Analysis of the Stationarity of East Asian Currencies Using Unit Root Test and Cointegration Test*

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ABSTRACT

This paper investigates the stationarity of East Asian currencies (ASEAN 6) by using a unit root test and cointegration test. We examine whether the Asian monetary unit (AMU) deviation indicators adjusted by the Balassa–Samuelson effect of ASEAN 6 are stationary over the short term by carrying out a unit root test. We also assess whether cointegration relationships exist over the long term by carrying out a cointegration test. Based on an empirical analysis of 57 combinations, we cannot find any combinations show a significant result. Based on our results, it is clear that exchange rate fluctuations among the East Asian currencies respond to each other asymmetrically and that the issue of exchange rate misalignment needs to be dealt with immediately.

Keywords: Unit Root Test, Cointegration Test, Exchange Rate Misalignment, Intra-Regional Exchange Rate Surveillance

JEL classification codes: F31, F33, F36

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1. Introduction

In 1997, a number of East Asian countries experienced a serious currency crisis. The crisis was blamed on the *de facto* dollar peg exchange rate regime and on double mismatches in currency and the redemption periods. In the aftermath of the Asian currency crisis, the monetary authorities of most East Asian countries came to perceive the importance of establishing an intra-regional exchange rate surveillance system in the East Asian area. In order to realize the establishment of this surveillance system, the Asian monetary unit (AMU), AMU deviation indicator, and AMU deviation indicator adjusted by the Balassa–Samuelson effect (hereafter referred to as the adjusted AMU deviation indicator) have been proposed, along with an intra-regional surveillance process based on these indicators. However, the implications of surveillance will vary depending on whether exchange rate misalignments have a tendency to converge over the long run.

More specifically, based on the need to establish a system for monitoring intra-regional exchange rates and their fluctuations, some policymakers and academics have suggested the introduction of a common basket system in the East Asian area (i.e., Kuroda & Kawai, 2003; Ogawa, 2004; Williamson, 2000). Among the various approaches to simulating a common currency basket, Ogawa and Shimizu (2005, 2006, 2010, 2011) thought that the AMU and the AMU deviation indicator are useful for enhancing intra-regional monetary cooperation. These indicators are expected to strengthen the abilities of a surveillance system, especially in the early detection of exchange rate misalignment. Furthermore, considering the high productivity growth rate in tradable goods sectors and transformations in foreign exchange regimes in some East Asian countries, Ogawa and Wang (2012) calculated the adjusted AMU deviation indicator. It can also identify in what currencies intra-regional exchange rate misalignments occur and how serious they are. However, if exchange rate misalignments occurring in the East Asian currencies involve linear relationships, this means that the currencies' exchange rate fluctuations follow similar trends over the long run and that exchange rate misalignments occurring in the East Asian countries are temporary episodes. Given this, it is necessary to clarify the exchange rate relationships in East Asian currencies when we focus on intra-regional monetary cooperation and exchange rate surveillance. In this paper, we aim to verify whether the East Asian currencies follow a trend of convergence over the long run, by using the adjusted AMU deviation indicators.

The results of our empirical analysis show that the adjusted AMU deviation indicators follow non-stationary processes, as shown by the unit root test. This means

that the adjusted AMU deviation indicators of East Asian currencies do not have the property of mean reversion and that the indicators diverge from each other in the long run. Meanwhile, we also examined whether the adjusted indicators follow a similar trend of fluctuation over the long run by using the error correction model. Of 57 combinations of six ASEAN currencies, 18 combinations have relationships of cointegration. Of these 18 combinations, 16 were rejected in an analysis of the statistical significance of the cointegration vector and the adjustment vector, and the other two were rejected by the consistency of the cointegration vector's sign (positive or negative). Thus, it is obvious that the exchange rates of East Asian countries respond to each other asymmetrically. In order to stabilize the macroeconomic variables of East Asian countries, it is important that exchange rate misalignment be addressed.

