Running Head: EXCHANGE RATE REGIMES AND INTERANTIONAL RESERVES

Exchange Rate Regimes and International Reserves

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Abstract

In this paper we use a new classification of exchange rate arrangements developed by Reinhart and Rogoff (2002) to test whether reserve holdings decrease with increasing exchange-rate flexibility. Using pooled data for 137 countries over the period 1980-2000, we find several new results. First, the degree of exchange rate flexibility has an inverted-U relationship with the country's reserve holdings. Exchange rate regimes with intermediate flexibility need more reserves than polar regimes (hard pegs and freely floating). Second, reserve holdings are smaller under hard pegs than under freely floating, implying that current large stockpiles of reserves in East Asian countries can be significantly reduced if they adopt a single currency. Finally, per capita GDP and reserve holdings have an inverted-U relationship, too, reflecting that their correlation would be negative for industrial countries, but positive for developing countries.

Keywords: exchange rate regime, international reserves, currency union
JEL Classification Code: F15, F31, F33

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1. Introduction

One of the unresolved issues in international finance is whether exchange rate regimes matter for countries' international reserve accumulation. Theory suggests that countries with fixed or heavily managed exchange rates should hold more reserves to defend their currency values than countries with more flexible regimes. However, all empirical results of the previous studies do not support this standard view. Moreover, more countries have shifted from pegs to floating exchange rate regimes after the currency and financial crises occurred in the 1990s, but world reserve holdings have continued to rise over time. In this paper we empirically reexamine the relationship between exchange rate regimes and countries' reserve holdings with updated data and new exchange rate arrangements developed by Reinhart and Rogoff (2002).

Previous empirical studies on the relation between exchange rate regimes and international reserve holdings concentrated primarily on testing whether there was a change in reserve behavior in March 1973 when the international monetary system moved from a pegged-rate system to a floating-rate regime. The first attempt to test the standard view is Williamson (1974) where he found no strong evidence of any difference between countries' reserve use in the pre- and post-1973 period. He argues that demand and supply curves for foreign exchange may be variant with respect to the exchange rate system, and that more reserves may be demanded due to destabilizing capital flows after departing from a par value system.

Frenkel (1978, 1980, 1983) explicitly uses the buffer stock model to test the stability of the demand for international reserves between the pegged exchange rate period (1963-72) and the flexible exchange rate period (1973-79).[1] Based on estimated results from the cross-sectional and pooled regressions for both periods, he concludes that while there was some evidence of a leftward structural change in reserve demand by both developed and developing countries after moving to the latter period, greater flexibility of exchange rates had not fundamentally changed the general patterns of reserve holdings. The reasoning

[1] The flexible exchange rate period is 1973-75 for Frenkel (1978, 1980).

he suggested is that the exchange rate has been adjustable rather than fixed during the pegged rate regime while it has been managed rather than free during the floating rate regime.

Heller and Khan (1978) further investigates the question raised by Frenkel (1978), for which they estimate ARIMA models for reserves of the six country groupings with quarterly data over the period 1964-76. The results show that industrial countries reduced the demand for reserves as exchange rates became more flexible, but the reverse held true for non-oil developing countries. Their explanation for this is that non-oil developing countries were concerned more about the greater degree of uncertainty and variability of their payments balances resulting from being pegged to a floating currency.

On the other hand, Grimes (1993) theoretically verifies that the same reserves might be held under a floating rate regime as a fixed rate regime if the opportunity cost of holding reserves is negligible and/or that central banks are extremely risk averse regarding reserve shortfalls.

Some other studies have examined that not all countries may behave the same way with respect to their demand for reserves even under a pegged exchange rate system. Edwards (1983) divides 41 developing countries into two groups: the first one maintained a fixed exchange rate during 1964-72 (adjusted their parities by less than 1% a year), and the second one had devaluations by at least 10% during this period. The estimation results prove that devaluation countries held, on average, less than fixed-rate countries, reflecting that countries with more flexible exchange-rate policies demanded smaller reserves.

Recent empirical results on this issue are mixed. Flood and Marion(2002) and Aizenman and Marion (2002, 2004) show, using panel data, that the volatility of the nominal effective exchange rates significantly reduces the level of reserves, suggesting that greater exchange-rate flexibility lower reserve holdings. On the other hand, Lane and Burke (2001) use cross-sectional data for 102 countries over the period 1981-95, and find no significant relationship between the exchange rate regime and the level of reserves.

Overall, previous empirical results for testing the standard view are inconclusive. The reason may be that all studies relied upon countries' officially-declared classifications of exchange rates that do not often describe actual country practice. Reinhart and Rogoff (2002) re-classified exchange rate regimes based on historical chronology and data on market-determined rates going back to 1946 for 153 countries. Using their new exchange rate arrangements and pooled data for 137 countries over the period 1980-2000, in this paper, we will identify the determinants of the country's reserve holdings and re-estimate the effect of the exchange rate system on the demand for reserves.

We find several new results. First, the exchange rate regime has an inverted-U relationship with the country's reserve holdings. Intermediate regimes need more reserves than polar regimes (hard pegs and freely floating). Second, reserve holdings are smaller under hard pegs than under freely floating, implying that countries with a single currency can significantly reduce their optimal reserve holdings. The third, minor result is that per capita GDP and reserve holdings have an inverted-U relationship, too.

In section 2, we describe the empirical specification and data, and analyze the regression results. Section 3 discusses reserve implications for a single currency in an East Asian perspective. The final section summarizes the paper's main findings.

