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UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

THREE ESSAYS IN INTERNATIONAL FINANCE: I. THE INTEREST RATE EFFECT ON ECONOMIC GROWTH II. THE DYNAMICS OF EXPORT GROWTH AND INTERNATIONAL BUSINESS CYCLES III. ARE REAL INTEREST RATES REALLY EQUAL?

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

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SONG ZAN CHIOU WEI
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THREE ESSAYS IN INTERNATIONAL FINANCE:

I. THE INTEREST RATE EFFECT ON ECONOMIC GROWTH II. THE DYNAMICS OF EXPORT GROWTH AND INTERNATIONAL BUSINESS CYCLES III. ARE REAL INTEREST RATES REALLY EQUAL?

A Dissertation APPROVED FOR THE
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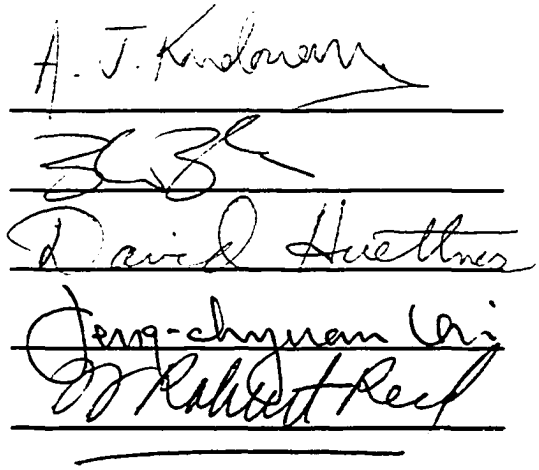

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Introduction

In the last two decades, there has been a growing interest in the study of the intemporal implications of open economy models. The importance of these studies is based upon the evidence that financial and commodity markets have been globalized in many respects. There has been an increasing mobility of capital across countries, such as the foreign ownership of financial and real assets, the flows of commodities, international investment through international stock, mutual funds, and the increasing number of multinational companies listing their stocks on foreign exchanges. The integration of financial markets has posted an unprecedented challenge to the local government and investors as the financial linkages have widely opened the gate for the coming of foreign disturbances. A closed economy model will no longer be suited to study the ever-changing global financial impacts. The understanding of international finance will help the governments to pursue independent stabilization policies, for the investors to decide how international events will affect firms, and determine which measures can be taken to exploit positive gains and thus insulate firms from harmful results.

The purpose of this study is to investigate how the newly industrialized countries (NICs) of Asia, such as Taiwan and Korea react to the international financial shocks. The choice of the NICs for our study is, on the one hand, due to very little literature concerning the Asian market integration and on the other, due to the increasing important

roles those countries have played in the world financial market. This study would provide us an opportunity to better understand the policy implications of those small open economies, which have already been examples for the less developed countries (LDCs).

In part I, we examine the effect of interest rates on the economic growth by extending Neusser's (1991) one-factor closed economic growth model to an open economy. In particular, we lay emphasis not only on the domestic but also on the foreign interest rate effects. The effects of foreign interest rates are distinguished by discussing the term structure (or yield curve) of interest rates, which is defined as spread between the yield on long-term bonds and short-term interest rates.

As it has been long recognized, spot interest rates are the indicators of real business conditions. Recently, Stock and Watson (1989) provide evidence that the slope of term structure is an important leading economic indicator. Estrella and Hardouvelis (1991) also provide evidence that a positive slope of the yield curve is associated with future increase in real economic activities in consumption, consumer durables, and investment. Plosser and Rouwenhorst (1994) explore the linkages between real economic growth and term structure across countries and find that foreign term structures have remarkable predictive power for domestic real economic growth rates.[1] Their motivations to study the term structure are all based on a straightforward economic intuition. When investors expect an economic downturn, the demand for long-term bonds increases; thus it pushes up the price and lowers the yields. As a consequence, the slope of the yield curve is tending to be flattening or negative. The flattening of yield curve indicates a

[1] More recent literature dicing the effects of term structure on economic growth includes Estrella and Mishkin (1997), Harvey (1997), Hagen and Kirchgassener (1996). Besides, the term structures are also used in predicting inflation. Related articles are Fama (1990), Jorion and Mishkin (1991).

decline in future real interest rate and lower interest rates are often associated with lower level of output growth.

Most empirical tests of the term structures have been done by a conventional regression technique which primarily adopts least square to test the goodness of fit. However, since most macroeconomic variables exhibit a non-stationary process, conventional testing procedures on a non-stationary time series would most likely result in a misleading t-statistics (the so-called spurious regression). Therefore, in Part I, the theory of cointegration is employed in a context of broader model to test the effects of term structure on real economic activities, including consumption, investment and money supply.

When we study the growth of Asian markets, the trade factor is an important issue that should not be ignored as most of the Asian countries are heavily dependent upon the export growth. In Part II, we will investigate the impacts both the internal and external disturbances have on the export growth. Two countries, such as Taiwan and South Korea are selected for this investigation.

The Taiwan and Korea economies have frequently been mentioned as a successful experience of the gain from an outward-oriented growth strategy. It is inevitable that the foreign sector plays an important part in both countries' economic stabilization and macroeconomic adjustments due to the lack of natural resources for both countries. This provides reasons why both economies have to be understood under the international trade environments. For instance, In the late 1970s, both countries faced a macroeconomic imbalance which was induced by the first and the second oil shocks, and the imbalance resulted in a high level of inflation, an appreciation the real exchange rate, a reduction in

export growth and a slowdown in economic growth. In 1981, both countries were engaging in the liberalization of their financial markets. An opener market brings to the two countries not only the issues of limited resource but also the transmission of economic fluctuations across countries as the trade-dependent economy would most likely subject to strong, prolonged foreign disturbances by feedback effects operating through the trade account.[2] Besides, the increasing current account transactions in financial goods and services could accelerate the channel for the transmission of financial innovations.

The study of foreign disturbance effects on export growth is conducted in an international business cycle model. The real business cycle (RBC) theory supports that the cumulative effect of permanent shocks to productivity explains economic fluctuations (see e.g., Baxter and Crucini, 1993; Stockman and Tesar, 1995). Recently, the closed-economy RBC model has been extended to an international setting by Backus, Kehoe and Kydland (1993). The proponents of international business cycle have given us some grounds for the study to base on. Elliot and Fatas (1996) postulate that the propagation of shocks is proportional to trade. They find that there is a strong asymmetry in that shocks to the U.S. propagate quickly to Japan and Europe while European and Japanese shocks have little impact in other countries' productivity. Hutchison (1992) examines whether Japanese output stability since the mid-1970s is attributable to the change of exchange rate policy. He finds that the flexible exchange rate regime is more effective in insulating the economy from foreign disturbances like U.S. GNP shocks and monetary shocks than

[2] Moreno (1991) also indicates that there are two main factors to determine the change in the demand for exports: the competitiveness of exporters, which is influenced by the foreign exchange rate and relative inflation rates, and the overall demand for goods abroad, which is influenced by the GNP growth of major trading partners.

is fixed rate regime. Thorbecke and Coppock (1996) examine the transmission of monetary policy. They overrule the traditional hypothesis of neutral nominal money effect and indicate that economic fluctuations are not due to real factors alone.

Since implications from the theoretical literature focus on the effects of structural disturbances, an structural vector autoregressive (VAR) technique, which is pioneered by Sims (1986) and Bernake (1986), is employed to estimate the structural disturbances. The structural VAR approach is applied to supplement the innovation information that could be lost using recursive Choleski decomposition. Two "illustrative" structural models are designed for the purpose: Model 1 is labeled as "external disturbance model", which assumes that volatility of domestic exports is exclusively determined by external disturbances; Model 2 is labeled as "domestic disturbance model", which assumes domestic disturbances and the oil shock will dominate the oil-dependent economies. A two-model setting has successfully helped us minimize unnecessary restrictions on the structure of economy and make a thorough comparison between domestic and foreign disturbances.

Another influential aspect of the international integration of financial markets is the possibility of reducing divergences between domestic interest rates and foreign interest rates or of increasing the degree to which yields in different financial markets move together over time. There have been an extensive literature analyzing the proposition that real interest rates are equal across countries (see e.g., Cumby and Obstfeld, 1984; Cumby and Mishkin 1986; Modjtahedi, 1988). These studies basically reject the short-run validity of the real interest rate parity (RIP). However, recent studies including Kugler and Neusser (1993), Katsimbris and Miller (1993), Throop (1994),

Goodwin and Grennes (1994) have provided evidence against the short-run failure of RIP across countries. These studies all point to risk premium, including foreign exchange risk premium, price stickiness in goods markets, as the main cause of the failure in the short run. Finally, they suggest to focus on the long-run validity of the proposition, and long-run time series analysis technique such as cointegration tests is thus proposed. However, their results are mixed, and the evidence for long-run convergence of interest rate is still weak.

In the last part of the dissertation, we will reinvestigate this important issue by using a time varying parameter (TVP) estimation. The time varying parameter estimation employs the Kalman filter in the context of a particular form of state space model. In doing so, we can supplement the existing literature in two respects. First, as Harvey (1997) points out that cointegration tests bases on autoregressive models, can like unit roots tests, have very poor statistic properties. For example, the first step to test the cointegration relationship is to assume that all the variables contain a unit root. However, the test for unit roots, which is often composed of deterministic trend plus a stationary component, is implausible in many time series analyses. In a time series structural model, the parameters are essentially assumed to follow a random walk. This leads to a stochastic trend in which level and slope are allowed to evolve over time. By using Kalman filter, the trend is extracted by a smoothing algorithm, and the parameters that govern the evolution of the trend are estimated by maximum likelihood. Second, theory of cointegration posits that if an equilibrium relationship exists, deviations from equilibrium should be stationary. But although the cointegration tests can provide the evidence of long-run validity of RIP, for the monetary authorities and investors the

answer to the question: "How long is long-run?" will be more imminently needed. By using a TVP estimation, we can actually test the length of the adjustment process, i.e. how many time periods for the interest rates to converge or diverge.

In sum, Part I tests the effect of interest rate on economic growth using monthly observations over the period 1985:1 to 1979:9 for four countries: the United States, Japan, Taiwan, South Korea. Our analysis includes the term structure of interest rate to account for the real economic activities. We analyze the short-run and long-run relationships between consumption, investment, money supply, real interest rates, and term structure by using the impulse response function and multivariate cointegration methodology proposed by Johansen (1988) and Johansen and Juselius (1990). Part II examines the responses of export growth to different source fluctuations using monthly observations over the period 1981:1 to 1997:9. Taiwan and South Korea are the sample countries in this study. The structural vector autoregressive (VAR) technique is used to interpret two "illustrative" models. An error correlation model is also employed as we find the VAR representation is not suited for Model 2. The purpose of Part III is to apply the method of time varying parameter (TVP) estimation to analyze the equality of real interest rates. The study attempts to supplement the existing literature in the field and accordingly discuss three different economic integrations, which are leading countries, European Community, and Asian market.

PART I

The Interest Rate Effect on Economic Growth: Time Series Evidence from Asia-Pacific Countries

1. Introduction

It is generally recognized that financial variables such as interest rates can be used to stabilize the domestic economy. More recently attention has been paid to understanding if foreign interest rates could influence the domestic real economic activities as there has been a significantly increasing integration of international financial markets in the last decade. This issue is critically important to the monetary authorities when they want to enforce their policy independently without taking into account the shocks of international factors. Besides, for the increasing multinational corporations and international financial services, the anticipation and interpretation of co-movement of domestic and foreign interest rates would certainly reduce the cost of capital price because it is interest sensitive.

Researchers have made enormous efforts to discover the interest rate effect across countries. Distinguished studies include Hartman (1984), Fung and Isberg (1992), Katsimbris and Miller (1993). They employ the technique of bilateral Granger causality in analyzing the linkage of real interest rates between U.S. and European Monetary System (EMS). However, these studies have provided mixed evidence on this issue, thus leaving the readers uncertain about direction of causality. The explanations for such

confusion are, on the one hand, due to the expansion in the size of Eurodollar and on the other, due to the methodology those studies employ. The Granger causality test has been criticized because it is very sensitive to the number of lags used in analysis. Besides, omitting relevant variables and the nonstationary characteristics of the variables can bias inferences from Granger causality tests.

Researchers have also come to believe the slope of term structure of interest rate (or yield curve), usually defined as the spread between the yields on the long-term government bonds and short-term interest rates, can be viewed as a piece of useful information to predict the inflation and real economic activities. Studies including Fama (1990), Estrella and Hardouvelis (1991), Kim and Limpaphayom (1997), and Estrella and Mishkin (1997) all provide evidence supporting the relation between term structure of interest rate and future economic activity. Among those studies, a naïve regression analysis, which includes output growth as independent variable and term structure as dependent variable, is often used. These studies all present significant results of goodness-of-fit tests. The predictive ability of term structure is further investigated in an international framework. Plosser and Rouwenhorst (1994) construct an analysis in a notion of "world interest rates" by using U.S., U.K., and Germany data. They extend the naïve equation and regress not only international term structure but also more relevant variables like money supply and domestic interest rate on domestic output. They find foreign term structure can forecast the economic activity of the countries with high and variable inflation such as U.K. In a similar fashion, Harvey (1997) uses an asset-pricing model to study the Canadian economic growth with both Canadian and U.S. term structure. He finds both countries' term structures have explanatory power to Canadian

GDP growth even though correlation between these two countries' yield curve and business cycles are implied. In most studies, the relationship between term structure and domestic economic growth has been described as such, negatively sloped yield curves imply recessions and positively sloped curves foretell economic recovery. The economic intuition behind this assertion is straightforward. When investors expect an economic downturn, the demand for long-term bonds increases; thus it pushes up the price and lowers the yield. As a consequence, the slope of the yield curve is getting flattening (or negative). The flattening of yield cure is indicative of a decline in future real interest rate and these lower rates are associated with a lower level of output growth.

However, studies using the conventional regression as a proxy to study the international effect of interest rate could easily fall into the following pitfalls. First, it has been argued that a simple regression without considering the stationarity of the variables could lead to spurious regression (Nelson and Plosser, 1982; Phillips, 1986), which shows the symptoms of high R^2, significant t-statistics, but meaningless results. Second, those studies may reveal a misleading message because they fail to consider the evidence of less than perfect integration and adjustment between domestic and foreign market, which in the short run could be attributed to transaction costs, the existence of taxation, a risk premium in the foreign exchange market, and other imperfection between the markets (Modjtahedi, 1988; Goodwin 1994; Throop, 1994). Finally, those studies all strongly imply that interest rates and output are not contemporaneously correlated. In fact, they should be viewed as being endogenous; that is, they are simultaneously determined (See for example, Neusser, 1991).

Another reason for the inconclusive empirical evidence in previous studies may be due to the fact that they solely emphasize the interaction of the industrialized countries. If the two-way causality effects are true, these studies may also suffer a simultaneous equation bias problem mentioned earlier. In other words, we can not tell if the source of fluctuations is domestic or if it comes from a foreign country. The goal of this study is to switch the focus from the industrialized countries to Asian financial markets as the latter has received little or no attention in the literature. In this study, three markets, including Japan, Taiwan, and South Korea are tested. We also assume that there is only one-way causal effect from U.S. to those markets. Except Japan, Taiwan and South Korea are supposed to endure much more impact by U.S. interest rate adjustments than those OECD countries as they are engaging in a larger sum of trade with United States. Besides, heavy foreign debt problem would most likely cause countries like South Korea to react to an upward adjustment of the foreign interest rates.

The main contributions of this study include the following. First, this study attempts to overcome the simple regression problem by reexamining the dynamic relationship between the output growth and interest rate in a context of a broader model. In this model the interaction of output with relevant variables; e.g., consumption, investment, money supply and term structure is identified. We also give an exclusive emphasis on the foreign effect and thus consider the foreign interest rate and term structure shocks to domestic output. Second, unlike most studies in the literature, the relevant time series variables such as interest rates and term structures are verified as nonstationary. It would be more appropriate to employ some recent advances in the time series analysis, including stationarity test and cointegration test in the conjunction. These

new techniques are applied to deal with the problem of nonstationarity in the data series and to test the long-run equilibrium relationships between variables. The long-run behavior of interest rates is supposed to allow the short-run variations of interest rates, which are created by the imperfect market conditions. Recent studies (e.g., Harvey 1988) show the cointegration inferences are also subject to a similar omission-of-variable bias and are not necessarily robust in a bivariate model to inclusion of other relevant variables that are thought to be underlying important variables. According to the existing problem, this study uses a multivariate VAR (vector autoregression) model, which adopts more relevant endogenous variables, in order to fill the void. Finally, we interpret the short-run dynamics between the variables in the VAR system by applying an error correction model (ECM). Then we also provide the impulse response and variance decomposition analysis (innovation accounting) to further examine the short-run response of variables to the innovations; that is, to trace out the time paths of the short-run effects of pure shocks.

The remaining part of the study is organized as follows. Section 2 motivates new variables to be included in the model and formulates the variable vector. Section 3 lays out the methodology employed. In section 4, we detail the data source and in Section 5 we test the domestic effects of interest rates on the economic activities. Section 6 extends the domestic model to an international context. The results are reported and analyzed in the same sections. The last section offers some conclusions of this study.

2. The Model

It is widely acknowledged that a well-specified structural model can outperform the univariate model (e.g., see Prothero, 1976; Mizon, 1991), even though the structural model is often restricted by some equilibrium conditions. Thus in specifying the variables of our model, we follow a neoclassical one-factor growth model, which is proposed by Neusser (1991). We assume an economy populated by a large number of identical agents who supply inelastically a constant amount of labor. The agents maximize lifetime utility by choosing consumption (C) and private investment or storage of goods (I). Each agent produces outputs with private inputs in a constant return-to-scale production function which is subjected to random shocks. The random shocks are assumed to follow an AR(1) with a drift process which operates like a labor-augment technical production. However, even though the efforts Neusser tries to extend the one-factor model from a single country to a multicountry model are proven to be unsuccessful, he attributes the variations to the notion of a "world interest rate". Plosser and Rouwenhorst (1994) construct artificial "world rates" when they regress the real growth to "world" term structures and world rates. They found both variables provide significantly explanatory power. As the world rates are artificially made by a weighting procedure, they are subject to criticism. In order to avoid this pitfall, we don't employ the concept in this study but instead assume one-way causality from U.S. and Japan interest rates and to Taiwan and South Korea interest rates without feedback. As Plosser and Rouwenhorst indicate, term spread can also obtain important information about the future course of monetary policy. Meanwhile, it has been widely known to policy-oriented economists that the changes in

the monetary bases could reflect actions taken by the central banks to alter reserves of the banking system in their attempt to change monetary aggregates. It is of equal interest to the consumers and investors to test whether the term structure is able to exert effect on consumption growth and investment growth. Thus, the basic model is set up as a function of consumption (C), investment (I), monetary (M), real interest rates, including foreign interest rate (i^f) and domestic interest rate(i^h), and the term structures, including foreign term structure ($r_f^L - r_f^S$) and domestic term structure ($r_h^L - r_h^S$). That is,[3]

$$\text{Output(Y)=(C, I, M, } i^f, i^h, r_f^L - r_f^S, r_h^L - r_h^S) \tag{4}$$

then a common-trend representation suggested by Stock and Watson (1988) can be shown as

$$X_t = \begin{bmatrix} Y_t \\ C_t \\ I_t \\ M_t \\ i_t^f \\ i_t^h \\ r_f^L(t) - r_f^s(t) \\ r_h^L(t) - r_h^s(t) \end{bmatrix} = \Phi\tau_t + \varepsilon_t \tag{5}$$

where Y_t, C_t, I_t stand for the logarithms of consumption, investment. Interest rates are all in level. τ_t is a 8×1 vector of random walks that serve as common trends driving the co-movements of $Y_t, C_t, I_t, M_t\ i_t^f, i_t^h, r_f^L(t) - r_f^s(t), r_h^L(t) - r_h^s(t)$ and ε_t is a vector of error term.

[3] The function is kind of ad hoc, but the purpose of this study is to explore the long-run implication of the effect of interest rate on growth. If a stable long-run relationship exists in the model, the error of missing important variables could pose no serious problems to the present study.

3. Empirical Methodology

3.1 Unit Root Test

In order to decide whether the variables series are stationary, a more complete investigation shall be carried out. For this purpose, the Augmented Dickey-Fuller (ADF) test is performed, and the cumulative distribution of the ADF test statistics is provided by Dickey and Fuller (1979, 1981). If the calculated statistic is less than its critical value from Fuller's table, then the variable is said to have no unit root. Thus it is a stationary. In selecting the number of lags in the ADF test, Akaike Information Criterion (AIC) and the Schwartz Baysesian Information Criterion (BIC) are conventionally used.

Consider the augmented Dickey-Fuller regression equation for y_t:

$$(1-L)y_t = \alpha_0 + \alpha_1 t + \gamma y_{t-1} + \sum_{i=1}^{N} \alpha_{i+1}(1-L)y_{t-1} + e_t \qquad (2)$$

where L is the lag operator, $(1-L)y_t$ means the first difference of y_t series such as $y_t - y_{t-1}$. t is a time trend, e_t, an error term, and N is the lag length to be determined by the minimum AIC and BIC.

3.2 Cointegration & Johansen's Test

The specific cointegration technique concept is fully developed in Engle and Granger (1987). The key idea of cointegration is that time-series variables, either non-stationary in level or stationary in first differences, tend to move together in the long-run

without drifting too far. In other words, if there exists a linear combination of them, which is itself statioanary, then the series are cointergrated. Therefore, it can be said that a common stochastic trend exists or the deviations from equilibrium are stationary with finite variance.

