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Evolution of Exchange Rate Behavior in the ASEAN-5 Countries

by Vladimir Klyuev and To-Nhu Dao

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Abstract

This paper examines exchange rate behavior in the ASEAN-5 countries (Indonesia, Malaysia, the Philippines, Singapore, and Thailand). It finds that for the last 10 years there is no evidence that their central banks target particular exchange rate levels against any currency or basket. Thus, contrary to some assertions, they do not belong to a U.S. dollar club, a Japanese yen club, a Chinese renminbi club, or an ASEAN club. At the same time, they clearly try to smooth short-term volatility, particularly vis-à-vis the U.S. dollar. The degree of smoothing declined noticeably after the Asian Financial Crisis and less obviously after the Global Financial Crisis, with heterogeneity across countries. Short-term smoothing without level targeting does not interfere with monetary policies aimed at price stability.

JEL Classification Numbers: F31; O24

Keywords: Exchange rate regimes; exchange rate volatility; fear of floating; currency blocks; ASEAN

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I. INTRODUCTION

Exchange rate policies of the ASEAN-5 countries have been subject to considerable scrutiny.[2] The reasons for the scrutiny include implications of the exchange rate regime for the conduct of monetary policy; concerns about (some of) these countries gaining competitive advantage by undervaluing their currencies; and the view of currency alignment as a reflection of global power structures (Henning, 2012).

Heavily managed exchange rate regimes are believed to have contributed to the accumulation of vulnerabilities that resulted in the Asian Financial Crisis (Goldstein, 1999). Post-crisis, most emerging markets professed greater exchange rate flexibility. However, as documented in the large literature on the "fear of floating" pioneered by Calvo and Reinhart (2002), many of them continued intervening in the foreign exchange markets. At the same time, the increasing use of exchange rate adjustment as a shock absorber has been noted by many observers (e.g., Shambaugh, 2015).

Despite considerable attention, the characterization of exchange rate policies in the ASEAN-5 remains somewhat contentious. Officially, the monetary policy frameworks of these countries center on price stability.[3] Indonesia, the Philippines, and Thailand are inflation targeters and profess floating exchange rates, while Malaysia and Singapore "monitor" the value of their currencies against undisclosed baskets.[4] Singapore relies on the exchange rate to conduct its monetary policy, whereas the other four countries use a short-term interest rate as the main policy instrument. All ASEAN-5 have fairly open capital accounts, which makes it challenging to control domestic monetary conditions and the exchange rate at the same time.

The authorities in the ASEAN-5 countries generally acknowledge that they intervene, at least occasionally, in foreign exchange markets. They maintain that intervention is aimed at smoothing excess volatility rather than targeting a specific level of the exchange rate, but some acknowledge that external competitiveness may be a consideration.

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[2] The group comprises Indonesia, Malaysia, the Philippines, Singapore, and Thailand—the founding members of the Association of Southeast Asian Nations (ASEAN).

[3] Price stability is the primary objective of the Bank Negara Malaysia (BNM), the Bangko Sentral ng Pilipinas (BSP), and the Monetary Authority of Singapore (MAS). The Bank Indonesia (BI) Act states that its ultimate objective is to achieve and maintain the stable value of the Indonesian rupiah, which has two aspects: a stable price of goods and services (internal price); and a stable exchange rate (external price). The Bank of Thailand (BOT) Act states its objectives as "maintaining monetary stability, stability of the financial system, and stability of the payments system." Thus, BI's and BOT's mandates do not stipulate the primacy of price stability—but they do not rule it out either, and in practice price stability can be expected to be the top priority since the BI and the BOT have adopted inflation targeting.

[4] The IMF (2015) classifies Indonesia, the Philippines and Thailand as floaters. Malaysia's exchange rate regime has been classified as "other managed" since BNM's adoption on July 21, 2005 of a managed float with the exchange rate of the Malaysian ringgit monitored against an undisclosed trade-weighted basket of currencies. MAS monitors the value of the Singapore dollar against an undisclosed basket of currencies and intervenes in the market to maintain this value within an undisclosed target band. The parameters of the band (its central parity, the width, and the crawl rate) are subject to change, with the direction but not magnitude of changes announced to the public. The IMF classification of Singapore's de facto regime varies with the actual path of the exchange rate. In the last few years it has been variably characterized as "other managed," "crawl-like," and "stabilized" arrangement.

Many analysts note patterns in observed exchange rate behavior and reserve movements inconsistent with pure floating or pure short-term smoothing.

Among those analysts, the question on what is the relevant anchor or reference currency remains unsettled. Some have heralded the emergence of a "Chinese renminbi bloc" (Kessler and Subramanian, 2012); others maintain that the U.S. dollar continues to be the dominant anchor currency in the region, even though the Chinese renminbi has taken on increasing importance in recent years (Kawai and Pontines, 2014); still others suggest that a synthetic regional currency—to which several East and Southeast Asian economies peg their currencies along the lines advocated by Williamson (1999 and 2005)—has in fact already emerged (Girardin, 2011). One reason why these competing claims are difficult to disentangle is that the Chinese renminbi has been managed quite tightly against the U.S. dollar for a long time. Thus, a currency with limited flexibility against the U.S. dollar will also have limited flexibility against the Chinese renminbi, and the other way around. Moreover, two currencies independently tied to either the U.S. dollar or the Chinese renminbi would also appear tied to one another, whether or not that is the intention.

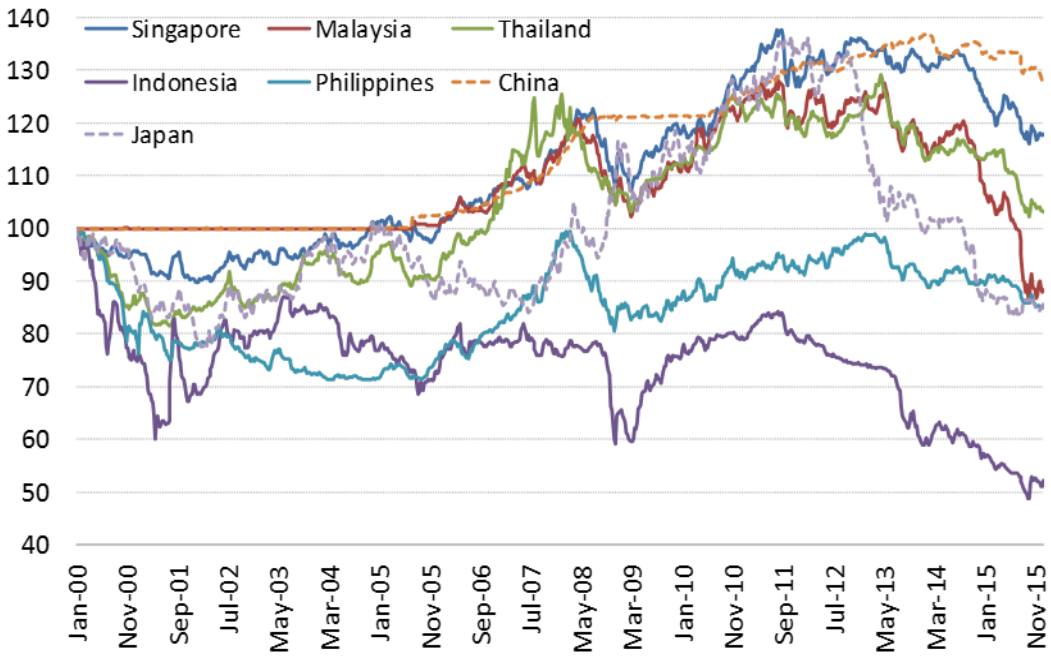
We use a variety of approaches to examine exchange rate behavior in the ASEAN-5, drawing a distinction between short-term flexibility—the extent to which the authorities limit day-to-day volatility in the exchange rate—and long-term flexibility—the extent to which parities are allowed to drift over longer horizons. Our methods include observation of the levels of exchange rates and their volatility as well as a variety of econometric techniques. This distinguishes our approach from the studies mentioned above, which rely largely on variants of one econometric approach pioneered by Frankel and Wei (1994 and 2008).

II. Exchange Rate Levels

Figure 1 shows the evolution of the ASEAN-5 exchange rates against the U.S. dollar since the beginning of this century.[5] It also shows the paths of the Japanese yen and the Chinese renminbi. With the obvious exception of the Malaysian ringgit peg to the U.S. dollar until July 2005, the graph depicts very large variation in all ASEAN-5 currencies over this 15-year horizon, with broad trends emerging and disappearing, occasional sharp turns, and quite a few ups and downs. The ASEAN-5 trajectories do not look qualitatively different from that of a freely floating currency (the Japanese yen), and they look quite different from the heavily managed Chinese renminbi.

[5] Appendix Figure A1 shows that evolution starting from 1990.

Figure 1. Exchange Rates Against U.S. Dollar
(2000w1=100; increase = appreciation)



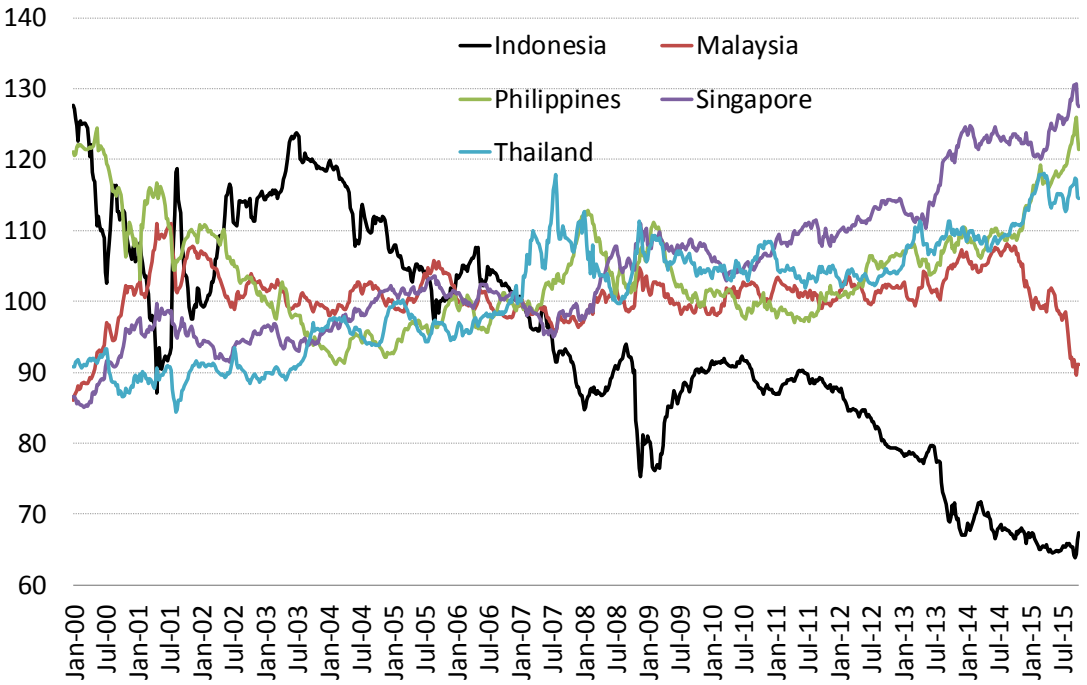
Sources: Haver Analytics; and IMF staff calculations.