2. Empirical Evidence: Exchange Rate System and Reserve Holdings

2.1 The Empirical Specification

To analyze the effect of the exchange rate system on international reserve holdings, we set up an estimating equation as follows:

$$\ln(RES_{it}) = \beta_0 + \beta_1 \ln(PGDP_{it}) + \beta_2 \ln(GDP_{it}) + \beta_3 \ln(TOPEN_{it}) + \beta_4 \ln(FOPEN_{it}) + \beta_5 \ln(INTEREST_{it}) + \beta_6 \ln(VOLATILITY_{it}) + \beta_{7j} DUMMY_{j,it} + e_{it} \quad (1)$$

where *RES* is actual holdings of reserves, *PGDP* is per capita GDP, and *GDP* is the Gross Domestic Products. *TOPEN* is trade openness measured as the ratio of exports plus imports to GDP. *FOPEN* is financial openness that is defined as the ratio of gross private capital flows to GDP. INTEREST means

lending interest rates used as a proxy for the opportunity cost of holding reserves, and VOLATILITY is export volatility. $DUMMY_j$ stands for the dummy for exchange rate regime, *j*. The subscripts, *i* and *t*, denote country *i* and year *t*, respectively.

The RHS variables are chosen as potential determinants of reserves on the basis of previous empirical studies.[2] Per capita GDP is included as a general control variable for the level of development. Regarding the standard of living, richer countries may accumulate larger reserves. However, richer countries are less subject to speculative attacks and financial crises so that they can survive with smaller reserves. Thus, the sign of β_1 is not unambiguous. Next, reserve holdings should increase with the size of international transactions, generally represented by GDP or population size. The regression results shown later are similar for either of the two variables; so we use GDP as the scaling factor. The sign of β_2 is expected to be positive.

Reserves should also be built up with the vulnerability of both real and financial external shocks such as terms-of-trade shocks and the currency and financial crises. To the extent that a country is more open in the real side as well as in the financial side, it is more vulnerable to such shocks. Thus real and financial-side openness both should be positively correlated with reserve holdings, that is, $\beta_3 \rangle 0$ and $\beta_4 \rangle 0$.

The demand for reserves should decrease with the opportunity cost of holding them ($\beta_5 \langle 0$). The opportunity cost variable is difficult to measure exactly. Recently, Flood and Marion (2002) defined it as the spread between the country's own bond yield (or, lending, deposit, money market rates) and the return on U.S. Treasury Bills. Instead we use the country's lending interest rate only as a proxy for the opportunity cost. The reason is that the estimation results show little difference between the lending rate only and its spread over the return on Treasury Bills.

[2] Determinants of reserves used here are based on the buffer stock model. Another view is the monetary approach to balance of payments where the disequilibrium of money market reflects changes in international reserves. See Frenkel(1983), Edwards (1983), Elbadawi (1990), Ford and Huang (1994), and Huang and Shen (1999). Also see Bahmani-Oskooee and Brown (2002) for a recent review of the literature on international reserves.

Reserve holdings should be positively correlated with reserve volatility, represented here by the volatility of export earnings, if they are intended to minimize adjustment costs caused by reserve shortfalls. So we expect $\beta_6 \rangle 0$. Finally, we add the dummies for historical exchange rate regimes classified by Reinhart and Rogoff (2002). The hypothesis to be tested in this section is that reserve holdings should decrease with exchange-rate flexibility.

2.2 Data

The data set consists of reserve information from the period 1980–2000 for 137 countries, listed in Table 1. The countries are chosen based on the availability of reserve data and other explanatory variables for estimation. The total reserves minus gold (.1L.DZF) series in million US dollars from the IFS CD-ROM from the International Monetary Fund (IMF) (2003) are used as a measure of international reserves. GDP, per capita GDP, lending interest rate, trade openness, and financial openness are taken from the World Development Indicators CD-ROM from the World Bank (2002). GDP and per capita GDP are measured in current US dollars. Lending interest rate is the rate charged by banks on loans to prime customers. Trade openness is defined as the ratio of merchandise exports plus imports to GDP, measured in current U.S. dollars. Financial openness is measured as the ratio of gross private capital flows to GDP in U.S. dollars. Export volatility is calculated as the coefficient of variation calculated from the monthly export data for the corresponding year (.70..DZF..). Table 2 reports summary statistics for the data described above.

→ Insert Tables 1 and 2 here

Reinhart and Rogoff (2002) used historical chronologies and data on market-determined parallel exchange rates to develop a new system of exchange rate regimes. They call their classification scheme as a "natural" system in contrast to the official IMF classification scheme that often fails to describe actual

country practice, implying that the large gap between *de jure* and *de facto* can exist in the latter case. Table 3 presents two kinds of the natural classification scheme of Reinhart and Rogoff. The first one consists of 14 types of exchange rate arrangements and the second covers 5 broader categories. What critically differs from the official classification scheme is, first, that the natural scheme captures regime changes by month and groups historical exchange rate arrangements into much finer grid of regimes in contrast with just three of four buckets for the official scheme. Second, the former has a new category, called "freely falling" regime, for countries whose twelve-month rate of inflation is over 40%.

→ Insert Table 3 here.

Tables 4 and 5 show frequency and share of each category for the fine and coarse grid classifications, respectively, for pooled data used in the regression. For the fine grid, which is coded from 1 to 14 (we call, 'mcode'), a dummy variable, FINE*j* is 1 if 'mcode' belongs to *j*; 0 otherwise (*j* = 1,2,3, ….,14). For the coarse grid that is coded from 1 to 5 (we call, mgcode), a dummy variable SYSTEM*j* is 1 if mgcode belongs to *j*; 0 otherwise (*j* = 1,2, ..,5). Here the exchange rate regime becomes more flexible as *j* increases.

→ Insert Tables 4 and 5 here.

