

The Financial Integration of Asian Market Revisited: Empirical Findings Using the Kalman Filter Analysis

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ABSTRACT

One influential aspect of 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. The issues of concern here relate to a basic mapping out of trends and cycles rather than attempts to model causality directly. In the study, these trends and cycles are derived using the Kalman filter and the practice of time varying parameter (TVP). Although our results shows 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.

Keywords: Financial Integration, Interest rates, TVP, Kalman filter

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1. INTRODUCTION

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 a imminent challenge to local monetary authorities when they attempt to pursue independent economic policies. 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, 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 owed 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 the international market is called "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 is the outcome of imperfect market situations?

Assume 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? (A 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 parameter 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 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. Different from previous works,¹ 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 liberation of Asian market in 1980s have provided us a opportunity to review how those newly industrialized countries react to traditional economic powers, such as the United States and Japan. 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 word, 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. Section 5 concludes this study.

2. REVIEW OF EARLIER WORKS

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

¹ 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.

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 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, 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, bilateral 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 occurring outside the country, and Eurodollar market is affected by events occurring 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 unidirectional causality 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 argue 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 long-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 rates 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. HYPOTHESES AND METHODOLOGY

3.1 Testing Hypotheses

In our study, each country are treated the same as a potential driving force of other country's interest rates variation, and we mainly focus on Asian Market Integration, which includes Japan, Taiwan and South Korea. The next equation is used for the purpose of this study

$$r_i^{JP} = A(t) + B(t)r_i^{TW} \quad (3)$$

where r^{TW} and r^{JP} are the ex post real interest rates for Taiwan and Japan. $A(t)$ is defined as risk premia, which are assumed 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 Taiwan and Japan as the reference countries. If we want to focus on the relationship of Japan and Korea (r^{KR}), the equation can be rewritten such as $r_i^{JP} = A(t) + B(t)r_i^{KR}$.

Generally, we would like to test the following hypotheses for equation (3). First, if the differences between Taiwan 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 Taiwan 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 Taiwan 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 exhibit a random walk behavior.

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 1999:9. All the interest rates data are taken from the International Financial Statistics (IFS). 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 rates and inflation rates over the period t to $t+1$ are denoted by i_t and π_t , respectively.

4.2 Empirical Results

It is shown 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 dropped 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 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 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. The results from regressing South Korea real interest rates on

Taiwan real rates are also obtained and they 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, the linkages between Japan and the two newly industrialized countries seem to be stably jointed, which may support, in part, the financial integration of Asian Market.

5. CONCLUSIONS

This paper 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 rate convergence, which can not be achieved by using the cointegration tests.

The results provide no evidence supporting the equality of real interest rates in Asian sample 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. 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 research is needed to adopt a more complete time series structural model in order to determine driving force of the risk premium.

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亞太金融市場整合狀態重探－卡爾曼過濾法之實證運用

邱魏頌正

摘要

本研究嘗試運用卡爾曼過濾法(Kalman filter)及時間變動參數(time varying parameter)來分析亞太金融市場整合狀況。此種實證方法適合用來探討景氣波動時利率市場之動態調整過程，不只彌補過去因果模型 (causal model)研究之缺陷，並改善一般迴歸模型一對一之靜態限制。本文結果雖未提供亞洲金融市場實質利率聚合之證明，但發現樣本國家間有某程度的互賴現象。

關鍵詞：金融整合，利率，時間變動參數 (TVP)，卡爾曼過濾法