Demand for Foreign Currency Reserves in Emerging Market Countries: Is Herding Applicable?

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Abstract

This paper examines the possibility of herding behavior in the demand for foreign currency reserves in 90 emerging market countries. A cross sectional absolute deviation model is utilized to detect herding by examining the volatility in the growth rates in reserves in the individual countries compared to the regional average. In addition, for comparison purposes, a contemporary model is utilized to measure the magnitude of herding. In general the results of the herding detection model exhibit herding behavior amongst Asian and Latin American and Caribbean countries, but not in Africa. Interestingly, the Asian countries show a greater tendency to herd than Latin American countries and Africa. We also observe that countries with greater monetary policy autonomy have a greater tendency to herd, while countries that belong to monetary unions are less likely to herd.

I. Introduction

The meeting of the G-20 nations in the fall of 2010, has once again highlighted the strategic importance of exchange rate policy on world trade patterns and the growth of the global economy at large. Implicit in the discussions of the G-20 nations was the economic growth in foreign currency reserves ensuing from large trade surpluses enjoyed by some emerging market countries such as China, Japan, Singapore and Taiwan. Interestingly, the surge in trade surpluses and growth in foreign currency reserves by the aforementioned emerging market countries has been attributed to a development strategy that has emphasized export led growth to the detriment of domestic demand led growth.

Economic theory suggest that foreign currency reserves (also known as international reserves) have traditionally being regarded as an instrument through which governments could accumulate sufficient buffer funds to bridge gaps in their balance of payment accounts. However, over the last decade, there has been a growing trend by emerging market countries to accumulate quantities of foreign exchange reserves beyond the three to four months of imports (5-20 percent of M2) considered by the International Monetary Fund (IMF) as optimal for balance of payment purposes. For example, in the 1980s, the reserves of emerging countries stood at 6.0 percent of GNP. But by 2007 they were reported at about 20 percent of GDP (Obstfeld, Shambaugh and Taylor, 2007). Figure I illustrates the rapid rise in foreign currency reserve holdings of emerging market countries while that in the advance countries have remained relatively flat over the last decade. The surge is even more pronounced in the emerging market countries of China and India where reserve growth rates exceeded 30 percent of GDP between 2001 and 2003 (Terada-Hagiwara, 2005).

Recognizing the important role that foreign currency reserves play in mitigating financial and economic crisis in emerging market countries, we seek in this paper not to emphasize the surge but the potential for existing demand determinants not yet investigated. In other words, in this study we posit that, there is still a consensus that the existing evidence has not exhausted the

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factors propelling the demand for foreign currency reserves in emerging market nations (Bird and Rajan, 2002; Flood and Marion, 2002; and Aizenman and Rierra-Crichton, 2007). And thus in this study we employ an interdisciplinary approach and attempt to bridge this gap with the application of herding behavior.

The practice of herding which originated from the animal world is seen everywhere today in human life, especially in investment decisions (Ming-Ming Lai, 2004). In finance it is typically defined as the behavioral tendency for investors to follow the actions of others (Banerjee, 1992; Graham, 1999; Chang et al, 2000; Welch, 2000, and Tan et. al. 2005). Similarly, this study views herding behavior in foreign currency reserves as the tendency for nations to imitate effective and sustainable policy directions of their neighbors. That is, nations may decide to increase their foreign currency reserves beyond expected levels without necessarily receiving adverse news about macroeconomic fundamentals but because they have observed their neighbors doing so and want to catch up to them.

This tendency to engage in imitative behavior could also be influenced by expert advice. Advice from development experts could encourage convergence or herding characteristics in reserve growth rates as professionals share experiences on what has worked in addressing development problems in other countries. Furthermore, emerging market nations that have gone through a crisis (high inflation, real exchange rate overvaluation, speculative attacks etc.) have been advised by development institutions to adhere to certain economic policy conditions including a minimum quantity of foreign currency reserves (buffer stock). In fact 'follow thy neighbor's best practice' is actually encouraged by development institutions such as the World Bank and International Monetary Fund and may be one of the explanations for the surge in reserve accumulation in emerging market nations. Therefore, this study posits that in the same way that agents in the financial market would make investment decisions based on the actions of other agents, there is a tendency for sovereign nations to do the same. After all, governments like the financial markets are made up of agents (in this case the agents are appointed / elected officials) supposedly acting in the best interest of their constituents.