2.3 Regression Results

Using pooled data from 1980 to 2000 for 137 countries, we estimate equation (1) by OLS (ordinary least squares), with Huber-White-sandwich corrected standard errors. The first attempt is to use the

dummies for 5 types of exchange-rate arrangements (SYSTEM1–SYSTEM5).[3] The regression results are shown in Table 6 where SYSTEM4 (freely floating) is used as a reference group.

All explanatory variables in equation (1) are included in column (a).[4] Regarding traditional control variables, first, the estimated coefficient of per capita GDP is positive, but insignificant. However, the coefficients on GDP, trade openness and financial openness are positive and significant at 1%. Larger countries hold more reserves. Countries more open to external trade in the real and financial side have more chances to face external shocks and thus demand greater international reserves. Lane and Burke (2001) also confirm that real openness is the most important determinant of cross-country variation in reserve accumulation. Flood and Marion (2002) show that both real and financial openness are positively correlated with reserve holdings.

The estimated coefficients of the opportunity cost variable and export volatility are not significant at all. Most empirical studies have been unable to find a significant opportunity cost effect, too.[5] We re-estimated equation (1) with an opportunity cost measure of Flood and Marion (2002), the spread between the country's lending interest rate and the return on U.S. Treasury Bills. But we find that its estimated coefficient is still insignificant with little change in the estimated values of the other explanatory variables. In contrast to other studies, on the other hand, export volatility does not significantly affect reserve holdings. An exception was Lane and Burke (2001) where export volatility has a wrong sign and its coefficient is insignificant in the full-sample regression. Ben-Bassat and Gottlieb (1992) did not use volatility as an explanatory factor in their empirics. Their theoretical model indicates an unambiguous relationship between reserve (or export) volatility and reserve holdings, but cannot explain why. The reason may be that monetary authorities have been concerned more about increased uncertainty in the

[3] Reinhart and Rogoff (2002) use this coarse grid classification to match with the four bucket official classification that consists of SYSTEM1 (peg), SYSTEM2 (limited flexibility), SYSTEM3 (managed floating), and SYSTEM4 (independent floating).

[4] We also used the ratio of reserves to GDP as a dependent variable after excluding GDP from RHS. But the estimation results for the other control variables are almost left intact.

[5] The exceptions are Edwards (1985), Landell-Mills (1989), and Ben-Bassat and Gottlieb (1992). In their literature survey, Bahmani-Oskooee and Brown (2002) conclude that the measure of opportunity cost is significant when countries are considered individually, but insignificant when data are pooled.

financial side during the 1980s-90s when capital mobility across countries becomes greater as capital account liberalization progresses.

For exchange rate regimes, SYSTEM2 and SYSTEM3 have positive estimated coefficients at 1% significance level, but no significance is found in SYSTEM1 and SYSTEM5. The results imply that the country's reserve holdings are larger under limited flexibility and managed floating regimes than under a freely floating regime.

Turning back to the relationship between per capita GDP and reserve holdings, the regression results of previous studies are not conclusive. For example, Aizenman and Marion (2002, 2003) show that the coefficient of per capita GDP is positive and highly significant. For Lane and Burke (2001), however, it is negative and insignificant for industrial country sample while it is positive and significant for several cases within the sample to developing countries. Thus we add the square of per capita GDP to equation (1), assuming that per capital GDP may have an inverted-U relationship with reserve holdings. The results are presented at column (b). As expected, PGDP and the squared term are positive and negative, respectively, at 1% significance level. The estimated figures imply that reserve holdings should increase with the standard of living from low-income to mid-income level, but thereafter decrease as income moves up to high level. Thus the relationship between per capita GDP and reserve holdings would be negative for industrial country sample, but positive for developing country sample. The income level where reserve holdings are maximized is roughly 14,487 US dollars.[6] Compared to column (a), the estimates for the other control variables are almost the same. The exceptions are that the sign of SYSTEM1 turns to negative, but still insignificant; SYSTEM5 becomes significant at 15% level.

In regressions (a) and (b), the opportunity cost and export volatility are insignificant. We do F-test to see whether the coefficients of both variables are all zero. The p-value of F-test is 0.4776, suggesting that the null hypothesis should not be rejected. Thus, these two variables are dropped in regression (c). What differs from regression (b) is that the coefficient of SYSTEM1 is negative and highly significant

[6] 0.824-2*0.043*ln(PGDP)=0, ln(PGDP)=9.581, PGDP=14,486

while SYSTEM5 loses its significance. The estimated figures infer that countries with SYSTEM1 (peg) hold reserves less by 18% than those with SYSTEM4 (freely floating).[7] On the other hand, countries having SYSTEM2 and SYSTEM3 hold them more by 23% and 33%, respectively.[8] Furthermore we did F-test to see whether there is a difference between SYSTEM2 and SYSTEM3. The p-value for the F-statistics is 0.1062, indicating that the null hypothesis that both coefficients are the same cannot be rejected at the 10% significance level.

➔ Insert Table 6 here.

As a second attempt, we used the dummies for 14 types of arrangements, ranging from FINE1 to FINE 14. The results are presented at Table 7 where FINE13 (freely floating) is used as a reference group. The regression results for the other control variables are very similar to those of Table 6. Regarding exchange rate regimes, FINE12 (managed floating) is the only variable whose coefficient is insignificant for all regressions. Focusing on regressions (b) and (c), all the coefficients of the other regimes are significant at least at 10% level, except FINE5 in (c). The estimated coefficients are negative for FINE1-FINE3, FINE5 and FINE14, but positive for the other regimes.

