# TESTING VALIDITY OF PURCHASING POWER PARITY FOR EMERGING ASIAN COUNTRIES: EVIDENCE FROM THAILAND, TAIWAN AND SOUTH KOREA

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# การทดสอบความเที่ยงตรงของทฤษฎีอำนาจซื้อเสมอภาค ในประเทศตลาดเกิดใหม่ในภูมิภาคเอเชีย: กรณีศึกษาของประเทศไทย ไต้หวัน และเกาหลีใต้

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต
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| Thesis Title | TESTING VALIDITY OF PURCHASING POWER PARITY FOR EMERGING ASIAN COUNTRIES: EVIDENCE FROM THAILAND, TAIWAN AND SOUTH KOREA |
| By | Miss Patima Prajakschitt |
| Field of Study | Finance |
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วัตถุประสงค์หลักของการศึกษาคือ เพื่อทดสอบทฤษฎีอำนาจซื้อเสมอภาคในกลุ่มประเทศตลาดเกิดใหม่ในเอเชีย โดยเลือกประเทศไทย ไต้หวัน และเกาหลีใต้เป็นประเทศกลุ่มตัวอย่าง การทดสอบพิจารณาผลจากการใช้อัตราเงินเฟ้อจากผลตอบแทนหลักทรัพย์ (Chowdhry, Roll, and Xia, 2005) และตัวแทนอัตราเงินเฟ้ออื่น ๆ ทั้งในระยะสั้นและระยะยาว ผลการทดสอบสมมติฐานอำนาจซื้อเสมอภาคในระยะสั้นด้วย least-squares regression พบว่าไม่ปฏิเสธสมมติฐานที่ระดับความเชื่อมั่น 95% ในกรณีการใช้อัตราเงินเฟ้อจากผลตอบแทนหลักทรัพย์ในประเทศไทยและไต้หวัน แต่ปฏิเสธสมมติฐานที่ระดับนัยสำคัญ 5% ในประเทศเกาหลีใต้ นอกจากนั้นยังปฏิเสธสมมติฐานในกรณีตัวแทนอัตราเงินเฟ้ออื่น ๆ ในทุกประเทศอีกด้วย สำหรับทฤษฎีอำนาจซื้อเสมอภาคในระยะยาว การศึกษานี้ทดสอบทั้งในระดับ strong form และ weak form โดยวิธี unit root test และ cointegration test ผลการทดสอบทฤษฎีในระดับ strong form พบหลักฐานสนับสนุนทฤษฎีที่ระดับนัยสำคัญ 5% ในประเทศไทยในกรณีการใช้ดัชนีราคาสินค้าระหว่างประเทศ (traded goods price index: TPI) เป็นตัวแทนราคา ส่วนการทดสอบทฤษฎีในระดับ weak form พบหลักฐานสนับสนุนทฤษฎีที่ระดับนัยสำคัญ 5% ในประเทศไต้หวันในกรณีการใช้ดัชนีราคาสินค้าระหว่างประเทศเป็นตัวแทนราคา สำหรับกรณีอื่น ๆ นอกเหนือจากที่กล่าวมาข้างต้นไม่พบหลักฐานสนับสนุนทฤษฎี

ภาควิชา การธนาคารและการเงิน ลายมือชื่อนิสิต Patima Prajakschitt
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This study tests the validity of relative purchasing power parity (PPP) in Thailand, Taiwan, and South Korea. This study examines on the effect of the inflation extracted from stock returns (Chowdhry, Roll, and Xia, 2005) and other inflation proxies in short run and long run. In short run, the results of least-squares regression method do not reject the hypothesis of short run PPP at 95% confidence level in the case of Thailand and Taiwan, using the extracted inflation as inflation proxy. In the case of South Korea, the result rejects the hypothesis at 5% significance level. The results also reject the hypothesis of short run PPP in the case of other inflation proxies. In long run, this study tests evidences of PPP in both strong form and weak form, using unit root and cointegration tests. The results support the validity of PPP in strong form at 5% significance level in the case of Thailand, using traded goods price index (TPI) as price proxy. The results also support the validity of PPP in weak form at 5% significance level in the case of Taiwan, using TPI as price proxy. In other cases, the results do not support the PPP.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| *COIN* | cointegration |
| *COINxPI* | cointegration test model using *xPI* as price proxy |
| $p_t$ | domestic price proxy |
| $\Delta p_t$ , $\pi$_xPI | inflation rate (calculated from *xPI* index) |
| $\pi$-$\pi$*_xPI _XX_YY | inflation rate calculated from *xPI* index of country XX - inflation rate calculated from *xPI* index of country YY |
| $p_{T_t}$ | traded goods price proxy |
| $\Delta p_{T_t}$ | inflation rate calculated from traded goods price proxy |
| $p_{NT_t}$ | non-traded goods price proxy |
| $\Delta p_{NT_t}$ | inflation rate calculated from non-traded goods price proxy |
| $\hat{R}_{ft}$ , Rft_XX | estimated risk free rate (of country XX) |
| Rft-Rft*_XX-YY | estimated risk free rate of country XX - estimated risk free rate of country YY |
| *REG* | regression |
| *REGxPI* | regression model using *xPI* as price proxy |
| *REGRFT* | regression model using extracted risk free rate as price proxy |
| *RER* | real exchange rate |
| *RERxPI* | real exchange rate model using *xPI* as price proxy |
| $s_t$ | nominal exchange rate (in the form of domestic currency/foreign currency) |
| $\Delta s_t$ , d_s_XX | nominal exchange rate differential (change across time of exchange rate of country XX) |

# CHAPTER I

# INTRODUCTION

## 1.1 Introduction

The purchasing power parity (PPP) is an exchange rate theory. The PPP explains that the exchange rate between one country and another country is in equilibrium when the purchasing power of these two domestic currencies at that rate is equal. This means that the identical basket of goods in these two countries has equal price when the price is measured in the domestic currency. From the basic definition, the purchasing power parity theory is developed into two versions: absolute version, which focuses on price level and exchange rate level at one point of time; and relative version, which focuses on the change in price and the change in exchange rate relative to one point of time.

A number of studies cast doubt on the validity of PPP. One of the important works in this issue is the paper of Rogoff (1996). Rogoff denominates this problem as "PPP Puzzle", which focuses on the problem of *the econometric methodology*, especially the power problem. PPP Puzzle also focuses on the problem that the mean reverting of real exchange rate takes too long time to be captured by unit root test that includes not enough observations. Besides the notion from Rogoff (1996), the other accepted explanation of the deviation of PPP is *the imperfections in goods market*, such as the existence of transaction cost and trade barrier. Moreover, the imperfect competition in goods market generates the hysteresis and pricing-to-market behavior, which make goods price different across countries. At the same time, *money market*, which determines exchange rate level, has a lower degree of imperfection. Therefore, goods price is sticky when compared to the movement of exchange rate. From this reason, PPP deviates from the theoretical level.

However, about the deviation of PPP, there is another factor that we have to concern. This factor is *the choice of price proxy*. The choice of price proxy is matter in PPP test, because the different price proxy can make the result of PPP test to be different even in the same country and sample period. The most appropriate price proxy for the PPP is still ambiguous. One of the classical perspectives: Cassel (1928) concludes that the most appropriate price proxy should include all goods in the country, while another side of perspective such as the study of Heckscher et al. (1930) and Viner (1937) concludes that the most suitable price proxy should include only tradable goods. In practice, there are many price proxies. These proxies consist of different proportion of traded and non-traded goods. However, the performances of them are still ambiguous. Many studies tend to conclude that the price proxies of traded goods yield a stronger evidence of PPP, while some studies conclude in the opposite way.

Although the theory of PPP is tested several times in its long history, the evidences of PPP usually come from the developed countries, while the evidences from the rest of the world are rarely found. In the Asian countries, we always find the evidence from Japan. In other Asian countries, such as "the four Asian tigers": South Korea, Taiwan, Hong Kong, and Singapore, although these countries have high degree of development, they are less frequently tested.

In the group of four Asian tigers, South Korea and Taiwan are the important trade partners of the United States. Among the Asian countries, except for China and Japan, South Korea and Taiwan are the top fifteen trading partners of the U.S. in 2004 – 2008[1] (Foreign Trade Division, U.S. Census Bureau). This shows that Taiwan and South Korea are the important country in the aspect of international trade. From this reason, *South Korea* and *Taiwan* are selected from the group of the four Asian tigers. Furthermore, this study also examines in *Thailand* as Thailand is one of the important emerging Asian country.

In the three selected countries, the conventional price indexes: consumer price index (CPI) and producer price index (PPI) are too sticky to capture the movement of the exchange rate. As shown in figure 1.1, 1.2, and 1.3, the CPI and PPI are relatively stable, while the exchange rates are fluctuating. Thus, it is interesting to test the PPP in these

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[1] Hong Kong and Singapore have smaller volume of trade with the U.S. However, these two countries play an important role as the financial center instead.

countries, using new price proxies that may capture the exchange rate movement better than these conventional price proxies.

**1.2 Motivation**

The evidences of PPP are tested in various countries in short run and long run. It is accepted that we can find the evidence to support PPP in long run easier than in short run. However, in long run, *the results are mixed*. There are many explanations of the deviation of PPP. The choice of price proxy is one of them. Chinn (1999), Fleissig and Strauss (2000), and Xu (2003) indicate that the different price indexes yield different results to the validity of PPP. The test results are varying, even though the test uses the data from the same country and the same sample period. This means that *the choice of price proxy is matter*.

The conventional price indexes, such as consumer price index and producer price index are doubted for their compatibility with PPP relationship. Figure 1.1, 1.2, and 1.3 support to this argument. The fitness of the CPI and the PPI to the movement of exchange rate is not satisfactory. So there are many attempts to construct new price proxies to be the better choice. Some of these price proxies are better fit to the PPP than the traditional price proxies. However, emerging Asian countries suffer from the limitation of data to construct some of these new price proxies. Moreover, the evidences of PPP in emerging Asian countries are rarely to find. From these reasons, it is interesting to re-examine the PPP in emerging Asian countries, using the applicable choices of the new price proxies that have a good performance in their evidences.

There are three inflation and price proxies used to test the PPP in this study. The first one is the extracted inflation from the study of Chowdhry, Roll, and Xia (2005) (C-R-X). This study provides us the challenging argument about the evidence of PPP in short run. The data from stock market, which fully reflects information, news, and expectation in the market, are used to extract the pure price inflation rate to test PPP. While the inflations in normal case, which are calculated from goods price index, are not much flexible, the extracted inflation of C-R-X is more flexible to the relevant factors in financial market than the normal case inflations. In the study of C-R-X, the extracted inflation satisfies the PPP in short run in the U.K., German, and Japan, using the U.S. as domestic country. This confirms that the extracted inflation immediately reflects the change in the market in short run. Because the extracted inflation of C-R-X is never been tested in Thailand, Taiwan, and South Korea, this inflation proxy is selected to test in this study.

In the case of the second price proxy, this study selects the traded goods price index (TPI) from the study of Xu (2003). The conclusion from the study of Xu (2003) indicates that the TPI is more appropriate than CPI and WPI for both PPP test and exchange rate forecast. According to the concept of PPP, trade volume has an important role, because the purchasing power is equalized between countries through arbitrage mechanism. The volume of trade activity reflects the opportunity of arbitrage. From this reason, the TPI is interesting to be tested in the country that has high trade activity, using its trade partner as exchange rate denominator. From the data, Thailand, Taiwan, and South Korea are the important trade partner of the U.S., so this study selects TPI from the study of Xu (2003) as the second price proxy to test PPP.

In addition, this study also tests the third price proxy: the comparative competitive of domestic goods, which is expressed by relative non-traded goods price of domestic country and traded goods price of foreign country. The concept of comparative competitive comes from the study of Edwards (1989). Dutton (1998) uses this concept to construct the new form of relative price to test PPP. From the data of total trade volume of Thailand, Taiwan, and South Korea, using the U.S. as foreign country, the portion of export volume is higher than import volume. So the comparative competitive of domestic goods might play an important role and may has the significant effect to the PPP between these country pairs. From this reason, the relative non-traded goods price of domestic country and traded goods price of foreign country is selected as the third price proxy to test PPP.

## 1.3 Objective

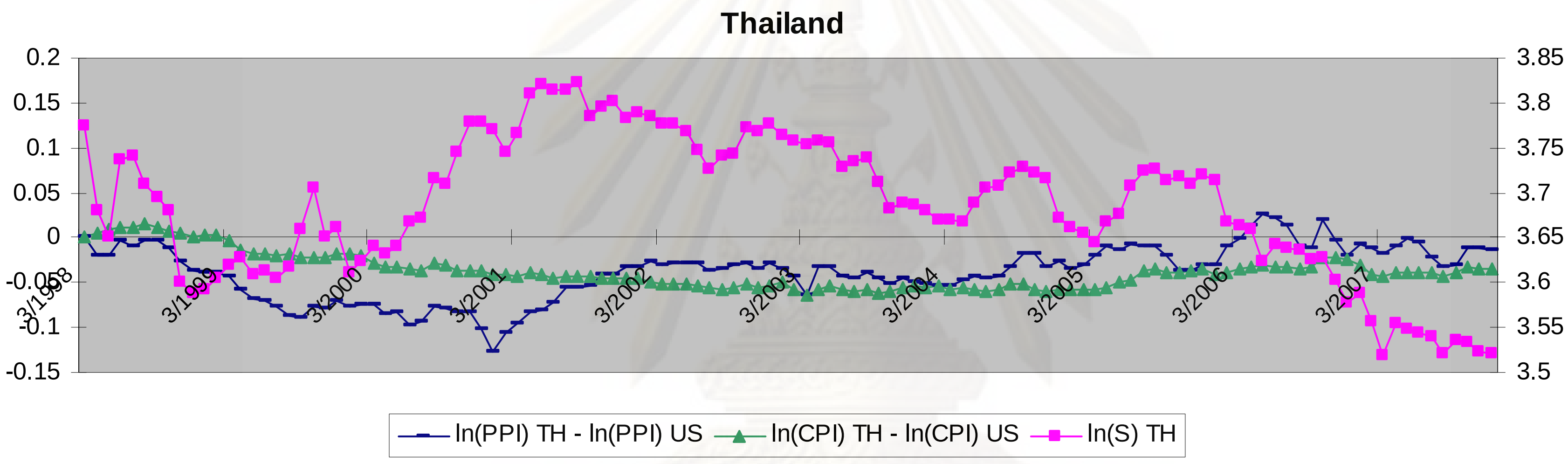
This study attempts to test the validity of relative purchasing power parity (PPP) in short run and long run in emerging Asian countries. This study selects Thailand, Taiwan, and South Korea as the sample countries, using monthly data from March 1998 to

December 2007. The inflation and price proxies for the tests in this study are the extracted inflation, which follows the methodology of Chowdhry, Roll, and Xia (2005); traded goods price index, which follows the construction method of Xu (2003); and the relative non-traded goods price of domestic country and traded goods price of foreign country, from the study of Edwards (1989).

**1.4 Organization**

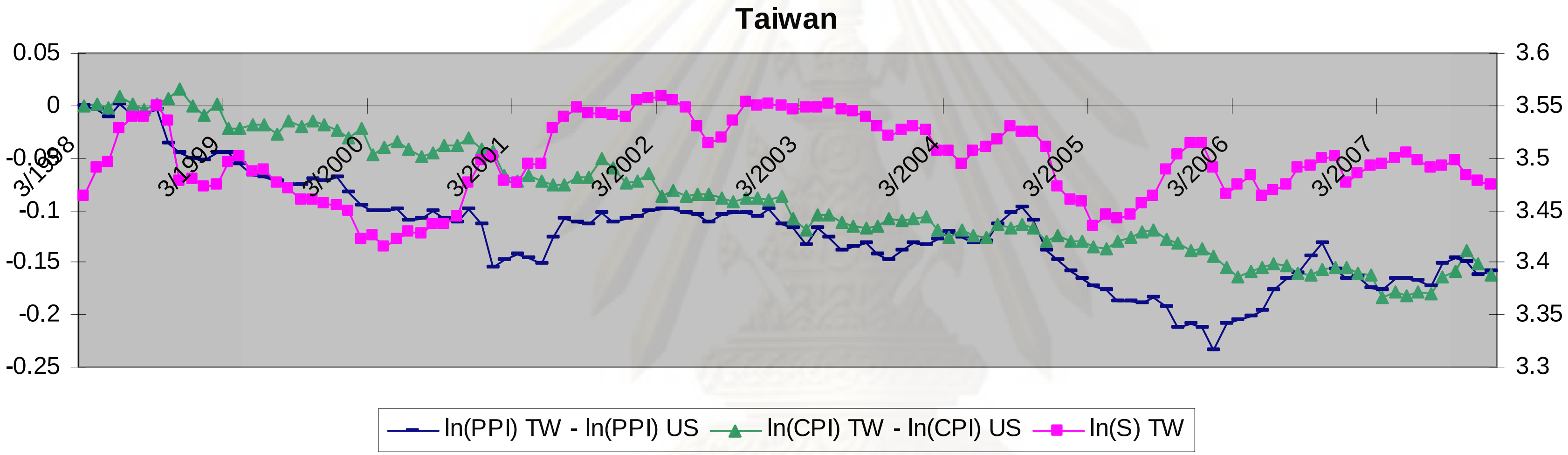
This study is organized into five chapters. The first chapter is an introduction. The motivation and objective of this study are also indicated in this chapter. The second chapter reviews the literatures and theoretical background that are related to this study. The third chapter examines on the methodology and data. The fourth chapter reports and analyzes the results from the tests, and the fifth chapter concludes the results and discusses about major findings and some limitations.

**Figure 1.1**: The Comparison between Relative PPI, Relative CPI, and Exchange Rate of Thailand and the U.S.




**Notes**: 1. TH denotes Thailand. 2. US denotes the United States. 3. ln(PPI) XX denotes log of producer price index of country XX. 4. ln(CPI) XX denotes log of consumer price index of country XX. 5. ln(S) XX denotes log of exchange rate of country XX. 6. The first and the second Y-axis indicate the scales of the relative price indexes and the exchange rate, respectively.

**Figure 1.2**: The Comparison between Relative PPI, Relative CPI, and Exchange Rate of Taiwan and the U.S.




**Notes**: 1. TW denotes Taiwan. 2. US denotes the United States. 3. ln(PPI) XX denotes log of producer price index of country XX. 4. ln(CPI) XX denotes log of consumer price index of country XX. 5. ln(S) XX denotes log of exchange rate of country XX. 6. The first and the second Y-axis indicate the scales of the relative price indexes and the exchange rate, respectively.

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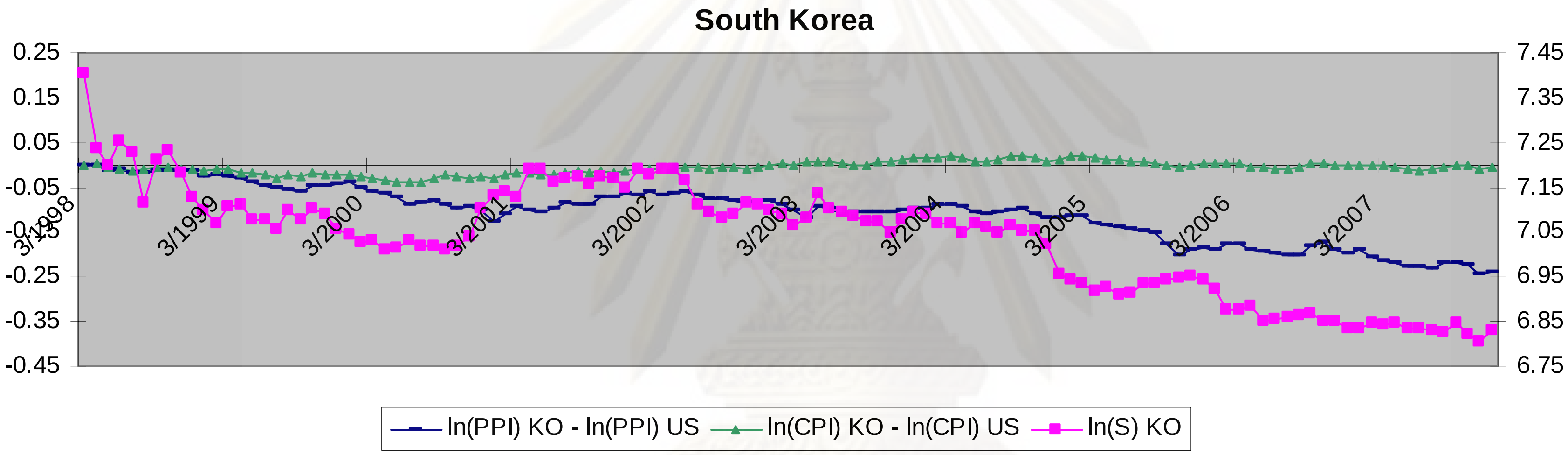
**Figure 1.3**: The Comparison between Relative PPI, Relative CPI, and Exchange Rate of South Korea and the U.S.




**Notes**: 1. KO denotes South Korea. 2. US denotes the United States. 3. ln(PPI) XX denotes log of producer price index of country XX. 4. ln(CPI) XX denotes log of consumer price index of country XX. 5. ln(S) XX denotes log of exchange rate of country XX. 6. The first and the second Y-axis indicate the scales of the relative price indexes and the exchange rate, respectively.

# CHAPTER II

# REVIEW OF LITERATURE
# AND THEORETICAL BACKGROUND

## 2.1 Review of Literature

The history of PPP test starts at the flexible exchange rate era (1920 – 1926) before the Bretton Woods system. In this era, PPP tests are based on the extremely short sample period. The tests always examine on the exchange rate of the European countries and the U.S. The study of Frenkel (1978) and Krugman (1978) are the examples of the study in this era. The results are mixed and significantly different up to econometric method, country, and sample period. The next era starts after the collapse of Bretton Woods system in 1970 and continues to present. The studies of PPP usually come from this era, because each country starts to use their exchange rate regime independently in this period. There are many models of test specification, because the PPP relationship can express in different form. The currencies that are selected to test still come from developed countries, especially the OECD countries. In this era, the sample period can be extended longer, but the results are still mixed.

Along the time span of PPP history, many issues concern about the validity of PPP. From all of them, three important issues are directly related to this study; the econometric method, the explanation of the PPP deviation, and the studies on the choices of price proxies that are used to test the PPP. The next three sections examine on all of them.

### 2.1.1 Evidences of PPP Using Different Econometric Method

One important issue in the empirical study of PPP is the test method, because the validity of PPP is dramatically robust from the test method. There are many eras of PPP test, indicated by the development of econometric method. The first method is the least-squares regression, the second method is the unit root test, and the third method is the cointegration test. After that, an evolution occurs to the field of PPP test. Multivariate and nonlinear time series are used to test the validity of PPP. However, this section reviews the three methodologies that are related to this study.

**2.1.1.1 Least-Squares Regression**

In the first era, linear regression analysis is used to test the PPP through the coefficient estimation in PPP equation. The implication of this method is the PPP relationship in short run. There are many works using ordinary least squares (OLS). The results are mixed. Frenkel (1978) runs regression on the dollar - pound, franc - dollar, and franc - pound exchange rates using the sample period between February 1921 and May 1925, the result supports PPP. Three years later, Frenkel (1981) applies the same test to the dollar - pound, dollar - French franc, and dollar - deutschmark using the sample period between June 1973 and July 1979. The results do not support PPP. Krugman (1978) uses the ordinary least squares (OLS) method applies to the same three exchange rates as in Frenkel (1981), over the interwar (July 1973 to December 1976) and the recent floating period (February 1920 to December 1925, 1926, 1923 for pound, French franc, and deutschmark respectively). The results reject the one-to-one relationship between exchange rate and relative prices.

An important problem of some literatures that use OLS in this era is that they do not test the stationary of the nominal exchange rate and relative prices. If these two variables are nonstationary, the equation is spurious. Therefore, the pre-checking for stationary of the series is very important when we use the least-squares regression to test the validity of PPP.

**2.1.1.2 Unit Root Test**

Unit root test is used to test PPP by testing for behavior of the real exchange rate series. The non-rejection of unit root (or nonstationary) hypothesis means that the series appears to be nonstationary and does not revert to its equilibrium level, so this evidence does not support the long run PPP. The real exchange rate test is the most restricted form of

PPP, because the unit root test in the real exchange rate series is equal to imposing the restriction of one on the coefficient of exchange rate and prices. The two main methods of unit root test are the augmented Dickey-Fuller (ADF) and the Phillip and Perron (PP). There are many literatures using these methods. The results do not support the validity of PPP.

Adler and Lehmann (1983) tests the martingale behavior of the real exchange rate series using monthly data between 1971 and 1981 of 43 countries from Australia, Europe, South America, and Africa. The results indicate the deviation from PPP.

Hakkio (1986) has an argument on the conventional unit root test such as DF and F test. The argument is that the rejection of unit root is rarely to find because of the power problem of these conventional test method, so we should not rely on the result of these tests too much. Rogoff (1996) indicates that the other two factors, which are slow mean reverting of PPP and small sample, reinforce the power problem. These factors can make the null hypothesis of unit root bias toward non-rejection.

Reunrojrung (2008) also concerns about the low power problem. This study tests the PPP in Thailand against four Southeast Asian neighbors and six bilateral FTA partners. This study uses ADF and PP as two from all methods to test the PPP. The results of these two methods do not support PPP in all cases. However, in order to take care of low power problem of ADF and PP by increasing the number of observations, this study also applies the panel unit root test. The results of some methods indicate the presence of PPP evidences in the group of SEA. However, the results do not indicate the presence of PPP in the group of FTA partners.

There are many attempts to develop new method to solve for the power problem. The examples are the Elliott, Rothenberg, and Stock (1996)'s Dickey-Fuller generalized least squares (DF-GLS) and the optimal point estimate ($P_T$). Moreover, Ng and Perron (2001) develops the Modified Information Criteria (MIC) to choose more appropriate lag length for unit root test. Though the new methods are tested by Monte-Carlo experiment and conclude a higher power in small sample than the traditional DF and ADF, the evidence from Darn´e and Hoarau (2007), which uses the DF-GLS and MIC, still rejects the PPP. This study tests for the mean-reversion of the real exchange rate and examines on the effect of shock from the depreciation in the Australian exchange rate, using the sample period of February 1970 to April 2005.

Moreover, the study of Chen (2008) also does not reject unit root in the PPP test using the DF-GLS and the MIC. This study tests the stationary of the real exchange rate constructed from the extracted inflation rate series of Chowdhry, Roll, and Xia (2005). The results indicate that the real exchange rate is not mean-reverting.

As discussed above, the unit root test is used as one method to test the evidences of PPP. The reasons of the rejection of PPP are still ambiguous that the rejection could results from the low power problem of unit root test as well as the real factor from the economy such as market structure and trade barriers, which cause the real exchange rate series deviate from its mean. As a result, the test results from this most restricted form of PPP always fail to support the PPP.

#### 2.1.1.3 Cointegration Test

There are two important methods to test cointegration relationship: Engle and Granger (1987) and Johansen multivariate cointegration test developed in Johansen (1988) and Stock and Watson (1988). The concept of PPP test using the cointegration test is that if exchange rate and price level are cointegrated, they have a comovement or long run equilibrium relationship with each other. This implies that the long run PPP holds. To test the cointegration, the integration order of the data series is checked first. If they are integrated at the same order, the process can continue to test for cointegration. So the problem of spurious equation does not occur, while it could occur in the OLS method.

Enders (1988) is one in the first group of studies that uses the cointegration method to test the validity of PPP (Moosa and Bhatti, 1997). The study of Enders applies the cointegration test method of Engle and Granger and unit root test. This study examines on the data of German, Canada, Japan, and the U.S. The sample period of January 1960 to April 1961 is used as the fixed exchange rate period, and January 1973 to November 1986 is used as the flexible exchange rate period. After the cointegration test, the error-correction model is estimated. The results indicate that the evidences of PPP are mixed.

Kim (1990) tests the cointegration between exchange rate, CPI, and WPI using yearly data of 1914 – 1972 and 1900 – 1972, respectively. The test applies to the bilateral exchange rate between the U.S. and Canada, French, Italy, Japan, and the U.K. using Engle and Granger method. The result indicates the cointegration relationship in the case of WPI but does not indicate the cointegration in the case of CPI.

Cheung and Lai (1993) tests PPP using the method of Johansen and maximum likelihood estimator. This study also examines on the proportionality and symmetry condition of PPP. The tests are applied on CPI and WPI using the exchange rate of the U.K., France, Germany, Switzerland, and Canada as foreign country and the U.S. as home country. The data cover the period from January 1974 to December 1989. The results support the hypothesis of long run PPP with measurement errors in prices.

Do ğ anlar (1997) tests for cointegration using Engle and Granger and Johansen method. The tests apply to five developing Asian countries; India, Indonesia, Pakistan, Philippine, and Turkey. The study uses quarterly data of exchange rate and relative CPI series from 1980 to 1995. The results indicate that there is no cointegration in all sample countries.

Baharumshah and Ariff (1997) tests the PPP in Malaysia, Indonesia, Thailand, Philippines and Singapore using the Johansen cointegration test. The test is applied on the quarterly data of 1974 – 1993. The results do not support the PPP.

From the above evidences, the results of PPP are mixed. The problem of the Engle and Granger method is the power problem. This problem may be the reason of the mixed results. Nevertheless, this problem cannot explain the rejection of PPP in large sample data and in the tests that use Johansen procedure (Sarno and Taylor, 2002). However, we still use cointegration test as an important method to test the PPP. Thus, we absolutely use cointegration test instead of OLS method in the case of integrated series.

### 2.1.2 Studies on the Explanations of PPP Deviation

Through the long time span of PPP studies, there are many attempts to develop econometric techniques. Besides the issue about the test methods, there is an argument that the concept of PPP is too idealistic. The PPP is just the theoretical perspective and hard to occur in practice. The reason behind this argument is that in the real world, there are many factors bring about the deviation of PPP from the theoretical level. The following section examines on some of these factors.

**2.1.2.1 The Difference between Goods Market and Financial Market**

The First explanation of PPP deviation is the difference between goods market, which determines price level; and financial market, which determines exchange rate level. Krugman (1986), Dixit (1989), and Delgato (1991) explain about the imperfections of goods market. The transportation cost, trade barrier, and menu cost[1] exist in goods market. The imperfect competition in goods market leads to barrier to entry for new comers. Moreover, the producer's behavior, such as hysteresis[2] and pricing-to-market (PTM)[3] also causes goods price unequal. Compared to financial market, there is much lower degree of these imperfections. Therefore, exchange rate can highly reflect demand, supply, and expectations. As a result, exchange rate is flexible while goods price is sticky.

Dornbusch (1976) explains the slower speed of adjustment of goods price as a reason of the "overshooting" of exchange rate. Given one level of goods price, the central bank announces the permanent increase in money supply. Domestic nominal interest rate decreases. This makes the nominal interest rate of domestic lower than that of the foreign country. To clear the market, market expects the depreciation of domestic currency, while

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[1] As explained in Delgato (1991), menu cost is the cost of changing for goods price. Menu cost comes from two parts. The first part is direct cost, results from administrative expenses occurred when the firms change their price, such as printing new menu or catalogue. The second part comes from the decreasing in revenue resulting from brand -switching of customers when goods price changes.

[2] Prices do not reverse instantaneously, or eventually, even though the original cause of the price changing is no longer present. (see more explanation in Dixit (1989))

[3] The prices of the same goods are different in each country, goods prices are quoted depending on demand in each market.

goods price remains constant. This leads to the jump depreciation of domestic currency. In the long run, price level increases. Market expects the appreciation of domestic currency after the short run jump, then the domestic nominal interest rate increases. As a result, domestic currency appreciates. However, the level is still higher than the initial level. From this mechanism of adjustment, we can see that the exchange rate immediately reflects to the shock and expectation, while the goods price slowly adjusts to these factors.

In another work, Mussa (1982) develops the model of exchange rate dynamics. The model treats the exchange rate as an asset price, which is affected by exogenous real and monetary factor. The changing in exchange rate reflects both expected changes in these exogenous factors and expectations occasioned by new information. Because of the expectations, exchange rate is more fluctuating than goods price. This could be one explanation of the PPP deviation.

**2.1.2.2 The Index Problem**

The second explanation of the deviation of PPP is the "index problem". The index problem is examined as an effect of price index construction (Wang, 2005). The difference in goods basket between two countries has an obvious effect to the PPP. The increasing in one good price may has a different effect to the price index of two countries if that good is included in one country's basket but not included in another country's basket. This circumstance can cause the PPP deviates from the parity.

Weighting scheme of price index also has an effect to the PPP between two countries. The changing in the price of the same goods will lead to the different effect on the price index of the two countries if these indexes use different weighting scheme. Moreover, there are some differences between price index in developing and developed country. The developing country usually spends high portion of income on basics such as food and clothing, while these goods take up a smaller portion in developed countries. These issues have to be concerned because they are probably significant in PPP test.

### 2.1.3 Studies on the Choices of Price Proxy

There are many studies about the validity of PPP. These studies use various types, components, and construction methods of price indexes. However, the conventional price indexes commonly used in literatures are always based on consumer price index (CPI), wholesale price index (WPI), producer price index (PPI), and gross domestic product (GDP) Deflator. However, these indexes are still doubted for their fitting to the PPP theory in the aspect of their ability to capture the movement of exchange rate. From this reason, there are many studies on alternative price proxies in the history of PPP. Some of them in the last ten years are reviewed in *appendix A*.

There are three works related to this study. The first one is the literature of Chowdhry, Roll, and Xia (2005) (C-R-X). This study uses Fama and French three-factor model (Fama and French, 1993), Carhart four-factor model (Carhart, 1997), and Fama and MacBeth two-step regression (Fama and MacBeth, 1973) to extract inflation from stock returns in United Kingdom, Japan, Germany using the U.S. Dollar as domestic currency. The results from univariate OLS estimation and panel seemingly unrelated regression (SUR) strongly support relative PPP in short run.

The second work is the study of Xu (2003). This study tests PPP using consumer price index (CPI), wholesale price index (WPI), and traded goods price index (TPI). The data come from the U.S. and eight trading partners: Canada, France, Germany, Italy, Japan, Korea, Netherland, and the U.K. The sample period starts from the first quarter of 1974 to the last quarter of 1997. This study uses the augmented Dickey and Fuller (ADF) unit root test, Engle and Granger (1987) cointegration test, and OLS estimation. The results indicate that *TPI* appears to be a more appropriate price index for both PPP test and exchange rate forecasting.

The third work is the study of Dotton (1998). This study constructs the “new measure” of inflation from CPI components. This study separates traded and nontraded goods out of each other and constructs the new measure of traded goods and nontraded goods. The wholesale price index (WPI) is used as traded goods price proxy, while the consumer price index (CPI) is used as nontraded goods price proxy. The test uses Canada, France, Japan, and the U.K. as domestic country and the U.S. as foreign country. The sample period is January 1968 – December 1991. This study uses the ADF method to test the real exchange rate constructed from three forms of relative price indexes. The comparative competitive, which is expressed by the relative price of foreign traded goods and domestic non-traded goods, is one of the three forms of relationship. The Johansen cointegration test is used to test the cointegration between exchange rate and price indexes. The results conclude no evidence of PPP in all cases in our concern. However, the relationship between foreign traded goods price and domestic nontraded goods price is interesting to be re-examined in emerging-Asian cases, because these countries have high export volume to the U.S. This condition may increase the effect of the comparative competitive, and may have a significant effect to PPP in these countries.