Consider two non-stationary time series variables, x_t and y_t are integrated in order d if those variables have achieved stationarity after being differenced d times. And if x_t and z_t are both integrated in the same order d, two I(d) variables are cointegrated if a linear combination exists such as $z_t = x_t - \alpha y_t$. α is the cointegration parameter that links the two time series together. The long-run static equilibrium correspondingly is $z_t = y_t$.

Johansen's test of cointegration based on a maximum likelihood estimation procedure provides an approach for estimating multiple cointegrating vectors as well as testing within the class of Gaussian vector regressive processes. Basically, for a set of n variables, if they share r cointegrating relationships, there must exist k= n-r stochastic trends among the co-movement of the cointegrated variables. Two tests known as λ_{max} and λ_{trace} tests are often used to determine the number of cointegrating vectors identified by r. The trace test evaluates the null hypothesis which allows to identify r or at least number of cointegrating vectors against an alternative hypothesis. The maximum eigenvalue test evaluates the null hypothesis r=0 against an alternative hypothesis such as $r \leq 1$. [4] The number of lags employed in the procedure can also be determined by the minimum AIC and BIC.

[4] Two tests , transformed from likelihood ratio test, are used to test the number of characteristic roots that are insignificantly from unity, the test statistics are

3.3 Error-Correction Model

In the cointegration analysis, the equilibrium error plays an important role in developing the error-correction model (ECM). In light of error-correction modeling, the standard granger causality test loses its forecastability since the standard granger causality test is valid only if independent and dependent variables are not cointegrated. Engle and Granger (1987) incorporate the ECM with the cointegration technique which permits the gradual adjustment of a dependent variable to the long-run equilibrium as long as the short-run dynamics are identified. Moreover, in the ECM a temporary disturbance to the explanatory variables, and a discrepancy between its actual and equilibrium values, will simultaneously affect the dependent variable. It implies that if the long-run relationships are established, at least, one way causality exists in those formulations.

If the residual shows the cointegration relationship among the variables in the cointegration equation, the white noise term can be incorporated to the ECM to detect the short-run dynamics. Define a vector $X_t = \left[Y_t, C_t, I_t, M_t, i_t, r^L - r^S\right]'$, which contains 6 variables. If all of 6 variables are I(1) processes, then an ECM can be written as

$$\Delta X_t = \sum_{i=1}^{p-1} \Pi_i \Delta X_{t-i} + \Pi X_{t-p} + \delta_t \qquad (3)$$

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln(1-\hat{\lambda}_i)$$
$$\lambda_{\max}(r, r+1) = -T \ln(1-\hat{\lambda}_{r+1})$$

where $\hat{\lambda}_i$ is the estimated values of the characteristic roots, T is the number of observation.

where δ_t is a vector white noise process and the matrix Π conveys the long-run information contained in the data. If the rank of Π is r, where $r \leq 6$, Π can be decomposed into two $6 \times r$ matrices, α and β, such as $\Pi = \alpha\beta'$. The matrix β consists of r linear cointegrating vector while α can be interpreted as a matrix of vector error-correction parameters (or speed of adjustment).

4. Data and Empirical Results

4.1 Data

This study tests the relationships between economic growth and interest rates using monthly observations over the period 1985:1 to 1997:9 for four countries: the United States, Japan, Taiwan, South Korea. We choose 1985:1 as a starting point partly because this period covers the same data series for all the countries and partly because after 1984 all the Asian markets have already deregulated their financial systems.[5] We use the monthly data instead of quarter data in light of increasing the degree of freedom in the estimation. All the data are logarithmic and seasonally adjusted except for interest rates which are in decimal percentage. All the data are obtained from the Citibase, the International Financial Statistics (IFS), the OECD Main Economic Indicators, The Bank of Korea, The Korea Investors Service, and the Executive Yuan of Taiwan (DGBAS).

[5] Kim and Limpahayom (1997) have examined the effect of economic regime on the relationship between the term structure of interest rate and future economic activity in Japan. They find that the explanatory power of yield curve is evidenced in the context of financial market deregulation and liberalization.

The output level, Y_t, is the industrial production index (1990 as base year) in month t. Money supply is measured by the seasonally adjusted M2 series.[6] We also combine both private and fixed components as our measurement of consumption and investment. The real interest rates are all money market rates deflated by the ex-post GDP-inflation index except for U.S. interest rate, which is the deflated yield on three-month T-bills. We use one-year, three-year, and five-year bonds yields as our long-term base rates,[7] and the term spreads between the real rate are respectively Term-1 (real rate and 1-year bond), Term-3 (real rate and 3-year bond) and Term-5 (real rate and 5-year bond).

[6] Plosser et al (1994) uses both future and current monetary growth to predict the output growth rate. However, to find a long-run implication of the variables, this study doesn't attempt to seek further the issue of future monetary growth.

[7] Basically, we use the long-term bonds yields for U.S. and Taiwan data, but because Japan and don't have 1-year bond, thus we employ 1-year bank debenture instead.

Table 1

ADF unit root tests for real interest rates and term structures, 1985:1-1997:9

Variable	Levels		First-Differenced	
	Lag(s)	ADF stat	Lag(s)	ADF stat
i^{us}	3	-2.05	2	-7.47
i^{tw}	9	-1.57	8	-8.18
i^{jp}	1	-0.32	0	-16.69
i^{kr}	0	-2.71	1	-12.64
US term1	8	-2.42	1	-9.96
US term3	13	-3.04	1	-9.19
US term5	3	-2.40	2	-8.48
TW term1	7	-2.60	6	-9.71
TW term3	2	-3.23	6	-10.08
TW term5	1	-2.89	1	-18.69
JP term1	3	-2.22	2	-19.65
JP term3	1	-2.26	2	-19.24
JP term5	2	-2.23	1	-12.35
KR term1	0	-3.01	0	-13.24
KR term3	0	-3.02	0	-13.26
KR term5	0	-2.88	6	-13.62

Note: Four countries are used in the tests, including United States (US), Taiwan (TW), Japan (JP), and Korea (KR).
There is a trend and constant in the equation. The 5% critical value is -3.45 with T=100.
The optimal lag length for the ADF regression is chosen by the BIC model selection criterion.

4.2 The Unit Root Test

Table 1 provides the results of the unit root test for the stationarity of the level as well as for the first-differenced interest rates. It is supposed that if the calculated ADF statistics is less than its critical value for the first-differenced data, then the variables are

integrated of order 0.[8] For the first-differenced series, the null hypothesis is rejected in all cases. Therefore, we conclude all the variables are I(1).

Table 2 reports the ADF test for the macroeconomic growth data. It is also clear that each of the sixteen (16) series contains a unit roots.

Table 2

ADF unit root tests for the macroeconomic growth data, 1985:1-1997:9

Variable	Levels		First-Differenced	
	Lag(s)	ADF stat	Lag(s)	ADF stat
US				
Y_t	12	-1.79	1	-11.55
M_t	18	-0.91	17	-7.02
I_t	15	-2.42	14	-14.15
C_t	14	-2.43	13	-10.77
TW				
Y_t	13	-2.26	14	-11.99
M_t	12	-1.02	11	-4.869
I_t	6	-2.73	5	-11.54
C_t	20	-1.65	19	-10.88
JP				
Y_t	20	-1.79	14	-3.59
M_t	16	-1.30	15	-10.86
I_t	12	-1.48	11	-9.32
C_t	15	-2.82	18	-4.83
KR				
Y_t	11	-0.81	11	-14.50
M_t	9	-1.06	0	-11.92
I_t	12	-0.64	11	-10.92
C_t	8	-1.01	10	-16.04

Note: There is a trend and constant in the equation. The 5% critcal value is -3.45 with T=100.

There is a constant in the equation. The 5% critical value is -2.89 with T=100

[8] Because the interest rates are usually considered as the borderline cases between I(0) and I(1), the paper also employs the Phillips-Person (PP) (1988) test statistics to reconfirm the results. The results are identical with ADF test.

Table 3
Cointegration test results for domestic countries

Country	Maximal eigenvalue test		Trace test	
	Null hypothesis	Test stat	Hypothesis	Test stat
U.S.	r=0	45.71	r=0	117.93
	r=1	20.84	r≤1	72.22
	r=2	18.93	r≤2	51.38
	r=3	16.65	r≤3	32.45
	r=4	10.23	r≤4	15.80
	r=5	5.57	r≤5	5.57
Japan	r=0	121.75	r=0	191.31
	r=1	34.22	r≤1	69.65
	r=2	22.62	r≤2	35.34
	r=3	8.87	r≤3	12.72
	r=4	2.48	r≤4	3.85
	r=5	1.37	r≤5	1.37
Taiwan	r=0	41.34	r=0	108.64
	r=1	29.71	r≤1	67.30
	r=2	19.36	r≤2	47.59
	r=3	14.33	r≤3	28.23
	r=4	10.79	r≤4	14.90
	r=5	4.10	r≤5	4.10
Korea	r=0	59.23	r=0	131.76
	r=1	30.03	r=1	72.54
	r=2	21.58	r=2	42.54
	r=3	11.00	r=3	21.23
	r=4	5.59	r=4	10.23
	r=5	4.63	r=5	4.63
Critical values	r=0	40.30	r=0	102.14
α=0.05	r=1	34.40	r=1	76.07
	r=2	28.14	r=2	53.12
	r=3	22.00	r=3	34.91
	r=4	15.67	r=4	19.96
	r=5	9.24	r=5	9.24

Note: The varibles in the cointegration vector include output (Y), consumption (C), investment (I), money (M), real interest rate (i), term structure (term5), and a constant. The number of lags used in the system is 4.

5. Domestic Effect of Interest Rates

5.1 Cointegration Test

In this section, we seek to explore the effects of the domestic real interest rates and term structures on the domestic fundamentals. The long-run cointegration tests are used to explain this conjuncture. Table 5 illustrates the cointegration test for each country. We conclude in the VAR system output (Y), consumption (C), investment (I), money supply (M), real interest rate (i) and the difference between the 5-year bond yields and short- term interest rates (Term5). We also define a constant as the seventh element in the cointegrating vector; thus the variable vector is given as,

$$X' = [Y, C, I, M, i, \text{Term5}, \text{constant}].$$

Table 3 reports the cointegration results using the Johansen (1988) and Johansen and Juselius (1990) maximum likelihood rank tests.[9] From λ_{trace} test, we can reject the null hypothesis of r =0 against the alternative of r=1 at the 95% critical levels for four countries. But the λ_{max} test can not reject the null hypothesis of r=1 against the null of r=2. This result strongly indicates that there is only a cointegrating vector for each country. Normalizing the cointegrating vector with respect to output (Y), a long-run equilibrium relationship for each country is as follows,

[9] As Johansen procedure implies, the result of cointegration test is very sensitive to the lag length. Hence LM test for the correlation in the residuals and LR test for the appropriate lags are performed. Both statistics show to choose the lags of 4.

U.S: $$Y_t = 0.916C_t + 0.652I_t + 0.411M_t - 0.016i_t + 0.085Term5(t) + 0.177 \quad (5)$$

Japan: $$Y_t = 0.766C_t + 0.046I_t + 1.648M_t - 0.048i_t + 0.128Term5(t) + 0.203 \quad (6)$$

Taiwan: $$Y_t = 0.026C_t + 0.706I_t + 2.083M_t - 0.009i_t + 0.129Term5(t) + 0.055 \quad (7)$$

South Korea: $$Y_t = 0.463C_t + 0.202I_t + 0.192M_t - 0.021i_t + 0.059Term5(t) - 0.716 \quad (8)$$

It is shown that the marginal propensity to consume for U.S. and Japan are significantly larger than zero,while for the Taiwan and South Korea cases, the propensity seems to be lower. Consistent with most term structure studies, there is a positive relationship between the term structure and the output all over the board during the period of 1985-1997. To further understand the interest rate effects on the output level, we also restrict the appropriate elements in the β matrix. Suppose β_i is the ith element in the β matrix, then β_5=0 would imply interest rate is not included in the system. β_6=0 means no term structure effect and β_5=β_6=0 indicates interest rate and term structure do not enter into the system. Table 4 reported the restrictions we impose on each cointegrating vector. We find there are no significant interest rate and term structure effects for Taiwan and Japan while there are significant effects on U.S. and South Korea.

Table 4
Restrictions on the cointegrating vector: domestic effect

Country	Null Hypothesis	LR Test(χ^2)	P Value
Taiwan	$\beta_5=0$	0.05	0.82
	$\beta_6=0$	1.13	0.29
	$\beta_5=\beta_6=0$	0.31	0.86
South Korea	$\beta_5=0$	6.00	0.01
	$\beta_6=0$	3.70	0.05
	$\beta_5=\beta_6=0$	9.44	0.01
Japan	$\beta_5=0$	0.76	0.38
	$\beta_6=0$	0.75	0.38
	$\beta_5=\beta_6=0$	1.38	0.50
U.S.	$\beta_5=0$	17.88	0.00
	$\beta_6=0$	25.62	0.00
	$\beta_5=\beta_6=0$	18.15	0.00

5.2 Short-Run Dynamic Analysis for Domestic Interest Rate

The impulse response analysis and variance decomposition can be used to examine the dynamics responses of fundamentals to real interest rate shock and term structure shock (we present the impulse responses for the Taiwan and South Korea cases only). Following the practice of Sims (1980), we order the relatively exogenous variable first, chosen by the contemporaneous correlation matrix of the innovations. The order of decomposition is as follows: M→Term structure→i→C→I→Y. Figures 1-2 plot the response of Taiwan's domestic fundamentals to the innovations of real interest rate and term structure. The effects of interest rate innovations decrease investment permanently and its effect build up over time. Even though it is shown that interest rate has negative effect on output, the variation is not statistically significant. Consumption and money supply decline after a small increase in their reactions to the interest rate shocks.

Generally, a permanent term structure shock increases all the fundamentals. Figures 3-4 illustrate the South Korea domestic interest rates effects. As is immediately evident from the figures, the domestic interest rate shocks are performing much stronger effects than the term structure shocks. With the exception of investment, the term structure does not appear to have a significant effect on South Korea fundamentals. In the second step, we use the variance decomposition to analyze the relative importance of different real interest rate factors in influencing the trend movements of the fundamentals. The results are presented in Tables 5-8.

Table 5

Impact of U.S. real interest rate and term structures: domestic effect

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{us}	1	4.11	0.64	0.32	2.70
	6	20.60	0.96	2.84	3.69
	12	26.17	1.36	6.50	5.04
	24	32.24	9.57	10.83	9.22
	36	33.63	17.20	12.06	10.83
	48	33.82	21.61	12.19	11.06
US Term 1	1	1.88	0.11	0.31	1.80
	6	7.58	1.79	0.87	3.91
	12	7.25	1.31	1.22	4.83
	24	5.69	0.75	1.45	4.62
	36	5.06	0.71	1.46	4.53
	48	4.87	0.73	1.46	4.50
US Term 3	1	2.72	0.31	0.11	3.40
	6	6.43	4.71	1.16	7.53
	12	5.07	4.67	1.91	11.76
	24	4.02	3.74	1.88	12.03
	36	4.14	3.87	1.93	11.92
	48	4.43	4.27	2.02	11.86
US Term 5	1	1.75	0.42	0.00	4.44
	6	4.72	4.28	1.44	12.35
	12	3.48	4.18	1.83	13.25
	24	3.15	3.99	1.85	14.33
	36	3.83	4.93	1.92	14.44
	48	4.66	6.08	2.12	14.39

It is found in Table 5 that the real interest rate significantly explains the forecast error variance of each time series in the U.S. case, 33% of the variance in the output, 17.2% of the variance in the money supply, 12.06% of variance of investment, and 10.83% of the consumption. However, only the term structure at longer maturities (Term3 and Term5) explains the variance of consumption after the shock occurs. In Japan, the interest rates, including real rates and Term5 explain the change in money supply (see Table 6) over time. In Taiwan (see Table 7), the Term5 and interest rate significantly explain the variations of money supply, while Term1 and Term5 show

Table 6
Imapct of Japan real interest rate and term structures:
domestic effect

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{JP}	1	0.22	0.43	0.55	0.89
	6	0.44	2.08	3.82	2.99
	12	0.79	4.35	6.11	2.95
	24	2.29	8.18	6.38	2.95
	36	3.45	10.49	6.01	2.96
	48	4.13	11.68	6.07	2.97
JP Term 1	1	0.07	0.51	6.97	0.39
	6	0.29	3.30	4.19	0.93
	12	0.29	3.26	6.25	0.92
	24	0.36	3.22	8.68	0.92
	36	0.51	3.41	10.42	0.93
	48	0.64	3.60	11.56	0.93
JP Term 3	1	0.24	0.27	0.74	0.21
	6	0.70	3.72	5.02	1.15
	12	0.71	3.76	7.98	1.16
	24	0.72	3.53	11.19	1.16
	36	0.76	3.42	13.00	1.16
	48	0.79	3.41	13.90	1.16
JP Term 5	1	1.27	0.54	0.28	0.51
	6	3.58	0.73	0.50	1.13
	12	3.63	3.48	0.38	1.13
	24	4.60	7.24	0.50	1.13
	36	7.06	14.29	0.51	1.14
	48	8.94	18.79	1.04	1.16

significant effect on consumption. The result is consistent with earlier arguments that interest rate adjustment does not have any significant impact on output level. In South Korea, except Term5, real interest and term structures play an important role in explaining the variables (see Table 8).

Table 7
Impact of Taiwan real interest rate and term structures: domestic effect

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{tw}	1	1.15	0.32	1.28	4.82
	6	2.08	0.71	1.49	4.48
	12	2.84	0.96	1.51	7.22
	24	4.71	8.40	1.52	5.65
	36	7.03	17.26	1.51	5.00
	48	8.32	21.59	1.52	4.81
TW Term 1	1	0.51	0.53	0.41	1.36
	6	2.27	3.03	1.78	5.80
	12	2.29	2.59	1.79	16.33
	24	2.54	2.17	1.86	6.85
	36	2.54	2.63	1.94	28.47
	48	2.61	4.17	1.94	27.66
TW Term 3	1	0.37	0.80	0.02	0.47
	6	0.83	2.48	0.65	3.83
	12	0.92	1.47	0.68	9.08
	24	1.79	1.12	0.76	13.99
	36	1.95	0.81	0.79	14.73
	48	1.97	0.97	0.79	14.32
TW Term5	1	0.00	0.19	1.01	0.59
	6	2.82	17.06	2.87	0.31
	12	5.04	31.83	2.90	0.23
	24	6.79	38.17	2.91	0.49
	36	6.65	31.06	2.99	1.51
	48	6.42	24.09	3.07	2.58

Table 8

Impact of Korea real interest rate and term structures: domestic effect

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{kr}	1	3.25	0.05	0.15	0.15
	6	2.15	0.37	0.67	0.67
	12	5.02	0.91	0.95	0.95
	24	8.33	5.42	5.63	5.63
	36	8.83	7.88	8.06	8.06
	48	8.95	8.68	8.77	8.77
KR Term 1	1	0.00	1.09	0.00	0.00
	6	3.53	1.29	0.47	0.47
	12	5.81	4.87	4.67	4.67
	24	6.72	8.25	8.36	8.36
	36	7.78	8.63	8.75	8.75
	48	8.41	8.72	8.79	8.79
KR Term 3	1	0.04	0.05	0.17	0.17
	6	4.11	0.37	0.55	0.55
	12	7.37	0.80	5.37	5.37
	24	8.81	5.23	10.28	10.28
	36	9.92	7.83	10.89	10.89
	48	10.58	8.67	10.95	10.95
KR Term 5	1	2.40	0.11	0.40	0.40
	6	0.90	0.63	3.64	3.64
	12	1.56	0.68	1.97	1.97
	24	2.78	1.81	1.58	1.58
	36	2.90	2.52	2.18	2.18
	48	2.79	2.68	2.52	2.52

6. The Foreign Effect of Interest Rates

6.1 Cointegration Test

At this point, we apply the test for cointegration to determine whether further evidence can be obtained on the lack of long-run international relationship. Using U.S. as the base country, we explore if U.S. real interest rate and term structures can dominate over the domestic effect in Asian market. We present only Taiwan and South Korea cases here. The variable vector for Taiwan follows as,

$X' = [Y, C, I, M, i^{tw}, TWterm5, i^{kr}, KRterm5, i^{jp}, JPterm5, i^{us}, USterm5, \text{constant}]$ and for the South Korea is

$X' = [Y, C, I, M, i^{kr}, KRterm5, i^{tw}, TWterm5, i^{jp}, JPterm5, i^{us}, USterm5, \text{constant}]$

Table 9

Cointegration test results for Taiwan and Koea data: international effect

Country	Maximal eigenvalue test		Trace test	
	Null hypothesis	Test stat	Hypothesis	Test stat
Taiwan	r=0	109.22	r=0	461.43
	r=1	87.94	r≤1	352.21
	r=2	65.76	r≤2	264.28
	r=3	45.24	r≤3	198.52
Korea	r=0	92.62	r=0	458.53
	r=1	73.58	r≤1	361.92
	r=2	62.48	r≤2	288.34
	r=3	48.73	r≤3	225.87
Critical values	r=0	72.14	r=0	397.44
α=0.05	r=1	65.79	r≤1	325.30
	r=2	58.69	r≤2	259.51
	r=3	52.40	r≤3	200.82

Note: Maxium lag in VAR is 4. The number of variables included in the system are 12 and an constant

The cointegration test results for the 13-variable vector are reported in Table 9. For both countries, we can reject the null hypothesis of r≤3 using λ_{trace} test (against the alternative of r≥3). But using the λ_{max} test, we can not reject the null of r=3. Therefore, it indicates that there are three cointegrating vectors in both systems. Our purpose here is to restrict the appropriate elements in the cointegrating matrix β, and seek to find out if there still have reasonable long-run relationships among the behavioral coefficients. Suppose β_i is the *i*th element in the β matrix, then take Taiwan for example, $\beta_7 = \beta_8 = \beta_9 = \beta_{10} = 0$ would indicate that Japan and South Korea do not enter into the system and only U.S. interest rate effects count. $\beta_7 = \beta_8 = 0$ would imply that Japan and U.S. interest rate effects are included. Finally, the restrictions, $\beta_9 = \beta_{10} = \beta_{11} = \beta_{12} = 0$, are applied to see how the interest rate effects South Korea has on Taiwan. The results are reported in Table 10 and it shows that for both countries, the likelihood ratio (LR) test suggests that we can reject all the restrictions at very significant level (p=0.00). This provides a strong evidence supporting the inclusion of foreign interest rate and term structure in the long-run relationships.

