03	45.11							0.94	8.18	17.88	17.85	32.59	35.82	0.42
	R	2.2	26.17	0.26							14.59	68.23	65.70	74.17	56.86	41.77	24.53
	C	64.2	70.79	21.75							84.47	23.60	16.41	7.98	10.55	22.41	75.04
	I	19															
Netherlands	W	63.1	6.28	52.53	0.9	2.5	1.7	0.7	1.0	0.8	0.41	2.35	2.96	0.03	0.16	0.42	0.16
	R	0.4	55.52	0.97	2.7	3.6	4.1	3.3	1.6	4.8	94.92	91.63	56.30	62.46	82.42	75.72	84.04
	C	18.9	38.21	31.75	14.3	17.5	12.9	8.2	5.5	3.3	4.66	6.02	40.74	37.51	17.42	23.86	15.81

	I	16.9															
Norway	W	5.8		3.00	2.1	1.7	0.9	0.3	0.3	0.3	1.51	2.79	1.41	6.45	1.93	3.65	3.40
	R	2		9.07	1.2	0.6	0.3	0.2	0.6	1.8	0.71	27.25	79.32	0.02	52.86	29.88	7.35
	C	51.7		66.24	79.4	44.7	29.6	24.6	22.3	16.0	97.78	69.96	19.28	93.53	45.21	66.48	89.25
	I	38.6															
Portugal	W	22.3	6.19	58.12							1.14	20.82	36.34	24.17	21.28	1.48	2.03
	R	1.9	42.60	2.61							90.36	2.31	2.38	0.17	5.50	11.33	30.43
	C	61	51.20	32.68							8.49	76.87	61.28	75.66	73.21	87.20	67.53
	I	13															
Spain	W	33.5	1.81	57.41	0.7	0.1	0.2	0.2	0.2	0.2	2.19	12.67	7.88	10.09	11.16	9.98	8.00
	R	4.5	37.96	0.33	0.8	0.8	1.3	1.7	1.3	0.3	54.71	47.79	70.97	72.26	68.01	69.39	68.16
	C	55.1	60.23	33.62	4.3	5.6	8.5	12.3	9.0	5.5	43.10	39.54	21.15	17.64	20.83	20.63	23.84
	I	5.4															
Sweden	W	19.5		20.65	0.8	1.1	1.9	2.8	2.9	2.6	0.67	4.42	11.65	3.71	4.34	6.85	5.59
	R	1.2		5.48	0.7	0.9	1.2	1.6	1.7	0.3	69.59	23.62	52.89	50.53	45.08	56.24	56.01
	C	46.6		59.02	23.4	26.0	16.2	9.7	5.5	2.8	29.74	71.97	35.46	45.76	50.58	36.91	38.40
	I	31.3															
Switzerland	W	23.8		41.56	0.4	0.6	0.7	0.7	0.5	0.8	0.19	3.37	6.63	15.49	13.93	11.99	14.26
	R	1.3		44.84	1.6	2.8	2.2	2.4	2.2	2.8	74.55	67.76	44.36	36.19	39.51	37.92	27.89
	C	62.3		0.44	5.4	7.5	7.6	7.3	6.0	4.2	25.26	28.88	49.02	48.32	46.56	50.09	57.85
	I	10.9															
United Kingdom	W	18.9		33.2	6.3	3.5	2.5	2.7	1.7	0.8	0.04	16.44	22.28	5.16	5.85	4.60	1.88
	R	2		5.23	0.7	0.8	0.5	0.1	0.1	0.1	92.58	13.82	14.78	14.55	4.14	48.68	35.99
	C	65.7		49.59	16.5	14.9	7.9	4.3	2.5	1.7	7.38	69.74	62.94	80.29	90.01	46.72	62.13
	I	11.4															

Note: W indicates World Factor; R indicates Regional Factor; C indicates Country-Specific Factor; while I indicates Idiosyncratic Error term.