## 2.2 Theoretical Background

In this study, the related theories can be separated into three groups. The first group is the relationship between prices and exchange rate; the law of one price, the absolute purchasing power parity, the relative purchasing power parity, and the real exchange rate. The second group is the econometric methodologies that are used in this study; least-squares regression, unit root test, and cointegration test. The third group contains three theories that are related to the extracted inflation rate; the Fama and French three-factor model, the Fama and Macbeth approach, and the Chowdhry, Roll, and Xia (2005) (C-R-X) approach.

For a brief demonstration in this part, the law of one price and the absolute purchasing power parity are shown in *appendix B*, and the econometric methodologies are shown in *appendix C*.

### 2.2.1 Relative Purchasing Power Parity

The *absolute PPP* is the relationship between exchange rate level and price level of two countries at one point of time. About the *relative PPP*, the relationship is examined on the change across time of exchange rate and the change across time of price level in two countries. Another definition of relative PPP is the relationship between the change across time of exchange rate and the *inflation* in two countries. The specification can be shown as:

$$\Delta s_t \approx \Delta p_t - \Delta p_t^* \quad . \tag{2.1}$$

where $\Delta s_t$ denotes the change across time of log of exchange rate, $\Delta p_t$ and $\Delta p_t^*$ denote the inflation rate calculated from log of price index of home country and foreign country, respectively.

### 2.2.2 Real Exchange Rate

*Exchange rate* is the *price* of one country's currency in terms of another country's currency. On the other hand, exchange rate is the *rate* that the different currency can be traded with each other. However, because exchange rate is constructed in terms of *prices*, exchange rate can be affected by the change in price level or inflation in each country.

One type of exchange rate that is usually used in practice is called nominal exchange rate. Another type of exchange rate that is adjusted in order to take away the effect of inflation is called *real exchange rate*.

Real exchange rate is equal to the nominal exchange rate adjusted by the relative national price level:

$$Q_t = S_t \frac{P_t^*}{P_t} \quad , \tag{2.2}$$

where $Q_t$ denotes real exchange rate, $S_t$ denotes nominal exchange rate in terms of domestic currency to foreign currency, $P_t$ and $P_t^*$ denote price index of home country and foreign country, respectively.

Real exchange rate can be expressed in the log form as:

$$q_t = s_t + p_t^* - p_t \quad , \tag{2.3}$$

where $q_t$ denotes log of real exchange rate, $s_t$ denotes log of nominal exchange rate, $p_t$ and $p_t^*$ denote log of domestic price index and foreign price index, respectively.

Dutton (1998) constructs the special form of real exchange rate from the concept of the international competitive in the study of Edwards (1989). This concept examines the effect of goods price produced abroad and goods price produced and consumed at home. A rise (fall) in the relative value of these two prices increases (decreases) the competitiveness of the domestic goods. Dutton (1998) uses this relationship to construct the real exchange rate in the following form:

$$q_t = s_t + p^*_{T_t} - p_{NT_t} \quad , \tag{2.4}$$

where $q_t$ denotes log of real exchange rate, $s_t$ denotes log of nominal exchange rate, $p^*_{T_t}$ denotes log of traded goods price index of foreign country, and $p_{NT_t}$ denotes log of nontraded goods price index of home country.

### 2.2.3 The Fama and French Three-Factor Model

The Fama and French three-factor model is an important asset pricing theory. Next to the basic framework – capital asset pricing model (CAPM), which introduces the market premium as a risk factor, Fama and French investigate the effect of other market risk factors to explain stock returns. According to Fama and French (1992), Fama and French try to measure the effect of five factors; market beta, size, leverage, book-to-market equity, and earning price ratios. The findings indicate that size and book-to-market equity have the important role in explaining stock returns. In the next study, Fama and French (1993) explicitly identifies three common risk factors for stock returns; market premium, size, and book-to-market equity.

In order to investigate the effect of these three factors, Fama and French use six portfolios formed based on size (market capital) and BTM (book value to market value of equity). In June of each year *t*, stocks are ranked based on size using the median size as a breakpoint to split the stocks into two groups: small (S) and big (B). In the same way, the stocks are also ranked into three groups based on BTM using the breakpoint of top 30% (high: H), middle 40% (medium: M), and bottom 30% (low: L).

Fama and French explain about the reason of using just two groups of size that the BTM plays more important role than size in explaining stock returns (Fama and French, 1992). From the ranking process, Fama and French get six portfolios: S-H, S-M, S-L, B-H, B-M, and B-L.

After the ranking process, Fama and French calculate value-weighted average return of the six portfolios each month from July of year *t* to June of year *t+1,* and then readjust the portfolio at June *t+1*.

The portfolio of small minus big (SMB) is the difference, each month, between simple average return on S-H, S-M, and S-L and the simple average return on B-H, B-M, and B-L. In the same way, the portfolio of high minus low (HML) is the difference, each month, between simple average return on S-H, and B-H and the simple average return on S-L and B-L.

Fama and French three-factor model can be expressed as this equation:

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}\lfloor Rm_t - R_{ft} \rfloor + \beta_{i2} SMB_t + \beta_{i3} HML_t + \varepsilon_t \,, \qquad (2.5)$$

where $R_{it}$ denotes the returns on asset *i*, $Rm_t$ denotes the value weighted return of the market portfolio, and $R_{ft}$ denotes the one-month T-bill rate as a proxy of risk free rate of return.

### 2.2.4 The Fama and MacBeth Approach

In the study of Fama and MacBeth (1973), Fama and MacBeth use the following two-parameter portfolio model of Tobin (1958), Markowitz (1959) and Fama (1965) to test the hypothesis about the relationship between average return and risk.

$$E(R_i) = E(R_f) + \beta_i \lfloor E(Rm) - E(R_f) \rfloor \,, \qquad (2.6)$$

(2.6) can be generalized to:

$$R_{it} = \gamma_{0t} + \gamma_{1t}\beta_i + \gamma_{2t}\beta_i^2 + \gamma_{3t} S_i + \eta_{it} \,. \qquad (2.7)$$

To estimate the $\hat{\gamma}s$ series, Fama and MacBeth use the two-step regression. In the first step, time series regression is run on each security *i* using equation (2.6) and get the estimated value $\hat{\beta}_i$. In the second step, given the $\hat{\beta}_i$ from the first step, cross-sectional regression is run on each *t* using (2.7), and get the $\hat{\gamma}s$ series. After that, Fama and MacBeth use the $\hat{\gamma}s$ series to test their hypotheses.

One of the hypotheses in the Fama and MacBeth's work is the Sharpe-Lintner (S-L) hypothesis:

$$E(\gamma_{0t}) = R_{ft} \,. \qquad (2.8)$$

From this hypothesis, C-R-X use the estimated $\hat{\gamma}_0$ as the estimated $R_{ft}$ (risk free rate of return). Furthermore, another contribution from the work of Fama and Macbeth (1973) to the work of C-R-X is the two-step regression approach.

### 2.2.5 The Chowdhry, Roll, and Xia (2005) (C-R-X) Approach

From the study of Chowdhry, Roll, and Xia (2005), C-R-X extract the pure price inflation rate from stock returns to test PPP. They use the Fama and French three-factor model and the Carhart four-factor model as the asset pricing model to capture “real effect” and use the Fama and MacBeth approach to extract the “pure price inflation rate” from the observed stock returns.

First, C-R-X assume that the following Fisher equation holds:

$$i = r + \pi \quad , \tag{2.9}$$

where *i* denotes the nominal interest rate, *r* denotes the real interest rate, and $\pi$ denotes the inflation rate. As a result of the Fisher equation, the following relationship holds:

$$R_{it} = r_{it} + \pi_t \quad \forall i \quad , \tag{2.10}$$

where $R_{it}$ denotes the nominal rate of return on asset *i*, $r_{it}$ denotes the real rate of return (or real interest rate) on asset $i$ , and $\pi_t$ denotes the pure price inflation.

C-R-X assume that all *real effect*s of all factors (include the real effect of inflation) are captured by the factors in the asset pricing model, so all *real effect*s are captured by the $r_{it}$ . As a consequence, the $\pi_t$ measures only *pure price inflation.*

From the above assumption, C-R-X extract the pure price inflation using the three-factor model. First, the SMB and HML are calculated follow the Fama and French (1993) method. After that, C-R-X run the two-step regression follow the Fama and Macbeth two-step approach.

Recall the Fama and French three-factor model:

$$R_{it} - R_{ft} = \alpha_i + \beta_{i1}\left[Rm_t - R_{ft}\right] + \beta_{i2}SMB_t + \beta_{i3}HML_t + \varepsilon_t. \tag{2.11}$$

However, in the real world, we can only observe the $TB_{t-1}$, which is the *expected* risk free return at time $t$ that is determined at time $t-1$ (or at the beginning of period *t*).

When apply $TB_{t-1}$ instead of $R_{ft}$, the three factor model above changes to the following equation:

$$R_{it} - TB_{t-1} = \alpha_i + \beta_{i1}\left[Rm_t - TB_{t-1}\right] + \beta_{i2}SMB_t + \beta_{i3}HML_t + \eta_{it} \ , \qquad (2.12)$$

where

$$\eta_{it} \equiv \left(1-\beta_{i1}\right)\left[R_{ft} - TB_{t-1}\right] + \varepsilon_{it} \ . \qquad (2.13)$$

Since $TB_{t-1} = E_{t-1}\left[R_{ft}\right]$, the $R_{ft} - TB_{t-1}$ measures the *unexpected* inflation plus the *unexpected* real rate of return, the error term $\eta_{it}$ is composed of two mean zero terms; linear function of unexpected component of risk free return and the error term $\varepsilon_{it}$.

The $R_{ft}$ is composed of two components: real risk free rate of return ($r_{ft}$) and inflation rate ($\pi_t$). Because the $TB_{t-1} = E_{t-1}\left[R_{ft}\right]$, we can rewrite that

$TB_{t-1} = E_{t-1}\left[r_{ft} + \pi_t\right] = r_{ft}^e + \pi_t^e$.

The (2.13) can be rewritten as:

$$\eta_{it} \equiv \left(1-\beta_{i1}\right)\left[\left(r_{ft} + \pi_t\right) - \left(r_{ft}^e + \pi_t^e\right)\right] + \varepsilon_{it} \ . \qquad (2.14)$$

The (2.12) and (2.14) are rearranged to (2.15) and (2.16) as follows:

$$R_{it} - \hat{\alpha}_i = \hat{\beta}_{i1}\left[Rm_t - TB_{t-1}\right] + \hat{\beta}_{i2}SMB_t + \hat{\beta}_{i3}HML_t$$
$$+ \left(1-B_{i1}\right)\left[\left(r_{ft} + \pi_t\right) - \left(r_{ft}^e + \pi_t^e\right)\right] + TB_{t-1} + \varepsilon_{it} \ , \qquad (2.15)$$

$$R_{it} - \hat{\alpha}_i = \hat{R}_{ft} + \hat{\beta}_{i1}\left[Rm_t - TB_{t-1}\right] + \hat{\beta}_{i2}SMB_t + \hat{\beta}_{i3}HML_t + \varepsilon_{it} \ , \qquad (2.16)$$

where

$$\hat{R}_{ft} = \left(1-B_{i1}\right)\left[\left(r_{ft} + \pi_t\right) - \left(r_{ft}^e + \pi_t^e\right)\right] + TB_{t-1} \ , \qquad (2.17)$$

$$\hat{R}_{ft} = \left[\left(1-\beta_{i1}\right)r_{ft} + \beta_{i1}r_{ft}^e\right] + \left[\left(1-\beta_{i1}\right)\pi_t + \beta_{i1}\pi_t^e\right] , \qquad (2.18)$$

where $R_{it}$ denotes the stock returns on industry $i$, $TB_{t-1}$ denotes the proxy of T-Bill rate, $Rm_t$ denotes the value-weighted return of the market portfolio, and $"e"$ denotes the expected value.

The two-step regression begins here. C-R-X run the *first step* (time series regression) on the equation (2.12) and get the estimated series of $\hat{\alpha}_i$, $\hat{\beta}_{1i}$, $\hat{\beta}_{2i}$, and $\hat{\beta}_{3i}$ of each industry *i*.

In the *second step*, C-R-X run cross-sectional regression on the (2.16) using the $\hat{\alpha}_i$, $\hat{\beta}_{1i}$, $\hat{\beta}_{2i}$, and $\hat{\beta}_{3i}$ from the first step. For each *t*, the industries returns ($R_{it}$) minus $\hat{\alpha}_i$ are run against the $\hat{\beta}_{i1}$, $\hat{\beta}_{i2}$, and $\hat{\beta}_{i3}$. From the cross-sectional regression, C-R-X get the time series of $\hat{R}_{ft}$.

From (2.18), it is obvious that $\hat{R}_{ft}$ is composed of two components, real rate of return (or real interest rate) (r) and pure price inflation ($\pi$). Because the real interest rate is unobservable, so we cannot separate the real interest rate from the pure price inflation. The contamination of the real interest rate could bias the result of the PPP test. However, C-R-X conclude to use this ex-post nominal risk-free rate ($\hat{R}_{ft}$) to test for PPP. This is applicable if the test meets two following conditions:

1) The $\hat{R}_{ft}$, is used in the test specification as the dependent variable.

2) The real interest rate differential ($r_{ft} - r_{ft}^*$) correlates with neither the inflation differential ($\pi_t - \pi_t^*$) nor the foreign exchange rate differential ($\Delta s_t$)[4].

As a result, C-R-X specify the equation specification of the PPP test as:

$$\hat{R}_{ft} - \hat{R}_{ft}^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \quad , \tag{2.19}$$

where * denotes the data of foreign country, $\Delta s_t$ denotes the change across time of exchange rate, $\varepsilon_t$ is the error term. This equation specification satisfies the first condition, while the second condition that assumed by C-R-X is acceptable when considered from empirical evidences. Thus, the test that uses this specification is not bias.

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[4] As explained by C-R-X, many general equilibrium models often assume that the real interest rate is not correlated with both pure price inflation and exchange rate. However, though the assumption can be set to keep continue the test, there are many studies (such as Bleaney, M. and Laxton, D. (2003)) that find the relationship between real interest rate and exchange rate only in the long run, while this study examines on the change in variables in monthly period (short run).

# CHAPTER III

# METHODOLOGY AND DATA

## 3.1 Methodology

In this study, three price indexes are used to test the validity of the purchasing power parity through econometric methods. This chapter explains about the tests that are performed in this study. The first part examines on the price proxies; hypothetical price index (HPI), traded goods price index (TPI), and the relative domestic consumer price index and foreign traded goods price index (CTPI). The second part examines on the test specifications, and the third part explains the overall process of the test.

### 3.1.1 Price Indexes

There are three forms of relative price proxies for PPP test in this study. The three relative price proxies are constructed from three price indexes; hypothetical price index (HPI), traded goods price index (TPI), and consumer price index (CPI). These price indexes have the different component and different objective of construction. Some important details are shown in the following part.

#### 3.1.1.1 Hypothetical Price Index (HPI)

In the study of Chowdhry, Roll, and Xia (2005) (C-R-X), HPI is constructed from the estimated risk free rate ( $\hat{R}_{ft}$ ). The method of $\hat{R}_{ft}$ estimation is explained in the theoretical background section. After the $\hat{R}_{ft}$ is estimated, HPI series is constructed follow this formula:

$$HPI_t = HPI_{t-1}\left(1 + \hat{R}_{ft}\right) \quad . \tag{3.1}$$

The $\hat{R}_{ft}$ is used as inflation rate for the HPI. The HPI in the first period (3:1998) is set equal to 100.

**3.1.1.2 Consumer Price Index (CPI)**

According to the *IMF's CPI manual*, the objective of construction of *CPI* is to measure the change in price level of goods and services acquired by households. The construction of this index is different in details among different country. However, the CPI maintains its objective of construction. Though the goods components are varying in different country, the CPI of all countries contains high portion of non-traded goods. As a result, Dutton (1998) uses the CPI as the price proxy of non-traded goods. Follow the study of Dutton (1998), this study also uses the CPI as the price proxy of non-traded goods in the third form of the relative price proxies.

**3.1.1.3 Traded Goods Price Index (TPI)**

In this study, the TPI is constructed from the import price index (MPI) and export price index (XPI). As defined in the *IMF's XMPI manual,* the *MPI* measures change in the price of goods and services produced by nonresidents of an economic territory and consumed by the residents, while the *XPI* measures change in the price of goods and services produced by the residents of an economic territory and consumed by nonresidents.

This study constructs the TPI from the MPI and the XPI, weighted average by the proportion of import and export expenditure in total trade expenditure. The construction method follows Xu (2003), the formula is:

$$TPI_t = \alpha_{I_t} MPI_t + \alpha_{X_t} XPI_t \ , \tag{3.2}$$

$$\alpha_{I_t} = \frac{MEXP_t}{TEXP_t} \ , \tag{3.3}$$

$$\alpha_{X_t} = \frac{XEXP_t}{TEXP_t} \ , \tag{3.4}$$

where $MEXP_t$ denotes the import expenditure, $XEXP_t$ denotes the export expenditure, and $TEXP_t$ denotes the total trade expenditure.

The TPI is used in the second and the third form of the relative price proxies.

#### 3.1.1.4 International Competitive of Domestic Goods (CTPI)

The concept of "international competitive of domestic goods" in this study comes from the study of Edwards (1989). The international competitive of domestic goods is the relative prices of traded goods of foreign country ( $p^*_{T_t}$ ) and non-traded goods of domestic country ( $p_{NT_t}$ ). The study of Edwards (1989) examines the effect of price of goods that produced abroad and price of goods that produced and consumed at home. A rise (fall) in this relative prices increases (decreases) the competitiveness of the domestic goods.

The study of Dutton (1998) uses the concept of the international competitive to test PPP in both real exchange rate and cointegration specification. In this study, this concept is also used as the third form of the relative price proxies to test the PPP using CPI as the proxy of non-traded goods price of domestic country ( $p_{NT_t}$ ) and TPI as the proxy of traded goods price of foreign country ( $p^*_{T_t}$ ).

### 3.1.2 Model Specifications

The evidences of PPP are tested by three test specifications. The first specification is the test of short run PPP using least-squares regression method. The second and the third specification is the test of long run PPP using unit root test and cointegration test.

#### 3.1.2.1 Short Run PPP

This study uses the ordinary least-squares (OLS) regression method to test the short run relationship between relative inflation and difference across time of exchange rate. The OLS is run on PPP equation using monthly data. The meaning of the model is that the relative value of "the change in price level" between two countries is equal to the change across time of exchange rate. Because this study uses monthly data, time horizon between $t$ and $t+1$ is one month. This implies the "short" time horizon allowed for an adjustment of the relevant variables, so this is the test of short run PPP.

The following equation is the specification of relative PPP.

$$\Delta s_t \approx \Delta p_t - \Delta p_t^* \tag{3.5}$$

$\Delta s_t$ denotes change across time of log of domestic currency in the form of direct quoted (domestic/foreign currency), $\Delta p_t$ denotes inflation rate calculated from log price index of home country, and $\Delta p_t^*$ denotes inflation rate calculated from log price index of foreign country.

This study uses two forms of test specification for the short run PPP. The first form uses $\Delta s_t$ as explanatory variable and the second form uses relative inflation as explanatory variable.

In the first specification, the reason behind using $\Delta s_t$ as explanatory variable is that the extracted inflation ( $\hat{R}_{ft}$ ) contains both pure price inflation and real interest rate. Moreover, the volatility of the $\hat{R}_{ft} - \hat{R}_{ft}^*$ is much higher than $\Delta s_t$. In order to circumvent the critical bias, C-R-X suggest using $\Delta s_t$ as explanatory variable and introducing an intercept to the test equation.

The model specifications of the short run test can be shown as:

$$\Delta p_t - \Delta p_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t , \qquad (3.6)$$

$$\Delta p_{NT_t} - \Delta p_{T_t}^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t , \qquad (3.7)$$

where $\Delta p_t$ denotes inflation rate of home country, $\Delta p_t^*$ denotes inflation rate of foreign country, $\Delta p_{NT_t}$ denotes inflation rate calculated from non traded goods price proxy of home country, $\Delta p_{T_t}^*$ denotes inflation rate calculated from traded goods price proxy of foreign country, and $\Delta s_t$ denotes change across time of domestic currency.

In the case of the $\hat{R}_{ft}$, C-R-X has an implicit assumption that the real interest rate differential has no correlation with both inflation differential and exchange rate differential. The test specification of $\hat{R}_{ft}$ (*REFRFT*) is constructed from (3.6). However, in order to compare the results of TPI inflation and CTPI inflation to the result of $\hat{R}_{ft}$ based on the first specification, *REGTPI* and *REGCTPI* are also constructed using (3.6) and (3.7), respectively. All test specifications can be shown as follows:

$$\hat{R}_{ft} - \hat{R}_{ft}^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \quad , \qquad REGRFT1$$

$$\Delta TPI_t - \Delta TPI_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \quad , \qquad REGTPI1$$

$$\Delta CPI_t - \Delta TPI_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \quad , \qquad REGCTPI1$$

$\hat{R}_{ft} - \hat{R}^*_{ft}$ denotes estimated risk free rate differential, $\Delta TPI$ denotes inflation calculated from log of TPI, $\Delta CPI$ denotes inflation calculated from log of CPI, $\Delta s_t$ denotes change across time of log of exchange rate. *REG* refers to *regression*. The * denotes the data of foreign country. In the model *REGCTPI1*, the CPI is used as the proxy of non-traded goods price and the TPI is used as the proxy of traded goods price.

The null hypothesis is $\beta_1 = 0, \beta_2 = 1$ to be the evidence to support PPP. This null hypothesis is tested against the general alternative hypothesis $\beta_1 \neq 0, \beta_2 \neq 1$, which means that this evidence does not support the short run PPP.

The following specifications are the second form of short run PPP. This form is also tested in this study to compare the results to the first form. This is the usually used PPP specification in other literatures. The relative inflation is used as explanatory variable, because in normal case (inflation calculated from goods price), $\Delta s_t$ is *usually* more fluctuating than inflation differential. The intercept ( $\alpha_1$ ) is introduced to capture other factor that explains the higher volatility of the $\Delta s_t$. The test specifications are shown as follows:

$$\Delta s_t = \alpha_1 + \alpha_2 \left( \hat{R}_{ft} - \hat{R}^*_{ft} \right) + \varepsilon_t \ , \qquad REGRFT2$$

$$\Delta s_t = \alpha_1 + \alpha_2 \left( \Delta TPI_t - \Delta TPI^*_t \right) + \varepsilon_t \ , \qquad REGTPI2$$

$$\Delta s_t = \alpha_1 + \alpha_2 \left( \Delta CPI_t - \Delta TPI^*_t \right) + \varepsilon_t \ . \qquad REGCTPI2$$

In the same way, the null hypothesis of this specification is $\beta_1 = 0, \beta_2 = 1$ to be the evidence to support PPP. The null hypothesis is tested against the general alternative hypothesis $\beta_1 \neq 0, \beta_2 \neq 1$, which means that this evidence cannot be used to support the short run PPP.

However, in the case of $\hat{R}_{ft}$, this study tests the specification *REGRFT2* as an additional evidence of $\hat{R}_{ft}$, using the usually used form of PPP, not examines this specification as PPP hypothesis test. The reason is that the volatility of the dependent variable ( $\Delta s_t$ ) is much lower than that of the explanatory variable $\left( \hat{R}_{ft} - \hat{R}^*_{ft} \right)$. Moreover, the $\hat{R}_{ft}$ contains both pure price inflation and real interest rate. The PPP expects the relationship between inflation differential and exchange rate differential but the meaning of the $\alpha_2$ is the explanation of *both real interest rate differential and inflation differential* on exchange rate differential. Therefore, the result of *REGRFT2* is bias if we use this model to test the PPP hypothesis.

**3.1.2.2 Long Run PPP**

The PPP can be classified based on the degree of validity as *strong form* and *weak form*. The definition of *strong form* and *weak form* is indicated in Drine and Rault (2008). The strong PPP restricts the cointegration coefficient between the nominal exchange rate ($s_t$) and the relative prices ($p_t - p_t^*$) equal to one. Under weak PPP, the nominal exchange rate ($s_t$) and the relative prices ($p_t - p_t^*$) are required to be cointegrated with each other. However, the cointegration coefficient can differ from unity. From the definition, the necessary condition of the strong PPP is the cointegration relationship between $s_t$ and $p_t - p_t^*$, and the sufficient condition is the one-to-one correspondence. In the case of weak PPP, although the cointegration coefficient is not restricted to be one, it should not too far from one. The reason is that the cointegration coefficient is allowed to vary from one because of the imperfections such as measurement error. However, these errors should occur in the acceptable bound. Therefore, the cointegration coefficient should not deviate too much from the theoretical value (one).

The validity of PPP in the long run is tested by two specifications. The first specification (univariate model) is the unit root test in real exchange rate series (*RER)*. The second specification (bivariate model) is the cointegration test for the comovement between nominal exchange rate and relative price proxy.

**1) The univariate model (unit root tests in real exchange rate series)**

The univariate model is the model of real exchange rate (*RER*). Real exchange rate is calculated from nominal exchange rate adjusted by price level of foreign and domestic country. In the log form, real exchange rate is represented by log nominal exchange rate plus log foreign price minus log domestic price. Because PPP predicts that the exchange rate of domestic country is equal to price ratio (or relative prices) of the two countries, real exchange rate is not permanently changed. This prediction leads to using unit root test to test in real exchange rate series.

The models of real exchange rate are given as:

$$q_t = s_t + p_t^* - p_t \quad ,$$

$$q_t = s_t + p_{T_t}^* - p_{NT_t} \quad ,$$

where $q_t$ denotes log of real exchange rate, $s_t$ denotes log of nominal exchange rate, $p_t^*$ denotes log of foreign price level, $p_t$ denotes log of domestic price level, $p_{T_t}^*$ denotes log of traded goods price index of foreign country, and $p_{NT_t}$ denotes log of non-traded goods price index of home country.

The real exchange rate model for the HPI, TPI, and CTPI can be shown as follows:

$$q_t = s_t + HPI_t^* - HPI_t \quad , \qquad RERHPI$$

$$q_t = s_t + TPI_t^* - TPI_t \quad , \qquad RERTPI$$

$$q_t = s_t + TPI_t^* - CPI_t \quad , \qquad RERCTPI$$

where $q_t$ denotes log of real exchange rate, $s_t$ denotes log of nominal exchange rate, $xPI_t^*$ denotes log of foreign price index, $xPI_t$ denotes log of domestic price index. *RER* refers to "Real Exchange Rate".

Because the real exchange rate is constructed from calculation, the coefficient of (*xPI**, *xPI* ) is equal to (1, -1) by construction. The stationary property of the real exchange rate series implies the cointegration between the nominal exchange rate ( $s_t$ ) and the relative prices ( $xPI_t^* - xPI_t$ ) by restricting the cointegration coefficient between ( $s_t$ ) and ( $xPI_t^* - xPI_t$ ) equal to one. This conforms to the explanation in Moosa and Bhatti (1997)[1].

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[1] *"in the jargon of cointegration analysis, this specification implies the imposition of the restriction (1, -1, 1) on the cointegrating vector* [(s, p, p*)]*"* and *"cointegration between the nominal exchange rate and relative prices is a necessary but not a sufficient condition ... the sufficient condition being that there is one-to-one correspondence between the nominal exchange rate and relative prices"* (Moosa and Bhatti, 1997: 195)

From the definition of strong PPP, the unit root test in the real exchange rate series is the strong PPP test. Since some biases in unit root test could occur from many factors such as short time period and mis-specification, this study uses the results from unit root test and the results from cointegration test to confirm the strong PPP. The evidence supports strong PPP if the result meets three conditions; the real exchange rate is stationary, cointegration relationship is present, and the cointegration coefficient is not far from one.

To test for unit root in the $q_t$ series, more than one method is used to confirm the result. All methods are briefly shown as follows.

**The Augmented Dickey - Fuller Tests (ADF)** is used to test unit root in real exchange rate. The specification can be shown as the following AR(p) form:

$$\Delta q_t = a_0 + \alpha q_{t-1} + \sum_{i=2}^{p} \beta_i \Delta q_{t-i+1} + \varepsilon_t \quad . \tag{3.8}$$

The null hypothesis is $\alpha = 0$ (nonstationary). The alternative hypothesis is $\alpha \neq 0$ (stationary). The result of unit root test supports the validity of strong PPP if the null hypothesis is rejected.

**The Phillips-Perron Tests (PP)** and the **Modified Point Optimal Tests (MPT)**[2] are also used as a robustness check for unit root tests**.** The MPT uses the AR GLS-detrended spectral density estimation method, which uses the detrended data from the study of Elliott, Rothenberg, and Stock (1996) (ERS) and applies with the **Modified Akaike Information Criteria (MAIC)** developed by Ng and Perron (2001). The Monte Carlo experiment indicates that the Modified Information Criteria applied on the detrended data has desirable size and power property (Ng and Perron, 2001).

However, a temporary shock (such as oil price shock) can occur in the real world and this shock can affect to the real exchange rate series. The standard ADF test could bias toward the non-rejection of unit root even if the series is stationary. To take account of the structural break, the unit root test method from the study of **Perron (1989)** is also used to test our real exchange rate series. Dummy variables are introduced to the test equation as follows:

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[2] The details of PP and MPT are shown in *appendix C*.

$$H_0: \quad q_t = a_0 + q_{t-1} + \mu_1 D_P + \mu_2 D_L + \varepsilon_t \quad . \tag{3.9}$$

$$H_1: \quad q_t = a_0 + a_2 t + \mu_2 D_L + \mu_3 D_T + \varepsilon_t \quad . \tag{3.10}$$

The dummy variable $D_p$ refers to a *pulse* dummy. Assume that a structural break occurs at $t = \tau + 1$, $D_p$ = 1 if $t = \tau + 1$ and zero otherwise. $D_L$ refers to a *level* dummy. $D_L$= 1 if $t > \tau$ and zero otherwise. $D_T$ refers to a *trend* dummy. $D_T(\tau + 1)$ = 1, $D_T(\tau + 2)$ = 2, ... , otherwise, $D_T$ = 0. The null hypothesis ($H_0$) is the unit root process with one time jump in level data and the permanent change in the drift term. The alternative hypothesis ($H_1$) is the stationary process with the permanent change in the drift term and the change in the slope of the trend.

To test the hypothesis, first estimate the residual from the alternative hypothesis ($\hat{y}_t$) and then test unit root in the estimated residual, using this test equation:

$$\hat{y}_t = a_1 \hat{y}_{t-1} + \sum_{i=1}^{k} \beta_i \Delta \hat{y}_{t-i} + \varepsilon_t \quad . \tag{3.11}$$

A rejection of the null hypothesis means that the unit root is rejected, so this evidence supports the PPP in the strong form.

**2) The bivariate model (cointegration test)**

This specification is designed to test the cointegration relationship between nominal exchange rate and relative prices. The cointegration coefficient between these two components is not restricted to be one. Therefore, this model is the test of long run PPP in the weak form. However, the test result of bivariate model can be used to confirm the strong PPP if the cointegration between the nominal exchange rate and the relative prices occurs and the estimated cointegration coefficient ($\beta_1$) is equal to one.

The testing models can be shown as:

$$s_t = \beta_0 + \beta_1 \left(p_t - p_t^*\right) + \varepsilon_t, \tag{3.12}$$

$$s_t = \beta_0 + \beta_1 \left(p_{NT_t} - p_{T_t}^*\right) + \varepsilon_t \, , \tag{3.13}$$

where $s_t$ denotes log of nominal exchange rate, $p_t$ denotes log of domestic price level, $p_t^*$ denotes log of foreign price level, $p_{NT_t}$ denotes log of nontraded goods price index of home country, and $p_{T_t}^*$ denotes log of traded goods price index of foreign country.

The test specifications are constructed as:

$$s_t = \beta_0 + \beta_1(HPI_t - HPI_t^*) + \varepsilon_t \; , \qquad COINHPI$$

$$s_t = \beta_0 + \beta_1(TPI_t - TPI_t^*) + \varepsilon_t \; , \qquad COINTPI$$

$$s_t = \beta_0 + \beta_1(CPI_t - TPI_t^*) + \varepsilon_t \; , \qquad COINCTPI$$

where $s_t$ denotes log of nominal exchange rate, $PI_t^*$ denotes log of foreign price index, and $PI_t$ denotes log of domestic price index.

**The Johansen method** is used to test the cointegration. The details are shown in *appendix C.*

For the cointegration test using trace statistic, the hypothesis is

$H_0$: *at most r* cointegrating vectors exist (at *r=0*, $H_0$ means *"no cointegration relationship"*)

$H_1$: *more than r* cointegrating vectors exist.

For the cointegration test using max-eigenvalue statistic, the hypothesis is

$H_0$: *r* cointegrating vectors exist (at *r=0*, $H_0$ means *"no cointegration relationship"*)

$H_1$: *r +1* cointegrating vectors exist.

From the definition of weak PPP, the test results support the weak PPP if the $H_0$ is rejected at *r=0* (null of *no cointegration* is rejected). The normalized estimated cointegration coefficient ( $\beta_1$ ) is not restricted to equal to one. However, it should be positive and not far from one, tested by Log likelihood ratio test.

The test procedure is examined in the third part. The conclusion of the model specifications is indicated in table 3.1 and table 3.2.

### 3.1.3 Process of the Tests

All process can be examined as follows:

**1. The indexes construction**

Before the testing process, HPI is constructed follow the equation (3.1) and TPI is constructed follow the equation (3.2) to (3.4).

**2. The testing process**

Regression model (*REG*)

Each series are tested for integration order. If all series are I(0), least-squares regression is run on *REG1 and REG2* to estimate the coefficients. After that, the individual coefficients are tested by t-test and the joint coefficients are tested by Wald test.

Real exchange rate model (*RER*)

Unit root test is applied on real exchange rate series using the method of ADF, PP, MPT, and Perron (1989).

Cointegration model (*COIN*)

Each series are tested for integration order. If not all series are integrated at the same order, this study concludes no cointegration. If all series are integrated at the same order, this study continues to test cointegration by Johansen method. If cointegration relationship occurs, the cointegration coefficient is tested by log likelihood ratio test.

The conclusion of the tests is shown in the table 3.3.

## 3.2 Scope and Data

This study focuses on the PPP relationship in the three emerging countries; Thailand, Taiwan, and South Korea using the United States as foreign country. The scope of this study is monthly data started from 3:1998 to 12:2007. The period of study is restricted by the availability of the data from stock markets, which are emerging market. Another factor is the change in exchange rate regime. Thailand changed the regime from basket peg to float in 7:1997 and South Korea changed the regime from managed float to clean float in 12:1997.

The local currency of Thailand, Taiwan, and South Korea is used in terms of direct quote (local currency to foreign currency) using the U.S. Dollar as denominator. All rates are collected from the Datastream.

The CPI, import goods price index (MPI), export goods price index (XPI), import expenditure, and export expenditure are collected from the Datastream. Before the tests, the price indexes are adjusted to the same base (3:1998).