One can notice broad co-movements among various subsets of the ASEAN-5 currencies over certain periods, which is not surprising given that they are neighbors, trading partners and competitors. At the same time, the magnitudes of exchange rate changes and the turning points differ across countries, and the groups of currencies moving together differ across periods. Thus, it is hard to make the case that the ASEAN-5 currencies or a subset thereof is bound together in a tight "club." This is evident in Figure 2, which shows the evolution of each ASEAN-5 currency against the equally weighted basket of the other four currencies.[6]

In the same vein, it is hard to talk about a Chinese renminbi club or a Japanese yen club (see Figures A3 and A4 for ASEAN-5 exchange rates against the Chinese renminbi and against the Japanese yen, respectively, since July 2005). There is no denying that the movements in the Chinese renminbi or the Japanese yen have an impact on the ASEAN-5 currencies. But it is patently not the case that any of the ASEAN-5 countries maintains a stable parity against the Chinese renminbi or the Japanese yen.

[6] If there were a tight ASEAN-5 club, the figure would show five nearly straight lines. If there was only one outsider (Indonesia clearly stands out), the other four lines would move all together. This is not the case. Figure A2 excludes Indonesia.

Figure 2. Exchange Rates Against Other ASEAN-5 Average
(1/1/2007=100, increase=appreciation)



Sources: Haver Analytics; and IMF staff calculations.

Formal econometric tests support these observations. If a currency is pegged to another currency or is only allowed to move in a fairly narrow band, the exchange rate between those two currencies should be stationary. This can be checked using a standard ADF unit root test.

The Asian Financial Crisis (AFC) and the Global Financial Crisis (GFC) were two watershed events where exchange rate regimes broke down at least temporarily as evidenced by large depreciations and currency volatility during those episodes. Moreover, the regimes may have changed after the crises. Thus we exclude the volatile crisis periods from our sample, and we apply econometric approaches to 4 periods: pre-AFC (January 1990–December 1996); inter-crisis I (January 1999–June 2005, when the Chinese renminbi and the Malaysian ringgit were pegged to the U.S. dollar); inter-crisis II (August 2005–June 2008); and post-GFC (June 2010–December 2015). Given the relative shortness of the periods under consideration, the results of the unit root tests should be considered as information complementing findings obtained via other methods rather than definitive proofs of stationarity or lack thereof.

Table 1 shows p-values from the ADF tests for the logs of various exchange rates for the four periods. We test for unit roots in the exchange rates of the ASEAN-5 currencies against the U.S. dollar, the Japanese yen, and the Chinese renminbi, as well as against one another—since the existence of an ASEAN-5 club would imply that member currencies move together against third currencies, and thus should be stationary against one another.[7]

[7] To emphasize, all cross rates among the club members should be stationary.

Table 1. P-values for Unit Root Tests for Cross Exchange Rates

Pre-AFC

	USD	RMB	JPY	IDR	MYR	PHP	SGD	THB
IDR	0.71	0.62	0.43	*	0.78	0.61	0.44	0.57
MYR	0.61	0.73	0.50	0.78	*	*0.04*	0.50	0.47
PHP	0.05	0.77	0.23	0.61	*0.04*	*	0.10	*0.04*
SGD	0.49	0.72	0.71	0.44	0.50	0.10	*	0.67
THB	*0.04*	0.69	0.52	0.57	0.47	*0.04*	0.67	*

Inter-crisis I

	USD	RMB	JPY	IDR	MYR	PHP	SGD	THB
IDR	0.24	0.24	0.13	*	0.24	0.26	0.23	0.10
MYR	**0.00**	**0.00**	0.36	0.24	*	0.49	0.25	0.27
PHP	0.49	0.49	0.59	0.26	0.49	*	0.72	0.77
SGD	0.25	0.26	0.15	0.23	0.25	0.72	*	0.32
THB	0.27	0.28	0.13	0.10	0.27	0.77	0.32	*

Inter-crisis II

	USD	RMB	JPY	IDR	MYR	PHP	SGD	THB
IDR	0.21	0.87	0.47	*	0.79	0.74	0.93	0.61
MYR	0.89	0.45	0.22	0.79	*	0.33	0.90	0.35
PHP	0.54	0.48	0.27	0.74	0.33	*	0.54	0.18
SGD	0.99	0.47	0.30	0.93	0.90	0.54	*	0.52
THB	0.55	0.52	0.35	0.61	0.35	0.18	0.52	*

Post-GFC

	USD	RMB	JPY	IDR	MYR	PHP	SGD	THB
IDR	0.98	0.93	0.06	*	0.56	0.85	0.79	0.81
MYR	1.00	0.99	0.59	0.56	*	0.98	0.99	0.91
PHP	0.43	0.60	0.83	0.85	0.98	*	0.07	0.32
SGD	0.48	0.68	0.82	0.79	0.99	0.07	*	0.24
THB	0.98	0.89	0.81	0.81	0.91	0.32	0.24	*

Note: P-values smaller than 0.1 are highlighted. Those between 0.01 and 0.05 are shown in italics. Those below 0.01 are shown in bold face. Abbreviations: USD – U.S. dollar, RMB – Chinese renminbi, JPY – Japanese yen, IDR – Indonesian rupiah, MYR – Malaysian ringgit, PHP – Philippine peso, SGD – Singapore dollar, THB – Thai baht.

Source: IMF staff calculations.

A detailed discussion of these results can be found in Appendix II. The key takeaway is that apart from the pre-2008 Malaysian ringgit peg to the U.S. dollar (and, indirectly, to the Chinese renminbi), we do not find solid evidence of the ASEAN-5 countries targeting the

levels of their currencies with respect to the U.S. dollar, the Chinese renminbi, the Japanese yen, or one another after the AFC.

Cointegration tests provide a complementary perspective on the same issue. Rather than examining whether the exchange rate between two currencies is stationary, we can check whether they move together against third currencies. If they do, their exchange rates against third currencies should form a stationary linear combination. The existence of such a combination can be tested using a cointegration test. In addition, in principle cointegration test can be used to discover more complex relationships involving more than two currencies, such as basket pegs. The choice of the numeraire currency is not very material as long as the exchange rates of the currencies we focus on vis-à-vis that numeraire are nonstationary. We use for that purpose the New Zealand dollar, which is a free-floating currency whose exchange rates against the U.S. dollar, the Chinese renminbi and all the ASEAN-5 currencies are nonstationary in all four periods under consideration.

Appendix III contains a detailed discussion of the extensive cointegration tests that we have conducted and their results. The results confirm the findings from the unit root tests. Apart from the 1999–2005 Malaysian ringgit peg to the U.S. dollar, it does not appear that the ASEAN-5 central banks are targeting the levels of their currencies to any specific parities with respect to one another or any major currencies or combinations of currencies, including the Chinese renminbi.

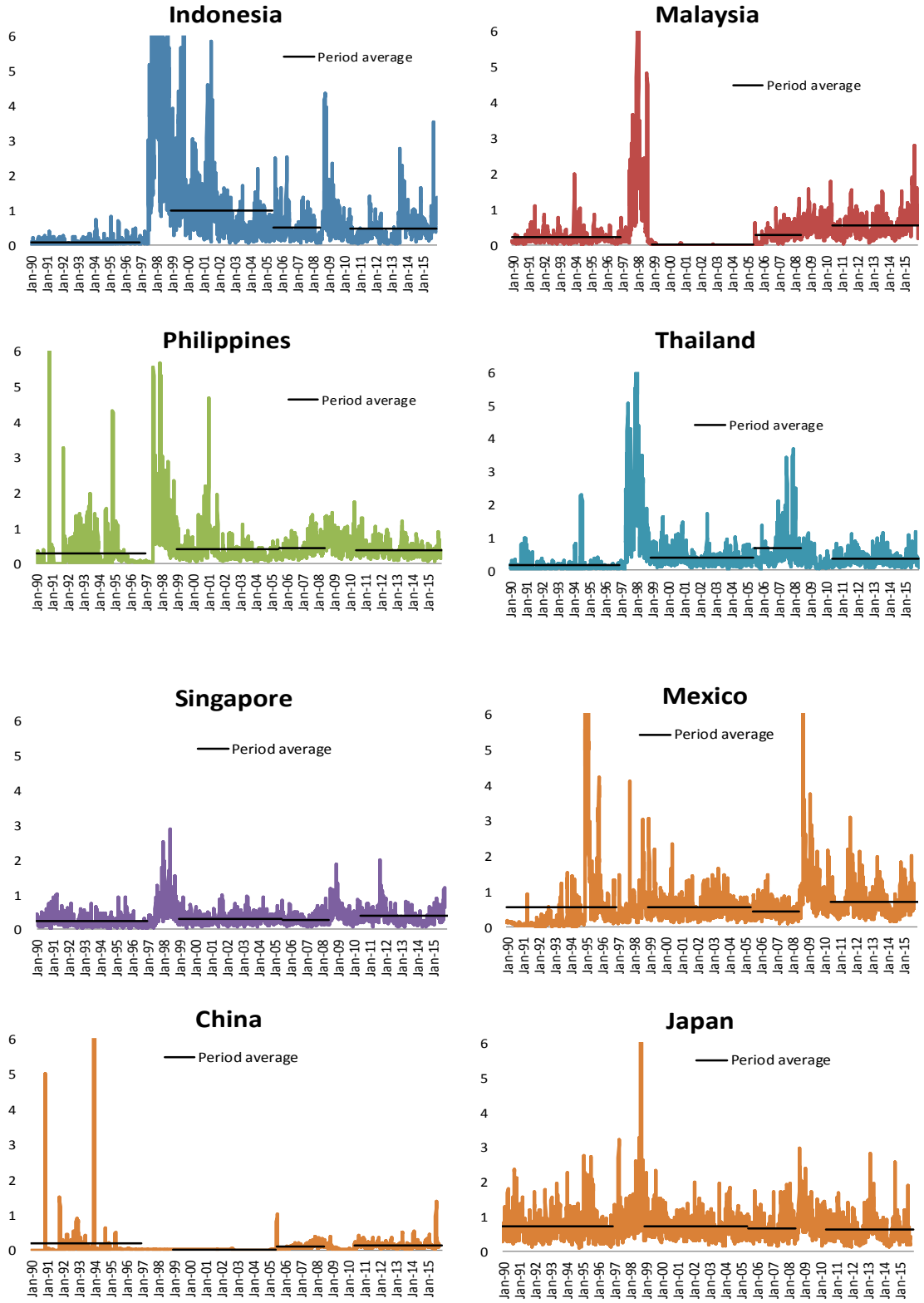
III. SHORT-TERM VOLATILITY

The absence of targeting a specific exchange rate level does not imply the lack of intervention in the foreign exchange market. As noted in the introduction, Singapore uses the exchange rate path as the instrument of monetary policy, while the other ASEAN-5 central banks admit openly that they intervene occasionally to avoid excessive currency movements. This section explores whether ASEAN-5 tolerance to exchange rate volatility has changed over time.

The most direct way to observe the evolution of exchange rate volatility is to plot the rolling coefficient of variation.[8] Figure 3 shows this coefficient taken over a 10-working-day window for the exchange rates of ASEAN-5 and three comparator countries against the U.S. dollar.

[8] The coefficient of variation is the ratio of the standard deviation to the mean over a sample period, expressed in percent.

Figure 3. Coefficient of Variation of Exchange Rates Against U.S. Dollar



Note: Daily exchange rates. Rolling 10-day window.

Sources: Haver Analytics; and IMF staff calculations.