Figure 3.1: World Factor

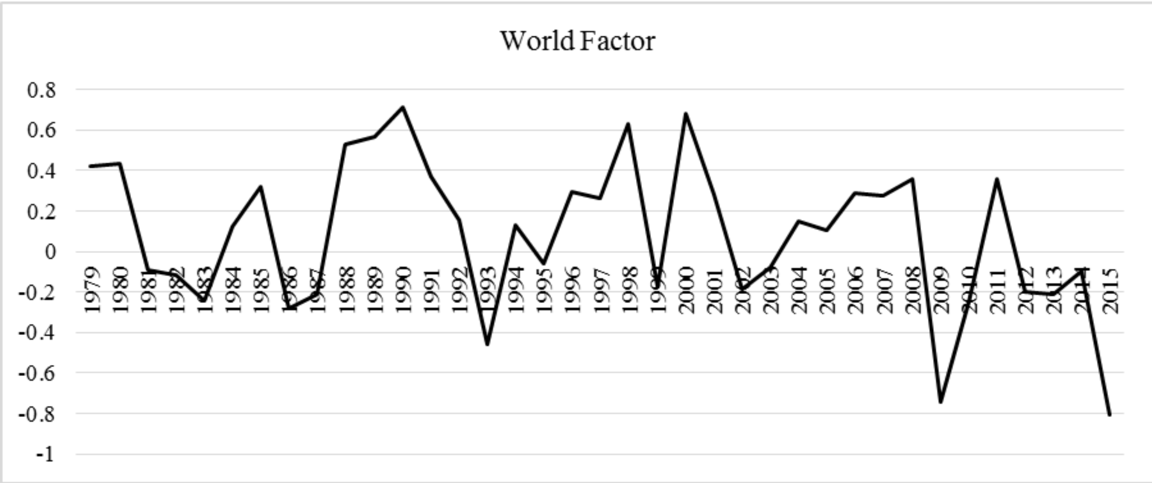


Figure 3.2: Regional Factors

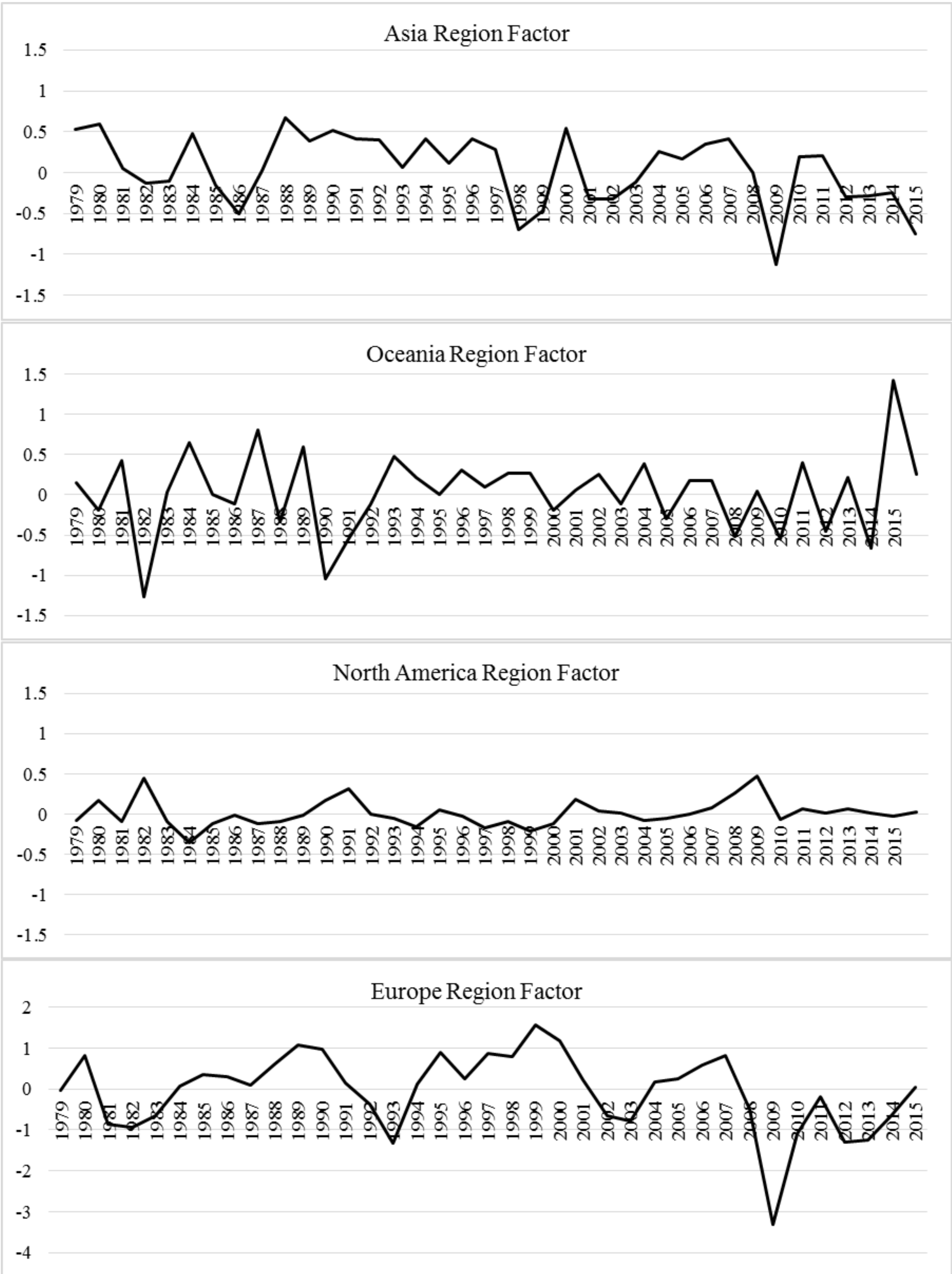


Figure 3.3: Rescaled Output and Dynamic Factors – Asia region

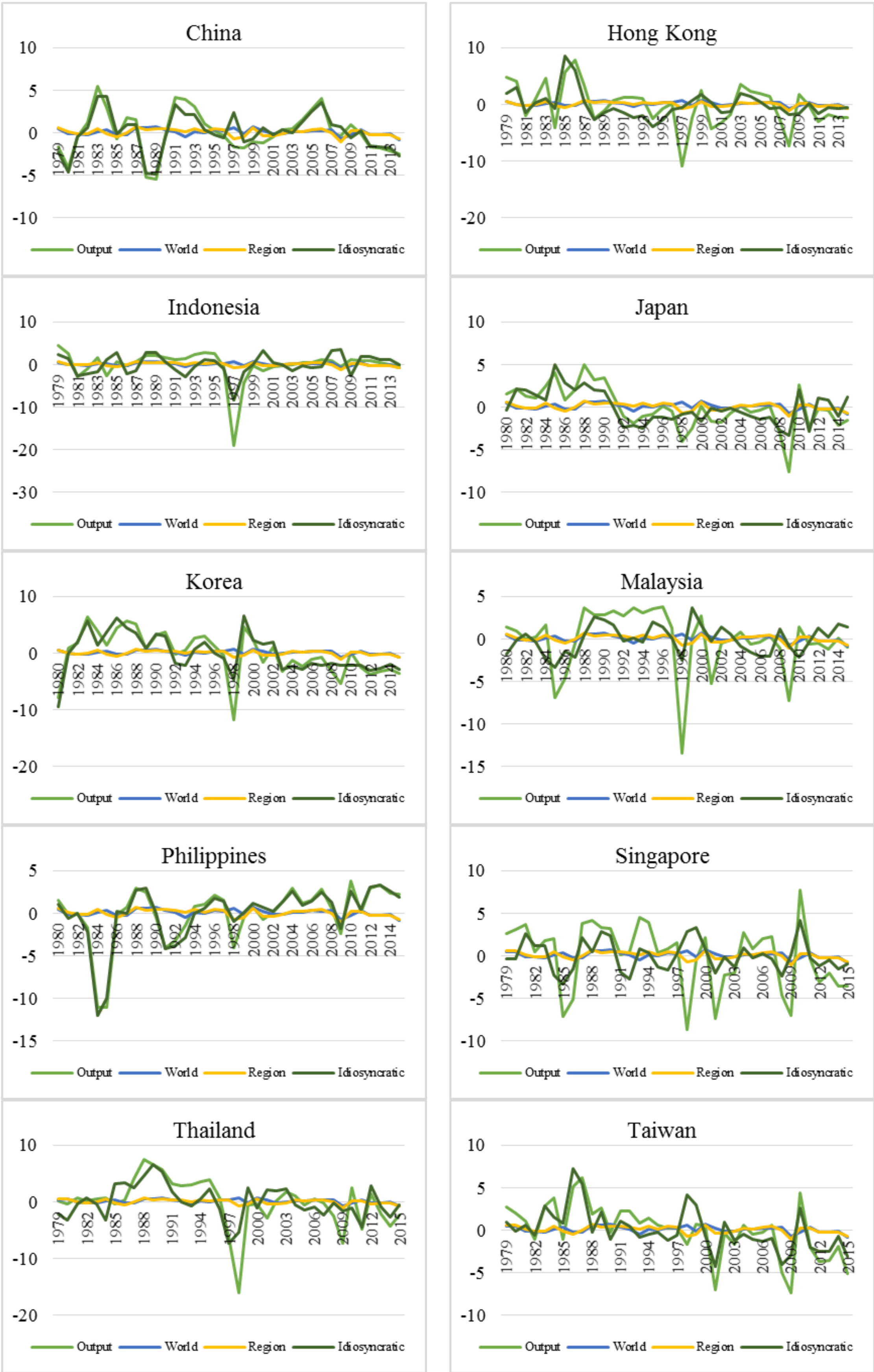


Figure 3.4: Rescaled Output and Dynamic Factors – North America region

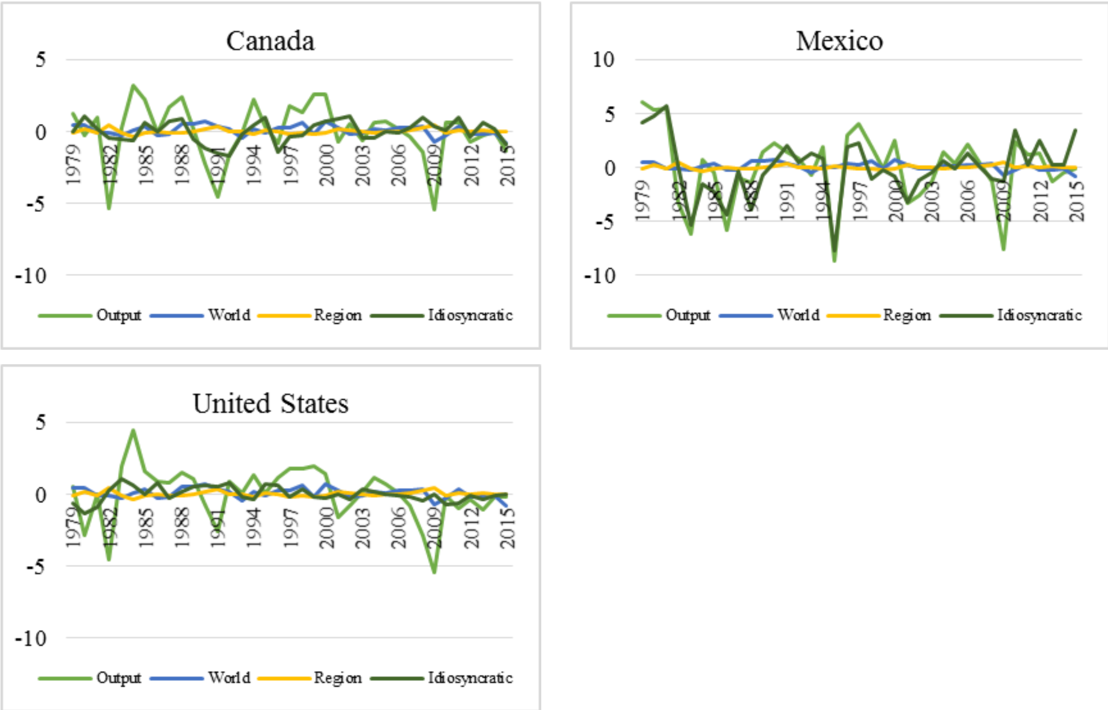


Figure 3.5: Rescaled Output and Dynamic Factors – Oceania region

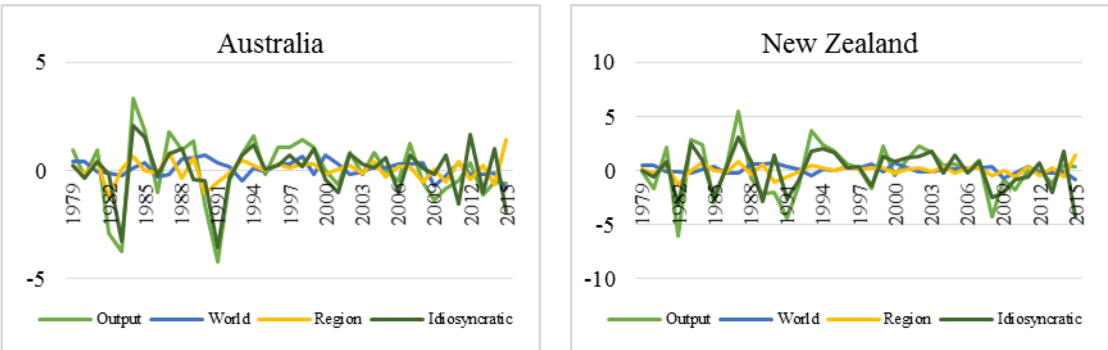


Figure 3.6: Rescaled Output and Dynamic Factors – Europe region

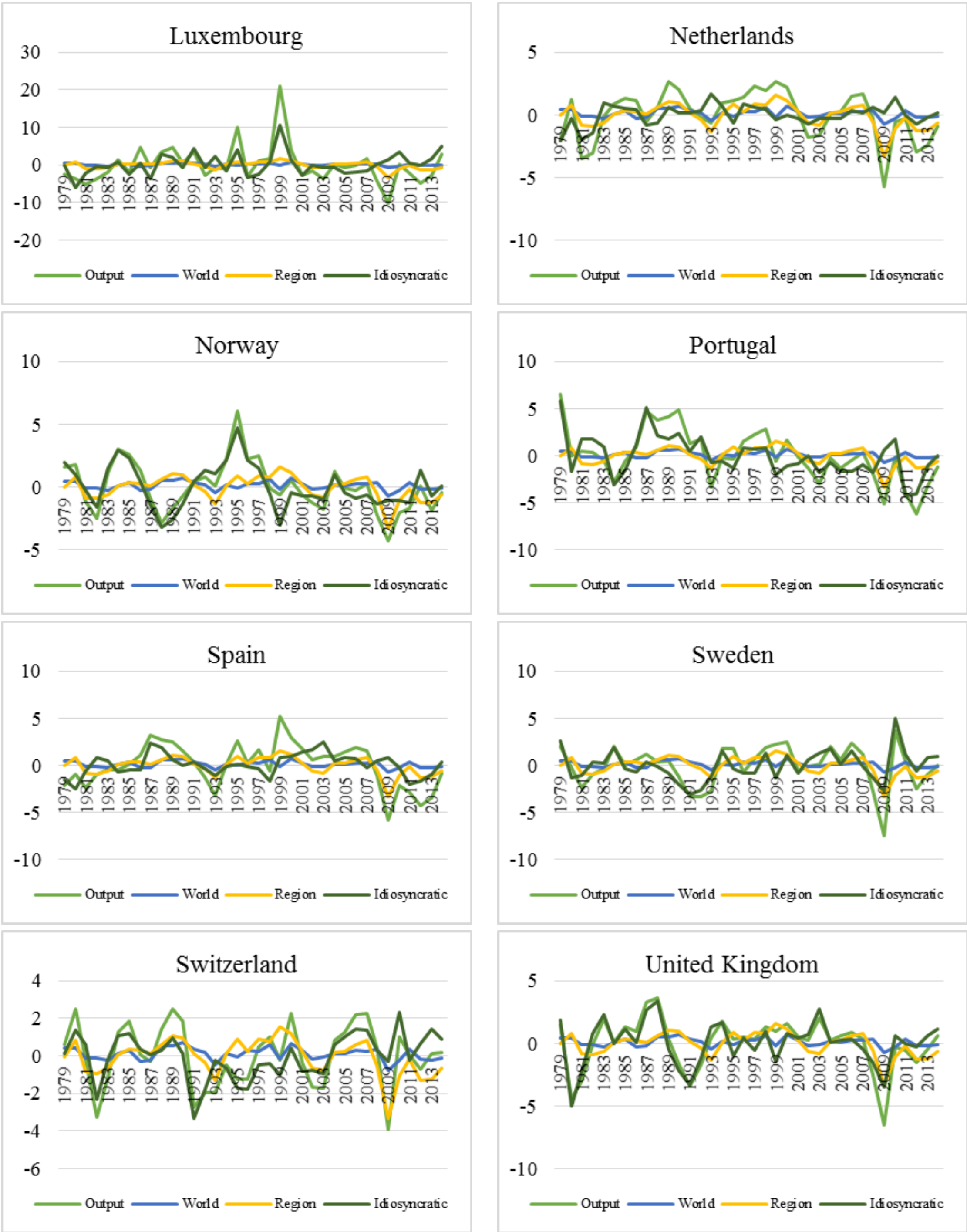

Luxembourg
30
20
10
0
-10
-20
Output World Region Idiosyncratic
Netherlands
5
0
-5
-10
Output World Region Idiosyncratic
Norway
10
5
0
-5
Output World Region Idiosyncratic
Portugal
10
5
0
-5
-10
Output World Region Idiosyncratic
Spain
10
5
0
-5
-10
Output World Region Idiosyncratic
Sweden
10
5
0
-5
-10
Output World Region Idiosyncratic
Switzerland
4
2
0
-2
-4
-6
Output World Region Idiosyncratic
United Kingdom
5
0
-5
-10
Output World Region Idiosyncratic

Figure 3.7: The Time-Varying Variance Attributable to World (FW), Region (FR) and Idiosyncratic Shocks (ɛ) – Asia Region

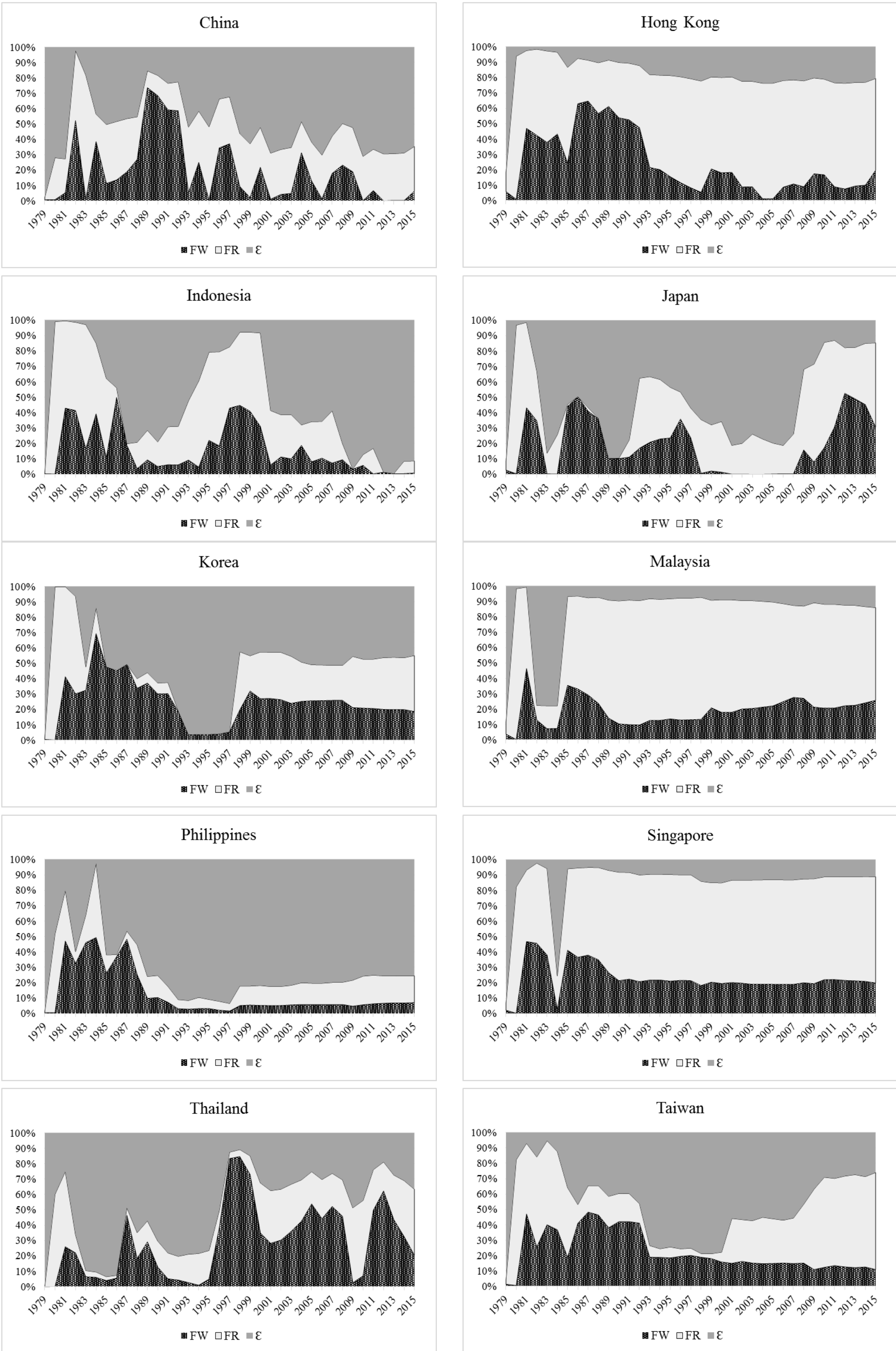
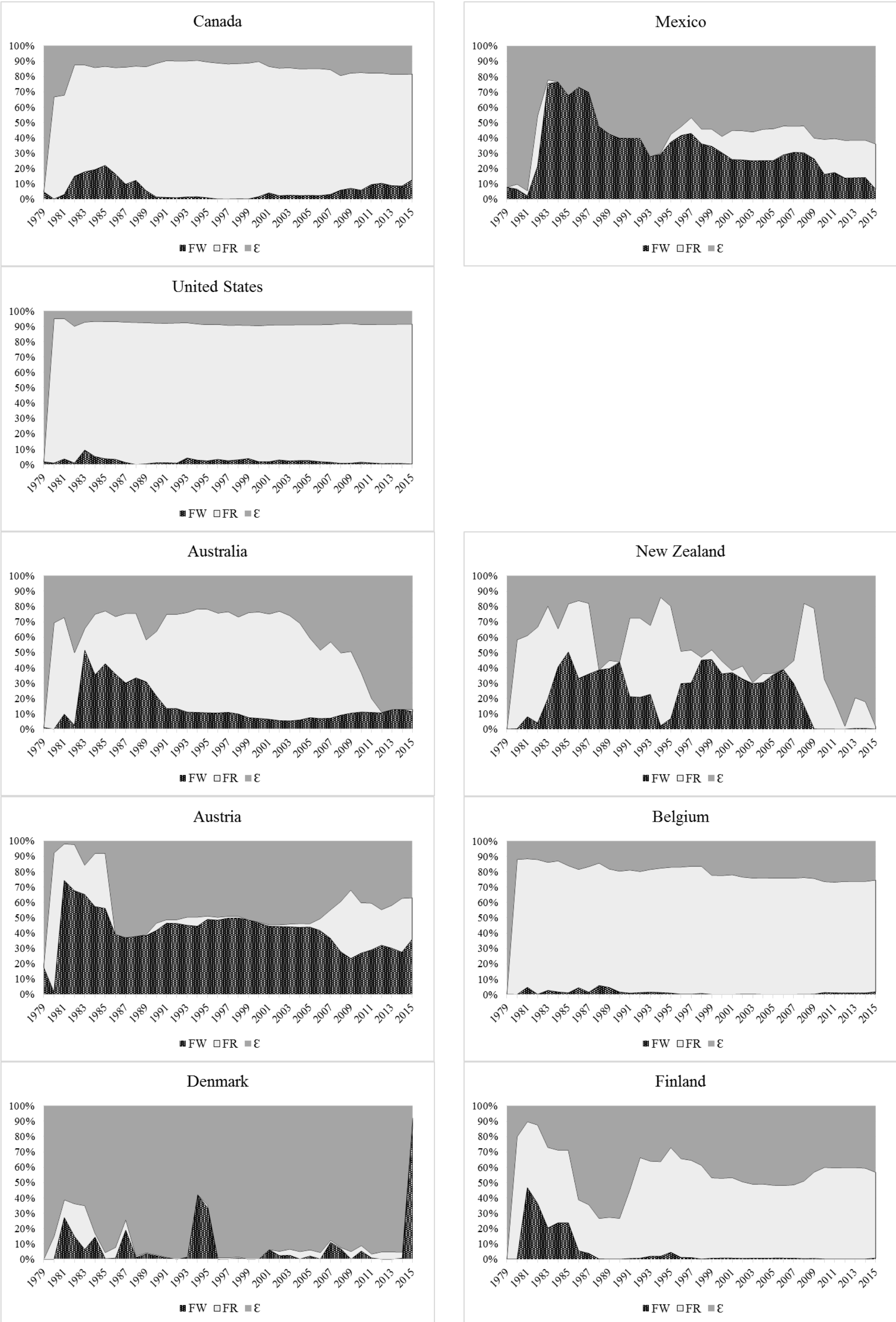
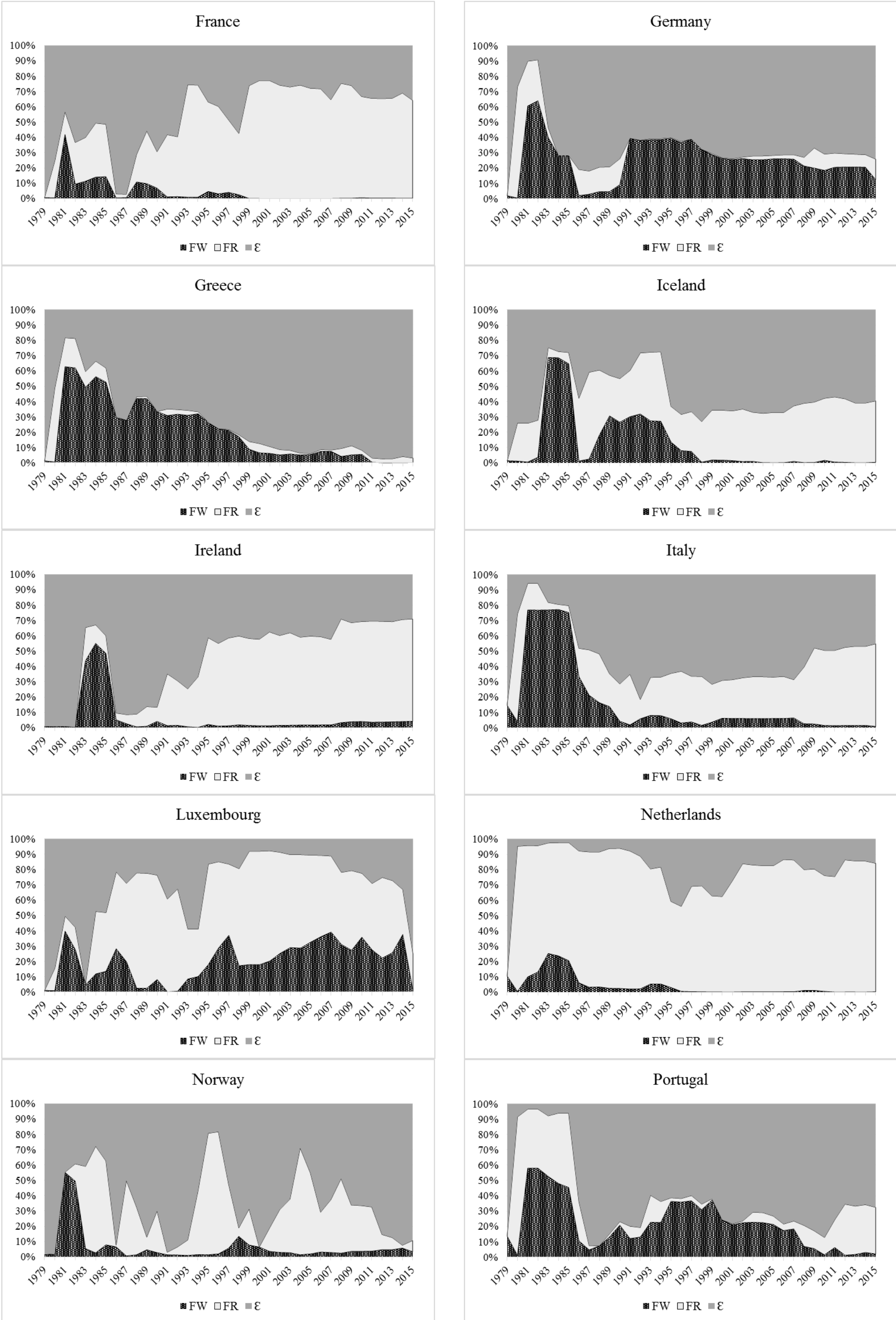
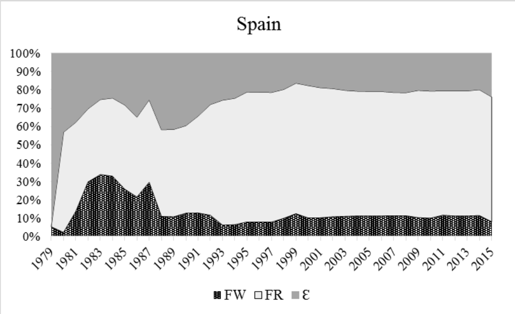
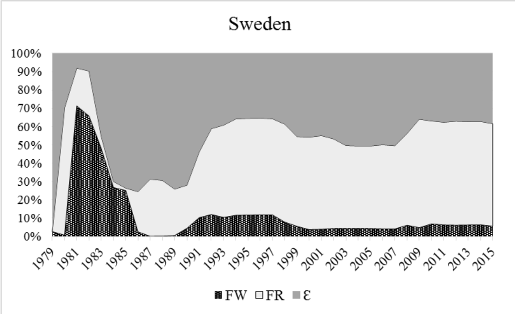