This paper is organized as follows. In section 1, we provide an outline of the paper as a whole. In section 2, we review previous studies on the measurements of exchange rate surveillance, which include the AMU, the AMU deviation indicator, and the adjusted AMU deviation indicator. In section 3, we clarify the economic implications of conducting a unit root test and cointegration test on the adjusted AMU deviation indicators. In section 4, we employ data from the adjusted AMU deviation indicators to test the stationarity of six ASEAN currencies through a unit root test, identify the long-term relationships between East Asian currencies through a cointegration test, and, finally, discuss the results of our empirical analysis. In section 5, we discuss the contributions of this paper and directions for future research.

2. AMU, AMU Deviation Indicator and Adjusted AMU Deviation Indicator for Intra-Regional Exchange Rate Surveillance

After the Asian currency crisis of 1997, the monetary authorities of East Asian countries realized the importance of intra-regional monetary cooperation. Unfortunately, the exchange rate fluctuations in East Asian currencies are still asymmetric and some East Asian countries maintain strong interconnecting relationships with the US dollar. Ogawa (2004) pointed out that the exchange rate fluctuations of East Asian currencies could be divided into two groups from the viewpoint of the asymmetric exchange rate response, and that intra-regional exchange rate misalignment was caused by asymmetric exchange rate fluctuations.[1] In order to detect or prevent exchange rate misalignment in its early stages, it is necessary for the monetary authorities of East Asian countries to monitor intra-regional exchange rates. To establish an intra-regional exchange rate surveillance system, the AMU, AMU deviation indicator, and adjusted AMU deviation indicator have been proposed by Ogawa and Shimizu (2005) and Ogawa and Wang

(2012).

2.1 Asian Monetary Unit (AMU)

In the aftermath of the Asian Currency Crisis, policymakers and academics recognized that it is necessary for the monetary authorities of East Asian countries to implement a surveillance system that can monitor intra-regional exchange rates, in order to eliminate exchange rate misalignment. The most effective measurement of surveillance is believed to be the employment of a common currency basket (i.e., Williamson, 1999; Williamson, 2001). With this in mind, Ogawa and Shimizu (2005) devised a new currency basket known as the Asian monetary unit (AMU). The AMU is a currency basket unit that is calculated based on the weighted average of the currencies of ASEAN+3 and follows the same procedures used to calculate the European Currency Unit (ECU). Each currency's weight in the currency basket is based on the share of GDP and trade volume. Because both the United States and the euro area are important trading partners of the East Asian countries, the AMU is denominated based on a weighted average of the US dollar and the euro. A weighted average of the US dollar and the euro vis-à-vis the AMU can be expressed as follows:[2]