Looking at these figures one can make the following observations. First, unsurprisingly, there is a noticeable spike in exchange rate volatility for the ASEAN-5 countries during the periods of the AFC and the GFC (with the former considerably larger in scale).

Second, except for Singapore, there is a perceptible difference in volatility between the periods preceding and following the AFC, but the differences are not the same for all the countries.[9] The Thai baht and the Indonesian rupiah exchange rates clearly became more variable, the latter by a very wide margin. The Philippine peso moved from stop-and-go policies of near-pegs followed by step devaluations or revaluations to relative flexibility. The Malaysian ringgit, on the other hand, was pegged to the U.S. dollar until July 2005. After de-pegging, its volatility increased gradually and eventually exceeded the level observed in the years before the AFC.

Third, there might be a slight uptick in volatility after the GFC, but it is less pronounced than the change after the GFC, except for Malaysia (and maybe Indonesia) in the most recent period. It is too early to tell whether these swings reflect exceptionally large shocks or signal a regime shift.

Fourth, exchange rate variability against the U.S. dollar in ASEAN-5 after the AFC remained lower than that in freer floating currencies such as the Mexican peso or the Japanese yen (even though one might expect the peso to be closely linked to the dollar given the extensive trade and financial linkages between Mexico and the United States), suggesting that ASEAN-5 central banks do not allow their currencies to fluctuate freely against the U.S. dollar—confirming the residual fear of floating.[10]

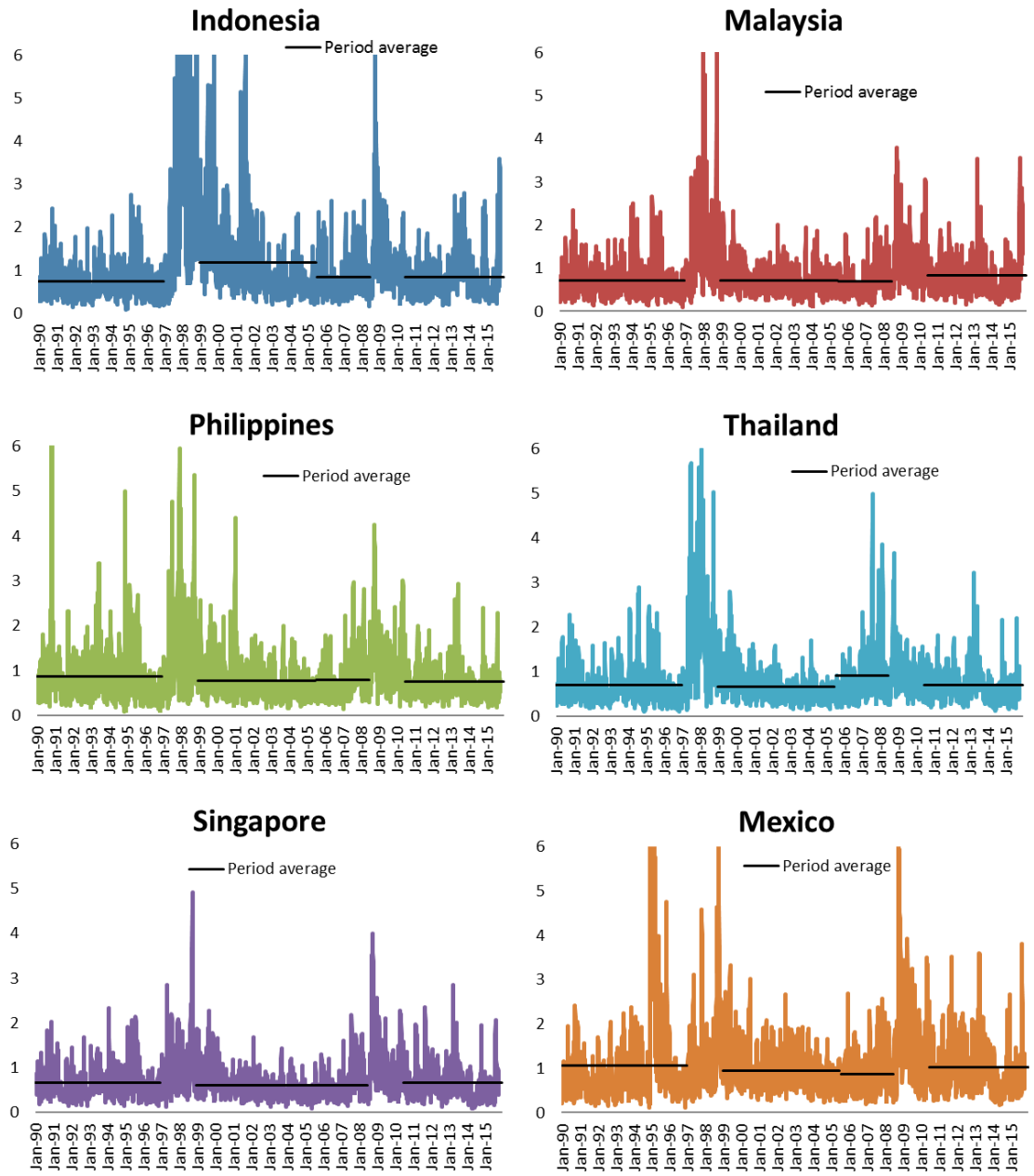
Plotting ASEAN-5 currency volatility against the Japanese yen (Figure 4) confirms that the U.S. dollar occupies a special place—ASEAN-5 currencies are allowed to fluctuate much more against the Japanese yen than against the U.S. dollar, even though trade and financial linkages between ASEAN-5 and Japan are at least as large as those between ASEAN-5 and the United States.[11]

[9] Volatility appears to have increased for Singapore, but the difference is marginal.

[10] Interestingly, the volatility of the Mexican peso/U.S. dollar exchange rate clearly increased after the GFC.

[11] Which is not the case for Mexico, giving a plausible explanation as to why the Mexican peso fluctuates more against the Japanese yen than against the U.S. dollar. This does not rule out, of course, that the Bank of Mexico might intervene to smooth oscillations against the dollar.

Figure 4. Coefficient of Variation of Exchange Rates Against Japanese Yen



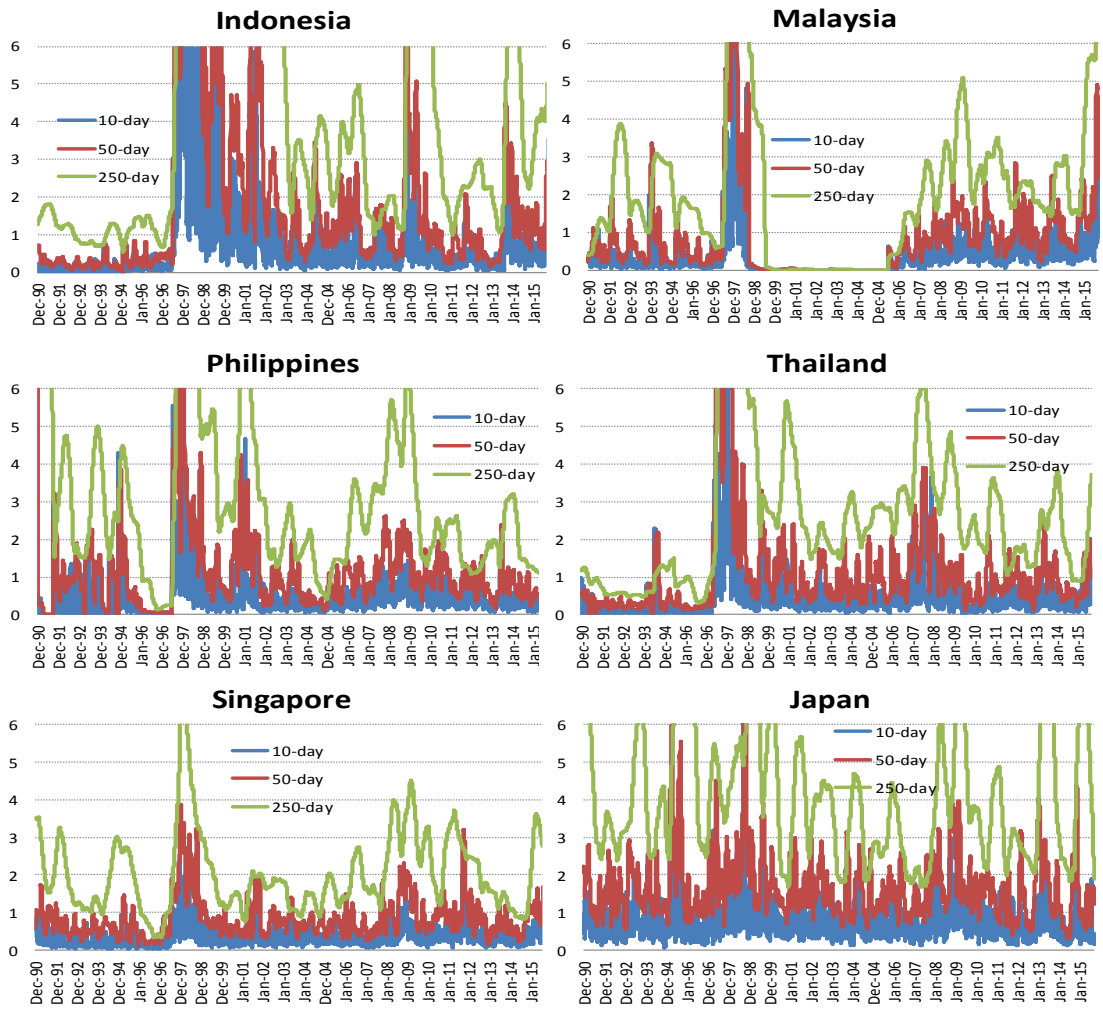
Note: Daily exchange rates. Rolling 10-day window.

Sources: Haver Analytics; and IMF staff calculations.

Figure 5 shows that the variability of the ASEAN-5 exchange rates against the U.S. dollar increases with time horizon. The picture would look different if the authorities tried to keep those rates within a fairly narrow band. These graphs are consistent with the notion that the authorities try to dampen day-to-day volatility of their currencies against the U.S. dollar, but allow them to move substantially over longer periods. One cannot necessarily conclude, however, that the authorities do not resist lasting shocks and trends at all.

Notably, the Japanese yen has larger volatility against the U.S. dollar than the ASEAN-5 currency at every horizon.[12]

Figure 5. Coefficient of Variation of Exchange Rates Against U.S. Dollar at Different Horizons



Sources: Haver Analytics; and IMF staff calculations.

[12] Figure A5 shows the coefficient of variation of the Australian dollar, New Zealand dollar, and Mexican peso against the U.S. dollar at the same horizons. The volatility of these currencies is similar to that of the Japanese yen and higher than that of the ASEAN-5 currencies.