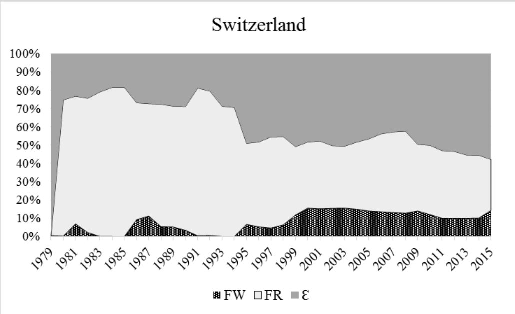
Figure 3.8: The Time-Varying Variance Attributable to World (FW), Region (FR) and Idiosyncratic Shocks (ℇ) – Other Region

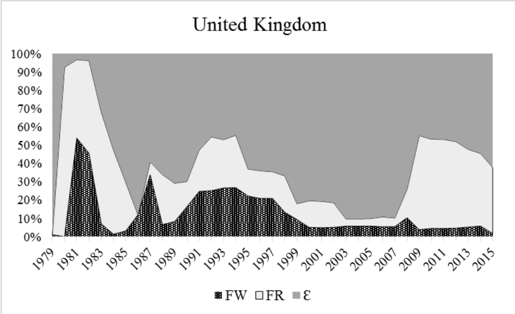



France
Germany
Greece
Iceland
Ireland
Italy
Luxembourg
Netherlands
Norway
Portugal
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
FW
FR
ε


Spain
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR ε


Sweden
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR ε


Switzerland
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR ε


United Kingdom
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR ε

BUSINESS CYCLE SYNCHRONIZATION IN ASIA: SPILLOVERS OR COMMON SHOCKS?

4.1 Introduction

In recent years, Asia has becomes more and more integrated with the global economy. Meanwhile, economic integration within Asia region has also progressed at a rapid speed together with growing intra-regional trade flows among the Asia region. This process of increasing inter and intra-regional integration is expected to have an effect on the degree of business cycle synchronization within the region and between the regions.

From a theoretical perspective, the issue of synchronization is relevant in the context of the possibility of greater monetary cooperation within the region. Taking the "optimal currency area" argument of Mundell (1961) as a starting point, a large number of studies have analyzed the issue of business cycle synchronization between Asian countries to check the possibility of regional monetary arrangement within the region, especially after the wake of the Asian crisis. Table 4.1 summarizes the selected literature on the issue of business cycle synchronization for Asian countries.

For this purpose, a dynamic factor model has recently been used to analyze the synchronized characteristics of countries growth dynamics. The dynamic factor model is able to extract the common growth features from co-movements in macroeconomic variables between countries. However, conventional dynamic factor model has two limitations:

1. The dynamic factor model with the static parameters assuming that both the stochastic process driving volatility and the nature of co-movements among variables has not changed over time.
2. The dynamic factor model with independent factors unable to explain the driving forces behind the co-movements.

For the first limitation, several studies have revealed the assumption of structural stability is invalid for many macroeconomic datasets, indicating that models with fixed parameters may not do well in describing macroeconomic data (McConnell and Perez-Quiros, 2000; Del Negro and Otrok, 2008). The belief that changes in the factor loadings over time may stem from policies adopted by specific countries, or from structural changes such as increased trade or economic integration of a country with the rest of the world. This is particularly important in Asia issue where Asian countries have experienced dynamic changes of regional economic linkages from the year 2000 to the present.

For the second limitation, an important question raised from it is whether the macroeconomics co-movement resulted from common shocks or spillover effects. In general, countries can be exposed to common shocks and respond in a similar fashion; meanwhile, the initial idiosyncratic shocks in one country can spillover to another country through trade and financial linkages. These factors could potentially important in determining the co-movement in macro variables of the countries. In the case of Asia, a common shock could stem from large dependence on external economies such as the United States or Euro area. On one hand, spillover effects could be the result of the strong intra-regional trade linkages in the region. Therefore, to distinguish the effects of common shocks and spillover effects, the conventional dynamic factor model was modified to explicitly take into account the cross-country spillover effects. This can be achieved by removing the independence assumption among the factors by allowing the correlation between the factors.

This study aims to investigate the driving forces behind the co-movements of macroeconomic variables at different levels across the time periods. Following the literature, a dynamic factor with a multilevel factor structure is considered to characterize the co-movements of international business cycles on the global level, regional level and country level, respectively (Kose *et al*., 2003; Nguyen, 2010; Lee and Azali, 2012). This study extends the conventional model to capture the spillover effects from China and the United States on the Asian countries over the time. As China has emerged as a major assembly and processing center, the increasing intra-regional trade is likely to have effects on strengthening the links between countries within the region. The United States as a large economy is also likely to have a spillover effect on other economies over time.

The paper is structured as followed: Section 4.2 reviews the empirical modelling strategy; section 4.3 provides some details about the data; section 4.4 presents the results and section 4.5 concludes the paper.

4.2 Methodology

This paper employs the Bayesian dynamic factor model with time-varying parameters and spillover effects in a multilevel form to decompose fluctuations in real aggregate output of every country into three components: (i) a world factor that is common to all countries; (ii) the regional factors that are common across countries belonging to the same region; (iii) the idiosyncratic terms that can be interpreted as the combination of two effects: country-specific shocks and potentially measurement error. To do so, we first allow the factor loadings of standard dynamic factor model to vary over time (refer to Section 4.2.2), then unrestricted the autoregressive coefficient matrix of the unobserved factors to allow the possible spillover effects (refer to Section 4.2.3).

4.2.1 Dynamic Factor Model with Static Parameters

Let *N* denote the number of countries and *T* the length of the time series. Observable variables are denoted $Y_{i,t}$, for $i = 1, \ldots, N$, $t = 1, \ldots, T$. There are three types of unobservable factors: single world factor (f_t^{world}), R regional factors ($f_{r,t}^{region}$, $r = 1, \cdots, R$) and *N* idiosyncratic error terms ($e_{i,t}$, $i = 1, \cdots, N$). The observable variable $Y_{i,t}$ for each country is modeled as being affected by a world factor f_t^{world}, a regional factor $f_{r,t}^{region}$ and an idiosyncratic error term $e_{i,t}$. All factors being latent,

$$Y_{i,t} = \beta_i^{world} f_t^{world} + \beta_i^{region} f_{r,t}^{region} + e_{i,t} \tag{1}$$

where the free parameters β_i^{world} and β_i^{region} are the matrices of factor loadings on factors f_t^{world} and $f_{r,t}^{region}$ reflecting the degree to which variation in $Y_{i,t}$ can be explained by each factor, with *r* denotes the region that country *n* belongs to. The idiosyncratic error term $e_{i,t}$ are assumed to be normally distributed.

The data generating process for factors and idiosyncratic error term are given by a vector autoregression (VAR) with diagonal autoregressive coefficient matrix and independent error terms. A VAR(1) specification of each factor and idiosyncratic error term are:

$$\begin{bmatrix} f_t^{world} \\ f_{r,t}^{region} \end{bmatrix} = \begin{bmatrix} \alpha^{world} & 0 \\ 0 & \alpha_r^{region} \end{bmatrix} \begin{bmatrix} f_{t-1}^{world} \\ f_{r,t-1}^{region} \end{bmatrix} + \begin{bmatrix} u_t^{world} \\ u_t^{region} \end{bmatrix} \tag{2}$$

$$\begin{bmatrix} e_{1,t} \\ e_{2,t} \\ \vdots \\ e_{N,t} \end{bmatrix} = \begin{bmatrix} \gamma_{1,1} & 0 & \cdots & 0 \\ 0 & \gamma_{2,2} & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & \gamma_{N,N} \end{bmatrix} \begin{bmatrix} e_{1,t-1} \\ e_{2,t-1} \\ \vdots \\ e_{N,t-1} \end{bmatrix} + \begin{bmatrix} v_{1,t} \\ v_{2,t} \\ \vdots \\ v_{N,t} \end{bmatrix} \tag{3}$$

where $\{u_t^{world}, u_t^{region}\} \sim i.i.d. N(0,1)$ and $v_{i,t} \sim i.i.d. N(0, \sigma_i^2)$ are independent of one another at all leads and lags. This special VAR specification allows one to separately identify the factors at different levels up to a scale normalization when some sign restrictions are given.

4.2.2 Dynamic Factor Model with Time-Varying Parameters

To allow the changes in the sensitivity of individual series to common factors, the factor loadings of standard dynamic factor model in Equation (1) are allowed to vary over time. The measurement equation then becomes:

$$Y_{i,t} = \beta_{i,t}^{world} f_t^{world} + \beta_{i,t}^{region} f_{r,t}^{region} + e_{i,t} \tag{4}$$

And the dynamics of the factor loadings are assumed to follow a random walk without drift process:

$$\beta_{i,t}^{k} = \beta_{i,t-1}^{k} + \sigma_{\eta_i} \eta_{i,t}$$

where $k = \{world, region\}$ and the last term is an i.i.d. innovation $\eta_{i,t} \sim N(0,1)$, with σ_{η_i} is the standard deviation of $\eta_{i,t}$. The innovations in the factor loadings for the k factors are independent from each other.

4.2.3 Dynamic Factor Model with Spillover Effects

Equation (3) rules out a possibility that different country-specific factors are correlated with each other. However, in practice, these factors might be correlated through "spillover effects". For example, a shock that is originated from a large economy such as the United States might have an impact on other economies over time. According to Bai and Wang (2015), the idiosyncratic error terms are possibly serially correlated. Hence, to allow the possible spillover effects, the autoregressive coefficient matrix in Equation (3) is allowed to be unrestricted:

$$\begin{bmatrix} e_{1,t} \\ e_{2,t} \\ \vdots \\ e_{N,t} \end{bmatrix} = \begin{bmatrix} \gamma_{1,1} & \gamma_{1,2} & \cdots & \gamma_{1,N} \\ \gamma_{2,1} & \gamma_{2,2} & \cdots & \gamma_{2,N} \\ \vdots & \vdots & \ddots & \vdots \\ \gamma_{N,1} & \gamma_{N,2} & \cdots & \gamma_{N,N} \end{bmatrix} \begin{bmatrix} e_{1,t-1} \\ e_{2,t-1} \\ \vdots \\ e_{N,t-1} \end{bmatrix} + \begin{bmatrix} v_{1,t} \\ v_{2,t} \\ \vdots \\ v_{N,t} \end{bmatrix} \tag{5}$$

where $v_{i,t} \sim i.i.d.N(0, \sigma_i^2)$ are independent of one another at all leads and lags. Equation (5) implies that factors can be correlated with each other, and it allows the spillover effects of country-level shocks to other economies too.

4.2.4 Identifications

There are two related identification problems in the model (1) – (3). The signs and the scales of the factors and the factor loadings are identified together.

Identification 1: Signs are identified by requiring one of the factor loadings to be positive for each of the factors. In particular, β_1^{world} and $\{\beta_i^{region}\}_{r_{i=1}}$ are all lower-triangular matrices with strictly positive diagonal terms. More specifically, the factor loading for the world factor is required to be positive for Chinese output; and the regional factors are identified by positive loadings for the output of the first country listed for each region in the Table 4.1.

Identification 2: Scales are identified by assuming each σ_i^2 is equal to a constant. It is sufficient to assume σ_i^2 is an identity matrix.

4.2.5 Bayesian Estimation Using Gibbs Sampling

This study employs the Bayesian Gibbs-sampling approach in estimating the unobserved factors and the parameters. Instead of sampling based on the joint posterior distribution of the unobserved factors and the parameters, the literature provides an easier solution to implement the Bayesian inference in the state-space model by sampling based on the conditional distributions for a subset of the parameters conditional on all the other parameters.

Therefore, this study implements the Gibbs sampling by successive iteration of the following steps, given appropriate prior distributions and arbitrary starting values for the model's parameters:

Step 1: Conditional on data $\{Y_{i,t}\}$ and all the parameters of the model, generate the unobserved factors $\{f_t^{world}, f_{r,t}^{region}\}$, and idiosyncratic error terms $\{e_{i,t}\}$.

Step 2: Conditional on the idiosyncratic error terms $\{e_{i,t}\}$, generate the parameters $\{\gamma_i\}$.

Step 3: Conditional on the unobserved factors $\{f_t^{world}, f_{r,t}^{region}\}$, generate the parameters $\left\{\alpha^{world}, \alpha_r^{region}\right\}$.

Step 4: Conditional on the data, idiosyncratic error terms and the unobserved factors, generate the parameters $\{\beta_{i,t}^{world}, \beta_{i,t}^{region}\}$.

Step 5: Conditional on data and the model's generated parameters, calculate δ_i^k (the mean of unobserved factors) and calculate the standardized unobserved factors.

The same steps are applied to estimate the unrestricted factors that capture the spillover effects, except for the step 2 that generates the parameters $\{\gamma_{i,j}, i = 1, \dots, N, j = 1, \dots, N\}$.

4.2.6 Variance Decomposition

As the factors are by construction orthogonal to each other, hence it is possible to perform variance decomposition for these three components in the dynamics of $Y_{i,t}$ based on Equation (4):

$$VAR(Y_{i,t}) = (\beta_{i,t}^{world})^2 VAR(f_t^{world}) + (\beta_{i,t}^{region})^2 VAR(f_{r,t}^{region}) + VAR(e_{i,t}).$$

The share of the variance $Y_{i,t}$ for country *n* accounted for by variation in the factor $k =$ {*world*, *region*} can be written as:

$$\frac{(\beta_{i,t}^{k})^2 VAR(f_t^k)}{VAR(Y_{i,t})},$$

and all these measures can be calculated at each pass of the Markov Chain. The estimates of the shares accounted for these three factors are important to evaluate whether the countries belong to the same region are eligible to form a regional monetary arrangement. In addition, the value of the share accounted for the region common factor, also able to capture how co-movement of business cycles are symmetric within a region.

4.3 Empirical Application

4.3.1 Countries and Regions

This study estimates a dynamic factor model over the period 1978 to 2015 comprising 33 countries: China, Hong Kong, Indonesia, Japan, Korea, Malaysia, the Philippines, Singapore, Taiwan, Thailand, Canada, Mexico, United States, Australia, New Zealand, Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom. These countries are aggregated into four regions: Asia, North America, Oceania and Europe. The details of these 33 countries and four regions classifications are given in Table 4.2.