The rest of the paper is organized as follows. Section 2 provides a brief literature review. The models, methodology and data are described in section 3. Section 4 reports the results, analysis and implications. And section 5 presents the conclusion.

II. Literature Review

A review of the literature that have examined the motivations for international reserve accumulation by emerging market countries, found none that has investigated the presence of herding behavior. Interestingly, in international finance, studies that have applied herding behavior seem to have concentrated mostly at the micro level (Graham, 1999; Welch, 2000; Lobao and Serra, 2002; Tan, Chiang, Mason, and Nelling, 2008). That is, existing empirical evidence on herding behavior has been done predominantly on financial markets activities in advanced countries. In fact, the literature points out that more empirical work needs to be done on developing nations' activities also, where a greater tendency to herd is likely to occur because of weak reporting requirements, lax enforcement of regulations, and costly information acquisition (Sushil Bikhchandani and Sunil Sharma 2001). Hence, this study is timely and will

contribute to the existing literature on the demand for foreign currency reserves by supplying empirical evidence on herding behavior at the macro level for 90 countries covering three geographic regions.

Exploring additional determinants of the demand for foreign currency reserves in emerging market countries is particularly important for several reasons: first, empirical evidence suggest that developing countries are prone to shocks (internal and external) that are three times that of advanced countries (Aizenman and Rierra-Crichton 2007). Given that most emerging market countries are price takers in the international market for their commodities, they frequently face uncertainties such as terms of trade shocks, sudden stops in capital inflow, poor crop yields and capital flight. The financial and economic destabilization caused by these shocks requires that governments have ready mechanism to cushion them as they emerge. Fisher (2001) adds that in an era of capital mobility, countries with greater reserves are better equipped to handle current and capital account shocks than countries with smaller reserves. In fact, empirical evidence found reserves to be an effective mitigating tool against terms of trade shocks especially for emerging market countries with limited access to global capital markets (Aizenman and Rierra-Crichton, 2007). Second, it has been observed that capital accumulation may cause growth in developing countries (Berthelemey and Sodeerling, 2001). Since capital accumulation and growth are positively related, then reserve accumulation beyond buffer stock levels should be encouraged, as over time if the country does not deplete its reserves to offset adverse shocks, such funds could be utilized for investment activities that promote growth. And third, traditionally, advanced countries have served as the major source of capital inflow for developing countries. However, the global financial crisis of 2008-2009 has imposed liquidity constraints on many advanced countries forcing them to reduce the flow of credit to developing countries. The reduction in capital inflow would have imposed severe hardship on emerging market countries had they not learned from the sudden stop experience of the 1980s and l990s and accumulated reserves in the post crisis years. The ability to draw on these reserves has certainly reduced their vulnerability to the reduced flow of capital from advance countries.

Furthermore, the increased integration of trade and investment activities around the world has also compelled nations to be mindful of global trends especially regarding the reserve levels of their neighbors, competitors or countries with whom they share the same characteristics (level of development, natural resources, export commodity, size, population etc.). For example, it is well documented that the financial crisis which began in Thailand in 1997, soon spilled over to other neighboring countries such as South Korea, Indonesia, Japan, Malaysia, Singapore and the Philippines (Charles Hill, 2011). Therefore, when a neighbor such as South Korea that has gone through a financial crisis begins to accumulate reserves to mitigate its risks of sudden stop of capital inflow, other nations in the region may follow suit so that they are not left behind. Therefore, the susceptibility of emerging market countries to similar types of shocks from external sources certainly requires these countries to be mindful of what is going on in their neighboring countries. That is the strategic behavior of one country tends to attract the attention of others especially if the action provides a benefit to the neighbor. In fact, some studies have found evidence of herding behavior in equity markets of South Korea and Taiwan in the aftermath of the Asian financial crises (Chang et al, 2000). This type of herding in financial markets has been coined as rational herding (Scharfstein and Stein, 1992). The authors theoretically explain that because of the principal- agent problem, managers have a tendency to

imitate the actions of others, completely ignoring their own private information in order to maintain their reputational capital in the market. In contrast, some theoretical explanations suggest that herding behavior relies on the psychology of the market and information asymmetry (i.e. the irrational view by Devenow and Welch, 1996). That is, there is a tendency for market participants to exhibit irrational behavior and follow the direction of the market consensus. An increase in information asymmetry they argue can increase the gap between those who know and those who do not know, resulting in herding. However, other studies caution that the link between information asymmetry and herding behavior is ambiguous at the micro level (Gelos and Wei 2002). Existing research on how transparency affects herding tendency of international investment funds, found no evidence that improvements in transparency implies a reduction in investor herding. Therefore, given the general lack of consensus of the influence of herding behavior at the micro level, in this study we deviate from institutional finance and examine herding at the macro level using models that have traditionally been applied to detect and measure this phenomenon in investment decisions.