IV. REGRESSION ANALYSIS

Finally, we use multiple regression analysis to move beyond the somewhat impressionistic examination of the volatility of ASEAN-5 exchange rates against a single currency conducted above. Following Frankel and Wei (1994), we regress changes in an ASEAN-5 currency (the Thai baht in the example below) against a numeraire currency (the New Zealand dollar in the example) on a constant and on changes in several other currencies against the same numeraire. The idea is that if the Thai baht is pegged to one of those currencies (or a basket), then it will move against third currencies as much as the currency it is pegged to does (or, in the case of a basket peg, as much as a linear combination of the currencies in the basket). Thus, if the Thai baht is pegged to one of the currencies in the equation, the coefficient on that currency will be very close to one and highly statistically significant, while all other coefficients will not be significant, and the R-squared will be close to one. In case of a basket peg, if all the currencies in the basket are represented on the right-hand side of the equation, the coefficients on those currencies will equal their weights in the basket (and thus add up to one), all other coefficients will equal zero, and the R-squared will again be close to one. The constant is introduced to accommodate a crawling peg.

$$\ln \frac{\left(NZD/THB\right)_t}{\left(NZD/THB\right)_{t-1}} = \beta_0 + \beta_{USD} \ln \frac{\left(NZD/USD\right)_t}{\left(NZD/USD\right)_{t-1}} + \beta_{JPY} \ln \frac{\left(NZD/JPY\right)_t}{\left(NZD/JPY\right)_{t-1}} + \beta_{EUR} \ln \frac{\left(NZD/EUR\right)_t}{\left(NZD/EUR\right)_{t-1}} + \beta_{GBP} \ln \frac{\left(NZD/GBP\right)_t}{\left(NZD/GBP\right)_{t-1}} + \varepsilon_t$$

If a country does not literally follow a peg, but still manages its exchange rate fairly tightly against some currency or a basket, the equation above can help reveal that fact. The coefficients would reflect the roles of different partner currencies if the Thai baht is managed against a basket, and their statistical significance as well as the overall R-squared would indicate the tightness of the exchange rate regime.[13]

We put different combinations of currencies on the right-hand side. In our basic specification we include only the four major currencies shown in the equation.[14] To test the hypotheses of a Chinese renminbi club or an ASEAN club, we then add the Chinese renminbi and the ASEAN-5 currencies to the equation. The results are shown in Table 2 and Table A1.

[13] To emphasize, the purpose of the regression is *not* to build the best possible model of exchange rate behavior. Rather, it is to check whether the behavior can be fully or largely explained by movements in other currencies, which would indicate a hard or soft peg. For that reason, we are not including in the equation other variables that could improve the goodness of fit (e.g., terms of trade).

[14] The U.S. dollar, the Japanese yen, the euro and the British pound. Pre-AFC, the Deutsche mark is used in place of the euro.

Table 2. Regression Results

Indonesian rupiah	Pre-AFC	Inter-I	Inter-II	Post-GFC	Inter-II	Post-GFC
constant	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**1.00**	**0.89**	**0.88**	**0.74**	**0.70**	**0.42**
Japanese yen	-0.01	**0.18**	**-0.13**	-0.01	**-0.13**	-0.01
European euro	0.00	-0.05	0.10	-0.02	0.10	-0.01
British pound	0.00	-0.13	0.04	**0.13**	0.05	**0.13**
Chinese renminbi					0.19	**0.33**
R-squared	**0.97**	**0.30**	**0.62**	**0.58**	**0.62**	**0.58**

Malaysian ringgit	Pre-AFC	Inter-I	Inter-II	Post-GFC	Inter-II	Post-GFC
constant	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**0.92**	**1.00**	**0.87**	**0.66**	0.27	**0.27**
Japanese yen	0.02	0.00	-0.03	-0.06	-0.03	-0.06
European euro	**0.04**	0.00	0.05	0.03	0.04	0.03
British pound	0.00	0.00	0.04	**0.16**	0.05	**0.15**
Chinese renminbi					**0.61**	**0.39**
R-squared	**0.88**	**1.00**	**0.87**	**0.61**	**0.88**	**0.62**

Philippine peso	Pre-AFC	Inter-I	Inter-II	Post-GFC	Inter-II	Post-GFC
constant	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**1.06**	**0.95**	**0.87**	**0.90**	**0.74**	**0.48**
Japanese yen	-0.02	**0.09**	0.01	-0.03	0.01	-0.03
European euro	0.02	0.01	0.10	0.00	0.10	0.00
British pound	**-0.06**	-0.06	-0.04	**0.06**	-0.04	0.06
Chinese renminbi					0.13	**0.43**
R-squared	**0.62**	**0.70**	**0.79**	**0.81**	**0.79**	**0.82**

Singapore dollar	Pre-AFC	Inter-I	Inter-II	Post-GFC	Inter-II	Post-GFC
constant	**0.000**	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**0.85**	**0.70**	**0.65**	**0.47**	**0.39**	**0.27**
Japanese yen	**0.09**	**0.19**	**0.06**	**0.04**	**0.06**	**0.04**
European euro	**0.09**	**0.05**	**0.16**	**0.17**	**0.15**	**0.17**
British pound	-0.01	0.00	0.03	**0.11**	0.03	**0.11**
Chinese renminbi					**0.27**	**0.21**
R-squared	**0.89**	**0.90**	**0.92**	**0.82**	**0.92**	**0.83**

Thai baht	Pre-AFC	Inter-I	Inter-II	Post-GFC	Inter-II	Post-GFC
constant	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**0.97**	**0.78**	**0.78**	**0.74**	**0.45**	**0.55**
Japanese yen	**0.04**	**0.17**	**0.10**	0.01	**0.10**	0.01
European euro	-0.03	0.03	0.02	**0.07**	0.01	**0.07**
British pound	-0.01	-0.02	0.04	0.05	0.05	0.05
Chinese renminbi					**0.34**	**0.20**
R-squared	**0.85**	**0.80**	**0.85**	**0.84**	**0.85**	**0.85**

Note: Red indicates the coefficient is significant at 5 percent level. Red and bold significant at 1 percent level. Based on HAC standard errors. Daily observations.

Source: IMF staff calculations.

In the six years before the AFC, the ASEAN-5 countries, except for the Philippines, followed fairly tight pegs, primarily against the U.S. dollar, as indicated by R-squared close to 0.9 and coefficients on the U.S. dollar that were close to one and highly statistically significant.[15] Singapore is shown to pursue a basket peg in which the U.S. dollar plays a dominant role, but the Japanese yen and the Deutsche mark have a weight of about 10 percent each. After the AFC, the Indonesian rupiah became considerably more volatile, while at the opposite edge of the spectrum the Malaysian ringgit was pegged to the U.S. dollar. Singapore appears to have shifted some weight from the U.S. dollar to the Japanese yen in its basket without changing materially the degree of regime tightness. Thailand seems to have moved to targeting a combination of the U.S. dollar, the Japanese yen, and possibly the euro, with the dominant weight still on the U.S. dollar, and to have allowed a little more flexibility. Finally, the Philippine peso shifted from intervals of stability occasionally interrupted by sharp movements before the AFC (which explains the low R-squared) to a fairly soft tie to the U.S. dollar.

After the Chinese renminbi and Malaysian ringgit pegs to the U.S. dollar were broken, the Malaysian currency moved more freely but retained a fairly strong link to the greenback. The Indonesian rupiah and the Philippine peso maintained rather large and statistically significant coefficients on the U.S. dollar, but the R-squared remained relatively low. There was no notable change in the Thai baht behavior.

Finally, after the GFC, the goodness of fit remained unchanged for the Thai baht and the Philippine peso and declined for the other three currencies, most notably for the Malaysian ringgit. It is too early to tell whether this shift is due to a more volatile environment or to a change in policy reaction, but most likely both explanations have an element of truth.[16]

Over the last decade the question has been raised on the role of the Chinese renminbi in ASEAN-5 exchange rate policies since China has emerged as a major trading partner and competitor for the regional economies, even though the U.S. dollar is the traditional anchor currency. It is difficult to answer the question unequivocally.

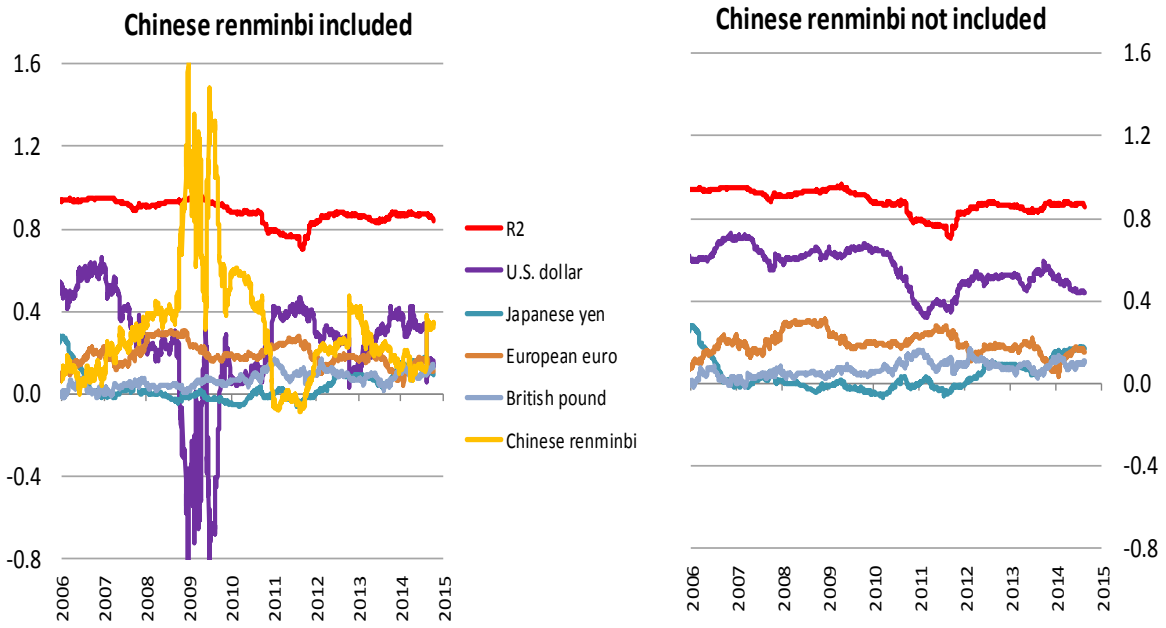
Given that the Chinese renminbi had been managed very tightly against the U.S. dollar until very recently, at short horizons there was very little difference between linking one's currency to the Chinese renminbi and to the U.S. dollar. As the last two columns of Table 2 show, adding the Chinese renminbi to the right-hand side of the regressions has virtually no impact on their fit. The addition shifts some weight from the U.S. Dollar to the Chinese

[15] The hypothesis of a strict U.S. dollar peg—with the coefficient on the U.S. dollar statistically indistinguishable from one—is rejected for Singapore and Thailand at the 1 percent significance level for every period. It cannot be rejected at the 1 percent level for Indonesia and the Philippines before the AFC and for Malaysia during the Malaysian ringgit peg to the U.S. dollar. The p-values for the Indonesian rupiah are 0.08 for the first inter-crisis period and 0.02 for the second—and the R-squared are quite low during those two periods. All the other p-values are below 1 percent.

[16] In similar regressions for the Mexican peso, the coefficient on the U.S. dollar is close to one (and highly statistically significant) and the R-squared is close to 0.7 in both inter-crisis periods. After the GFC, the coefficient on the dollar drops 0.43 and the R-squared falls to 0.35, indicating a large decrease in the degree of comovement between the Mexican peso and the U.S. dollar vis-à-vis the New Zealand dollar.

renminbi without affecting the other coefficients (except for the intercept).[17] Taken at face value, the results suggest that particularly in recent years the Chinese renminbi has started playing a role comparable to that of the U.S. dollar in ASEAN-5 central banks' approach to managing currency volatility. This is an interesting finding, but we would not overemphasize its significance. For all practical purposes, in the short run limiting the movements of a currency against the U.S. Dollar is equivalent to limiting its movements against the Chinese renminbi, and given the near multicollinearity, linear regression is not the best way to distinguish which one the policymakers are really interested in.[18] Figure 6 shows the instability in the U.S. dollar and Chinese renminbi coefficients resulting from near collinearity using Singapore as an example. These two rolling coefficients vary widely while the other coefficients are considerably more stable and neither they nor the R-squared is affected by the introduction of the Chinese renminbi in the regression.