In order to uncover worldwide co-movement, this study estimates common dynamic components in annual real Gross Domestic Product (GDP). Following Otrok and Whiteman (1998), each series is log first-differenced and demeaned. Working in growth rates can avoid the problem that the size of the country can drive the world component and direct impact on the measurement of the world business cycle.

The priors for all the parameters are normal with mean zero and precision equal to one. As the data are growth rates, this prior embodies the notion that growth is not serially correlated. This study uses 15000 draws, and discards the first 2000 in the actual implementation of the Gibbs sampler. Estima RATS program is used in the estimation.

The source for the data is the CEIC Global database.

4.3.2 Modeling Approach

To illustrate the equations in state-space matrix form, the dynamic factor model framework for this study can be represented as following:

Measurement Equation

$$\begin{bmatrix} Y_{1,t} \\ \vdots \\ Y_{11,t} \\ \vdots \\ Y_{14,t} \\ \vdots \\ Y_{16,t} \\ \vdots \end{bmatrix} = \begin{bmatrix} \beta_{1,t}^{world} & \beta_{1,t}^{region} & 0 & 0 & 0 \\ \vdots & \vdots & 0 & 0 & 0 \\ \beta_{11,t}^{world} & 0 & \beta_{11,t}^{region} & 0 & 0 \\ \vdots & 0 & \vdots & 0 & 0 \\ \beta_{14,t}^{world} & 0 & 0 & \beta_{14,t}^{region} & 0 \\ \vdots & 0 & 0 & \vdots & 0 \\ \beta_{16,t}^{world} & 0 & 0 & 0 & \beta_{16,t}^{region} \\ \vdots & 0 & 0 & 0 & \vdots \end{bmatrix} \begin{bmatrix} f_t^{world} \\ f_{1,t}^{region} \\ f_{2,t}^{region} \\ f_{3,t}^{region} \\ f_{4,t}^{region} \end{bmatrix} + \begin{bmatrix} e_{1,t} \\ \vdots \\ e_{11,t} \\ \vdots \\ e_{14,t} \\ \vdots \\ e_{16,t} \\ \vdots \end{bmatrix}$$

Transition Equations

$$\begin{bmatrix} f_t^{world} \\ f_{1,t}^{region} \\ f_{2,t}^{region} \\ f_{3,t}^{region} \\ f_{4,t}^{region} \end{bmatrix} = \begin{bmatrix} \alpha^{world} & 0 & 0 & 0 & 0 \\ 0 & \alpha_1^{region} & 0 & 0 & 0 \\ 0 & 0 & \alpha_2^{region} & 0 & 0 \\ 0 & 0 & 0 & \alpha_3^{region} & 0 \\ 0 & 0 & 0 & 0 & \alpha_4^{region} \end{bmatrix} \begin{bmatrix} f_{t-1}^{world} \\ f_{1,t-1}^{region} \\ f_{2,t-1}^{region} \\ f_{3,t-1}^{region} \\ f_{4,t-1}^{region} \end{bmatrix} + \begin{bmatrix} u_t^{world} \\ u_{1,t}^{region} \\ u_{2,t}^{region} \\ u_{3,t}^{region} \\ u_{4,t}^{region} \end{bmatrix}$$

and

$$\begin{bmatrix} e_{1,t} \\ \vdots \\ e_{11,t} \\ \vdots \\ e_{13,t} \\ \vdots \\ e_{16,t} \\ \vdots \end{bmatrix} = \begin{bmatrix} \gamma_{1,1} & 0 & 0 & 0 & \gamma_{1,13} & 0 & 0 & 0 \\ \vdots & \ddots & 0 & 0 & \vdots & 0 & 0 & 0 \\ \gamma_{11,1} & 0 & \gamma_{11,11} & 0 & \gamma_{11,13} & 0 & 0 & 0 \\ \vdots & 0 & 0 & \ddots & \vdots & 0 & 0 & 0 \\ \gamma_{13,1} & 0 & 0 & 0 & \gamma_{13,13} & 0 & 0 & 0 \\ \vdots & 0 & 0 & 0 & \vdots & \ddots & 0 & 0 \\ \gamma_{16,1} & 0 & 0 & 0 & \gamma_{16,13} & 0 & \gamma_{16,16} & 0 \\ \vdots & 0 & 0 & 0 & \vdots & 0 & 0 & \ddots \end{bmatrix} \begin{bmatrix} e_{1,t-1} \\ \vdots \\ e_{11,t-1} \\ \vdots \\ e_{13,t-1} \\ \vdots \\ e_{16,t-1} \\ \vdots \end{bmatrix} + \begin{bmatrix} v_{1,t} \\ \vdots \\ v_{11,t} \\ \vdots \\ v_{13,t} \\ \vdots \\ v_{16,t} \\ \vdots \end{bmatrix}.$$

4.4 Results

4.4.1 The Dynamic Factors

Figures 4.1 and 4.2 present the posterior mean of the world factor and regional factors, including Asia region, North America region, Oceania region, and Europe region. To compare the results obtained from spillover with no spillover effects model, the posterior mean of the unobserved world and regional factors are plotted together.

In addition, to examine which unobserved common factors are particularly important in explaining the co-movements of real GDP growth of respective countries, we further plot the world, regional, and country-specific factors together with the real GDP growth in Figures 4.3, 4.4, 4.5, and 4.6.

As compared to the no spillover effect model, Figure 4.1 shows that the spillover effect model well explains the world business cycles from 1979 to 2015: for example, world recession of the early 1980's due to the oil crisis, the European Monetary System crisis in 1992–93, the financial crisis 1998–1999, the collapse of Lehman Brothers in 2008–2009, and the subsequent Euro area fiscal crisis in 2010 and after.

In terms of regional factors, business cycles are better explained by the spillover effect model than the no spillover effect model. For example, Asian regional factor exhibits a sharp downturn in 1997 due to the Asian financial crisis; North American regional factor shows a fall around 2008 due to global financial crisis; Oceania region factor shows a downturn in 2008 due to the recession in the early 2008s; European regional factor exhibits a sharp fall around 2008 due to the collapse of Lehman Brothers in 2008.

4.4.2 The Variance Decomposition

Tables 4.3 and 4.4 present the variance decomposition results for each country in Asia region and other regions, respectively. We calculate the variances due to the world, regional, and idiosyncratic errors/country-specific factor, respectively. To have a brief summary, we plot the variance decomposition results for each country in chart form, reported in Figure 4.7 and Figure 4.8.

In Table 4.3, it is clearly observed that five out of ten Asian countries show different results between the spillover and no spillover effect models. When taking into account the spillover effect, most Asian countries including Hong Kong, Japan, Taiwan and Thailand show that country-specific component plays an important role in causing variations in real output. On the other hand, Indonesia shows that the variations are largely explained by the regional factors.

Table 4.4 shows that some countries in North America, Oceania and Europe regions have the different results between the spillover and no spillover effect models. In the no spillover effect model, regional factor explains the significant fraction of the fluctuations in Canada, the United States, Australia, Belgium, Finland, France, Ireland, Luxembourg, Netherlands, Spain and Sweden. After taking into account the spillover effects, the variation of all these countries explained by the country-specific factor.

4.5 Conclusion

This paper aims to study the dynamic co-movements of macroeconomic aggregates in a broad cross-section of countries through a Bayesian dynamic factor model. The co-movements of real outputs are decomposed into the world, regional and idiosyncratic error term. The main interest of this paper is whether the co-movements resulted from common shocks or spillover effects. Therefore, in order to capture the spillover effects among the factors, we relax the independent assumption of the factors, by allowing the autoregressive coefficient of the idiosyncratic terms to be unrestricted. This enables us to develop a framework that isolates the country-specific shock and allows the shocks to spillover to other countries. Given China has emerged as a major assembly and processing center and the United States still has a large economic influence, these two countries are likely to have the spillover effect on other economies over time. This study advances the conventional model to capture the spillover effects from China and the United States to the Asian countries over the sample period.

As the factors are unobservable, and they are merely extracted based on the hypothesized relationships to observed time series, it is hard to judge which model performs better, dynamic factor model with spillover effect or without spillover effect. However, business cycles are better explained by the unobserved factors from spillover effect model than the unobserved factors from no spillover effect model

We find that substantial fractions of economic fluctuations are explained by the country-specific factor in Asian countries. The exceptions are Indonesia, Malaysia and Singapore, which appear that regional factor explains the majority of their output volatility. This may due to the economic impact of Indonesia-Malaysia-Singapore Growth Triangle arrangement that promotes sub-regional economic cooperation and integration between them.

Besides, results show that most of the Asian countries appear to have relatively little co-movements with the rest of the world.

In order to examine the underlying factors behind Asian countries synchronization in the form of a more disaggregated analysis using different GDP demand components, previous studies included the consumption and investment components in their analysis (Kose *et al*., 2003). However, due to data limitation, it is unfortunate that this study is limited by the lack of information on common consumption and investment dynamics. Further work will certainly be needed in the future in order to better understand the co-movement of Asian countries.

References:

Allegret, J. and Essaadi, E. (2011). Business cycles synchronization in East Asian economy: Evidence from time-varying coherence study. *Economic Modelling*, **28**(1): 351 – 365.

Artis, M. J. and Okubo, T. (2012). Business cycle, currency and trade, revisited. *Pacific Economic Review*, **17**(1): 160 – 180.

Bai, J. and Wang, P. (2015). Identification and Bayesian Estimation of Dynamic Factor Models. *American Statistical Association*, **33**(2): 221 – 240.

Berdiev, A. N. and Chang, C. (2015). Business cycle synchronization in Asia-Pacific: New evidence from wavelet analysis. *Journal of Asian Economics*, **37**: 20 – 33.

Chen, S., Huang, C. and Huang Y. (2012). International economic linkages between Taiwan and the world: A global vector autoregressive approach. *Academia Economic Papers*, **40**(3): 343 – 375.

Chow, H. K. and Kim, Y. (2003). A common currency peg in East Asia? Perspectives from Western Europe. *Journal of Macroeconomics*, **25**(3): 331 – 350.

Del Negro, M. and Otrok, C. (2008). Dynamic factor models with time-varying parameters: measuring changes in international business cycles. *Federal Reserve Bank of New York Staff Reports*, no. 326.

Dreger, C. and Zhang, Y. (2014). Does the economic integration of China affect growth and inflation in industrial countries? *Economic Modelling*. **38**: 184 – 189.

Dufrénot, G. and Keddad, B. (2014). Business cycles synchronization in East Asia: A Markov-switching approach. *Economic Modelling*, **42**: 186 – 197.

Dungey, M. and Vehbi, T. (2015). The influences of international output shocks from the US and China on ASEAN economies. *Journal of Asian Economics*, **39**(C): 59 – 71.

Feldkircher, M. and Korhonen, I. (2014). The rise of China and its implications for the global economy: Evidence from a global vector autoregressive model. *Pacific Economic Review*, **19**(1): 61 – 89.

Fujiwara, I. and Takahashi, K. (2012). Asian financial linkage: Macro-finance dissonance. *Pacific Economic Review*, **17**(1): 136 – 159.

Hallett, A. H. and Richter, C. (2009). Is the US no longer the economy of first resort? Changing economic relationships in the Asia-Pacific region. *International Economics and Economic Policy*, **6**(2): 207 – 234.

He, D. and Liao, W. (2012). Asian business cycle synchronization. *Pacific Economic Review*, **17**(1): 106 – 135.

Kim, S. H., Kose, M. A. and Plummer, M. G. (2003). Dynamics of business cycles in Asia: Differences and similarities. *Review of Development Economics*, **7**(3): 462 – 477.

Kim, S., Lee, J. and Park, C. (2011). Emerging Asia: Decoupling or recoupling. *The World Economy*, **34**(1): 23 – 53.

Kose, M. A., Otrok, C. and Whiteman, C. H. (2003). International business cycles: world, region, and country-specific factors. *The American Economic Review*, **93**(4): 1216 – 1239.

Lee, G. H. Y. and Azali, M. (2012). Is East Asia an optimum currency area? *Economic Modelling*, **29**(2): 87 – 95.

McConnell, M. M. and Perez-Quiros, G. (2000). Output fluctuations in the United States: What has changed since the early 1980's? *American Economic Review*, 90(5): 1464 – 76.

Moneta, F. and Rüffer, R. (2009). Business cycle synchronization in East Asia. *Journal of Asian Economics*, **20**: 1 – 12.

Mundell, R. (1961). A theory of optimum currency area. *American Economic Review*, **60**: 657 – 665.

Nguyen, T. (2010). An analysis of East Asian currency area: Bayesian dynamic factor model approach. *International Review of Applied Economics*, **24**(1): 103 – 117.

Sato, K., Zhang, Z. and McAleer, M. (2011). Identifying shocks in regionally integrated East Asian economies with structural VAR and block exogeneity. *Mathematics and Computers in Simulation*, **81**(7): 1353 – 1364.

Su, C., Chang, H., Chang, T. and Yin, K. (2014). Monetary convergence in East Asian countries relative to China. *International Review of Economics and Finance*, **33**(C): 228 – 237.

Table 4.1: Asian Business Cycles Synchronization

Author (Year)	Country/ Data Frequency	Methodology	Variables	Findings
Allegret and Essaadi (2011)	N = 10 CN, HK, ID, JP, MY, PH, SG, KR, TW, TH	New measure based on the time-varying coherence function 1975Q1 – 2007Q1	• Real GDP	• China and Japan share common comovements with the rest of Asian countries only at long-run frequency. • Regional integration remains driven by external factors.
Artis and Okubo (2012)	N = 21 • Asia1: (East Asia + Oceania) JP, CN, AU, NZ • Asia2: (Colony) AU, NZ, JP, CN, UK, NL, FR • Asia3: (Asia-Pacific) AU, NZ, JP, CN, CA, US	GVAR • 1st Globalization era: 1870 – 1914 • The bloc economy: 1915 – 1959 • 2nd Globalization era: 1960 – 2004	• Trade – export intensity between countries • GDP • CU – dummy for currency unions	• No business cycle synchronization in Asia for any time period.
Berdiev and Chang (2015)	N = 13 CN, JP, US and other Asia-Pacific countries (AU, HK, ID, KR, MY, NZ, PH, SG, TH, TW)	Wavelet analysis 1993:2 – 2012:4	• Real GDP	• High degree of comovement between China and other Asia-Pacific economies at long-run frequency around the global financial crisis. • The strength of business cycle synchronization increases between Japan and other Asia-Pacific economies at long-run frequency for the entire sample period. • High degree of comovement between US and other Asia-Pacific economies at 2–4 years frequencies.
Chow and Kim (2003)	N = 22 15 EU 7 East Asian (HK, ID, KR, MY, PH, SP, TW)	Regression model EU: 1965Q1 – 1997Q1 EA: 1971Q1 – 1997Q1	• Output (Industrial Production)	• The domestic output of East Asia are strongly influenced by country-specific shocks.
Dufrénot and Keddad (2014)	N = 8 ASEAN-5, CN, JP, US	Markov Switching model with Time-Varying Transition Probabilities	• Real GDP	• ASEAN-5 are not fully synchronized with each other and strong

		1975Q1 – 2010Q2		dependence on external demand (CN, JP and US).
He and Liao (2012)	N = 16 9 emerging Asian economies (HK, CN, ID, SK, MY, PH, SP, TW, TH) G-7 countries	Structural VAR with multilevel factor model 1981Q1 – 2008Q4	• Real GDP	• Output fluctuations in Asia remain intensified by global factor but less synchronized than industrial countries. • Regional factors have become increasingly important. • Supply shocks contributed more to the synchronization in Asian economies' output fluctuation than demand shocks.
Kim et al. (2003)	N = 14 ID, KR, MY, PH, SG, TW, TH G-7 economies	Hodrick and Prescott (HP) 1960 – 1996	• Aggregate output • Exports • Imports	• Business fluctuations in output in Asian countries are significantly positively correlated with their measures of the Asian business cycles (evidence of a regional business cycle specific to the Asian countries).
Kim et al. (2011)	N = 16 9 Asia: CN, HK, ID, KR, MY, PH, SG, TW, TH G-7 economies	Panel VAR model 1990Q1 – 1996Q4 2000Q1 – 2007Q2	• G7 aggregate output • East Asian aggregate output • East Asian individual output	• Real economic interdependence increased significantly in the post-crisis period, suggesting 'recoupling', rather than decoupling in recent years. • Output shocks from major industrial countries have a significant positive effect on emerging East Asian economies, and vice versa.
Lee and Azali (2012)	N = 28 ID, MY, PH, SG, TH, CN, JP, KR, 17 EU, 3 NA	Bayesian State-space model 1970 – 2007	• Real GDP • Consumption • Investment	• Increasing role of region factor although country-specific factors are significant.
Moneta and Rüffer (2009)	N = 10 CN, HK, ID, JP, MY, PH, SG, KR, TW, TH	Dynamic factor model, following Monfort *et al.* (2003) Set 1: 1975Q1 – 2005Q3 Set 2: 1993Q1 – 2005Q3	• Real output • Others: exports, private consumption and gross fixed capital formation	• Output dynamics is substantially explained by a single common dynamic factor except for China and Japan