Reserve implications for the estimation results can be summarized as follows: compared to a freely floating regime, first, countries hold fewer reserves under hard peg regimes such as currency union, dollarization, currency board, and pre-announced horizontal band. However, more reserves are held under de facto peg. The possible explanation for this result is that under hard pegs, monetary authorities should hold reserves more for the transactional motive, but less for the precautionary motive since they are less subject to speculative attacks. As capital account liberalization progresses with greater capital mobility, the latter motive becomes the more important factor for the country's reserve accumulation. Among hard

[7] $RES_{SYSTEM1}/RES_{SYSTEM4}=e^{-0.1202}=0.82$
[8] $RES_{SYSTEM2}/RES_{SYSTEM4}=e^{0.204}=1.23$, $RES_{SYSTEM3}/RES_{SYSTEM4}=e^{0.287}=1.33$

pegs, FINE1 has the least value: for regression (c), countries with FINE1 (a single currency) hold reserves less by 53%[9] than those with FINE13 (freely floating).

As expected, second, countries with intermediate regimes such as crawling pegs or bands demand larger reserves. FINE11 (moving band ($\leq \pm 2\%$))has the highest value: FINE11 needs reserves more by 203%[10] compared to FINE13. A surprising result is, however, that a managed floating regime does not differ from a freely floating regime in reserve holdings. As Calvo and Reinhart (2002) assert, the reason may be that in many cases the authorities subject to freely floating have been attempting to stabilize the exchange rate through direct intervention in the foreign exchange market.

Finally, the level of reserves is lower under freely falling relative to freely floating. Most of countries that experienced a freely falling regime are the transition economies[11] and developing countries that have been exposed to large fiscal deficits, high foreign debt, political corruption, and/or political instability. The reason that countries with a freely falling regime hold smaller reserves may be that foreign debt substitutes for reserves as a means of financing external transaction (Lane and Burke, 2001). As Aizenman and Marion (2002, 2003) argues, furthermore, countries with high discount rates, political instability or political corruption may hold smaller precautionary reserve balances.

➔ Insert Table 7 here.

In Table 8, we used only the dummies of FINE1-FINE3 to focus on a currency union. FINE1 indicates "No separate legal tender" which includes a currency union such as euro, dollarization etc., FINE2, "Pre announced peg or currency board arrangement", and FINE3, "Pre announced horizontal band that is narrower than or equal to $\pm 2\%$". The results confirm that all three dummies are negative and significant at 1% level with little change in the estimates for the other control variables. In case of

[9] $RES_{FINE1}/RES_{FINE13}=e^{-0..746}=0.47$
[10] $RES_{FINE11}/RES_{FINE13}=e^{1.111}=3.03$

regression (c), FINE1 and FINE2 need fewer reserves than the benchmark (FINE4-FINE14) by 55% and 59% respectively.[12] We also performed F-tests to see the equality of FINE1 and FINE2, FINE2 and FINE3, and FINE1 and FINE3. The p-values are 0.5779, 0.0039, and 0.0005, respectively. This means that the null hypothesis for the equality of FINE1 (or, FINE2) and FINE3 could be rejected while the equality of FINE1 and FINE2 holds. The figures reflect that the demand for reserves decreases by 34%[13] when the regime changes from FINE3 to FINE1.

➔ Insert Table 8 here.

The regression results obtained up to now suggest that the exchange rate regime be nonlinearly correlated with the country's reserve holdings. Based on the estimated values for the dummies, we assume an inverted-U relationship between reserves and the exchange rate regime. In columns (a)-(c) of Table 9, we replaced the regime dummies by 'mcode' and its squared term where 'mcode' represents the numbers ranging from 1 to 14 in the fine grid. The results show that mcode and the squared term are positive and negative, respectively, at 1% significance level, thus verifying the inverted-U relationship.

We also tried to draw a graph for this inverted-U relationship and identify a regime that holds the largest reserves. To do this, we first extract the residuals from regressing reserves on the other control variables in column (d). Next, we regress the estimated residuals on mcode and the squared term. The results are shown in column (e) and drawn at Figure 1 where the residuals and mcode are juxtaposes at the vertical and horizontal axes, respectively. The figure clarifies, first, that reserve holdings are smaller under extreme exchange rate regimes (hard pegs and freely floating) than under intermediate regimes. Second, hard pegs demand fewer reserves than freely floating. Third, we can roughly derive a mcode number of holding maximum reserves, which is about 8.9.

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[11] In the 1990s, freely falling accounts for 41 percent of the observations for the transition economies (Reinhart and Rogoff, 2002).

[12] $RES_{FINE1}/RES_{other}=e^{-0.794}=0.45$, $RES_{FINE2}/RES_{other}=e^{-0.883}=0.41$

[13] $RES_{FINE1}/RES_{FINE3}=e^{-0.794-(-0.382)}=e^{-0.412}=0.66$

➔ Insert Table 9 here.

➔ Insert Figure 1 here.

3. Reserve Implications for a Currency Union

The empirical results in section 2 verify that FINE1 needs the least reserve holdings among exchange rate regimes. This implies that the member countries of a currency union hold fewer reserves than otherwise. As discussed above, they may have smaller precautionary balances since they are less affected by currency crises and speculative pressures. For instance, Spain put a lot of money in Argentina and was heavily hit by the 2001 Argentine crisis. However, Spanish peseta was safe from speculative attacks. The main reason is that Spain was a member of EMU (European Economic and Monetary Union).

Since the 1997 Asian currency crisis, East Asian countries have accumulated large stocks of reserves. The world's top five holders of reserves are all within the Far East. Aizenman and Marion (2003) interpreted the build-up of large reserves in East Asian countries as representing precautionary holdings, particularly due to loss aversion against a future crisis. However, some argue that such large stock piles of reserves are too excessive since reserves can be invested into more profitable assets overseas, or criticize these East Asian countries as a mercantilist. On the other hand, the successful launch of the euro in 1999 initiated academic and political interest in the possibility of monetary integration in the East Asian region. Based on our empirical analysis, we will discuss reserve implications for an East Asian currency union in this section.