Figure 6. Rolling Regression Coefficients and R-squared for Singapore Dollar



Note: Daily observations. 260-day window.

Source: IMF staff calculations.

Over the longer run the Chinese renminbi moved materially against the U.S. dollar in the second inter-crisis period and after the GFC. Thus, a U.S. dollar peg and a Chinese renminbi peg would look very different at horizons exceeding several months. However, at such horizons, neither regime appears to be a fair representation of the exchange rate policy for any of the ASEAN-5 currencies after July 2005—as we saw above, their exchange rates against both the U.S. dollar and the Chinese renminbi are nonstationary.

[17] This remains true if the sample period is limited to 2015 only, even though the course of the Chinese renminbi may have become less predictable lately.

[18] This question may not even have an answer since the policymakers do not have to make that choice, even in their minds.

What about the ASEAN club? Adding the four ASEAN partner currencies to the regressions in the last two periods improves the goodness of fit by a few percentage points, and many coefficients come out statistically significant (Table A1). This could be consistent with the notion that the ASEAN-5 central banks react to the behavior of their ASEAN-5 partners and competitors. On the other hand, these correlations could reflect common shocks. We are leaning toward the latter interpretation and plan to explore the issue further in future work. Regressions at different horizons (weekly and monthly changes) and using alternative currencies as numeraire (Singapore dollar, Swiss franc, Mexican peso) confirm these findings.[19]

As an additional robustness check, we augment the regressions with an exchange market pressure (EMP) variable as suggested by Frankel and Wei (2008). EMP is calculated as the sum of percentage changes in the exchange rate and in reserves over the same period of time (typically a month):

$EMP_t = \Delta E_t / E_{t-1} + \Delta R_t / R_{t-1}$

It is designed to capture various shocks exerting pressure on the exchange rate, to which the central bank can react by allowing the exchange rate to adjust or by intervening (e.g., by purchasing reserves to stave off an appreciation pressure). The augmented regression will take the following form:

$$d\ln\left(\frac{NZD}{THB}\right)_t = \beta_0 + \beta_{USD} d\ln\left(\frac{NZD}{USD}\right)_t + \beta_{JPY} d\ln\left(\frac{NZD}{JPY}\right)_t + ... + \delta\left[d\ln\left(\frac{NZD}{THB}\right)_t + d\ln R_t\right] + \varepsilon_t$$

In case of a hard peg to another currency or a basket, the exchange rate will move little compared to reserves (which play the role of a shock absorber), so the coefficient δ on the EMP variable will be close to zero (reserve movements do not help explain changes in the exchange rate with respect to an arbitrary numeraire). In case of a pure float, reserves do not change materially, so the EMP variable nearly equals the change in the exchange rate.[20] With the dependent variable essentially represented on the right-hand side of the equation, the coefficient on EMP will be close to one, and so will be the R-squared. In the intermediate cases such as managed float or adjustable peg, δ will be between zero and one, and the R-squared will be below one.

[19] Results of these and other robustness checks are available from the authors upon request.

[20] In reality, reserves can move even without intervention because of valuation changes. Also, countries that do not intervene much may not have a lot of reserves, so percent change in reserves may still look substantial. To provide a benchmark for comparison, the EMP coefficient for the Mexican peso was around 0.6 in the two inter-crisis periods and 0.75 in the post-GFC period, statistically different from both zero and one. For the Hong Kong dollar, which is pegged to the U.S. dollar in a currency board arrangement, the coefficient was less than 0.01 in absolute value and not significantly different from zero in all four periods. Instead of looking at reserves, an alternative, which also has conceptual challenges, is to use the overall balance of payments, but that data is typically available only at quarterly frequency. Another question is how to scale reserve changes, which is our measure of intervention. In the literature, they have been scaled by their own size (so looking at percent change, as in the equation above), or relative to the monetary base. We have tried different measures without material difference to the results.

Figure 7 (left panel) shows that the value of ASEAN-5's international reserves has generally been more volatile than the value of their currencies in U.S. dollars, with changes in both usually going in the same direction. This suggests that shocks have been accommodated through a combination of exchange rate movements and intervention, although valuation changes likely account for some of the correlation.[21] Plotting reserves and exchange rates in levels (Figure 7, right panel) reveals a long period of reserve accumulation, from the early 2000s through 2011, temporarily interrupted by the GFC. This episode of mostly one-sided intervention may suggest that even though the ASEAN-5 central banks did not target a particular exchange rate level, they did try to prevent their currencies from appreciating "too much," even in the long term rather than intervening only to smooth volatility. Of course, that policy also helped build up reserves for self-insurance purposes—which was particularly important in the years following the AFC.

[21] For example, a broad U.S. dollar depreciation would both increase the exchange rates of ASEAN-5 currencies vis-à-vis the U.S. dollar and boost the U.S. dollar value of their reserves to the extent they are partially held in non-U.S. dollar currencies. It should be noted, however, that, say, a 1percent U.S. dollar depreciation against all other currencies would raise ASEAN-5 exchange rates against the U.S. dollar by 1 percent and increase the U.S. dollar value of their reserves by less than that. Hence, valuation changes alone are unlikely to account for the fact that reserves volatility tends to be higher than exchange rate volatility in the ASEAN-5.

Figure 7: Exchange Rates Against U.S. Dollar and Reserves in U.S. Dollars

Month-on-month change (percent) | Index (Jan-2000=100)

Sources: Haver Analytics; IMF's International Finance Statistics database; and IMF staff calculations.

Table 3 contains the results of regressions at monthly frequency with the EMP variable. Before the AFC, the EMP coefficients were close to zero, except for Singapore, indicating a large extent of intervention. After the Asian crisis, the coefficients have become bigger, with the exception of Singapore and, during the Malaysian ringgit peg to the U.S. dollar, Malaysia. However, the coefficients never got anywhere near one, except maybe for Indonesia during the first inter-crisis period.[22] This suggests that the ASEAN-5 currencies are quite far from a pure float. Thus the EMP regressions confirm our finding that after the AFC the ASEAN-5 other than Singapore have decreased the amount of intervention aimed at smoothing fluctuations in their currency values, but have not fully abandoned that policy.

Table 3. Regression Results with EMP Variable

Indonesian rupiah	**Pre-AFC**	**Inter-I**	**Inter-II**	**Post GFC**
constant	-0.003	-0.004	-0.003	-0.006
U.S. dollar	**0.95**	**0.42**	**0.80**	**0.80**
Japanese yen	-0.01	-0.13	0.01	-0.06
European euro	-0.01	0.05	-0.25	-0.07
British pound	0.01	-0.20	0.03	-0.09
EMP	-0.01	**0.78**	**0.29**	**0.29**
R-squared	**0.93**	**0.87**	**0.79**	**0.80**
Malaysia ringgit	**Pre-AFC**	**Inter-I**	**Inter-II**	**Post GFC**
constant	0.001	0.000	0.001	-0.004
U.S. dollar	**0.87**	**1.00**	**0.86**	**0.53**
Japanese yen	0.08	0.00	-0.10	-0.07
European euro	0.04	0.01	0.17	-0.19
British pound	0.00	-0.02	-0.14	0.23
EMP	0.00	0.01	**0.14**	**0.30**
R-squared	**0.62**	**1.00**	**0.91**	**0.79**
Singapore dollar	**Pre-AFC**	**Inter-I**	**Inter-II**	**Post GFC**
constant	-0.003	-0.002	0.000	0.000
U.S. dollar	**0.56**	**0.58**	**0.70**	**0.47**
Japanese yen	0.01	**0.11**	-0.03	0.03
European euro	**0.07**	0.05	0.06	0.04
British pound	0.00	-0.03	-0.02	0.00
EMP	**0.31**	**0.22**	**0.22**	**0.29**
R-squared	**0.94**	**0.92**	**0.96**	**0.93**
Philippine peso	**Pre-AFC**	**Inter-I**	**Inter-II**	**Post GFC**
constant	-0.004	-0.005	0.000	-0.001
U.S. dollar	**0.91**	**0.56**	**0.98**	**0.58**
Japanese yen	0.01	0.01	0.00	-0.01
European euro	0.02	0.10	-0.03	-0.01
British pound	-0.07	-0.03	-0.28	0.05
EMP	0.06	**0.28**	**0.22**	**0.27**
R-squared	**0.33**	**0.80**	**0.93**	**0.93**
Thai baht	**Pre-AFC**	**Inter-I**	**Inter-II**	**Post GFC**
constant	-0.001	-0.006	-0.006	-0.002
U.S. dollar	**0.77**	**0.64**	**0.76**	**0.66**
Japanese yen	**0.08**	0.00	-0.14	**-0.10**
European euro	**0.05**	0.01	-0.22	**-0.13**
British pound	0.01	-0.16	0.23	-0.03
EMP	**0.05**	**0.42**	**0.43**	**0.54**
R-squared	**0.96**	**0.84**	**0.96**	**0.96**

Note: Red indicates the coefficient is significant at 5 percent level. Red and bold significant at 1 percent level. Based on HAC standard errors. Monthly observations.

Source: IMF staff calculations.

[22] All the coefficients are statistically different from one at the 1 percent significance level. The p-value for the coefficient on the Indonesian rupiah during the first inter-crisis period is 0.006, and all the others much smaller.

Table 4 shows p-value for the Chow tests of coefficient stability between adjacent periods. It indicates regime changes for the Indonesian rupiah, the Thai baht, and possibly the Philippine peso after the AFC, but the hypothesis of no change in the coefficients for the Malaysian ringgit and the Singapore dollar is not rejected. The finding for Singapore is not surprising given that there was no change in the official monetary policy framework and that other indicators do not suggest a noticeable change either. On the other hand, the Malaysian ringgit was pegged to the U.S. dollar after the AFC, so the test result appears counterintuitive. It should be noted, however, that the test looks only at the values of the coefficients, but not at the tightness of the peg as indicated by the R-squared. Thus the test suggests that the U.S. dollar was the principal anchor for the Malaysian ringgit both before and after the AFC. However, the R-squared points to a much tighter peg after the AFC.

The test does reveal a regime change for the Malaysian ringgit after it was taken off the dollar peg in 2005, and it also suggests a change in the behavior of the Indonesian rupiah. Finally, a break in the behavior of all the ASEAN-5 currencies other than the Indonesian rupiah is found after the GFC.

Table 4. Chow Test P-values for Regressions with EMP Variable

	Pre-AFC vs Inter-1	Inter-1 vs Inter-2	Inter-2 vs Post-GFC
Indonesian rupiah	0.000	0.000	0.949
Malaysian ringgit	0.702	0.000	0.007
Philippine peso	0.059	0.252	0.011
Singapore dollar	0.231	0.477	0.007
Thai baht	0.000	0.131	0.000

Source: IMF staff calculations.