Note: AU – Australia; CA – Canada; CN – China; FR – France; ID – Indonesia; IN – India; JP – Japan; KR – Korea; MY – Malaysia; NL – Netherlands; NZ – New Zealand; PH – Philippines; PK – Pakistan; SG – Singapore; TH – Thailand; UK – United Kingdom

Table 4.2: Countries and Regions

Regions		Countries		Regions		Countries	
$r1$	Asia	*c1*	China	$r4$	Europe	*c16*	Austria
		c2	Hong Kong			*c17*	Belgium
		c3	Indonesia			*c18*	Denmark
		c4	Japan			*c19*	Finland
		c5	Korea			*c20*	France
		c6	Malaysia			*c21*	Germany
		c7	Philippines			*c22*	Greece
		c8	Singapore			*c23*	Iceland
		c9	Taiwan			*c24*	Ireland
		c10	Thailand			*c25*	Italy
$r2$	North America	*c11*	Canada			*c26*	Luxembourg
		c12	Mexico			*c27*	Netherlands
		c13	United States			*c28*	Norway
$r3$	Oceania	*c14*	Australia			*c29*	Portugal
		c15	New Zealand			*c30*	Spain
						c31	Sweden
						c32	Switzerland
						c33	United Kingdom

Table 4.3: Variance Decomposition – Spillover and No Spillover Models (Asia Region)

		No Spillover Model							Spillover Model						
Country	Factor	1980	1990	1995	2000	2005	2010	2015	1980	1990	1995	2000	2005	2010	2015
China	World	0.80	68.52	0.50	21.85	12.91	0.15	6.34	0.10	6.75	25.84	16.46	14.40	8.89	6.74
	Region	27.30	13.17	47.72	26.01	25.28	28.85	29.13	0.34	24.70	7.30	8.18	10.82	23.84	40.32
	Idiosyncratic	71.90	18.32	51.78	52.14	61.81	71.00	64.53	99.56	68.55	66.87	75.36	74.78	67.27	52.94
Hong Kong	World	0.86	53.78	15.53	18.00	1.12	16.74	19.67	2.86	50.88	36.10	37.97	35.57	29.97	27.12
	Region	92.97	36.03	65.79	62.05	75.23	62.21	59.74	8.91	17.45	17.20	23.92	25.67	27.80	29.39
	Idiosyncratic	6.17	10.19	18.68	19.95	23.65	21.05	20.58	88.23	31.67	46.69	38.11	38.77	42.22	43.49
Indonesia	World	0.04	4.92	21.93	30.94	7.99	5.67	0.67	16.86	0.01	53.72	45.23	3.97	12.70	21.21
	Region	99.01	16.05	57.31	60.79	26.11	7.01	7.89	49.74	35.59	0.09	47.98	67.76	61.33	39.50
	Idiosyncratic	0.95	79.03	20.76	8.27	65.90	87.32	91.44	33.40	64.40	46.19	6.79	28.27	25.97	39.29
Japan	World	0.31	10.14	23.59	1.34	0.14	17.22	30.59	5.67	6.95	12.65	0.01	0.78	34.00	21.80
	Region	96.60	0.37	32.93	32.96	20.14	68.48	54.78	17.16	0.26	1.36	9.43	9.68	7.08	9.88
	Idiosyncratic	3.09	89.49	43.49	65.70	79.72	14.30	14.63	77.17	92.78	85.99	90.56	89.53	58.92	68.32
Korea	World	0.08	30.11	3.76	27.00	25.63	20.84	18.63	21.50	4.02	0.11	67.35	13.29	17.60	9.05
	Region	99.70	7.13	0.03	30.39	23.47	31.90	36.48	63.80	0.12	8.67	7.47	14.86	18.07	14.50
	Idiosyncratic	0.22	62.75	96.21	42.61	50.90	47.26	44.89	14.70	95.86	91.22	25.17	71.85	64.33	76.46
Malaysia	World	0.27	10.36	13.60	17.87	22.06	20.62	25.72	8.53	19.66	19.20	27.77	29.05	27.17	27.55
	Region	98.05	80.05	78.22	73.32	67.58	67.58	60.32	25.75	64.86	60.47	57.18	55.91	57.41	56.28
	Idiosyncratic	1.68	9.60	8.18	8.80	10.36	11.80	13.96	65.72	15.48	20.33	15.05	15.04	15.42	16.16
Philippines	World	0.41	10.29	3.13	5.17	5.71	5.59	6.96	0.37	16.27	7.63	12.79	11.73	16.01	14.95
	Region	51.29	14.42	5.96	13.02	13.95	18.66	17.49	1.13	2.79	22.75	13.78	12.83	8.78	17.66
	Idiosyncratic	48.30	75.29	90.91	81.81	80.34	75.75	75.54	98.50	80.93	69.62	73.44	75.44	75.21	67.38
Singapore	World	0.19	21.33	21.03	19.48	18.99	22.00	19.88	0.89	27.81	38.68	43.67	41.19	50.61	32.99
	Region	82.06	70.50	69.35	65.46	67.87	66.84	69.06	2.52	60.34	41.86	28.27	35.74	24.88	51.29
	Idiosyncratic	17.74	8.17	9.62	15.06	13.14	11.16	11.07	96.58	11.85	19.46	28.06	23.07	24.51	15.73
Taiwan	World	0.06	12.80	4.94	34.95	53.80	6.96	20.43	0.45	5.81	2.19	29.57	28.35	28.62	29.00
	Region	60.02	16.90	18.60	32.56	21.01	49.12	42.93	1.35	18.76	7.10	33.26	33.47	33.84	34.14
	Idiosyncratic	39.92	70.30	76.46	32.49	25.20	43.92	36.64	98.20	75.43	90.70	37.17	38.18	37.54	36.86
Thailand	World	0.54	42.03	18.47	15.80	14.84	12.29	10.93	1.10	34.00	13.43	14.03	22.74	30.36	25.36
	Region	81.74	18.38	7.13	6.42	29.11	58.64	63.09	3.40	2.35	0.84	1.39	2.18	2.49	4.52
	Idiosyncratic	17.72	39.59	74.40	77.78	56.05	29.07	25.98	95.50	63.66	85.73	84.58	75.08	67.15	70.13

Table 4.4: Variance Decomposition – Spillover and No Spillover Models (Other Region)

		No Spillover Model							Spillover Model						
Country	**Factor**	**1980**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**1980**	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**
								North America Region							
Canada	World	0.06	1.33	0.83	1.56	2.34	5.74	12.54	51.81	1.71	1.64	1.46	0.99	3.05	1.49
	Region	66.72	87.30	88.70	88.29	82.84	76.89	69.16	3.88	48.20	40.31	42.23	42.94	38.13	39.14
	Idiosyncratic	33.22	11.37	10.47	10.14	14.83	17.37	18.30	44.31	50.09	58.06	56.30	56.07	58.83	59.37
Mexico	World	6.54	39.64	37.25	30.33	25.20	16.17	6.49	5.13	39.91	33.78	26.74	6.44	4.04	0.95
	Region	3.33	0.31	5.15	10.74	20.85	22.97	29.60	0.66	5.65	9.52	11.55	14.63	10.83	11.37
	Idiosyncratic	90.13	60.05	57.60	58.93	53.96	60.86	63.91	94.21	54.44	56.70	61.71	78.92	85.13	87.69
United States	World	0.92	1.12	2.36	1.83	2.52	1.49	0.34	79.49	0.36	0.93	0.28	0.77	7.92	6.35
	Region	94.12	91.06	88.84	88.68	88.63	89.85	91.18	5.63	38.92	21.53	25.50	30.00	3.48	7.87
	Idiosyncratic	4.96	7.82	8.81	9.50	8.85	8.66	8.48	14.88	60.72	77.54	74.22	69.24	88.60	85.78
								Oceania Region							
Australia	World	0.01	21.51	10.57	6.96	7.50	11.14	11.30	53.64	14.11	1.76	3.34	0.02	0.66	1.36
	Region	69.38	42.26	67.66	69.50	51.78	25.46	1.57	0.71	29.75	31.16	23.53	1.60	0.97	2.15
	Idiosyncratic	30.61	36.23	21.76	23.55	40.72	63.40	87.13	45.66	56.14	67.07	73.14	98.38	98.37	96.49
New Zealand	World	0.26	43.70	6.83	36.02	35.45	0.05	0.01	63.45	0.27	2.46	9.61	7.77	9.45	7.15
	Region	58.11	0.27	73.52	8.38	1.11	32.54	1.77	2.13	76.81	64.17	51.32	45.99	25.46	29.76
	Idiosyncratic	41.62	56.03	19.65	55.60	63.45	67.41	98.22	34.42	22.92	33.37	39.08	46.24	65.08	63.09
								Europe Region							
Austria	World	1.44	41.64	48.87	46.58	43.88	26.85	35.93	0.51	46.78	42.15	32.78	23.07	6.47	12.41
	Region	90.81	4.81	2.23	0.66	2.26	32.95	27.14	31.14	12.49	9.90	3.83	0.88	0.34	0.06
	Idiosyncratic	7.75	53.54	48.90	52.75	53.86	40.20	36.94	68.35	40.73	47.95	63.38	76.06	93.20	87.52
Belgium	World	0.07	1.63	0.93	0.03	0.09	1.33	1.79	0.88	9.56	0.07	2.83	9.91	24.04	13.39
	Region	88.04	78.81	82.11	77.55	75.88	72.29	72.85	15.85	6.36	17.24	24.32	24.91	26.99	27.57
	Idiosyncratic	11.90	19.56	16.95	22.42	24.03	26.38	25.36	83.27	84.08	82.69	72.86	65.17	48.97	59.04
Denmark	World	0.00	2.13	33.34	0.18	2.01	5.26	85.46	0.06	0.20	16.56	0.68	2.92	18.86	81.92
	Region	14.90	0.71	1.92	0.06	4.09	3.66	6.64	1.47	0.15	0.14	2.44	3.18	20.24	9.79
	Idiosyncratic	85.09	97.16	64.73	99.76	93.90	91.09	7.91	98.47	99.66	83.30	96.88	93.90	60.91	8.29

Finland	World	0.03	0.03	4.51	0.71	0.69	0.12	0.72	0.66	0.01	12.71	4.07	5.18	14.87	7.45
	Region	79.94	26.71	68.43	52.20	47.63	59.83	56.03	13.97	9.17	29.50	25.77	24.71	26.70	20.04
	Idiosyncratic	20.03	73.27	27.06	47.08	51.68	40.05	43.25	85.37	90.82	57.78	70.16	70.10	58.43	72.51
France	World	0.40	6.78	4.62	0.01	0.00	0.50	0.13	0.02	5.99	2.05	6.58	8.54	18.48	9.74
	Region	24.11	23.89	58.50	77.10	72.09	66.22	64.08	1.14	1.66	0.00	11.80	17.43	22.78	17.33
	Idiosyncratic	75.49	69.33	36.88	22.88	27.91	33.28	35.79	98.84	92.35	97.94	81.62	74.03	58.74	72.94
Germany	World	0.41	9.16	39.36	26.26	26.00	18.48	12.39	0.00	34.24	51.83	12.39	11.66	18.54	0.15
	Region	72.69	16.98	0.57	0.52	2.32	10.69	13.48	14.91	1.31	0.06	0.08	2.05	7.44	6.17
	Idiosyncratic	26.89	73.86	60.07	73.22	71.68	70.83	74.12	85.09	64.45	48.11	87.53	86.30	74.02	93.68
Greece	World	0.53	33.41	26.46	6.46	5.41	5.48	0.21	0.04	21.65	25.03	5.25	2.94	3.92	0.32
	Region	48.38	0.14	0.01	6.12	0.70	2.71	2.90	5.89	5.19	4.83	1.31	2.97	2.57	4.62
	Idiosyncratic	51.09	66.45	73.53	87.42	93.89	91.81	96.89	94.07	73.16	70.14	93.44	94.09	93.50	95.07
Iceland	World	1.09	26.53	13.63	1.72	0.01	1.59	0.32	0.96	28.55	32.17	17.84	19.44	1.91	1.00
	Region	24.90	28.54	23.27	32.71	32.94	40.61	40.15	1.66	12.03	8.15	16.66	18.26	35.07	30.13
	Idiosyncratic	74.01	44.93	63.11	65.57	67.05	57.80	59.53	97.38	59.42	59.68	65.50	62.30	63.02	68.88
Ireland	World	0.85	4.09	2.08	1.19	1.71	4.01	4.15	0.19	3.69	7.96	9.82	12.24	22.50	16.19
	Region	0.00	9.29	56.64	56.56	58.08	65.30	66.84	0.01	6.76	13.78	15.10	16.51	15.75	16.86
	Idiosyncratic	99.15	86.62	41.28	42.26	40.22	30.70	29.01	99.80	89.55	78.27	75.09	71.25	61.75	66.95
Italy	World	4.09	4.27	5.90	6.25	6.07	1.51	0.88	1.47	19.65	16.23	6.07	2.93	2.55	3.57
	Region	70.27	24.41	29.64	24.71	27.05	49.05	53.96	11.01	10.94	6.02	1.99	0.00	1.36	3.32
	Idiosyncratic	25.63	71.32	64.46	69.04	66.88	49.43	45.16	87.52	69.41	77.75	91.93	97.07	96.09	93.10
Luxembourg	World	0.94	8.18	17.88	17.85	32.59	35.82	0.42	0.51	8.33	17.43	37.40	36.77	37.18	25.99
	Region	14.59	68.23	65.70	74.17	56.86	41.77	24.53	0.61	5.72	20.32	34.15	35.31	37.35	29.47
	Idiosyncratic	84.47	23.60	16.41	7.98	10.55	22.41	75.04	98.88	85.95	62.25	28.45	27.91	25.47	44.54
Netherlands	World	0.41	2.35	2.96	0.03	0.16	0.42	0.16	0.00	0.09	3.88	4.71	6.30	13.06	8.53
	Region	94.92	91.63	56.30	62.46	82.42	75.72	84.04	33.70	31.87	32.24	36.73	42.75	44.28	41.12
	Idiosyncratic	4.66	6.02	40.74	37.51	17.42	23.86	15.81	66.30	68.04	63.87	58.56	50.95	42.66	50.34
Norway	World	1.51	2.79	1.41	6.45	1.93	3.65	3.40	0.64	0.90	0.07	0.05	0.45	3.84	1.49
	Region	0.71	27.25	79.32	0.02	52.86	29.88	7.35	0.00	3.39	8.29	4.37	8.29	9.81	6.11
	Idiosyncratic	97.78	69.96	19.28	93.53	45.21	66.48	89.25	99.35	95.71	91.65	95.58	91.26	86.34	92.40
Portugal	World	1.14	20.82	36.34	24.17	21.28	1.48	2.03	0.38	16.91	17.98	22.82	6.27	5.76	11.87
	Region	90.36	2.31	2.38	0.17	5.50	11.33	30.43	39.40	6.40	0.01	0.70	7.10	2.64	0.78
	Idiosyncratic	8.49	76.87	61.28	75.66	73.21	87.20	67.53	60.22	76.69	82.01	76.48	86.63	91.59	87.35