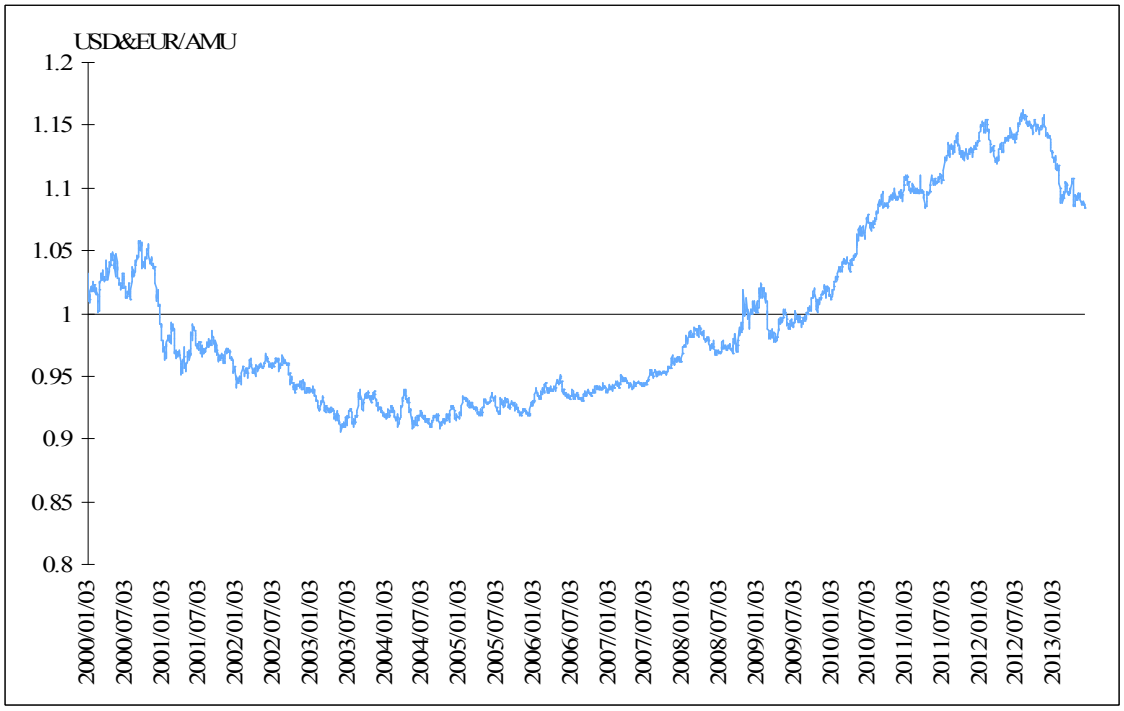
$$\begin{aligned}\frac{USD\ \&\ EUR}{AMU} = {} & 0.0039\times\frac{USD\ \&\ EUR}{BND} + 6.5556\times\frac{USD\ \&\ EUR}{KHR} + 3.1592\times\frac{USD\ \&\ EUR}{CNY} \\ & + 490.0725\times\frac{USD\ \&\ EUR}{IDR} + 25.3757\times\frac{USD\ \&\ EUR}{JPY} + 121.6898\times\frac{USD\ \&\ EUR}{KRW} \\ & + 10.0825\times\frac{USD\ \&\ EUR}{LAK} + 0.1802\times\frac{USD\ \&\ EUR}{MYR} + 0.0212\times\frac{USD\ \&\ EUR}{MMK} \\ & + 0.9570\times\frac{USD\ \&\ EUR}{PHP} + 0.1120\times\frac{USD\ \&\ EUR}{SGD} + 1.9481\times\frac{USD\ \&\ EUR}{THB} \\ & + 310.3313\times\frac{USD\ \&\ EUR}{VND}\end{aligned} \tag{1}$$

where USD denotes the US dollar, EUR denotes the euro, BND denotes the Brunei dollar, KHR denotes the Cambodian riel, CNY denotes the Chinese yuan, IDR denotes the Indonesian rupiah, JPY denotes the Japanese yen, KRW denotes the Korean won, LAK denotes the Laos kip, MYR denotes the Malaysian ringgit, MMK denotes the Myanmar kyat, PHP denotes the Philippine peso, SGD denotes the Singapore dollar, THB denotes the Thai baht, and VND denotes the Vietnamese dong.

Figure 1 shows the exchange rate of the US dollar and the euro vis-à-vis the AMU from the beginning of 2000 to May of 2013. The AMU was clearly weaker than a weighted average of the US dollar and the euro from late 2000 until the end of 2008. Over that period, many East Asian currencies depreciated against the US dollar and the

euro, due to active capital flows such as the yen carry trade. However, the trend of depreciation appeared to stagnate in the middle of 2005, when the Chinese monetary authority made an announcement regarding the reform of its foreign exchange regime. From the end of 2005, the AMU appreciated against the US dollar and the euro, and followed a significant uptrend of appreciation after the bankruptcy of Lehman Brothers. Some of the euro member countries plunged into a serious debt crisis at the time, and the excessive depreciation of the euro particularly accelerated the appreciation of the AMU.

Figure 1. Exchange Rate of Asian Monetary Unit



Source: RIETI online database.

2.2 AMU Deviation Indicator

In strengthening surveillance over intra-regional exchange rates, the AMU deviation indicator is considered to be useful for monitoring exchange rate misalignments of the East Asian currencies. The AMU deviation indicator is derived from the exchange rate of AMU and a national currency. It is an index for measuring how much an actual exchange rate diverges from the benchmark rate. The AMU deviation indicator is expected to enhance a monetary authority's ability to monitor exchange rate overvaluation or undervaluation, and especially to identify intra-regional exchange rate misalignment.