Even though there are three cointegrating vectors, there is only one with a significant economic meaning. We normalize this cointegrating vector with respect to output, and the result yields the following long-run equilibrium relationship,

$$Y_t = 0.888C_t + 0.631I_t + 0.442M_t - 0.104i_t + 0.145Term5(t) - 0.013i_t^{kr} + 0.131KRTerm5(t) - 0.099i_t^{jp} + 0.079JPTerm5(t) - 0.013i_t^{us} + 0.131USTerm5(t) + 0.223 \quad (12)$$

The long-run relationship for South Korea is as follows,

$$Y_t = 0.029C_t + 0.012I_t + 0.450M_t - 0.028i_t + 0.025Term5(t) - 0.001i_t^{tw} + 0.019TWTerm5(t) - 0.091i_t^{jp} + 0.104JPTerm5(t) - 0.013i_t^{us} + 0.000USTerm5(t) + 0.150 \quad (13)$$

It shows that for both countries, domestic output has a negative relationship with the foreign real interest rates, while it has a positive relationship with the foreign term structure. However, the parameter magnitudes of U.S. term structure are surprisingly small in South Korea case. The overall negative signs of foreign interest rates may indicate an international tramissional effect of fluctuactions on domestic output level., that is, higher domestic interest rate reduces the demand for investment, consumption, and money supply which in turn cause the decreased demand for foreign goods. This domestic demand shocks finally spread to other countries, especially to those export-oriented coutries. The same assumption can also apply to the overall positive sign of foreign term structure. As hypothesized earlier, the positive sign of term structure is indicative of an economic boom. The higher economic growth would likely stimulate an higher demand for foreign goods, which in turn benefits those countries with strong bilateral trade ties.

The speed of adjustment (α) renders us some insight on the endogeneity of the variables. Suppose $\alpha_{i,j}$ indicates that the response of the *i*th variable to the *j*th cointegrating vector. Take Taiwan interest rate (*i*) for example, the speed of adjustment

corresponding to ($\alpha_{5,1}$, $\alpha_{5,2}$, $\alpha_{5,3}$) is (-0.964, 0.653, -2.049) with t statistics equal to (-3.262, 2.879, -3.444). This result suggests that Taiwan interest rates are endogenous in the cointegrated system; that is, this variable is responding to the disequlibrium. The estimated speed adjustment coefficients for South Korea money supply are ($\alpha_{4,1}$, $\alpha_{4,2}$, $\alpha_{4,3}$) = (0.655, -0.474, -0.816) with t statistics equal to (2.858, -2.283, -3.104). This indicates that South Korea money supply is endogenous.

Table 10

Restrictions on the cointegrating vector : international effect

Country	Null Hypothesis	LR Test(χ^2)	P Value
Taiwan	$\beta_7=\beta_8=\beta_9=\beta_{10}=0$	51.07	0.00
	$\beta_9=\beta_{10}=\beta_{11}=\beta_{12}=0$	27.07	0.00
	$\beta_8=\beta_{10}=\beta_{12}=0$	28.50	0.00
	$\beta_7=\beta_9=\beta_{11}=0$	19.39	0.00
	$\beta_7=\beta_8=0$	28.49	0.00
South Korea	$\beta_7=\beta_8=\beta_9=\beta_{10}=0$	41.19	0.00
	$\beta_9=\beta_{10}=\beta_{11}=\beta_{12}=0$	32.66	0.00
	$\beta_8=\beta_{10}=\beta_{12}=0$	18.68	0.00
	$\beta_7=\beta_9=\beta_{11}=0$	31.91	0.00
	$\beta_7=\beta_8=0$	13.16	0.00

6.2 Innovations Accounting

Figure 5 plots the impulse responses of Taiwan growth rates to U.S. real interest rate shocks. An U.S. interest rate shock decreases domestic investment and consumption permanently and its effect builds up. The positive interest rate shock increases Taiwan output and money supply temporarily, but in two months, the domestic market reacts to

the shock negatively. In Figure 6, the effects of term structure innovations die out on output, investment and consumption after first month, but generally there is a positive long-lasting effect. This is consistent with the earlier assumption of the transmissional channel of fluctuations. As for South Korea (see Figures 7 & 8), the effects of U.S. interest rate shocks cause a significant drop in output level and money supply. However, the investment increases with a temporary increase in U.S. interest rate. Even though the effect of U.S. term structure shock is positive, it seems to have weak influence on the South Korea fundamentals (see Figure 8).

Table 11

The impact of U.S. interest rates on Japan

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{us}	1	1.49	2.24	0.01	0.16
	6	4.09	4.14	1.15	1.64
	12	4.21	4.95	2.18	1.64
	24	4.05	4.81	3.31	1.71
	36	4.36	4.89	3.98	1.72
	48	4.69	5.57	4.42	1.72
US Term 1	1	0.13	2.40	0.70	0.02
	6	0.20	3.58	0.59	0.59
	12	1.87	3.16	0.39	0.62
	24	1.89	2.92	0.31	0.66
	36	1.90	2.77	0.30	0.66
	48	1.88	2.69	0.29	0.29
US Term 3	1	0.07	2.04	2.25	0.00
	6	0.68	7.40	1.19	0.70
	12	0.79	6.32	2.93	0.75
	24	0.97	5.48	7.30	0.76
	36	0.98	5.24	8.87	0.76
	48	1.05	5.29	9.22	0.76
US Term 5	1	0.40	0.27	1.97	0.04
	6	0.95	9.06	1.04	1.02
	12	1.42	9.29	3.63	1.23
	24	1.72	8.28	11.79	1.26
	36	1.73	7.97	15.33	1.26
	48	1.85	8.18	16.52	1.27

Table 12

The impact of U.S. interest rates on Taiwan

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{us}	1	0.00	0.36	0.74	1.42
	6	0.90	2.94	2.60	1.46
	12	1.05	3.54	3.13	1.30
	24	1.92	3.30	3.83	2.05
	36	2.69	6.70	3.98	2.91
	48	2.91	9.72	3.98	3.45
US Term 1	1	0.00	1.74	0.33	0.42
	6	0.71	3.30	1.76	1.23
	12	2.30	3.58	1.77	3.31
	24	4.26	3.76	1.84	6.68
	36	4.82	3.91	1.86	7.54
	48	4.91	3.98	1.86	7.63
US Term 3	1	0.02	0.76	1.23	0.07
	6	0.76	0.84	3.15	0.69
	12	1.15	0.49	3.18	1.53
	24	1.74	0.30	3.25	3.58
	36	1.91	0.26	3.26	4.16
	48	1.96	0.25	3.26	4.27
US Term 5	1	0.19	0.12	0.72	0.19
	6	0.15	0.14	3.68	0.49
	12	1.08	0.13	3.73	0.40
	24	1.26	0.17	3.81	0.89
	36	1.38	0.16	3.81	1.17
	48	1.41	0.15	3.81	1.27

Table 13
The impact of U.S. interest rates on Korea

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{us}	1	0.39	2.20	0.54	2.41
	6	1.09	1.50	0.67	5.45
	12	1.56	1.70	0.94	5.27
	24	3.90	2.15	3.44	5.04
	36	4.78	3.90	5.28	5.18
	48	4.99	4.86	5.79	5.33
US Term 1	1	0.04	0.28	0.10	0.05
	6	1.36	1.62	0.24	3.08
	12	3.29	2.60	0.19	2.77
	24	3.93	1.32	1.17	2.87
	36	3.71	1.33	1.85	2.91
	48	3.39	1.42	1.92	2.92
US Term 3	1	0.68	0.53	0.03	0.20
	6	1.64	0.87	0.50	2.70
	12	7.39	0.98	0.47	2.58
	24	10.89	5.47	6.14	2.71
	36	11.48	9.75	10.68	2.92
	48	11.70	11.93	12.66	3.16
US Term 5	1	0.53	0.55	0.29	1.01
	6	1.50	1.36	1.11	2.11
	12	6.08	0.91	0.88	2.21
	24	12.68	6.16	6.37	2.23
	36	15.60	12.30	12.81	2.46
	48	17.26	16.03	16.57	2.97

In Tables 11-13, we report variance decomposition analysis for Japan, Taiwan and Korea using U.S. as the base country. The results show that in Japan-U.S. case, the U.S. term structure, especially Term5, explains substantial proportion of variance in investment and to a lesser extent, the variance in money change. The U.S. interest rate seems to have little effect on Taiwan growth at any level (see Table 12). For South Korea, the U.S. term structure at longer maturities has a significant explanatory power to the variations of output, money and investment over time (see Table 13). We also

compare the interaction between Taiwan and Korea by using this approach. Table 14 presents the response of Taiwan to South Korea real interest rate shocks. It is surprising to note that both South Korean interest rate and term structure shocks explain mostly Taiwan consumption variations at any level beginning from a short period. Nevertheless, only Taiwan Term1 shows a significant explanatory power to the forecast error variance of Korean consumption (see Table 15).

Table 14
The impact of Korea interest rates on Taiwan

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{kr}	1	0.87	0.19	0.00	0.26
	6	1.36	1.39	0.69	10.06
	12	1.52	1.12	0.74	15.61
	24	1.50	1.28	0.76	20.31
	36	1.63	1.57	0.79	21.56
	48	1.78	1.71	0.82	21.64
KR Term 1	1	2.29	0.19	0.46	0.00
	6	2.41	0.08	0.50	6.75
	12	2.78	0.23	0.50	14.03
	24	2.82	1.76	0.51	18.54
	36	3.06	2.42	0.57	18.03
	48	3.13	2.46	0.61	17.44
KR Term 3	1	2.03	0.23	0.51	0.00
	6	2.14	0.05	0.57	6.76
	12	2.55	0.29	0.57	14.47
	24	2.59	1.80	0.58	18.96
	36	2.81	2.45	0.64	18.39
	48	2.89	2.51	0.68	17.75
KR Term 5	1	0.76	0.02	0.08	0.42
	6	2.04	3.44	0.52	17.37
	12	2.58	6.54	0.58	24.46
	24	2.54	10.77	0.63	26.00
	36	2.53	12.30	0.70	26.17
	48	2.53	13.01	0.75	26.33

Table 15
The impact Taiwan interest rates on Korea

Innovations	Horizon (months)	Variables			
		Y_t	M_t	I_t	C_t
i^{tw}	1	1.04	0.10	8.28	1.18
	6	0.46	0.34	3.61	1.63
	12	1.77	0.63	1.71	1.46
	24	2.56	1.37	1.03	1.37
	36	2.52	1.35	1.29	1.35
	48	2.24	1.35	1.53	1.35
TW Term 1	1	3.03	0.06	2.33	4.06
	6	1.09	0.18	1.00	8.22
	12	2.46	2.18	0.84	8.90
	24	5.11	4.21	1.08	9.23
	36	6.67	5.58	3.34	9.25
	48	7.18	6.39	5.20	9.25
TW Term 3	1	3.04	0.00	2.76	2.59
	6	1.65	0.59	1.23	4.07
	12	2.19	2.00	1.07	4.44
	24	4.25	3.28	0.72	4.41
	36	5.68	4.41	2.18	4.39
	48	6.18	5.22	3.83	4.37
TW Term 5	1	0.68	0.16	0.09	0.28
	6	2.21	0.65	0.25	2.50
	12	2.00	2.87	0.24	2.73
	24	1.77	1.80	0.19	2.62
	36	1.76	1.30	0.34	2.52
	48	1.65	1.15	0.57	2.41

7. Conclusions

The objective of this study is to reexamines the relationship between interest rates and economic growth, in which we use output, consumption, investment, and money supply as proxy. We also employ a VAR (vector autoregression) system and cointegration test to interpret the long-run interaction among different variables. The

empirical model studied in this paper incorporates most of arguments in the literature that concerns the domestic and foreign interest rate effects. The analysis of the results reported in the previous sections indicates the evidence of a stable long-run relationship between the output and the real variables. Also, for Taiwan and South Korea, whether the sources of fluctuations come from domestic or foreign countries, there is a negative relationship between real interest rate and the fundamentals while a positive correlation between term structure and the fundamentals. The results suggest there is a transmissional channel of fluctuations across countries.

Restricting the cointegrating vector when we look at the domestic interest rate effect, we find that both interest rate and term structure are not significant factors in the Japan and Taiwan systems. However, there is strong evidence indicating that foreign interest rate and term structure play an important role in domestic economic activities and even outplay the domestic real rates, especially in newly developed countries of Taiwan and South Korea. Besides, the innovation accounting also reveals an inseparable relationship among Asian markets. However, this study which focuses only on the interest rate effects is not suited to analyze potential impacts of international flow of knowledge and of trade interdependency on growth, which counts for the dramatic GNP growth in those newly industrialized Asian countries. Further research is suggested to extend the simple model to analyze the effects of economic integration on the international transmission of technological shocks and trade flows.