Spain	World	2.19	12.67	7.88	10.09	11.16	9.98	8.00	0.36	3.84	6.48	22.00	18.83	19.39	15.50
	Region	54.71	47.79	70.97	72.26	68.01	69.39	68.16	4.52	0.91	11.04	19.99	19.62	23.83	18.34
	Idiosyncratic	43.10	39.54	21.15	17.64	20.83	20.63	23.84	95.12	95.24	82.48	58.01	61.55	56.78	66.17
Sweden	World	0.67	4.42	11.65	3.71	4.34	6.85	5.59	0.06	0.82	10.67	18.15	19.83	32.36	27.43
	Region	69.59	23.62	52.89	50.53	45.08	56.24	56.01	12.67	6.95	0.21	2.83	3.31	7.25	6.92
	Idiosyncratic	29.74	71.97	35.46	45.76	50.58	36.91	38.40	87.27	92.23	89.12	79.03	76.86	60.38	65.65
Switzerland	World	0.19	3.37	6.63	15.49	13.93	11.99	14.26	0.99	15.90	0.85	1.71	0.16	1.65	0.00
	Region	74.55	67.76	44.36	36.19	39.51	37.92	27.89	11.24	7.13	5.67	5.69	11.00	12.71	6.23
	Idiosyncratic	25.26	28.88	49.02	48.32	46.56	50.09	57.85	87.77	76.97	93.48	92.60	88.84	85.63	93.77
United Kingdom	World	0.04	16.44	22.28	5.16	5.85	4.60	1.88	0.64	2.61	0.15	1.52	0.96	7.06	5.33
	Region	92.58	13.82	14.78	14.55	4.14	48.68	35.99	48.23	49.07	38.92	14.85	8.13	2.01	0.14
	Idiosyncratic	7.38	69.74	62.94	80.29	90.01	46.72	62.13	51.13	48.32	60.93	83.63	90.91	90.92	94.54