III. Models

The theoretical foundation for the models used in this analysis is based on the notion that the tendency for emerging market countries to herd in their demand for foreign currency reserves is similar to the income convergence theory posited by the traditional neoclassical growth theory (Robert Solow, 1956). The neoclassical growth model suggests that incomes in regions with similar capital-labor-ratios have a tendency to converge. Recently, several authors (such as Obstfeld and Rogoff, 2000; and Flood and Rose, 2002) have applied the convergence theory to interest rates and they postulates that in an integrated world with no capital flow barriers, arbitrage should encourage convergence in real interest rates on assets with identical risks in any financial market regardless of the location. Following the same reasoning, this study predicts convergence in the foreign currency reserve growth rates of developing countries in the same geographic region that have gone through a financial crisis (i.e. have similar characteristics). The convergence hypothesis is used as a preliminary test of herding behavior by employing the panel unit root technique to investigate the presence of common trends in reserve accumulation of the countries in the respective regions. Stationarity in the cross country differences of the macroeconomic variable (in this case the growth rate in reserves) exhibits conditional convergence which we interpret as preliminary evidence of convergence / common trends (Li and Papel, 1999).

Next, to add robustness in our analysis, we apply a more powerful cross sectional absolute deviation model with slight modifications (Chang, Cheng and Kharana, 2000). The cross sectional absolute deviation (CSAD) is an extension of the cross sectional standard deviation (CSSD) traditionally used to detect herding behavior in equity markets (Christie and Huang, 1995). The authors (Christie and Huang, 1995) suggest that during periods of severe market volatility, uncertainty regarding investment outcome increases. Therefore, investors have a tendency during such times to ignore their abilities and base their investment decisions on the collective actions in the market. This tendency for investors' actions to converge during periods of market stress usually results in returns that cluster around the market return. Similarly, this study argues that following the financial and debt crisis of the 1990s, emerged a period of economic uncertainty for emerging market countries. Economic uncertainty, coupled with rising oil prices of the mid 2000s facilitated the herding tendency proposed in this study.

Prior to applying the CSAD model, we use the Granger causality technique to test for correlations between the dependent and independent variables in the model. We then proceed with the application of the CSAD model in the detection of herding behavior and examine the relationship between the volatility in the growth rate of foreign currency reserves in the individual countries relative to the regional mean. The assumption is that emerging market countries are all mindful of each others reserve accumulation trend and given their past experiences with sudden stops of capital inflow, their actions regarding reserve accumulation seem to be moving in the same direction over a period of time. This tendency for the growth rate in reserves of these countries to cluster around the regional mean should result in a lower volatility in reserve growth rates amongst the countries which suggests herding behavior. Of course, a notable shortcoming of this model is that it is only useful for detecting herding and not for measuring the extent of herding. Therefore, this study goes a step further and employs a herding measurement model - the Lakonishok, Shleifer and Vishny, (1992) model (henceforth LSV) to compare the proportion of countries in a region that increased their reserves during each quarter with the proportion expected if no herding existed. If the proportion of nations in a region with positive growth rates in reserves is greater than the expected proportional growth rate for the region, then herding exist.

A. Methodology

As discussed in the theoretical foundation above, the econometric procedure for the detection of herding behavior in this paper uses three major tests. First, we test the convergence hypothesis using panel unit root test (Li and Papel, 1999). A model similar to the Augmented Dickey Fuller (ADF) test is run:

$$\Delta(R_{i,t}-R_{.t})=\alpha_1+\alpha_2(R_{i,t-1}-R_{.t-1})+\sum_{z=1}^{Li}\beta_{i,z}\Delta(R_{i,t-z}-R_{.t-z})+\xi_{i,t} \quad (1)$$

where $R_{i,,t}$ is the growth rate in reserves in country *i* at time *t*, $R_{r,t}$ is the weighted average growth rate in reserves for the region, I = 1…..N (number of countries in the region) and t = 1…..T (number of years). Li and Papel (1999) explain that testing the convergence hypothesis entails a test of whether the series ($R_{i,t} - R_{r,t}$) exhibits a unit root, because as $R_{i,t}$ catches up to $R_{r,t}$, ($R_{i,t} - R_{r,t}$,) should become an I(0) or level stationary.