To extract the ex-post risk free rate in the case of Thailand, Taiwan, and South Korea, the following data are required; risk free rate of return proxy, market capital, book-to-market equity, market portfolio index, and sector price index; all series are collected from the Datastream. Noted that the sectors are classified according to the local stock market in order to have sufficient observations and acceptable standard error in the second step of Fama and MacBeth approach. In the case of the United States, SMB, HML, and industry return index are already provided in the Kenneth French's data library[3].

The details of the risk-free rate proxy, market portfolio index, and sector price index for the extraction of the ex-post risk free rate are shown as follows:

**Thailand**

- Proxy of risk-free rate: government securities-bank loan rate
- Market portfolio index: Bangkok SET
- Sector price indexes: 24 sectors price index classified according to the Thailand Stock Exchange; BNGKAGR, BNGKFDI, BNGKHHG, BNGKFHN, BNGKPPC, BNGKBNK, BNGKFIN, BNGKINS, BNGKAUT, BNGKPPM, BNGKPAK, BNGKPET, BNGKCNM, BNGKPDV, BNGKENG, BNGKMIN, BNGKCOM, BNGKENR, BNGKHCS, BNGKHOT, BNGKTLO, BNGKPFS, BNGKCMM, and BNGKELC
- Noted that the BNGKIMM is cut off from the procedure because the sample period of this sector is insufficient. The portion of the average market capital of this sector to total market capital is 1.5%. So the exclusion has not much effect to the test.

**Taiwan**

- Proxy of risk-free rate: interbank rate overnight
- Market portfolio index: Taiwan Composite

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[3] http://mba.tuck.dartmount.edu/pages/faculty/ken.french/

- Sector price indexes: 22 sectors price index classified according to the Taiwan stock market; TACABLE, TATRANS, TATOURS, TATEXTS, TASTEEL, TARUBBER, TAPLTIC, TAPAPLP, TAOTHER, TAGLASS, TAFOODS, TAELTRN, TAELECM, TAELMCH, TACONST, TACHEMS, TACMENT, TAFINAN, TAAUTOM, TACEMEN, TAPLAST, and TARETAL

**South Korea**

- Proxy of risk-free rate: interbank rate overnight
- Market portfolio index: Korea Composite
- Sector price indexes: 20 sectors price index classified according to the South Korea Stock Exchange; KORBANK, KORCHEM, KORCOMM, KORCNST, KORELEC, KORELGA, KORFINS, KORFBEV, KORINSR, KORBMET, KORMACH, KORMCMP, KORNMMP, KORWPLP, KORPHRM, KORSECS, KORTWAP, KORTRNS, KORTRNW, and KORWHLS
- Noted that two sectors: KORMEDI and KORSERV are cut off because the data are initiated at 12:2000, too short period to be tested. The portion of the average market capital of these two sectors to total market capital is 0.28% and 4.35%, respectively.

**United States**

- Proxy of risk-free rate: CITIGROUP 1 month T-Bill, collected from the Datastream
- Market portfolio index: S&P 500 from the Datastream
- Industries return indexes: 30 industries return index classified according to the four-digits SIC code, include the NYSE, AMEX and NASDAQ. The 30 industries are Food, Beer, Smoke, Games, Books, HsHld, Clths, Hlth, Chems, Txtls, Cnstr, Steel, FabPr, ElcEq, Autos, Carry, Mines, Coal, Oil, Util, Telcm, Servs, BusEq, Paper, Trans, Whlsl, Rtail, Meals, Fin, and Other.

**Table 3.1:** Conclusion of Inflation and Price Proxies

| proxy | model | | inflation proxy (short run) | | price proxy (long run) | | literature |
|---|---|---|---|---|---|---|---|
| | **short run** | **long run** | **domestic country** | **foreign country** | **domestic country** | **foreign country** | |
| 1. | *REGRFT* | *RERHPI* | $\hat{R}_{ft}$ | $\hat{R}^{*}_{ft}$ | HPI | HPI* | C-R-X (2005) |
| | | *COINHPI* | | | | | |
| 2. | *REGTPI* | *RERTPI* | $\triangle$TPI | $\triangle$TPI* | TPI | TPI* | Heckscher et al. (1930) and Viner (1937) |
| | | *COINTPI* | | | | | |
| 3. | *REGCTPI* | *RERCTPI* | $\triangle$CPI | $\triangle$TPI* | CPI | TPI* | Edwards (1989) |
| | | *COINCTPI* | | | | | |

**Notes**: *REG* refers to "regression", *RER* refers to "real exchange rate", *COIN* refers to "cointegration", * denotes the data of foreign country, *RFT* denotes the extracted risk free rate, *HPI* denotes the hypothetical price index, *TPI* denotes the traded goods price index, and *CTPI* denotes the relative non-traded goods price of domestic country and traded goods price of foreign country.



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**Table 3.2:** Conclusion of Test Specifications

| model | specification | method |
|---|---|---|
| *REG1* | $\Delta p_t - \Delta p_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t,$ | least-squares regression |
| *REG2* | $\Delta s_t = \alpha_1 + \alpha_2 \left( \Delta p_t - \Delta p_t^* \right) + \varepsilon_t,$ | least-squares regression |
| *RER* | $q_t = s_t + p_t^* - p_t$ | unit root test |
| *COIN* | $s_t = \beta_0 + \beta_1 \left( p_t - p_t^* \right) + \varepsilon_t$ | cointegration test |

**Notes**: $\triangle p$ denotes inflation proxy of domestic country, $\triangle p^*$ denotes inflation proxy of foreign country, $\triangle$s denotes change across time of exchange rate, $p$ denotes log of domestic price level, $p^*$ denotes log of foreign price level, and $q$ denotes log of real exchange rate.

**Table 3.3** Conclusion of Test Methods

| | ***REG*** | ***RER*** | ***COIN*** |
|---|---|---|---|
| **pretest** | integration order | - | integration order |
| **model** | *REGRFT, REGTPI, REGCTPI* | *RERHPI, RERTPI, RERCTPI* | *COINHPI, COINTPI, COINCTPI* |
| **method** | least-squares regression | ADF, PP, MPT and Perron (1989) | Johansen |
| **null hypothesis** | $\beta_1 = 0$, $\beta_2 = 1$ | $\alpha = 0$ (nonstationary) | "no cointegration relationship" |

**Notes**: *REG* refers to “regression”, *RER* refers to “real exchange rate”, *COIN* refers to “cointegration”, *RFT* denotes the extracted risk free rate, *HPI* denotes the hypothetical price index, *TPI* denotes the traded goods price index, and *CTPI* denotes the relative non-traded goods price of domestic country and traded goods price of foreign country.

# CHAPTER IV

# RESULTS

## 4.1 Preliminary Analysis

Table 4.1 reports the summary statistics of the data used in this study. Consider the CPI inflation ($\pi$_CPI) of all countries and CPI inflation differential ($\pi$-$\pi$*_CPI) of all country pairs, the standard deviation (s.d.) of these series are lower than the standard deviation of the change across time of exchange rate (d_s). This means that the volatility of CPI inflation is too low to capture the movement of exchange rate. Moreover, when we consider the table 4.2, the correlation between CPI inflation differential ($\pi$-$\pi$*_CPI) and the change across time of exchange rate (d_s) of Thailand, Taiwan, and South Korea are 0.03, 0.003, and 0.08, respectively. These correlations are very low. This is one of the reasons why the other inflation proxies that may capture the movement of exchange rate better than the CPI are examined and tested in this study.

The market portfolio return ( $Rm$ ), SMB, and HML are used to estimate the estimated risk free rate ( $\hat{R}_{ft}$ ). Consider the table 4.1, the standard deviation of the $Rm$ of the U.S. is the lowest in the four countries, while the standard deviation of the $Rm$ of the three emerging Asian countries; Thailand, Taiwan, and South Korea is not much different from each other. Consider the SMB and HML of the emerging countries; in the Korean market, the mean of SMB and HML has the highest magnitude. This means that the returns of the “High (H)” portfolio are much different from the “Low (L)” portfolio, and the returns of the “Small (S)” portfolio are much different from the “Big (B)” portfolio. In other words, the stock returns in Korea stock market are highly scattered compared to Thailand and Taiwan. In the case of Taiwan, the s.d. of SMB and HML are lower than South Korea but higher than Thailand, while the s.d. of $Rm$ are not much different from the group. This means that the returns in Taiwan stock market are less scatter than that in Korea stock market, but more scatter than that in Thailand stock market.

Please be noted that the outliers are excluded from *each* portfolios; H-S, H-B, M-S, M-B, L-S, and L-B. This study does not use *all stocks* as one dataset to exclude the outliers. As a result, the value of SMB and HML could be fluctuating if the market is volatile. However, the SMB and HML from the present method can reflect the "true" values around each portfolio's mean better than the method that uses all stocks as one data set.

The $Rm$, SMB, and HML are used as regressors in the first step regression (2.13) to estimate $\hat{\alpha}_i$, $\hat{\beta}_{1i}$, $\hat{\beta}_{2i}$, and $\hat{\beta}_{3i}$. Referring to table 4.3 to 4.6, the number of the estimated betas of SMB and HML ($\hat{\beta}_{2i}$ and $\hat{\beta}_{3i}$) that are significantly different from zero is quite low. For $\hat{\beta}_{2i}$ and $\hat{\beta}_{3i}$, none of all countries have % of significance exceed 62.5%. South Korea has the lowest % of significance (30%). This implies that the Fama and French's three factors cannot explain the returns so well, especially in Korea stock market.

After the $\hat{\alpha}_i$, $\hat{\beta}_{1i}$, $\hat{\beta}_{2i}$, and $\hat{\beta}_{3i}$ are estimated and used in the second step regression, the $\hat{R}_{ft}$ are extracted. Referring to table 4.1, the mean of the $\hat{R}_{ft}$ of the U.S. is almost the same as the mean of the T-Bill of the U.S. This occurs in the U.S. because there is no process of outlier exclusion in the first step regression in the U.S. As a result, every observations of the T-Bill (*every t*) are used in the extraction process and this makes the mean of the $\hat{R}_{ft}$ almost equal to the mean of the T-Bill. In the case of Thailand, Taiwan, and South Korea, outliers in the series of industry return, $Rm$, SMB, and HML are excluded in some points of time series ($t$). As a result, some observations of T-Bill are not used in the first- step regression. So the mean of the $\hat{R}_{ft}$ in the case of Thailand, Taiwan, and South Korea is a little lower than the mean of T-Bill.

The series of $\hat{R}_{ft}$ consists of inflation and real interest rate as two main components. The volatility of this series results from the volatility of these two main components, plus the estimation error. Consider the standard deviation (s.d.) of CPI inflation ($\pi$_CPI) of all countries, standard deviation of the CPI inflation of Taiwan is the highest, followed by South Korea, Thailand, and the U.S., respectively. In the case of the real interest rate, the standard deviation of T-Bill (a proxy of real interest rate) of South Korea is the highest, followed by Thailand, Taiwan, and the U.S., respectively. From the volatility of these two main components, because South Korea has the highest volatility in real interest rate, and the highest estimation error, the $\hat{R}_{ft}$ of South Korea is the most overshooting. In the case of Taiwan, this market has the highest volatility in inflation rate, so the $\hat{R}_{ft}$ of Taiwan is the second most overshooting.

Referring to table 4.1, consider the standard deviation (s.d.) of the change across time of exchange rate (d_s) and the set of inflation proxies differential (Rft-Rft*, π-π*_CPI, π-π*_TPI, and π-π*_CTPI), the standard deviation of TPI inflation differential (π-π*_TPI) is the closest value to the standard deviation of the change across time of exchange rate (d_s) in all countries. Referring to table 4.2, the TPI inflation differential (π-π*_TPI) and the change across time of exchange rate (d_s) in all countries is the most correlated pair. The implication from table 4.1 conforms to the implication from table 4.2.

Figure 4.1.1 to 4.3.3 show the relationship in the test specification of the short run PPP. The figure of the estimated risk free rate differential (Rft-Rft*) in all countries is overshooting compared to the change across time of exchange rate (d_s), while the figure of TPI inflation differential (π-π*_TPI) and CTPI inflation differential (π-π*_CTPI) are lower in magnitude compared to the change across time of exchange rate (d_s). The results of the regressions are discussed in the next section.

### 4.2 Short Run PPP

The first regression model uses the exchange rate differential as explanatory variable,

$$\hat{R}_{ft} - \hat{R}^{*}_{ft} = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \qquad REGRFT1$$

$$\Delta TPI_t - \Delta TPI^{*}_t = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \qquad REGTPI1$$

$$\Delta CPI_t - \Delta TPI^{*}_t = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t \qquad REGCTPI1$$

$\hat{R}_{ft} - \hat{R}^{*}_{ft}$ denotes estimated risk free rate differential, $\Delta s_t$ denotes exchange rate differential (or change across time of exchange rate). *REG* refers to *regression*. This specification is used to test short run PPP follow the literature of C-R-X.

The second regression model uses the inflation differential as explanatory variable,

$$\Delta s_t = \alpha_1 + \alpha_2\left(\hat{R}_{ft} - \hat{R}^*_{ft}\right) + \varepsilon_t \qquad REGRFT2$$

$$\Delta s_t = \alpha_1 + \alpha_2\left(\Delta TPI_t - \Delta TPI^*_t\right) + \varepsilon_t \qquad REGTPI2$$

$$\Delta s_t = \alpha_1 + \alpha_2\left(\Delta CPI_t - \Delta TPI^*_t\right) + \varepsilon_t \qquad REGCTPI2$$

The results of the first and the second model are shown in table 4.7.1 to table 4.9.2. The following part examines on these results.

**1) Extracted Inflation**

<u>*REGRFT1*</u>

Under the hypothesis of PPP, the intercept ($\beta_1$) is expected to be zero and the slope ($\beta_2$) is expected to be one in the specification *REGRFT1*. However, the intercept in our cases is not expected to be zero, because mean of the intercept is given by mean of real interest rate differential that contaminates in the estimated risk free rate. According to (2.18), the component of the $\hat{R}_{ft}$ is given as

$$\hat{R}_{ft} = \left[(1-\beta_{i1})r_{ft} + \beta_{i1}r^e_{ft}\right] + \left[(1-\beta_{it})\pi_t + \beta_{i1}\pi^e_t\right] ,$$

$$\hat{R}_{ft} - \hat{R}^*_{ft} \approx (\Delta\, \textit{real interest rate}) + (\Delta\, \textit{inflation rate}) .$$

$\hat{R}_{ft}$ denotes estimated risk free rate, $r_{ft}$ denotes real interest rate, and $\pi_t$ denotes inflation rate. "$^e$" refers to expected value.

From the above relationship, the test equation $\hat{R}_{ft} - \hat{R}^*_{ft} = \beta_1 + \beta_2\Delta s_t + \varepsilon_t$ is observable counterpart to $(\Delta\, \textit{real interest rate}) + (\Delta\, \textit{inflation rate}) = \beta_1 + \beta_2\Delta s_t + \varepsilon_t$. If the average real interest rate of domestic and foreign country is close to each other, we can expect $\beta_1$=0[1]. But in our case, the mean of T-Bill proxy of Thailand, Taiwan, and South Korea is relatively high compared to the mean of T-Bill rate of the U.S. This can be explained as a result of the status of emerging market. The required rate of return in these countries is higher than that in the high-developed country such as the U.S., so the real

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[1] In the cases of the C-R-X's work, the average T-Bill rate of the U.S., the U.K., German and Japan is 0.48, 0.71, 0.44, and 0.30, respectively.

interest rate differentials in our cases are far from zero. As a result, the estimated intercept cannot be expected to equal to zero. Under the PPP hypothesis in the specification *REGRFT1*, we can expect only $\beta_2 = 1$.

*In the case of Thailand*, the average T-Bill proxy of Thailand is 4.8341 while the average T-Bill proxy of the U.S. is 0.2802. The difference is 4.5539, while our intercept is 4.3862; two values are close to each other. This can confirm that the intercept estimated from the regression is approximately equal to T-Bill rate differential, and also approximately equal to the real interest rate differential. Though T-Bill is not exactly equal to real interest rate (because of the contamination of inflation rate), T-Bill is widely used instead of real interest rate (because real interest rate is unobservable).

Assume that real interest rate differential is correlated to neither exchange rate differential nor inflation differential. The slope of *REGRFT1* ($\beta_2$) reflects the relationship between the pure price inflation differential and the exchange rate differential. In the case of Thailand, the estimated coefficient of exchange rate is 0.9597, rejects null hypothesis of zero. The size approaches one and does not reject null hypothesis of one at even 10% significance level. The estimated intercept ($\beta_1$) is 4.3862, rejects null hypothesis of zero. As explained above, the intercept is given by mean of real interest rate differential. Thus, the hypothesis of short run PPP in this case is not rejected.

*In the case of Taiwan*, the coefficient of exchange rate differential ($\beta_2$) is equal to 0.8625 and does not reject null hypothesis of one at even 10% significance level. So the hypothesis of PPP is not rejected. However, the $\beta_2$ is not significantly different from zero (but accept one). This should be interpreted carefully. Compare the $\beta_2$ of Taiwan to the $\beta_2$ in the case of Thailand, the $\beta_2$ of Taiwan is not significantly different from zero, but $\beta_2$ of Thailand is significant. Consider the standard error (s.e.) of $\beta_2$, the standard error of Taiwan is 0.7567 which is higher than that of Thailand (0.3543). The high standard error of $\beta_2$ results from the high standard deviation (s.d.) of $\hat{R}_{ft} - \hat{R}^*_{ft}$ of Taiwan. From table 4.1, the standard deviation of $\hat{R}_{ft} - \hat{R}^*_{ft}$ of Taiwan is equal to 9.33, higher than the standard deviation of $\hat{R}_{ft} - \hat{R}^*_{ft}$ of Thailand (6.92). Since the $\hat{R}_{ft} - \hat{R}^*_{ft}$ of both Thailand and Taiwan uses the same $\hat{R}^*_{ft}$, the high fluctuation of $\hat{R}_{ft} - \hat{R}^*_{ft}$ of Taiwan results from the fluctuation of the $\hat{R}_{ft}$ of Taiwan. This is the reason of the insignificant $\beta_2$ in this country. In the case of the intercept ($\beta_1$) of Taiwan, the estimated intercept rejects null hypothesis of zero. The difference between Taiwan's average T-Bill rate and the U.S.'s average T-Bill rate is 2.5076 while the intercept is 2.1074. This can be interpreted in the same way as in the case of Thailand. The presence of the significant intercept is the result of high real interest rate differential. As a conclusion, short run PPP is not rejected in the case of Taiwan using $\hat{R}_{ft}$ as inflation proxy.

*In the case of South Korea*, the estimated coefficient of exchange rate differential ($\beta_2$) is -0.3699, the size is not significantly different from zero and rejects the null hypothesis of one at 5% significance level. This means that the exchange rate differential cannot explain the inflation differential. Thus, the null hypothesis of PPP is rejected. In the case of the estimated intercept ($\beta_1$), the value is 3.9912. The result of t-test rejects null hypothesis of zero at 1% significance level. The difference between the country's average T-Bill rate and U.S.'s average T-Bill rate is 4.8307. The intercept is still be interpreted as the real interest rate differential. As a conclusion, short run PPP is rejected in the case of South Korea using $\hat{R}_{ft}$ as inflation proxy.

From the results, it can be concluded that we find the evidence to support short run PPP in Thailand and Taiwan using extracted inflation as inflation proxy. However, we cannot find the evidence to support short run PPP in South Korea. Nevertheless, the estimated intercept and coefficient from the specification *REGRFT1* in all countries have high standard error. Moreover, the adjusted R square is low (compared to the results of TPI inflation). The reason is discussed in the preliminary analysis and the result of Taiwan. The conclusion on this issue is given in chapter V.

*REGRFT2*

The theory of PPP expects the relationship between exchange rate and prices. In the previous section, it is shown explicitly that the $\hat{R}_{ft} - \hat{R}^*_{ft}$ is composed of real interest rate differential and inflation differential. So the meaning of the estimated coefficient is the explanation of both real interest rate differential and inflation differential on the exchange rate differential. Moreover, the volatility of the explanatory variable (estimated risk free rate differential) is much higher than the volatility of the dependent variable (exchange rate differential). From this reason, it is not suggested by C-R-X to use this specification to test PPP in the case of the $\hat{R}_{ft}$. So this study tests this specification as additional evidence of $\hat{R}_{ft}$ using the usually-used PPP specification. This study does not examine this specification as PPP test in the case of $\hat{R}_{ft}$.

*In the case of Thailand*, the coefficient of the estimated risk free rate differential ($\alpha_2$) is 0.0766, the size approaches zero. However, this coefficient rejects null hypothesis of zero at 1% significance level. This indicates that the compounded effect of real interest rate differential plus inflation differential can weakly explain the exchange rate differential. Nevertheless, this coefficient rejects null hypothesis of one. This confirms that the relationship is weak. The intercept ($\alpha_1$) is significantly different from zero. This means that there is other factor that affects the exchange rate differential.

*In the case of Taiwan and South Korea*, the coefficient of the estimated risk free rate differential ($\alpha_2$) does not reject null hypothesis of zero and rejects null hypothesis of one at 1% significance level. This means that the real interest rate differential plus inflation differential does not significantly explain the exchange rate differential. The intercept ($\alpha_1$) does not reject null hypothesis of zero at even 10% significance level. Therefore, there is no other factor explains the exchange rate differential.

As a conclusion on the evidences of the estimated risk free rate, when the exchange rate differential is used as explanatory variable, the coefficient ($\beta_2$) is significant in the case of Thailand. On the contrary, when the estimated risk free rate is used as explanatory variable, the coefficient ($\alpha_2$) is not significant in all countries. The reason is that the $\hat{R}_{ft} - \hat{R}^*_{ft}$ is too volatile to explain the exchange rate differential. In case of the evidences of PPP, using *REGRFT1*, the null hypothesis of short run PPP is not rejected in Thailand and Taiwan, but rejected in the case of South Korea. However, in our cases, it can only conclude that the relationship between *one component* in the estimated risk free rate and exchange rate is present. The validity of PPP in short run can be supported using the *pure price inflation*, which is one component of the estimated risk free rate, as inflation proxy. The validity cannot be supported using the *estimated risk free rate* as inflation proxy.

**2) Traded Goods Price Index (TPI)**

<u>*REGTPI1*</u>

*In all countries*, standard error of all estimated coefficients ($\beta_1$ and $\beta_2$) is lower than that of *REGRFT1*. Moreover, the adjusted R square is higher than that of *REGRFT1*. This means that the model *REGTPI1* is better fit to the data than the case of *REGRFT1*. The coefficient of exchange rate differential ($\beta_2$) is 0.4516, 0.3238, and 0.3217 for Thailand, Taiwan, and South Korea, respectively. These coefficients reject null hypothesis of zero at 1% significance level. However, these coefficients reject null hypothesis $\beta_2 = 1$ at 1% significance level, so these coefficients are significantly different from one. Consider the intercept ($\beta_1$), the intercept in all countries is not significantly different from zero at 5% significance level. Thus, there is no other factor explains the TPI inflation differential. The joint coefficient hypothesis $\beta_1 = 0, \beta_2 = 1$ is rejected at 1% significance level. Therefore, the PPP hypothesis is rejected.

<u>*REGTPI2*</u>

*In all countries*, the estimated coefficient of TPI inflation rate differential ($\alpha_2$) is equal to 0.5880, 0.5011, and 0.4407 for Thailand, Taiwan, and South Korea, respectively. These coefficients are significantly different from zero and one at 1% significance level, while the estimated intercept ($\alpha_1$) does not reject zero at even 10% significance level in all countries. So the relationship between exchange rate differential and TPI inflation differential is significant and there is no other factor contaminated in the relationship. However, the coefficient ($\alpha_2$) is significantly different from one. Moreover, the joint coefficient hypothesis $\alpha_1 = 0, \alpha_2 = 1$ is rejected at 1% significance level. Therefore, the hypothesis of PPP is rejected.

As a conclusion of the TPI inflation in short run, the relationship between exchange rate differential and TPI inflation differential is present in short run and there is no other factor in the relationship between these two variables. However, the hypothesis of short run PPP is rejected in both two specifications in all countries. Therefore, we cannot conclude that short run PPP is valid using TPI inflation in Thailand, Taiwan, and South Korea.

**3) Domestic CPI and Foreign TPI (CTPI)**

*REGCTPI1*

*In the case of Thailand and South Korea*, the estimated coefficient of exchange rate differential ($\beta_2$) and the estimated intercept ($\beta_1$) are not significantly different from zero at even 10% significance level. The hypothesis $\beta_2 = 1$ is rejected at 1% significance level in these two countries, and the joint coefficient hypothesis $\beta_1 = 0, \beta_2 = 1$ is also rejected. Therefore, the hypothesis of short run PPP is rejected.

*In the case of Taiwan*, the estimated coefficient of exchange rate differential ($\alpha_2$) is 0.0875, the size approaches zero. However, this coefficient rejects null hypothesis of zero at 10% significance level. So the relative value of domestic CPI - foreign TPI can be weakly explained by the exchange rate differential. The estimated intercept ($\alpha_1$) rejects null of zero at 5% significance level, so there is other factor that explains the CTPI inflation differential. However, the coefficient ($\alpha_2$) rejects null hypothesis of one at 1% significance level and the joint coefficient hypothesis $\alpha_1 = 0, \alpha_2 = 1$ is also rejected. Thus, the hypothesis of short run PPP is rejected.

*REGCTPI2*

*In all countries*, the estimated coefficient ($\alpha_2$) is not significantly different from zero at even 10% significance level. The estimated intercept ($\alpha_1$) of all countries cannot reject zero at even 10% significance level. From the results, using CTPI inflation differential as explanatory variable, the CTPI inflation differential cannot explain the nominal exchange rate differential in all countries. The hypothesis of short run PPP is rejected.

As a conclusion of the CTPI inflation in short run, the hypothesis of short run PPP is rejected in all countries.

## 4.3 Long Run PPP

The evidences of PPP in long run are tested by two specifications: univariate model (unit root tests in real exchange rate series) and bivariate model (cointegration test).

**The univariate model (unit root tests in real exchange rate series)** is given as:

$$q_t = s_t + HPI_t^* - HPI_t \qquad RERHPI$$

$$q_t = s_t + TPI_t^* - TPI_t \qquad RERTPI$$

$$q_t = s_t + TPI_t^* - CPI_t \qquad RERCTPI$$

$q_t$ denotes log of real exchange rate, $s_t$ denotes log of nominal exchange rate, $xPI_t^*$ denotes log of foreign price index, $xPI_t$ denotes log of domestic price index. "*RER*" refers to "Real Exchange Rate".

The figures of real exchange rate constructed from HPI, TPI, and CTPI are shown in figure 4.4.1, 4.4.2, and 4.4.3, respectively. The test results of ADF, PP, MPT, and Perron (1989) are shown in table 4.10 to 4.13, respectively.

Continue to **the bivariate model (cointegration test).** The test specifications can be shown as:

$$s_t = \beta_0 + \beta_1(HPI_t - HPI_t^*) + \varepsilon_t \qquad COINHPI$$

$$s_t = \beta_0 + \beta_1(TPI_t - TPI_t^*) + \varepsilon_t \qquad COINTPI$$

$$s_t = \beta_0 + \beta_1(CPI_t - TPI_t^*) + \varepsilon_t \qquad COINCTPI$$

* denotes the index of foreign country. The figures of the nominal exchange rate ($s_t$) and the relative price proxies ($xPI_t - xPI_t^*$) are shown in figure 4.5.1 to 4.7.3. The test results are shown in table 4.14, 4.15, and 4.16 in the case of Thailand, Taiwan, and South Korea respectively.

### 4.3.1 Strong PPP

The necessary condition to support strong PPP is the cointegration between the exchange rate and the relative prices. The sufficient condition is the one-to-one correspondence between these two components.

#### 1) Hypothetical Price Index (HPI)

*In the case of Thailand*, from the model *RERHPI*, the result of ADF method cannot reject null hypothesis of unit root at even 10% significance level. The result of the method of PP and MPT also cannot reject unit root. Though the result of Perron (1989) indicate that this series is stationary after taking the structural breaks into account, this evidence is not enough to support the validity of strong PPP. The reason is that, from table 4.14, the result of cointegration test on the model *COINHPI* indicates no cointegration relationship between the nominal exchange rate ($s_t$) and the relative HPI indexes $(HPI_t - HPI_t^*)$. From these test results, this case does not satisfy the necessary condition of strong PPP. From this reason, it cannot be concluded that we have enough evidence to support strong PPP in the case of Thailand using HPI as price proxy.

*In the case of Taiwan and South Korea*, from the model *RERHPI*, the result of ADF method cannot reject null hypothesis of unit root at even 10% significance level. Moreover, the results of the other unit root tests also do not reject unit root. Therefore, the real exchange rate series constructed from HPI of these two countries are nonstationary. Referring to table 4.15 and 4.16, cointegration relationship between the nominal exchange rate ($s_t$) and the relative HPI indexes $(HPI_t - HPI_t^*)$ in Taiwan and South Korea is not found. As a conclusion, the test results do not support strong PPP using HPI as price proxy in Taiwan and South Korea.

**2) Traded Goods Price Index (TPI)**

*In the case of Thailand*, from the model *RERTPI*, the result of ADF method cannot reject null hypothesis of unit root at even 10% significance level. However, the result from the method of PP rejects null hypothesis of unit root at 5% significance level. Moreover, when structural breaks are taken into account, the result from the method of Perron (1989) rejects null hypothesis of unit root at 1% significance level. From these evidences, it can conclude that this series is stationary. In the viewpoint of cointegration, referring to table 4.14, the cointegration between the nominal exchange rate ($s_t$) and the relative prices $(TPI_t - TPI_t^*)$ occurs and log likelihood ratio test indicates that the normalized cointegration coefficient ($\beta_1$) is not far from one. As a conclusion, from the results of unit root and cointegration test, this case satisfies the necessary condition (cointegration relationship) and sufficient condition (one-to-one relationship). Therefore, the test results support strong PPP in Thailand using TPI as price proxy.

*In the case of Taiwan,* the result of Breusch - Godfrey (LM test) indicates that autocorrelation presents at lag *p=0 to 2*, but not present at lag *p=3*. At lag 3, the result of ADF cannot reject unit root at 5% significance level but reject at 10%. To check for robustness, lag *p=4* is also tested for unit root. The result cannot reject unit root at even 10% significance level. This means that, in this case, the rejection of unit root from the ADF method is sensitive to lag length. Based on ADF test, we cannot conclude that this series is stationary. However, the result of PP method rejects unit root at 1% significance level. Continue to check for robustness by MPT method, the result of MPT does not reject unit root at even 10% significance level. After the possible structural breaks are taken into account, the result from the method of Perron (1989) cannot reject the null hypothesis of unit root at even 10% significance level. From these test results, we cannot conclude that *RERTPI* of Taiwan is stationary. Therefore, this series does not satisfy the condition of strong PPP. As a result, we cannot conclude that strong PPP is valid in Taiwan using TPI as price proxy.

*In the case of South Korea,* from the model *RERTPI*, the results from all methods cannot reject null hypothesis of unit root at even 10% significance level. Therefore, it cannot conclude that this series is stationary. Thus, the test results do not support strong PPP in South Korea using TPI as price proxy.

**3) Domestic CPI and foreign TPI (CTPI)**

*In the case of Thailand,* from the model *RERCTPI*, the results from all methods cannot reject null hypothesis of unit root at even 10% significance level. From these results, we cannot find the evidence to support strong PPP in Thailand using CTPI as price proxy.

*In the case of Taiwan,* from the model *RERCTPI*, the result of MPT method rejects unit root at 5% significance level. However, the results of the other methods cannot reject unit root at even 10% significance level. So it is not enough to conclude that the *RERCTPI* is stationary. Therefore, the *RERCTPI* does not satisfy the condition of strong PPP. We cannot conclude that strong PPP is valid in Taiwan using CTPI as price proxy.

*In the case of South Korea,* from the model *RERCTPI*, the result of PP method rejects null hypothesis of unit root at 5% significance level. However, the results of the other methods cannot reject unit root at even 10% significance level. From these results, it is not enough to conclude that this series is stationary. Again, the *RERCTPI* of South Korea does not satisfy the condition of strong PPP and we cannot conclude that strong PPP is valid in South Korea using CTPI as price proxy.

The nonstationary in real exchange rate series can be found usually in the empirical evidences. This could be the result of the slow mean reverting property of real exchange rate and the short sample period. This study tries to take account of structural break since the non-rejection of unit root could come from structural break. However, the slow mean-reverting cannot be controlled. Moreover, the sample period is limited. As a consequence, more than one method is used in this study to confirm the results of unit root test.

From all test results, we find the evidence to support strong PPP only in the case of Thailand, using TPI as price proxy. For the other cases, though the null hypothesis of unit root is rejected when tested by some methods in some cases, the result from only one method is not enough to conclude that the series is stationary. Moreover, to confirm the strong PPP, the result from cointegration test should consistent with the result from unit root test. However, because of the problem of the unit root tests, the conclusion might be changed if this study includes more observations.

### 4.3.1 Weak PPP

To be the evidence to support weak PPP, the nominal exchange rate ( $s_t$ ) and the relative price proxies ( $xPI_t - xPI_t^*$ ) are cointegrated. The normalized cointegration coefficient can differ from one. However, the size should not deviate from one too much.

**1) Hypothetical Price Index (HPI)**

*In all countries*, the result of both trace and max eigenvalue statistic indicates no cointegration relationship in the model *COINHPI*. As a result, there is no evidence to support weak PPP using HPI as price proxy in all countries.

**2) Traded Goods Price Index (TPI)**

*In the case of Thailand, lag 4* is selected by AIC. LM test result indicates that there is no autocorrelation. Trace statistic indicates 2 cointegrating vectors at 5% significance level. Max-eigenvalue statistic indicates 2 cointegrating vectors at 10% significance level. To check for lag robustness, lag 3, 5 are also tested. The results indicate the presence of cointegrating vector. This means that the presence of cointegrating vector is not sensitive to lag length. Therefore, it can be concluded that the cointegration relationship exists in this case. At lag 4, the first normalized cointegrating vector is [-1, 1.1834]. The direction is correct. From log likelihood ratio test, the LR statistic is equal to 1.0549. This indicates that the null hypothesis [-1, 1] is not rejected. We can conclude that the cointegration relationship exists and the cointegration coefficient is not far from one. However, because strong PPP encompasses weak PPP and the TPI also satisfies other condition of strong PPP, this case supports strong PPP in Thailand.

*In the case of Taiwan,* AIC suggests *lag 2*. Trace statistic indicates 2 cointegrating vectors at 1% significance level, while max eigenvalue indicates 2 cointegrating vectors at 10% significance level. To check for lag robustness, cointegration test also applies to *lag 3* and *lag 4*. The result indicates cointegration relationship at lag 3 and lag 4. LM test is applied to check for autocorrelation in all lag cases. The result indicates no autocorrelation. Thus, we can conclude the result based on *lag 2* that the cointegration exists. The first normalized cointegrating vector is [-1, 1.5606]. The coefficient of the relative prices ($\beta_1$) has a correct sign. The $\beta_1$ is tested by log likelihood ratio test. The LR statistic is equal to 0.8424. This means that the null hypothesis [-1, 1] is not rejected. As a conclusion, the test results support weak PPP in Taiwan using TPI as price proxy.

*In the case of South Korea*, AIC suggests *lag 2*. The result of both trace and max eigenvalue statistic indicates no cointegration relationship. Therefore, there is no evidence to support weak PPP in South Korea using TPI as price proxy.