Figure 1: Responses to interest rate innovations: Taiwan Domestic Effect

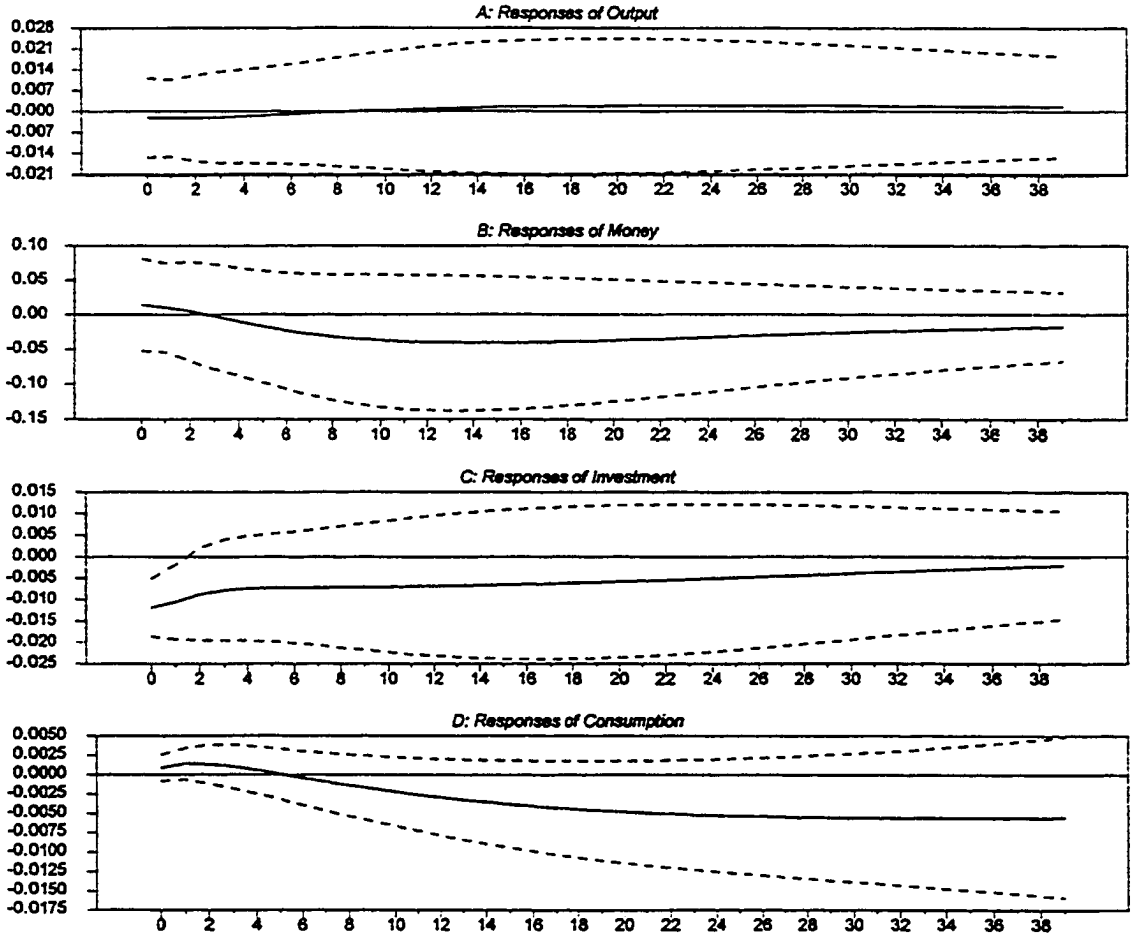


Figure 2: Responses to term structure innovations: Taiwan Domestic Effect

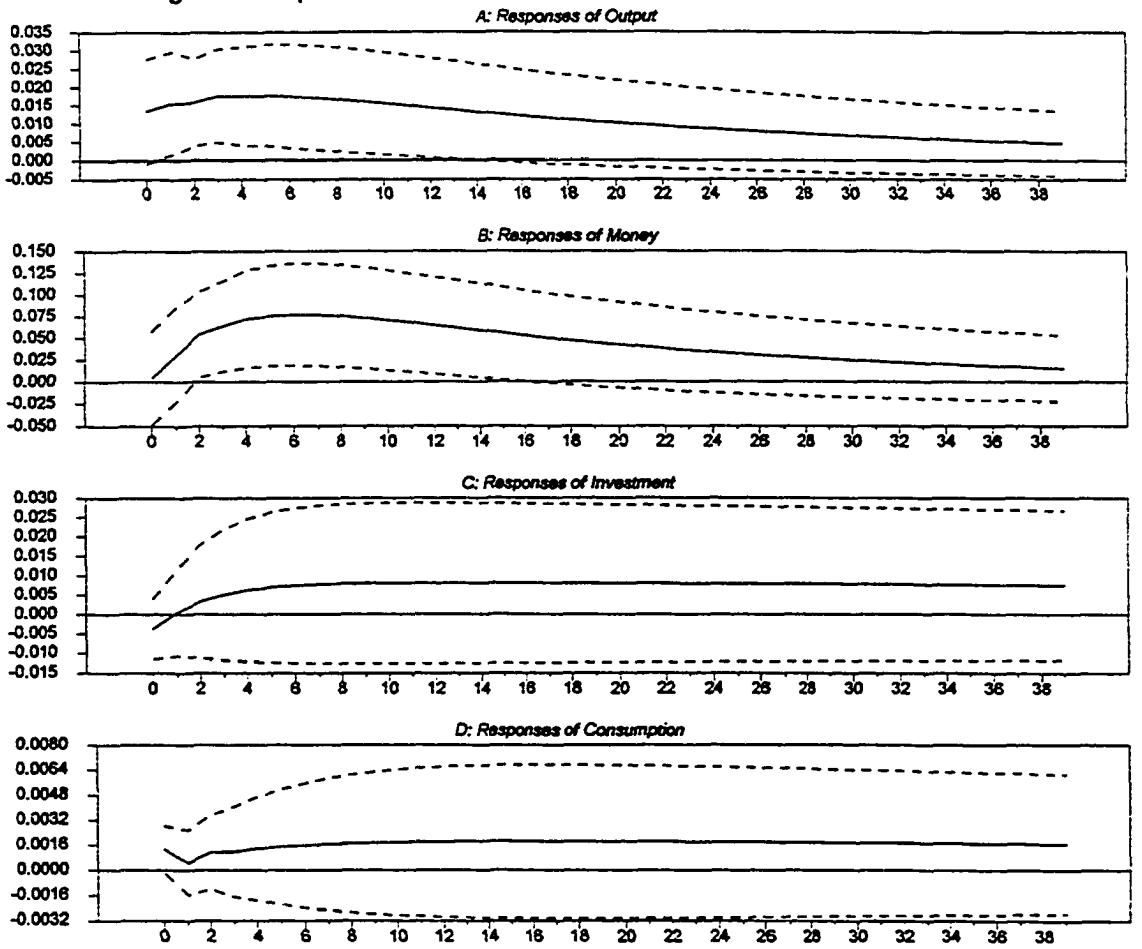


Figure 3: Responses to interest rate innovations: South Korea Domestic Effect

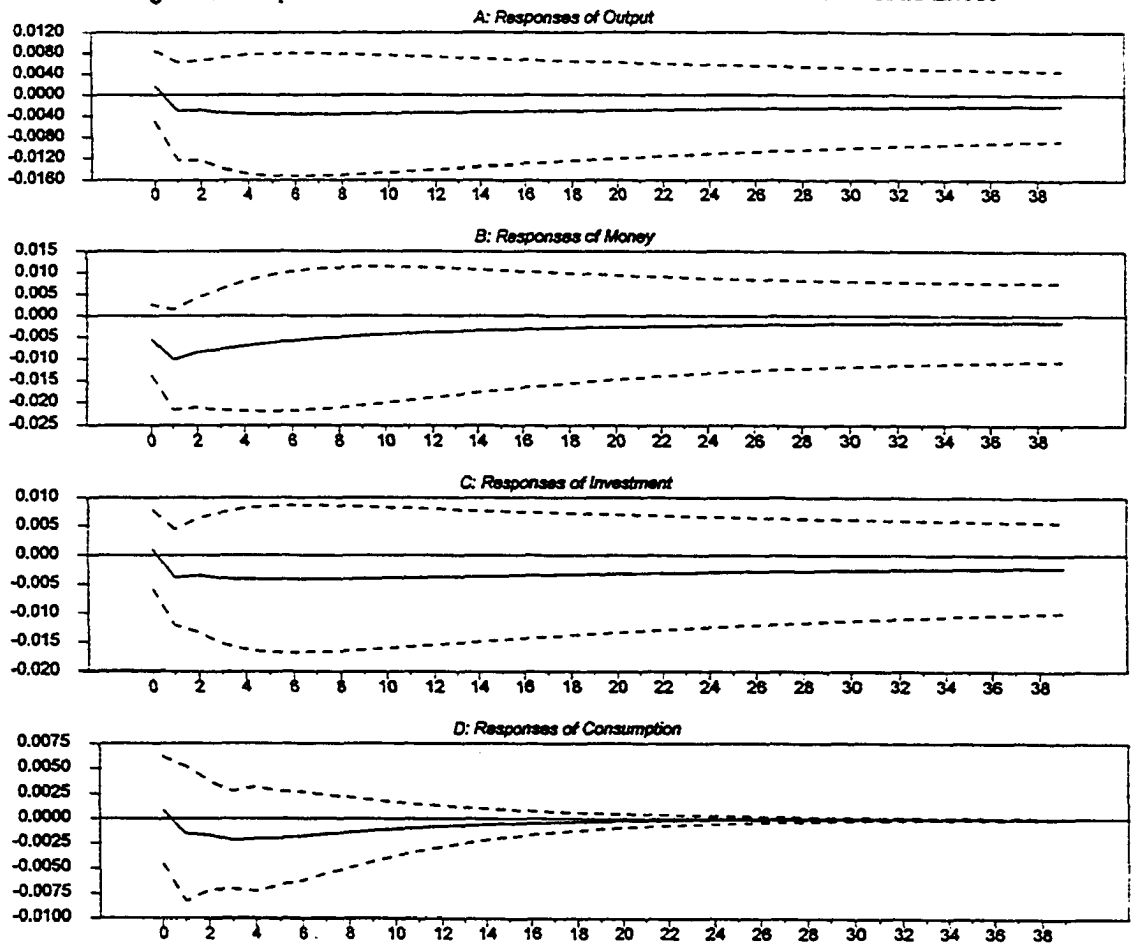


Figure 4: Responses to term structure innovations: South Korea Domestic Effect

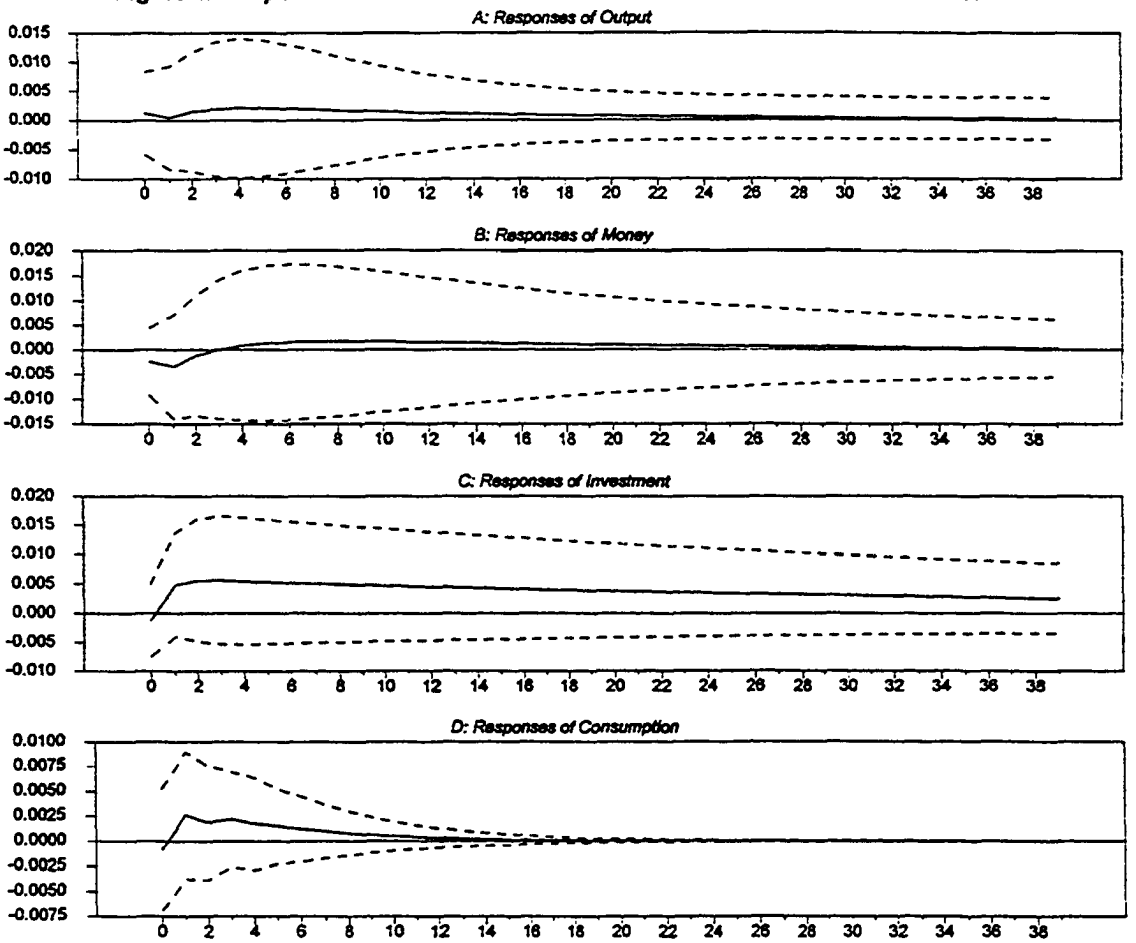


Figure 5: Responses to U.S. interest rate innovations: Taiwan Case

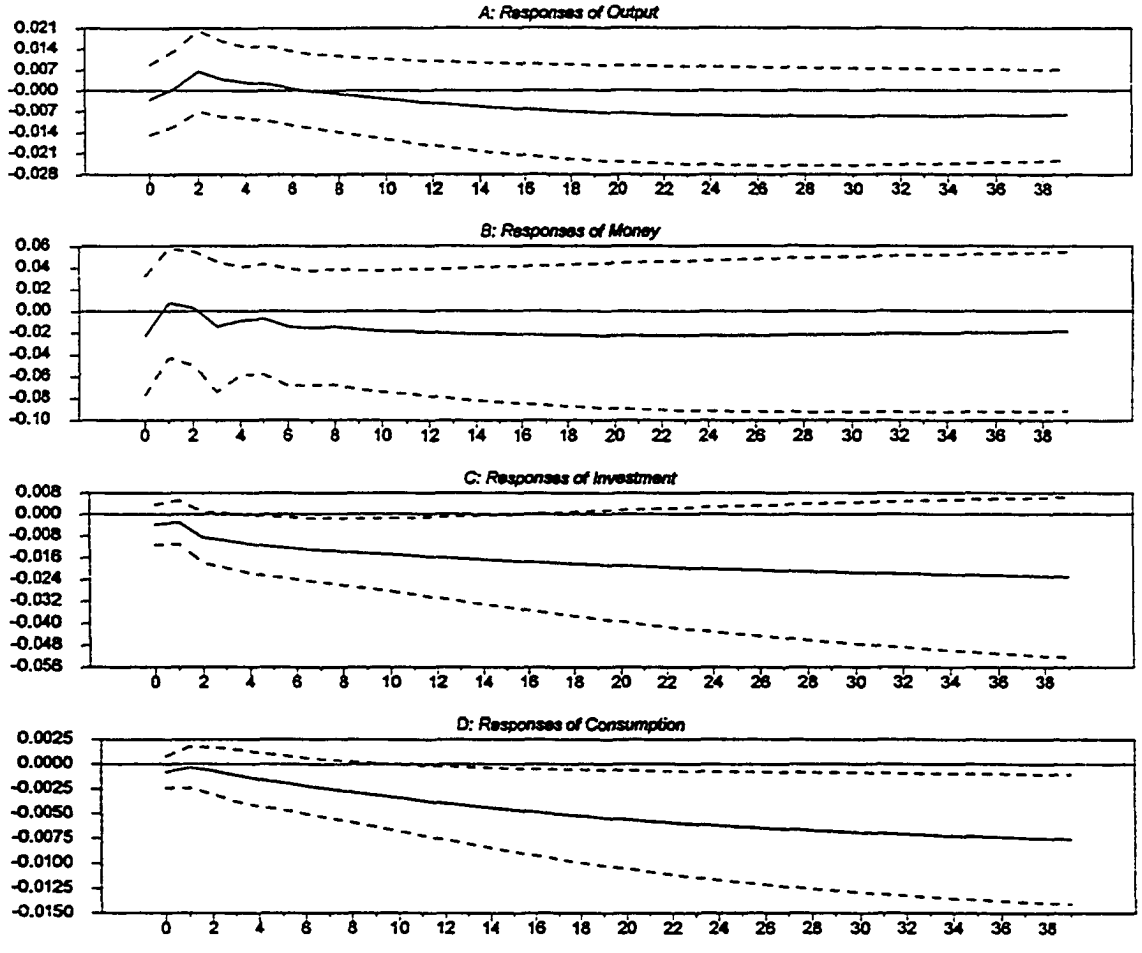


Figure 6: Responses to U.S. term structure innovations: Taiwan Case

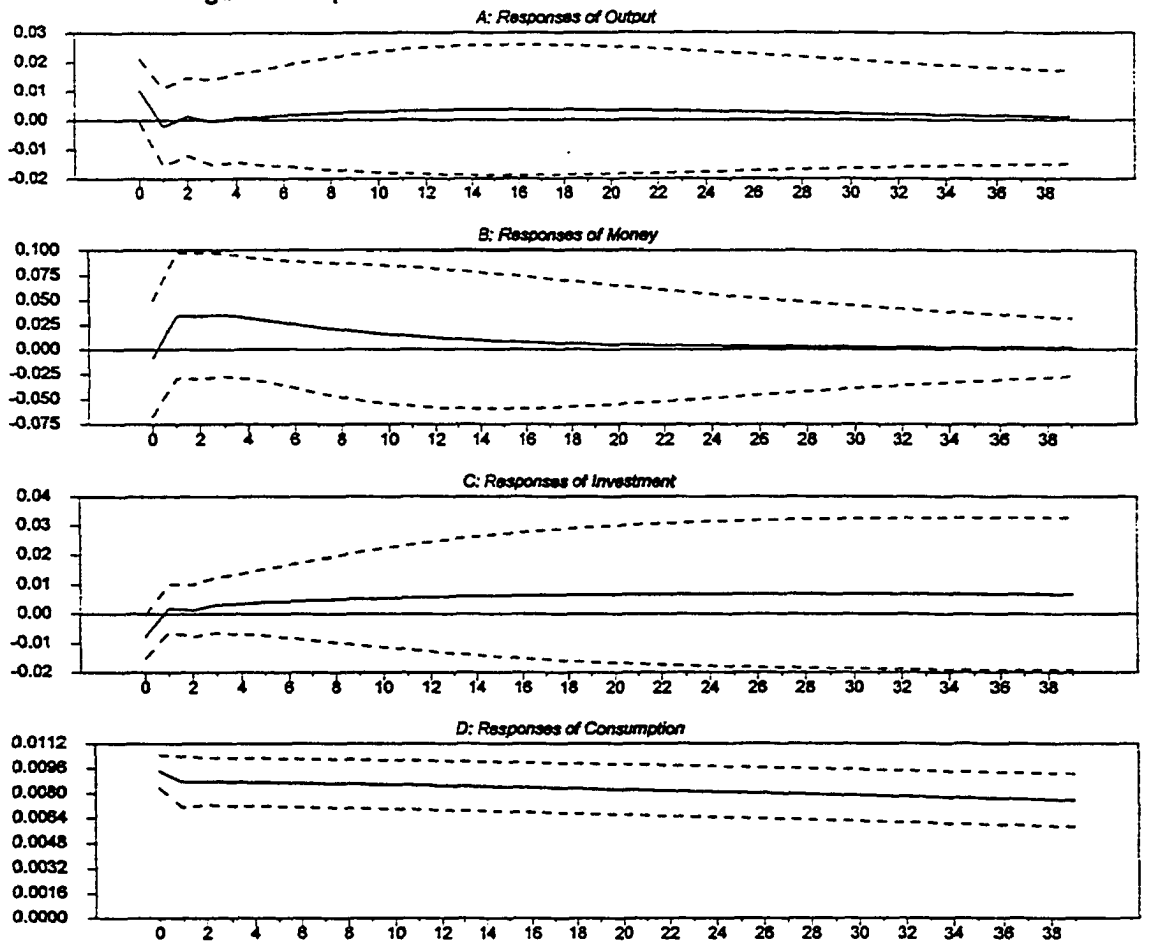


Figure 7: Responses to U.S. interest rate innovations: South Korea Case

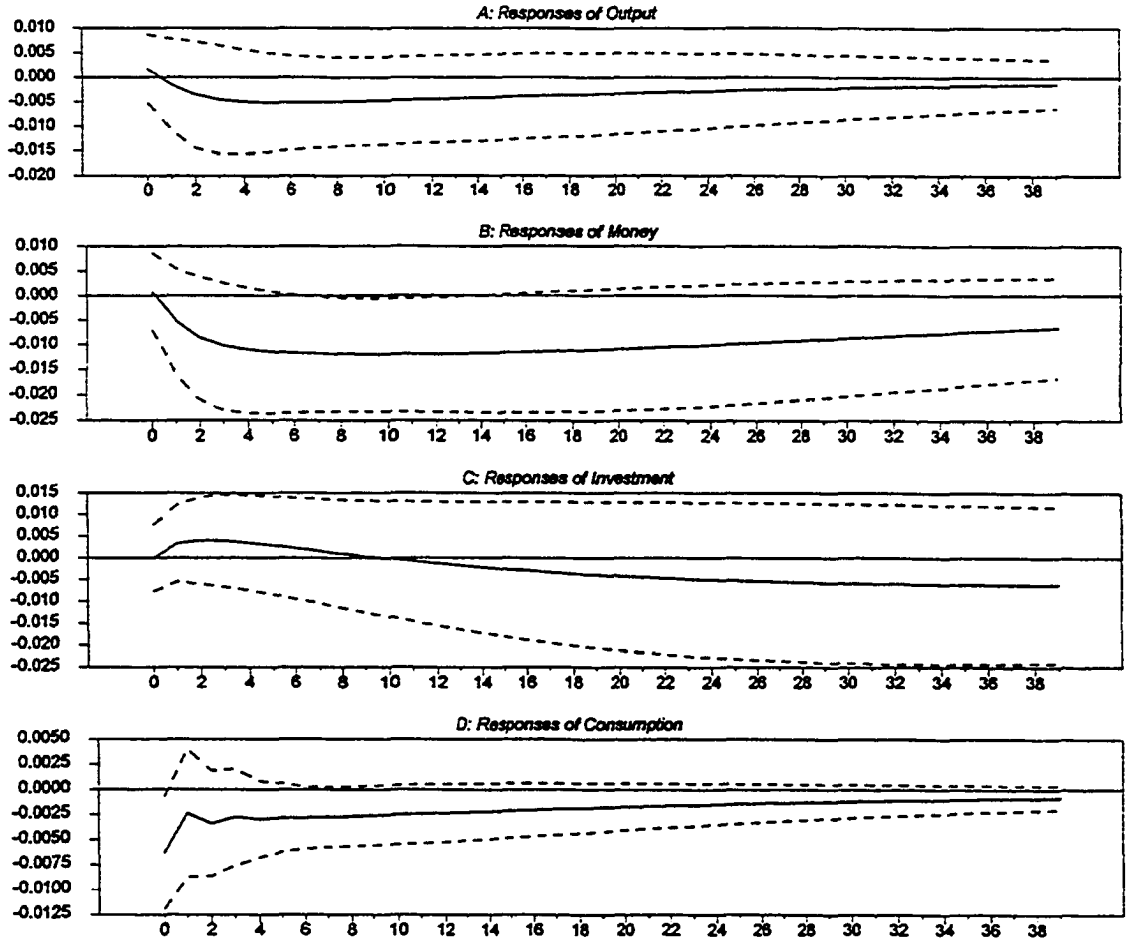
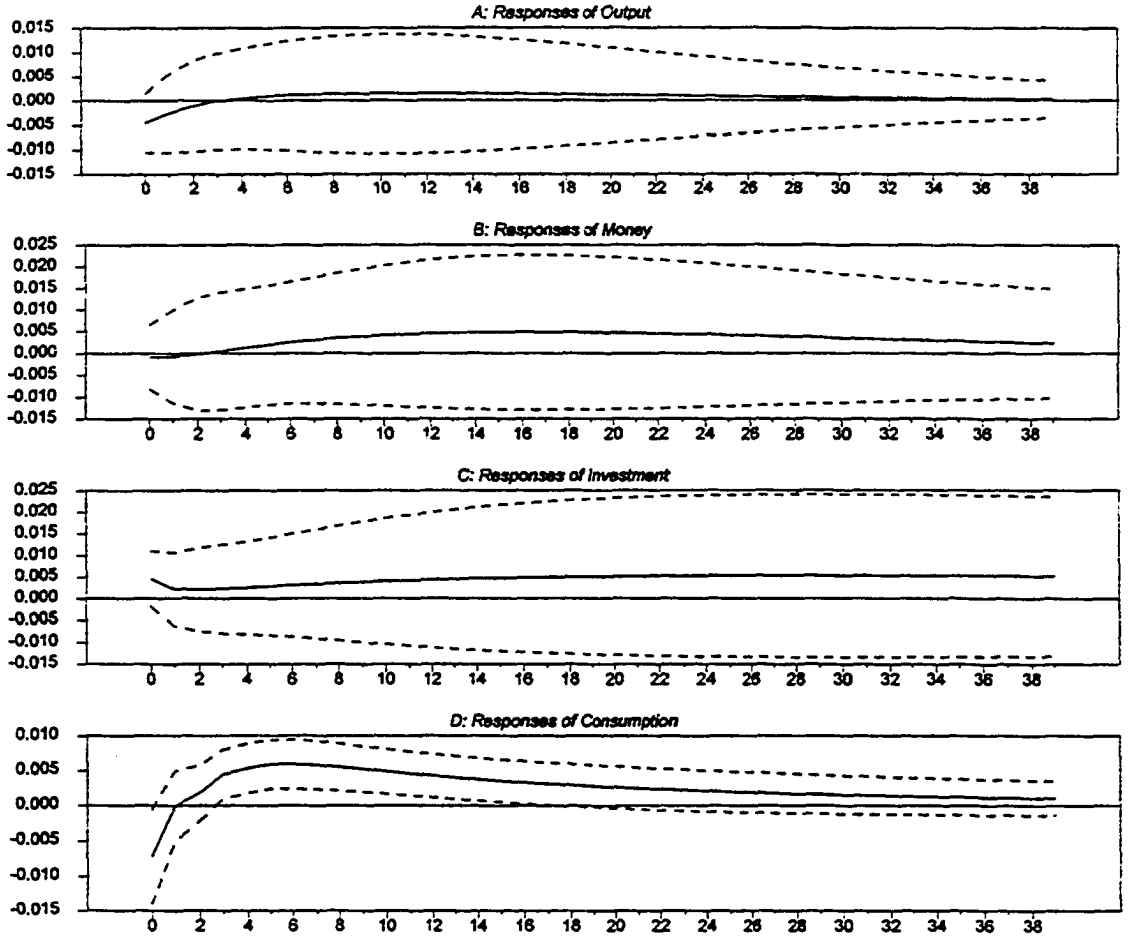


Figure 8: Responses to U.S. term structure innovations: South Korea Case



PART II

The Dynamics of Export Growth and International Business Cycles: The Experiences of Taiwan and South Korea

1. Introduction

The concept of real business cycle (RBC), which is an expression of cyclical behaviors of macroeconomic components, refers to the hypothesis that the cumulative effect of permanent shocks to productivity explains the macroeconomic fluctuation. Over the last decade, the dynamics of business cycles have been a popular debate to economists concerning the relative persistence of positive and negative shocks to the economy. In recent years, owing to a significant international economic interdependence, authors, e.g.; Baxter and Crucini (1993), Backus, Koehoe, and Kydland (1992, 1993), Dellas (1993), Stockman and Tesar (1995), Elliott and Fatas (1996), have made prominent contributions to extend the closed RBC model to an international setting. It is generally assumed that the openness of international financial and goods market can induce more freedom and rapid channel for the transmission of economic fluctuations across countries. Those papers have yielded important stylized facts aiding us in understanding the natures of business cycles. First, there is a positive correlation in the output level over short horizon. Second, money responds positively to fluctuation in production, which is induced by technological shocks. Third, trade flows exert a

significant macroeconomic effect on trade-dependent economies, which in turn smooth consumption intertemporally.

Dellas (1986) conducts an international aspect of cyclical behavior of the United States, the United Kingdom, German and Japan from 1960 to 1982. However, he finds the trade flows among these industrial countries are not the main engine responsible for the international business cycles. He attributes this ambiguous finding to the presence of common external oil shocks, similar economic background among the countries, and weaker trading links to each other. In 1995, Dellas extends the trade-based cycles studies to "smaller, more trade-dependent economies as well as countries with stronger bilateral trade ties." He finds the external shocks account for a significant variation of domestic output in the long run, and the role of trade is stronger before rather than after 1973. His explanations are that after 1973, the world experiences the two oil shocks, and the increasing integration of financial market has downplayed the role of trade.

However, we doubt the moderate significance of trade interdependence that Dellas concludes is subject to his choice of sample countries. Those industrial countries, such as U.S., German, Switzerland have the long standing economic power in the world economy. The transmission of economic fluctuations through trade account would possibly need longer time to exercise effect. In fact, after the oil shocks of earlier 1980s, Asian market has been playing an important part in world trade than those industrial countries did before. The newly industrialized countries (NICs) such as Taiwan, South Korea, Hong Kong and Singapore all experienced a rapid boom during the mid-1980s due mainly to increased exports, which has significantly led to stronger trading ties to the United States. These export-oriented developments are supposed to have faster

transmission channel to the economic fluctuations, which is either of domestic or foreign origin.