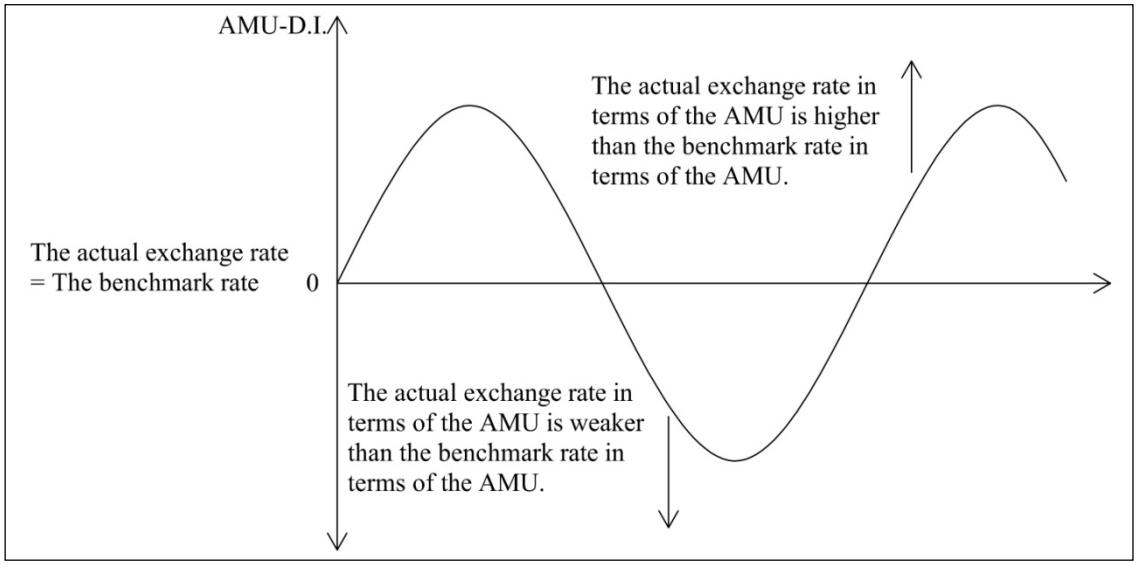
According to the frequency of data updates and the purposes of the surveillance

involved, the AMU deviation indicator can be divided into the nominal AMU deviation indicator, in terms of nominal exchange rate, and the real AMU deviation indicator, by taking into account the inflation rate differential. The nominal AMU deviation indicator represents the differential between an actual exchange rate and the benchmark rate. Therefore, it can be given by the following equation:

$$\textit{The Nominal AMU Deviation Indicator}(\%) = \frac{\left(\frac{AMU}{N.C.}\right)^{Actual} - \left(\frac{AMU}{N.C.}\right)^{Benchmark}}{\left(\frac{AMU}{N.C.}\right)^{Benchmark}} \times 100 \qquad (2)$$