As a conclusion, we find the cointegration in Thailand and Taiwan, using TPI as price proxy. The cointegration relationship in the case of Thailand is one of all evidences to support strong PPP, while the cointegration in the case of Taiwan supports weak PPP. In the case of South Korea using TPI as price proxy, there is no evidence to support weak PPP.

**3) Domestic CPI and foreign TPI (CTPI)**

*In the case of Thailand*, from the model *COINCTPI*, the result indicates one cointegrating vector. The result is not sensitive to lag length. The normalized cointegrating vector is [1, 2.5111], which has a correct sign. However, the result of log likelihood ratio test indicates that the null hypothesis [-1, 1] is rejected. Therefore, it can be concluded that the cointegration relationship exists but the coefficient is too far from the theoretical level. We cannot conclude that weak PPP is valid in Thailand using CTPI as price proxy.

*In the case of Taiwan and South Korea,* the result of both trace and max eigenvalue statistic indicates no cointegration relationship. Thus, the evidence to support weak PPP cannot be found in Taiwan and South Korea using CTPI as price proxy.

As a conclusion, we cannot find the evidence to support weak PPP using CTPI as price proxy in all countries.

From the results of cointegration test, we find the cointegration relationship between exchange rate and relative prices in Thailand using TPI and CTPI as price proxy (*TH COINTPI* and *TH COINCTPI*). Furthermore, we find the cointegration in Taiwan using TPI as price proxy (*TW COINTPI*). In the case of *TH COINCTPI*, the cointegration coefficient is too far from unity. Thus, this case does not support weak PPP. In the case of *TH COINTPI* and *TW COINTPI*, the cointegration coefficient is correct in direction and the size is not significantly different from one. The results of cointegration test support weak PPP in Taiwan using TPI as price proxy. Furthermore, the results support strong PPP in Thailand using TPI as price proxy.

**Table 4.1**: Summary Statistics

| country | variables | mean | median | s.d. | max | min |
|---|---|---|---|---|---|---|
| U.S. | market portfolio returns | 0.50616 | 0.65584 | 4.15653 | 12.80179 | -10.49529 |
| | SMB | 0.34085 | 0.18000 | 3.67121 | 14.62000 | -11.60000 |
| | HML | 0.16212 | 0.20500 | 4.57484 | 14.92000 | -20.79000 |
| | T-Bill | 0.28016 | 0.31716 | 0.13510 | 0.49266 | 0.06572 |
| | Rft_US | 0.28068 | 0.67449 | 5.44914 | 14.95409 | -12.43977 |
| | π_TPI_US | 0.20956 | 0.25574 | 0.79038 | 2.35221 | -2.04285 |
| | π_CPI_US | 0.22095 | 0.19522 | 0.33631 | 1.13291 | -0.78092 |
| Thailand | market portfolio returns | 0.29398 | 0.31927 | 8.27639 | 22.76088 | -24.04338 |
| | SMB | -0.01795 | -0.06931 | 4.76573 | 12.99088 | -14.24588 |
| | HML | 1.87479 | 1.58649 | 5.87896 | 25.24925 | -19.36044 |
| | T-Bill | 4.83405 | 4.00000 | 2.60057 | 12.50000 | 2.75000 |
| | Rft_TH | 4.48513 | 4.38131 | 5.50408 | 21.44869 | -10.33860 |
| | π_TPI_TH | 0.06411 | 0.08188 | 1.79034 | 6.29295 | -6.86780 |
| | π_CPI_TH | 0.19926 | 0.13843 | 0.39976 | 1.51721 | -0.69869 |
| | d_s_TH | -0.14979 | -0.23703 | 1.95061 | 4.60923 | -5.38553 |
| | Rft-Rft*_TH-US | 4.20445 | 3.70106 | 6.92488 | 22.38829 | -13.64338 |
| | π-π*_TPI_TH-US | -0.15294 | -0.06522 | 1.81098 | 6.87662 | -6.88829 |
| | π-π*_CTPI_TH-US | -0.01030 | -0.06565 | 0.72849 | 2.42858 | -1.94018 |
| | π-π*_CPI_TH-US | -0.02169 | -0.00376 | 0.37962 | 1.01955 | -1.03276 |
| Taiwan | market portfolio returns | 0.02054 | -0.12137 | 7.50407 | 19.46860 | -18.81373 |
| | SMB | -0.68292 | -1.03206 | 5.37555 | 15.26718 | -14.44617 |
| | HML | 0.61292 | 0.62425 | 7.07044 | 22.85951 | -17.77097 |
| | T-Bill | 2.78776 | 1.94600 | 1.79600 | 7.28000 | 0.95800 |
| | Rft_TW | 2.47933 | 2.94270 | 8.59308 | 28.99899 | -16.80987 |
| | π_TPI_TW | 0.11101 | 0.17577 | 1.18827 | 2.60936 | -4.09932 |
| | π_CPI_TW | 0.06754 | 0.07901 | 0.83647 | 2.09989 | -1.92578 |
| | d_s_TW | 0.06328 | 0.12068 | 1.24535 | 3.50966 | -3.85108 |
| | Rft-Rft*_TW-US | 2.19865 | 1.73737 | 9.32546 | 29.36075 | -20.80352 |
| | π-π*_TPI_TW-US | -0.09855 | -0.09902 | 1.06443 | 3.35270 | -4.11981 |
| | π-π*_CTPI_TW-US | -0.14202 | -0.15471 | 1.03169 | 3.21676 | -2.94224 |
| | π-π*_CPI_TW-US | -0.15342 | -0.08183 | 0.85863 | 1.93487 | -2.53633 |
| Korea | market portfolio returns | 1.16024 | 1.29361 | 8.77902 | 26.12342 | -20.06552 |
| | SMB | -0.73498 | -0.88791 | 10.33654 | 28.19143 | -33.72115 |
| | HML | 2.87842 | 3.55736 | 9.80408 | 27.05815 | -38.15707 |
| | T-Bill | 5.11085 | 4.44000 | 3.26385 | 22.64000 | 3.24000 |
| | Rft_KO | 4.37877 | 5.88181 | 15.29213 | 49.85868 | -37.75712 |
| | π_TPI_KO | -0.13259 | 0.22465 | 2.37759 | 4.85215 | -7.46459 |
| | π_CPI_KO | 0.21399 | 0.22581 | 0.41656 | 1.46291 | -0.67574 |
| | d_s_KO | -0.32534 | -0.36670 | 2.32465 | 6.39764 | -6.84011 |
| | Rft-Rft*_KO-US | 4.09809 | 4.36529 | 16.00518 | 47.97505 | -42.61458 |
| | π-π*_TPI_KO-US | -0.34642 | -0.31854 | 2.05120 | 4.10038 | -6.92404 |
| | π-π*_CTPI_KO-US | 0.00444 | -0.00318 | 0.76571 | 2.03429 | -2.35221 |
| | π-π*_CPI_TW-US | -0.00696 | -0.03367 | 0.41120 | 0.86663 | -0.76680 |

**Notes**: 1. Rft_XX denotes estimated risk free rate ( $\hat{R}_{ft}$ ) of XX. 2. π_TPI_XX denotes ln(TPI) inflation of XX. 3. π_CPI_XX denotes ln(CPI) inflation of XX. 4. d_s_XX denotes difference across time of ln(exchange rate) of XX. 5. Rft-Rft*_XX-US denotes estimated risk free rate of XX - estimated risk free rate of the U.S. 6. π-π*_TPI_XX-US denotes ln(TPI) inflation of XX - ln(TPI) inflation of the U.S. 7. π-π*_CTPI_XX-US denotes ln(CPI) inflation of XX - ln(TPI) inflation of the U.S. 8. π-π*_CPI_XX-US denotes ln(CPI) inflation of XX - ln(CPI) inflation of the U.S.

**Table 4.2**: Correlation Coefficients of Inflation Proxies Differential and Exchange Rate Differential

| | Rft-Rft*_TH-US | π-π*_TPI_TH-US | π-π*_CTPI_TH-US | π-π*_CPI_TH-US | d_s_TH |
|---|---|---|---|---|---|
| Rft-Rft*_TH-US | 1.00000 | 0.17339 | 0.02645 | 0.04918 | 0.27105 |
| π-π*_TPI_TH-US | 0.17339 | 1.00000 | 0.31165 | 0.18628 | 0.51532 |
| π-π*_CTPI_TH-US | 0.02645 | 0.31165 | 1.00000 | 0.54441 | -0.02607 |
| π-π*_CPI_TH-US | 0.04918 | 0.18628 | 0.54441 | 1.00000 | 0.02975 |
| d_s_TH | 0.27105 | 0.51532 | -0.02607 | 0.02975 | 1.00000 |

| | Rft-Rft*_TW-US | π-π*_TPI_TW-US | π-π*_CTPI_TW-US | π-π*_CPI_TW-US | d_s_TW |
|---|---|---|---|---|---|
| Rft-Rft*_TW-US | 1.00000 | -0.03398 | 0.11048 | -0.02465 | 0.11479 |
| π-π*_TPI_TW-US | -0.03398 | 1.00000 | 0.07659 | -0.06021 | 0.40280 |
| π-π*_CTPI_TW-US | 0.11048 | 0.07659 | 1.00000 | 0.80598 | 0.10547 |
| π-π*_CPI_TW-US | -0.02465 | -0.06021 | 0.80598 | 1.00000 | 0.00338 |
| d_s_TW | 0.11479 | 0.40280 | 0.10547 | 0.00338 | 1.00000 |

| | Rft-Rft*_KO-US | π-π*_TPI_KO-US | π-π*_CTPI_KO-US | π-π*_CPI_KO-US | d_s_KO |
|---|---|---|---|---|---|
| Rft-Rft*_KO-US | 1.00000 | -0.17430 | -0.05360 | -0.04409 | -0.05442 |
| π-π*_TPI_KO-US | -0.17430 | 1.00000 | -0.05309 | 0.24349 | 0.37655 |
| π-π*_CTPI_KO-US | -0.05360 | -0.05309 | 1.00000 | 0.60615 | 0.05369 |
| π-π*_CPI_KO-US | -0.04409 | 0.24349 | 0.60615 | 1.00000 | 0.07680 |
| d_s_KO | -0.05442 | 0.37655 | 0.05369 | 0.07680 | 1.00000 |

**Notes:** 1. Rft-Rft*_XX-US denotes estimated risk free rate ( $\hat{R}_{ft}$ ) of XX - estimated risk free rate of the U.S. 2. π-π*_TPI_XX-US denotes ln(TPI) inflation of XX - ln(TPI) inflation of the U.S. 3. π-π*_CTPI_XX-US denotes ln(CPI) inflation of XX - ln(TPI) inflation of the U.S. 4. π-π*_CPI_XX-US denotes ln(CPI) inflation of XX - ln(CPI) inflation of the U.S. 5. d_s_XX denotes difference across time of ln(exchange rate) of XX.



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**Table 4.3:** The Estimated Coefficients from Time Series Regression of Excess Industry Returns on the Three Factors of the United States (30 industries)

| sector | α | β1 | β2 | β3 | Adj.R Square |
|---|---|---|---|---|---|
| Food | 0.25928 | 0.38523*** | -0.12745 | 0.22534*** | 0.21640 |
| (s.e.) | (0.3250) | (0.1088) | (0.1348) | (0.0847) | |
| t-stat | 0.7978 | 3.5396 | -0.9454 | 2.6619 | |
| Beer | 0.09306 | 0.53068*** | -0.18316 | 0.18010 | 0.16678 |
| (s.e.) | (0.4318) | (0.1907) | (0.1602) | (0.1123) | |
| t-stat | 0.2155 | 2.7828 | -1.1433 | 1.6034 | |
| Smoke | 1.07170 | 0.36711** | -0.00514 | 0.44422** | 0.05725 |
| (s.e.) | (0.7920) | (0.1803) | (0.3195) | (0.2106) | |
| t-stat | 1.3532 | 2.0362 | -0.0161 | 2.1096 | |
| Games | 0.08814 | 1.15157*** | 0.56048*** | 0.33803*** | 0.66013 |
| (s.e.) | (0.3493) | (0.0794) | (0.0972) | (0.0741) | |
| t-stat | 0.2523 | 14.4955 | 5.7647 | 4.5642 | |
| Books | -0.03534 | 0.72565*** | 0.05640 | 0.00907 | 0.43167 |
| (s.e.) | (0.3243) | (0.0750) | (0.0903) | (0.0857) | |
| t-stat | -0.1090 | 9.6704 | 0.6242 | 0.1058 | |
| Hshld | 0.23535 | 0.52048*** | -0.10336 | 0.05422 | 0.22935 |
| (s.e.) | (0.3667) | (0.1538) | (0.1647) | (0.080) | |
| t-stat | 0.6418 | 3.3838 | -0.6274 | 0.6779 | |
| Clths | 0.05966 | 0.98261*** | 0.20319 | 0.46072*** | 0.47662 |
| (s.e.) | (0.4030) | (0.1457) | (0.1962) | (0.0959) | |
| t-stat | 0.1480 | 6.7441 | 1.0358 | 4.8027 | |
| Hlth | 0.20533 | 0.51320*** | -0.24679** | -0.15986 | 0.29072 |
| (s.e.) | (0.2647) | (0.1016) | (0.1054) | (0.0993) | |
| t-stat | 0.7756 | 5.0496 | -2.3419 | -1.6095 | |
| Chems | 0.14195 | 0.79584*** | 0.06068 | 0.31175** | 0.41751 |
| (s.e.) | (0.3459) | (0.1045) | (0.1412) | (0.1245) | |
| t-stat | 0.4104 | 7.6154 | 0.4299 | 2.5034 | |
| Txtls | -0.50479 | 0.76231*** | 0.67858*** | 0.68005*** | 0.48073 |
| (s.e.) | (0.3795) | (0.1024) | (0.1164) | (0.0916) | |
| t-stat | -1.3302 | 7.4450 | 5.8282 | 7.4240 | |
| Cnstr | 0.04352 | 0.88041*** | 0.31124** | 0.26718*** | 0.45959 |
| (s.e.) | (0.4026) | (0.1405) | (0.1405) | (0.0809) | |
| t-stat | 0.1081 | 6.2678 | 2.2154 | 3.3006 | |
| Steel | 0.34281 | 1.50608*** | 0.73518*** | 0.04796 | 0.58192 |
| (s.e.) | (0.4896) | (0.1589) | (0.1443) | (0.1682) | |
| t-stat | 0.7002 | 9.4808 | 5.0939 | 0.2852 | |

**Table 4.3** (continue)

| sector | α | $\beta_1$ | $\beta_2$ | $\beta_3$ | Adj.R Square |
|---|---|---|---|---|---|
| FabPr | 0.21132 | 1.22507*** | 0.67056*** | 0.28847*** | 0.71361 |
| (s.e.) | (0.3598) | (0.0867) | (0.1110) | (0.0752) | |
| t-stat | 0.5874 | 14.1367 | 6.0392 | 3.8384 | |
| ElcEq | 0.53803* | 1.15161*** | 0.05863 | -0.05209 | 0.59752 |
| (s.e.) | (0.3002) | (0.0882) | (0.1238) | (0.0954) | |
| t-stat | 1.7925 | 13.0625 | 0.4735 | -0.5462 | |
| Autos | -0.46483 | 1.13879*** | 0.36810*** | 0.63016*** | 0.50593 |
| (s.e.) | (0.4522) | (0.1069) | (0.1235) | (0.0928) | |
| t-stat | -1.0280 | 10.6502 | 2.9817 | 6.7939 | |
| Carry | 0.45155 | 0.92860*** | 0.02061 | 0.40624*** | 0.39498 |
| (s.e.) | (0.4818) | (0.1464) | (0.1962) | (0.1408) | |
| t-stat | 0.9372 | 6.3439 | 0.1050 | 2.8853 | |
| Mines | 0.97213* | 0.60767*** | 0.36383* | 0.11276 | 0.11623 |
| (s.e.) | (0.5478) | (0.1596) | (0.1861) | (0.1296) | |
| t-stat | 1.7747 | 3.8072 | 1.9548 | 0.8703 | |
| Coal | 3.02144** | 0.91147** | 0.37935 | -0.03651 | 0.07784 |
| (s.e.) | (1.2393) | (0.3566) | (0.3764) | (0.2123) | |
| t-stat | 2.4381 | 2.5561 | 1.0079 | -0.1720 | |
| Oil | 0.90603** | 0.66735*** | 0.01646 | 0.25826** | 0.23744 |
| (s.e.) | (0.3569) | (0.1053) | (0.1537) | (0.1038) | |
| t-stat | 2.5387 | 6.3349 | 0.1071 | 2.4877 | |
| Util | 0.53872 | 0.33748** | -0.04442 | 0.36218** | 0.18885 |
| (s.e.) | (0.3686) | (0.1292) | (0.1692) | (0.1457) | |
| t-stat | 1.4614 | 2.6111 | -0.2625 | 2.4863 | |
| Telcm | -0.32525 | 1.03261*** | -0.02185 | 0.00962 | 0.48280 |
| (s.e.) | (0.3438) | (0.1273) | (0.1698) | (0.1365) | |
| t-stat | -0.9459 | 8.1098 | -0.1287 | 0.0704 | |
| Servs | -0.10045 | 1.38464*** | 0.45878*** | -0.45274*** | 0.72219 |
| (s.e.) | (0.2956) | (0.1449) | (0.1514) | (0.1340) | |
| t-stat | -0.3399 | 9.5553 | 3.0303 | -3.3795 | |
| BusEq | -0.03637 | 1.58916*** | 0.80897*** | -0.41022*** | 0.68570 |
| (s.e.) | (0.4713) | (0.1869) | (0.1473) | (0.1332) | |
| t-stat | -0.0772 | 8.5024 | 5.4902 | -3.0798 | |
| Paper | 0.09441 | 0.75544*** | 0.01326 | 0.31710*** | 0.40895 |
| (s.e.) | (0.3621) | (0.0998) | (0.1444) | (0.0991) | |
| t-stat | 0.2607 | 7.5721 | 0.0918 | 3.1999 | |

**Table 4.3** (continue)

| sector | α | $\beta_1$ | $\beta_2$ | $\beta_3$ | Adj.R Square |
|---|---|---|---|---|---|
| Trans | -0.03488 | 0.83396*** | 0.16694 | 0.34252*** | 0.46474 |
| (s.e.) | (0.3229) | (0.1066) | (0.1109) | (0.0682) | |
| t-stat | -0.1080 | 7.8249 | 1.5051 | 5.0191 | |
| Whlsl | -0.03043 | 0.65969*** | 0.29681* | 0.06014 | 0.38039 |
| (s.e.) | (0.3293) | (0.0707) | (0.1610) | (0.1057) | |
| t-stat | -0.0924 | 9.3358 | 1.8435 | 0.5692 | |
| Rtail | 0.10005 | 0.92979*** | 0.10764 | 0.08758 | 0.52348 |
| (s.e.) | (0.2847) | (0.1154) | (0.1105) | (0.0922) | |
| t-stat | 0.3514 | 8.0555 | 0.9741 | 0.9503 | |
| Meals | 0.26602 | 0.75569*** | 0.05589 | 0.29976** | 0.38636 |
| (s.e.) | (0.3710) | (0.1215) | (0.1777) | (0.1278) | |
| t-stat | 0.7170 | 6.2198 | 0.3146 | 2.3461 | |
| Fin | 0.14684 | 0.93119*** | -0.16481 | 0.21770*** | 0.60035 |
| (s.e.) | (0.2838) | (0.0986) | (0.1157) | (0.0647) | |
| t-stat | 0.5174 | 9.4407 | -1.4241 | 3.3647 | |
| Other | -0.40020 | 0.76034*** | 0.04305 | 0.08841 | 0.30542 |
| (s.e.) | (0.4265) | (0.1110) | (0.1510) | (0.1338) | |
| t-stat | -0.9384 | 6.8470 | 0.2851 | 0.6609 | |
| No. of significant coefficient | 4 | 30 | 11 | 18 | |
| % of significance | 13.33333 | 100 | 36.66667 | 60 | |

**Notes**: This table reports the coefficients from the first step Fama and MacBeth regression. The Newey-West adjusted s.e. are shown in parenthesis. The t-statistics of each coefficients report the significance of the coefficients. (*,**,*** significantly different from zero at 10%, 5% and 1% significance level, respectively)

**Table 4.4**: The Estimated Coefficients from Time Series Regression of Excess Industry Returns on the Three Factors of Thailand (24 industries)

| sector | α | $\beta_1$ | $\beta_2$ | $\beta_3$ | Adj.R Square |
|---|---|---|---|---|---|
| BNGKAGR | -1.59681*** | 0.62818*** | 0.17303 | 0.10870 | 0.35453 |
| (s.e.) | (0.1019) | (0.1943) | (0.1037) | (0.5838) | |
| t-stat | -2.7354 | 6.1616 | 0.8904 | 1.0482 | |
| BNGKFDI | -1.42524** | 0.60693*** | 0.21379*** | 0.16156* | 0.56513 |
| (s.e.) | (0.0726) | (0.0763) | (0.0972) | (0.5621) | |
| t-stat | -2.5357 | 8.3653 | 2.8031 | 1.6618 | |
| BNGKHHG | -1.58402** | 0.86862*** | 0.71840*** | 0.43147*** | 0.63774 |
| (s.e.) | (0.0713) | (0.1011) | (0.0866) | (0.7362) | |
| t-stat | -2.1516 | 12.1788 | 7.1072 | 4.9833 | |
| BNGKFHN | -1.82626*** | 0.67141*** | 0.63021*** | 0.22290*** | 0.61969 |
| (s.e.) | (0.0757) | (0.1172) | (0.0828) | (0.4656) | |
| t-stat | -3.9226 | 8.8714 | 5.3754 | 2.6932 | |
| BNGKPPC | -2.88437*** | 0.21576** | 0.27402 | 0.26612** | 0.04578 |
| (s.e.) | (0.0888) | (0.1959) | (0.1076) | (0.5780) | |
| t-stat | -4.9903 | 2.4294 | 1.3985 | 2.4733 | |
| BNGKBNK | 0.02828 | 1.14665*** | -0.24327 | -0.05104 | 0.85879 |
| (s.e.) | (0.0681) | (0.1636) | (0.1625) | (0.6408) | |
| t-stat | 0.0441 | 16.8278 | -1.4869 | -0.3141 | |
| BNGKFIN | 0.19352 | 1.37286*** | 0.06046 | 0.15050 | 0.75297 |
| (s.e.) | (0.1034) | (0.1853) | (0.1386) | (0.7997) | |
| t-stat | 0.2420 | 13.2758 | 0.3263 | 1.0859 | |
| BNGKINS | -1.87489*** | 0.55399*** | 0.31806*** | 0.21006** | 0.54996 |
| (s.e.) | (0.0925) | (0.0927) | (0.0889) | (0.5570) | |
| t-stat | -3.3659 | 5.9908 | 3.4293 | 2.3628 | |
| BNGKAUT | -0.96465 | 0.81082*** | 0.58715*** | 0.45318*** | 0.54896 |
| (s.e.) | (0.1147) | (0.1176) | (0.1438) | (0.9554) | |
| t-stat | -1.0097 | 7.0698 | 4.9913 | 3.1521 | |
| BNGKPPM | -1.59245** | 0.58484*** | 0.35983* | 0.28981** | 0.33823 |
| (s.e.) | (0.0887) | (0.1928) | (0.1345) | (0.6261) | |
| t-stat | -2.5435 | 6.5957 | 1.8667 | 2.1544 | |
| BNGKPAK | -1.19510* | 0.83551*** | 0.86419*** | 0.48548*** | 0.63156 |
| (s.e.) | (0.0769) | (0.1541) | (0.1159) | (0.6251) | |
| t-stat | -1.9119 | 10.8703 | 5.6093 | 4.1889 | |
| BNGKPET | 0.35367 | 1.20555*** | 0.36397* | 0.23815* | 0.68081 |
| (s.e.) | (0.1122) | (0.2050) | (0.1396) | (0.7925) | |
| t-stat | 0.4463 | 10.7402 | 1.7751 | 1.7058 | |
| BNGKCNM | 0.37291 | 1.08207*** | -0.13067 | 0.37276*** | 0.76991 |
| (s.e.) | (0.0770) | (0.1389) | (0.1129) | (0.6663) | |
| t-stat | 0.5596 | 14.0441 | -0.9408 | 3.3031 | |

**Table 4.4** (continue)

| sector | α | $\beta_1$ | $\beta_2$ | $\beta_3$ | Adj.R Square |
|---|---|---|---|---|---|
| BNGKPDV | 0.76848 | 1.28226*** | 0.14706 | 0.41851** | 0.77872 |
| (s.e.) | (0.0783) | (0.1783) | (0.1899) | (0.8406) | |
| t-stat | 0.9142 | 16.3691 | 0.8250 | 2.2043 | |
| BNGKENG | 0.16020 | 0.83399*** | 0.13666 | -0.06372 | 0.60150 |
| (s.e.) | (0.0708) | (0.1782) | (0.1712) | (0.8645) | |
| t-stat | 0.1853 | 11.7735 | 0.7667 | -0.3723 | |
| BNGKMIN | -1.34491 | 0.79645*** | 0.7010*** | 0.14762 | 0.21978 |
| (s.e.) | (0.1314) | (0.2339) | (0.1890) | (1.2011) | |
| t-stat | -1.1198 | 6.0632 | 2.9972 | 0.7810 | |
| BNGKCOM | -1.57440*** | 0.59887*** | -0.02872 | 0.18828* | 0.55489 |
| (s.e.) | (0.0683) | (0.1225) | (0.1122) | (0.5459) | |
| t-stat | -2.8839 | 8.7655 | -0.2345 | 1.6785 | |
| BNGKENR | -1.16858** | 0.84919*** | 0.20840** | -0.13787* | 0.70255 |
| (s.e.) | (0.0618) | (0.1025) | (0.0771) | (0.5460) | |
| t-stat | -2.1401 | 13.7485 | 2.0335 | -1.7887 | |
| BNGKHCS | 0.07246 | 0.61963*** | 0.22058 | 0.08752 | 0.31485 |
| (s.e.) | (0.1361) | (0.1997) | (0.1582) | (0.9434) | |
| t-stat | 0.0768 | 4.5536 | 1.1047 | 0.5531 | |
| BNGKHOT | -2.13479*** | 0.49452*** | 0.34749*** | 0.17985*** | 0.42835 |
| (s.e.) | (0.0574) | (0.0811) | (0.0667) | (0.4155) | |
| t-stat | -5.1385 | 8.6175 | 4.2860 | 2.6953 | |
| BNGKTLO | 0.10905 | 1.06874*** | -0.07933 | 0.37576*** | 0.66846 |
| (s.e.) | (0.0996) | (0.1438) | (0.1334) | (0.8551) | |
| t-stat | 0.1275 | 10.7285 | -0.5518 | 2.8159 | |
| BNGKPFS | -2.24296*** | 0.61449*** | 0.52367** | 0.17485 | 0.29471 |
| (s.e.) | (0.1327) | (0.2324) | (0.1512) | (0.8399) | |
| t-stat | -2.6705 | 4.6289 | 2.2530 | 1.1567 | |
| BNGKCMM | 0.69441 | 0.93451*** | -0.01717 | -0.55817*** | 0.71514 |
| (s.e.) | (0.0704) | (0.1764) | (0.1415) | (0.7302) | |
| t-stat | 0.9510 | 13.2737 | -0.0974 | -3.9448 | |
| BNGKELC | -0.53255 | 0.85024*** | 0.08061 | -0.23530 | 0.46050 |
| (s.e.) | (0.1211) | (0.1694) | (0.1420) | (1.0197) | |
| t-stat | -0.5223 | 7.0232 | 0.4759 | -1.6570 | |
| No. of significant coefficient | 12 | 24 | 12 | 15 | |
| % of significance | 50 | 100 | 50 | 62.5 | |

**Notes**: This table reports the coefficients from the first step Fama and MacBeth regression. The Newey-West adjusted s.e. are shown in parenthesis. The t-statistics of each coefficients report the significance of the coefficients. (*,**,*** significantly different from zero at 10%, 5% and 1% significance level, respectively)

**Table 4.5**: The Estimated Coefficients from Time Series Regression of Excess Industry Returns on the Three Factors of Taiwan (22 industries)

| sector | α | $\beta_1$ | $\beta_2$ | $\beta_3$ | Adj.R Square |
|---|---|---|---|---|---|
| TAAUTOM | -1.54975** | 0.59404*** | 0.04405 | 0.58643*** | 0.48023 |
| (s.e.) | (0.6715) | (0.0762) | (0.1221) | (0.0890) | |
| t-stat | -2.3080 | 7.7994 | 0.3608 | 6.5925 | |
| TAFINAN | -1.30471*** | 0.85777*** | -0.10829 | 0.49339*** | 0.73620 |
| (s.e.) | (0.3573) | (0.0487) | (0.1079) | (0.0938) | |
| t-stat | -3.6518 | 17.6008 | -1.0035 | 5.2601 | |
| TACMENT | -0.18852 | 0.92339*** | -0.13442 | 0.85524*** | 0.66335 |
| (s.e.) | (0.6524) | (0.0826) | (0.1351) | (0.0881) | |
| t-stat | -0.2890 | 11.1827 | -0.9947 | 9.7099 | |
| TACHEMS | -0.22122 | 0.83415*** | 0.48039*** | 0.41941*** | 0.82988 |
| (s.e.) | (0.3444) | (0.0539) | (0.0727) | (0.0647) | |
| t-stat | -0.6424 | 15.4722 | 6.6059 | 6.4869 | |
| TACONST | -0.20764 | 1.04928*** | 0.68510*** | 0.77321*** | 0.75968 |
| (s.e.) | (0.7629) | (0.0547) | (0.1294) | (0.0733) | |
| t-stat | -0.2722 | 19.1746 | 5.2956 | 10.5475 | |
| TAELMCH | -0.85747*** | 0.75620*** | 0.31808*** | 0.30715*** | 0.81794 |
| (s.e.) | (0.2482) | (0.0354) | (0.0672) | (0.0591) | |
| t-stat | -3.4551 | 21.3601 | 4.7362 | 5.1994 | |
| TAELECM | 0.70209*** | 1.10201*** | -0.08935 | -0.34565*** | 0.94164 |
| (s.e.) | (0.2040) | (0.0227) | (0.0623) | (0.0326) | |
| t-stat | 3.4421 | 48.5968 | -1.4349 | -10.6037 | |
| TAELTRN | 0.77568*** | 1.11227*** | -0.12152** | -0.38138*** | 0.92998 |
| (s.e.) | (0.2259) | (0.0255) | (0.0704) | (0.0377) | |
| t-stat | 3.4339 | 43.6278 | -1.7262 | -10.1282 | |
| TAFOODS | -0.37586 | 0.83257*** | 0.38921*** | 0.53238*** | 0.66361 |
| (s.e.) | (0.5919) | (0.0703) | (0.1254) | (0.0841) | |
| t-stat | -0.6350 | 11.8458 | 3.1033 | 6.3334 | |
| TAGLASS | -0.98507* | 0.69998*** | 0.12268 | 0.52096*** | 0.54489 |
| (s.e.) | (0.5051) | (0.0913) | (0.1219) | (0.0806) | |
| t-stat | -1.9503 | 7.6706 | 1.0062 | 6.4598 | |
| TAOTHER | -0.75872** | 0.75133*** | 0.30139*** | 0.29702*** | 0.74494 |
| (s.e.) | (0.3394) | (0.0472) | (0.0957) | (0.0512) | |
| t-stat | -2.2356 | 15.9231 | 3.1498 | 5.8033 | |
| TAPAPLP | -0.60694 | 0.95420*** | 0.27560** | 0.76135*** | 0.75145 |
| (s.e.) | (0.6241) | (0.0708) | (0.1199) | (0.0723) | |
| t-stat | -0.9725 | 13.4764 | 2.2990 | 10.5241 | |
| TAPLTIC | 0.33643 | 0.92061*** | -0.12464 | 0.38595*** | 0.65089 |
| (s.e.) | (0.4859) | (0.0658) | (0.0881) | (0.1125) | |
| t-stat | 0.6924 | 13.9959 | -1.4150 | 3.4320 | |

**Table 4.5** (continue)

| sector | α | β1 | β2 | β3 | Adj.R Square |
|---|---|---|---|---|---|
| TARUBBR | 0.05358 | 0.84367*** | 0.47432*** | 0.44644*** | 0.64059 |
| (s.e.) | (0.5935) | (0.0569) | (0.1046) | (0.0655) | |
| t-stat | 0.0903 | 14.8148 | 4.5356 | 6.8196 | |
| TASTEEL | -0.67830 | 0.66363*** | 0.09650 | 0.52623*** | 0.50422 |
| (s.e.) | (0.5701) | (0.0768) | (0.1139) | (0.0971) | |
| t-stat | -1.1899 | 8.6410 | 0.8471 | 5.4191 | |
| TATEXTS | -0.20644 | 0.98632*** | 0.11467 | 0.63096*** | 0.83571 |
| (s.e.) | (0.3653) | (0.0417) | (0.0788) | (0.0544) | |
| t-stat | -0.5651 | 23.6704 | 1.4557 | 11.6018 | |
| TATOURS | -1.27148** | 0.68034*** | 0.23468*** | 0.45974*** | 0.58801 |
| (s.e.) | (0.6318) | (0.0726) | (0.0843) | (0.0811) | |
| t-stat | -2.0124 | 9.3743 | 2.7843 | 5.6682 | |
| TATRANS | -0.29582 | 0.83657*** | -0.03762 | 0.64908*** | 0.66438 |
| (s.e.) | (0.5778) | (0.0825) | (0.1570) | (0.0796) | |
| t-stat | -0.5120 | 10.1362 | -0.2396 | 8.1551 | |
| TACABLE | -0.28739 | 1.05643*** | 0.32671*** | 0.41472*** | 0.79263 |
| (s.e.) | (0.6009) | (0.0399) | (0.0923) | (0.0508) | |
| t-stat | -0.4783 | 26.5061 | 3.5393 | 8.1709 | |
| TACEMEN | -0.44415 | 0.86623*** | -0.05645 | 0.75702*** | 0.71414 |
| (s.e.) | (0.5817) | (0.0667) | (0.1176) | (0.0745) | |
| t-stat | -0.7636 | 12.9896 | -0.4802 | 10.1639 | |
| TAPLAST | 0.13951 | 0.89011*** | 0.02903 | 0.37974*** | 0.73271 |
| (s.e.) | (0.3972) | (0.0540) | (0.0671) | (0.0914) | |
| t-stat | 0.3513 | 16.4753 | 0.4329 | 4.1568 | |
| TARETAL | -0.93353* | 0.68487*** | 0.07744 | 0.33584*** | 0.60336 |
| (s.e.) | (0.5160) | (0.0605) | (0.1435) | (0.0764) | |
| t-stat | -1.8093 | 11.3151 | 0.5396 | 4.3933 | |
| No. of significant coefficient | 9 | 22 | 10 | 22 | |
| % of significance | 40.90909 | 100 | 45.45455 | 100 | |

**Notes**: This table reports the coefficients from the first step Fama and MacBeth regression. The Newey-West adjusted s.e. are shown in parenthesis. The t-statistics of each coefficients report the significance of the coefficients. (*,**,*** significantly different from zero at 10%, 5% and 1% significance level, respectively)