Figure 4.1: World Factor

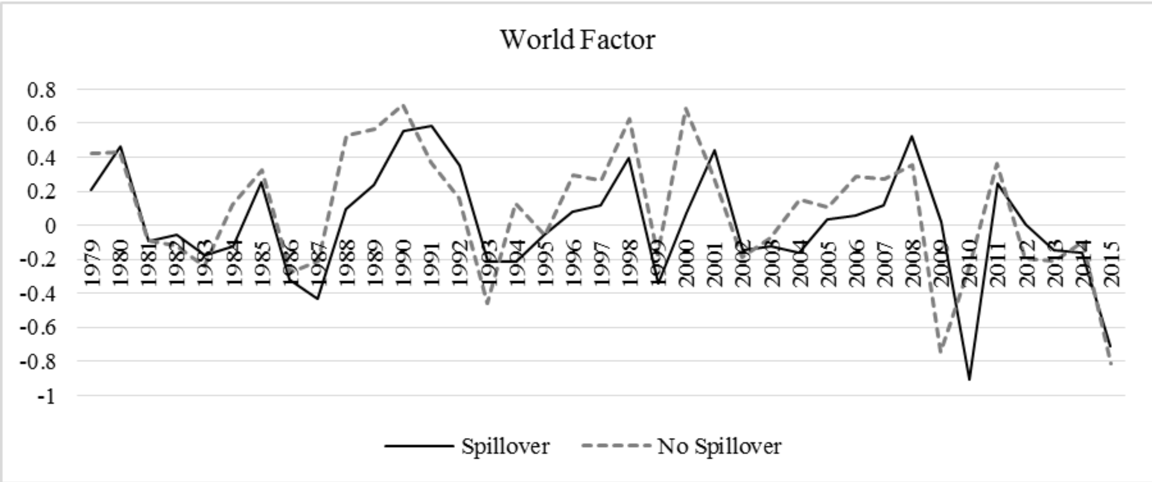


Figure 4.2: Regional Factors

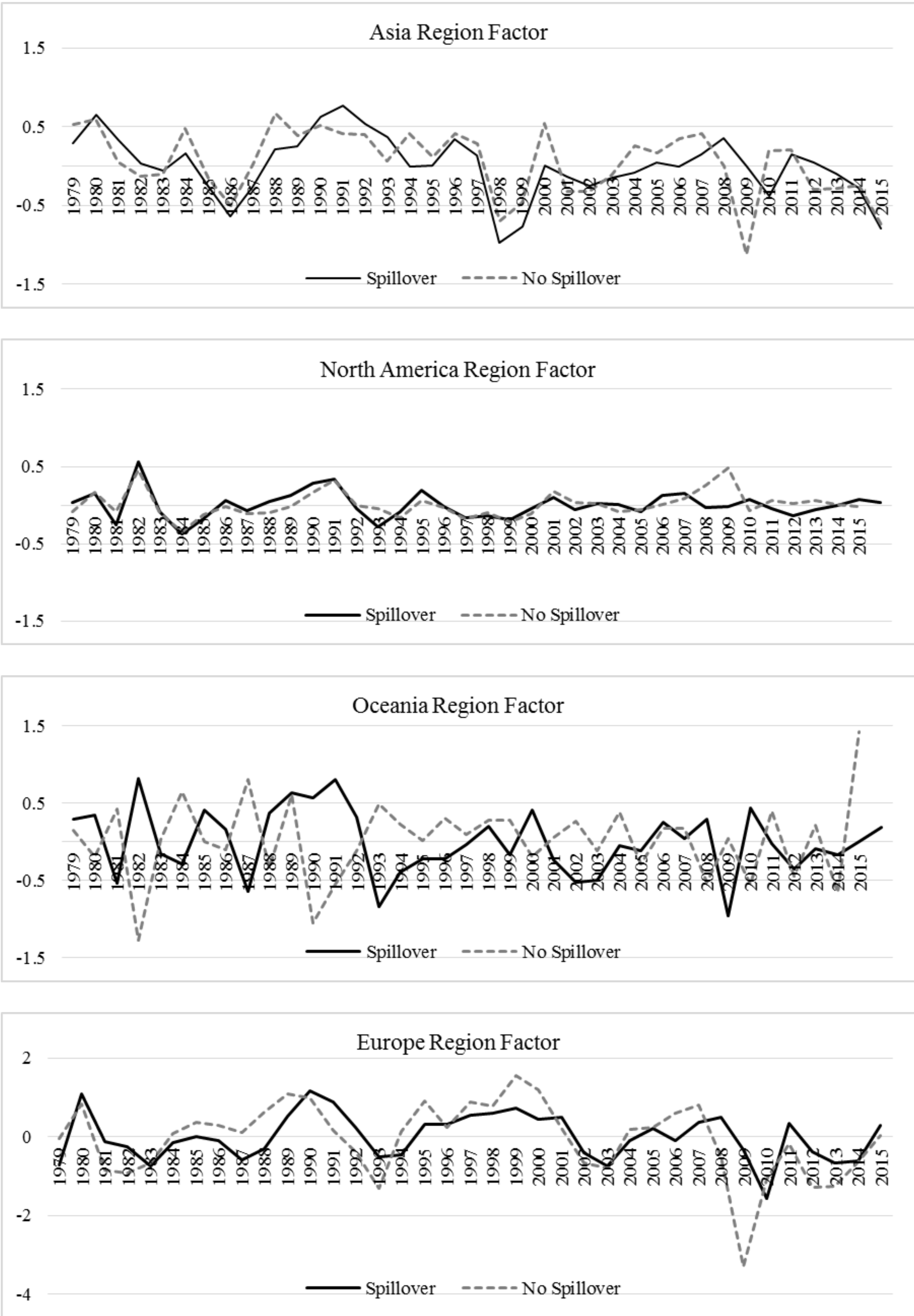


Figure 4.3: Rescaled Output and Dynamic Factors – Asia region

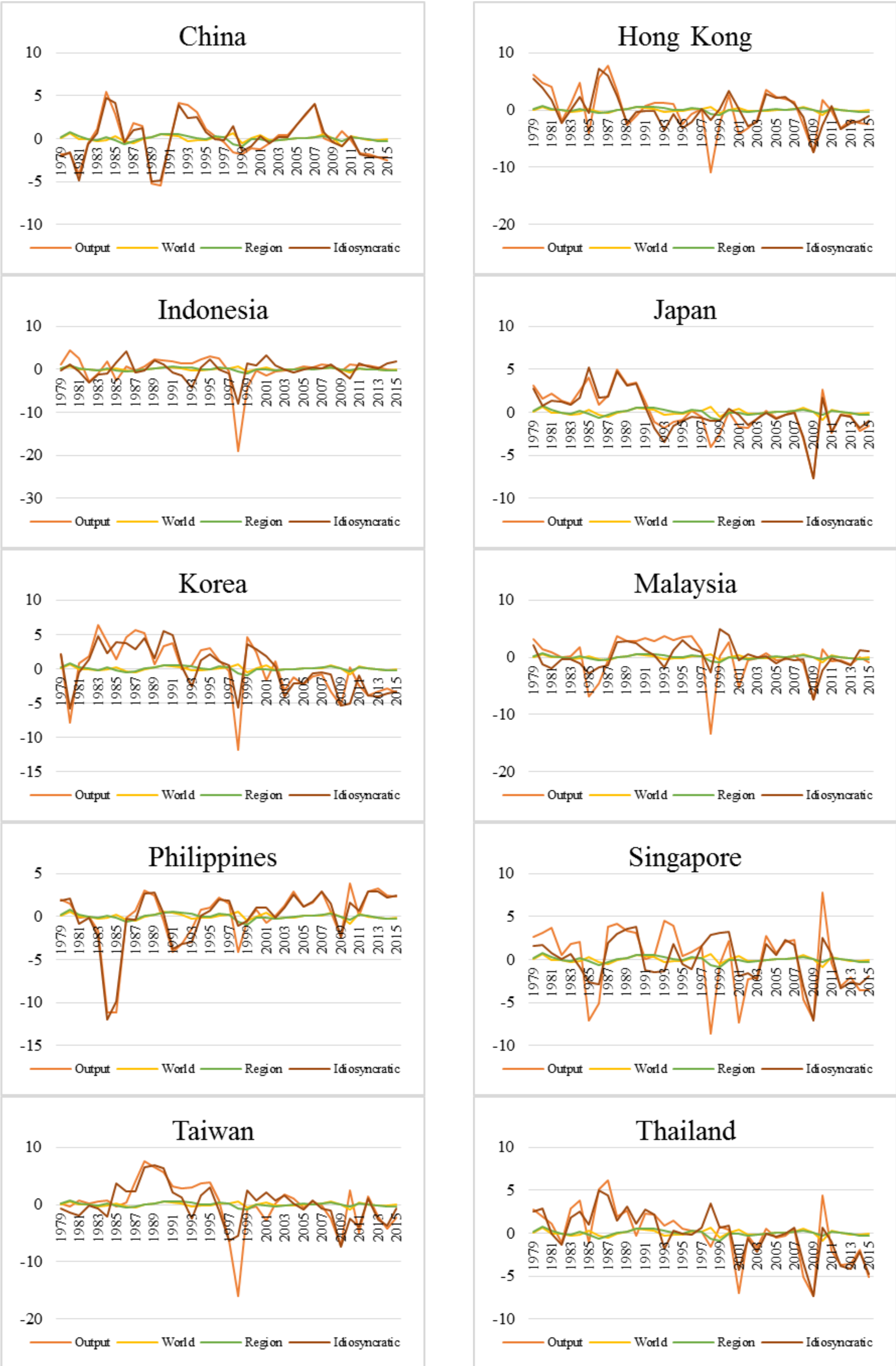


Figure 4.4: Rescaled Output and Dynamic Factors – North America region

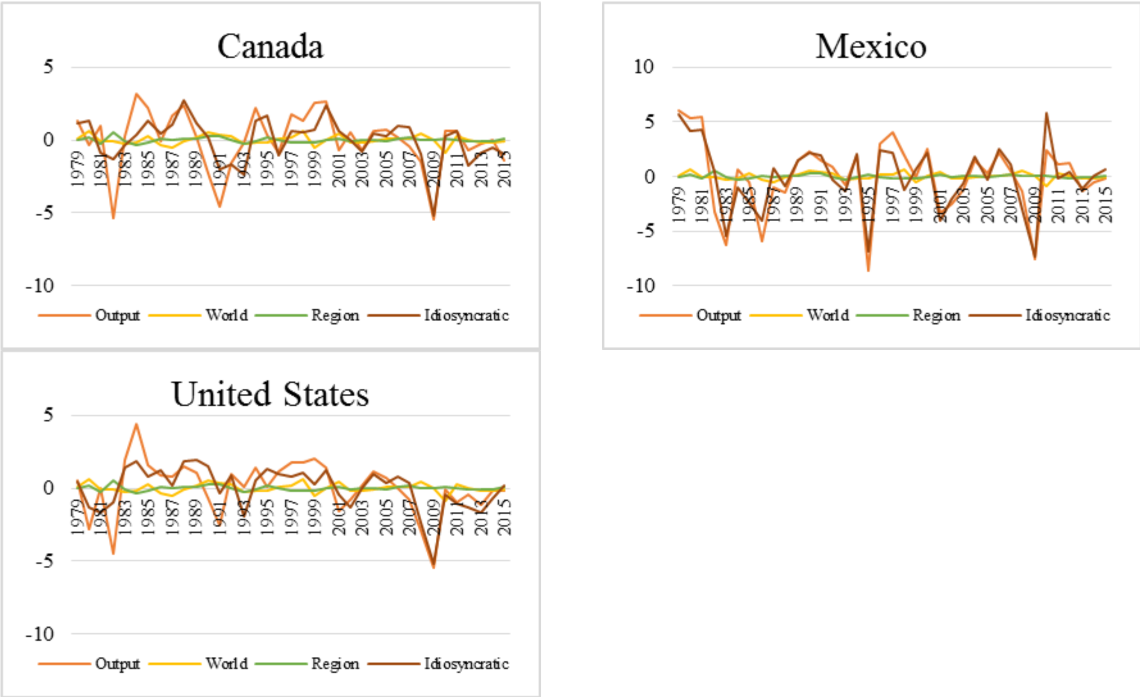


Figure 4.5: Rescaled Output and Dynamic Factors – Oceania region

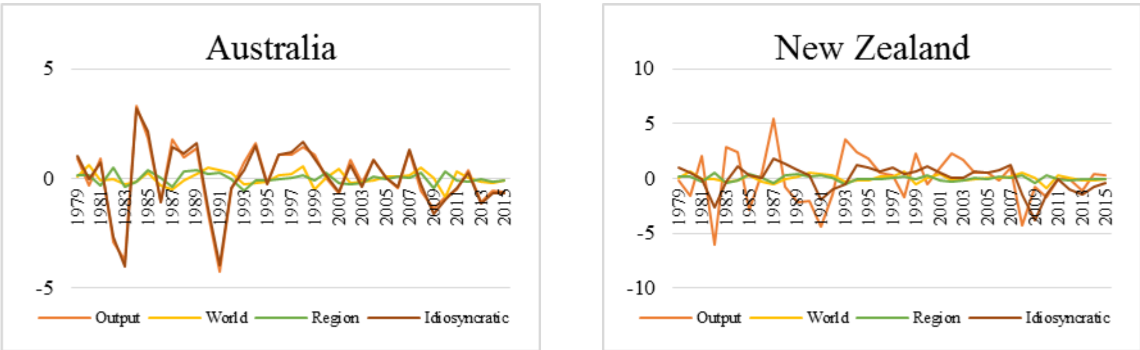
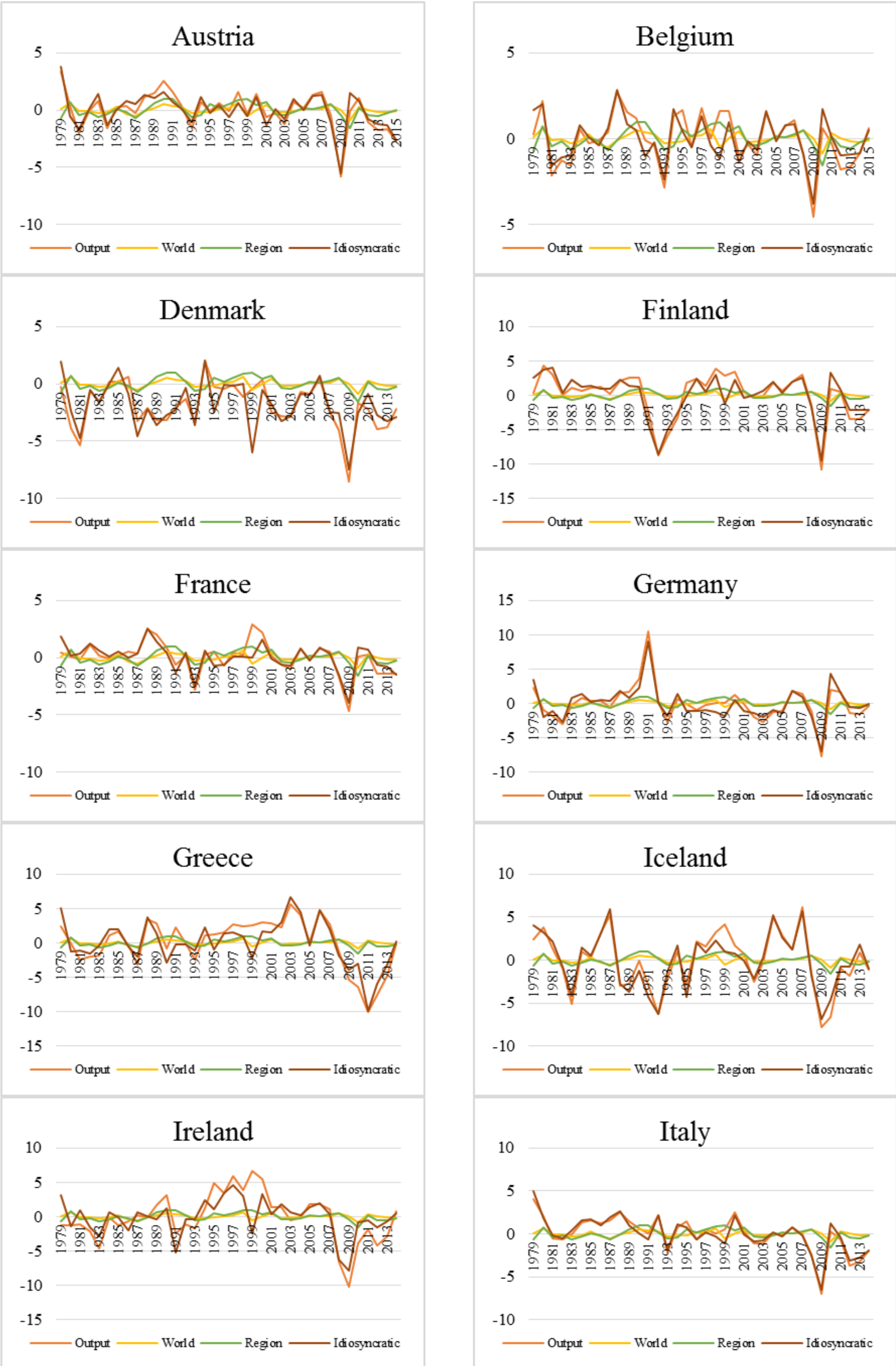


Figure 4.6: Rescaled Output and Dynamic Factors – Europe region



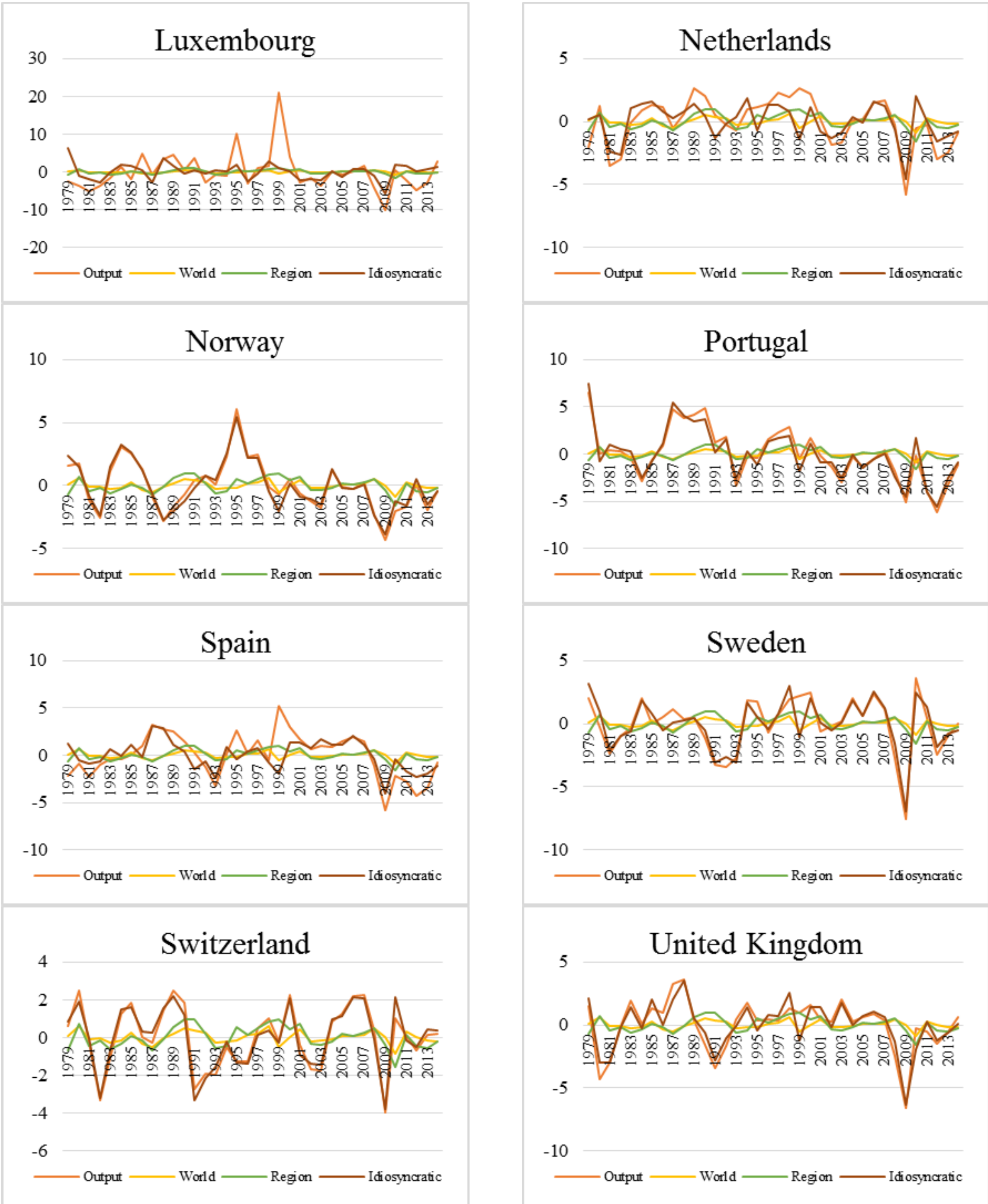

Luxembourg
30
20
10
0
-10
-20
Netherlands
5
0
-5
-10
Norway
10
5
0
-5
Portugal
10
5
0
-5
-10
Spain
10
5
0
-5
-10
Sweden
5
0
-5
-10
Switzerland
4
2
0
-2
-4
-6
United Kingdom
5
0
-5
-10
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013
Output
World
Region
Idiosyncratic

Figure 4.7: The Time-Varying Variance Attributable to World (FW), Region (FR) and Idiosyncratic Shocks (Ɛ) – Asia Region

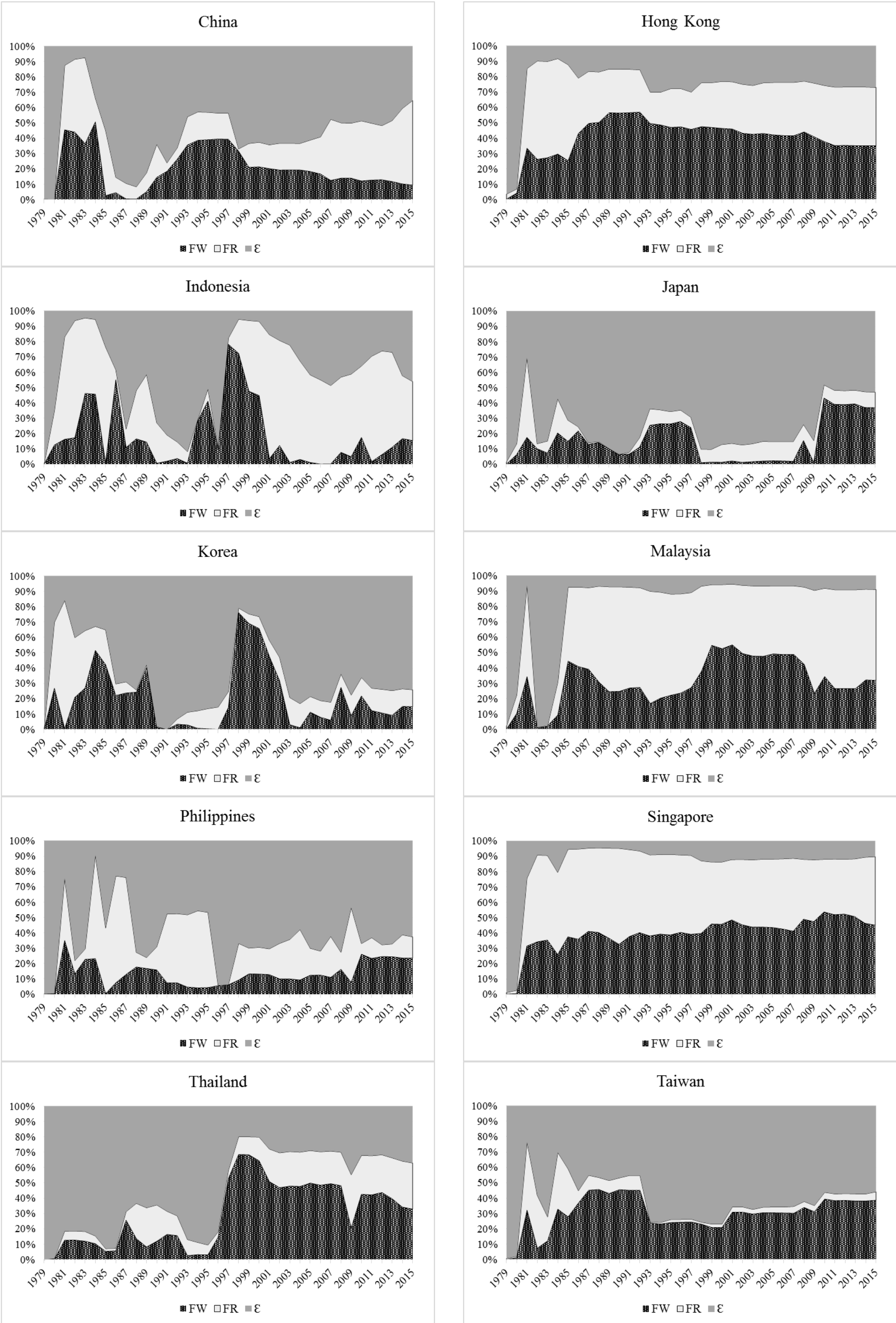
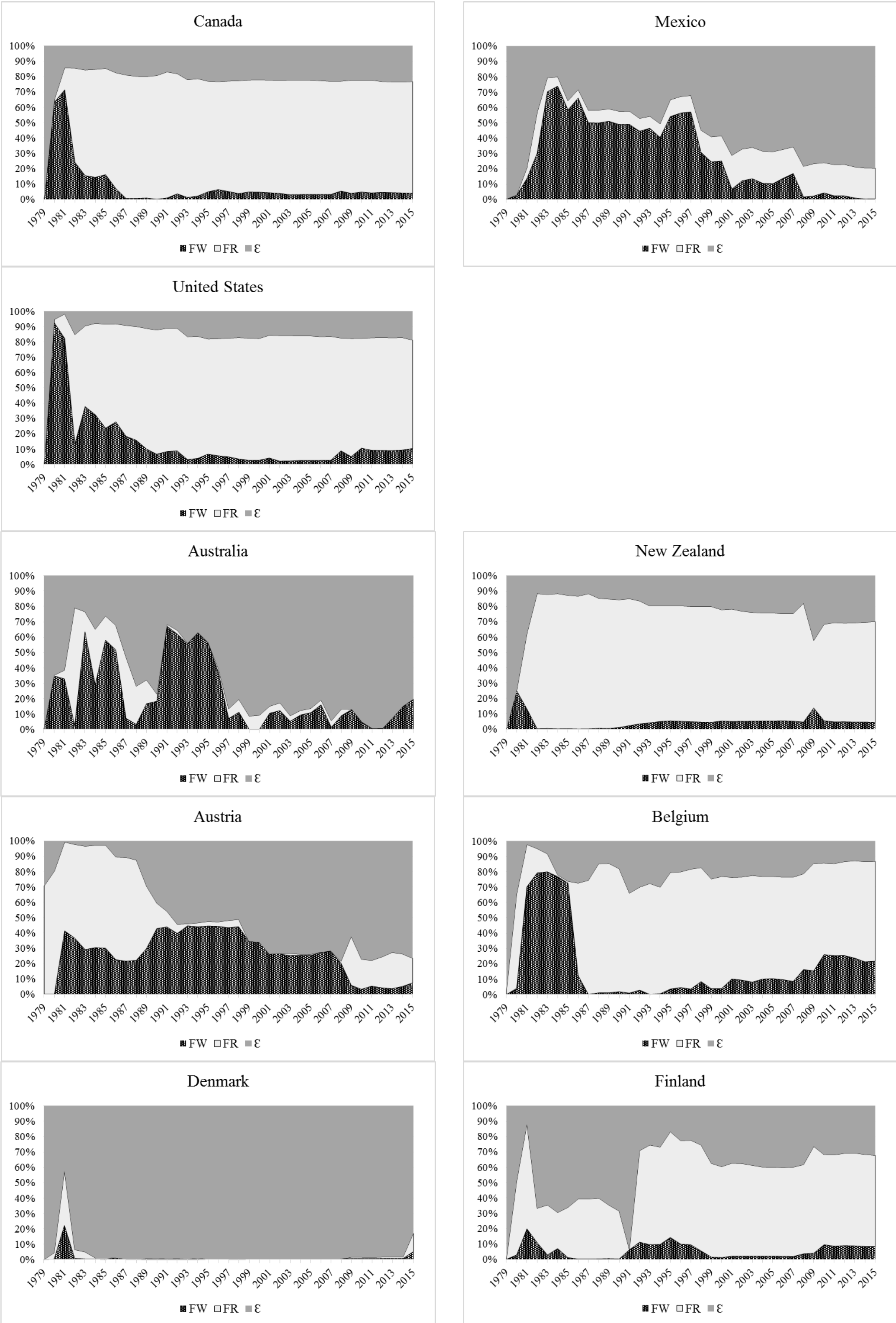
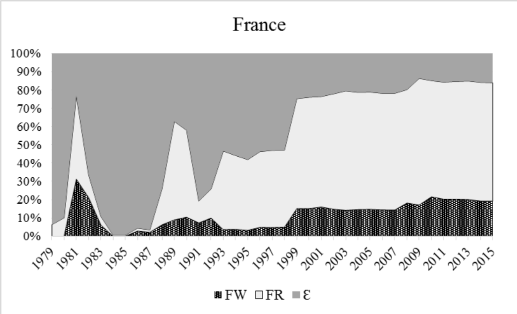
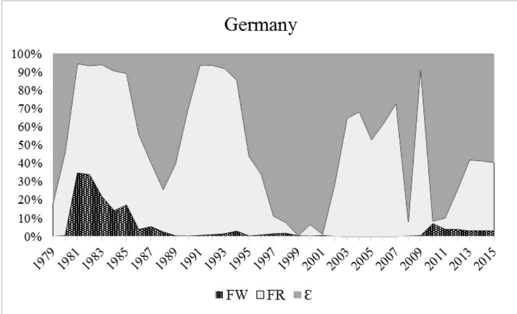
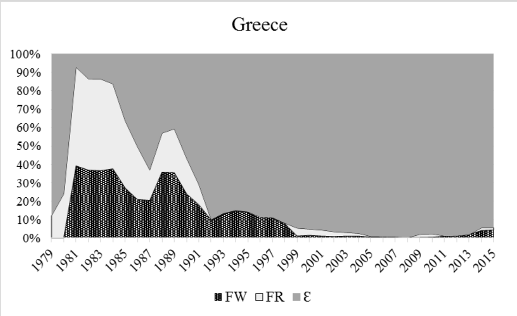