V. CONCLUSIONS

The monetary and exchanger rate frameworks of the ASEAN-5 currencies have evolved over time.[23] Singapore has been the most consistent in its approach, using a crawling peg to an undisclosed basket and parameters[24] as the instrument of its monetary policy directed at price stability. The other four countries have undergone a variety of transitions, settling eventually on inflation-targeting frameworks with floating exchange rates in Indonesia, the Philippines and Thailand, and a managed float in Malaysia.

These changes have been reflected in the behavior of the ASEAN-5 exchange rates. Before the Asian Financial Crisis (AFC), particular in the two years preceding the onset of the crisis, their currencies were tightly managed against the U.S. dollar. After the AFC, the exchange rates have become significantly more flexible, with the exception of a period through July 2005 when the Malaysian ringgit was pegged to the U.S. dollar.

[23] See Peiris and others (2016) for a broad discussion of the evolution of monetary policy frameworks in the ASEAN-5 countries.

[24] The rate of crawl and the width of the band.

Direct observation and a variety of econometric tests make it clear that the ASEAN-5 no longer target specific levels of their exchange rates with respect to other currencies—be it the U.S. dollar, the Japanese yen, the Chinese renminbi, other ASEAN currencies, or a combination thereof. Thus, contrary to what some analysts have suggested, there is no U.S. dollar club, or Japanese yen club, or Chinese renminbi club, or ASEAN club. This does not necessarily mean that the authorities do not try to influence the strength of their currencies beyond the short term. That statement cannot be proved or disproved solely on the basis of observed exchange rate behavior, but prolonged periods of mostly one-sided intervention suggests that the ASEAN-5 central banks have tried to moderate trend shifts in their currencies. What is true, however, is that this did not amount to defending a particular parity.

At the same time, the fear of floating is not completely gone. Our analysis suggests that the central banks intervene in foreign exchange markets to smooth currency movements—which officials generally acknowledge. They primarily try to reduce the volatility of their exchange rates vis-à-vis the U.S. dollar—which also smooths movements against the Chinese renminbi, since in the short run the Chinese renminbi is tightly managed against the U.S. dollar. As a result, in the short term the variation of the ASEAN-5 currencies with respect to the U.S. dollar is considerably smaller than against other currencies including the Japanese yen—despite Japan's geographic proximity and the large role it plays in trade and FDI flows to the ASEAN-5. It is also smaller than the volatility of freer floating currencies, such as the Japanese yen, the Australian dollar, the New Zealand dollar, and the Mexican peso, with respect to the U.S. dollar. At the same time, regression analysis indicates that these countries—most notably Singapore, in line with its basket peg—do pay some attention to currencies other than the U.S. dollar in managing their exchange rate volatility.

The degree of smoothing short-term currency fluctuations declined noticeably after the AFC for Indonesia and Thailand as well as—compared to the immediate pre-AFC period—in the Philippines. The change in Singapore was less pronounced, and in Malaysia it did not take place until the Malaysian ringgit was taken off the U.S. dollar peg in July 2005. One can also discern an increase in exchange rate volatility after the Global Financial Crisis, although Malaysia is the only ASEAN-5 country where this change is pronounced.

Given that currency intervention is directed at reducing short-term exchange rate fluctuations rather than defending a particular level, the exchange rate policies of the ASEAN-5 central banks are not inconsistent with their mandates for domestic macroeconomic stability.

The scope of this paper is rather narrow—to document the behavior of the ASEAN-5 exchange rates in terms of their short- and long-run volatility relative to other currencies. With these facts established, potential extensions could include trying to explain changes in that behavior, linking it to the evolution of monetary frameworks, domestic and global economic and political factors, etc.

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Appendix I. Additional Tables and Graphs

Figure A1. Exchange Rates Against U.S. Dollar
(2000w1=100; increase = appreciation)

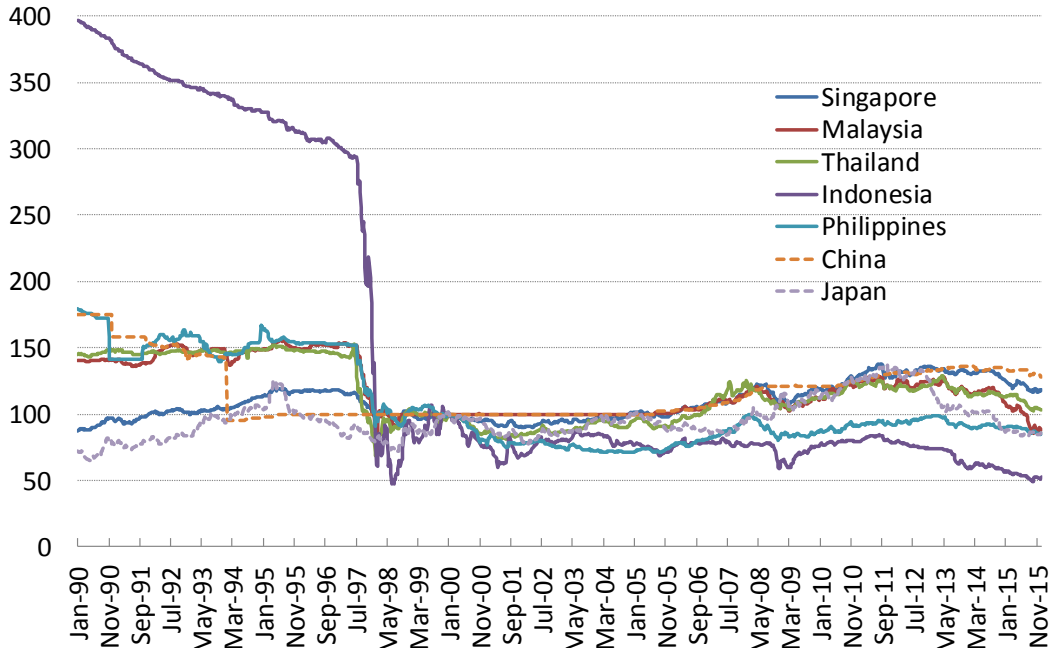
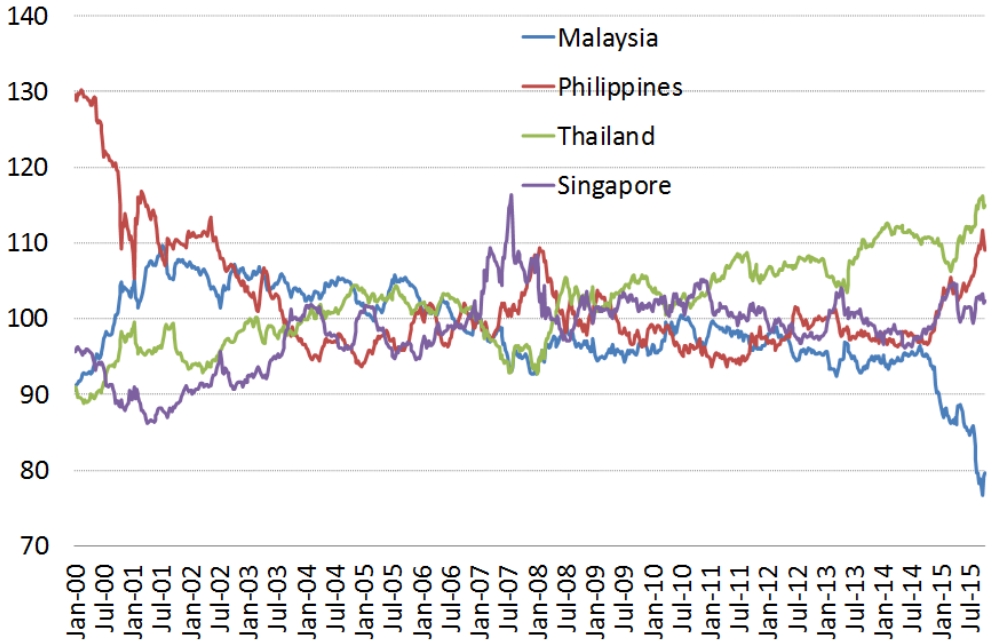


Figure A2. Exchange Rates Against Other ASEAN-4 Average
(2000w1=100, increase=appreciation)



Note: ASEAN-4 includes Malaysia, Philippines, Singapore, and Thailand.

Sources: Haver Analytics; and IMF staff calculations.

Figure A3. Exchange Rates Against Chinese Renminbi
(2000w1=100, increase=appreciate)