**Table 4.6**: The Estimated Coefficients from Time Series Regression of Excess Industry Returns on the Three Factors of South Korea (20 industries)

| sector | $\alpha$ | $\beta_1$ | $\beta_2$ | $\beta_3$ | Adj.R Square |
|---|---|---|---|---|---|
| KORBANK | -0.99359 | 0.93160*** | -0.14953 | -0.04915 | 0.60173 |
| (s.e.) | (0.8999) | (0.0858) | (0.1151) | (0.1163) | |
| t-stat | -1.1041 | 10.8574 | -1.2989 | -0.4225 | |
| KORCHEM | 0.40622 | 0.97802*** | 0.07602 | 0.11313** | 0.82753 |
| (s.e.) | (0.4913) | (0.0446) | (0.0467) | (0.0492) | |
| t-stat | 0.8269 | 21.9490 | 1.6293 | 2.3014 | |
| KORCOMM | -1.22706 | 0.73613*** | -0.16102* | -0.22045** | 0.60310 |
| (s.e.) | (0.9333) | (0.0649) | (0.0815) | (0.0847) | |
| t-stat | -1.3147 | 11.3386 | -1.9757 | -2.6013 | |
| KORCNST | 0.05605 | 1.04962*** | 0.14764 | 0.11951 | 0.56815 |
| (s.e.) | (0.9957) | (0.0898) | (0.1103) | (0.0935) | |
| t-stat | 0.0563 | 11.6831 | 1.3390 | 1.2783 | |
| KORELEC | 0.68140 | 1.11140*** | 0.06415 | -0.02506 | 0.70679 |
| (s.e.) | (0.8757) | (0.0892) | (0.1115) | (0.0843) | |
| t-stat | 0.7781 | 12.4565 | 0.5751 | -0.2971 | |
| KORELGA | -1.38186** | 0.68663*** | 0.07350 | -0.06179 | 0.50328 |
| (s.e.) | (0.5346) | (0.0758) | (0.0686) | (0.0511) | |
| t-stat | -2.5849 | 9.0635 | 1.0718 | -1.2095 | |
| KORFINS | -0.10980 | 1.04433*** | -0.04611 | -0.05399 | 0.69930 |
| (s.e.) | (0.7523) | (0.0758) | (0.0836) | (0.0858) | |
| t-stat | -0.1460 | 13.7828 | -0.5513 | -0.6291 | |
| KORFBEV | -0.66217 | 0.89115*** | 0.07218 | 0.10576* | 0.71450 |
| (s.e.) | (0.5275) | (0.0438) | (0.0660) | (0.0586) | |
| t-stat | -1.2552 | 20.3552 | 1.0942 | 1.8052 | |
| KORINSR | 1.49238 | 1.05040*** | 0.06831 | -0.02021 | 0.60575 |
| (s.e.) | (0.9498) | (0.0749) | (0.1016) | (0.0545) | |
| t-stat | 1.5712 | 14.0309 | 0.6721 | -0.3711 | |
| KORBMET | 0.41941 | 0.92920*** | 0.09834** | 0.05555 | 0.65448 |
| (s.e.) | (0.6614) | (0.0575) | (0.0438) | (0.0579) | |
| t-stat | 0.6341 | 16.1738 | 2.2468 | 0.9592 | |
| KORMACH | 0.64286 | 1.08988*** | 0.09844 | 0.12773 | 0.62856 |
| (s.e.) | (0.9270) | (0.0793) | (0.1014) | (0.0797) | |
| t-stat | 0.6935 | 13.7448 | 0.9709 | 1.6030 | |
| KORMCMP | 0.38548 | 1.04142*** | 0.09888* | 0.02250 | 0.91720 |
| (s.e.) | (0.3355) | (0.0355) | (0.0536) | (0.0294) | |
| t-stat | 1.1490 | 29.3325 | 1.8447 | 0.7656 | |

**Table 4.6** (continue)

| sector | α | $\beta_1$ | $\beta_2$ | $\beta_3$ | Adj.R Square |
|---|---|---|---|---|---|
| KORNMMP | -0.59616 | 0.95952*** | 0.26010*** | 0.12444 | 0.60778 |
| (s.e.) | (0.7080) | (0.0946) | (0.0785) | (0.0902) | |
| t-stat | -0.8420 | 10.1385 | 3.3142 | 1.3788 | |
| KORWPLP | -1.75448** | 0.96784*** | 0.11576 | 0.20692*** | 0.64274 |
| (s.e.) | (0.7125) | (0.0618) | (0.0895) | (0.0613) | |
| t-stat | -2.4624 | 15.6698 | 1.2927 | 3.3733 | |
| KORPHRM | -1.18136* | 0.85421*** | 0.14445** | 0.27935*** | 0.53350 |
| (s.e.) | (0.6704) | (0.1113) | (0.0668) | (0.0912) | |
| t-stat | -1.7622 | 7.6750 | 2.1617 | 3.0641 | |
| KORSECS | 1.70979 | 1.26767*** | 0.22080 | -0.01683 | 0.55875 |
| (s.e.) | (1.1371) | (0.1132) | (0.1409) | (0.0883) | |
| t-stat | 1.5037 | 11.2016 | 1.5668 | -0.1907 | |
| KORTWAP | -2.22180*** | 0.85536*** | 0.34538*** | 0.13812 | 0.62085 |
| (s.e.) | (0.7121) | (0.0822) | (0.0716) | (0.1064) | |
| t-stat | -3.120 | 10.4088 | 4.8233 | 1.2977 | |
| KORTRNS | 0.28915 | 1.0720*** | 0.08685 | 0.06478 | 0.71298 |
| (s.e.) | (0.8364) | (0.0549) | (0.0876) | (0.0553) | |
| t-stat | 0.3457 | 19.5233 | 0.9909 | 1.1710 | |
| KORTRNW | 1.84431* | 1.24985*** | 0.05285 | 0.11603 | 0.62763 |
| (s.e.) | (0.9613) | (0.1150) | (0.0994) | (0.0899) | |
| t-stat | 1.9185 | 10.8721 | 0.5317 | 1.2906 | |
| KORWHLS | -0.28160 | 1.08883*** | -0.01878 | 0.11127*** | 0.73158 |
| (s.e.) | (0.6017) | (0.0470) | (0.0885) | (0.0423) | |
| t-stat | -0.4680 | 23.1445 | -0.2123 | 2.6285 | |
| No. of significant coefficient | 5 | 20 | 6 | 6 | |
| % of significance | 25 | 100 | 30 | 30 | |

**Notes**: This table reports the coefficients from the first step Fama and MacBeth regression. The Newey-West adjusted s.e. are shown in parenthesis. The t-statistics of each coefficients report the significance of the coefficients. (*,**,*** significantly different from zero at 10%, 5% and 1% significance level, respectively)

**Figure 4.1.1**: The Comparison between Estimated Risk Free Rate Differential and Exchange Rate Differential (TH-US)

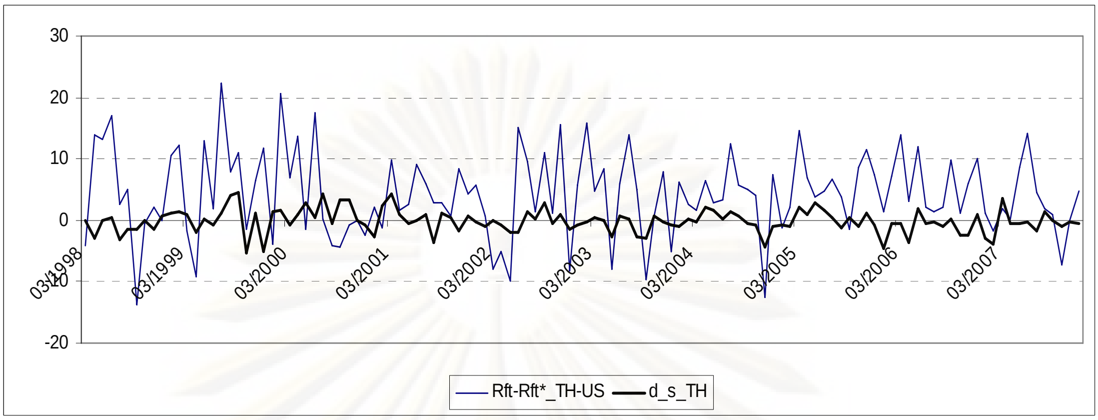



**Figure 4.1.2:** The Comparison between TPI Inflation Differential and Exchange Rate Differential (TH-US)

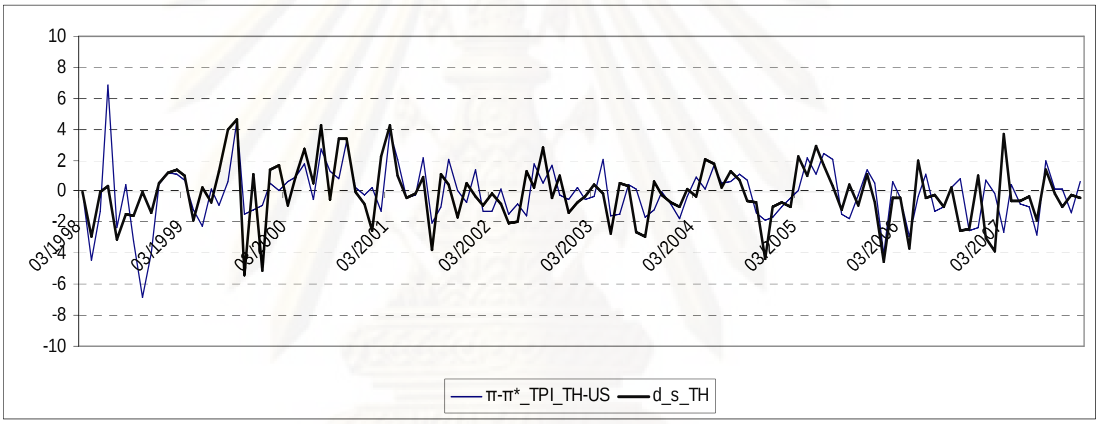
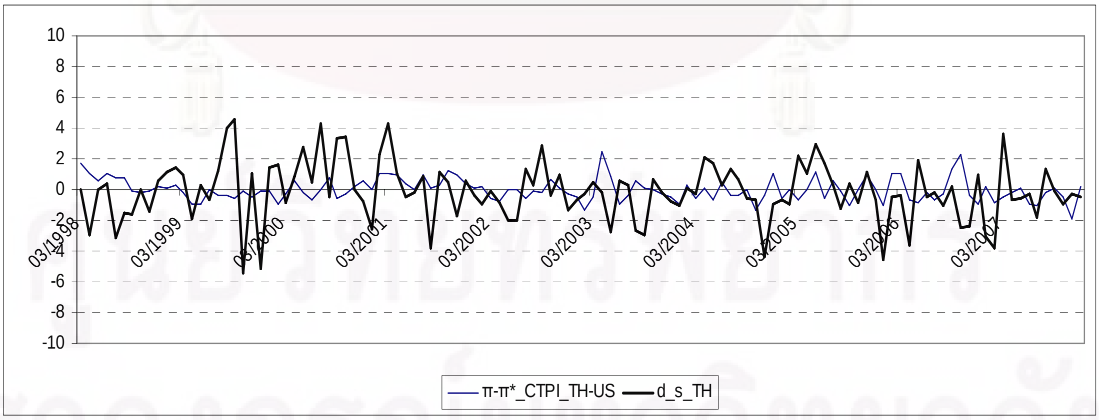



**Figure 4.1.3:** The Comparison between CPI inflation of Domestic Country - TPI inflation of Foreign Country and Exchange Rate Differential (TH-US)




**Notes:**

1. Rft-Rft*_XX-US denotes estimated risk free rate ($\hat{R}_{ft}$) of XX - estimated risk free rate ($\hat{R}_{ft}$) of the U.S.

2. π-π*_TPI_XX-US denotes ln(TPI) inflation of XX - ln(TPI) inflation of the U.S.

3. π-π*_CTPI_XX-US denotes ln(CPI) inflation of XX - ln(TPI) inflation of the U.S.

4. d_s_XX denotes difference across time of ln(exchange rate) of XX.

**Figure 4.2.1:** The Comparison between Estimated Risk Free Rate Differential and Exchange Rate Differential (TW-US)

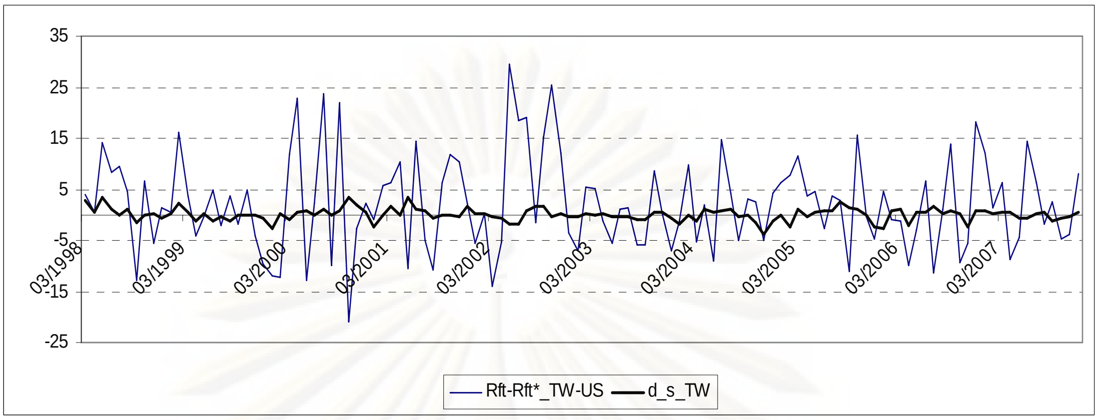



**Figure 4.2.2:** The Comparison between TPI Inflation Differential and Exchange Rate Differential (TW-US)

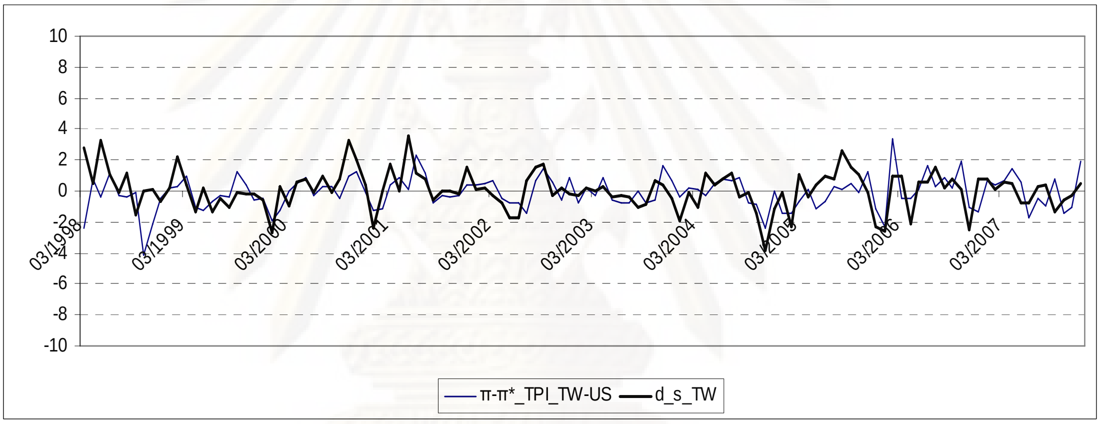
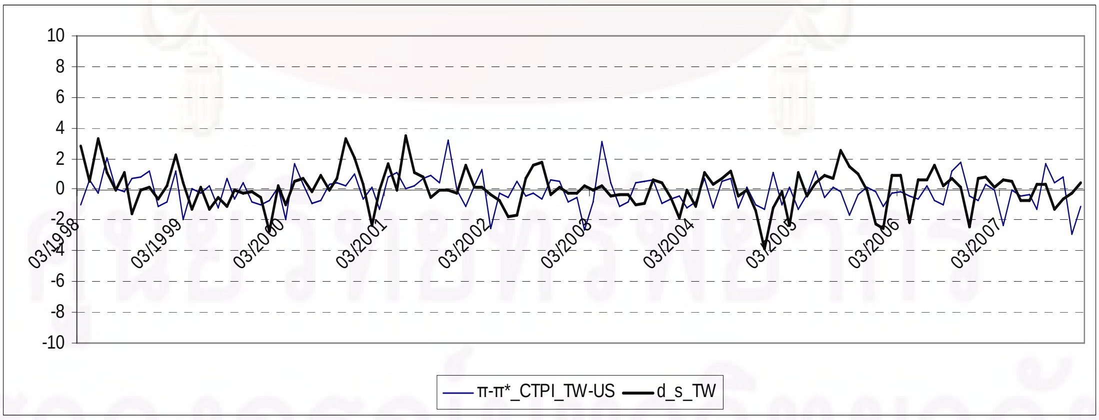



**Figure 4.2.3:** The Comparison between CPI inflation of Domestic Country - TPI inflation of Foreign Country and Exchange Rate Differential (TW-US)




**Notes:**

1. Rft-Rft*_XX-US denotes estimated risk free rate ($\hat{R}_{ft}$) of XX - estimated risk free rate ($\hat{R}_{ft}$) of the U.S.

2. π-π*_TPI_XX-US denotes ln(TPI) inflation of XX - ln(TPI) inflation of the U.S.

3. π-π*_CTPI_XX-US denotes ln(CPI) inflation of XX - ln(TPI) inflation of the U.S.

4. d_s_XX denotes difference across time of ln(exchange rate) of XX.

**Figure 4.3.1:** The Comparison between Estimated Risk Free Rate Differential and Exchange Rate Differential (KO-US)

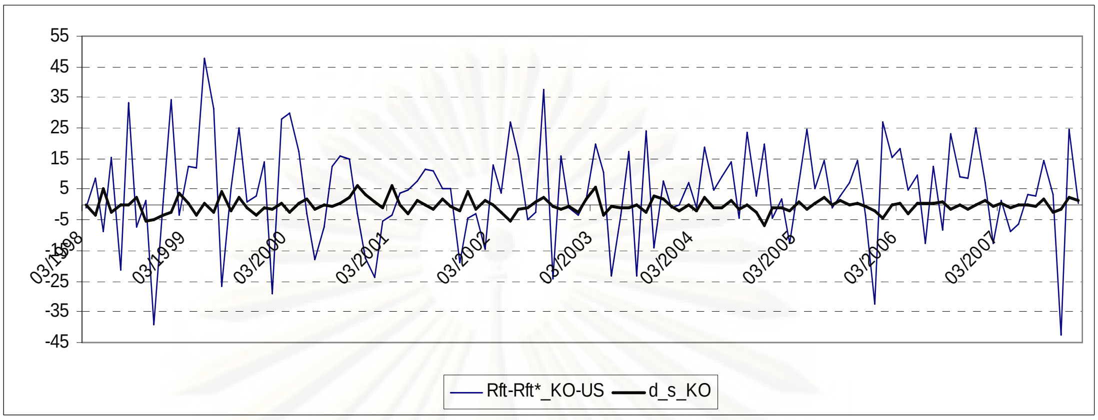



**Figure 4.3.2:** The Comparison between TPI Inflation Differential and Exchange Rate Differential (KO-US)

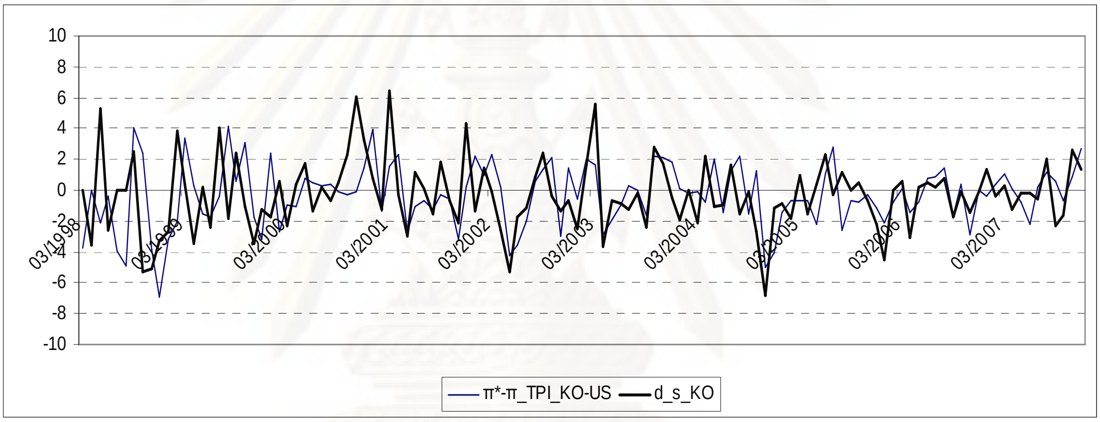
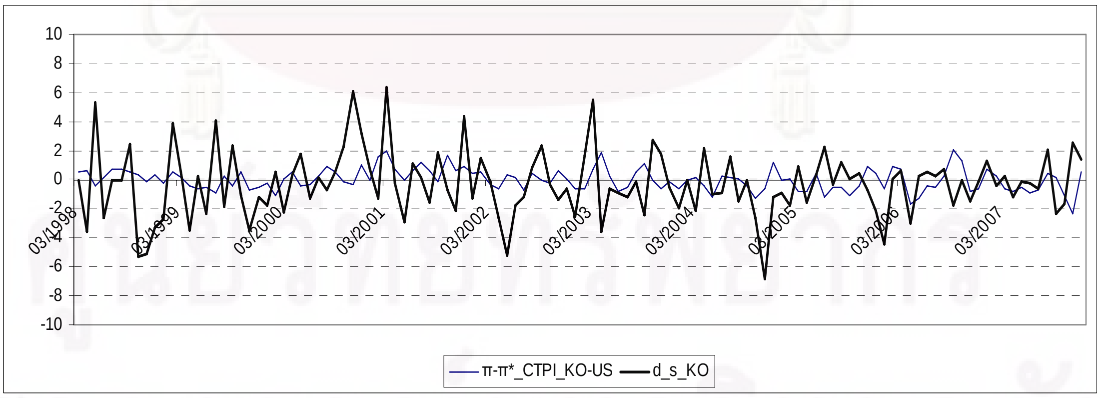



**Figure 4.3.3:** The Comparison between CPI inflation of Domestic Country - TPI inflation of Foreign Country and Exchange Rate Differential (KO-US)




**Notes:**

1. Rft-Rft*_XX-US denotes estimated risk free rate ( $\hat{R}_{ft}$ ) of XX - estimated risk free rate ( $\hat{R}_{ft}$ ) of the U.S.

2. π-π*_TPI_XX-US denotes ln(TPI) inflation of XX - ln(TPI) inflation of the U.S.

3. π-π*_CTPI_XX-US denotes ln(CPI) inflation of XX - ln(TPI) inflation of the U.S.

4. d_s_XX denotes difference across time of ln(exchange rate) of XX.

**Table 4.7.1**: The Results of the Least-Squares Regression *REG1* in the Case of Thailand

| model | estimated coefficient | | | test separated coefficient | | | | test joint coefficient | |
|---|---|---|---|---|---|---|---|---|---|
| | $\beta_1$ | $\beta_2$ | Adj. R Square | Ho: | $\beta_1 = 0$ | $\beta_2 = 0$ | $\beta_2 = 1$ | Ho: | $\beta_1=0, \beta_2=1$ |
| *REGRFT1* | **4.386163** | **0.959688** | 0.0652700 | t-stat | 7.02237*** | 2.70886*** | -0.113786 | F-stat | 25.61332*** |
| (s.e.) | (.6246) | (.35428) | | | | | | p-value | 0.00000 |
| *REGTPI1* | **-0.016546** | **0.451633** | 0.2590580 | t-stat | -0.157513 | 5.33656*** | -6.47958*** | F-stat | 23.46288*** |
| (s.e.) | (.10504) | (.08463) | | | | | | p-value | 0.00000 |
| *REGCTPI1* | **-0.029988** | **-0.009594** | -0.0081640 | t-stat | -0.395168 | -0.293821 | -30.91982*** | F-stat | 482.33690*** |
| (s.e.) | (.07589) | (.03265) | | | | | | p-value | 0.00000 |

**Notes**: This table reports the results of the regression $\Delta p_t - \Delta p_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t$. Newey-West adjusted s.e. are shown in parenthesis. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.

**Table 4.7.2**: The Results of the Least-Squares Regression *REG2* in the Case of Thailand

| model | estimated coefficient | | | test separated coefficient | | | | test joint coefficient | |
|---|---|---|---|---|---|---|---|---|---|
| | $\alpha_1$ | $\alpha_2$ | Adj. R Square | Ho: | $\alpha_1 = 0$ | $\alpha_2 = 0$ | $\alpha_2 = 1$ | Ho: | $\alpha_1=0, \alpha_2=1$ |
| *REGRFT2* | **-0.474569** | **0.076556** | 0.0652700 | t-stat | -1.937244* | 3.12429*** | -37.68698*** | F-stat | 1284.3810*** |
| (s.e.) | (.24497) | (.024503) | | | | | | p-value | 0.00000 |
| *REGTPI2* | **-0.100281** | **0.587994** | 0.2590580 | t-stat | -0.714047 | 4.98645*** | -3.4940*** | F-stat | 6.38418*** |
| (s.e.) | (.14044) | (.11792) | | | | | | p-value | 0.00240 |
| *REGCTPI2* | **-0.151811** | **-0.070867** | -0.0081640 | t-stat | -0.770731 | -0.293140 | -4.42965*** | F-stat | 9.83303*** |
| (s.e.) | (.19697) | (.24175) | | | | | | p-value | 0.00010 |

**Notes**: This table reports the results of the regression $\Delta s_t = \alpha_1 + \alpha_2 \left(\Delta p_t - \Delta p_t^*\right) + \varepsilon_t$. Newey-West adjusted s.e. are shown in parenthesis. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.



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**Table 4.8.1**: The Results of the Least-Squares Regression *REG1* in the Case of Taiwan

| **model** | **estimated coefficient** | | | **test separated coefficient** | | | | **test joint coefficient** | |
|---|---|---|---|---|---|---|---|---|---|
| | $\beta_1$ | $\beta_2$ | Adj. R Square | Ho: | $\beta_1 = 0$ | $\beta_2 = 0$ | $\beta_2 = 1$ | Ho: | $\beta_1=0, \beta_2=1$ |
| *REGRFT1* | **2.107435** | **0.862515** | 0.0045970 | t-stat | 2.611319** | 1.139911 | -0.18170 | F-stat | 3.439507** |
| (s.e.) | (.80704) | (.75665) | | | | | | p-value | 0.03540 |
| *REGTPI1* | **-0.084671** | **0.323793** | 0.1549600 | t-stat | -1.122212 | 3.98260*** | -8.31722*** | F-stat | 35.04004*** |
| (s.e.) | (.07545) | (.0813) | | | | | | p-value | 0.00000 |
| *REGCTPI1* | **-0.155412** | **0.087455** | 0.0025260 | t-stat | -1.988011** | 1.80357* | -18.81924*** | F-stat | 184.3910*** |
| (s.e.) | (.07817) | (.04849) | | | | | | p-value | 0.00000 |

**Notes**: This table reports the results of the regression $\Delta p_t - \Delta p_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t$. Newey-West adjusted s.e. are shown in parenthesis. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.

**Table 4.8.2**: The Results of the Least-Squares Regression *REG2* in the Case of Taiwan

| **model** | **estimated coefficient** | | | **test separated coefficient** | | | | **test joint coefficient** | |
|---|---|---|---|---|---|---|---|---|---|
| | $\alpha_1$ | $\alpha_2$ | Adj. R Square | Ho: | $\alpha_1 = 0$ | $\alpha_2 = 0$ | $\alpha_2 = 1$ | Ho: | $\alpha_1=0, \alpha_2=1$ |
| *REGRFT2* | **0.030244** | **0.015278** | 0.0045970 | t-stat | 0.207848 | 1.063130 | -68.52147*** | F-stat | 2925.1020*** |
| (s.e.) | (.14551) | (.01437) | | | | | | p-value | 0.00000 |
| *REGTPI2* | **0.095436** | **0.501074** | 0.1549600 | t-stat | 0.814022 | 3.97826*** | -3.96121*** | F-stat | 7.97592*** |
| (s.e.) | (.11724) | (.12595) | | | | | | p-value | 0.00060 |
| *REGCTPI2* | **0.082341** | **0.127208** | 0.0025260 | t-stat | 0.617232 | 1.609644 | -11.04409*** | F-stat | 61.02419*** |
| (s.e.) | (.1334) | (.07903) | | | | | | p-value | 0.00000 |

**Notes**: This table reports the results of the regression $\Delta s_t = \alpha_1 + \alpha_2 (\Delta p_t - \Delta p_t^*) + \varepsilon_t$. Newey-West adjusted s.e. are shown in parenthesis. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.



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**Table 4.9.1**: The Results of the Least-Squares Regression *REG1* in the Case of South Korea

| **model** | **estimated coefficient** | | | **test separated coefficient** | | | | **test joint coefficient** | |
|---|---|---|---|---|---|---|---|---|---|
| | $\beta_1$ | $\beta_2$ | Adj. R Square | Ho: | $\beta_1 = 0$ | $\beta_2 = 0$ | $\beta_2 = 1$ | Ho: | $\beta_1=0$, $\beta_2=1$ |
| *REGRFT1* | **3.991165** | **-0.369884** | -0.0058620 | t-stat | 3.32759*** | -0.581885 | -2.15504** | F-stat | 7.22658*** |
| (s.e.) | (1.19942) | (.63566) | | | | | | p-value | 0.00110 |
| *REGTPI1* | **-0.150010** | **0.321749** | 0.1341280 | t-stat | -1.042214 | 4.46242*** | -9.40683*** | F-stat | 46.05076*** |
| (s.e.) | (.14393) | (.0721) | | | | | | p-value | 0.00000 |
| *REGCTPI1* | **-0.006365** | **0.017750** | -0.0059410 | t-stat | -0.071730 | 0.577819 | -31.97428*** | F-stat | 631.37790*** |
| (s.e.) | (.08873) | (.03072) | | | | | | p-value | 0.00000 |

**Notes**: This table reports the results of the regression $\Delta p_t - \Delta p_t^* = \beta_1 + \beta_2 \Delta s_t + \varepsilon_t$. Newey-West adjusted s.e. are shown in parenthesis. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.

**Table 4.9.2**: The Results of the Least-Squares Regression *REG2* in the Case of South Korea

| **model** | **estimated coefficient** | | | **test separated coefficient** | | | | **test joint coefficient** | |
|---|---|---|---|---|---|---|---|---|---|
| | $\alpha_1$ | $\alpha_2$ | Adj. R Square | Ho: | $\alpha_1 = 0$ | $\alpha_2 = 0$ | $\alpha_2 = 1$ | Ho: | $\alpha_1=0$, $\alpha_2=1$ |
| *REGRFT2* | **-0.292414** | **-0.008007** | -0.0058620 | t-stat | -1.251367 | -0.565163 | -71.14674*** | F-stat | 3147.4590*** |
| (s.e.) | (.23368) | (.01417) | | | | | | p-value | 0.00000 |
| *REGTPI2* | **-0.188585** | **0.440686** | 0.1341280 | t-stat | -1.032730 | 4.73223*** | -6.00612*** | F-stat | 18.10673*** |
| (s.e.) | (.18261) | (.09312) | | | | | | p-value | 0.00000 |
| *REGCTPI2* | **-0.323365** | **0.162421** | -0.0059410 | t-stat | -1.508057 | 0.571240 | -2.94579*** | F-stat | 5.51820*** |
| (s.e.) | (.21443) | (.28433) | | | | | | p-value | 0.00520 |

**Notes**: This table reports the results of the regression $\Delta s_t = \alpha_1 + \alpha_2 \left(\Delta p_t - \Delta p_t^*\right) + \varepsilon_t$. Newey-West adjusted s.e. are shown in parenthesis. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.