We first consider the coarse grid of exchange rate regimes for eight East Asian countries (China, Korea, Japan, Indonesia, Malaysia, Philippines, Singapore and Thailand), shown in Table 10. Columns (a) and (c) represent each country's current exchange rate system (mgcode) and actual reserve balances in

2001, respectively. Column (b) shows the ratio of hypothetical reserves to current reserve balances where the former is defined as reserve balances that would be if a country adopts SYSTEM1, and calculated from column (c) in Table 6. Hypothetical reserve balances are shown in column (d). The figures in the table indicate that if all countries choose SYSTEM1, reserve balances can decrease by 39% and 18% for SYSTEM3 (Philippines, Singapore and Thailand) and SYSTEM4 (Korea, Japan and Indonesia), respectively. The total reserves of eight East Asian countries would fall from 892,405.6 to 750,620.8 million US dollars, thus decreasing by 16%.

➔ Insert Table 10 here.

Table 11 shows the case of the fine grid of exchange rate regimes for the same East Asian countries.. The estimates derived from column (c) in Table 7 imply that if all East Asian countries adopt a single currency, China (FINE4) would save international reserves by 65%. Likewise reserve holdings would be reduced by 49% for Korea, Japan and Indonesia (FINE13) and for Philippines, Singapore and Thailand (FINE12), and by 22% for Malaysia (FINE2). Total reserves in this region can decrease by 52%, up to 426,858.1 million US dollars. All these figures reflect that an East Asian currency union can contribute to significantly reducing currently excessive holdings of reserves in this region and to lead them to be invested for more profitable assets.

➔ Insert Table 11 here.

4. Concluding Remarks

Using Reinhart and Rogoff's new exchange rate arrangements, we find in this study that reserve holdings are significantly and nonlinearly correlated with the exchange rate system. In contrast to the

previous empirical results, which depended mostly upon the official IMF classification, the exchange rate regime has an inverted-U relationship with reserves. First, reserve holdings are smaller under polar regimes (hard pegs and freely floating) than under intermediate regimes. Second, hard pegs demand reserves less than freely floating.

Regarding the other determinants of the demand for reserves, country size, real openness and financial openness all raise reserve holdings while the opportunity cost and export volatility are not significant variables. Unlike previous studies, however, per capita GDP and reserve holdings have an inverted-U relationship, reflecting that their correlation would be negative for industrial countries, but positive for developing countries.

The first implication of our empirical results is that the exchange rate system matters for the country's reserve holdings. In the official classification, freely floating accounts for over 30 percent of observations in the past decade. In the new classification, however, the share of freely floating is only 5.1 percent the total observations as shown in Tables 4 and 5. Limited flexibility, which is dominated by *de facto* crawling peg and crawling narrow-band in the new scheme, is the second most important grouping over the past decade, just behind pegs. On the other hand, its share is very small under the official scheme. That is, *de facto* intermediate regimes still dominate world currency arrangements even though more countries have shifted to *de jure* floating exchange rates in the 1990s. This fact is one of the main reasons that world reserve holdings did not cease to rise over time.

The second implication is related to a choice of a monetary regime. A currency union enhances trade among members and growth via trade (Frankel and Rose, 2002). Our results also confirm that countries with a single currency can substantially reduce their demand for reserve holdings. Thus adopting a single currency may be a valuable option for regions such as an East Asian region that experienced monetary and financial instability. The literature[14] reached a consensus on the conclusion that East Asian countries almost meet the economic preconditions of EMU countries before the Maastricht Treaty was signed in

[14] Among them are Bayoumi and Mauro (1999), Eichengreen and Bayoumi (1999) and Baek and Song (2002).

1991. Contrary to the EMU, however, a significant gap still remains among the East Asian countries in non-economic factors. In East Asia, political cooperation and institutionalization may be the prerequisites for discussions on the plausibility of a single currency based on economic conditions.

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<Appendix>

Table 1. Country List

	Country		Country		Country		Country
1	Albania	41	France	81	Malawi	121	Swaziland
2	Algeria	42	Gabon	82	Malaysia	122	Sweden
3	Antigua and Barbuda	43	Gambia, The	83	Mali	123	Switzerland
4	Argentina	44	Georgia	84	Malta	124	Tajikistan
5	Armenia	45	Germany	85	Mauritania	125	Tanzania
6	Australia	46	Ghana	86	Mauritius	126	Thailand
7	Austria	47	Greece	87	Mexico	127	Togo
8	Azerbaijan	48	Grenada	88	Micronesia, Fed.Sts.	128	Tunisia
9	Belarus	49	Guatemala	89	Moldova	129	Turkey
10	Belgium	50	Guinea	90	Mongolia	130	Uganda
11	Benin	51	Guinea-Bissau	91	Morocco	131	United Kingdom
12	Bolivia	52	Guyana	92	Myanmar	132	Ukraine
13	Bosnia & Herzegovina	53	Haiti	93	Nepal	133	Uruguay
14	Botswana	54	Honduras	94	Netherlands	134	United States
15	Brazil	55	Hong Kong	95	New Zealand	135	Venezuela
16	Bulgaria	56	Hungary	96	Nicaragua	136	Zambia
17	Burkina Faso	57	Iceland	97	Niger	137	Zimbabwe
18	Burundi	58	India	98	Nigeria		
19	Cameroon	59	Indonesia	99	Norway		
20	Canada	60	Ireland	100	Pakistan		
21	Central African Rep.	61	Israel	101	Panama		
22	Chad	62	Italy	102	Paraguay		
23	Chile	63	Jamaica	103	Peru		
24	China,P.R.: Mainland	64	Japan	104	Philippines		
25	Colombia	65	Jordan	105	Poland		
26	Congo, Dem. Rep. of	66	Kazakhstan	106	Portugal		
27	Costa Rica	67	Kenya	107	Romania		
28	C?e d'Ivoire	68	Korea	108	Russia		
29	Croatia	69	Kuwait	109	Saudi Arabia		
30	Cyprus	70	Kyrgyz Republic	110	Senegal		
31	Czech Republic	71	Lao People's Dem.Rep	111	Singapore		
32	Denmark	72	Latvia	112	Slovak Republic		
33	Dominica	73	Lebanon	113	Slovenia		
34	Dominican Republic	74	Lesotho	114	South Africa		
35	Ecuador	75	Liberia	115	Spain		
36	Egypt	76	Libya	116	Sri Lanka		
37	El Salvador	77	Lithuania	117	St. Kitts and Nevis		
38	Equatorial Guinea	78	Luxembourg	118	St. Lucia		
39	Estonia	79	Macedonia, FYR	119	St. Vincent & Grens		
40	Finland	80	Madagascar	120	Suriname		