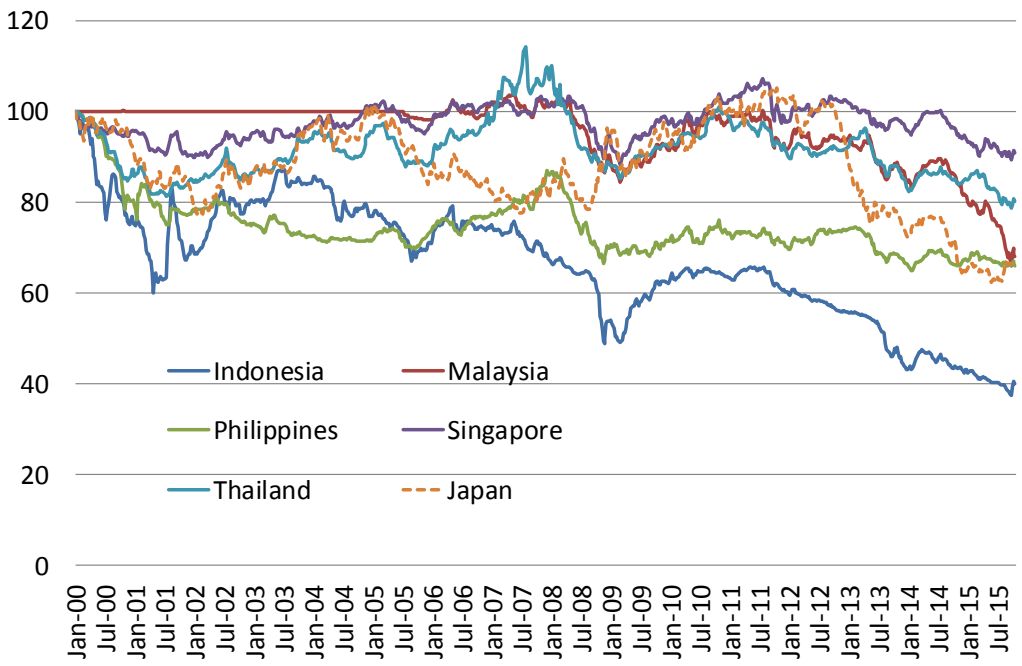
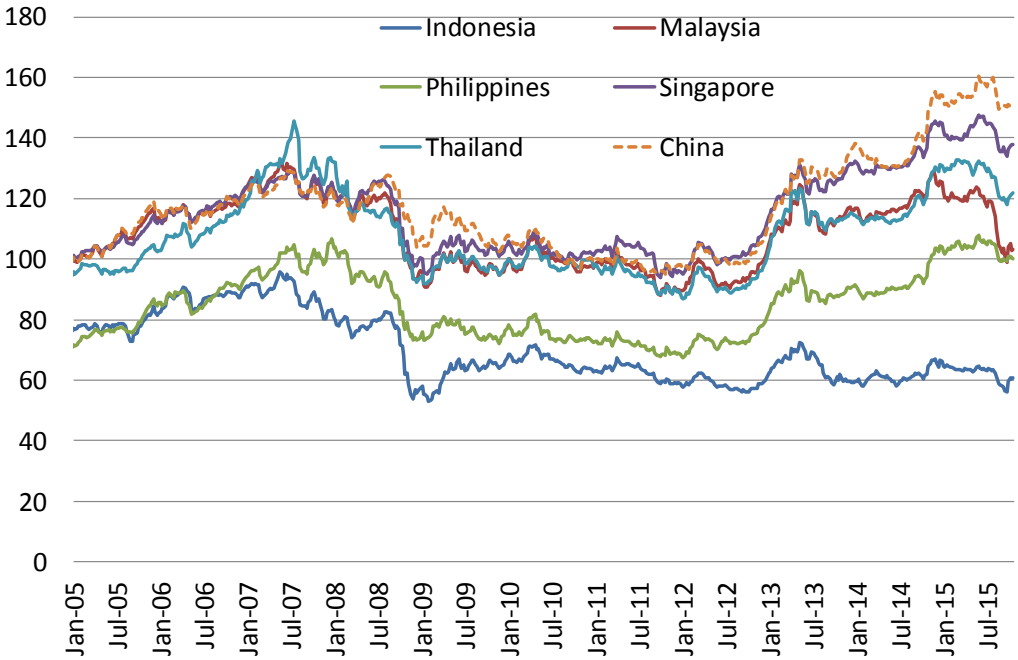
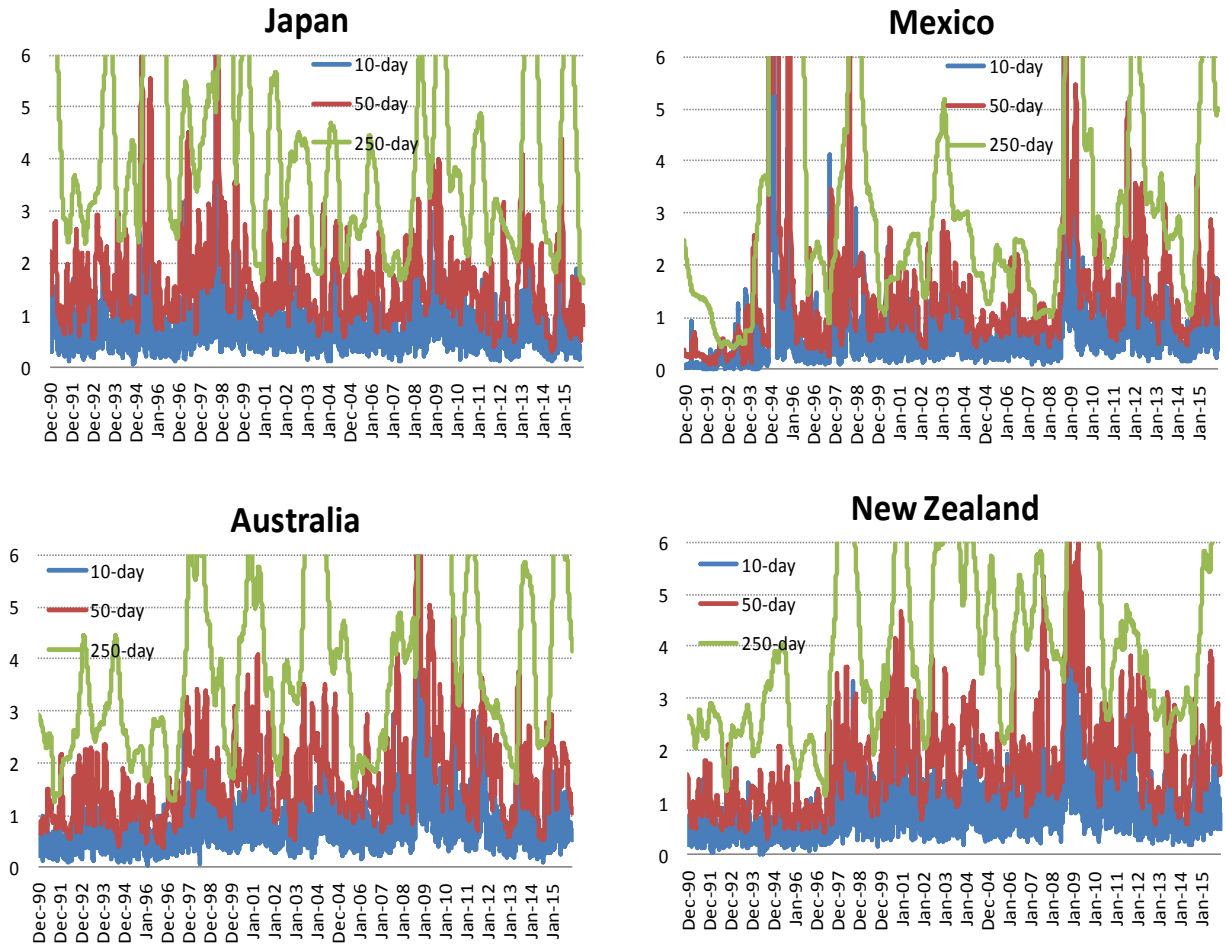


Figure A4. Exchange Rates Against Japanese Yen
(2000w1=100, increase=appreciate)



Sources: Haver Analytics; and IMF staff calculations.

Figure A5. Coefficient of Variation of Exchange Rates Against U.S. Dollar at Different Horizons



Sources: Haver Analytics; and IMF staff calculations.

Table A1. Regression Results

	Inter-II				Post GFC			
	4 majors	4M+RMB	4M+ ASEAN-4	4M+RMB +ASEAN-4	4 majors	4M+RMB	4M+ ASEAN-4	4M+RMB +ASEAN-4
Indonesian rupiah								
Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**0.88**	0.70	0.03	0.26	**0.74**	**0.42**	**0.26**	0.14
Japanese yen	**-0.13**	**-0.13**	-0.16	-0.16	-0.01	-0.01	-0.01	-0.01
European euro	0.10	0.10	0.00	0.01	-0.02	-0.01	**-0.09**	**-0.09**
British pound	0.04	0.05	0.01	0.01	**0.13**	**0.13**	0.05	0.05
Chinese renminbi		0.19		-0.25		**0.33**		0.13
Thai baht			**0.12**	**0.13**			**0.26**	**0.26**
Malaysian ringgit			0.46	0.47			**0.25**	**0.25**
Singapore dollar			**0.35**	**0.35**			**0.30**	**0.29**
Philippine peso			0.16	0.16			-0.02	-0.03
R-squared	0.62	0.62	0.68	0.68	0.58	0.58	0.64	0.64
Malaysian ringgit								
Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**0.87**	**0.27**	**0.27**	**-0.13**	**0.66**	**0.27**	-0.14	**-0.22**
Japanese yen	-0.03	-0.03	-0.05	-0.05	-0.06	-0.06	**-0.08**	**-0.08**
European euro	0.05	0.04	-0.06	-0.06	0.03	0.03	**-0.10**	**-0.10**
British pound	0.04	0.05	0.03	0.04	**0.16**	**0.15**	0.03	0.03
Chinese renminbi		0.61		0.44		**0.39**		0.08
Thai baht			0.03	0.02			**0.27**	**0.27**
Indonesian rupiah			0.10	0.10			**0.14**	**0.14**
Singapore dollar			0.47	0.45			**0.65**	**0.65**
Philippine peso			0.20	0.20			**0.22**	**0.21**
R-squared	0.87	0.88	0.91	0.92	0.61	0.62	0.74	0.74
Singapore dollar								
Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**0.65**	0.39	0.28	0.23	**0.47**	**0.27**	**0.18**	0.11
Japanese yen	**0.06**	**0.06**	**0.06**	**0.06**	**0.04**	**0.04**	**0.05**	**0.05**
European euro	**0.16**	**0.15**	**0.14**	**0.14**	**0.17**	**0.17**	**0.15**	**0.15**
British pound	0.03	0.03	0.01	0.01	**0.11**	**0.11**	**0.06**	**0.06**
Chinese renminbi		0.27		0.06		**0.21**		0.07
Thai baht			**0.10**	**0.10**			**0.13**	**0.13**
Indonesian rupiah			**0.04**	**0.04**			**0.05**	**0.05**
Malaysian ringgit			0.27	0.27			**0.22**	**0.21**
Philippine peso			0.01	0.01			0.02	0.02
R-squared	0.92	0.92	0.94	0.94	0.82	0.83	0.87	0.87
Philippine peso								
Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
U.S. dollar	**0.87**	0.74	0.37	0.54	**0.90**	**0.48**	**0.60**	**0.31**
Japanese yen	**0.01**	**0.01**	0.03	0.03	-0.03	-0.03	-0.02	-0.02
European euro	0.10	0.10	0.05	0.06	0.00	0.00	-0.03	-0.03

Table A1. Regression Results (continued)

		Inter-II				Post GFC			
		4 majors	4M+RMB	4M+ ASEAN-4	4M+RMB +ASEAN-4	4 majors	4M+RMB	4M+ ASEAN-4	4M+RMB +ASEAN-4
	Indonesian rupiah			0.08	0.08			-0.01	-0.01
	British pound	-0.04	-0.04	-0.06	-0.07	**0.06**	0.06	0.02	0.02
	Chinese renminbi		0.13		-0.18		**0.43**		**0.32**
	Thai baht			**-0.01**	**0.00**			**0.24**	**0.23**
	Malaysian ringgit			0.46	0.47			**0.16**	**0.15**
	Singapore dollar			0.05	0.05			0.05	0.04
	R-squared	0.79	0.79	0.83	0.83	0.81	0.82	0.84	0.84
Thai baht									
	Constant	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	U.S. dollar	**0.78**	0.45	0.49	0.29	**0.74**	**0.55**	**0.41**	**0.38**
	Japanese yen	**0.10**	**0.10**	**0.09**	**0.09**	0.01	0.01	0.02	0.02
	European euro	0.02	0.01	-0.04	-0.05	**0.07**	**0.07**	0.04	0.04
	British pound	0.04	0.05	0.03	0.03	0.05	0.05	0.00	0.00
	Chinese renminbi		0.34		0.22		**0.20**		0.03
	Indonesian rupiah			**0.05**	**0.05**			**0.06**	**0.06**
	Malaysian ringgit			0.05	0.03			**0.12**	**0.12**
	Singapore dollar			**0.32**	**0.32**			**0.18**	**0.18**
	Philippine peso			**0.00**	**0.00**			**0.14**	**0.14**
	R-squared	0.85	0.85	0.86	0.86	0.84	0.85	0.88	0.88

Note: Red indicates the coefficient is significant at 5 percent level. Red and bold significant at 1 percent level. Based on HAC standard errors. Daily observations.

Source: IMF staff calculations.

Appendix II. Unit Root Test Results

For the pre-AFC period, the hypothesis of no unit root is rejected at the 5 percent significance level for the Thai baht and the Philippine peso exchange rates against the U.S. dollar. This confirms the narrative of quasi-dollar-pegs in Southeast Asia before the AFC.[1] In addition, the unit root hypothesis is rejected for the Philippine peso exchange rates against the Malaysian ringgit and the Thai baht (at the 5 percent significance level) and against the Singapore dollar (at the 10 percent significance level).