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**Figure 4.4.1:** Real Exchange Rate Constructed from Hypothetical Price Index

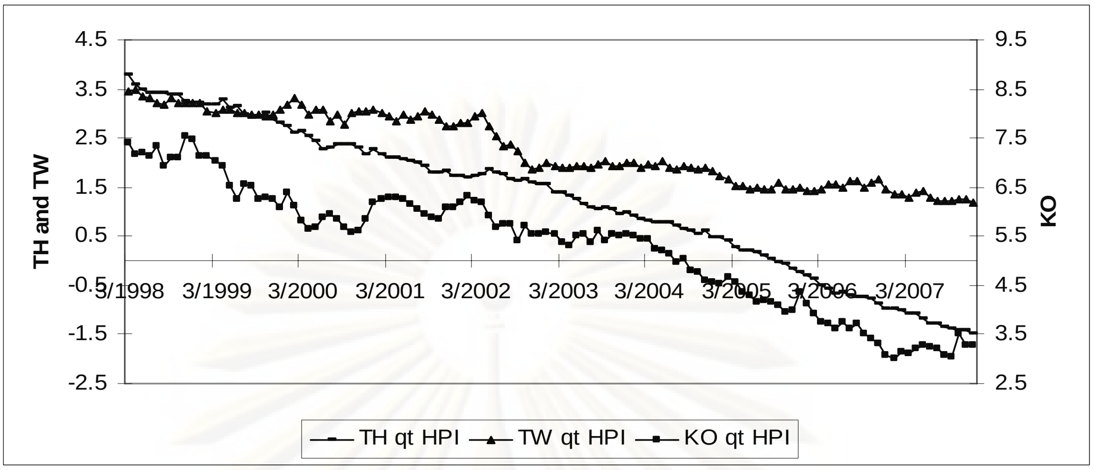



**Figure 4.4.2:** Real Exchange Rate Constructed from Traded Goods Price Index

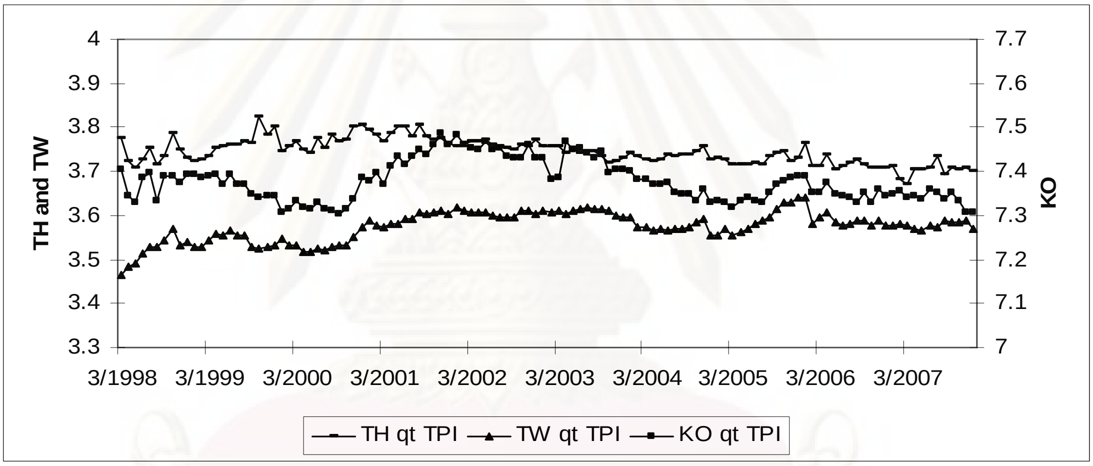
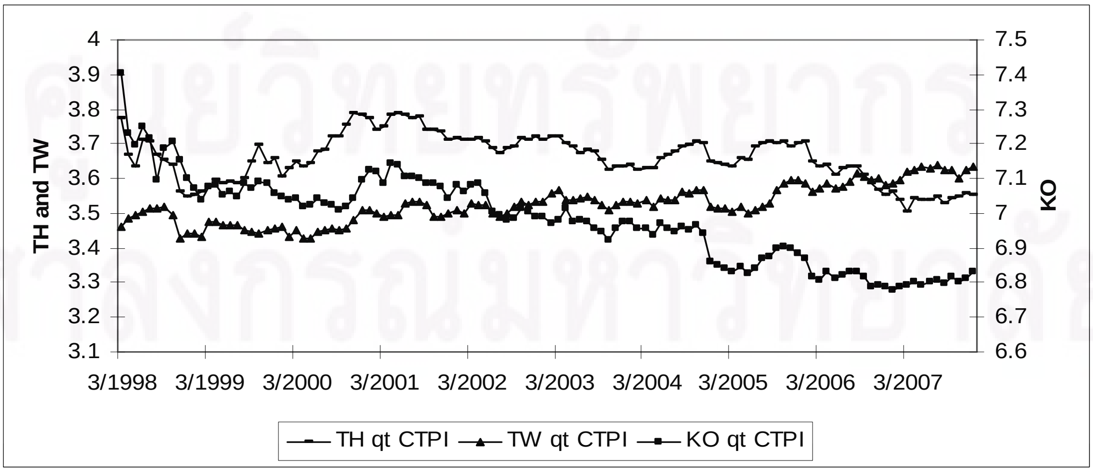



**Figure 4.4.3:** Real Exchange Rate Constructed from Consumer Price Index of Domestic country and Traded Goods Price Index of Foreign Country




**Note**: XX_qt_xPI denotes real exchange rate series constructed from xPI index of country XX**.**

**Table 4.10**: The Results of Unit Root Test on Real Exchange Rate Using ADF Method

| country | model | deterministic assumption | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | constant+trend | | | constant | | | none | | |
| | | t-stat | p - value | lag | t-stat | p - value | lag | t-stat | p - value | lag |
| Thailand | *RERHPI* | -1.6890 | 0.7501 | **0** | 0.3265 | 0.9788 | **0** | -1.0729 | 0.2549 | **6** |
| | *RERTPI* | -3.3775 | 0.0595 | **2** | -1.7134 | 0.4219 | **2** | -0.1950 | 0.6139 | **2** |
| | *RERCTPI* | -2.0882 | 0.5466 | **0** | -1.9857 | 0.2928 | **0** | -0.8844 | 0.3309 | **0** |
| Taiwan | *RERHPI* | -2.6060 | 0.2786 | **0** | -0.8523 | 0.7999 | **0** | -2.4197** | 0.0156 | **0** |
| | *RERTPI* | -3.1492 | 0.1001 | **0** | -3.52270*** | 0.009 | **0** | 0.7522 | 0.8753 | **0** |
| | | -2.7596 | 0.2154 | 1 | -3.1212** | 0.0277 | 1 | 0.6780 | 0.8609 | 1 |
| | | -2.6037 | 0.2796 | 2 | -2.9716** | 0.0406 | 2 | 0.6514 | 0.8555 | 2 |
| | | -2.5292 | 0.3137 | 3 | -2.6390* | 0.0882 | 3 | 0.3544 | 0.7856 | 3 |
| | | -2.2854 | 0.4381 | 4 | -2.3997 | 0.1441 | 4 | 0.3323 | 0.7797 | 4 |
| | *RERCTPI* | -3.3622 | 0.0617 | 0 | -1.2362 | 0.657 | **0** | 0.9324 | 0.9058 | **0** |
| South Korea | *RERHPI* | -2.6454 | 0.2614 | **0** | -0.8402 | 0.8036 | **0** | -2.3911** | 0.0169 | **0** |
| | *RERTPI* | -1.8950 | 0.6507 | **1** | -1.6886 | 0.4344 | **1** | -0.2769 | 0.5843 | **1** |
| | | -1.5266 | 0.8149 | 2 | -1.2480 | 0.6517 | 2 | -0.2363 | 0.5991 | 2 |
| | | -1.5703 | 0.7987 | 3 | -1.3631 | 0.598 | 3 | -0.3918 | 0.5408 | 3 |
| | *RERCTPI* | -5.55410*** | 0.000047 | **0** | -3.3355** | 0.0155 | **0** | -1.7438* | 0.0771 | **0** |
| | | -3.5611** | 0.0377 | 1 | -1.8453 | 0.3571 | 1 | -1.3830 | 0.1542 | 1 |
| | | -2.8055 | 0.1984 | 2 | -1.8303 | 0.3643 | 2 | -1.9564** | 0.0486 | 2 |
| | | -3.2608* | 0.0782 | 3 | -1.8111 | 0.3735 | 3 | -1.5921 | 0.1046 | 3 |
| | | -3.3678* | 0.0610 | 4 | -1.6836 | 0.4368 | 4 | -1.4315 | 0.1414 | 4 |

**Notes**: 1. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.

2. One-side p-values are obtained from MacKinnon (1996).

3. The automatic lag selection using Akike Information Criteria, appears as bold figures in "lag" column. However, lag length is selected manually if the automatic lag contains autocorrelation.

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**Table 4.11**: The Results of Unit Root Test on Real Exchange Rate Using Philip-Perron Method

| country | model | deterministic assumption | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | constant+trend | | | constant | | | none | | |
| | | Adj. t-stat | p - value | bandwidth | Adj. t-stat | p - value | bandwidth | Adj. t-stat | p - value | bandwidth |
| Thailand | *RERHPI* | -1.6237 | 0.7778 | 8 | 0.5558 | 0.9879 | 6 | -2.93110*** | **0.0037** | 7 |
| | *RERTPI* | -4.90740*** | **0.0006** | 5 | -3.4351** | **0.0116** | 5 | -0.8926 | 0.3275 | 16 |
| | *RERCTPI* | -2.2097 | 0.4795 | 2 | -2.0987 | 0.2457 | 2 | -0.8669 | 0.3384 | 2 |
| Taiwan | *RERHPI* | -2.6060 | 0.2786 | 0 | -0.8099 | 0.8124 | 5 | -2.60350*** | **0.0095** | 5 |
| | *RERTPI* | -3.1930* | **0.0909** | 4 | -3.5235*** | **0.0090** | 3 | 0.7809 | 0.8805 | 1 |
| | *RERCTPI* | -3.1412 | 0.1018 | 9 | -0.8055 | 0.8136 | 14 | 1.7107 | 0.9786 | 22 |
| Korea | *RERHPI* | -2.5868 | 0.2871 | 1 | -0.7069 | 0.8400 | 8 | -3.08020*** | **0.0023** | 9 |
| | *RERTPI* | -2.1228 | 0.5275 | 3 | -2.0136 | 0.2808 | 3 | -0.5583 | 0.4734 | 5 |
| | *RERCTPI* | -5.74530*** | **0.000022** | 6 | -3.3577** | **0.0145** | 5 | -1.9149* | 0.0533 | 4 |

**Notes**: 1. *,**,*** reject null hypothesis at 10%, 5% and 1% significance level, respectively.

2. The test uses the Newey - West Bandwidth, Bartlett kernel Spectral Density Estimator.

3. One-side p-values are obtained from MacKinnon (1996).

**Table 4.12**: The Results of Unit Root Test on Real Exchange Rate Using Ng and Perron (2001) MPT

| country | model | deterministic assumption | | | |
|---|---|---|---|---|---|
| | | constant+trend | | constant | |
| | | P-stat | lag | P-stat | lag |
| Thailand | *RERHPI* | 13.8862 | 0 | 92.2364 | 0 |
| | *RERTPI* | 7.31072 | 2 | 7.17818 | 2 |
| | *RERCTPI* | 13.4636 | 0 | 10.1175 | 0 |
| Taiwan | *RERHPI* | 7.31459 | 0 | 72.1741 | 0 |
| | *RERTPI* | 18.2626 | 0 | 20.3044 | 0 |
| | *RERCTPI* | 5.26701** | 0 | 11.0537 | 0 |
| Korea | *RERHPI* | 7.22192 | 0 | 68.6694 | 0 |
| | *RERTPI* | 12.5179 | 1 | 4.97342 | 1 |
| | *RERCTPI* | 14.8606 | 0 | 48.7615 | 0 |

**Note**: ** rejects null hypothesis at 5% significance level.



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**Table 4.13**: The Results of Unit Root Test on Real Exchange Rate with Structural Break Using Perron (1989) Method

(a): structural break at 12/2004

| **country** | **model** | **t-statistics of *a* $_1$** |
|---|---|---|
| Thailand | *THHPI* | -4.10990 |
| | *THTPI* | -5.35641*** |
| | *THCTPI* | -3.09887 |
| Taiwan | *TWHPI* | -2.79669 |
| | *TWTPI* | -3.37012 |
| | *TWCTPI* | -3.81324 |
| Korea | *KOHPI* | -3.59997 |
| | *KOTPI* | -3.11787 |
| | *KOCTPI* | -2.30544 |

critical value for $\lambda = 0.686$

| | | |
|---|---|---|
| 1% | | -4.7682 |
| 5% | | -4.1884 |

(b): structural break at 2/2006

| **country** | **model** | **t-statistics of *a* $_1$** |
|---|---|---|
| Thailand | *THHPI* | -4.14248** |
| | *THTPI* | -5.14345*** |
| | *THCTPI* | -3.03744 |
| Taiwan | *TWHPI* | -2.85142 |
| | *TWTPI* | -3.36149 |
| | *TWCTPI* | -3.79142 |
| Korea | *KOHPI* | -3.25359 |
| | *KOTPI* | -3.45415 |
| | *KOCTPI* | -2.00887 |

critical value for $\lambda = 0.8$

| | | |
|---|---|---|
| 1% | | -4.7 |
| 5% | | -4.04 |

**Notes**: This table reports the results of the unit root test with structural break, $a_1$ results from estimating $\hat{y}_t = a_1 \hat{y}_{t-1} + \sum_{i=1}^{k} \beta_i \Delta \hat{y}_{t-i} + \varepsilon_t$ . ** and *** reject null hypothesis at 5% and 1% significance level, respectively. Critical values are obtained and extrapolated from Perron (1989).

**Figure 4.5.1:** Nominal Exchange Rate and Relative Hypothetical Price Index (TH-US)

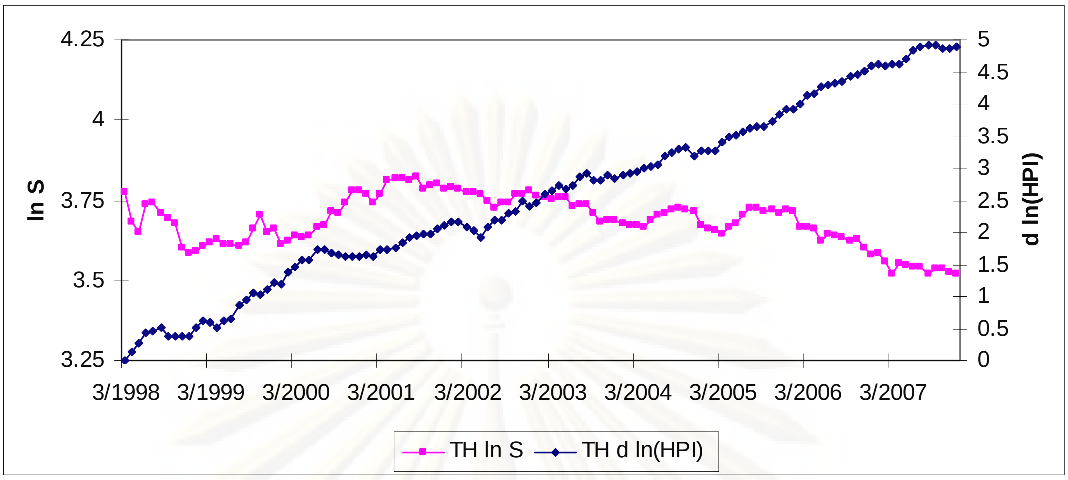



**Figure 4.5.2:** Nominal Exchange Rate and Relative Traded Goods Price Index (TH-US)

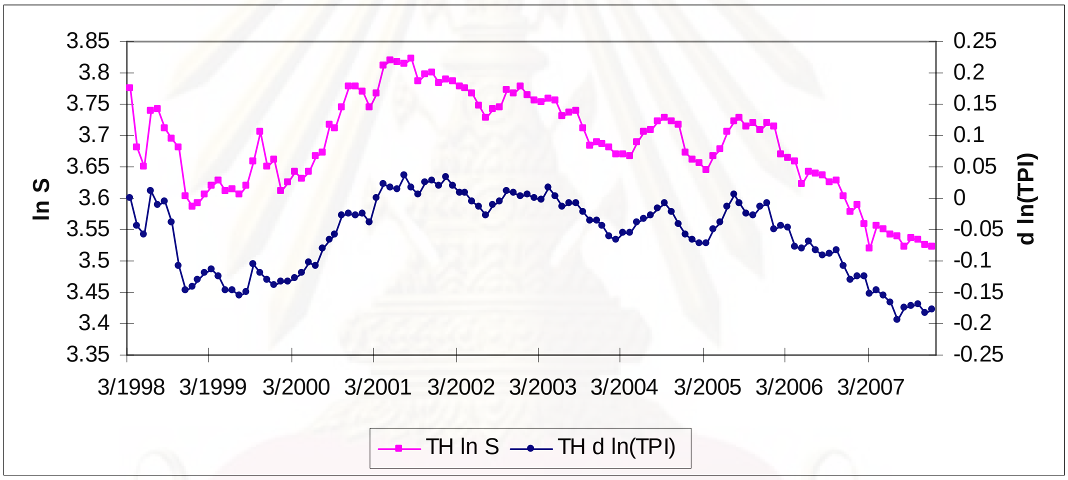
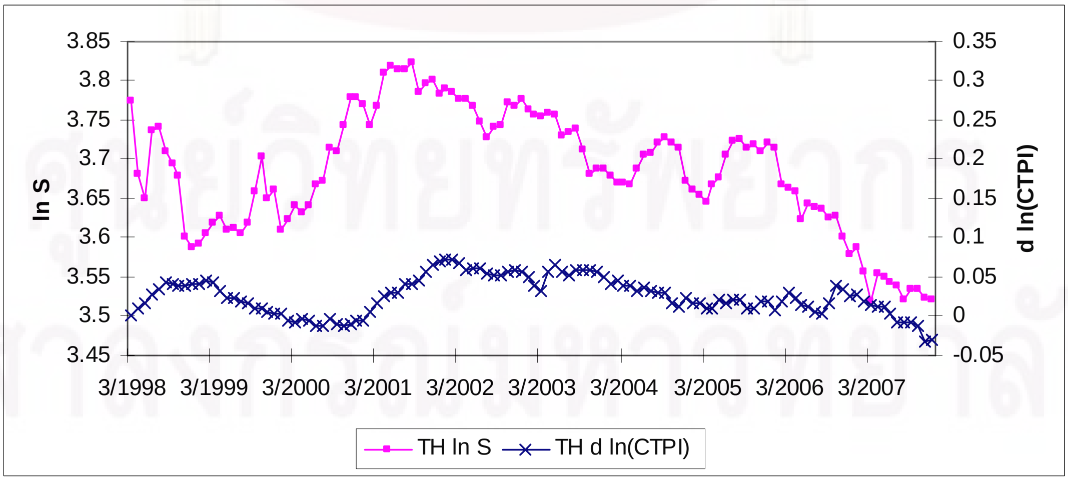



**Figure 4.5.3:** Nominal Exchange Rate and Relative Consumer Price Index of Domestic Country-Traded Goods Price Index of Foreign Country (TH-US)




**Notes**: 1. d_s_XX denotes difference across time of ln(exchange rate) of XX. 2. XX d ln(xPI) denotes ln(xPI) of XX- ln(xPI) of the U.S. 3. XX d ln(CTPI) denotes ln(CPI) of XX - ln(TPI) of the U.S.

**Figure 4.6.1:** Nominal Exchange Rate and Relative Hypothetical Price Index (TW-US)

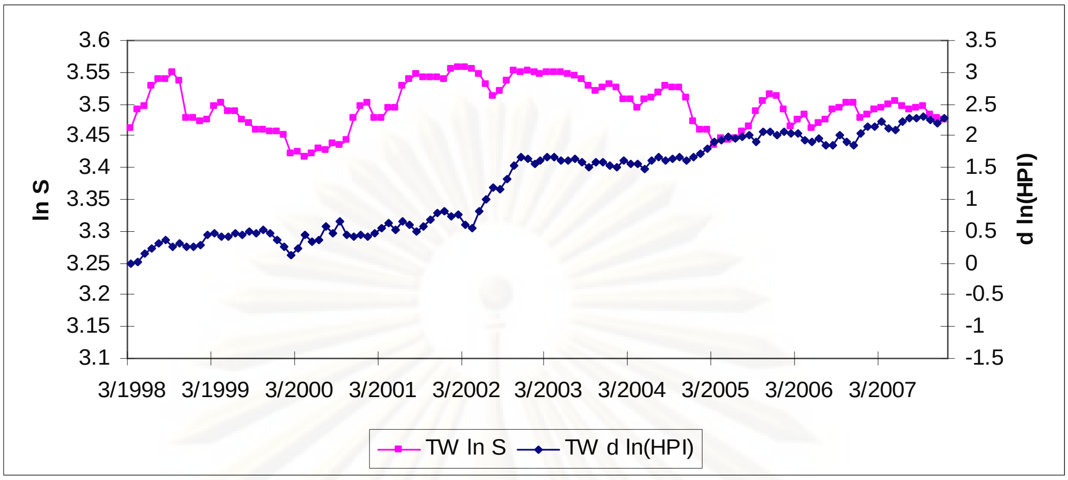



**Figure 4.6.2:** Nominal Exchange Rate and Relative Traded Goods Price Index (TW-US)

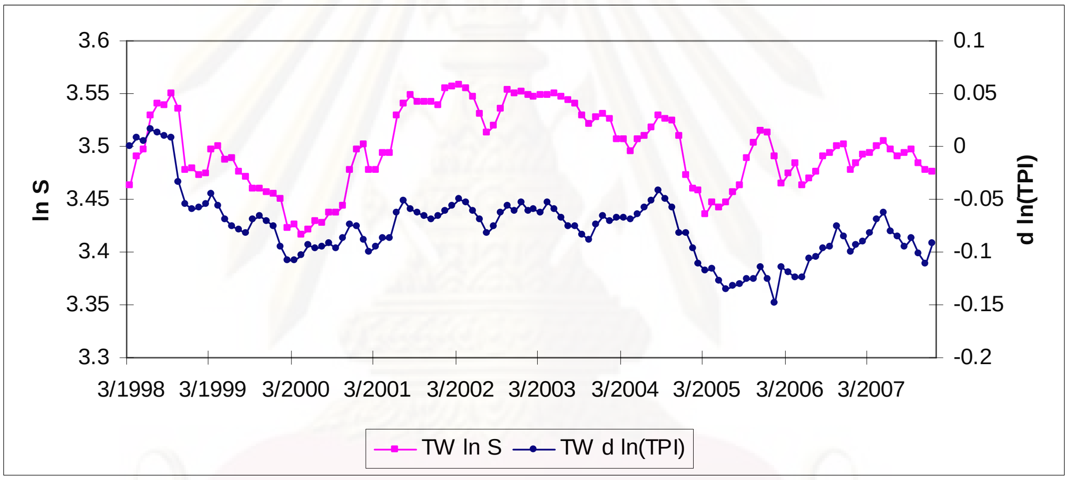
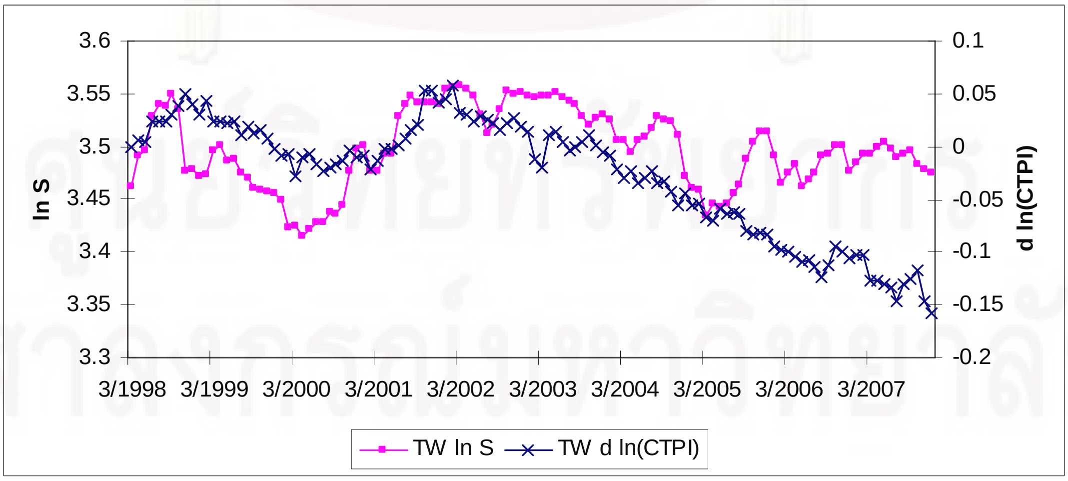



**Figure 4.6.3:** Nominal Exchange Rate and Relative Consumer Price Index of Domestic Country-Traded Goods Price Index of Foreign Country (TW-US)




**Notes**: 1. d_s_XX denotes difference across time of ln(exchange rate) of XX. 2. XX d ln(xPI) denotes ln(xPI) of XX- ln(xPI) of the U.S. 3. XX d ln(CTPI) denotes ln(CPI) of XX - ln(TPI) of the U.S.

**Figure 4.7.1:** Nominal Exchange Rate and Relative Hypothetical Price Index (KO-US)

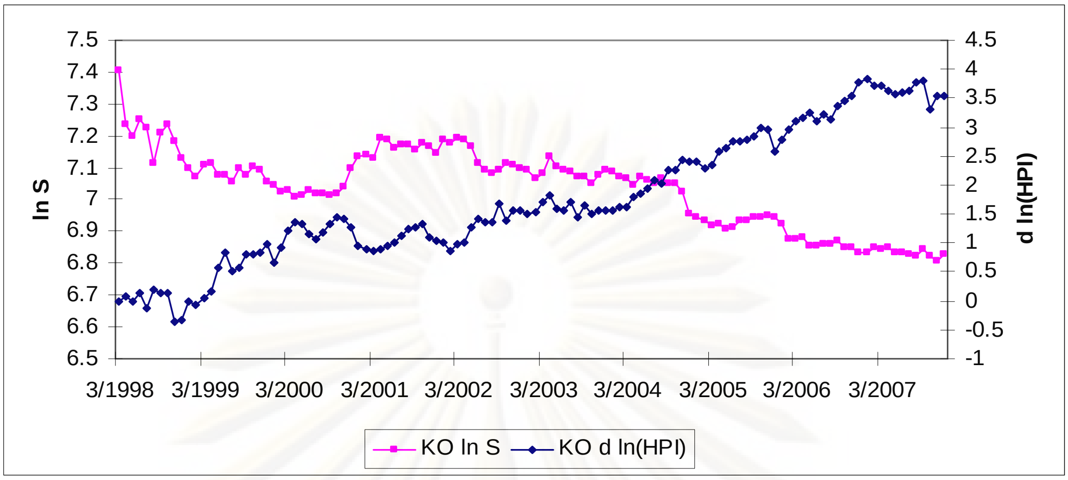



**Figure 4.7.2:** Nominal Exchange Rate and Relative Traded Goods Price Index (KO-US)

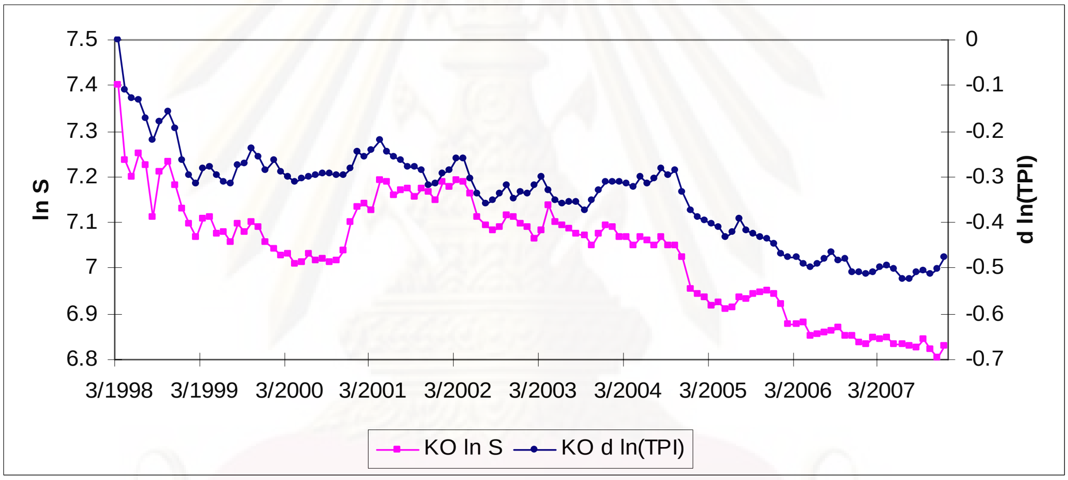
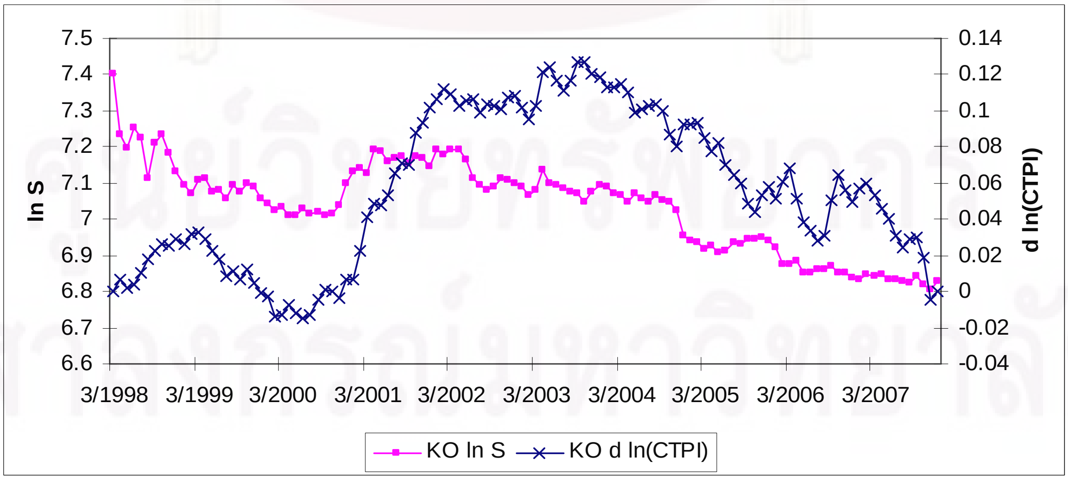



**Figure 4.7.3:** Nominal Exchange Rate and Relative Consumer Price Index of Domestic Country-Traded Goods Price Index of Foreign Country (KO-US)




**Notes**: 1. d_s_XX denotes difference across time of ln(exchange rate) of XX. 2. XX d ln(xPI) denotes ln(xPI) of XX- ln(xPI) of the U.S. 3. XX d ln(CTPI) denotes ln(CPI) of XX - ln(TPI) of the U.S.

**Table 4.14**: The Results of the Johansen Cointegration Test in the Case of Thailand

| **country** | **model** | **deterministic assumption** | **lag** | **trace** | | | **max eigenvalue** | | | **cointegrating vector** | | **normalized cointegrating vector** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Ho** | **statistics** | **p - value** | **Ho** | **statistics** | **p - value** | **St** | **(PI-PI*)** | **St** | **(PI-PI*)** |
| Thailand | *COINHPI* | linear trend in level data intercept in CE | **2** | Ho:r≤0 | 3.7316 | 0.9240 | Ho:r=0 | 3.5494 | 0.9036 | | | | |
| | | | | Ho:r≤1 | 0.1822 | 0.6695 | Ho:r=1 | 0.1822 | 0.6695 | | | | |
| | | | 3 | Ho:r≤0 | 2.4210 | 0.9870 | Ho:r=0 | 2.4210 | 0.9776 | | | | |
| | | | | Ho:r≤1 | 0.0000 | 0.9997 | Ho:r=1 | 0.0000 | 0.9997 | | | | |
| | | | 4 | Ho:r≤0 | 2.6231 | 0.9813 | Ho:r=0 | 2.6194 | 0.9688 | | | | |
| | | | | Ho:r≤1 | 0.0037 | 0.9504 | Ho:r=1 | 0.0037 | 0.9504 | | | | |
| | *COINTPI* | linear trend in level data intercept in CE | 3 | Ho:r≤0 | 16.2385** | 0.0386 | Ho:r=0 | 10.5162 | 0.1802 | -39.77438 | 53.43859 | -1 | 1.34354 |
| | | | | Ho:r≤1 | 5.7223** | 0.0167 | Ho:r=1 | 5.7223 | 0.0167 | 16.26533 | -2.597696 | -1 | 0.15971 |
| | | | **4** | Ho:r≤0 | 19.7870** | 0.0106 | Ho:r=0 | 12.9844* | 0.0788 | **-44.87940** | **53.11106** | **-1** | **1.18342** |
| | | | | Ho:r≤1 | 6.8026*** | 0.0091 | Ho:r=1 | 6.8026*** | 0.0091 | 1.281249 | 17.11592 | -1 | -13.35878 |
| | | | 5 | Ho:r≤0 | 13.9895* | 0.0832 | Ho:r=0 | 10.5777 | 0.1767 | -47.31892 | 53.61983 | -1 | 1.13316 |
| | | | | Ho:r≤1 | 3.4118 | 0.0647 | Ho:r=1 | 3.4118 | 0.0647 | | | | |
| | | | 6 | Ho:r≤0 | 12.0804 | 0.1531 | Ho:r=0 | 8.2784 | 0.3511 | | | | |
| | | | | Ho:r≤1 | 3.8020 | 0.0512 | Ho:r=1 | 3.8020 | 0.0512 | | | | |
| | *COINCTPI* | linear trend in level data intercept in CE | **6** | Ho:r≤0 | 24.4857*** | 0.0017 | Ho:r=0 | 23.8846*** | 0.0011 | **-25.17272** | **63.21226** | **-1** | **2.51114** |
| | | | | Ho:r≤1 | 0.6011 | 0.4381 | Ho:r=1 | 0.6011 | 0.4381 | | | | |
| | | | 7 | Ho:r≤0 | 27.1615*** | 0.0006 | Ho:r=0 | 26.70** | 0.0003 | -27.32894 | 72.39950 | -1 | 2.64919 |
| | | | | Ho:r≤1 | 0.4616 | 0.4969 | Ho:r=1 | 0.4616 | 0.4969 | | | | |
| | | | 8 | Ho:r≤0 | 20.8264*** | 0.0071 | Ho:r=0 | 19.4990*** | 0.0068 | -30.40416 | 82.32211 | -1 | 2.70759 |
| | | | | Ho:r≤1 | 1.3274 | 0.2493 | Ho:r=1 | 1.3274 | 0.2493 | | | | |

**Notes:** 1. *, **, *** reject null hypothesis at 10%, 5% and 1% significance level, respectively. 2. The automatic lag selection using Akike Information Criteria appears as bold figures in "lag" column. However, lag length is selected manually if the automatic lag contains autocorrelation. 3. P-values are obtained from MacKinnon, Haug, and Michelis (1999)**.**



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**Table 4.15**: The Results of the Johansen Cointegration Test in the Case of Taiwan

| **country** | **model** | **deterministic assumption** | **lag** | **trace** | | | **max eigenvalue** | | | **cointegrating vector** | | **normalized cointegrating vector** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Ho** | **statistics** | **p - value** | **Ho** | **statistics** | **p - value** | **St** | **(PI-PI*)** | **St** | **(PI-PI*)** |
| Taiwan | *COINHPI* | linear trend in level data intercept in CE | **3** | Ho:r≤0 | 8.9116 | 0.3736 | Ho:r=0 | 8.4466 | 0.3351 | | | | |
| | | | | Ho:r≤1 | 0.4649 | 0.4953 | Ho:r=1 | 0.4649 | 0.4953 | | | | |
| | | | 4 | Ho:r≤0 | 6.8754 | 0.5922 | Ho:r=0 | 6.5047 | 0.5493 | | | | |
| | | | | Ho:r≤1 | 0.3707 | 0.5426 | Ho:r=1 | 0.3707 | 0.5426 | | | | |
| | | | 5 | Ho:r≤0 | 6.4748 | 0.6394 | Ho:r=0 | 6.1898 | 0.5890 | | | | |
| | | | | Ho:r≤1 | 0.2850 | 0.5934 | Ho:r=1 | 0.2850 | 0.5934 | | | | |
| | *COINTPI* | linear trend in level data intercept in CE | 1 | Ho:r≤0 | 18.4352** | 0.0175 | Ho:r=0 | 12.0399 | 0.1092 | -21.36574 | 39.14543 | -1 | 1.83216 |
| | | | | Ho:r≤1 | 6.3953** | 0.0114 | Ho:r=1 | 6.3953 | 0.0114 | 25.16534 | 4.825185 | -1 | -0.19174 |
| | | | **2** | Ho:r≤0 | 20.6695*** | 0.0076 | Ho:r=0 | 12.9185* | 0.0807 | **-25.65035** | **40.02926** | **-1** | **1.56057** |
| | | | | Ho:r≤1 | 7.7510*** | 0.0054 | Ho:r=1 | 7.7510*** | 0.0054 | 22.53523 | 10.41487 | -1 | -0.46216 |
| | | | 3 | Ho:r≤0 | 19.7214** | 0.0108 | Ho:r=0 | 12.0969 | 0.1070 | -16.61776 | 43.16973 | -1 | 2.59781 |
| | | | | Ho:r≤1 | 7.6245*** | 0.0058 | Ho:r=1 | 7.6245 | 0.0058 | 31.49977 | -5.491313 | -1 | 0.17433 |
| | | | 4 | Ho:r≤0 | 17.5017** | 0.0246 | Ho:r=0 | 12.8459* | 0.0827 | -21.39082 | 45.69142 | -1 | 2.13603 |
| | | | | Ho:r≤1 | 4.6559** | 0.0309 | Ho:r=1 | 4.6559** | 0.0309 | 29.97337 | 0.120591 | -1 | -0.00402 |
| | *COINCTPI* | linear trend in level data intercept in CE | **2** | Ho:r≤0 | 8.6369 | 0.4000 | Ho:r=0 | 8.1125 | 0.3674 | | | | |
| | | | | Ho:r≤1 | 0.5243 | 0.4690 | Ho:r=1 | 0.5243 | 0.4690 | | | | |
| | | | 3 | Ho:r≤0 | 8.4502 | 0.4186 | Ho:r=0 | 7.9671 | 0.3821 | | | | |
| | | | | Ho:r≤1 | 0.4831 | 0.4870 | Ho:r=1 | 0.4831 | 0.4870 | | | | |
| | | | 4 | Ho:r≤0 | 6.3559 | 0.6535 | Ho:r=0 | 5.9257 | 0.6228 | | | | |
| | | | | Ho:r≤1 | 0.4302 | 0.5119 | Ho:r=1 | 0.4302 | 0.5119 | | | | |

**Notes:** 1. *, **, *** reject null hypothesis at 10%, 5% and 1% significance level, respectively. 2. The automatic lag selection using Akike Information Criteria appears as bold figures in "lag" column. However, lag length is selected manually if the automatic lag contains autocorrelation. 3. P-values are obtained from MacKinnon, Haug, and Michelis (1999).