Next, the cross sectional absolute deviation (CSAD) is used to examine the relationship between the volatility in foreign currency reserve growth rates in the individual countries in each region relative to the regional average (as in Christie and Huang, 1995 and Chang et al 2000). The analysis begins with a cross sectional average deviation of growth rate equation specified as:

$$CSAD_t = 1/N \sum_{i=1}^{N} \left| R_{it} - R_{rt} \right| \quad (2)$$

where CSAD is the cross sectional absolute deviation – a measure of reserve growth rate volatility and R_{it} represents the growth rate in reserves in the individual countries in each region. R_{rt} is the weighted average growth rate in reserves for the region and N is the total number of countries in the respective regions. Next, since herding is most likely to occur during periods of economic stress, the CSAD regression specification was modified with a dummy variable to represent the uncertainty in international markets in the post crisis era. The uncertainty dummy (dr) takes a value of 1 if R_{it} moves in the same direction as R_{rt} and zero otherwise. That is, the non-linear equation expressing the relationship between CSAD and R_{rt} was estimated as:

$$CSAD_t = \alpha + \lambda_1 R_{r,t}*dr + \lambda_2 R^2_{r,t}*dr + \lambda_3 R_{r,t}*R^2_{r,t} + \xi_t \quad (3)$$

A negative and significant λ_2 suggests the presence of herding.

The next step in this analysis involves the measurement of the extent of herding. For this purpose, the model posited in LSV (Lakonishok, Shleifer and Vishny, 1992)) is employed. At the micro level the LSV model defines herding as the tendency for firms to trade a given security together and in the same direction more often than would be expected if they were trading randomly and independently (Lobao and Serra, 2002). Applying this definition at the macro level yields the following equation:

$$H(i,t) = \left| p(i,t) - p(t) \right| - AF(i,t) \quad (4)$$

where

$$p(i,t) = \frac{B(i,t)}{N}$$

$$p(t) = \frac{\sum_{i=1}^{N} p(i,t)}{N}$$

$$AF(i,t) = \mathrm{E}\left[\left| p(i,t) - \mathrm{E}\left(p(i,t) \right) \right| \right]$$

where p_{it} is the ratio of the number of nations that had positive growth rates in reserves during the quarter to the total number of nations (N) in the region; p_t is the expected value (E) of the proportion of nations that should have positive growth rates if they were acting independently; and B_{it} represents the nations (*i*) whose growth rates in reserves were positive during quarter *t*. AF is an adjustment factor which allows the model to capture the random variation of p_{it} around its expected value, under the null hypothesis of independent actions and assuming B_{it} has a binomial distribution with parameter p=p(t)* (Labao and Serra, 2000). Under the null hypothesis, if $H_{it} = 0$, then herding is absent in the international reserve accumulation of these nations. Deviations from p_t above the adjustment factor AF suggest the extent of herding.

Although the LSV method is considered a standard measure of herding behavior, it has its shortcomings(see Laboa and Serra, 2000 and Sushil and Sunil, 2001). The most notable of these shortcomings is that the measure uses volume or number of activities rather than the value of these activities. The problem here is that the measure may fail to exhibit herding if the total value of positive growth rates in reserves far exceeded the total value of negative growth rates.

B. Data

This study uses quarterly foreign exchange reserve data for 90 countries from 1997q1 to 2008q4. The data was retrieved from the International Monetary Fund's International Financial Statistics (2009) database. The data represents the post crisis years for the respective regions. Chang and Valesco's (1998) classification of crisis episodes in emerging market countries were used to determine dates for the post crisis years in each region. For Africa (34 nations) the post

crisis period spanned from 1997q1 to 2008q3, Asia (28 nations) from 1999q1 to 2008q4 and Latin America and Caribbean (28 nations) from 1999q1to 2008q4.