During the first inter-crisis period, the unit root test unequivocally picks up the Malaysian ringgit peg to the U.S. dollar (and, indirectly, to the Chinese renminbi). No other ASEAN-5 currency appears linked to any major currency. However, the p-value for the baht-rupiah exchange is borderline at 10 percent. Mechanically this reflects the fact the Thai baht and the Indonesian rupiah both moved down against the U.S. dollar at the beginning of that period, then up, and then down again in a broadly synchronous fashion. However, it is hard to suspect that the policymakers intentionally tried to maintain the baht-rupiah rate within a narrow range. Most likely, the result reflects common or co-incidental shocks—after all, at the 10 percent significance level 10 percent is the probability of rejecting the null hypothesis even if it is true.

There are no stationary currency combinations during the second inter-crisis period.

Finally, after the GFC the ASEAN-5 currencies remained nonstationary against the U.S. dollar. The ADF tests suggest that the Indonesian rupiah-Japanese yen and the Singapore dollar-Philippine peso exchange rates might have been stationary after the GFC.[2] The former result likely reflects primarily the steep declines in both currencies that started in 2011. While simultaneous, to a large extent these declines can be attributed to country-specific factors—quantitative easing in Japan and domestic vulnerabilities in Indonesia. As for the Singapore dollar and the Philippine peso, both currencies underwent the same broad up and down arc as the other ASEAN-5 (and many other EM) currencies in the post-GFC period. The size of the swings against the U.S. dollar was relatively small for these two currencies, probably reflecting their political stability and low commodity dependence as well as fairly small trade linkages with China for the Philippines and a managed exchange rate regime for Singapore. Those forces likely held these two currencies relatively close to one another.

[1] One may wonder why the other three currencies have not been picked by the test. Indonesia had a de facto crawling peg against the U.S. dollar. If a trend is included in the test, the p-value drops to 0.11. The Malaysian ringgit and the Singapore dollar moved within narrow ranges against the U.S. dollar from the late 1994 but exhibited more variation in the earlier years—resulting in nonstationarity for the whole period 1990–96.

[2] The unit root hypothesis is rejected at the 10 percent significance level, but not at 5 percent.

Appendix III. Cointegration Tests

Given the history of hard and soft pegs to the U.S. dollar as well as the hypotheses of a Chinese renminbi club and an ASEAN club, we first test bilateral cointegration of the ASEAN-5 exchange rates with the U.S. dollar, the Chinese renminbi, and one another. For the pre-AFC period, the Johansen test finds only one cointegrating relationship at the 10 percent significance level—between the Thai baht and the U.S. dollar, with the cointegrating vector [1, -0.98], confirming the quasi-peg revealed by the unit root test. No cointegration has been found between any of the ASEAN-5 currencies and the Chinese renminbi. For several currency pairs p-values exceed 10 percent, but the purported cointegrating vectors are quite close to [1, -1] hinting at loose pegs to the U.S. dollar and (via the U.S. dollar) to one another.[1]

During the first inter-crisis period, the Malaysian ringgit is found to cointegrate with the U.S. dollar and the Chinese renminbi at the 1 percent significance level and cointegrating vector [1, -1] in both cases. This comes as no surprise at the Malaysian ringgit and the Chinese renminbi were both pegged to the U.S. dollar during that period. At the 5 percent significance level, the Singapore dollar is found to cointegrate with the U.S. dollar (as well as the Chinese renminbi and the Malaysian ringgit) with the vector [1, -0.87]. Mechanically, such a relationship could suggest a basket peg with at an 87 percent weight on the U.S. dollar and a 13 percent weight on the numeraire currency (see Appendix IV). While there is hardly a reason to believe that Singapore included the New Zealand dollar in its target basket with such a high weight, over the period in question the New Zealand dollar was highly correlated with the euro, which is a reasonable candidate for the Singapore dollar basket. This may explain why there is no unit root in the Singapore dollar/U.S. dollar exchange rate even though the two currencies are cointegrated. As in the pre-AFC period, several pairs of ASEAN-5 currencies are found to have putative cointegrating vectors close to [1, -1] even though the p-values are too high for the hypothesis of no cointegration to be rejected.

During the second inter-crisis period, no cointegration is found between any of the ASEAN-5 currencies and the U.S. dollar, the Chinese renminbi, or any of the other ASEAN-5 currencies. Moreover, unlike in the previous two periods, the putative cointegrating vectors are quite far from [1, -1], and often the two components even have the same sign. This confirms the results of the unit root tests for that period.

Finally, after the GFC, no cointegration is found between any of the ASEAN-5 currencies and the U.S. dollar. Bilateral cointegration tests between individual ASEAN-5 currencies

[1] Such pairs include (Philippine peso, U.S. dollar)—consistent with the unit root found in the Philippine peso/U.S. dollar exchange rate—as well as (Malaysian ringgit, U.S. dollar), (Malaysian ringgit, Philippine peso), (Malaysian ringgit, Thai baht), and (Philippine peso, Thai baht). If the Swiss franc is used as the numeraire, the trace test finds a cointegrating relationship between the Philippine peso and the U.S. dollar at the 10 percent significance level, while the maximum eigenvalue test rejects the relationship.

and the Chinese renminbi do not suggest a Chinese renminbi peg for the pre-GFC or post-GFC periods.[2]

This analysis confirms the results in Appendix II regarding targeting the level of a specific exchange rate.[3] As the next step, we conduct cointegration tests involving more than two variables.

The first series of tests explores the possibility of a basket peg for the ASEAN-5 currencies to a combination of the four major currencies. For the pre-AFC period, only one cointegrating relationship is found. It is between the Thai baht and the four major currencies, with most weight on the U.S. dollar.[4] So while the bilateral cointegration test is indicative of a Thai baht peg to the U.S. dollar, this multivariable test suggests the possibility of a basket peg (the weights add up to one), with the U.S dollar playing the dominant role.

During the first inter-crisis period, the Johansen test finds two cointegrating relationships among the major currencies—one between the euro and the pound and another one involving also the U.S. dollar and the Japanese yen. For that reason, during that period we only keep the U.S. dollar and the Japanese yen in the test as likely the most relevant currencies for the ASEAN-5 region. With that, we find two relationships—a very strong one between the Malaysian ringgit and the U.S. dollar, reflecting the peg; and a weaker one between the Singapore dollar, the U.S. dollar and the Japanese yen.[5] The latter relationship implies that Singapore followed a basket peg at the time.[6]

No cointegrating relationship is found in the second inter-crisis period. Post-AFC, at the 10 percent level only one test indicates cointegration—the maximum eigenvalue test for the

[2] Only one cointegrating relationship is found (between the Malaysian ringgit and the Chinese renminbi in the post-GFC period with the p-value close to 5 percent for both the trace and the maximum eigenvalue tests, but the cointegrating vector does not suggest a peg (both components have the same size, suggesting that the two currencies tend to move in opposite directions with respect to the New Zealand dollar).

[3] We also tested for cointegration between the Indonesian rupiah and the Japanese yen in the post-GFC period, given that the ADF test rejects a unit root in the Indonesian rupiah/Japanese yen exchange rate at the 10 percent significance level (though not at 5 percent). The Johansen test found no cointegration.

[4] The weights are 0.85 for the U.S. dollar, 0.07 for the Japanese yen, 0.06 for the British pound, and 0.03 for the Deutsche Mark.

[5] P-value of 0.056 for the trace test and 0.054 for the maximum eigenvalue test.

[6] The coefficients are 0.70 on the U.S. dollar and 0.22 on the Japanese yen. As discussed in Appendix IV, this implies a 0.08 weight on the New Zealand dollar in the basket. It is, of course, unlikely that Singapore would have such a high weight (if any) on the New Zealand dollar, and more plausibly 0.08 is the combined weight on the euro and the British pound (which happened to track closely one another and the New Zealand dollar during that period).

Thai baht. However, the combination of positive and negative weights in the cointegrating vector does not suggest exchange rate targeting.

Thus, the tests involving individual ASEAN-5 countries and the major currencies reveal a Thai baht peg to a basket heavily dominated by the U.S. dollar in the pre-AFC period; a hard Malaysian ringgit peg to the U.S. dollar and a softer Singapore dollar peg to a U.S. dollar-dominated basket during the first inter-crisis period; and no level targeting against the major currencies since 2005.

If we throw the Chinese renminbi into the mix, things get complicated. The Johansen test finds one cointegrating relationship between some of the ASEAN-5 currencies, the four major currencies, and the Chinese renminbi during the second inter-crisis period or the post-GFC period (or both) at the 5 percent significance level. However, in none of those cases does the cointegrating vector suggest a basket peg, with the negative coefficients on the non-ASEAN-5 currencies adding up to about minus one when the coefficient on the ASEAN-5 member is normalized to one. Instead, the non-ASEAN-5 coefficients tend to be large and have different signs. Most prominently, the largest in absolute value coefficients are on the U.S. dollar and Chinese renminbi (on the order of 10), and they have opposite signs. This does not look like a basket peg. Thus, we do not find evidence of ASEAN-5 currencies tracking a combination of the four major currencies and the Chinese renminbi.[7]

Finally, the hypothesis of a cointegrating relationship among the five ASEAN-5 currencies is rejected. This suggests that an ASEAN-5 club, or a subset thereof, does not exist.[8]

[7] The Phillips-Ouliaris test, which looks at whether the residuals from the regressions of the ASEAN-5 currencies on the U.S. dollar, Japanese yen, euro, British pound, and Chinese renminbi (all vis-à-vis the New Zealand dollar) have unit roots, rejects cointegration for all the ASEAN-5 currencies for both periods at the 5 percent level.

[8] If a cointegrating relationship existed among some of the ASEAN-5 currencies, a test involving all of them should have discovered it. In fact, if N of the five currencies were pegged to one another (including via some synthetic aggregate), the test should have found N-1 cointegrating relationships.

Appendix IV. Interpreting the Cointegration Vector

Suppose the log of the EUR/SGD exchange rate is cointegrated with the log of the EUR/USD exchange rate, with a cointegrating vector [1, -β], where 0<β<1. This means that a following relationship holds:

$$\log\left(\frac{EUR}{SGD}\right)_t = \alpha + \beta \log\left(\frac{EUR}{USD}\right)_t + \varepsilon_t,$$

where ε_t is stationary. Switching to any different numeraire (e.g., SDR) we can obtain:

$$\log\left(\frac{SDR}{SGD}\right)_t = \log\left(\frac{SDR}{EUR}\right)_t + \log\left(\frac{EUR}{SGD}\right)_t = \log\left(\frac{SDR}{EUR}\right)_t + \alpha + \beta \log\left(\frac{EUR}{USD}\right)_t + \varepsilon_t =$$
$$= \log\left(\frac{SDR}{EUR}\right)_t + \alpha + \beta\left[\log\left(\frac{SDR}{USD}\right)_t - \log\left(\frac{SDR}{EUR}\right)_t\right] + \varepsilon_t =$$
$$= \alpha + \beta \log\left(\frac{SDR}{USD}\right)_t + (1-\beta)\log\left(\frac{SDR}{EUR}\right)_t + \varepsilon_t$$

Econometrically, this means that the SDR/SGD exchange rate is cointegrated with the SDR/USD and SDR/EUR exchange rates. Economically, this would suggest that the Singapore dollar follows a basket consisting of the US dollar and the euro with the weights β and (1- β), respectively.

More broadly, if a cointegration tests suggest a cointegrating relationship where one currency in the units of a certain numeraire is a linear combination of other currencies with weights adding up to less than one, it may indicate a basket peg with the numeraire currency belonging to the basket (and making up the missing weight).