Source: Selected from Reinhart and Rogoff (2002)

Table 2. Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Reserves(RES)	2448	7633.138	19527.91	0.04	354902
Reserve Ratio(res/gdp)	2400	1.08E-07	1.38E-07	9.43E-11	1.25E-06
GDP(GDP)	2554	1.64E+11	6.69E+11	2.72E+07	9.84E+12
Per capita GDP(PGDP)	2461	6699.274	6936.811	344	50100
Lending interest rate(INTEREST)	2006	87.40024	2726.134	2.07	122000
Trade openness(TOPEN)	2521	77.50398	50.84178	1.53	439
Financial openness(FOPEN)	2273	14.35398	26.83184	0.0293	649
Export volatility(EXVOL)	1856	0.184149	0.140069	0.019214	1.381729

Source: authors' calculation from IFS CD-ROM, IMF (2003) and WDI CD-ROM, World Bank (2002).

Table 3. Exchange Rate System classified by Reinhart and Rogoff (2002)

Natural Classification bucket	Number assigned to category in fine grid (mcode; FINE)	Number assigned to category in coarse grid (mgcode; SYSTEM)
No separate legal tender	1	1
Pre announced peg or currency board arrangement	2	1
Pre announced horizontal band that is narrower than or equal to ±2%	3	1
De facto peg	4	1
Pre announced crawling peg	5	2
Pre announced crawling band that is narrower than or equal to ±2%	6	2
De facto crawling peg	7	2
De facto crawling band that is narrower than or equal to ±2%	8	2
Pre announced crawling band that is narrower than or equal to ±2%	9	2
De facto crawling band that is narrower than or equal to ±5%	10	3
Moving band that is narrower than or equal to ±2%(i.e., allows for both appreciation and depreciation over time)	11	3
Managed floating	12	3
Freely floating	13	4
Freely falling	14	5

Source: Reinhart and Rogoff (2002) page 21 Table 4 and author's classification

Table 4. Statistics for fine grid classification

mcode(FINE)	Frequency	Percent	Cumulative percent
1	131	4.9	4.9
2	550	20.57	25.47
3	2	0.07	25.54
4	227	8.49	34.03
5	16	0.6	34.63
6	20	0.75	35.38
7	217	8.12	43.49
8	453	16.94	60.43
9	8	0.3	60.73
10	229	8.56	69.3
11	32	1.2	70.49
12	287	10.73	81.23
13	135	5.05	86.28
14	367	13.72	100
Total	2,674	100	

Source: authors' calculation from Reinhart and Rogoff (2002).

Table 5. Statistics for coarse grid classification

mgcode(SYSTEM)	Frequency	Percent	Cumulative percent
1	910	34.03	34.03
2	707	26.44	60.47
3	555	20.76	81.23
4	135	5.05	86.28
5	367	13.72	100
Total	2,674	100	

Source: authors' calculation from Reinhart and Rogoff (2002).

Table 6. Coarse Grid Exchange Rate Arrangements and Demand for International Reserves[1,2,3]

Dependent Variable	ln(*RES*)		
	(a)	(b)[4]	(c)[5]
Constant	-18.975***	-24.833***	-22.291***
	(0.506)	(1.295)	(1.231)
ln(*PGDP*)	0.040	1.527***	0.824***
	(0.029)	(0.315)	(0.278)
ln(*PGDP*) * ln(*PGDP*)		-0.090***	-0.043**
		(0.019)	(0.017)
ln(*GDP*)	0.940***	0.946***	0.947***
	(0.017)	(0.017)	(0.015)
ln(*TOPEN*)	0.760***	0.734***	0.664***
	(0.058)	(0.059)	(0.053)
ln(*FOPEN*)	0.148***	0.157***	0.144***
	(0.035)	(0.036	(0.031)
ln(*Interest*)	0.039	-0.017	
	(0.034)	(0.036	
ln(*Volatility*)	0.045	0.058	
	(0.051)	(0.051)	
SYSTEM1	0.038	-0.043	-0.202**
	(0.082)	(0.080)	(0.083)
SYSTEM 2	0.218***	0.139**	0.204***
	(0.070)	(0.070)	(0.072)
SYSTEM 3	0.297***	0.249***	0.287***
	(0.075)	(0.075)	(0.076)
SYSTEM 5	-0.111	-0.148[#]	-0.079
	(0.098)	(0.096	(0.084)
R^2	0.868	0.868	0.845
F-statistics	965.15	965.15	1495.89
Probability > F	0.0000	0.0000	0.0000
No of observations	1376	1376	2141

Source: authors' calculation

Notes:

1. *RES* stands for the international reserves, *PGDP* is per capita GDP, *GDP* is the Gross Domestic Product, *TOPEN* is trade openness, *FOPEN* is financial openness, *Interest* is lending interest rate, *Volatility* is the export volatility.
2. [#], *, **, and *** denote significance at the 15%, 10%, 5%, and 1% levels, respectively.
3. Huber-White-sandwich corrected standard errors in parentheses.
4. From column (b), F-test for linterest=lexvol=0, F(2, 1364) =0.74, Prob > F = 0.4776
5. From column (d), F-test for system2 =system3, F(1, 2131) = 2.61, Prob > F = 0.1062

Table 7. Fine Grid Exchange Rate Arrangements and Demand for International Reserves[1,2,3]

Dependent Variable	ln(*RES*)		
	(a)	(b)[4]	(c)[5]
Constant	-18.258***	-23.483***	-20.180***
	(0.503)	(1.238)	(1.240)
ln(*PGDP*)	0.008	1.337***	0.615**
	(0.029)	(0.302)	(0.274)
ln(*PGDP*) * ln(*PGDP*)		-0.081***	-0.032*
		(0.018)	(0.017)
ln(*GDP*)	0.931***	0.936***	0.910***
	(0.018)	(0.018)	(0.017)
ln(*TOPEN*)	0.672***	0.648***	0.573***
	(0.058)	(0.058)	(0.056)
ln(*FOPEN*)	0.206***	0.215***	0.176***
	(0.032)	(0.032)	(0.032)
ln(*Interest*)	0.034	-0.013	
	(0.034)	(0.035)	
ln(*Volatility*)	0.037	0.049	
	(0.049)	(0.049)	
FINE1	-0.675**	-0.748***	-0.746***
	(0.131)	(0.129)	(0.143)
FINE2	-0.175[#]	-0.252***	-0.496***
	(0.115)	(0.117)	(0.106)
FINE3	-0.299***	-0.329***	-0.316***
	(0.096)	(0.096)	(0.098)
FINE4	0.376***	0.306***	0.298***
	(0.088)	(0.085)	(0.080)
FINE5	-0.548*	-0.654**	-0.047
	(0.293)	(0.297)	(0.169)
FINE6	0.531***	0.418***	0.583***
	(0.112)	(0.114)	(0.118)
FINE7	0.301***	0.203**	0.232***
	(0.087)	(0.087)	(0.083)
FINE8	0.195**	0.136*	0.151**
	(0.076)	(0.076)	(0.074)
FINE9	0.631***	0.543**	0.626***
	(0.229)	(0.231)	(0.232)
FINE10	0.369***	0.319***	0.295***
	(0.089)	(0.091)	(0.085)
FINE11	1.117***	1.054***	1.111***
	(0.140)	(0.131)	(0.135)
FINE12	0.082	0.047	0.063
	(0.087)	(0.087)	(0.082)

FINE14	-0.124	-0.162*	-0.146*
	(0.098)	(0.097)	(0.081)
R^2	0.745	0.741	0.854
F-statistics	658.37	649.66	918.00
Probability > F	0.0000	0.0000	0.0000
No of observations	1376	1376	2141

Source: authors' calculation

Notes:

1. *RES* stands for the international reserves, *PGDP* is per capita GDP, *GDP* is the Gross Domestic Product, *TOPEN* is trade openness, *FOPEN* is financial openness, *INTEREST* is lending interest rate, *Volatility* is the export volatility.
2 #, *, **, and *** denote significance at the 15%, 10%, 5%, and 1% levels, respectively.
3. Huber-White-sandwich corrected standard errors in parentheses.
4. From column (b), F-test for linterest=lexvol=0, F(2, 1355) =0.55, Prob > F = 0.5743
5. From column (c),

F-test for fine1 = fine2, F(1, 2122) = 2.67, Prob > F = 0.1026
F-test for fine2 = fine3, F(1, 2122) = 1.97, Prob > F = 0.1605
F-test for fine1 = fine3, F(1, 2122) = 9.62, Prob > F = 0.0020

Table 8. Exchange Rate System (FINE1-FINE3) and Demand for International Reserves[1,2,3]

Dependent Variable	ln(*RES*)		
	(a)	(b)4	(c)5
Constant	-17.793***	-24.332***	-21.123***
	(0.505)	(1.249)	(1.304)
ln(*PGDP*)	0.030	1.681***	1.087***
	(0.029)	(0.308)	(0.305)
ln(*PGDP*)*ln(*PGDP*)		-0.100***	-0.059***
		(0.018)	(0.018)
ln(*GDP*)	0.912***	0.919***	0.881***
	(0.018)	(0.017)	(0.018)
ln(*TOPEN*)	0.725***	0.684***	0.639***
	(0.055)	(0.056)	(0.063)
ln(*FOPEN*)	0.202***	0.213***	0.140***
	(0.033)	(0.033)	(0.038)
ln(*Interest*)	-0.044	-0.102***	
	(0.031)	(0.034)	
ln(*Volatility*)	0.026	0.041	
	(0.050)	(0.050)	
FINE1	-0.948***	-0.967***	-0.794***
	(0.119)	(0.118)	(0.129)
FINE2	-0.423***	-0.447***	-0.883***
	(0.092)	(0.093)	(0.096)
FINE3	-0.488***	-0.463***	-0.382***
	(0.087)	(0.086)	(0.089)
R^2	0.871	0.873	0.860
F-statistics	1218.9	1156.0	1636.3
Probability > F	0.0000	0.0000	0.0000
No of observations	1376	1376	1760

Source: authors' calculation

Notes:

1. *RES* stands for the international reserves, *PGDP* is per capita GDP, *GDP* is the Gross Domestic Product, *TOPEN* is trade openness, *FOPEN* is financial openness, *Interest* is lending interest rate, *Volatility* is the export volatility.
2 #, *, **, and *** denote significance at the 15%, 10%, 5%, and 1% levels, respectively.
3. Huber-White-sandwich corrected standard errors in the parentheses.
4. From column (c),

