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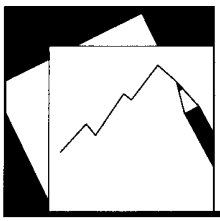

IMF Working Paper

How much should I hold? Reserve Adequacy in Emerging Markets and Small Islands

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How much should I hold? Reserve Adequacy in Emerging Markets and Small Islands

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Abstract

This paper investigates the drivers of reserves in emerging markets (EMs) and small island (SIs) and develops an operational metric for estimating reserves in SIs taking into account their unique characteristics. It uses quantile regression techniques to allow the estimated factors driving reserves holdings to vary along the reserves' holding distribution and tests for equality among the slope coefficients of the various quantile regressions and the overall models. F-tests comparing the inter-quantile differences could not reject the null that the models for the different quantiles of SIs reserve distribution were similar but this was rejected for EMs distribution suggesting that models explaining drivers of reserve holdings should take into account the country's reserve holdings. Empirical analysis suggests that the metric performs better than existing metrics in reducing crisis probabilities in SIs.

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I. INTRODUCTION

How much reserve should countries hold? The surge in reserves in the last decade in large emerging market economies (EMs) has led to questions about what is driving these high reserves holdings but for many small islands (SIs) the concern is whether reserves are too low.[2] There is little consensus in the literature on what constitutes an adequate level of reserves and the methodologies for assessing this have varied.[3] This paper examines reserves adequacy in emerging markets (EMs) and small islands (SI), contributing to the literature in three main ways:

- To the best of our knowledge, this is the first paper that estimates the observed cross-country preferences of reserves for 23 SIs. In line with the literature, we draw on drawing on variants of the "buffer-stock model" (Frenkel and Javanoic, 1981) and estimate OLS regression with fixed effects in SIs and compare these findings with those for 49 EMs providing a fresh look at the factors driving reserve accumulation in EMs.

- This is the first paper, that we are aware of, that examines the institutional, current and capital account motives for holding reserves allowing these factors to vary along the reserves' holding distribution. It tests for equality among the slope coefficients of the various quantile regressions and whether the models determining reserve holdings for countries at the lower quantile are statistically different from those at the higher quantiles.[4] If elasticities vary across countries, then the typical reserve holdings models in

[2] This paper defines small islands using the UN classification of small island developing states. These states were first identified as a distinct group of countries at the UN Conference on Environment and Development in 1992. They countries differ from larger economies in three main dimensions: population, GDP and land area. We exclude SIs that are not members of the IMF (e.g., American Samoa, and Niue). Currently, the UN lists 51 SIs. Given its small land area we also include Sri Lanka in the analysis. With the exception of Dominican Republic, Jamaica, and Sri Lanka, all these economies are small states with populations less than one million. Bayoumi et al., 2005, define tourism-dependent countries as those where tourism exports exceed a threshold of 20 percent of total export receipts.

[3] For a discussion of precautionary saving behavior, see Aizenman and Marion, 2003 and Eichengreen, 2004. The literature has generally examined reserve holdings using traditional metrics, combination metrics, cross-country empirical models of precautionary reserve demand and optimal reserve models that take into account self-insurance mechanism.

[4] Only two papers in the reserve literature have allowed for the effect of regressors varying according to the level of reserves— Ghosh et al., 2012 and Sula, 2011. However, they do not test for statistical significance of the differences in the models (i.e., overall, is the model explaining reserve holdings at lower quantiles significantly different from that at higher quantiles). In addition, Gosh et al., 2012, does not test for the constant elasticity hypothesis while Sula, 2011, who introduced quantile regression to the reserve literature, focuses mainly on current account related motives for reserve accumulation.

OLS regression mask the potential heterogeneity across the reserve distribution given their focus on the conditional mean.[5]

- It fills the void in the literature by developing a user-friendly operational metric for estimating reserve holdings in SIs building on the IMF (2011a, b) approach. By focusing on economies with similar characteristics and likely BOP pressures, this can better capture the crisis episodes and tailor the thresholds to SIs' distribution of potential shock events.

Our findings, drawing on the buffer stock model, suggest that import share and exchange rate volatility are key drivers of reserve holdings in SIs while for EMs it is import share and financial depth. Specifically, economies with higher import shares hold higher reserves suggesting that vulnerability to current account shocks could be an important determinant of reserve holdings. In addition, SIs with more flexible exchange rate regimes tend to hold less reserves. This is broadly consistent with literature that suggests that economies with fixed exchange rate regimes need higher reserves as buffer to manage an exchange rate regime. For EMs, we find that economies with higher broad money to GDP tend to hold higher reserves. These findings are broadly consistent with IMF (2011a) which found that current account variables and broad money where significant factors influencing reserve holdings in EMs.

The findings from quantile regression models suggest that there are significant differences in cross-country preferences across distribution of reserve holdings. Overall, the findings also suggest that there are more significant differences within EMs than between EMs and SIs. F-tests comparing the interquantile differences could not reject the null that the models were similar for SIs but this was rejected for the EM models in all the quantiles with the exception of the 50^{th} –75^{th} interquantile regression. The findings from the inter-quantile regressions indicate that there are significant differences between the quantiles driven by differences in the elasticities of import share, short-term debt and government effectiveness. Most notably, short-term debt has a positive effect on reserve holdings for EMs and increases across the reserve distribution but the converse applies for SIs. In contrast, Ghosh et al., 2012, examining EMs found that short-term debt has a large positive impact at the lower end but not at the positive tail of the distribution. From a policy perspective, it implies that different models should be used to assess drivers of demand holdings for EMs.