Besides, the volatility in the prices of oil would still represent the most identifiable aggregate shocks to the export-oriented countries having a heavy dependence on imported oil, although after 1980s the effect of oil price shock has been weaker.[10] We assume that oil price shock will serve as a critical mechanism in the policy making process of those exporting countries. That is, the volatility of oil prices worsens their competitiveness when the hiking oil prices increase the production costs. To offset this price effect, the governments would most possibly react with a depreciation of their currencies (the so-called exchange pass-through relationship). The oil price shocks, which accelerate the volatility of exchange rates, are supposed to be quickly transmitted to those export-led countries rather than to the industrial countries who have less trade ties to the United States.

Even though there has been an extensive literature concerning the international business cycles, but little attention has been paid to the dynamic structures of foreign disturbances.[11] In this chapter, we would examine the predictions of real business cycle model with regard to the different effects of domestic and foreign disturbances. In doing so, we use smaller open economies which have increasing bilateral trading ties to the United States. Two newly industrialized countries (NICs) such as Taiwan, and South Korea, are included for this study. Theoretically, we expect U.S. disturbances will affect

[10] Hooker (1996) has offered evidence against the weaker effect of asymmetric oil prices on macroeconomy using recent data.

[11] Elliot and Fatas (1996) conduct a model using data from Japan, U.S. and Europe. They find positive cross-country co-movements in productivity are due to the transmission of U.S. shocks, but Japan and European shocks do not have significant effect on other countries' productivity.

these two countries through foreign trade, the exchange rate and the aggregate price level (Dornbusch 1983, Marston 1985, McCallum 1994). Since shocks from these two small open economies could have little impact on the United States, we also assume that U.S. disturbances are exogenous in the formation of our model.[12]

The goal of this study is to identify the sources of economic fluctuations after Taiwan and South Korea liberalized their financial markets in 1981. In particular, we want to know if the greater openness of financial sectors will insulate the foreign disturbances, or if those shocks to domestic real activities are basically of domestic original.

To shed light on these hypotheses, we employ a structural vector autoregressive (VAR) technique developed by Bernanke (1980), Blanchard and Watson (1986) and Sims (1986) to estimate the structure disturbances. By using VAR and cointegration techniques, we find that foreign disturbances explain substantial portions of variations of Taiwan's exports, but explain little of South Korea's exports. However, domestic disturbances play an important part in both countries. Cointegration tests also suggest the long-run neutrality of money supply.

The rest of the study is organized in the following manner. Section 2 presents the empirical VAR model and discusses the identification issues. In Section 3, we detail the data source and report the empirical results. Section 4 concludes our study.

[12] This assumption may need further empirical evidence. Moreno (1991) indicates recent efforts by major Asian economies, which include Taiwan, South Korea, and Japan, to improve access to their market will tend to increase the responsiveness of the demand for U.S. exports to foreign GNP. However, in his study, this assumption is not statistically significant.

2. The Structural VAR Model

This paper examines a structural model of a small open economy and two "illustrative" models are constructed to trace out the importance of various structural innovations. The structural vector autoregressive (VAR) technique used in this study is developed by Bernanke (1986), Blanchard and Watson (1986) and Sims (1986). The structural VAR approach is applied to supplement the innovation information that could be lost using traditional recursive Choleski technique. Cooley and LeRoy (1985) have criticized that Choleski factorization which identify orthogonal shocks as structural disturbance could be misspecified. They argue this technique fails to explain the "true" structural interpretations as it implies a recursive contemporaneous model that is rarely derived from economic theory.

Our structural VAR model is different from traditional one-model setting, which is based on two "illustrative" systems. Model 1 is denoted as "external disturbance model" by assuming that the volatility of domestic exports is exclusively determined by external disturbances, such as U.S. GNP (USGNP), U.S. prices (USP), U.S. nominal money supply (USM), and real world oil prices (OIL). Model 2 is regarded as "domestic disturbance model" that includes domestic exchange rate (π), money supply (M), and the oil prices as dominant disturbances for the oil-importing countries. Both Model 1 and 2 share the same explanatory variable– the oil prices, as we think of the oil price as a common disturbance, which can be regarded as 'exogenous' external or internal disturbances that would simultaneously affect the world economy, (see, for example,

Dellas (1994)). Splitting our model into two parts would distinguish our study twofold. First, we can deal with two common problems associated with the VAR representation. The larger model does not only need more a priori restrictions to be specified in order to recover the structural VAR equations but also typically yields large standard errors because they estimate many parameters. Two modeling settings would minimize unnecessary and irrational restrictions on the structure of the economy. Second, if the external disturbance model explains little portions of the variations of domestic exports, we may suppose that domestic disturbances may be primarily responsible for the dynamics of export growth; thus, an empirical study of Model 2 could further aid us in identifying the domestic shocks. Of course, both models' expressions are somewhat ad hoc and one may argue they ignore some other important interactions among the variables. However, since this study is conducted on a two-country basis, and if both models can yield reasonable results across countries, then it would lend support to use the split models.

We follow by demonstrating conditions under which a dynamic simultaneous system of linear equations yields a VAR reduced from. It is assumed that the structural system is represented by a linear-invariant, stochastic dynamic relationship,

$$X = A(L)\varepsilon \tag{1}$$

where X is $k\times1$ vector of endogenous variable. $A(L) = I + A_1 L + A_2 L^2 + ... + A_p L^p$, is an $k\times k$ matrices polynomial in the lag operator L. ε, fundamental structural disturbances, are

assumed to be a vector of serially independent distributed error terms with zero mean and constant variance; that is, $\text{cov}(\varepsilon) = \sigma^2 I$ and I is an identity matrix.

The Wold moving average (VMA) representation is given by

$$X = B(L)e \tag{2}$$

where B (L) is an invertible $k \times k$ matrix with B(0)=I and e is a $k \times 1$ vector of white noise innovations with $Eee' = \Omega$. The VMA representation provides us a useful tool to examine the dynamic response of X sequence to the structural disturbances included in e vector.

We further assume that the linear relationship between e and ε is such that

$$e = C(0)\varepsilon \tag{3}$$

where C (0) is $k \times k$ matrix with full rank, and combining equations (1), (2) and (3) yields,

$$A(L) = B(L)C(0) \tag{4}$$

we can also obtain the variance-covariance matrix from equation (3), such that

$$C(0)C(0)' = \Omega \tag{5}$$

Thus, in order to recover estimates of the structural disturbances, e, it is necessary to identify C(0). For example, our model 1 includes four variables, which are exports, oil prices, U.S. GNP, and money supply, as there are 16 ($k \times k$) independent elements in Ω and 10 ($k \times (k+1)/2$) unknown elements in C(0), we need to impose 6 ($k^2 - k(k+1)/2 = k(k-1)/2$

) restrictions on C(0) to identify the structural parameters. Once C(0) is determined, A(L) can be derived from (4).

In our model, we first assume a structure of block exogeneity in which oil is exogeneous to the rest variables, and all of U.S. variables are exogeneous to Taiwan and South Korea exports; that is, either contemporaneous or the lagged values of the exogeneous variables don't have any effect in the formation of C(0) matrix. We accordingly built the restricted C(0). let C_{ij} be the ijth element of C(0), then the C(0) matrix has the following form

Model 1:

$$\begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} \\ 0 & C_{23} & 0 & 0 \\ 0 & C_{32} & C_{33} & C_{34} \\ 0 & 0 & C_{43} & C_{44} \end{bmatrix} \begin{bmatrix} \Delta EX \\ \Delta OIL \\ \Delta USGNP \\ \Delta USM \end{bmatrix} = \begin{bmatrix} \varepsilon_{ex} \\ \varepsilon_{oil} \\ \varepsilon_{y} \\ \varepsilon_{m} \end{bmatrix}$$

in which Δ is the difference operator (eg., $\Delta EX=(EX_t-EX_{t-1})$, and all variables are in logarithm form. As there are 6 zero restrictions on C(0) matrix, the system is exactly identified.

The domestic model is generally based on two types of restrictions, one is the restriction of exogeneous oil price mentioned earlier, and the other are the contemporaneous restrictions, which assume that the demand for export and exchange rate are independent of contemporaneous shocks to the money supply. While making the second assumption, this study may fall into a potential theoretical pitfall. Under Baldwin's hysteressis model (1988), he indicates that if market-entry costs are sunk, nominal shocks can have persistent real effects through altrering domestic market

structure. Sargent (1987) also points out that variations in the money stock generated via open market operations may not be netural due to the fiscal effects of changes in the government's interest payments. However, our study would still be based upon this assumption, but only focus on the short-run effect of the nominal money supply shock. Combining those restrictions, C(0) is defined as

Model 2:
$$\begin{bmatrix} C_{11} & C_{12} & C_{13} & C_{14} \\ 0 & C_{22} & 0 & 0 \\ C_{31} & C_{32} & C_{33} & C_{34} \\ 0 & 0 & 0 & C_{44} \end{bmatrix} \begin{bmatrix} \Delta EX \\ \Delta OIL \\ \Delta \pi \\ \Delta M \end{bmatrix} = \begin{bmatrix} \varepsilon_{ex} \\ \varepsilon_{oil} \\ \varepsilon_{\pi} \\ \varepsilon_{m} \end{bmatrix}$$

in which there are 6 restrictions on C(0) matrix. The system is also exactly identified.

3. Data and Empirical Results

3.1 The Data

This study investigates the responses of export growth to different sources of macroeconomic fluctuations using monthly observation over the period 1981:1 to 1997:9. We choose this period mainly because both Taiwan and South Korea began their market liberalization regimes in 1981. All the data are obtained from International Financial Statistics except those for Taiwan, which are from the executive Yuan of Taiwan (DGBAS). The domestic (Taiwan and Korea) variables include 'TWEX': total Taiwan exports to the U.S., deflated by Taiwan consumer price index (1990 as base year);

'KREX': total South Korea exports to the U.S., deflated by Korea CPI; 'M': Seasonally adjusted M2 series; 'π': real exchange rate which are relative to the U.S. dollar. The foreign (U.S.) variables are 'USGNP': the industrial production series with 1990 as base year; 'USM': monthly aggregate M2; 'USP': consumer price index (1990 as base year). "OIL' is the world real price of oil, proxied by the crude oil price index of the United Arab Emirates deflated by the world non-fuel price index. All variables are in logarithms and seasonally adjusted.

Table 1
Phillips-Perron Unit Root Test

Variable	Level		First-Difference	
	$z(\tau_\mu)^1$	$z(\tau_\tau)^2$	$z(\tau_\mu)$	$z(\tau_\tau)$
USGNP	-2.01	-2.17	-4.71*	-4.98*
USM	-1.41	-1.28	-3.69*	-3.97*
OIL	-1.72	-2.71	-4.86*	-4.88*
TWEX	-0.98	-1.87	-6.73*	-6.98*
KREX	-2.15	-2.87	-7.14*	-7.81*
TWM	-1.78	-1.98	-4.17*	-4.21*
KRM	-1.47	-1.74	-3.99*	-4.02*
TWπ	-2.01	-2.13	-7.41*	-7.61*
KRπ	-1.57	-1.69	-6.19*	-6.43*

Notes: 1. There is no trend in the equation. The 5% critical value is -2.23 with T= 250

2. There is a trend in the equation. The 5% critical value is -3.45 with T= 250

3.2 Tests of Order of Integration

In order to justify the appropriateness of the structural VAR models in last section, it is necessary to show that each individual series is integrated of order 1 (I(1)) and there exists no cointegration vector among the variables. As conventional

augumented Dicky Fuller (ADF) tests (1979, 1981) are subjected to having lower power against autoregressive alternatives with roots near unity. We employ the Phillips-Perron (1988) test to examine the unit root in the series. The Phillips-Perron test which would tolerate weakly dependent and heterogeneously distributed disturbances is supposed to have greater explanatory power than ADF tests.[13]

Table 1 provides the results of the unit root test for the stationarity of the level as well as for the first-differenced series. Both statistics of $z(\tau_\mu)$ and $z(\tau_\tau)$ show all the variables are nonstationary in level, but are stationary in first difference. Therefore, we conclude that all the variables are I(1).

Table 2

Cointegration test results for Model 1: X= (USGNP, OIL, USM, EX)'

Country	Maximal eigenvalue test		Trace test	
	Null hypothesis	Test stat	Null hypothesis	Test stat
Taiwan				
	r=0	18.22	r=0	30.83
	r=1	10.14	r≤1	12.61
	r=2	2.40	r≤2	2.47
	r=3	0.07	r≤3	0.07
South Korea				
	r=0	20.02	r=0	33.73
	r=1	8.65	r≤1	13.71
	r=2	5.02	r≤2	5.16
	r=3	0.04	r≤3	0.04
Critical Value				
	r=0	28.14	r=0	53.12
	r=1	22.00	r≤1	34.12
	r=2	15.67	r≤2	19.96
	r=3	9.24	r≤3	9.24

Note: X denotes the variables included in the cointegration vector. The number of lags used in the system is 4

[13] We also conduct the ADF tests for reference, and the results are consistent with the conclusions of PP

3.3 Cointegration tests

Engle and Granger (1987) demonstrate that a VAR in differences will be misspecified if the variables are cointegrated. The differenced system would no longer have a multivariate time series representation with an invertible moving average. Thus, it is necessary to determine if the nonstationarity of the level variables is due to the common stochastic trends before we employ the VAR techniques. If the level variables are nonstationary but share a common trend; in other words, there exists a linear combination of the level variables, which is stationary, then the VAR model should be replaced by an error correction representation (ECM). For this purpose, we apply the Johansen (1988) and Johansen and Juselius (1991) maximum likelihood rank tests to test the long-run equilibrium relationships among the variables. Table 2 reports the cointegration results for Model 1.[14] From λ_{trace} test, we can not reject the null hypothesis of r =0 against the alternative of r=1 at the 95% critical levels for four countries. The λ_{max} test also can not reject the null hypothesis of r=0 against the null of r=1. This result strongly indicates that there no cointegrating vector for each country.

In sum, based on the findings that each individual series is I (1) process, and there exists no cointegrating relationships for Model 1, we then proceed to apply the VAR representation in the first-differenced variables of interest.

As Model 1 is an exactly identified decomposition, our goal is to use the Sims-Bernanke procedure (1986) to retrieve the contemporaneous relationship among the

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test.

variables. Using 6 restrictions in C(0), we obtain the following contemporaneous coefficients and their standard errors in parentheses,

Taiwan:
$$\underset{}{\Delta EX} + \underset{(0.108)}{0.298\,\Delta OIL} - \underset{(0.260)}{0.881\,\Delta USGNP} - \underset{(0.054)}{0.317\Delta USM} = \varepsilon_{ex}$$

South Korea:
$$\underset{}{\Delta EX} + \underset{(0.160)}{0.549\,\Delta OIL} - \underset{(0.385)}{0.255\,\Delta USGNP} - \underset{(0.083)}{0.356\Delta USP} = \varepsilon_{ex}$$

In Taiwan's equation, the coefficients for oil price, USGNP, and USP are all statistically significant at the level of 0.01, but USM is insignificant. In South Korea's equation, oil price is significant at 0.01 level, while USGNP and USM are insignificant in the equation. This results explain that for both countries, oil prices are the main factors creating the slowdown in exports. As for Taiwan, the negative coefficients of U.S. variables suggest that Taiwan would accelerate its exports to U.S. in response to the increasing foreign market demand. Even though U.S. factors are insignificant for South Korea, this does not mean that South Korea is not interested in the foreign factors when they engage trades with the United States.

[14] As Johansen procedure implies, the result of cointegration test is very sensitive to the lag length. Hence LM test for the correlation in the residuals and LR test for the appropriate lags are performed. Both statistics show to choose the lags of 4.

Table 3

Cointegration test results for Model 2: X= (EX, OIL, π , M)'

Country	Maximal eigenvalue test		Trace test	
	Null hypothesis	Test stat	Null hypothesis	Test stat
Taiwan	r=0	37.17	r=0	63.59
	r=1	19.07	r≤1	26.41
	r=2	4.90	r≤2	7.32
	r=3	2.43	r≤3	2.43
South Korea	r=0	32.24	r=0	62.68
	r=1	16.17	r≤1	30.44
	r=2	12.97	r≤2	14.27
	r=3	1.29	r≤3	1.29
Critical Value	r=0	28.14	r=0	53.12
	r=1	22.00	r≤1	34.91
	r=2	15.67	r≤2	19.96
	r=3	9.24	r≤3	9.24

Note: X denotes the variables included in the cointegration vector. The number of lags used in the system is 4

Table 3 reports the cointegration results for Model 2. From λ_{trace} test, we can reject the null hypothesis of r =0 against the alternative of r=1 at the 95% critical levels for both countries while the λ_{max} test can not reject the null hypothesis of r=1 against the null of r=2. This result suggests that there is only a cointegrating vector for each country. As there exists a cointegrating relationship among the variables, the VAR representation is no longer justifiable; thus we replace Model 2 by a ECM. As defined earlier, Model 2 contains a vector in level, $X = [EX\ OIL\ \pi\ M]'$. Since all of the variables are I(1) process, equation (1) can be written as the following error correlation representation

$$\Delta X_t = \sum_{i=1}^{p-1} \Pi_i \Delta X_{t-i} + \Pi X_{t-p} + \delta_t \qquad (6)$$

where δ_t is a vector white noise process and the matrix Π conveys the long-run information contained in the data. If the rank of Π is r, where $r \leq 4$, Π can be decomposed into two $4 \times r$ matrices, α and β, such as $\Pi = \alpha\beta'$. The matrix β consists of r linear cointegrating vector while α can be interpreted as a matrix of vector error-correction parameters (or speed of adjustment).

We next report the long–run cointegrating relationship in Model 2. In order to reveal the exports as a dependent variable, we normalize this cointegrating vector with respect to exports (EX). The result yields the following relationship (with asymptotic statistics in parentheses),

Taiwan:

$$EX = -0.026\ OIL - 0.260\ \pi + 0.514\ M$$
$$\text{(-2.617)} \quad \text{(-3.107)} \quad \text{(0.124)}$$

South Korea:

$$EX = -0.307\ OIL - 0.422\ \pi + 0.224\ M$$
$$\text{(-2.897)} \quad \text{(-4.183)} \quad \text{(1.79)}$$

It is shown that for each country, the real oil prices and exchange rate are statistically significant and they both affect the exports negatively. The negative sign of the oil prices may explain both countries are heavily dependent on imported oil, and an unexpected rise in the oil prices would bring up the domestic price level and finally reflects its costs on exports. The signs of exchange rate and money supply are as

hypothesized. However, there is no significant money effect on exports for both countries.[15] This result could be used to reinforce the earlier assumption of long-run neutrality of money. As money supply is found insignificant in the long-run relationships, in order to reveal the trend movement of the real exports we impose a restriction on the β matrix (M=0). The result in Table 4 shows there is only one cointegration vector in the new three-variable model (EX, OIL, π) in both cases. We show the long-run equilibrium with asymptotic t statistics in parentheses as follow

Taiwan:

$$EX + 0.081\ OIL + 0.782\ \pi = 0$$
$$(-3.07) \quad (-4.13)$$

South Korea:

$$EX + 0.259\ OIL + 0.266\ \pi = 0$$
$$(-3.84) \quad (-5.01)$$

[15] We also restricted the money supply (M) as equal to zero in the β matrix. The likelihood ratio test suggests this restriction is binding for both countries. The significance level are 0.01 and 0.00 for Taiwan and South Korea, respectively.

Table 4

Cointegration test results for Model 2: X= (EX, OIL, π)'

Country	Maximal eigenvalue test		Trace test	
	Null hypothesis	Test stat	Null hypothesis	Test stat
Taiwan	r=0	27.13	r=0	43.28
	r=1	12.21	r≤1	16.25
	r=2	4.14	r≤2	4.14
South Korea	r=0	25.14	r=0	43.11
	r=1	11.53	r≤1	17.97
	r=2	6.44	r≤2	6.44
Critical Value	r=0	22.00	r=0	34.12
	r=1	15.67	r≤1	19.96
	r=2	9.24	r≤2	9.24

Note: X denotes the variables included in the cointegration vector. The number of lags used in the system is 4

The unconstrained α also gives the adjustment speed parameters. For Taiwan, the estimated parameters are (α_{EX}, α_{OIL}, α_{π}, α_{M})= (-0.015, -0.00, -0.016, -0.019) with t statistic equal to (-3.036, -0.007, -2.017, -0.472). This result suggests oil prices, exchange rate and money supply are weakly exogenous with exports to be relatively endogenous in the system. Therefore, we conclude that export is the main variable responding to disequilibrium in the Taiwan system. The South Korea case also supports the same version that export is relatively endogenous, where α is equal to (-0.00, 0.00, 0.00, -0.004) and corresponding t statistic is (-0.10, 1.004, 2.325, -1.725).

Table 5

Variance decomposition for Model 1

		USM	USGNP	OIL	EX
TWEX	1	3.88	10.42	10.17	75.43
	6	2.69	11.69	18.24	67.38
	12	2.17	11.42	20.17	66.24
	24	1.14	11.38	25.21	62.24
	36	1.61	11.37	27.14	59.88
	48	1.11	11.36	29.41	58.12
KREX	1	0.98	0.45	17.12	81.45
	6	1.14	1.72	18.24	78.90
	12	1.15	1.76	18.41	78.68
	24	1.16	1.67	20.14	77.03
	36	1.16	2.00	21.47	75.37
	48	1.16	2.36	24.41	72.07

3.4 Impulse Responses and Variance Decompositions

In this section, we investigate the dynamic responses of exports to various shocks in the system.[16] Answers to these questions would allow us have better understanding of how export responds to the sources of fluctuations which could be of foreign or domestic origin.