F-test for fine1 = fine2, F(1, 1750) = 0.31, Prob > F = 0.5779
F-test for fine2 = fine3, F(1, 1750) = 12.0, Prob > F = 0.0005
F-test for fine1 = fine3, F(1, 1750) = 8.34, Prob > F = 0.0039

Table 9. Exchange Rate System (MCODE) and Demand for International Reserves[1,2,3]

Dependent Variable	ln(*RES*)				Residual from (d)[4]
	(a)	(b)	(c)	(d)	(e)
Constant	-18.938***	-24.465***	-21.758***	-23.705***	-0.741***
	(0.485)	(1.272)	(1.167)	(1.185)	(0.092)
ln(*PGDP*)	0.018	1.408***	0.670**	1.042***	
	(0.029)	(0.308)	(0.259)	(0.267)	
ln(*PGDP*) * ln(*PGDP*)		-0.084***	-0.034**	-0.056***	
		(0.018)	(0.016)	(0.016)	
ln(*GDP*)	0.928***	0.935***	0.924***	0.969***	
	(0.017)	(0.017)	(0.015)	(0.014)	
ln(*TOPEN*)	0.713***	0.687***	0.613***	0.688***	
	(0.057)	(0.057)	(0.053)	(0.053)	
ln(*FOPEN*)	0.192***	0.199***	0.177***	0.113***	
	(0.032)	(0.033)	(0.030)	(0.032)	
ln(*Interest*)	0.023	-0.034			
	(0.031)	(0.034)			
ln(*Volatility*)	0.037	0.048			
	(0.050)	(0.049)			
MCODE	0.209***	0.204***	0.270***		0.231***
	(0.024)	(0.024)	(0.024)		(0.023)
MCODE*MCODE	-0.013***	-0.012***	-0.016***		-0.013***
	(0.001)	(0.001)	(0.001)		(0.001)
R^2	0.871	0.873	0.849	0.839	0.054
F-statistics	1264.67	1181.53	1978.43	2584.49	50.79
Probability > F	0.0000	0.0000	0.0000	0.0000	0.0000
No of observations	1376	1376	2141	2141	2141

Source: authors' calculation

Notes:

1. *RES* stands for the international reserves, *PGDP* is per capita GDP, *GDP* is the Gross Domestic Product, *TOPEN* is trade openness, *FOPEN* is financial openness, *Interest* is lending interest rate, *Volatility* is the export volatility.

2 #, *, **, and *** denote significance at the 15%, 10%, 5%, and 1% levels, respectively.

3. Huber-White-sandwich corrected standard errors in the parentheses.
4. The dependent variable is the residual calculated from column (d).

Table 10. Current and Hypothetical Reserve Holdings in East Asian Countrie: The Coarse Grid

Country	SYSTEM (mgcode) (a)	$RES_{SYSTEM1}$ /$RES_{SYSTEM*}$ (b)	Current Reserves* (c)	Hypothetical Reserves (d)=(b)*(c)
China	1	1	215,605	215,605
Korea	4	0.82[1)]	102,753	84,257.5
Japan	4	0.82[1)]	395,155	324,027.1
Indonesia	4	0.82[1)]	27,246.2	22,341.9
Malaysia	1	1	30,474.4	30,474.4
Philippine	3	0.61[2)]	13,442.4	8,199.9
Singapore	3	0.61[2)]	75,374.8	45,978.6
Thailand	3	0.61[2)]	32,354.8	19,736.4
Total		0.84	892,405.6	750,620.8

Source: authors' calculation from Reinhart and Rogoff (2002), IFS CD-Rom, IMF, and column (c) in Table 6.
Notes: Hypothetical reserves are defined as reserve balances that would be if a country adopts SYSTEM1.
* million US dollars (2001).
1. $RES_{SYSTEM1}/RES_{SYSTEM4} = e^{-0.202} = 0.82$
2. $RES_{SYSTEM1}/RES_{SYSTEM3} = e^{-0.202-(0.287)} = e^{-0.489} = 0.61$

Table 11. Current and Hypothetical Reserve Holdings in East Asian Countrie: The Fine Grid

.

Country	FINE (mcode) (a)	RES_{FINE1} /RES_{FINE*} (b)	Current Reserves* (c)	Hypothetical Reserves (d)=(b)*(c)
China	4	0.35[1)]	215,605	75,461.8
Korea	13	0.51[2)]	102,753	50,404.0
Japan	13	0.51[2)]	395,155	201,529.1
Indonesia	13	0.51[2)]	27,246.2	13,895.6
Malaysia	2	0.78[3)]	30,474.4	23,770.0
Philippine	12	0.51[4)]	13,442.4	6,855.6
Singapore	12	0.51[4)]	75,374.8	38,441.1
Thailand	12	0.51[4)]	32,354.8	16,500.9
Total		0.48	892,405.6	426,858.1

Source: authors' calculation from Reinhart and Rogoff (2002), IFS CD-Rom, IMF, and column (c) in Table 7.
Notes: : Hypothetical reserves are defined as reserve balances that would be if a country adopts FINE1.
* million US dollars (2001).
1. $RES_{FINE1}/RES_{FINE4} = e^{-0.746-0.298} = e^{-1.044} = 0.35$
2. $RES_{FINE1}/RES_{FINE13} = e^{-0.675} = 0.51$
3. $RES_{FINE1}/RES_{FINE2} = e^{-0.746-(-0.496)} = e^{-0.250} = 0.78$
4. $RES_{FINE1}/RES_{FINE12} = e^{-0.746-(0.063)} = e^{-0.683} = 0.51$

<Figure 1> Exchange Rate Regimes (mcode) and Reserve Holdings