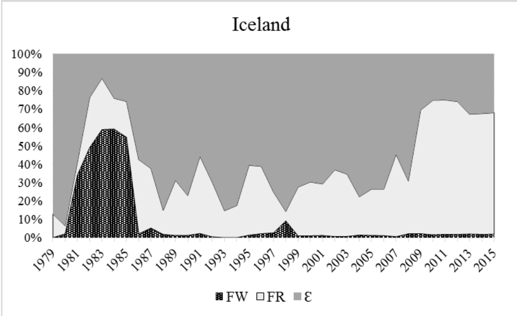
Figure 4.8: The Time-Varying Variance Attributable to World (FW), Region (FR) and Idiosyncratic Shocks (Ɛ) – Other Region

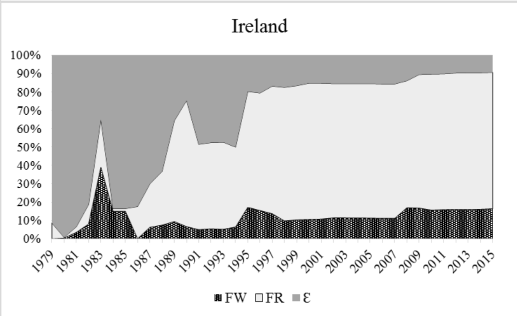


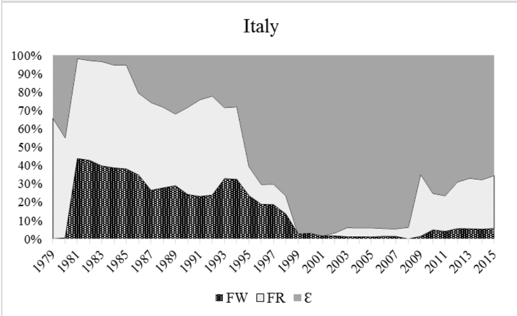

France
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ

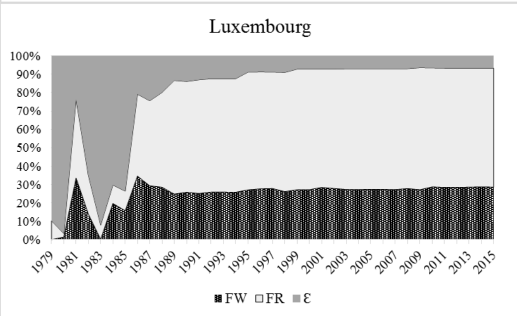

Germany
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ

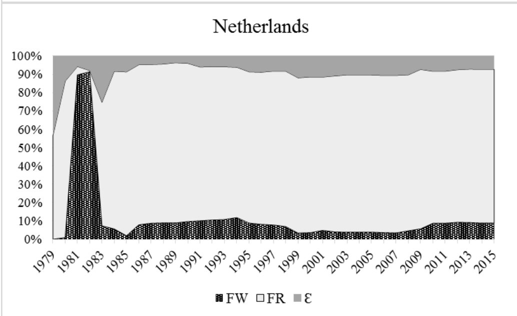

Greece
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ

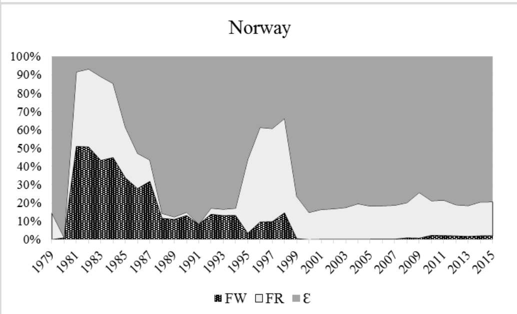

Iceland
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ

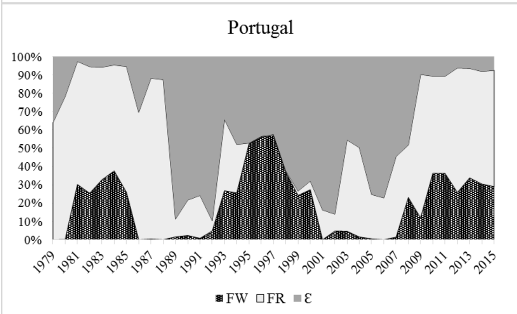

Ireland
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ

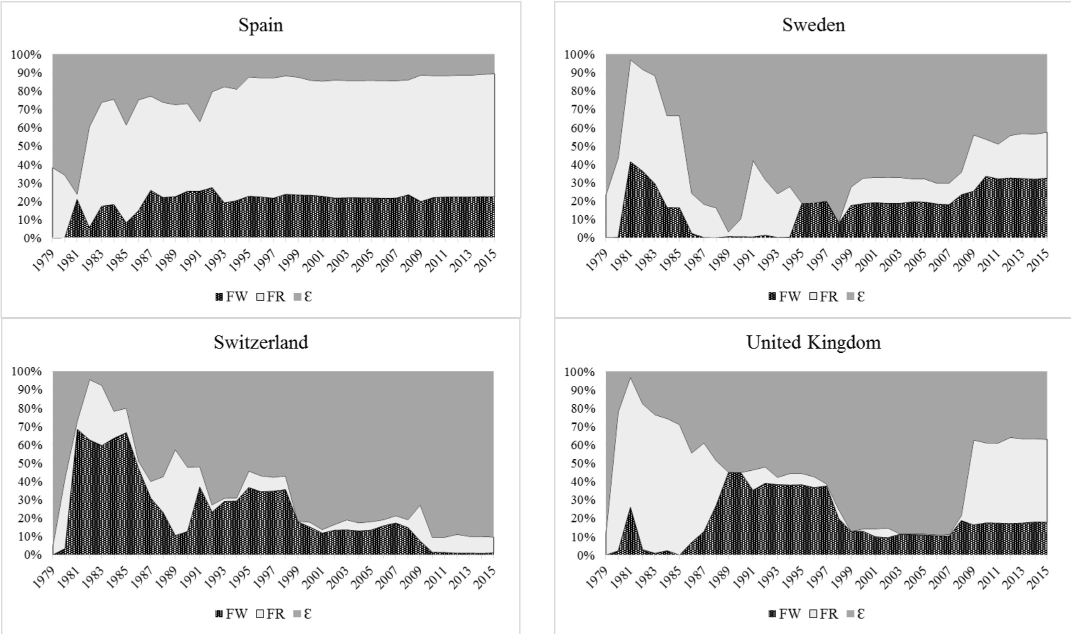

Italy
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ


Luxembourg
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ


Netherlands
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ


Norway
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ


Portugal
100% 90% 80% 70% 60% 50% 40% 30% 20% 10% 0%
1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015
FW FR Ɛ


Spain
Sweden
Switzerland
United Kingdom
FW FR ε

CONCLUSION

This PhD dissertation aims to examine the empirical feasibility of the Asian countries in forming a regional monetary arrangement through different perspectives. The main contribution of this PhD dissertation is to overcome the methodological limitations of the standard VAR and conventional DFM that have been widely applied in this issue. For that purpose, this PhD dissertation consists of three independent research papers, with the first research paper employs the Global Vector Autoregressive (GVAR) model, and the second research paper employs the dynamic factor model (DFM) with time-varying parameters, while the third research paper employs the DFM with time-varying parameters and spillover effects. All the three research papers examined the relative importance of world, regional, and country-specific shocks or factors toward Asian economies. This enables us to understand the sources of economic fluctuation in each countries so that a better policy decision could be make.

The main findings of the three research papers are as follows:

(1) The first research paper found that Asian economies tend to show significantly positive and longer responses to a Chinese real output shock than to a U.S. shock, in terms of both real output and inflation shocks, although the U.S. still has a greater financial effect on Asian economies in terms of interest rate shocks. In contrast to the responses to a Chinese real output shock, Asian economies' responses to a Japanese real output shock are far less statistically significant.

(2) The second research paper found that the relative contributions of the world, regional and country-specific components change over time for most of the Asian countries. Among the factors, country-specific factor still explains a noticeable fraction of output volatility in many Asian economies; but, not in Hong Kong, Malaysia and Singapore cases. The co-movement of real output fluctuation in these three countries are mainly explained by regional factor. Besides, the results show that the regional factor captures the greatest share of output fluctuations in Japan, Taiwan and Thailand since the year 2010.

(3) After taking into account the spillover effects from China and United States, the third research paper found some different results from second research paper. The results found regional factor no longer the main component in explaining Japan, Taiwan and Thailand's economic fluctuations, but the country-specific factor instead. Besides, for Malaysia, Indonesia and Singapore cases, regional factor appear to explain the majority of their output volatility.

In summary, the considerable co-movement of activity for Asian economies appears to be driven to a large extent by country-specific factor, indicate that Asian countries are more favorable for its own independent counter-cyclical monetary policy. Although the first research paper show that China's output and inflation shock have significant influence on Asian economies, both second and third research paper indicate the regional factor plays only a minor role in explaining fluctuations in Asian economic activity. This may explains a noticeable important of China economy on Asian countries, but not the significant share of regional factor on Asian economies. Though these results are not encouraging in establishing a regional monetary arrangement between Asian countries, to make a final conclusion, many more studies that are outside the scope of this study need to be done to examine the suitability of Asian countries to form a regional monetary arrangement.

From a policy analysis perspective, a number of interesting results emerge. The rising role of regional (Chinese) shocks in driving business cycles and inflation indicates that Asian economies meet some of the key preconditions in establishing a regional monetary union. However, Asian economies are financially affected by the United States, in that nominal interest rates of Asian economies are significantly influenced by a United States interest rate shock. To facilitate regional monetary arrangements, China needs further financial liberalization and removal of capital controls to strengthen its financial linkages with other Asian economies.

BIOGRAPHY

PERSONAL INFORMATION

Full Name : Ong Sheue Li
Gender : Female
Date of Birth : August 19, 1986
Nationality : Malaysian

ACADEMIC QUALIFICATION

Doctor of Philosophy in Economics Oct 2013 – Sept 2016

Major : International Economics
University : Yokohama National University (YNU), Japan
Grade : CGPA (4.36 / 4.50)
Dissertation : Time Series Analysis of Economic Integration in Asia

Master of Science by Research Jan 2010 – Dec 2011

Major : Mathematics with Economics
University : Universiti Malaysia Sabah (UMS), Malaysia
Thesis : Testing for linear and nonlinear relationship in the stock-bond relation: Malaysia evidence.

Bachelor of Science July 2006 – May 2009

Major : Computational Mathematics
University : Universiti Malaysia Terengganu (UMT), Malaysia
Grade : Dean's list (CGPA: 3.68 / 4.00)
Final Year Project : Designs 3-dimensional objects using bicubic Bézier surface.

ACADEMIC AWARD

Achievement	Year
Awarded (Scholarship of Japanese Government (Monbukagakusho, MEXT))	Oct 2013 – Sept 2016
Awarded (Outstanding Master of Research's Student award (Science))	2012
Awarded (Aspiration Postgraduate award)	2012
Awarded (Scholarship of UMS Postgraduate Assistance Scheme)	Jan 2010 – Dec 2011
Awarded Dean List for six semesters by Universiti Malaysia Terengganu	July 2006 – May 2009

TEACHING EXPERIENCE

Part Time Tutor Jul 2009 – Jan 2012

Employer : Universiti Malaysia Sabah (UMS)
Department : School of Science and Technology;
School of Education and Social Department
City, Country : Kota Kinabalu, Malaysia
Subjects : Linear Algebra, Real Analysis

PROFESSIONAL EXPERIENCE

Research Assistant

Employer		: Universiti Malaysia Sabah (UMS)
Department		: Centre for Research and Innovation
City, Country		: Kota Kinabalu, Malaysia
Aug – Dec 2012	Project Grant FRG 0234	: Identifying key variables to support the developing an indicators to measure the socio-economic contributions of IBFC on the development of Labuan and neighbouring states.
Jan – Jun 2012	Projects Grant FRG 0256	: A reexamination on the role of exports and domestic demand in economic growth: Some empirical evidence from nonlinear approach.

Internship Trainee

Employer	: Central Bank of Malaysia (BNM)	Apr 2008 – Jul 2008
City, Country	: Kuala Lumpur, Malaysia	
Department	: Operational Risk Specialists Unit (ORSU)	
Employer	: Edith Cowan University	Feb 2016 – Mac 2016
City, Country	: Perth, Australia	
Department	: School of Business and Law	

PUBLICATIONS

Refereed Journals:

1 S. L. Ong and C. M. Ho (2014). Testing for linear and non-linear Granger non-causality hypothesis between stock and bond: The cases of Malaysia and Singapore. *The Singapore Economic Review*, 59(5), pp. 1 – 18.

2 R. C. J. Chia, S. Y. Lim and S. L. Ong (2014). Long-run validity of purchasing power parity and cointegration analysis for low income African countries. *Economics Bulletin*, 34(3), pp. 1438 – 1447.

3 S. Y. Lim, S. L. Ong and C. M. Ho (2012). Co-movement between Malaysian stock index and bond index: Empirical evidence from rank tests for cointegration. *The IUP Journal of Applied Finance*, 18(1), pp. 5 – 18.

4 S. L. Ong and C. M. Ho (2011). Testing for linear and nonlinear Granger causality in the stock return and stock trading volume relation: Malaysia and Singapore cases. *Labuan Bulletin of International Business Finance*, 9, pp. 44 – 57.

Working Paper:

1 S. L. Ong and K. Sato (2015). Regional or global shock? A global vector autoregressive analysis of Asian monetary integration. *CESSA Working Paper* 2015 – 09.

Proceeding:

1 S. L. Ong and K. Sato (2014). Regional shock or global shock? A global VAR analysis on economic and monetary integration in Asia. The 14th International Convention of the East Asian Economic Association (1 – 2 November).

2 S. L. Ong and K. Sato (2014). Regional shock or global shock? A global VAR analysis on economic and monetary integration in Asia. 2014 Asia-Pacific Business Conference (27 – 29 November).

3 S. L. Ong and C. M. Ho (2011). Testing for linear and nonlinear Granger noncausality hypothesis between stock and bond: In Malaysia and Singapore cases. *Abstract book of Singapore Economic Review Conference 2011* (4 – 6 August), pp. 162 – 163.

4 S. L. Ong, S. Y. Lim and C. M. Ho (2010). On a causal relationship between stock and bond: In Malaysia case. *Proceeding of 4th International Borneo Business Conference 2010* (13 – 15 December), 1, pp. 773 – 779.

RESEARCH ACTIVITIES

Venue	Event	Role	Year
Perth, Australia	2014 Asia Pacific Business Conference (APBC)	Presenter	Nov 14
Bangkok, Thailand	The 14th International Convention of the East Asian Economic Association (EAEA)	Presenter	Nov 14
Kota Kinabalu, Malaysia	Seminar Matematik ke-2/2012	Committee member	Nov 12
Kota Kinabalu, Malaysia	Fundamental Research Grant Scheme (FRGS) FRG0256-SS-22010 One-day workshop	Committee member	May 12
Kota Kinabalu, Malaysia	Seminar Matematik Bil.2/2011	Committee member	Nov 11
Labuan, Malaysia	Applied panel data analysis (APDA) workshop	Participant	Oct 11
Singapore	Singapore Economic Review Conference (SERC) 2011	Presenter	Aug 11
Kota Kinabalu, Malaysia	Seminar Matematik 2011	Committee member and presenter	July 11
Kota Kinabalu, Malaysia	Pereka 2011	Participant	Jun 11
Miri, Malaysia	4th International Borneo Business Conference (IBBC 2010)	Presenter	Dec 10
Kota Kinabalu, Malaysia	Seminar Pascasiswazah SST 2010	Presenter	Jun 10
Kota Kinabalu, Malaysia	One-day seminar on Mathematics 2010	Presenter	Mac 10
Kota Kinabalu, Malaysia	Customized Maple Fundamentals	Participant	Jan 10
Kota Kinabalu, Malaysia	Customized Matlab Fundamentals	Participant	Jan 10

TECHNICAL SKILL

Language: Fluent in speaking and good in writing Malay, English and Mandarin.

Software Skill and Programming Knowledge: Eviews, RATS Estima, Maple, Matlab, Microsoft Office, C++ Programming