As the VMA representation in equation (2) is an essential feature of Sim's (1980) methodology which allow us to trace out the time path of various shocks on the variables

[16] As suggested earlier, Model 1 is based on the analysis of first-differenced series; however, the results using level variables is very similar to those of first-differenced variables. This can be explained by the VMA expression in equation (7). Impulses of the level variables are simply found by the cumulated sum of the impulses of the first-differenced variables. In order to reveal the relationships of Model 1 and Model 2, we only report the results of the level variables. References for other results are available upon request.

contained in the VAR system. To highlight the use of the VMA representation, we rewrite equation 2 in such form [17]

$$X_t = \sum_{i=0}^{\infty} \phi_i e_{t-i} \tag{7}$$

where ϕ_i matrices are termed as impulse response functions, which are generated by successive substitution of lagged A(L) in equation (1).

Figures 1 and 2 show the dynamic responses of exports to internal innovations. The dotted lines are two-standard-error confidence interval. Significance at 0.05 level would require that the point estimate be different from zero no less than 2 standard errors. For both countries, exports respond mainly to own shock positively, while the exchange rate shock has a negative impact on exports. These results are consistent with the long-run equilibrium relationship established earlier. A money supply shock would boost up exports in both countries, but its effect quickly dies out after first month. In general, the external shocks generate temporary but insignificant effects on exports in all cases with only exception of oil price shock to exports. Basically, those foreign disturbances have quickly diminishing effects on the export growth. The explanations of this phenomenon may be due to that the lagging U.S. GNP growth and money supply dissuade, through the exchange rate and income effects, consumers from purchasing more foreign goods and as a consequence, the exports would go through a stagnant process. The drops in U.S. consumer prices could further worsen the trade balance situation.

[17] For simpler explanation of the impulse response function, we did not include constant terms in the VAR

Table 6

Variance decomposition for Model 2

		OIL	M	π	EX
TWEX	1	8.52	7.07	7.16	77.25
	6	10.41	6.09	8.57	74.93
	12	16.17	4.14	8.57	71.12
	24	17.72	3.44	8.57	70.27
	36	20.41	2.91	8.57	68.11
	48	23.01	1.01	8.57	67.41
KREX	1	16.11	9.00	6.27	68.62
	6	20.41	8.21	7.23	64.15
	12	22.54	6.29	7.63	63.54
	24	23.48	5.29	7.71	63.52
	36	25.61	3.49	7.83	63.07
	48	27.01	1.59	7.84	63.56

Next, the forecast variance decompositions are used to supplement the analysis of the impulse responses. This methodology would help us to better understand the relative contribution of each shock to the system. Table 5 and 6 report the decomposition of error variance of each variable due to structural innovations at different steps.[18] The results generally support the previous discussions. Taiwan and South Korea's exports are liable to the oil prices shock (see Table 5). However, it seems that U.S. disturbances account for a significant fraction of the variance of Taiwan exports (the effect accumulates to 23.2 percent at 6 months), while U.S. does not quite exert influence on South Korea exports

system. Suppose equation (1) has the simple standard form, $X_t = A_1 X_{t-1} + e_t$. By using backward iteration and assuming that the stability condition is met, we can derive the form of equation (7).

[18] We only focus on the responses of exports to various shocks, and other responses are available upon request.

(only 22.87 percent at 6 months). U.S. money supply shock is neutral for both countries in the sample period, however.

For Model 2 (see Table 6), both country's exports variations are mainly explained by shocks to exports itself, exchange rate, oil prices, and to a lesser degree, by domestic money supply. Domestic money shock to exports is quickly diminishing after 24 months. Combing the results of Table 5 and Table 6 gives us an important finding in this paper. Oil price is the main variable creating the business cycle fluctuations of heavy oil-imported countries like Taiwan and South Korea. The volatility of Taiwan's exports to U.S. is not only determined by domestic disturbances but also the U.S. disturbances. Relatively, South Korea' exports is subject to domestic disturbances, but foreign (U.S.) disturbances show a little impact.

4. Conclusions

This study investigates the sources of macroeconomic fluctuations with respect to Taiwan and South Korea' exports growth. Two structural VAR models are developed to analyze the relative contributions of foreign and domestic disturbances to both countries. Model 1, which includes mainly the external variables, is used to determine the sources of foreign disturbances. We find that change in the real variables has a significant and persistent influence on the variations of Taiwan exports, while U.S. disturbances has insignificant and short-lived effect on South Korea exports. The results also suggest the ineffectiveness of U.S. money supply policy.

However, the VAR structure of Model 2, which mainly discusses the domestic policy instruments, is found to be questionable in the VAR representation. In tackling this problem, we employ a vector error correction model (VECM) to estimate the common stochastic trend. From the results we conclude that there is a long-run equilibrium relationship of exports, oil prices and exchange rate for both countries, but not the money supply variable. This result also lends support to the hypothesis of long-run neutral money effect on domestic export growth.

Figure 1: Responses of Taiwan Exports to Internal Innovations

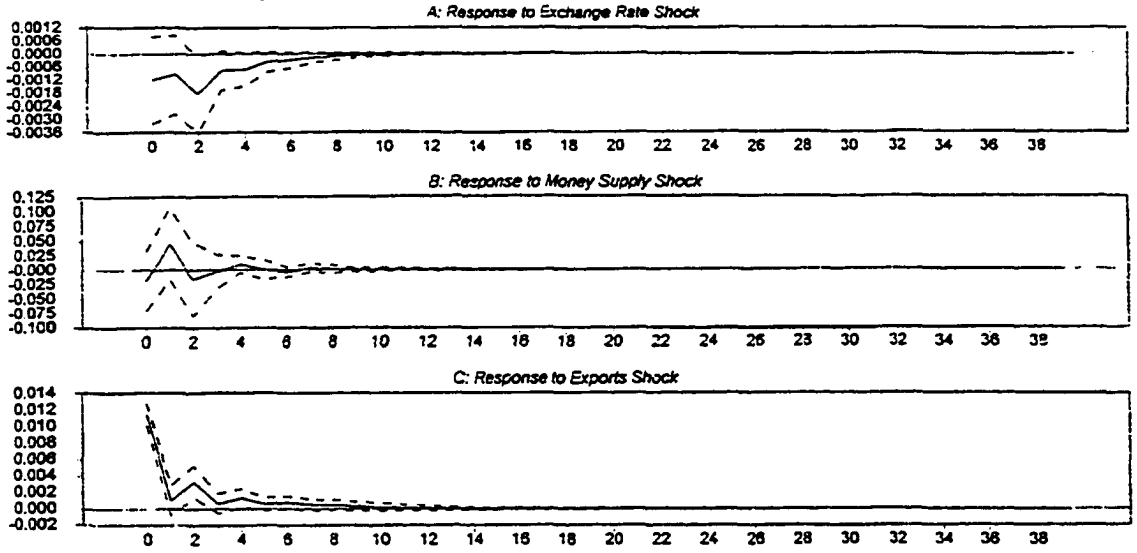


Figure 2: Responses of South Korea Exports to Internal Innovations

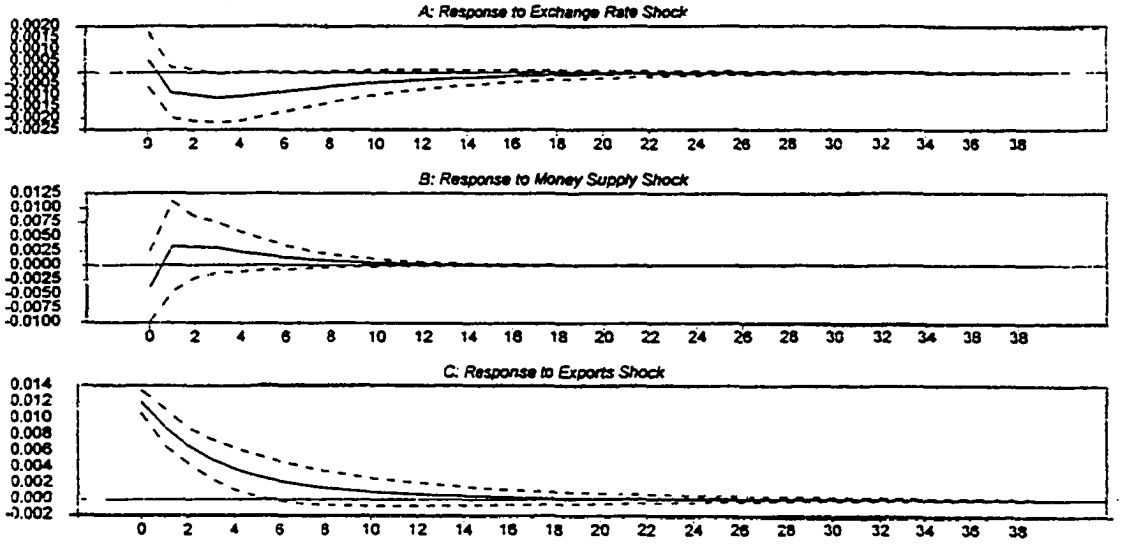


Figure 3: Responses of Taiwan Exports to External Innovations

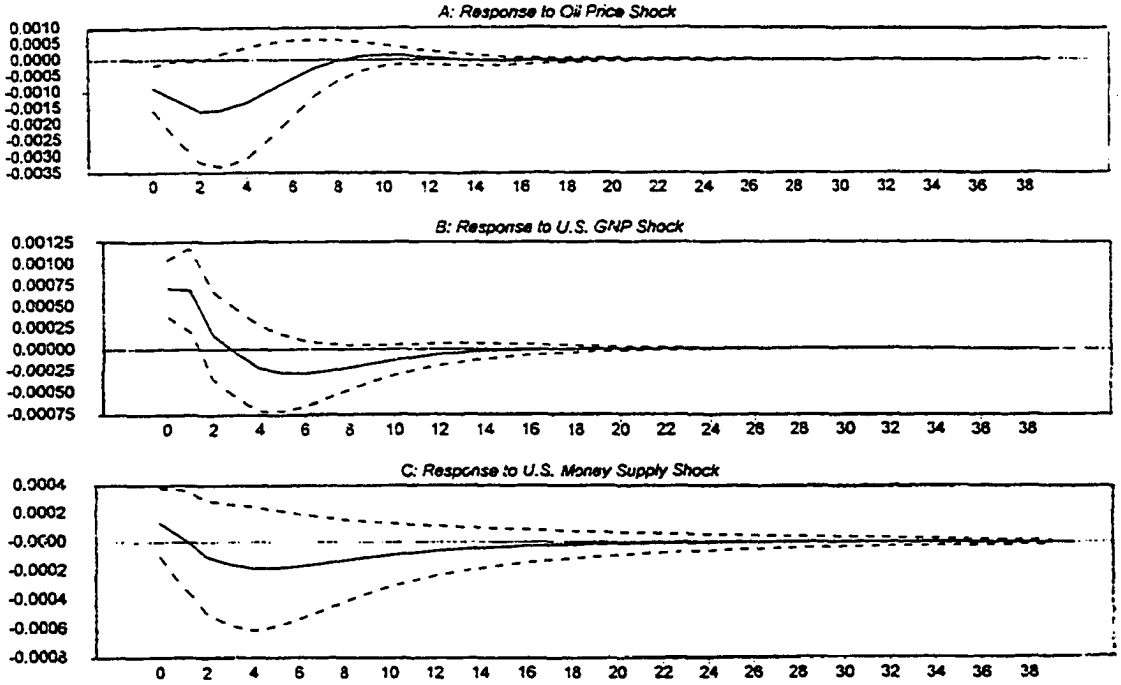
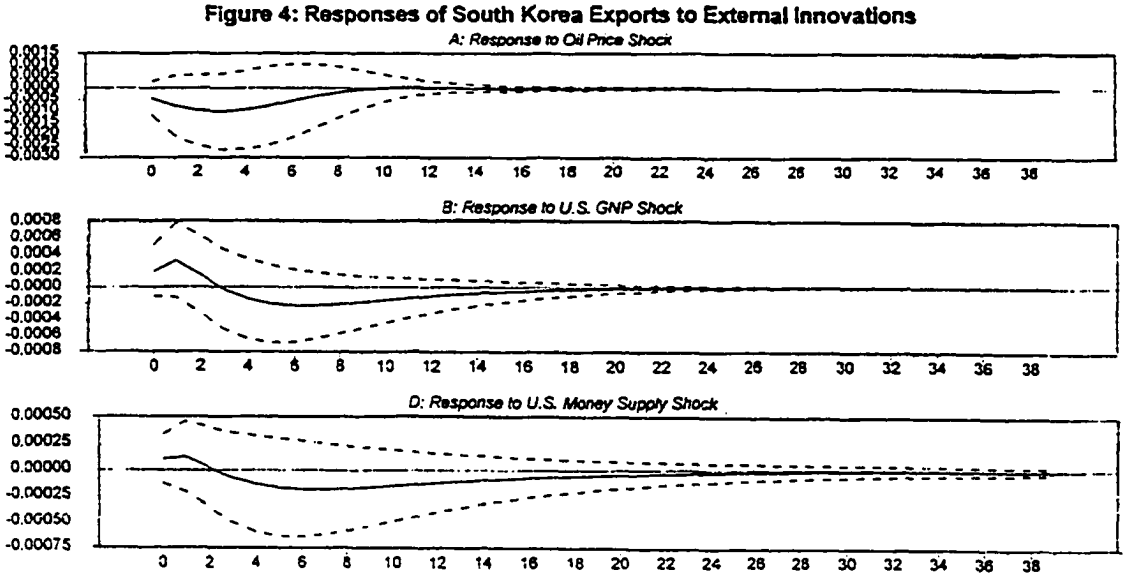


Figure 4: Responses of South Korea Exports to External Innovations



PART III

Are Real Interest Rates Really Equal? A Multi-Country Evidence on the Equality of Interest Rates

1. Introduction

Why should real interest rates be equal across countries? And how long will it take to maintain the equal relationship? Recently, those questions have been studied in an extensive literature due to significant evidence indicating the increasing integration of financial market in last two decades (for example, Cumby and Obstfeld, 1984; Hartman, 1984; Modjtahedi, 1988; Fung and Isberg, 1992; Kugler and Neusser, 1993; Katsimbris and Miller; 1993, Goodwin and Grennes, 1994). Researchers have presumed that the international integration of financial market would reduce the gap between interest rate at home and abroad because the government-imposed barriers to international flow of capital were gradually relaxed. The equality of real interest rates, which implies foreign monetary effect could be transmitted to domestic country, has posed an imminent challenge to local monetary authorities when they attempt to purse independent economic policies. Besides, The equality of real rates could be a watchdog for the international investors because the anticipation and interpretation of co-movement of domestic and foreign interest rates would certainly reduce the cost of capital price which is interest sensitive. This provides the reasons why researchers have employed different

econometric examinations to analyze the movements in real rate and the degree of linkage between real rates in different countries.

Unfortunately, most researchers have emphasized the first questions, but even worse, those results have yielded mixed evidence for the equality of real interest rates. Criticism upon the mixed results has focused on the misuse of methodology. For example, Modjtahedi (1988), Krugler and Neusser (1993) and Goodwin and Grennes (1994) have attributed the mixed results to the drawback of conventional regression methodology: the long-run dynamic behavior of real interest rates is ignored. They argue that the failure of short-run validity of the real interest rate parity (RIP) could be explained by the less than perfect integration and adjustment between domestic and foreign market, which in the short run could be attributed to transaction costs, the existence of taxation, a risk premium in the foreign exchange rate market, and other imperfection between the markets. As a result, they call for a long-run econometric tests, including VAR multi-step forecast (Modjtahedi), co-dependent time series (Krugler and Neusser), and cointegration technique (Goodwin and Grennes). Modjtahedi concludes that the long-run real interest rate differentials are not always zero, and Krugler and Neusser, Goodwin and Grennes have come to the same conclusion that deviations from RIP are significant but disappear in the long run. But the long run test also strikes us with several wonders: To what degree can the international market be called a "perfect" market? And is the elimination of the gap between real interest rates indicative of the "perfect" state? Or inversely, is the widening gap between real interest rates the outcome of imperfect market situations?

Assume that the previous studies have persuaded us that there is a long-run equilibrium relationship between real interest rates, but the central question arises: How long is long-run? (the question puzzles Modjtahedi). This question would be more intriguing to local monetary authorities and investors. However, those VAR-based time series analysis could not give us a satisfactory answer to our curiosity. In this paper, we propose an alternative which is based on the concept of the Kaman Filter, originally developed by Kalman (1960). In the literature the commonly used method is least square optimization. The Kalman filter is a natural extension of this approach. In fact, it can be thought of simply as regression model in which the explanatory variables are functions of time and the parameters are time varying. Harvey (1997), a proponent of this technique, has criticized that VAR-based cointegration methods are limited in scope. First, VAR analysis, like unit root test, has very poor statistical properties. Harvey points out that a structural model can extend the restrictive use of a deterministic trend that are commonly assumed in most VAR analyses. For example, the test for unit roots, which is composed of deterministic trend plus a stationary component, is implausible in many time series analyses. In a structural time series model, the parameters are essentially assumed to follow a random walk. This leads to a stochastic trend in which level and slope are allowed to evolve over time. By using the Kalman filter, the trend is extracted by a smoothing algorithm, and the parameters that govern the evolution of the trend are estimated by maximum likelihood.

One purpose of this study is to show that conventional tests of interest rate equality using the framework of cointegration and unit-root testing may not provide us

satisfactory answers. Differing from previous works,[19] testing the stationarity of real interest is irrelevant to our model setting. The real interest rates are all used in levels. Also, the contribution of this study to the existing literature regarding the equality of interest rates is twofold. First, to the best of our knowledge, there is lack of research carried out to test for the convergence of real interest rates across Asian market. The recent financial liberalization of Asian market in 1980s has provided us an opportunity to review how those newly industrialized countries react to traditional economic powers, such as the United States and Japan. Likewise, the topic of European Community is reinvestigated by the study in contrast to earlier works in this field. Second, by applying the time varying parameter estimation, the readers are provided with the information of when real rates would tend to maintain a equal relationships with each other in the whole time span; in other words, the short-run and long-run effects of interest rates can be immediately understood.

The scheme of this paper is follows. Section 2 reviews the earlier work of the field. Section 3 describes the methodology and formulates the basic equations and testing hypotheses. Section 4 details the data sources and reviews the empirical results under three headings: the linkage between leading economic countries, the Asian market integration, and European Community integration. Section 5 concludes this study.

[19] There have been dichotomous results for testing the unit root of the real interest rate. The confused results have led to different approaches analyzing the equality of real rates. For example, when real interest rates are proved to be I(1), then the VAR and cointegration tests are often applied; when real rates behave as I(0), the conventional regression and co-dependent approach are usually proposed.

2. Review of Earlier Work

The international linkage of interest rates is recently studied by testing for the equality of real interest rates across countries. Most of the researchers focus on the interest rate co-movement between U.S. and the industrial countries such as European Monetary System (EMS). The line of research generally follows such a regression equation:

$$i_t^h = \alpha_1 + \beta_1 i_t^f + \varepsilon_1 \quad (1)$$

$$i_t^f = \alpha_2 + \beta_2 i_t^h + \varepsilon_2 \quad (2)$$

where i_t^h and i_t^f stand for domestic real interest rate and foreign interest rate respectively. It is supposed that interest rate parity will stand when the joint hypothesis that $\alpha=0$ and $\beta=1$ is not rejected.

Cumby and Mishkin (1986) base their research on the regression analysis in analyzing the linkage of real interest rate between U.S. and EMS. Their results indicate that real rates within European Community are not more closely linked with one another than they are with U.S. real rates. Besides, European real rates typically do not move one-for-one with U.S. real rates, thus leaving open the possibility that European monetary policy could influence U.S. economic activities. The conventional regression test has, however, been challenged for several reasons. First is the methodological critique. It is criticized that a simple regression without considering the stationarity of the variables could lead to a spurious regression (Granger and Newbold 1974; Phillips 1986), which shows the symptoms of higher R^2, significant t-statistics,but meaningless results. Second is that regression analysis could not provide the direction of causality. In this regard,

bilatral granger causality test is often employed to reach the conclusion. Hartman (1984) uses Granger causality test to examine the Eurodollar and U.S. domestic financial market. He concludes that there is a two-way causality between Europe and U.S. money market. That is, U.S. financial market is affected significantly by events occuring outside the country, and Eurodollar market is affected by events occuring in the United States. It is interesting to note that after 1984, researchers conduct quite similar studies but come up with different results. Katsimbris and Miller (1993) use trivariate causality and conclude in accordance with Cumby and Mishkin. Nevertheless, Fung and Isberg (1992) find the causality effects seem to be inconsistent over time. There exists undirectional casuality from Europe to U.S. market. They explain the phenomenon is due to the expansion in the size of Eurodollar market and increase in the volume of Eurodollar futures trading after 1984.

Even with mixed results, those studies all strongly suggest the conventional regression of real interest rates may be misleading because they fail to consider the evidence of less than perfect integration and adjustment between domestic and foreign markets which in the short run could be attributed to transaction costs, the existence of taxation, a risk premium in the foreign exchange market,and other imperfection between markets.