IV. Results and Analysis

The investigation of whether conditional convergence exist using the ADF panel unit root test is reported on Table I. Based on the test results (Table I) we can reject the null hypothesis of a unit root in all the countries in the panel at the 1% level. This suggests that there is a possibility of common trends in the accumulation of foreign currency reserves in all the three geographical areas in the sample during their respective post crisis periods.

Next, Granger causality tests were also conducted to assess whether the independent variables in equation 3 cause volatility in the growth rates of foreign currency reserves (CSAD). These results are reported on Table II. In Asia and Latin America, we can strongly reject the null hypothesis that the weighted average regional growth rate in reserves $R_{r;}$ and the square of the reserve growth rate in each country $R^2_{r,t}$ does not granger cause CSAD based on the F-statistics. We infer from this that, volatility in the growth rates in foreign currency reserves at the regional level and that of the individual countries are correlated and may be moving toward a regional norm. However, in the case of Africa, the results of the causality test do not confirm the existence of any correlations. This is so because the F-statistics suggest that we cannot reject the null hypothesis that R_r and $R^2_{r,t}$ does not granger cause CSAD.

The estimation of the herding detection model (equation 3) which is based on the cross sectional average deviation of the growth rates in reserves in the respective regions commenced using the ordinary least square method with no fixed effects and the results for all the three regions are presented in Table III. The growth rate in foreign currency reserves for the individual countries is represented by the variable λ_1. The results of the summary statistics show that on an average, the foreign currency reserves of the individual Asian countries grew faster than the other two regions at 6.3%. This finding is not surprising. Economic theory suggests that foreign currency reserves are necessary in order to maintain a peg. As many of the countries in the region have adopted a soft or hard peg to the U.S. dollar, they have also had to increase their holdings of the anchor currency in order to maintain the peg. In addition, some authors have suggested that the strategy of the Asian countries to promote export led growth is a major driver of the demand for foreign currency reserves in the region (Dooley et al, 2003). Foreign currency reserve they argued is used to promote exports through competitive exchange rates. In fact, in the meeting of the G-20 nations in South Korea in the fall of 2010, market driven exchange rates were emphasized as opposed to policies that promote currency undervaluation for competitive purposes. In Latin America, although some of the individual countries had positive average growth rates, their λ_1 coefficient is negative and significant. In contrast, the African λ_1 coefficient is positive but negligible.

Looking at the non-linear term, which is the variable of interest – λ_2, we find support for the Granger causality test reported on Table II above. The coefficient λ_2 is negative and significant at the 1% level for Latin America. This suggests that reserve accumulation trends in Latin America have been moving in the same direction over a period of time which exhibits herding behavior. Similarly, the coefficient λ_2 is negative and significant at the 1% level for Asia suggesting that herding behavior may be a determinant of the demand for foreign currency

reserves in this region as well. However, in Africa, as predicted by the Granger causality test, growth rates in reserve accumulation do not seem to be converging over time. The results of the herding detection model show λ_2 to be positive, negligible and insignificant. Further examination of the herding detection results suggest that although herding exists in Latin America and Asia, its influence is minimal. That is the herding detection coefficient - λ_2 of -0.025 and -0.016 for Latin America and Asia respectively is very low.

A second set of estimation (equation 4) was carried out to verify the predictions of the herding detection model by measuring the magnitude of herding. The results are reported in Tables IV, V, and VI. In Latin America (Table VI) over 42 quarterly periods, the estimated average level of herding is measured at 0.0405. This suggests that about 4.05 percent of the countries in the region have a tendency to accumulate reserves based on the regional average. This low level of herding measure is not surprising. It is in line with the low coefficient reported by the herding detection model. In contrast to Latin America, the herding measure for Asia (Table V) is estimated at 0.5132. This level which is higher than that of Latin America suggest that in about 51.32 percent of the countries in Asia, the demand for international reserves may be influenced by the regional average. This higher measure of herding in Asia as apposed to Latin America is slightly surprising. Based on the herding detection model, the herding measure for Latin America should have been at a higher level than that of Asia. This tendency for the LSV model to overestimate the level of herding has been documented at the micro level by some studies (such as that by Lobao and Serra, 2002). As expected, the herding level for Africa (Table IV) is estimated at 0.0059 which is in line with the prediction of the herding detection model that no herding (negligible) exists in the region. Unfortunately, with this model we are unable to test for the statistical significance of the results. Additionally, as mentioned above, several other limitations of the model are listed in Laboa and Serra, (2000) and Sushil and Sunil (2001). The most notable is that the model takes only the volume of activity (in this case number of increases in reserves) and disregards the total value of the activity. This restriction can underestimate the magnitude of herding. Jones, Lee and Weis have also shown that the expected value of H_{it} may be negative when the volume of activity is low since the adjustment factor AF takes larger values. Future improvement in the model should take into consideration the value of activities (reserve accumulation), as higher values of activity would reflect a higher demand for reserves and thus impact the magnitude of herding.