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**Table 4.16**: The Results of the Johansen Cointegration Test in the Case of South Korea

| country | model | deterministic assumption | lag | trace | | | max eigenvalue | | | cointegrating vector | | normalized cointegrating vector | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Ho | statistics | p - value | Ho | statistics | p - value | St | (PI-PI*) | St | (PI-PI*) |
| South Korea | *COINHPI* | linear trend in level data intercept in CE | **2** | Ho:r≤0 | 5.5710 | 0.7455 | Ho:r=0 | 5.1768 | 0.7194 | | | | |
| | | | | Ho:r≤1 | 0.3943 | 0.5301 | Ho:r=1 | 0.3943 | 0.5301 | | | | |
| | | | 3 | Ho:r≤0 | 7.3746 | 0.5345 | Ho:r=0 | 7.0544 | 0.4827 | | | | |
| | | | | Ho:r≤1 | 0.3203 | 0.5714 | Ho:r=1 | 0.3203 | 0.5714 | | | | |
| | | | 4 | Ho:r≤0 | 6.9449 | 0.5841 | Ho:r=0 | 6.6123 | 0.5360 | | | | |
| | | | | Ho:r≤1 | 0.3326 | 0.5641 | Ho:r=1 | 0.3326 | 0.5641 | | | | |
| | *COINTPI* | linear trend in level data intercept in CE | **2** | Ho:r≤0 | 8.7413 | 0.3899 | Ho:r=0 | 8.2159 | 0.3572 | | | | |
| | | | | Ho:r≤1 | 0.5253 | 0.4686 | Ho:r=1 | 0.5253 | 0.4686 | | | | |
| | | | 3 | Ho:r≤0 | 7.9402 | 0.4718 | Ho:r=0 | 6.9224 | 0.4984 | | | | |
| | | | | Ho:r≤1 | 1.0179 | 0.3130 | Ho:r=1 | 1.0179 | 0.3130 | | | | |
| | | | 4 | Ho:r≤0 | 6.3064 | 0.6593 | Ho:r=0 | 4.7680 | 0.7708 | | | | |
| | | | | Ho:r≤1 | 1.5385 | 0.2148 | Ho:r=1 | 1.5385 | 0.2148 | | | | |
| | *COINCTPI* | linear trend in level data intercept in CE | **3** | Ho:r≤0 | 11.5966 | 0.1773 | Ho:r=0 | 10.0274 | 0.2101 | | | | |
| | | | | Ho:r≤1 | 1.5692 | 0.2103 | Ho:r=1 | 1.5692 | 0.2103 | | | | |
| | | | 4 | Ho:r≤0 | 10.2816 | 0.2597 | Ho:r=0 | 8.5179 | 0.3285 | | | | |
| | | | | Ho:r≤1 | 1.7638 | 0.1842 | Ho:r=1 | 1.7638 | 0.1842 | | | | |
| | | | 5 | Ho:r≤0 | 9.2712 | 0.3409 | Ho:r=0 | 6.1742 | 0.5910 | | | | |
| | | | | Ho:r≤1 | 3.0969 | 0.0784 | Ho:r=1 | 3.0969 | 0.0784 | | | | |

**Notes:** 1. *, **, *** reject null hypothesis at 10%, 5% and 1% significance level, respectively. 2. The automatic lag selection using Akike Information Criteria appears as bold figures in "lag" column. However, lag length is selected manually if the automatic lag contains autocorrelation. 3. P-values are obtained from MacKinnon, Haug, and Michelis (1999).



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**Table 4.17**: The Results of Cointegration Coefficients Test

| country | model | deterministic assumption | lag | restricted log-likehood | LR Statistic | degrees of freedom | p-value |
|---|---|---|---|---|---|---|---|
| Thailand | *COINTPI* | linear trend in level data intercept in CE | **4** | 647.7659 | 1.054945 | 1 | 0.304371 |
| Thailand | *COINCTPI* | linear trend in level data intercept in CE | **6** | 694.8139 | 10.81466 | 1 | 0.001007 |
| Taiwan | *COINTPI* | linear trend in level data intercept in CE | **2** | 739.2639 | 0.842392 | 1 | 0.358714 |

**Notes:** This table reports the results of the test restriction: normalized cointegration coefficient [$s_t$, ($PI_t$-$PI_t^*$)] = [-1,1] in the case that the cointegration test indicates the cointegration relationship. Hypothesized number of cointegrating vector =1.

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# CHAPTER V

# CONCLUSION AND DISCUSSION

In this study, three inflation proxies are used to test for validity of purchasing power parity in Thailand, Taiwan, and South Korea. The sample period starts from March 1998 to December 2007, totally 118 observations. The limitation of the sample period comes from the financial crisis in 1997. The data in the period of crisis, especially the data from stock market, are too volatile to be used. Moreover, the sub prime crisis in 2008 causes the data of South Korea turn to fluctuate again. Look back to the older period around the early 1990s; the stocks in the markets are available in small numbers, because Thailand, Taiwan, and South Korea are emerging markets. Therefore, it is quite inappropriate to calculate SMB and HML in this period. As a result, the sample period in this study is the best choice under the given conditions.

However, since it is the middle period between two crises, some noises still appear in the data. As a result, under the limited period and data conditions, there are some limitations transfer to the test and the results. The following part concludes and discusses about them.

## 5.1 Short Run PPP

### Extracted Inflation

From the results of the model *REGRFT1*, the null hypothesis of PPP is not rejected in Thailand and Taiwan, but rejected in South Korea. Interpret based on statistical perspective, the evidences to support short run PPP are found in Thailand and Taiwan, but the evidences are not found in South Korea. However, the insignificant coefficient of exchange rate differential ( $\beta_2$ ) in the case of Taiwan has to be interpreted carefully.

The insignificant coefficient results from high standard error, which results from high standard deviation of the $\hat{R}_{ft}$ series. The source of the fluctuation of $\hat{R}_{ft}$ is originated from the stock market. Noises in the stock market, the small number of stocks, and other factors[1] cause the bias in the calculated SMB and HML. The SMB and HML cannot explain the asset returns as much as expected in the inflation extraction approach. As a result, the estimated betas of the SMB and HML from the first step Fama and MacBeth regression are much lower than one and insignificant in some industries (indicated in table 4.4 to 4.6). When these betas are used in the cross-sectional regression (the second step), the estimated intercepts ( $\hat{R}_{ft}$ ) are overshooting (especially in South Korea). Consequently, the standard error of the coefficients in *REGRFT1* is high, and the adjusted R square is low.

In the case of the significant intercept term ( $\beta_1$ ) in *REGRFT1*, from chapter IV, it is discussed and concluded that it is given by mean of the difference between real interest rate of domestic country and that of foreign country. Therefore, if the two countries in our consideration have the same level of development, the average risk free rate of these two countries can be close to each other. As a consequence, the intercept of the model *REGRFT1*can be expected to be zero, and we can expect $\beta_1 = 0, \beta_2 = 1$ in the joint coefficient test to confirm more precisely the short run PPP.

**Traded Goods Price Index (TPI)**

In Thailand, Taiwan, and South Korea, the results from using TPI differential as inflation proxy in the model *REGTPI1 and REGTPI2* have an obvious implication. There is no other factor appears in the relationship between exchange rate differential and TPI inflation differential, indicated by the insignificant intercepts in both two models ( $\beta_1$ and $\alpha_1$ ). The coefficients ( $\beta_2$ and $\alpha_2$ ) are significantly different from zero. So the relationship between exchange rate differential and TPI inflation differential is present. However, the estimated coefficients reject null hypothesis of one. So the hypothesis of PPP is rejected. As a conclusion, there is a relationship between the TPI inflation differential and the exchange rate differential in all countries. However, it cannot be concluded that short run PPP valid using TPI inflation as inflation proxy in Thailand, Taiwan, and South Korea.

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[1] such as infrequent trading in Thailand (Sintaweewat, 2006)

**Domestic CPI and Foreign TPI (CTPI)**

In Thailand, Taiwan, and South Korea, the short run relationship between the domestic CPI inflation - foreign TPI inflation and exchange rate differential is not statistically found in Thailand and South Korea, but weakly found in Taiwan. However, the short run PPP is rejected in all countries. The conclusion is that we cannot find the evidence to support short run PPP in Thailand, Taiwan, and South Korea, using CTPI inflation as inflation proxy.

## 5.2 Long Run PPP

In this study, the first method of long run PPP test is unit root test. Unit root test is usually used as one methodology to test for mean reverting in real exchange rate. However, unit root test has its limitation. Unit root test is consistent when using long sample period that contains sufficient observation. Moreover, we cannot choose high order of lag length in the test that includes limited observation, because one more lag order means the lost of one usable observation. Therefore, the autocorrelation test is very important in this circumstance to confirm that there is no autocorrelation in the lag that we choose.

From the limitation of unit root test, this study places importance on the autocorrelation test and tries to use more than one method to confirm the results. However, if the sample period is extended out, the results in this study might be changed.

The second method of the long run PPP test is cointegration test. The limited observation also has an effect to lag selection. The autocorrelation test is applied. Moreover, lag robustness check is used to confirm the results.

The degree of validity of long run PPP can be categorized as weak and strong level. The weak PPP is indicated by the cointegration between nominal exchange rate and relative prices. Moreover, the cointegration coefficient should not far from one. In the case of the strong PPP, the evidence is indicated by the one-to-one correspondence between the nominal exchange rate and relative prices, this means that the real exchange rate series should appear to be stationary to satisfy strong PPP. From the condition of weak and strong PPP, we can see that strong PPP encompasses weak PPP.

**Hypothetical Price Index (HPI)**

In Thailand, Taiwan, and South Korea, the results from unit root test and cointegration test indicate that the evidence to support long run PPP cannot be found when using HPI as price proxy. We can see that the estimated risk free rate ( $\hat{R}_{ft}$ ) which consists of the extracted inflation rate supports the short run PPP, but *does not* support the long run PPP. However, there are some differences between the result interpretation in short run and long run. In short run, the coefficient ( $\beta_2$ ) can be interpreted as the explanation of exchange rate differential on the pure price inflation differential while the intercept ( $\beta_1$ ) can be interpreted as the real interest rate differential. On the contrary, in long run, test result of HPI just demonstrates the combined effect of the pure price inflation and the real interest rate, because the HPI consist of both pure price inflation and real interest rate and we cannot separate these two components. Thus, in long run, we can only conclude the result of the $\hat{R}_{ft}$ index, not the pure price inflation index. However, if we could separate between the pure price inflation and the real interest rate, we would obviously specify more about the evidence of the pure price inflation in long run.

**Traded Goods Price Index (TPI)**

The results of cointegration test indicate that in the case of Thailand and Taiwan, the cointegration between exchange rate and relative TPI exists and the coefficient is not far from unity. So these two cases satisfy the condition of weak PPP. However, the results from unit root tests indicate that the real exchange rate constructed from TPI of Thailand appears to be stationary while that of Taiwan appears to be nonstationary. Therefore, the test results of TPI in the case of Thailand support the strong PPP while the test results in the case of Taiwan support just the weak PPP. In the case of South Korea, we cannot find the evidence to support PPP in both strong and weak form.

**Domestic CPI and Foreign TPI (CTPI)**

The results of unit root test indicate that the real exchange rate series constructed from CTPI of all countries are nonstationary. The cointegration test indicates one cointegration relationship in the case of Thailand, but the cointegration coefficient is too far from the theoretical level of PPP. Therefore, the test result in the case of Thailand does not support long run PPP. As a conclusion, from all test results, we cannot conclude that both strong and weak PPP valid using CTPI as price proxy in all countries.

In the long run, the important adjustment mechanism driving PPP revert to the equilibrium is the *arbitrage mechanism*.

The TPI *does not* support PPP in short run but support PPP in long run in the case of Thailand and Taiwan. This may come from price behavior. In short run, the traded goods price cannot capture the movements in financial market as good as the extracted inflation, because the price is sticky. However, in long run, the index of traded goods price has better comovement with exchange rate than the HPI and the domestic CPI - foreign TPI. The reason is that, in the theory of PPP, the equilibrium exchange rate level is determined by the equality of purchasing power between two countries which is equalized through arbitrage mechanism. Thus, the purchasing power refers to the purchasing power of tradable goods (which can be arbitraged). This means that the price index of tradable goods is more appropriate for long run PPP than HPI and CTPI.

The CPI contains high portion of non-tradable goods that cannot be arbitraged. In addition, we cannot observe from the result of CTPI that the “international competitive of domestic goods” (domestic CPI - foreign TPI) has a significant correlation to the PPP. The main factor making the long run PPP valid should be the presence of “tradable goods” in the price proxy rather than other factor. Thus, the evidence to support long run PPP cannot be found using the CTPI as price proxy.

For the HPI, this price proxy contains the contaminated factor (real interest rate) that does not directly relate to the purchasing power. So the real exchange rate constructed from HPI does not revert to its mean and the cointegration between relative HPI and exchange rate does not exist. Thus, the HPI does not support the validity of long run PPP. However, since the HPI is not the pure price inflation index, it is interesting to carry on this issue in further study, especially if we could find an appropriate method to separate the *pure price inflation* from the real interest rate.

The analysis continues to find out the reason why the evidences to support long run PPP are found in Thailand and Taiwan when tested by TPI, while the evidence cannot be found in South Korea when tested by the same price proxy. The explanation is not straightforward. There are many factors support arbitrage mechanism. Some factors are examined here. The first factor is the *tariff* (tax for traded goods), which is the obvious factor that has an effect to trade activity between countries. High tariff means high cost of traded goods that results in higher price. As a consequence, goods prices are hard to be equal between countries under the high tariff rate. This leads to the deviation of PPP. The second factor is the *trade volume*. Trade volume is also important to the validity of PPP; high trade volume reflects high trade activity that means the high opportunity of arbitrage transaction. The last factor is the *nature of traded goods* between countries. The goods that is easy to be arbitraged and relatively free from price discrimination support the validity of PPP. As a conclusion, *low tariff*, *high trade volume*, and *nature of traded goods* are the factors in our consideration.

Table 5.1 reports the MFN tariff[2] of the United States, Thailand, Taiwan, and South Korea. From the data, the import tariff of the U.S. is the lowest, followed by Taiwan and Thailand. South Korea has the highest import tariff.

Table 5.2 reports the trade volume between Thailand-U.S., Taiwan-U.S., and South Korea-U.S.; as shown in the third and the sixth column, the import and export volume between South Korea-U.S. is the highest, followed by Taiwan-U.S. and Thailand-U.S, respectively. However, consider the fourth and the seventh column, which show the *portion of import and export volume to total trade volume* of the three country pairs. We can see that the portion of *import* volume of Taiwan is the highest, followed by South Korea and Thailand. In the case of the portion of *export* volume, this portion of Taiwan is the highest, followed by Thailand and South Korea.

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[2] MFN: Most Favored Nation, MFN tariff is a tariff rate that WTO members use for other members

Table 5.3 reports the trade to GDP ratio[3]. Trade to GDP ratio reflects the importance of trade to the country's economy. From the table, in the period 2003 – 2005 and 2006 – 2008, the trade to GDP ratio of Thailand is the highest, followed by Taiwan, and South Korea, respectively.

Table 5.4 reports the import and export volume between Thailand-U.S., Taiwan-U.S., and South Korea-U.S., classified by 2-digit SITC (Standard International Trade Classification). From the data, the trade volume in each category is not much different between each country pair. The most noticeable figures are the export volume of '84': articles of apparel and clothing accessories of Thailand and the export volume of '78': road vehicles (including air-cushion vehicles) of South Korea. From these two items, we can see that the important traded goods of Thailand is the "apparel" and "clothing accessories", which the price is easy to equate between countries. In the case of the important goods of South Korea, the "road vehicles" obviously uses "pricing-to-market"[4] strategy. Moreover, the road vehicles; such as the cars, in the same model are much different in details in different countries. The differences in details are varying up to consumer's preference in each country. In the case of the cars, it is almost impossible that the price of this good should equal between countries. From this viewpoint, we can see that the nature of the important goods of Thailand is more supportive of the PPP than that of South Korea.

As discussed above, South Korea has the highest MFN tariff and the lowest trade to GDP ratio. Moreover, the nature of the main export good to the U.S. quite does not support the PPP. These factors might explain why the evidences to support PPP are not found in South Korea. From the data, Thailand has the highest trade to GDP ratio. In addition, the main export good to the U.S. quite supports the PPP. In the case of Taiwan,

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[3] Trade to GDP ratio is estimated as an economy's total trade of goods and commercial services (exports + imports, balance of payments basis) divided by GDP, on the basis of data for the three latest years available. GDP is measured in nominal terms and with market exchange rates. (definition from the data source: WTO).

[4] The prices of the same goods are different in each country. Goods prices are quoted depending on demand in each market.

this country has the lowest MFN tariff rate and the highest portion of trade volume with the U.S. to total trade volume. These factors help us explain why the evidences to support PPP can be found in Thailand and Taiwan, using traded goods price index as price proxy.

However, more than *tariff, trade volume, and nature of traded goods*, we ought to concern about exchange rate as well. Exchange rate could affect the PPP test results, because exchange rate is directly used as one variable in the test equation. The movement of exchange rate is affected by two main factors: market mechanism and exchange rate policy, including capital control and exchange rate intervention.

From the available evidences, Thailand, Taiwan, and South Korea control their capital flows through different measure in different time, to cope with exchange rate speculation and to prevent excessive exchange rate volatility. About the exchange rate policy, Thailand changed the regime from basket peg to managed float in September 1997. After the change, Bank of Thailand occasionally intervenes in the market to stabilize the currency.

In the case of Taiwan, though Taiwan announces the clean float exchange rate policy, the Central Bank of China (CBC) retains the power to intervene in order to restrict speculative activity (Thurbon, 2001). Moreover, the report of Martin (2008) explicitly indicates that Taiwan uses managed float regime.

In the case of South Korea, the country changed the exchange rate regime from managed float to clean float in December 1997. The explicit evidence of the intervention in South Korea cannot be found in the period 1999 – 2007. Moreover, the study of Pontines and Siregar (2009) tests the evidences of exchange rate intervention in South Korea and concludes that there is no evidence of government intervention after 2000. From these evidences, among the three emerging countries, *the exchange rate of South Korea could be viewed as the most market-driven rate*.

The occasional intervention from central bank, under the objective of stabilization, helps the authority to limit the exchange rate fluctuation and might have a positive effect to PPP relationship. The intervention could absorb the excessive volatility of exchange rate if the authority takes action in the appropriate occasion. However, the exchange rate intervention is usually viewed as the obstacle of market mechanism. We could not conclude the effect of exchange rate intervention to the validity of PPP. In some cases, we can find evidences that conclude that the deviation of PPP under fixed regime is smaller than floating regime, such as the study of Genberg (1978). However, the conclusion on this issue requires additional evidence.

As a conclusion for our cases, the evidences of long run PPP when tested by TPI could be explained by the economic factors that relate to arbitrage mechanism; *tariff, trade volume, and nature of traded goods*. Moreover, we also find the interesting issue about the difference between exchange rate policy of the countries that we *find* the evidence to support PPP, and exchange rate policy of the country that we *cannot find* the evidence to support PPP. However, the contribution of this issue to the explanation on our test results is not as strong as the contribution from the factors of arbitrage mechanism.

**Table 5.1**: Most Favored Nation (MFN) Tariff

| **country** | **simple average (%)** | **trade weighted average (%)** |
|---|---|---|
| United States | 3.5*** | 2.2** |
| Thailand | 10.5** | 4.8* |
| Taiwan | 6.1*** | 1.8** |
| South Korea | 12.2*** | 7.5* |

**Notes**: This table reports the average rate (agriculture and non-agriculture) of the Most Favored Nation (MFN) Tariff Rate. MFN tariff is a tariff rate that WTO members use for other members. *, **, *** indicate the data of 2006, 2007, 2008, respectively.

**Data Source**: WTO Statistics Database

**Table 5.2**: Trade Volume between Thailand-U.S., Taiwan-U.S., and South Korea-U.S.

| | import | | | export | | |
|---|---|---|---|---|---|---|
| **Thailand** | **world** | **U.S.** | **% U.S./ world** | **world** | **U.S.** | **% U.S./ world** |
| 1998 | 42,971,000,000 | 5,233,361,000 | 12.17882 | 54,456,000,000 | 13,434,336,000 | 24.67007 |
| 1999 | 50,342,000,000 | 4,983,526,000 | 9.89934 | 58,440,000,000 | 14,323,770,000 | 24.51022 |
| 2000 | 61,924,000,000 | 6,642,509,000 | 10.72687 | 69,057,000,000 | 16,389,063,000 | 23.73266 |
| 2001 | 61,962,000,000 | 5,995,120,000 | 9.67548 | 64,968,000,000 | 14,728,562,000 | 22.67049 |
| 2002 | 64,645,000,000 | 4,859,500,000 | 7.51721 | 68,108,000,000 | 14,799,272,000 | 21.72912 |
| 2003 | 75,824,300,000 | 5,841,663,000 | 7.70421 | 80,323,600,000 | 15,180,650,000 | 18.89936 |
| 2004 | 94,409,800,000 | 6,368,437,000 | 6.74553 | 96,248,200,000 | 17,578,945,000 | 18.26418 |
| 2005 | 118,177,580,000 | 7,256,616,000 | 6.14043 | 110,936,420,000 | 19,889,756,000 | 17.92897 |
| 2006 | 128,773,170,000 | 7,915,383,000 | 6.14676 | 129,721,710,000 | 22,466,333,000 | 17.31887 |
| 2007 | 139,965,680,000 | 8,336,419,000 | 5.95605 | 152,097,740,000 | 22,754,660,000 | 14.96055 |
| **average** | **83,899,453,000** | **6,343,253,400** | **8.26907** | **88,435,667,000** | **17,154,534,700** | **20.46845** |
| | **import** | | | **export** | | |
| **Taiwan** | **world** | **U.S.** | **% U.S./ world** | **world** | **U.S.** | **% U.S./ world** |
| 1998 | 105,441,746,000 | 18,157,132,000 | 17.22006 | 112,466,938,000 | 33,122,902,000 | 29.45123 |
| 1999 | 111,448,898,000 | 19,121,126,000 | 17.15686 | 123,625,648,000 | 35,198,495,000 | 28.47184 |
| 2000 | 140,641,909,000 | 24,380,278,000 | 17.33500 | 151,356,875,000 | 40,514,187,000 | 26.76733 |
| 2001 | 107,944,361,000 | 18,151,574,000 | 16.81568 | 125,899,640,000 | 33,391,321,000 | 26.52217 |
| 2002 | 113,330,563,000 | 18,394,301,000 | 16.23066 | 135,080,000,000 | 32,199,347,000 | 23.83724 |
| 2003 | 128,129,986,000 | 17,487,899,000 | 13.64856 | 150,298,061,000 | 31,599,871,000 | 21.02480 |
| 2004 | 169,249,930,000 | 21,585,196,000 | 12.75344 | 182,431,815,000 | 34,623,583,000 | 18.97892 |
| 2005 | 182,614,400,000 | 21,614,497,000 | 11.83614 | 198,431,700,000 | 34,825,829,000 | 17.55054 |
| 2006 | 202,698,100,000 | 22,709,361,000 | 11.20354 | 224,017,300,000 | 38,211,855,000 | 17.05755 |
| 2007 | 219,251,600,000 | 25,828,669,000 | 11.78038 | 246,676,900,000 | 38,277,594,000 | 15.51730 |
| **average** | **148,075,149,300** | **20,743,003,300** | **14.59803** | **165,028,487,700** | **35,196,498,400** | **22.51789** |
| | **import** | | | **export** | | |
| **South Korea** | **world** | **U.S.** | **% U.S./ world** | **world** | **U.S.** | **% U.S./ world** |
| 1998 | 93,282,000,000 | 16,538,271,000 | 17.72933 | 132,313,000,000 | 23,936,461,000 | 18.09079 |
| 1999 | 119,752,000,000 | 22,953,951,000 | 19.16791 | 143,686,000,000 | 31,261,995,000 | 21.75716 |
| 2000 | 160,481,000,000 | 27,901,881,000 | 17.38641 | 172,267,000,000 | 40,300,349,000 | 23.39412 |
| 2001 | 141,098,000,000 | 22,196,592,000 | 15.73133 | 150,439,000,000 | 35,184,728,000 | 23.38804 |
| 2002 | 152,126,000,000 | 22,595,871,000 | 14.85339 | 162,471,000,000 | 35,575,187,000 | 21.89633 |
| 2003 | 178,827,000,000 | 24,098,587,000 | 13.47592 | 193,817,000,000 | 36,963,336,000 | 19.07126 |
| 2004 | 224,463,000,000 | 26,186,736,000 | 11.66639 | 253,845,000,000 | 46,167,937,000 | 18.18745 |
| 2005 | 261,238,000,000 | 27,571,606,000 | 10.55421 | 284,419,000,000 | 43,781,441,000 | 15.39329 |
| 2006 | 309,383,000,000 | 32,219,124,000 | 10.41399 | 325,465,000,000 | 45,803,587,000 | 14.07328 |
| 2007 | 356,846,000,000 | 34,401,710,000 | 9.64049 | 371,489,000,000 | 47,562,311,000 | 12.80315 |
| **average** | **199,749,600,000** | **25,666,432,900** | **14.06194** | **219,021,100,000** | **38,653,733,200** | **18.80549** |

unit: U.S. Dollars at current price

**Note**: This table reports import and export volume between Thailand-U.S., Taiwan-U.S., and South Korea-U.S. The ten-year average is simple average.

**Data Source**: WTO Statistics Database

**Table 5.3**: Trade to GDP Ratio

| country | 2003-2005 | 2006-2008 |
|---|---|---|
| Thailand | 137.75 | 151.54 |
| Taiwan | 120.22 | 137.45 |
| South Korea | 79.90 | 90.53 |

unit: %

**Notes**: Trade to GDP ratio is estimated as an economy's total trade of goods and commercial services (exports + imports, balance of payments basis) divided by GDP, on the basis of data for the three latest years available. GDP is measured in nominal terms and with market exchange rates. (definition from the data source)

**Data Source**: WTO Trade Profile

**Table 5.4**: Average Import and Export Volume (1998-2007) between Thailand-U.S., Taiwan-U.S., and South Korea-U.S., Classified by 2-Digit SITC

| | Thailand | | | | Taiwan | | | | South Korea | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SITC code** | **import** | **% import** | **export** | **% export** | **import** | **% import** | **export** | **% export** | **import** | **% import** | **export** | **% export** |
| '00' | 4,935 | 0.07780 | 93 | 0.00054 | 3,011 | 0.01451 | 1,690 | 0.00480 | 7,971 | 0.03106 | 239 | 0.00062 |
| '01' | 2,977 | 0.04693 | 139 | 0.00081 | 132,246 | 0.63754 | 2,080 | 0.00591 | 445,045 | 1.73395 | 83 | 0.00021 |
| '02' | 19,827 | 0.31257 | 718 | 0.00418 | 16,709 | 0.08055 | 1,222 | 0.00347 | 37,295 | 0.14531 | 2,177 | 0.00563 |
| '03' | 34,920 | 0.55050 | 1,560,768 | 9.09257 | 32,760 | 0.15793 | 155,183 | 0.44089 | 298,900 | 1.16455 | 69,503 | 0.17981 |
| '04' | 72,909 | 1.14938 | 166,837 | 0.97194 | 729,020 | 3.51453 | 19,142 | 0.05438 | 650,493 | 2.53440 | 27,750 | 0.07179 |
| '05' | 39,946 | 0.62973 | 240,368 | 1.40031 | 266,557 | 1.28505 | 33,137 | 0.09415 | 242,719 | 0.94566 | 33,131 | 0.08571 |
| '06' | 8,707 | 0.13726 | 33,009 | 0.19230 | 8,965 | 0.04322 | 17,131 | 0.04867 | 22,749 | 0.08863 | 4,458 | 0.01153 |
| '07' | 5,255 | 0.08284 | 22,619 | 0.13177 | 13,344 | 0.06433 | 4,772 | 0.01356 | 37,924 | 0.14776 | 4,071 | 0.01053 |
| '08' | 77,529 | 1.22222 | 34,956 | 0.20365 | 96,260 | 0.46406 | 3,088 | 0.00877 | 133,640 | 0.52068 | 191 | 0.00049 |
| '09' | 28,554 | 0.45015 | 90,242 | 0.52572 | 96,906 | 0.46717 | 40,287 | 0.11446 | 127,237 | 0.49573 | 52,971 | 0.13704 |
| '11' | 3,273 | 0.05160 | 27,394 | 0.15959 | 26,478 | 0.12765 | 8,710 | 0.02475 | 26,096 | 0.10167 | 23,802 | 0.06158 |
| '12' | 20,491 | 0.32303 | 19,451 | 0.11332 | 50,280 | 0.24240 | 434 | 0.00123 | 71,234 | 0.27754 | 20,424 | 0.05284 |
| '21' | 45,901 | 0.72362 | 805 | 0.00469 | 171,040 | 0.82457 | 204 | 0.00058 | 413,870 | 1.61249 | 50 | 0.00013 |
| '22' | 121,564 | 1.91642 | 50 | 0.00029 | 434,474 | 2.09456 | 966 | 0.00275 | 240,941 | 0.93873 | 107 | 0.00028 |
| '23' | 28,234 | 0.44510 | 286,686 | 1.67015 | 39,308 | 0.18950 | 16,424 | 0.04666 | 38,037 | 0.14819 | 67,621 | 0.17494 |
| '24' | 25,678 | 0.40481 | 9,428 | 0.05492 | 62,776 | 0.30263 | 13,954 | 0.03964 | 118,446 | 0.46148 | 608 | 0.00157 |
| '25' | 67,146 | 1.05854 | 906 | 0.00528 | 102,473 | 0.49401 | 623 | 0.00177 | 321,022 | 1.25074 | 9 | 0.00002 |
| '26' | 131,409 | 2.07162 | 18,860 | 0.10987 | 134,612 | 0.64895 | 69,588 | 0.19771 | 164,419 | 0.64060 | 124,060 | 0.32096 |
| '27' | 14,546 | 0.22931 | 1,174 | 0.00684 | 68,636 | 0.33089 | 1,071 | 0.00304 | 61,031 | 0.23778 | 7,224 | 0.01869 |
| '28' | 88,600 | 1.39676 | 2,986 | 0.01740 | 292,337 | 1.40933 | 16,253 | 0.04618 | 641,003 | 2.49742 | 17,613 | 0.04557 |
| '29' | 12,466 | 0.19653 | 42,314 | 0.24651 | 17,334 | 0.08357 | 49,140 | 0.13961 | 37,728 | 0.14699 | 17,091 | 0.04422 |
| '32' | 81 | 0.00128 | NA | NA | 15,025 | 0.07243 | 13 | 0.00004 | 52,312 | 0.20382 | 3 | 0.00001 |
| '33' | 78,473 | 1.23709 | 107,028 | 0.62351 | 88,374 | 0.42604 | 228,413 | 0.64894 | 397,707 | 1.54951 | 1,205,433 | 3.11857 |
| '34' | 569 | 0.00897 | 77 | 0.00045 | 2,874 | 0.01386 | 1,566 | 0.00445 | 9,907 | 0.03860 | 2,574 | 0.00666 |

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**Table 5.4** (continue)

| | Thailand | | | | Taiwan | | | | South Korea | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITC code | import | % import | export | % export | import | % import | export | % export | import | % import | export | % export |
| '41' | 299 | 0.00471 | 36 | 0.00021 | 5,441 | 0.02623 | 76 | 0.00021 | 21,844 | 0.08511 | 356 | 0.00092 |
| '42' | 343 | 0.00540 | 1,358 | 0.00791 | 8,634 | 0.04162 | 4,869 | 0.01383 | 39,578 | 0.15420 | 484 | 0.00125 |
| '43' | 1,310 | 0.02065 | 1,043 | 0.00608 | 3,845 | 0.01854 | 84 | 0.00024 | 4,862 | 0.01894 | 345 | 0.00089 |
| '51' | 159,738 | 2.51822 | 16,799 | 0.09786 | 1,082,194 | 5.21715 | 142,412 | 0.40461 | 1,384,793 | 5.39532 | 382,105 | 0.98854 |
| '52' | 52,222 | 0.82326 | 4,019 | 0.02342 | 274,137 | 1.32159 | 30,403 | 0.08638 | 361,771 | 1.40950 | 39,368 | 0.10185 |
| '53' | 29,560 | 0.46600 | 17,505 | 0.10198 | 91,914 | 0.44311 | 16,211 | 0.04606 | 120,853 | 0.47086 | 60,448 | 0.15639 |
| '54' | 57,242 | 0.90240 | 5,602 | 0.03263 | 149,997 | 0.72312 | 9,658 | 0.02744 | 182,065 | 0.70935 | 31,658 | 0.08190 |
| '55' | 73,254 | 1.15482 | 15,882 | 0.09253 | 164,901 | 0.79497 | 36,694 | 0.10425 | 181,274 | 0.70626 | 32,748 | 0.08472 |
| '56' | 52,987 | 0.83532 | 16 | 0.00010 | 21,864 | 0.10540 | 30 | 0.00009 | 140,372 | 0.54691 | 617 | 0.00160 |
| '57' | 132,554 | 2.08967 | 136,670 | 0.79620 | 477,909 | 2.30395 | 164,796 | 0.46820 | 473,146 | 1.84343 | 221,231 | 0.57234 |
| '58' | 48,683 | 0.76747 | 34,326 | 0.19997 | 125,421 | 0.60464 | 281,306 | 0.79922 | 139,510 | 0.54355 | 279,021 | 0.72185 |
| '59' | 109,433 | 1.72518 | 29,330 | 0.17087 | 349,251 | 1.68370 | 72,631 | 0.20635 | 432,154 | 1.68372 | 131,246 | 0.33955 |
| '61' | 18,391 | 0.28993 | 14,095 | 0.08212 | 51,764 | 0.24955 | 25,453 | 0.07231 | 53,095 | 0.20686 | 8,234 | 0.02130 |
| '62' | 8,935 | 0.14086 | 170,270 | 0.99194 | 27,484 | 0.13250 | 387,053 | 1.09966 | 35,345 | 0.13771 | 577,205 | 1.49328 |
| '63' | 3,348 | 0.05277 | 148,925 | 0.86759 | 20,026 | 0.09654 | 97,712 | 0.27761 | 31,949 | 0.12448 | 4,659 | 0.01205 |
| '64' | 40,299 | 0.63530 | 36,578 | 0.21309 | 158,125 | 0.76231 | 55,735 | 0.15835 | 164,014 | 0.63902 | 343,950 | 0.88983 |
| '65' | 55,823 | 0.88004 | 313,974 | 1.82912 | 62,712 | 0.30233 | 686,771 | 1.95119 | 134,273 | 0.52314 | 897,233 | 2.32123 |
| '66' | 140,239 | 2.21082 | 488,137 | 2.84374 | 216,836 | 1.04534 | 219,075 | 0.62241 | 165,877 | 0.64628 | 162,573 | 0.42059 |
| '67' | 21,533 | 0.33946 | 155,440 | 0.90554 | 66,898 | 0.32251 | 674,675 | 1.91682 | 86,222 | 0.33593 | 1,120,888 | 2.89984 |
| '68' | 47,281 | 0.74537 | 37,384 | 0.21779 | 184,914 | 0.89145 | 92,840 | 0.26377 | 329,624 | 1.28425 | 148,491 | 0.38416 |
| '69' | 61,681 | 0.97239 | 356,562 | 2.07722 | 135,974 | 0.65552 | 2,733,906 | 7.76731 | 208,513 | 0.81239 | 829,648 | 2.14638 |
| '71' | 114,937 | 1.81194 | 114,635 | 0.66783 | 261,893 | 1.26256 | 220,107 | 0.62535 | 590,463 | 2.30051 | 562,949 | 1.45640 |
| '72' | 161,257 | 2.54217 | 50,790 | 0.29589 | 1,732,461 | 8.35202 | 642,415 | 1.82517 | 1,411,049 | 5.49762 | 728,494 | 1.88468 |
| '73' | 51,429 | 0.81076 | 23,082 | 0.13447 | 516,318 | 2.48912 | 307,861 | 0.87467 | 383,150 | 1.49280 | 188,209 | 0.48692 |
| '74' | 291,582 | 4.59669 | 343,391 | 2.00049 | 769,898 | 3.71160 | 1,544,247 | 4.38737 | 848,407 | 3.30549 | 1,086,640 | 2.81124 |
| '75' | 557,737 | 8.79255 | 2,751,036 | 16.02671 | 812,674 | 3.91782 | 7,292,596 | 20.71902 | 1,035,539 | 4.03458 | 4,339,382 | 11.22640 |