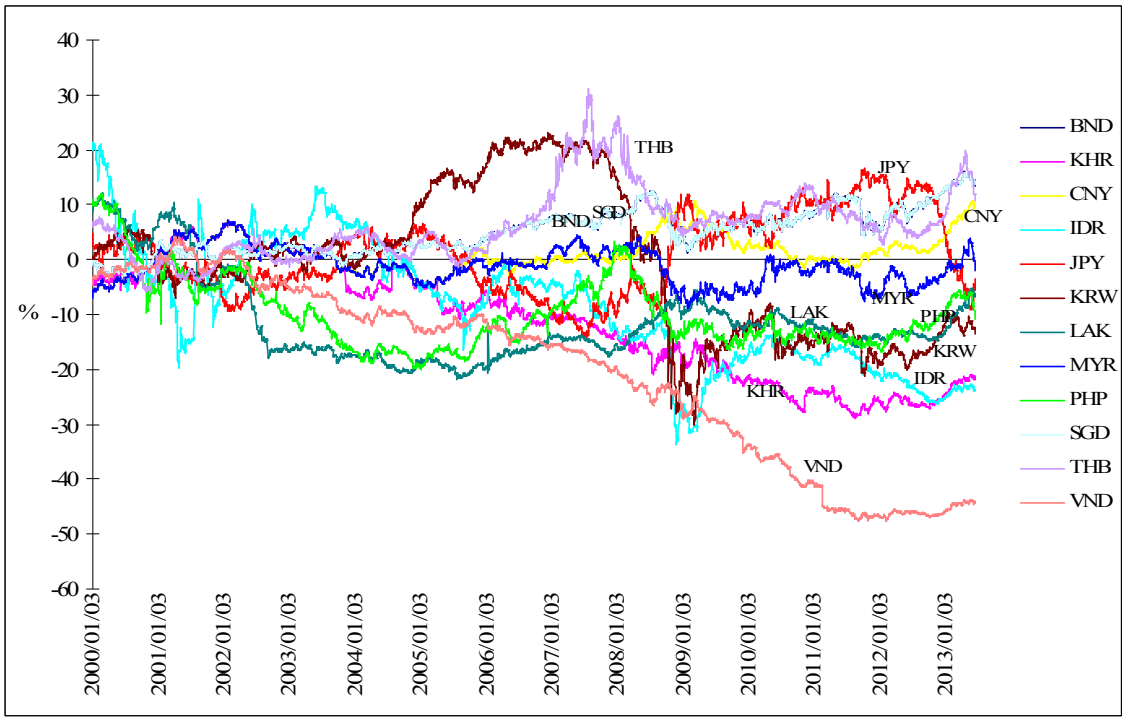
Because the nominal exchange rate, in terms of the AMU vis-à-vis a national currency, can be updated in real time, the nominal AMU deviation indicator is useful for daily real-time exchange rate surveillance. As shown in Figure 2, if the nominal AMU deviation indicator is positive, the exchange rate of the AMU to a national currency is overvalued. If it is negative, the exchange rate of the AMU to a national currency is undervalued. Figure 3 shows the nominal AMU deviation indicator of each currency from the beginning of 2000 to 2013. It clearly shows that fluctuations in the Brunei dollar, the Chinese yuan, the Malaysian ringgit, and the Singapore dollar have been less than 10% in either direction during the whole sample period. Overall, fluctuations in the nominal AMU deviation indicators have increased since around 2005. In particular, after the BNP Paribas shock occurred in the summer of 2007, most East Asian currencies were affected by the substantial depreciation of the euro, and the divergence spread of the nominal AMU deviation indicators between the maximum and the minimum was near to 70%.

Figure 2. Overvaluation or Undervaluation of the AMU Deviation Indicator



Source: RIETI online database.

Figure 3. Nominal AMU Deviation Indicators



Note: The monetary authority of Myanmar officially announced the introduction of floating exchange rate system in April 2012. Nevertheless, the official exchange rates issued by the monetary authority are different from the market rates under the floating exchange rate system. Additionally, Datastream, which is a data source for the AMU, does not yet reflect the market rates for Myanmar. Until Datastream adopts the market rates, Myanmar's AMU deviation indicator will be put on hold. However, as the weight of the Myanmar kyat in the AMU is less than 0.5%, the tentative measurement will not affect the performances of the AMU and the AMU deviation indicators.
Source: RIETI online database.

On the other hand, the real AMU deviation indicator can be calculated by taking into account inflation rate differentials, and can be expressed by the following equation:

$$\begin{aligned} &\textit{The Rate of Change of Real AMU Deviation Indicator}\,(\%) \\ &= \textit{The Rate of Change in Nominal AMU Deviation Indicator of Country "}i\textit{"} - \left(\dot{P}_{AMU} - \dot{P}_i\right) \end{aligned} \tag{3}$$

where $\dot{P}_{AMU}$ is the inflation rate of ASEAN+3 and $\dot{P}_i$ is the inflation rate of country "i".

Due to data constraints, the real AMU deviation indicator can only be calculated monthly, and time lags occur in updating the latest data. The real AMU deviation