A. Implications

The results of this study highlight several monetary policy implications. We observe that regions with greater monetary policy autonomy such as Asia show a greater tendency towards herding in foreign currency reserves than their counterparts in Latin America and Africa. In Africa for example; where no herding is detected (negligible), most of the countries in the study belong to a monetary or currency union such as the Central African Economic and Monetary Union (CAEMC), the West African Economic and Monetary Union (WAEMU) or the Common Monetary Area in Southern Africa (CMA). As part of the institutional arrangement of these monetary unions, the activities of the central banking system such as decisions on foreign currency reserve accumulation is exogenous to the member governments. This is especially true in the CAEMC and the WAEMU where the accumulation of reserves is not paramount given the guaranteed financial support from the French treasury to maintain the fixed exchange rate system and for trade purposes. This unlimited credit line is not available to the Asian countries that do

not belong to a monetary union and thus the need to accumulate foreign currency reserves to mitigate external shocks is greater. In fact, the uncertainty faced by many emerging market countries in global financial markets over the last couple of years (2008-2009) lends support to the contingency planning (increase in reserves) which most of Asia has implemented since the financial crisis of the 1990s. The surge in reserves has provided the necessary liquidity in these countries and prevented the banking crisis experienced in the advanced countries from 2008 to 2009. That is, the reserve accumulation strategy pursued by emerging market countries in their post financial crisis years has enabled them to concentrate on their economic development agenda albeit the global liquidity constraints which plagued the advanced countries recently. It is also projected that the recent global liquidity constraint would have hijacked the development plans and imposed severe hardship on emerging market countries had they not learned from their respective sudden stop experiences of the l990s and accumulated reserves in the post crisis years.

Despite the fact that the reserves accumulated by emerging market countries have benefited the advanced countries as well during the global financial slowdown of 2008-2009, the advanced countries and the U.S. in particular continue to be concerned about the impact of surplus reserves on the current exchange rate system. This concern was evident during the G-20 meetings in South Korea in the fall of 2010 where the member nations cautioned each other to refrain from using surplus reserves to direct exchange rates in favor of their domestic policies. The accumulation of surplus reserves is also of particular concern to the U.S. because the reserves are denominated mostly in the dollar. This puts pressure on the U.S. economy and currency to remain strong, a condition which is difficult for any nation to guarantee. The U.S. economy is part of an integrated global economy which is currently weak and thus like many other nations has been using monetary policies to promote domestic demand.

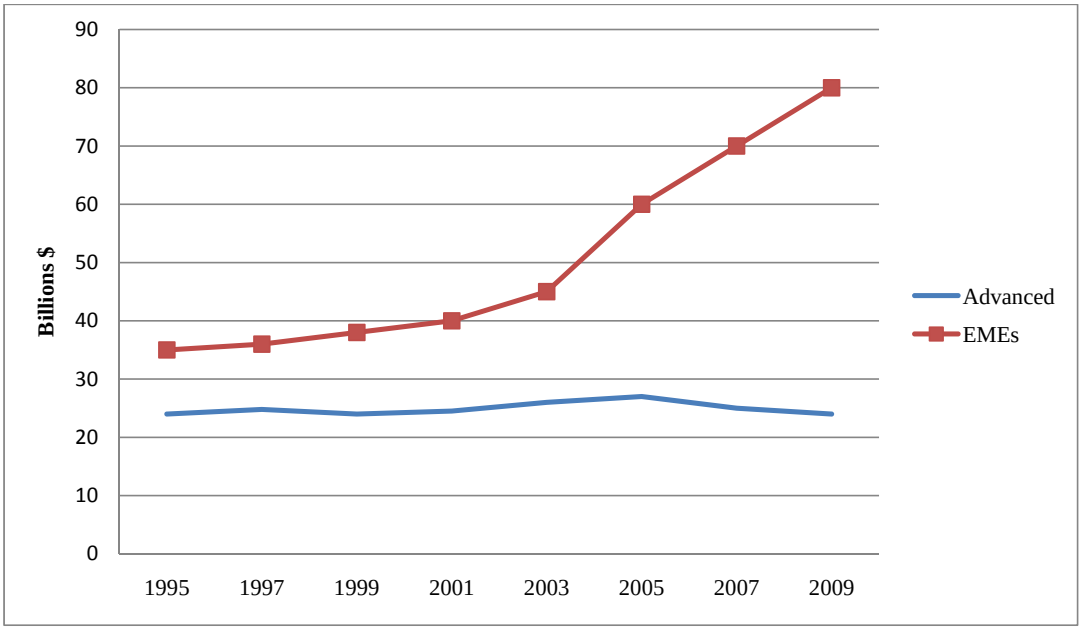
It is also feared that the excess dollars accumulated could result in capital flight if not managed effectively. Therefore, it is important that the government clearly define its reserve objectives to the central bank, which in turn would develop a corresponding reserve management strategy to mitigate potential mismanagement. Blackman (1982) suggests that rather than lumping all foreign currency reserves into one pool which may paint a picture of excess accumulation, these funds should be allocated into different accounts to reflect the respective objectives of holding reserves (such as liquidity, income, rainy day fund, defend the value of the local currency, etc).