According to reasons mentioned above, recent studies switch their focus on real interest rate parity from a short-run view to a long-run perspective. A long-run perspective is supposed to allow the variations in differentials between real interest rates which are created by the imperfect market conditions. Modjtahedi (1988) first derive a linear dynamic stochastic process to test the equality of ex-ante interest rates between

U.S. and OECD countries. The empirical evidence rejects the short-run equality of ex-ante real interest rates and indicates there is significant time variation in the short-run deviations from long-run interest differentials, but real interest differentials convey to their lon-run equilibrium in a period of six months. It is worthy to note that the long-run interest rate values are not always zero which is contrary to common hypothesis of a zero long-run mean of the real interest rate differentials. Using a test for cointegration, Goowin and Grennes (1994) provide results which are consistent with the notion of a long-run equilibrium relationship between real interest rates in the U.S. and rates in the major industrial countries, which implies that there is a stronger link among the financial markets of the major industrial countries. However, in a related study, Throop (1994) provides evidence against the equality of real interest rates across countries. He attributes the mixed results to the ever-changing currency risk premia. Throop emphasizes that exchange rate expectations and premia for exchange rate risk are the main force driving the wedge between real interest rates. He suggests to perform empirical studies to isolate the fundamental economic factors that tend to cause changes in the currency risk premia. In applying cointegration testing procedure, it is well known to assume the relevant variables series are nonstationary. In above studies, interest rates series are all suggested as I(1) processes, which mean they all contain a unit root. But in the paper of Neusser (1991, 1993), the ex-post real interest rartes are suggested to be stationary. His stationary multivariate time series approach based on the concept of co-dependence shows that deviations from real interest rate parity are significant in the short run but disappear in the long run.

It is shown that most of the literature have concentrated on finding the short-run and long-run relationships between real interest rates; however, the dynamics of real interest rate differentials are often ignored. It will be more interesting to study the dynamics as the monetary authorities can judge their policy effectiveness immediately. In the following section, we will try to employ a different methodology to interpret this important issue.

3. Testing Hypotheses and Methodology

3.1 Testing Hypotheses

In our study, even though each country is treated the same as a potential driving force of other countries' interest rates variation, we would like to generally divide our focus into three dimensions in contrast to previous work. Three country groups are used in this purpose, which are in turn with the headings: I. Leading Countries' Linkage, which concludes U.S., Germany and Japan as our sample countries, II. Asian Market Integration, which includes Japan, Taiwan and South Korea, III. European Market Integration, which uses Germany, UK, and France as samples.

I. Leading Countries' Linkage:

$$r_t^{US} = A(t) + B(t) r_t^{JP} + \varepsilon_{1t} \tag{3}$$

where r^{US} and r^{JP} are the *ex post* real interest rates for U.S., Germany and Japan. A(t) is defined as risk premia, which are asumed to stand for the imperfection existing between both markets. Both A(t) and B(t) are carried out as time-varying parameter (TVP). This equation mainly takes the United States and Japan as the reference countries. If we want to focus on the relationship of US and Germany (r^{GR}), the equation can be rewritten such as $r_t^{US} = A(t) + B(t)r_t^{GR} + \varepsilon_t$.

Generally, we would like to test the following hypotheses for equation (3). First, If the differences between Germany and Japan real rates are getting smaller, we would expect to see the time varying parameter of A tending toward zero (0) over time, and B is tending toward 1. Second, if A and B maintains as a constant line, this would indicate that there is a stable relationship between US and Japan real interest rates. Third, if the value of B is stable but the risk premia (A) is showing a tendency of sharp increase or decrease, and deviating from zero, then there is no stable relationship between US and Japan. Similarly, if the the time varying parameter of B is unstable but risk premia is stationary, a stable relationships could not stand. Furthermore, the TVP of B tending to zero would lead to a possibility that the relationship between interest rates in any two countries exhibits a random walk behavior. Next we look at two regional integrations, and the hypotheses generally follow the above discussion.

II. The Asian market integration:

$$r_t^{JP} = A(t) + B(t)r_t^{TW} + \varepsilon_{2t} \qquad (4)$$

where r^{TW} is Taiwn *ex post* real rate. If we focus on the relationship between Japan and South Korea, then Taiwan interest rate will be replaced by South Korea interest rate (r^{KR}).

III. The European Community Integration:

$$r_t^{GR} = A(t) + B(t) r_t^{UK} + \varepsilon_{3t} \tag{5}$$

where r^{UK} is the United Kingdom *ex post* real rate. Similarly, we can replace this term by some other European countries, such as r^{FR} (France).

3.2 Methodology

In this section a standard state space formulation of the time varying parameter (TVP) is presented, with the appropriate Kalman filter equation for the univariate case, following Harvey (1987),

Our basic equation takes the following matrix form,

$$r_t^1 = \begin{bmatrix} 1 & r_t^2 \end{bmatrix} \begin{bmatrix} A_t \\ B_t \end{bmatrix} + \varepsilon_t$$

Compactly, we rewrite the above equation as

$$y_t = \delta' z_t + \varepsilon_t$$

(6)

which is defined as the measurement equation,where y_t is a measured variable (r_t^1), z_t the state vector of unobserved variables (A_t and B_t), δ' is a vector of parameters and $\varepsilon_t \sim NID(0, \Gamma_t)$. The state equation is then given as a general AR(1) process,

$$z_t = \psi z_{t-1} + \omega_t \tag{7}$$

where ψ are parameters and $\omega \sim NID(0, Q_t)$, Q_t are sometimes referred to as the hyperparameters. The appropriate Kalman filter prediction equations are then given by

defining $\hat{z}_t$ as the best estimate of z_t based on information up to t, and P_t as the covariance matrix of estimate $\hat{z}_t$, and stating:

$$\hat{z}_{t|t-1} = \psi\, \hat{z}_{t-1} \tag{8}$$

and

$$P_{t|t-1} = \psi\, P_{t-1}\, \psi' + Q_t$$

(9)

Once the current observation on becomes available, we can update these estimates using the following equations:

$$\hat{z}_t = \hat{z}_{t-1} + P_{t|t-1}\delta(y_t - \delta'\, \hat{z}_{t|t-1})/(\delta'\, P_{t|t-1}\delta + \Gamma_t) \tag{10}$$

and

$$P_t = P_{t|t-1} - P_{t|t-1}\delta\delta'\, P_{t|t-1}/(\delta'\, P_{t|t-1}\delta + \Gamma_t) \tag{11}$$

Equation (8)-(11) then represent jointly the Kalman filter equations.

If we then define the one-step-ahead prediction errors as,

$$v_t = y_t - \delta' z_{t|t-1} + \beta'\omega_t \tag{12}$$

then the concentrated log likelihood function can be shown to be proportional to

$$\log(l) = \Sigma \log(f_t) + N \log(\Sigma v_t^2 / N f_t)$$

where $f_t = \delta'\, P_{t|t-1}\delta + \Gamma_t$ and $N = T - k$, where k is the number of periods needed to derive estimates of the state vector; that is the likelihood function can be expressed a function of the one-step-ahead predictioon errors, suitably weighted.

Equipped with these formulae, we can estimate time-varying parameter models such as (6) and (7) directly. We do this by first specifying δ_t as a vector of known variables (in this case the interest rates) and z_t as a vector of time varying parameters (A_t and B_t). If ψ is assumed to be constant identity matrix, then additionally we have specified the from of the time variation within our model: each of the stochastic parameters follow a random walk. Finally, Q_t is specified as a diagonal matrix, the elements of which are to be estimated maximum likelihood given the form of the likelihood function outlined. Given this specification, the assumptions outlined, and the likelihood function defined above, we can estimate time-varying models of the form (3), (4) and (5).

4. Data and Empirical Results

4.1 Data

This study tests the convergence of real interest rates using monthly observations over the period 1970:1 to 1996:9 for five industrialized countries, and 1978:1 to 1997:9 for two newly industrialized countries, namely France, German, Japan, the United Kingdom, the United States, Taiwan, and South Korea. All the interest rates data are taken from the International Financial Statistics (IFS), the OECD Main Economic Indicators and the Executive Yuan of Taiwan (DGBAS). Inflation rates are measured by changes in the seasonally adjusted consumer prices indices (CPI). For all the countries,

the nominal interest rates are mainly taken from the short-term Treasury bills rates. The real interest rates are defined from the Fisher condition as: $r_t = i_t - \pi_t$, where r_t denotes the domestic *ex post* real interest rate, and nominal interest rartes and inflation rates over the period t to $t+1$ are denoted by i_t and π_t, respectively.

4.2 Empirical Results

I. Leading Countries' Linkage

Figures 1-3 plots the time-varying parameters A and B for U.S., Japan and Germany. It is basically shown that for the whole period, the TVP of B are postively moving up , while the TVP of A is slowly tending to zero. This implies that those countries' real interest rates have a tendency of getting equal. However, the relationships beteween US and Japan are not significant (see Figure 1). Even though B is tending to move up, but it only reaches to 0.5 until 1996. Using Germany as a pivot country, the convergence of real interest rates are getting clear. In Figure 2 and 3, A (the risk premium) is slowly going near zero, and B is going up closely to unity. The results strongly suggest that there are linkages among the financial markets.

II. Asian Market Integration

It is shown from Figure 4 that even in the earlier 1980s the time varying estimator (TVP) maintains a stable value (0.7), accompanied with a stable premium close to 0. This indicates that at least there is a stable relationship between Taiwan real interest rate and Japan. However, beginning from 1982 and ending in 1986, B was sharply changed from 0.7 to 0.4, indicating that there is a widening gap between Taiwan and Japan real rates.

Thus, the differentials are not clear. The TVP of B is clearly stable after 1986, we can see there is strong evidence of a stable relationship. The results may explain there is a market structure break happening in 1981, a starting point of Taiwan financial market liberalization. The fluctuation of B value can be described as a transitional period. The relationship between South Korea and Japan, as indicated in Figure 5, is surprisingly stable in the whole picture. With B going around 0.1 and constant risk premia since 1981, it is strongly suggested there is a similar path of real rate moving. Figure 6 exhibits the results from regressing South Korea real interest rates on Taiwan real rates. The results can be used to reinforce the above argument. Since both countries began their financial liberalization in 1981, the B parameter is showing a sharp increase from 0.1 to 4.1, which may represent a period of market readjustment. To conclude, there is no clear evidence indicating the equality of real interest rates among those countries, but from 1986, there was a stationary interest rate differential between Japan and the two newly industrialized countries, which may support, in part, the financial integration of Asian Market.

III. European Community Integration

European Community is long described as an integrated financial market unit and our results generally support this point of view. Figure 7 and 8 exhibits that beginning from 1973, the TVP of A and B were keeping at a stale value of 0.25, and a long-run stable relationship is clear. Figure 9 indicates there is a stronger relationship between UK and France. The convergence of real interest rates between UK and France is much clearer with the value of B tending toward unity and A toward zero. This result is

basically contrary to most of the research which mainly assumes "German leadership" hypothesis (the dominant role of Germany in the EMS). [20]

5. Conclusions

This essay attempts to discuss the equality of real interest rates in a different perspective. The use of time-varying parameter, which is based on the technique of the Kalman Filter, allows us to go beyond the conventional regression analysis, and discover the whole evolution of real interest rates convergence, which can not be achieved by using the cointegration tests.

The results provide evidence for linkages among the leading countries such as Germany, U.S. and Japan, even though the link between U.S. and Japan is relatively weak. Generally, There is no evidence supporting the equality of real interest rates in sample Asian countries, but their relationships between real interest rates are stable since 1986. The result indicates there is some degree of interdependence in the latter periods. European Community is proven to be a more complete integration of financial markets. It is interesting to not that UK and France are tending to have an equal real interest rates, and the "German leading" hypothesis is not necessarily true.

As suggested by most authors, the risk premium is playing an important role contributing to the differentials between real interest rates. In our study, we also fail to isolate the fundamental economic factors that cause changes in the risk premia. Further

[20] Authors such as Karfakis and Moschos (1990) have concentrated on the bi-variate analysis of interest rate linkages within EMS. They present the evidence of unidirectional interest rate linkages from Germany to other EMS countries, and support the dominant role of Germany in EMS.

research is needed to adopt a more complete time series structural model in order to determine driving force of the risk premium.