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**Table 5.4** (continue)

| | Thailand | | | | Taiwan | | | | South Korea | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SITC code** | **import** | **% import** | **export** | **% export** | **import** | **% import** | **export** | **% export** | **import** | **% import** | **export** | **% export** |
| '76' | 158,981 | 2.50629 | 2,383,177 | 13.88368 | 520,496 | 2.50926 | 3,427,975 | 9.73923 | 883,299 | 3.44144 | 6,478,881 | 16.76149 |
| '77' | 1,656,232 | 26.10998 | 1,653,895 | 9.63510 | 4,978,388 | 24.00031 | 6,363,977 | 18.08072 | 5,548,783 | 21.61873 | 6,224,160 | 16.10250 |
| '78' | 70,440 | 1.11046 | 165,265 | 0.96278 | 195,515 | 0.94256 | 1,418,584 | 4.03034 | 468,041 | 1.82354 | 7,513,084 | 19.43707 |
| '79' | 562,794 | 8.87226 | 2,877 | 0.01676 | 1,616,630 | 7.79362 | 174,200 | 0.49492 | 2,274,732 | 8.86263 | 250,157 | 0.64718 |
| '81' | 5,879 | 0.09269 | 51,105 | 0.29772 | 14,827 | 0.07148 | 176,234 | 0.50070 | 23,706 | 0.09236 | 33,298 | 0.08614 |
| '82' | 7,859 | 0.12389 | 360,032 | 2.09744 | 16,128 | 0.07775 | 815,838 | 2.31788 | 29,840 | 0.11626 | 90,785 | 0.23487 |
| '83' | 1,739 | 0.02741 | 186,675 | 1.08751 | 9,416 | 0.04539 | 84,779 | 0.24087 | 29,169 | 0.11365 | 76,213 | 0.19717 |
| '84' | 3,505 | 0.05525 | 2,091,979 | 12.18724 | 15,857 | 0.07644 | 1,654,827 | 4.70154 | 38,103 | 0.14846 | 1,813,762 | 4.69238 |
| '85' | 4,689 | 0.07393 | 301,276 | 1.75514 | 3,727 | 0.01797 | 98,755 | 0.28057 | 18,175 | 0.07081 | 86,066 | 0.22266 |
| '87' | 229,209 | 3.61341 | 184,261 | 1.07345 | 1,417,070 | 6.83155 | 435,630 | 1.23767 | 1,231,482 | 4.79800 | 205,477 | 0.53159 |
| '88' | 28,169 | 0.44407 | 196,324 | 1.14373 | 256,442 | 1.23628 | 297,617 | 0.84556 | 299,081 | 1.16526 | 156,228 | 0.40418 |
| '89' | 218,974 | 3.45206 | 1,353,401 | 7.88451 | 631,913 | 3.04639 | 2,741,762 | 7.78963 | 839,411 | 3.27045 | 1,117,393 | 2.89080 |
| '93' | 44,917 | 0.70809 | 170,828 | 0.99519 | 98,873 | 0.47666 | 653,590 | 1.85692 | 149,105 | 0.58093 | 565,470 | 1.46293 |
| '95' | 63 | 0.00099 | 12 | 0.00007 | 23 | 0.00011 | 84 | 0.00024 | 655 | 0.00255 | 76 | 0.00020 |
| '97' | 14,302 | 0.22546 | 697 | 0.00406 | 35,453 | 0.17091 | 2,591 | 0.00736 | 15,259 | 0.05945 | 1,193 | 0.00309 |
| '98' | NA | NA | 129,722 | NA | NA | NA | 426,435 | NA | NA | NA | 181,757 | NA |
| '99' | 109,457 | 1.72556 | NA | NA | 256,973 | 1.23884 | NA | NA | 260,256 | 1.01399 | NA | NA |
| **Total** | **6,343,293** | **100.00000** | **17,165,315** | **99.24428** | **20,743,010** | **100.00000** | **35,197,586** | **98.78845** | **25,666,558** | **100.00000** | **38,653,370** | **99.52978** |

unit: thousand U.S.Dollar

**Notes**: This table reports the average import and export volume for the period 1998-2007, classified by SITC (Standard International Trade Classification). Definition of SITC code is indicated in the following section.

**Data Source**: U.S International Trade Statistics (WTO)



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| SITC code | definition |
|---|---|
| '00' | Live animals other than fish, crustaceans, molluscs and aquatic invertebrates of division 03 |
| '01' | Meat and meat preparations |
| '02' | Dairy products and birds' eggs |
| '03' | Fish (not marine mammals), crustaceans, molluscs and aquatic invertebrates, and preparations thereof |
| '04' | Cereals and cereal preparations |
| '05' | Vegetables and fruit |
| '06' | Sugars, sugar preparations and honey |
| '07' | Coffee, tea, cocoa, spices and manufactures thereof |
| '08' | Feeding stuff for animals (not including unmilled cereals) |
| '09' | Miscellaneous edible products and preparations |
| '11' | Beverages |
| '12' | Tobacco and tobacco manufactures |
| '21' | Hides, skins and furskins, raw |
| '22' | Oil seeds and oleaginous fruits |
| '23' | Crude rubber (including synthetic and reclaimed) |
| '24' | Cork and wood |
| '25' | Pulp and waste paper |
| '26' | Textile fibers (other than wool tops and other combed wool) and their wastes (not manufactured into yarn or fabric) |
| '27' | Crude fertilizers (imports only), except those of division 56, and crude minerals (excluding coal, petroleum and precious stones) |
| '28' | Metalliferous ores and metal scrap |
| '29' | Crude animal and vegetable materials, n.e.s. |
| '32' | Coal, coke and briquettes |
| '33' | Petroleum, petroleum products and related materials |
| '34' | Gas, natural and manufactured |
| '41' | Animal oils and fats |
| '42' | Fixed vegetable fats and oils, crude, refined or fractionated |
| '43' | Animal or vegetable fats and oils processed; waxes and inedible mixtures or preparations of animal or vegetable fats or oils, n.e.s. |
| '51' | Organic chemicals |
| '52' | Inorganic chemicals |
| '53' | Dyeing, tanning and coloring materials |

| SITC code | definition |
|---|---|
| '54' | Medicinal and pharmaceutical products |
| '55' | Essential oils and resinoids and perfume materials; toilet, polishing and cleansing preparations |
| '56' | Fertilizers (exports include group 272; imports exclude group 272) |
| '57' | Plastics in primary forms |
| '58' | Plastics in nonprimary forms |
| '59' | Chemical materials and products, n.e.s. |
| '61' | Leather, leather manufactures, n.e.s., and dressed furskins |
| '62' | Rubber manufactures, n.e.s. |
| '63' | Cork and wood manufactures other than furniture |
| '64' | Paper, paperboard, and articles of paper pulp, paper or paper board |
| '65' | Textile yarn, fabrics, made-up articles, n.e.s., and related products |
| '66' | Nonmetallic mineral manufactures, n.e.s. |
| '67' | Iron and steel |
| '68' | Nonferrous metals |
| '69' | Manufactures of metals, n.e.s. |
| '71' | Power generating machinery and equipment |
| '72' | Machinery specialized for particular industries |
| '73' | Metalworking machinery |
| '74' | General industrial machinery and equipment, n.e.s., and machine parts, n.e.s. |
| '75' | Office machines and automatic data processing machines |
| '76' | Telecommunications and sound recording and reproducing apparatus and equipment |
| '77' | Electrical machinery, apparatus and appliances, n.e.s., and electrical parts thereof (including nonelectrical counterparts of household type, n.e.s.) |
| '78' | Road vehicles (including air-cushion vehicles) |
| '79' | Transport equipment, n.e.s. |
| '81' | Prefabricated buildings; sanitary, plumbing, heating and lighting fixtures and fittings, n.e.s. |
| '82' | Furniture and parts thereof; bedding, mattresses, mattress supports, cushions and similar stuffed furnishings |
| '83' | Travel goods, handbags and similar containers |
| '84' | Articles of apparel and clothing accessories |
| '85' | Footwear |
| '87' | Professional, scientific and controlling instruments and apparatus, n.e.s. |

| SITC code | definition |
|---|---|
| '88' | Photographic apparatus, equipment and supplies and optical goods, n.e.s.; watches and clocks |
| '89' | Miscellaneous manufactured articles, n.e.s. |
| '93' | Special transactions and commodities not classified according to kind |
| '95' | Coin, including gold coin; proof and presentation sets and current coin |
| '97' | Gold, nonmonetary (excluding gold ores and concentrates) |
| '98' | Estimate of import items valued under $251 and of other low valued items nonexempt from formal entry |
| '99' | Estimate of non-Canadian low value shipments; compiled low value shipments to Canada; and various export shipments not identified by kind |

**Data Source**: U.S International Trade Statistics (WTO)

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## APPENDIXES

# APPENDIX A

## OTHER STUDIES ON ALTERNATIVE PRICE PROXIES

There are two main classic opinions about the most appropriate price proxy to test the PPP. **The first viewpoint** is stated by Cassel (1928) (cited in Viner (1937)). This viewpoint indicates that the appropriate components of price index should be **all goods** in the market. Cassel relies on the asset market view of exchange rate determination, which defines an exchange rate as a measure of purchasing power of the national money (or currency). In order to be the measure of purchasing power of the country, the component of the index should include all goods in the country as much as possible.

**The second viewpoint** is contradictory to the first. This viewpoint states that the price index should contain **purely tradable goods** (Heckscher et al., 1930 and Viner, 1937). The reason is that the effect of arbitrage in goods prices equalizes the prices between countries. If all goods in the basket that we use to calculate the price index are tradable, the price should equal between countries through arbitrage mechanism.

The above two classic viewpoints are the fundamental of the alternative price proxy in further studies. This section reviews some of them in the early ten years.

Chinn (1999) tests the validity of PPP in eight Asian currencies using Johansen and Horvath - Watson cointegration test. The methods are applied to bilateral and multilateral exchange rates deflated by CPI, *producer price index (PPI)*, and *export goods price index*. The results indicate that PPI yields the greatest evidence of stationary.

Fleissig and Strauss (2000) uses *six different price indexes: aggregate CPI, goods except food, food, fuel and electricity, rent, and services except rent*. These indexes are tested by four methods of panel unit root. The results generally support PPP as the real exchange rates deflated by most price indexes follow the stationary process. In the case of half-life estimation, real exchange rates deflated by the indexes composed of higher traded components adjust quicker than real exchange rate deflated by the indexes composed of higher non-tradable components.

Chowdhury and Sarno (2003) constructs the *alternative price index (API)* by excluding the non-tradable components in CPI and readjusting the weight of the remaining components equal to one hundred percent. The components of the new-constructed price index are purely tradable. Chowdhury and Sarno use the nonlinear econometric technique: smooth transition autoregressive (STAR) to analyze real exchange rate series constructed from the API. The countries in the sample are Germany, France, Italy, UK, and Japan using the U.S. as the reference country. The test provides evidence that the nonlinear mean reverting property of the real exchange rate constructed from the API is stronger than that constructed by CPI.

Chen (2008) has an argument on the study of Chowdhry, Roll, and Xia (2005) (C-R-X). Chen constructs the real exchange rate series using official nominal exchange rate and the extracted inflation differential series, which comes from the dataset of C-R-X. The series are tested by ADF and PP. Furthermore, the DF-GLS test (proposed by Elliot et al. (1996)), four modified tests (M-tests) (proposed by Ng and Perron (2001)), and the modified information criteria (MIC) are used. The result indicates that the real exchange rate series is nonstationary.

As discussed above, some studies support the validity of the PPP, while some studies do not support. However, this issue is still interesting because the price proxies can be derived from many economic factors. Therefore, we can develop in many ways to get closer to the "most fit" price proxy for the theory of PPP.

# APPENDIX B

# LAW OF ONE PRICE
# AND ABSOLUTE PURCHASING POWER PARITY

## B.1 Law of One Price (LOP)

The purchasing power parity is developed from the Law of One Price (LOP) theory (or law of one good, one price). Law of one price states that the price of the same good is the same in different countries. In the hypothesized world, there is no trade barrier, transaction cost, and tariff. Goods price can be easily equalized across countries by the arbitrage mechanism. The theory of LOP is developed to two versions: absolute LOP and relative LOP. These two versions can be shown as follows.

### B.1.1 Absolute Law of One Price

The main idea of absolute LOP is that the exchange rate in the form of *direct quoted* is equal to the amount of home currency required to buy one unit of foreign currency (Hallwood and Ronald, 2006). The equilibrium condition can be shown as this equation:

$$S_t = \frac{P_t^i}{P_t^{i*}} \quad . \tag{B.1.1}$$

(B.1.1) can be rearranged as:

$$P_t^i = S_t P_t^{i*} \ , \tag{B.1.2}$$

where $S_t$ denotes the nominal exchange rate in terms of domestic currency to foreign currency, $P_i^i$ denotes the price of goods *i* in terms of domestic currency, and $P_i^{i*}$ denotes the price of goods *i* in terms of foreign currency.

### B.1.2 Relative Law of One Price

As indicated in Sarno and Taylor (2002), relative version of LOP is the relatively weaker condition:

$$\frac{P^*_{i,t+1}S_{t+1}}{P_{i,t+1}} = \frac{P^*_{i,t}S_t}{P_{i,t}} \quad , \qquad i = 1, 2, \ldots, N, \tag{B.1.3}$$

As shown in the above equation, the absolute LOP can be interpreted as the equality across time of the proportion of price of one good in foreign country to that in home country, adjusted by nominal exchange rate. If absolute condition holds, the relative condition holds, but not vises versa.

## B.2 Absolute Purchasing Power Parity

The concept of PPP is developed from the concept of the law of one price (LOP). The difference between these two theories is that, for PPP, price of "goods" is the price of "basket of goods". There are two versions of PPP: absolute and relative.

Absolute PPP is derived from the absolute LOP by using the price proxy of basket of goods instead of price of one good,

$$S_t = \frac{\sum_{i=1}^{N} \alpha_i P_{i,t}}{\sum_{i=1}^{N} \alpha_i^* P_{i,t}^*} \quad , \tag{B.2.1}$$

where $S_t$ denotes the nominal exchange rate in terms of domestic currency to foreign currency, $\alpha_i$ and $\alpha_i^*$ denote the weights of goods *i* in the basket of goods in domestic and foreign country, respectively, $\sum_{i=1}^{N} \alpha_i = 1$ and $\sum_{i=1}^{N} \alpha_i^* = 1$, $P_{i,t}$ and $P_{i,t}^*$ denote the price of good *i* in terms of domestic currency and foreign currency, respectively.

The log form of absolute PPP can be shown as:

$$s_t = \sum_{i=1}^{N} \alpha_i \ln P_{i,t} - \sum_{i=1}^{N} \alpha_i^* \ln P_{i,t}^*, \tag{B.2.2}$$

where $s_t$ denotes log of nominal exchange rate, $\alpha_i$ and $\alpha_i^*$ denote the weights of goods *i* in the basket of goods, $\sum_{i=1}^{N} \alpha_i = 1$ and $\sum_{i=1}^{N} \alpha_i^* = 1$, $P_{i,t}$ and $P_{i,t}^*$ denote the price of good *i* in terms of domestic currency and foreign currency, respectively.

Rewrite (B.2.2) as:

$$s_t = \rho_t - \rho_t^* \quad , \tag{B.2.3}$$

where $s_t$ denotes log of nominal exchange rate, $\rho_t$ and $\rho_{t.}^*$ denote log of price index of domestic country and foreign country, respectively.

# APPENDIX C

# ECONOMETRIC METHODOLOGY

## C.1 Ordinary Least Squares (OLS)

According to Gujarati (2003), ordinary least square (OLS) is one of the most powerful and popular methods of regression analysis. Follow the demonstration in Gujarati (2003), the concept of the ordinary least-squares regression can be show as:

$$Y_i = \beta_1 + \beta_2 X_i + u_i \ . \tag{C.1.1}$$

Next, estimate the (C.1.1):

$$Y_i = \hat{\beta}_1 + \hat{\beta}_2 X_i + \hat{u}_i \ , \tag{C.1.2}$$

$$= \hat{Y}_i + \hat{u}_i \ , \tag{C.1.3}$$

where $\hat{Y}_i$ is the estimated value of $Y_i$, $\hat{\beta}_1$ is the estimated value of $\beta_1$, $\hat{\beta}_2$ is the estimated value of $\beta_2$, and $\hat{u}_i$ is the estimated value of $u_i$.

Rearrange the (C.1.3) as:

$$\hat{u}_i = Y_i - \hat{Y}_i \tag{C.1.4}$$

$$= Y_i - \left(\hat{\beta}_1 + \hat{\beta}_2 X_i\right), \tag{C.1.5}$$

(C.1.4) shows that the $\hat{u}_i$ is the difference between the actual and the estimated $Y_i$.

Rearrange (C.1.4) as:

$$\sum \hat{u}^2 = \sum (Y_i - \hat{Y}_i)^2 \ . \tag{C.1.6}$$

Given *n* sets of the estimated variables, to get close to the actual $Y_i$ as much as possible, the estimator should be able to select the set of estimated variable that minimizes the sum square residual ( $\sum \hat{u}^2$ ).

## C.2 Unit Root Test

### C.2.1 Augmented Dickey - Fuller Test (ADF)

The augmented Dickey-Fuller test (ADF) is one method of unit root tests. ADF is developed from the Dickey-Fuller (DF) test, which is represented by the first- order autoregressive (AR(1)):

$$y_t = a_0 + a_1 y_{t-1} + a_2 t + \varepsilon . \tag{C.2.1}$$

Subtract $y_{t-1}$ from both side:

$$\Delta y_t = a_0 + \alpha y_{t-1} + a_2 t + \varepsilon_t \ , \tag{C.2.2}$$

where $\alpha$ denotes ( $a_1 - I$ ), $I$ is an identity matrix.

AR(p) is introduced to the DF test, then we get the augmented Dickey-Fuller test:

$$\Delta y_t = a_0 + \alpha y_{t-1} + a_2 t + \sum_{i=2}^{p} \beta_i \Delta y_{t-i+1} + \varepsilon_t \ . \tag{C.2.3}$$

The null hypothesis and the alternative hypothesis can be shown as:

$H_0$: $\alpha = 0$ (nonstationary)

$H_1$: $\alpha < 0$ (stationary)

The $\alpha$ is estimated by OLS. The t-statistic is compared to the appropriate critical value: $\tau$ , $\tau_\mu$, and $\tau_\tau$. If the null hypothesis is not rejected, we can conclude that the series contains unit root.

### C.2.2 Phillips and Perron Test (PP)

Since the Dickey-Fuller test assumes that the errors are white noise, Phillips and Perron (1988) modifies the test statistics to decline this assumption. The PP test allows the disturbances to be weakly dependence and heterogeneously distributed. The following explanations are based on the demonstrations in the original paper and Banerjee, Anindya. et al. (1993).

First, let $y_t$ follow the data generating mechanism:

$$y_t = \mu + \rho y_{t-1} + \mu_t \ . \tag{C.2.4}$$

Consider these forms of least-squares regression equations:

$$y_t = \hat{\mu} + \hat{\rho} y_{t-1} + \hat{\mu}_t \ , \tag{C.2.5}$$

and

$$y_t = \tilde{\mu} + \tilde{\beta}\left(t - \frac{1}{2}T\right) + \tilde{\rho}y_{t-1} + \tilde{\mu}_t \ , \qquad \text{(C.2.6)}$$

where ( $\hat{\mu}$ , $\hat{\rho}$ ) and ( $\tilde{\mu}$ , $\tilde{\beta}$ , $\tilde{\rho}$ ) are the conventional least-squares regression coefficients.

Phillip and Perron develop the set of Z statistics to test the null hypothesis of $\rho$ =1 in the different model: (C.2.5) and (C.2.6).

In order to demonstrate the test statistics of the PP, first define:

$$S_t = \sum_{j=1}^{t} u_j , \qquad \text{(C.2.7)}$$

$$\sigma^2 = \lim_{T\to\infty} E\left(T^{-1}S_T^2\right), \qquad \text{(C.2.8)}$$

$$\sigma_u^2 = \lim_{T\to\infty} T^{-1}\sum_{t=1}^{T} E\left(u_t^2\right). \qquad \text{(C.2.9)}$$

Next, define the consistent estimator of $\sigma_u^2$ as:

$$S_u^2 = T^{-1}\sum_{t=1}^{T} \hat{u}_t^2 \ , \qquad \text{(C.2.10)}$$

and define the consistent estimator of $\sigma^2$ as:

$$S_{Tl}^2 = T^{-1}\sum_{t=1}^{T} \hat{u}_t^2 + 2T^{-1}\sum_{j=1}^{l}\sum_{t=j+1}^{T} \hat{u}_t\hat{u}_{t-j} . \qquad \text{(C.2.11)}$$

To guarantee a non-negative estimator, the modified estimator of $\sigma^2$ is defined as:

$$\tilde{S}_{Tl}^2 = T^{-1}\sum_{t=1}^{T} \hat{u}_t^2 + 2T^{-1}\sum_{j=1}^{l} \omega_l(j)\sum_{t=j+1}^{T} \hat{u}_t\hat{u}_{t-j} , \qquad \text{(C.2.12)}$$

where $\omega_l(j) = 1 - j(l+1)^{-1}$, $l$ is the lag truncation parameter.

The test statistics of the model (C.2.5) are:

$$Z(\hat{\rho}) = T(\hat{\rho}-1) - \frac{1}{2}\left(S_{Tl}^2 - S_u^2\right)\left[T^{-2}\sum_{t=2}^{T}\left(y_{t-1} - \bar{y}_{-1}\right)^2\right]^{-1} , \qquad \text{(C.2.13)}$$

and alternatively,

$$Z(t(\hat{\rho})) = \left(S_u / S_{Tl}\right)t(\hat{\rho}) - \frac{1}{2}\left(S_{Tl}^2 - S_u^2\right)\left\{S_{Tl}\left[T^{-2}\sum_{t=2}^{T}\left(y_{t-1} - \bar{y}_{-1}\right)^2\right]^{1/2}\right\}^{-1} , \qquad \text{(C.2.14)}$$

where $t(\hat{\rho})$ is the t-statistics associated with testing the null hypothesis of $\rho$ =1.

For the model (C.2.6), the test statistics can be shown as:

$$Z\left(\hat{\hat{\rho}}\right)=T\left(\hat{\hat{\rho}}-1\right)-\left(T^{6}/24\right)\left(D_{x}^{-1}\right)\left(S_{Tl}^{2}-S_{u}^{2}\right), \tag{C.2.15}$$

and alternatively,

$$Z\left(t\left(\hat{\hat{\rho}}\right)\right)=\left(S_{u}/S_{Tl}\right)t\left(\hat{\hat{\rho}}\right)-\left[T^{3}/\left(4\sqrt{3}\right)\right]\left(D_{x}^{-1/2}S_{Tl}^{-1}\right)\left(S_{Tl}^{2}-S_{u}^{2}\right). \tag{C.2.16}$$

Where the $D_x$ is defined as the determinant of the inner product of the data matrix of (C.2.6):

$$\begin{aligned} D_{x}&=\left[T^{2}\left(T^{2}-1\right)/12\right]\sum_{t=2}^{T}y_{t-1}^{2}-T\left(\sum_{t=2}^{T}ty_{t-1}\right)^{2} \\ &+T\left(T+1\right)\sum_{t=2}^{T}ty_{t-1}\sum_{t=2}^{T}y_{t-1}-\left[T\left(T+1\right)\left(2T+1\right)/6\right]\left(\sum_{t=2}^{T}y_{t-1}\right)^{2}. \end{aligned} \tag{C.2.17}$$

The table of the critical values is provided in Phillips and Perron (1988).

### C.2.3 Dickey-Fuller with GLS Detrending (DF-GLS) and Point Optimal Test (PT)

Elliott, Rothenberg, and Stock (1996) (ERS) develops the ADF method by modifying the equation specification of ADF unit root test to the "detrended" $y_t$. Furthermore, a Monte Carlo experiment indicates that this modified test works well in small sample. The following explanations are based on the equation specifications in the EVIEWS 5 User Guide.

First, ERS defines a quasi-difference function of $y_t$, which represents the specific point alternative as:

$$d\left(y_{t}|\alpha\right)=\begin{cases} y_{t} & if\ t=1 \\ y_{t}-\gamma y_{t-1} & if\ t>1 \end{cases} \tag{C.2.18}$$

Using OLS regression, run the quasi-difference $y_t$ (or $d\left(y_t|\alpha\right)$) on the quasi-difference $x_t$:

$$d\left(y_{t}|\alpha\right)=d\left(x_{t}|\alpha\right)'\delta\left(\alpha\right)+\eta_{t}\ , \tag{C.2.19}$$

where $x_t$ are optional exogenous regressors, which may consist of constant, or constant and trend, $\hat{\delta}\left(\alpha\right)$ is estimated from the above OLS regression.

ERS recommends using $\alpha = \overline{\alpha}$ , while $\overline{\alpha}$ is defined as:

$$\overline{\alpha} = \begin{cases} 1-7/T & if \quad x_t = \{1\} \\ 1-13.5/T & if \; x_t = \{1, t\} \end{cases} \tag{C.2.20}$$

Define the GLS detrended data $y_t^d$ as:

$$y_t^d \equiv y_t - x_t^{'}\hat{\delta}(\overline{\alpha}) \cdot \tag{C.2.21}$$

ERS generates the modified test regression by substituting the GLS detrended $y_t^d$ into the ADF test equation:

$$\Delta y_t^d = \alpha y_{t-1}^d + \beta_1 \Delta y_{t-1}^d + ... + \beta_p \Delta y_{t-p}^d + \varepsilon_t \quad . \tag{C.2.22}$$

The $DF - GLS^{\tau}$ critical values are provided by ERS to use in the case of the model that contain both drift and time trend while Dickey-Fuller distribution can be used in the case of the model with only drift.

Base on the residual from the regression (C.2.19):

$$\hat{\eta}_t(\alpha) = d(y_t|\alpha) - d(x_t|\alpha)' \delta(\alpha) \cdot \tag{C.2.23}$$

The ERS point optimal test statistic ($P_T$) is given as:

$$P_T = \frac{(SSR(\overline{\alpha}) - \overline{\alpha} SSR(1))}{f_0} \quad , \tag{C.2.24}$$

where SSR denotes sum square of residual of $\hat{\eta}_t$ , $f_0$ is the parameterized estimator of the residual spectral density at frequency zero. There are two types of $f_0$ : autoregressive estimator (AR) and Kernel sum-of-covariance estimator (SC).

The SC estimator is based on the weighted sum of the autocovariances, while the AR estimator is based on the residual variance. AR estimator estimates coefficients from this auxiliary regression:

$$\Delta \tilde{y}_t = \alpha \tilde{y}_{t-1} + \varphi \tilde{x}'_t \delta + \beta_1 \Delta \tilde{y}_{t-1} + ... + \beta_p \Delta \tilde{y}_{t-p} + \varepsilon_t \quad . \tag{C.2.25}$$

For the detrended data from the DF-GLS method, $\tilde{y}_t = y_t^d$ and $\varphi$=0.

The AR estimator is given by:

$$s_{AR}^2 = \frac{\hat{\sigma}_{\varepsilon}^{\;2}}{\left(1 - \sum_{i=1}^{n} \beta_i\right)^2} \quad . \tag{C.2.26}$$

### C.2.4 Ng and Perron (2001) Modified Point Optimal Test (MPT) and Modified Akike Information Criteria (MAIC)

Perron and Ng (1996) and Ng and Perron (2001) develop the modified point optimal test (MPT). The MPT is applied on the DF-GLS and the modified Akike information criteria (MAIC). The following specifications follow the EVIEWS 5 User Guide.

The MPT can be shown as:

$$MP_T^{GLS} = \begin{cases} \dfrac{\left[\bar{c}^2 T^{-2}\sum_{t=1}^{T}\bar{y}_{t-1}^2 - \bar{c}T^{-1}\bar{y}_T^2\right]}{s_{AR}^2}, if x_t = \{1\} & \text{(C.2.27)} \\ \dfrac{\left[\bar{c}^2 T^{-2}\sum_{t=1}^{T}\bar{y}_{t-1}^2 + (1-\bar{c})T^{-1}\bar{y}_T^2\right]}{s_{AR}^2}, if x_t = \{1, t\} & \text{(C.2.28)} \end{cases}$$

where:

$$\bar{c} = \begin{cases} -7 & if x_t = \{1\} \quad \text{(C.2.29)} \\ -13.5 & if x_t = \{1, t\} \quad \text{(C.2.30)} \end{cases}$$

The modified Akike information criteria (MAIC) can be shown as:

$$MIC(k) = \ln(\hat{\sigma}_k^2) + \frac{C_T(\tau_T(k)+k)}{T-k_{\max}} , \quad \text{(C.2.31)}$$

while $\hat{\sigma}_k^2 = (T-k_{\max})^{-1}\sum_{t=k_{\max}+1}^{T}\hat{e}_{tk}^2$ , $\tau_T(k) = \ln(\hat{\sigma}_k^2)^{-1}\hat{\beta}_0^2\sum_{t=k_{\max}+1}^{T}\tilde{y}_{t-1}^2$ , $k$ denotes lag order, $e$ denotes error term, $C_T = 2$.

The study of Ng and Perron (2001) concludes that the MAIC applied with the detrended data has desirable size and power property.

### C.2.5 Perron (1989) Unit Root Test for Structural Break

Perron develops unit root test method to take account of structural break. Dummy variables are introduced to take account of the deviations that come from temporary shock. The null hypothesis and the alternative hypothesis are given as:

$$H_0: \quad q_t = a_0 + q_{t-1} + \mu_1 D_P + \mu_2 D_L + \varepsilon_t \ . \qquad \text{(C.2.32)}$$

$$H_1: \quad q_t = a_0 + a_2 t + \mu_2 D_L + \mu_3 D_T + \varepsilon_t \ . \qquad \text{(C.2.33)}$$

The dummy variable $D_p$ refers to a *pulse* dummy. Assume that a structural break occurs at $t = \tau + 1$, $D_p$ = 1 if $t = \tau + 1$ and zero otherwise. $D_L$ refers to a *level* dummy. $D_L$= 1 if $t > \tau$ and zero otherwise. $D_T$ refers to a *trend* dummy. $D_T(\tau + 1)$ = 1, $D_T(\tau + 2)$ = 2, ... , otherwise, $D_T$ = 0.

To test the unit root, first estimate the residual from the alternative hypothesis (given by $\hat{y}_t$). After that, test unit root in the residual series $\hat{y}_t$.

$$\hat{y}_t = a_1 \hat{y}_{t-1} + \sum_{i=1}^{k} \beta_i \Delta \hat{y}_{t-i} + \varepsilon_t \cdot \qquad \text{(C.2.34)}$$

The critical values of the $t_{a_1}$ are provided in Perron (1989).

## C.3 Johansen Cointegration Test

The reason behind using the cointegration test to test for the validity of PPP is that the PPP indicates the co-movement between nominal exchange rate and prices. In this study, the Johansen cointegration method is applied. The explanations and equations in this topic are based on the demonstrations in the original paper and Enders (2004).

The Johansen (1988) and the Stock and Watson (1988) provide the effective method to test the cointegration, especially in the case of multiple cointegrating vectors. This method is the generalized multivariate ADF, which is significantly based on the relationship between characteristic roots and rank of matrix $\pi$. Johansen follows the fashion of the ADF method, using the following AR(p):

$$\Delta x_t = \pi x_{t-1} + \sum_{i=1}^{p-1} \pi_i \Delta x_{t-i} + \varepsilon_t \quad , \qquad \text{(C.3.1)}$$

where $x_t$ and $\varepsilon_t$ is the $(n \cdot 1)$ vector, $\pi = \left( I - \sum_{i=1}^{p} A_i \right)$, $\pi_i = -\sum_{j=i+1}^{p} A_j$, $A_i$ and $A_j$ are the $(n \cdot n)$ matrixes.

The rank(r) of $\pi$ is the number of independent cointegrating vectors.

- if rank( $\pi$ ) = 0, there is no cointegration (accept the null)
- if rank( $\pi$ ) = n, the vector process is stationary (contain full rank)
- if 1 < rank( $\pi$ ) < n, there are more than one cointegrating vectors

Next, estimate the $\pi$ matrix and get the characteristic roots of $\pi$ (or $\lambda_i$ ). The rank of $\pi$ is equal to the number of the $\lambda_i$ that differs from zero. Thus, if there are cointegrated vectors, the estimated values of $\lambda_i$ are 0< $\lambda_i$ <1 such that $\lambda_1 > \lambda_2 > ... > \lambda_n$ . If there are no cointegrating vectors, all of the $\lambda_i$ are equal to zero.

To test for the number of the $\lambda_i$ that differs from zero, there are two test statistics: trace statistic and max-eigenvalue statistic,

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln\left(1-\hat{\lambda}_i\right) \quad , \qquad \text{(C.3.2)}$$

$$\lambda_{\max}(r, r+1) = -T \ln\left(1-\hat{\lambda}_{r+1}\right) \quad , \qquad \text{(C.3.3)}$$

where $\hat{\lambda}_i$ = value of the estimated characteristic root of $\pi$ (or so-called eigenvalue), T= number of usable observations.

In the case of $\lambda_{trace}$ test statistics, the null hypothesis is that the number of the cointegrating vectors is less than or equal to r. In the case of $\lambda_{\max}$ test statistics, the null hypothesis is that the number of the cointegrating vectors is equal to r. The critical values are obtained from the Monte Carlo experiment, the values are shown in the original paper. The magnitude of the critical values depends on the number of the non-cointegrating vectors (n-r) and the form of vector $A_0$ .

# VITA

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