V. Conclusion

The objective of this study was to examine if herding behavior is a determinant of the demand for foreign currency reserves in emerging market countries. Using quarterly data on foreign exchange reserves in 90 nations covering three geographic regions (Africa, Asia and Latin America and Caribbean), this study finds evidence of herding using a cross sectional standard deviation model. Three tests were applied to investigate the presence of herding: one to test for convergence, the second tested for causality and the third was to detect the presence of herding. The test of convergence reveals that there is a possibility of common trends in the accumulation of international reserves amongst Asian, Latin America and African countries. Although the test of causality does not totally support the test of convergence, it suggests that in two of the regions - Asia and Latin America, there exist some correlations between the volatility in foreign currency reserves at the country level and at the regional level. In an effort to resolve

the inconsistency presented by these two preliminary tests, the more powerful cross sectional standard deviation model was employed to detect the presence of herding. The results of the herding detection model are more in line with that of the causality test. The herding detection model suggests that herding behavior is a determinant of the demand for foreign currency reserves in Asia and Latin America but not in Africa. To verify the robustness of the herding detection model, a contemporary herding behavior model proposed by Lakonishok et al (1992) was used to determine the magnitude of herding. Interestingly, the herding measurement model confirms the results of the tests of causality and that of the herding detection model. The Lakonishok et al model shows that herding behavior is greater in Asia and minimal in Latin America. And as predicted by the herding detection model, the magnitude of herding in Africa is negligible.

Figure 1
Foreign currency reserves as a percent of import of goods and services
(Three year averages)



Source: IMF workding paper: Reserve accumulation and International Monetary Stability
Emerging market nations include: Brazil, Chile, China, Hong Kong, India, Indonesia, Malaysia, Mexico, Philippines, Poland, South Korea, Taiwan, Turkey, Singapore and Russia.

Table I
Panel Unit Root Test Results for Common Trend in Reserve Growth Rates
(Conditional Convergence Hypothesis)

Method	# of observation	T-Statistics	P-Value
AFRICA			
ADF test	1927	913.27	0.0000
ASIA			
ADF test	888	363.82	0.0000
LATIN AMERICA			
ADF test	1470	861.51	0.0000

ADF null: unit root (assumes individual unit root process). The optimal lag length was estimated by the AIC criteria.

Table II
Pairwise Granger Causality Test

Variables	# of observations	F-Statistics	Lags
Africa			
$R^2_{r,t}$ does not granger cause CSAD	322	0.01160	1
R_r does not granger cause CSAD	322	0.00038	1
Asia			
$R^2_{r,t}$ does not granger cause CSAD	336	2.13821	1
R_r does not granger cause CSAD	336	3.95068	1
Latin America			
$R^2_{r,t}$ does not granger cause CSAD	259	2.02613	7
R_r does not granger cause CSAD	259	1.70136	7

$R^2_{r,t}$ is the square of the reserve growth rate in each country. CSAD was derived from equation (3) above.
R_r is the weighted average regional growth rate.