Figure 1: US versus Japan

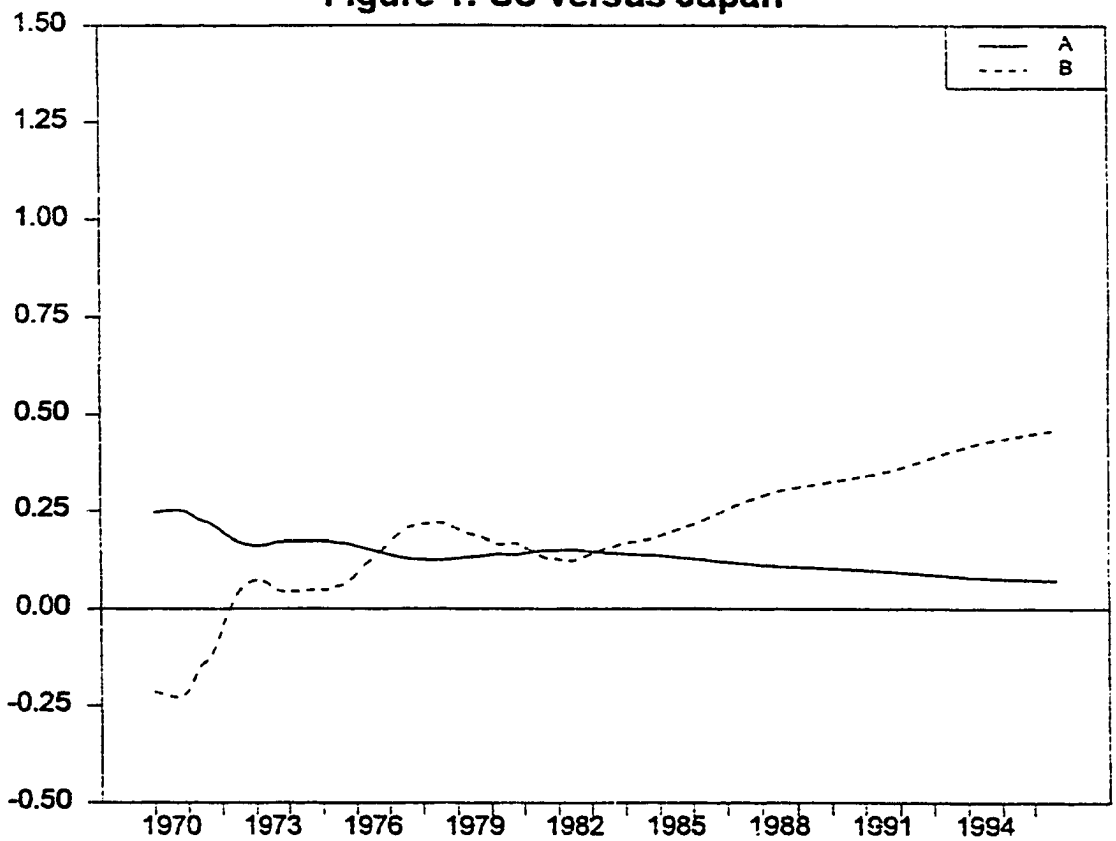


Figure 2: US versus Germany

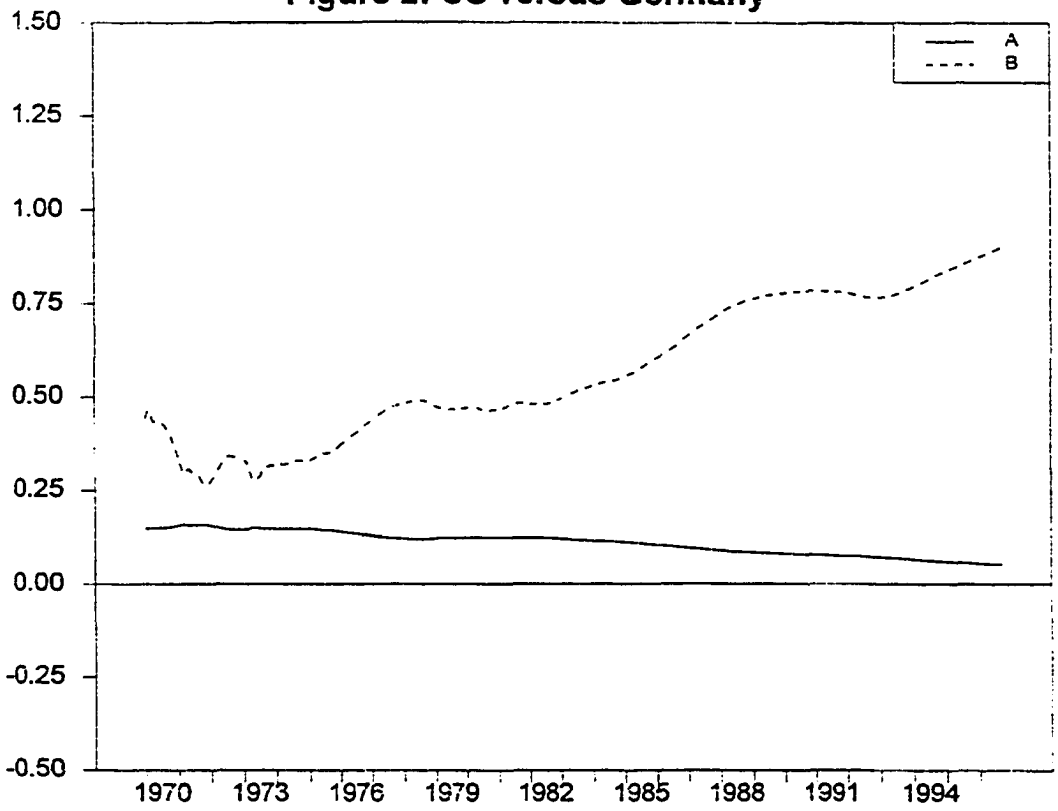


Figure 3: Japan versus Germany

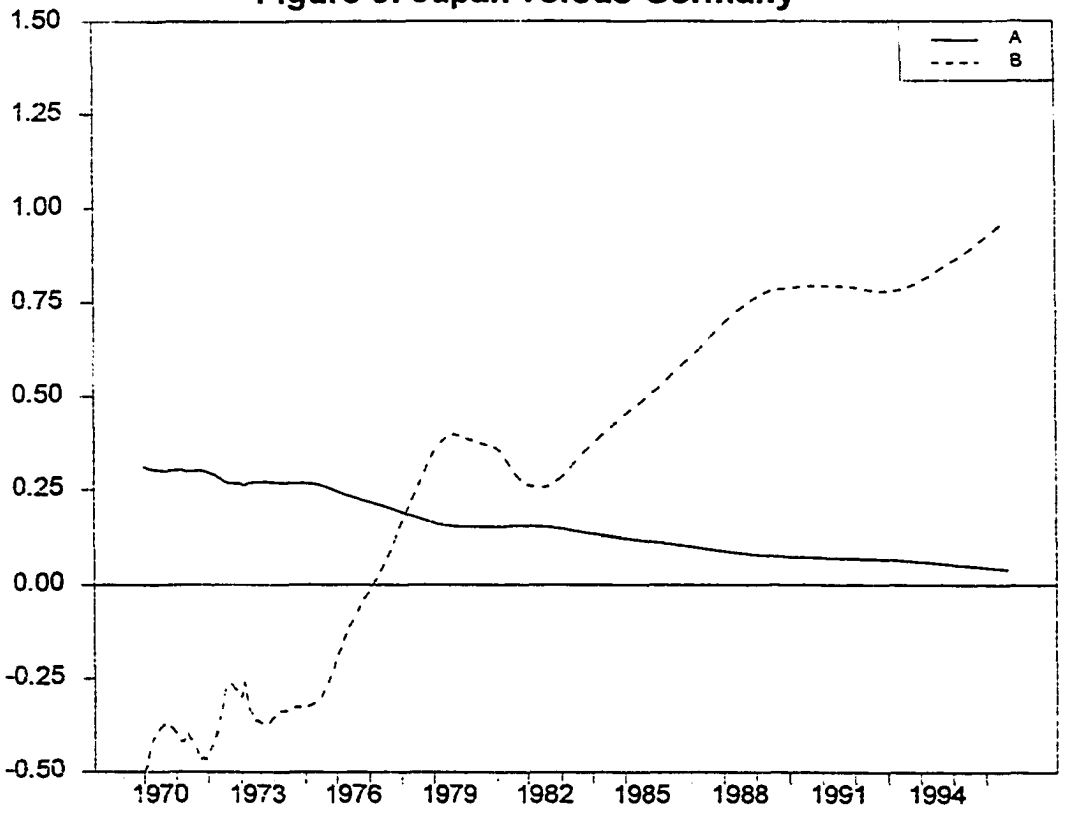


Figure 4: Taiwan versus Japan

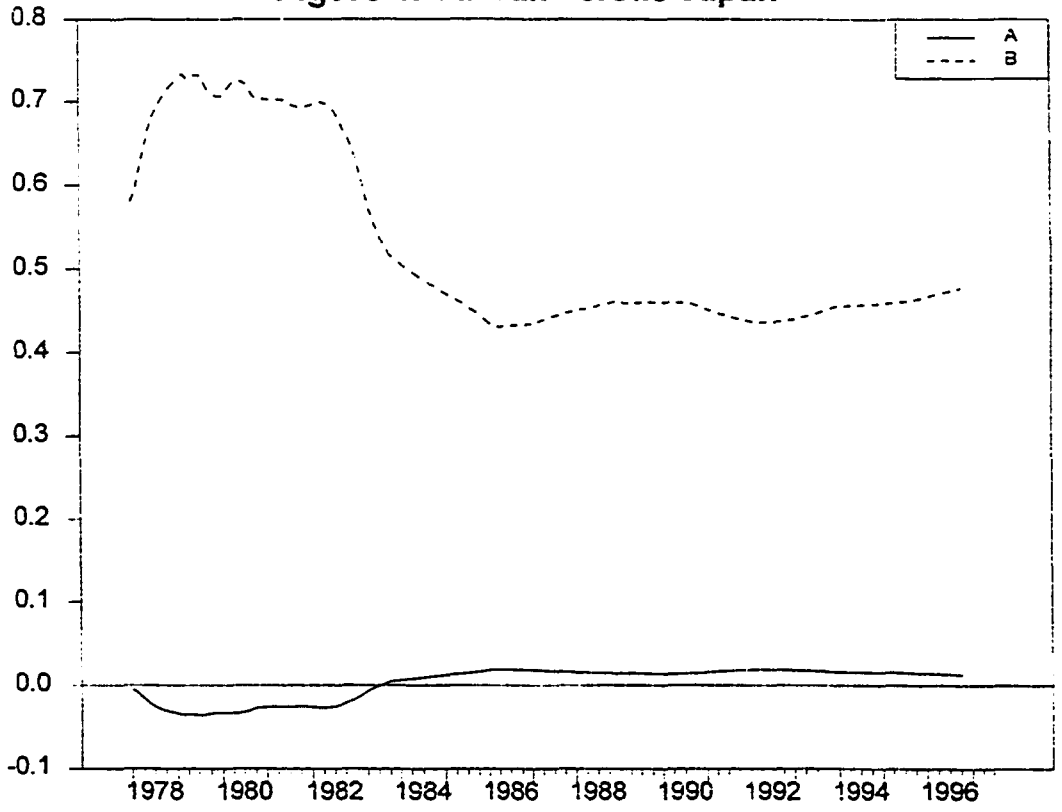


Figure 5: South Korea versus Japan

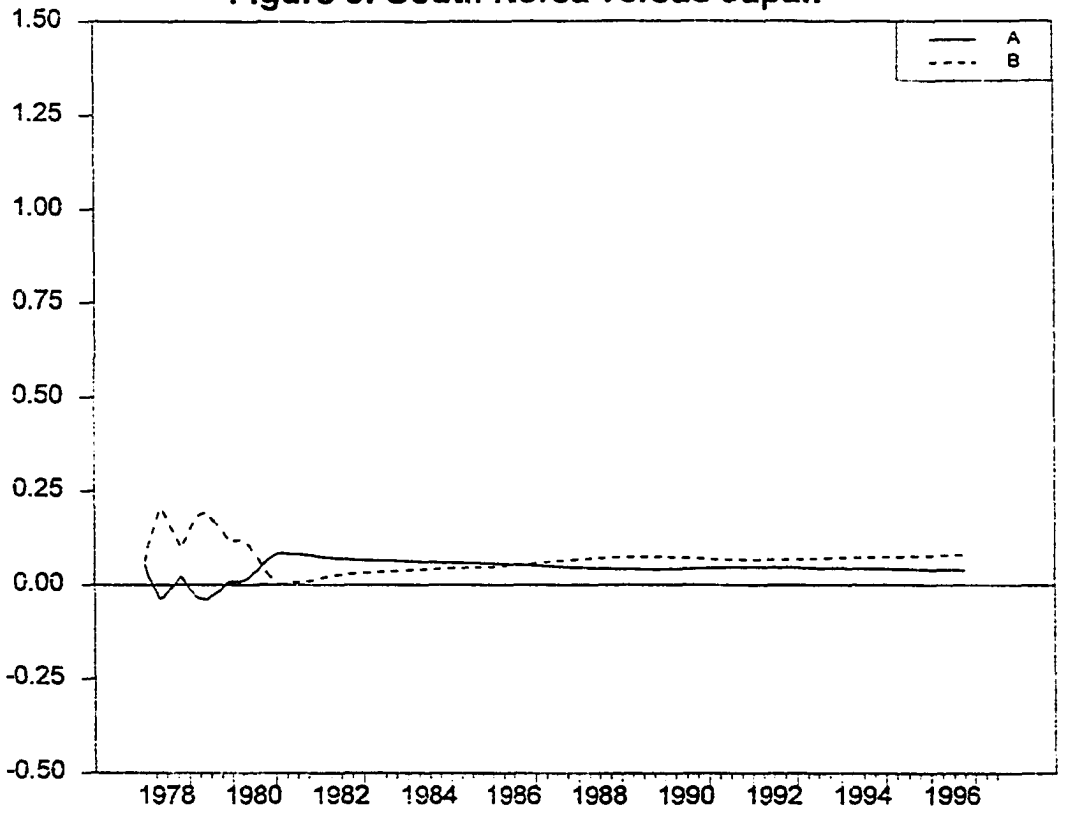


Figure 6: South Korea versus Taiwan

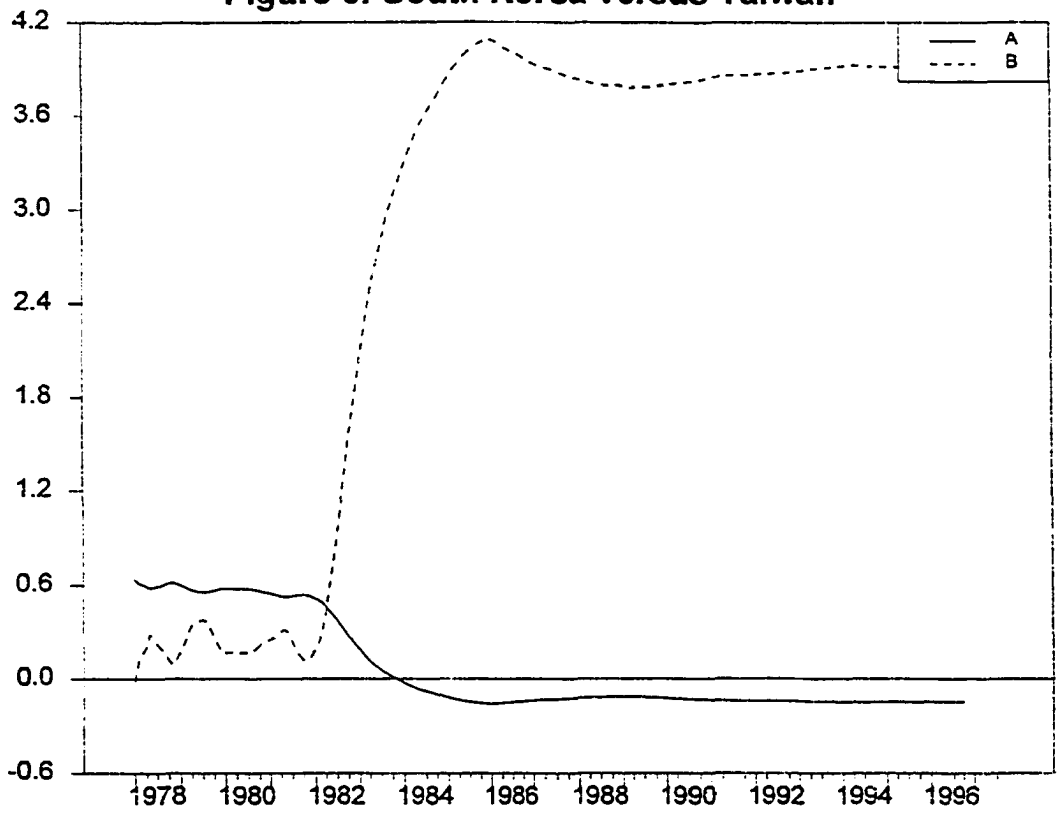


Figure 7: Germany versus UK

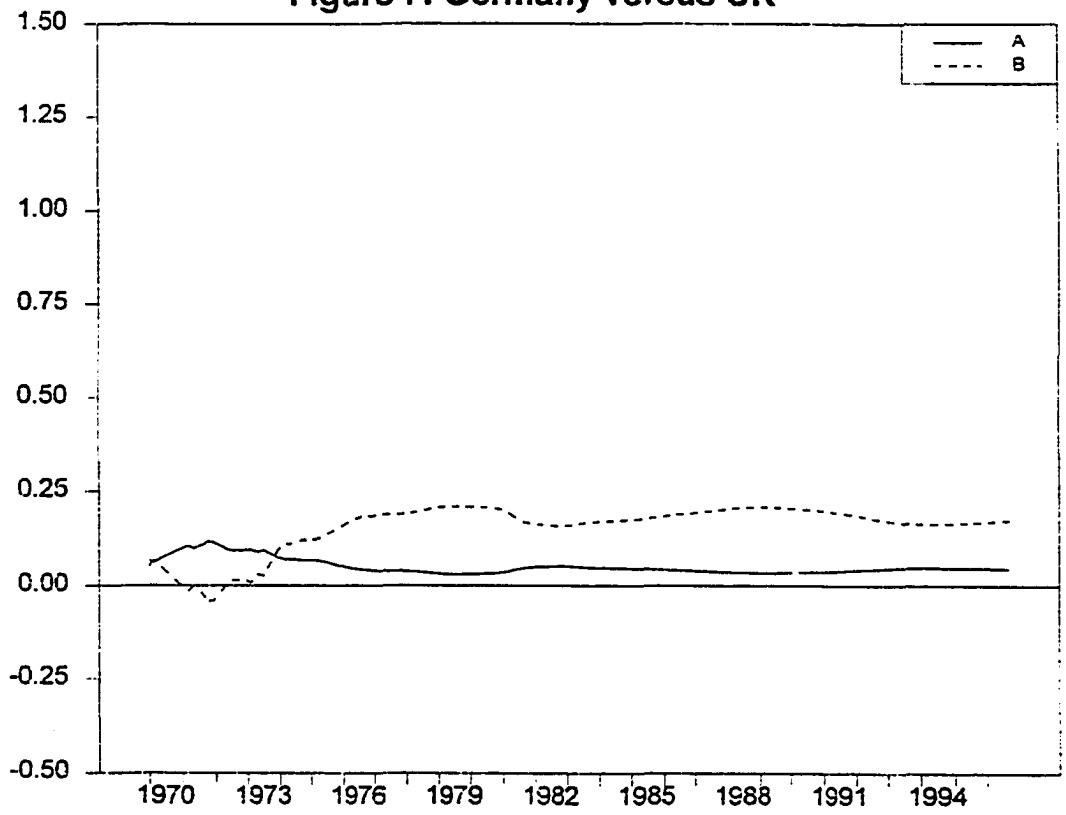


Figure 8: Germany versus France

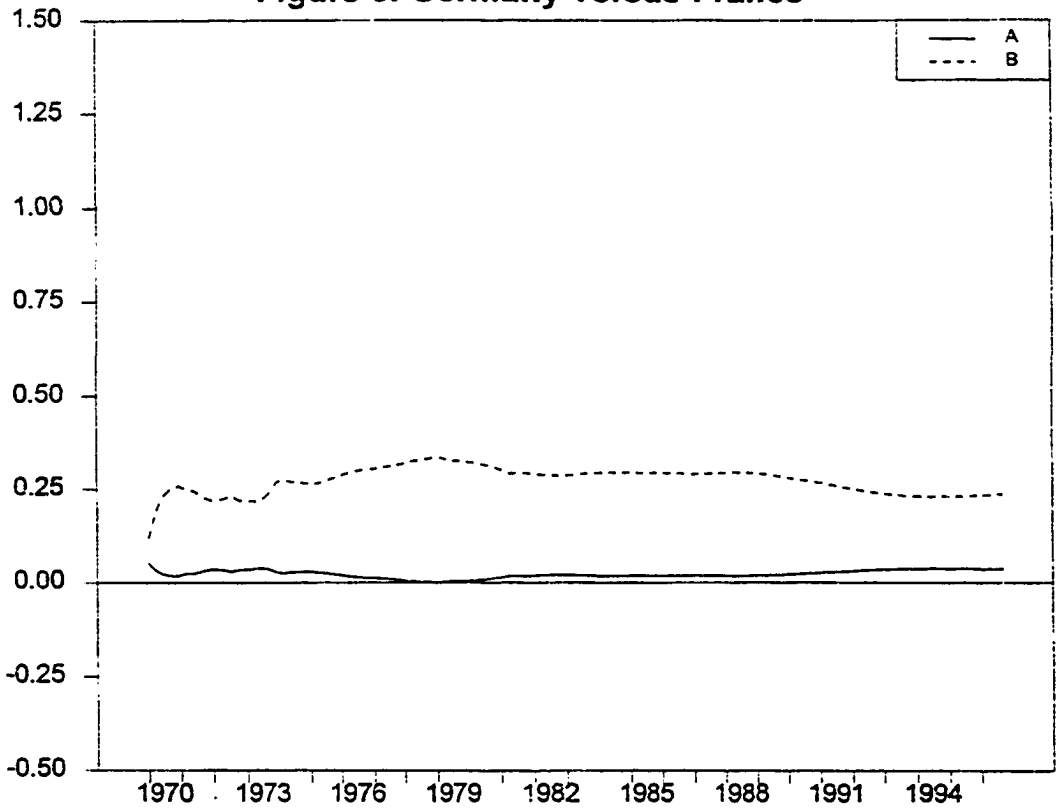
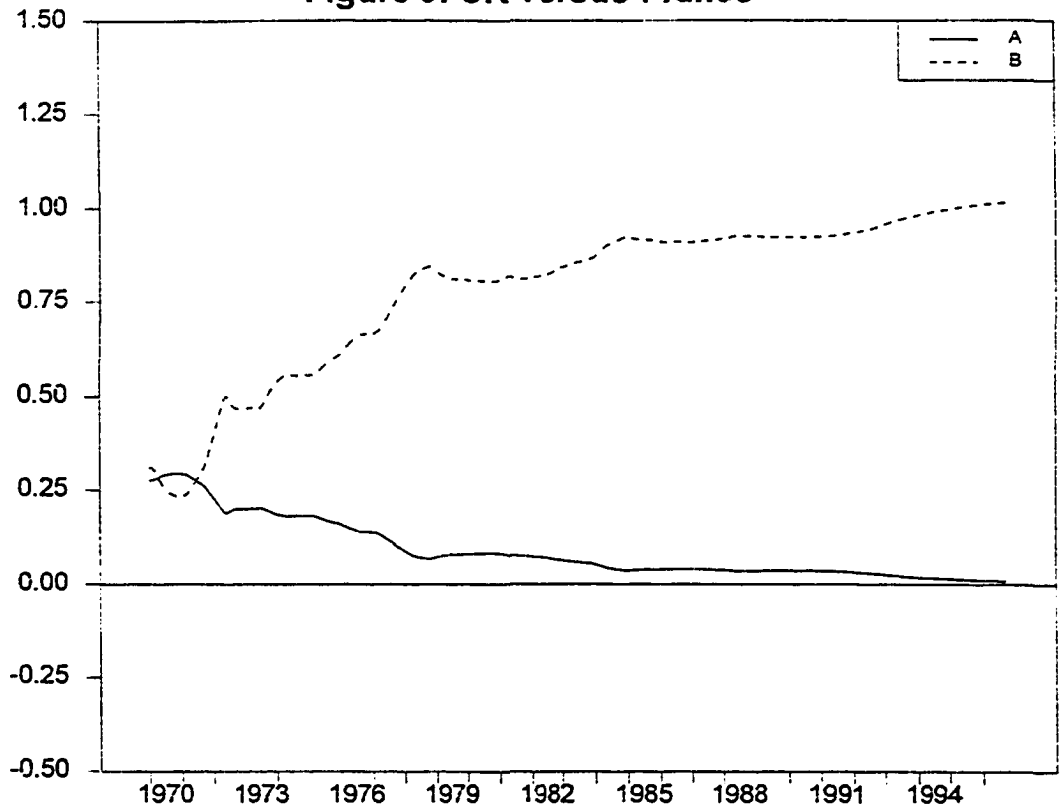


Figure 9: UK versus France



Summary

This dissertation is composed of three parts and its objective is to investigate the interactions of global financial markets in a variety of dimensions. Our results strongly suggest that those newly industrialized countries such as Taiwan and Korea be not insulted from the economic fluctuations originated from abroad. Thus, the policy implementation for both countries' growth would require a global point of view. The following gives a brief summary of the dissertation.

Part I offers an investigation of the sources of trend movements of the economic growth. Some recent advances in the time series analysis, including the cointegration tests, the vector error correction model, and the common stochastic trend approach with impulse response and variance decomposition, are employed to examine the long-run equilibrium relationship regarding the determination of output and relative importance of real shocks, such as real interest rates and term structure, in affecting the real economic activities. The empirical model studied in this paper incorporates most of the arguments in the literature concerning the sources of movements of economic growth. The tests are also conducted to show how government policies, such as spending, investment, money supply, react to changes in the real interest rates. Two aspects of interest rate effects are therefore examined. In the closed economy model, evidence from the cointegration tests indicates the existence of a stable long-run relationship between output and real interest rates and term structure, with the expected signs. But when we restrict the cointegrating vector, we find there are no significant interest rate and term structure effects for Taiwan and Japan while there are significant effects on U.S. and South Korea. The results that

both the foreign interest rate and term structures exert stronger and significant effect on smaller open economy like Taiwan and South Korea imply smaller degree of policy independence for both countries.

Part II examines the sources of macroeconomic fluctuations in Taiwan and South Korea. Using two structural VAR models and introducing cointegration restrictions we study the effects of innovations giving domestic and foreign effects (mainly U.S.) on export growth. The empirical evidence shows that changes in real variables have a significant and persistent influence on the variation of the export growth while the monetary disturbances have only short-lived effect. Such a result implies the ineffectiveness of the monetary policy designed to stimulate the long-term export growth. Besides, U.S. disturbances are found to be very important for explaining fluctuations in exports in Taiwan, while they have insignificant and short-run effect on South Korea's exports. Comparing the influences of the different real factors, the variance decompositions and impulse response function show that changes in the world oil prices have the most important and robust effects on exports in the study. The findings suggest that further attention to oil price shock for countries having a heavy dependence on imported oil is needed in the future.

Part III discusses the equality of real interest rates. The issues of concern here relate to a basic mapping out of trends and cycles rather than attempts to model causality directly. These trends and cycles are derived using the Kalman filter and the practice of time varying parameter (TVP). Although our results show no evidence of real interest rate convergence in sample Asian countries, it indicates there is some degree of interdependence because their real interest rates have maintained quite stable

relationships since 1986. The study also finds no evidence supporting the German dominant role in EMS. On the contrary, other countries, like UK and France are having a very significant convergence of real interest rates.

In sum, with all the evidence indicating the integration of financial markets, further research and knowledge of international finance will be required to determine the extent to which various factors contribute to ability for the government to enforce the policy independently and the efficiency for the local firms to be insulated from harmful loss.

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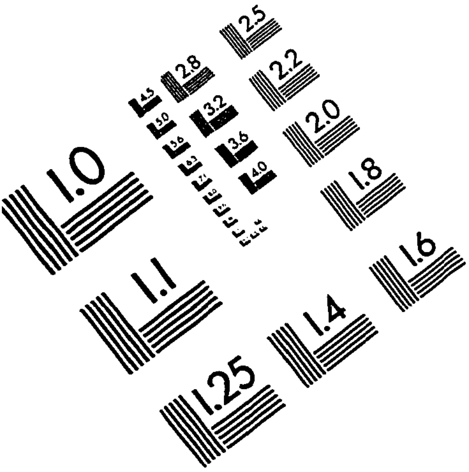
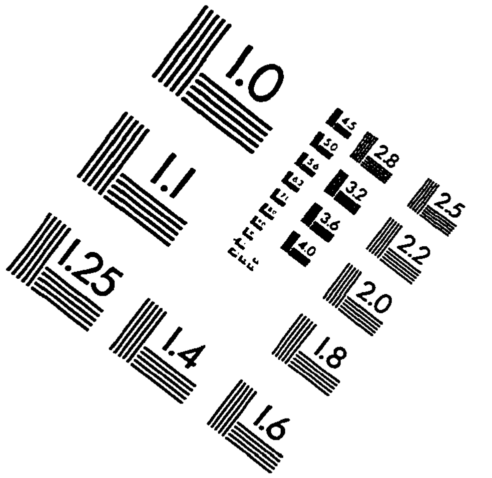
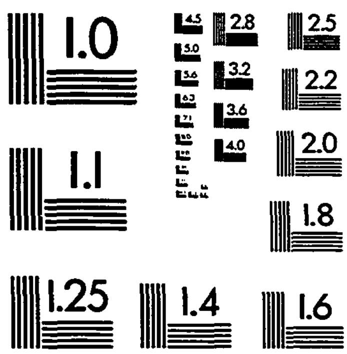
IMAGE EVALUATION TEST TARGET (QA-3)







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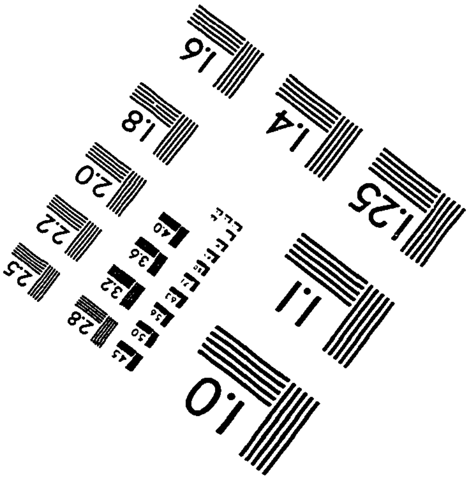

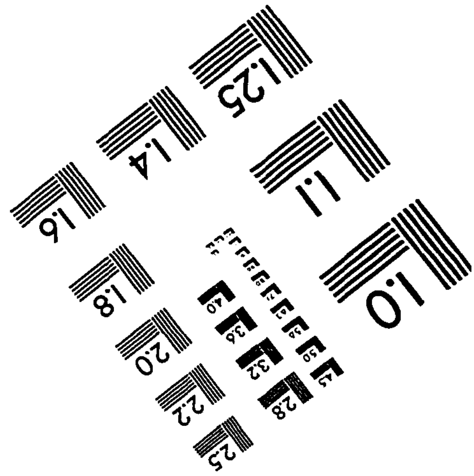

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