Table III
Results of the Herding Behavior Detection Model (model 3)

Variables	Latin America	Asia	Africa
$R_{r,t}$ λ_1	-0.469912* (-3.992900)	0.063662 (2.999413)	0.005245 (0.153031)
$R^2_{r,t}$ λ_2	-0.025183* (-2.061958)	-0.016347 (-3.473556)	0.000254 (0.886979)
$R_{r,t}$* $R^2_{r,t}$ λ_3	0.002795* (3.759082)	……..	…….
Constant	7.903950 (9.170185)	0.104435 (4.687654)	3.470766 (14.25198)
R-squared	.09	.11	.34
F-statistics	3.00	4.06	18.52
Durbin Watson	1.86	1.81	1.71

T- Statistics are in parenthesis. *Significant at the 1% level. A negative and significant $R^2_{r,t}$ exhibits herding

Table IV
Results of Herding Measurement Model – Africa

Period*	**B_{it}**	**P_{it}**	**P_{it}-E(P_{it})**	**H**
1997	29	0.5700	0.0500	-0.0600
1998	28	0.4300	0.1900	0.0400
1999	28	0.5500	0.1100	-0.0150
2000	31	0.5975	0.0975	-0.0025
2001	30	0.5800	0.0800	-0.0300
2002	29	0.5700	0.0700	-0.0300
2003	29	0.5650	0.0550	-0.0400
2004	35	0.6775	0.1075	0.0325
2005	33	0.6400	0.0800	0.0050
2006	27	0.7325	0.1225	0.0725
2007	39	0.7550	0.1450	0.0950
2008	34	0.6633	0.0533	0.0033
Average		**0.6109**	**0.0967**	**0.0059**

*Average of 4 quarters. B_{it} =# of nations whose reserves in period t > t-1; $P_{it} = B_{it}/N$; where N= # of nations in the sample. P_{it}-E(P_{it}) = $\sum(B_{it}/N)$ / average(B_{it}/N); and $H(i.t) = |p(i,t) - p(t)| - AF(i,t)$ signifies no herding in Africa. The higher the value, the greater the tendency to herd.

Table V
Results of Herding Measurement Model – Asia

Period*	B_{it}	P_{it}	P_{it}-E(P_{it})	H
1999	16	0.6775	0.0950	0.5125
2000	14	0.5850	0.1125	0.6050
2001	14	0.5625	0.1950	0.6275
2002	15	0.6375	0.0950	0.5525
2003	16	0.6550	0.1350	0.5350
2004	15	0.6150	0.0825	0.5750
2005	18	0.7375	0.1075	0.4525
2006	19	0.7700	0.0900	0.4200
2007	21	0.8750	0.1925	0.3150
2008	16	0.6533	0.0667	0.5367
Average		**0.6768**	**0.1172**	**0.5132**

B_{it} **=#** of nations whose reserves in period t > t-1; $P_{it} = B_{it}/N$; where N= # of nations in the sample P_{it}-E(P_{it}) = $\sum(B_{it}/N)$ / average(B_{it}/N); and $H(i.t) = |p(i,t) - p(t)| - AF(i,t)$. A value of .51 signifies herding in Asia. The higher the value, the greater the tendency to herd.

Table VI
Results of Herding Measurement Model – Latin America

Period*	B_{it}	P_{it}	P_{it}-E(P_{it})	H
1998	23	0.5000	0.1200	0.1200
1999	19	0.5275	0.1375	0.0925
2000	22	0.5975	0.0175	0.0250
2001	21	0.5825	0.1275	0.0625
2002	18	0.5000	0.1450	0.1225
2003	18	0.4925	0.1075	0.1300
2004	24	0.6650	0.0750	-0.0350
2005	26	0.7075	0.1275	-0.0250
2006	23	0.6450	0.0450	-0.0250
2007	24	0.6675	0.1325	0.0000
2008	25	0.6900	0.1250	-0.0225
Average		0.5977	0.1055	0.0405

* Average of 4 quarters. B_{it} **=#** of nations whose reserves in period t > t-1; $P_{it} = B_{it}/N$; where N= # of nations in the sample. P_{it}-E(P_{it}) = $\sum(B_{it}/N)$ / average(B_{it}/N); and $H(i.t) = |p(i,t) - p(t)| - AF(i,t)$. The value of .03 signifies herding in Latin America. The higher the value, the greater the tendency to herd.

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