Reserve holdings in SIs are determined using a metric that is a weighted function of broad money, short-term debt and exports. Reflecting the higher vulnerability of SIs to shocks, these weights are higher than those implied by the IMF (2011a, b) metric. Empirical analysis suggests that a reserve holding of about 75-100 percent of the metric reduces the probability

[5] One key assumption of the constant elasticity specification that is generally used to estimate demand for reserves is the homogeneity of the regressors across the sample (i.e., the coefficients of the regressors are assumed to be identical regardless of the level of reserves).

of the crisis to less than 2 percent. Robustness tests suggest that this metric performs better than others. Many SIs however hold reserve levels that are either lower or significantly higher than suggested by metric raising question of what determines their reserve holdings.

The rest of the paper is structured as follows: Section II examines what determines the reserve holdings in countries. It begins with some stylized facts on reserve holdings, presents modeling strategy and findings from cross-country regression estimation of drivers of reserve adequacy. Section III develops metric for SIs and assesses its performance of this metric in reducing the probability of a crisis and compares it against other metrics using logit regression. Section IV concludes.

II. WHAT DETERMINES RESERVE HOLDINGS?

Given the large welfare costs from holding too few reserves and the opportunity cost of holding reserves it is important to understand motivations influencing reserve holdings. Despite their high vulnerability to shocks, SIs have on average held reserves close to (and sometimes lower) than suggested by traditional benchmarks whilst EMs have held significantly higher reserves than would be suggested by the benchmarks despite the opportunity costs entailed (Figure 1).[6] To the extent that reserve holdings reflect precautionary considerations, regression-based models can provide a useful assessment as to why some countries choose to hold low or very high reserves based on their revealed preferences. Use of the reserve demand model for assessing reserve adequacy relies on the assumption that, averaged across countries and over the regression sample period, countries are neither systematically under-nor-over insured from a precautionary perspective. To the extent that individual countries' reserve holdings are significantly lower or higher than the model's prediction suggests that are motivations (precautionary or non-precautionary not captured in the model) are influencing reserve demand.[7]

The literature has generally identified four groups of independent variables as drivers of the observed cross-country preferences of reserves:[8]

- Current account vulnerabilities: Imports and export earnings are the most-commonly used variables to capture external shocks to the current account. The literature has found imports and the volatility of real earnings to be positively correlated with reserves (Cheung and Ito, 2009; Aizenman and Marion, 2003; Flood and Marion, 2002, Dabla-Norris et al., 2011[9]). Some of the literature has also considered the impact of trade

[6] Reserves are defined as external assets that are readily available and controlled by monetary authorities. We exclude gold assets because of valuation problems as well as its relatively small share in reserves held by most monetary authorities.

[7] See IMF, 2011a, for a discussion.

[8] IMF, 2003, and Aizenman and Marion, 2003, develop models for EMs.

[9] However, Dabla-Norris et al., 2011, note that export volatility is significant for LIC commodity exporters not non-LIC commodity exporters.

openness, noting that a broader measure of current account vulnerability is needed to adequately capture the adjustment costs (e.g., Aizenman et al., 2004).

- Capital account vulnerabilities: Following the Asian crisis, the literature has increasingly examined resilience to capital account vulnerabilities (e.g., Radelet and Sachs, 1998; Aizenman et al., 2004). Broad money has been used to capture the risks from potential currency mismatches and drains arising from bank deposit runs to currency holdings and capital flight can put pressure on central bank reserve holdings (e.g., Calvo, 1996; Wijnholds and Kapteyn, 2001; and Obstfeld et al., 2008). The literature has found that countries with a high ratio of short-term debt to reserves tend to suffer deeper economic crises (Sachs et al., 1996). Some of the literature has pushed for inclusion of all external financing exposures including FDI and portfolios flows, noting that high exposures increase vulnerability to financial crises (e.g., Radelet and Sachs, 1998; Aizenman et al., 2004; and Feldstein, 1999). However, the relationship between capital flows and reserves however is unambiguous and depends on the type of capital flow.[10] The literature has not found evidence of FDI outflows during times of stress (IMF, 2011).

- Exchange rate regime: Since economies with more managed exchange rate regimes need a large reserve stockpile to defend the parities of their domestic currencies to the ones they have pegged to, the literature postulates that these countries would hold more reserves (see Frenkel, 1974; Edwards, 1983). However, since some countries classified as floaters are in reality peggers, using exchange rate regime as a variable could result in measurement problems (Gosselin and Parent, 2005 and Calvo and Reinhart, 2000). Reflecting this most of the literature has considered the nominal effective exchange rate volatility (Gosselin and Parent, 2005; Reinhart and Rogoff, 2002, Aizenman and Marion, 2003; and Flood and Marion, 2002).[11]

- Opportunity cost: Theory suggests that reserves should be negatively correlated with the opportunity cost of holding them, but the effect is quite inconspicuous in the literature (e.g., Flood and Marion, 2002, Dabla-Norris et al., 2011). This is largely due to difficulty in assigning a single interest rate for reserve holdings while accounting for their risks.

The literature has also included a number of controls including:

- Economic size: The volume of international financial transactions, and therefore reserve holdings, would be expected to increase with economic size. The literature has

[10] Some of the literature notes that a country may hold lower reserves if it has secured access to capital markets (Cheung and Ito, 2009) while others note that economies in the 'periphery' hold reserves to ensure importation of financial intermediaries from abroad, hence the capital flows are positively correlated to reserves (Dooley et al., 2005).

[11] A few others have constructed alternative dummy variables (e.g., Reinhart and Rogoff, 2002 and Obstfeld et al., 2008).

controlled for this by either including a separate scaling regressor or scaling all variables in the model (Choi et al., 2007, Delatte and Fouquau, 2009; Aizenman and Marion, 2004; and Flood and Marion, 2002).[12]

- Crisis episodes: The literature has included controlled for the effects of a currency crisis, a banking crisis or a twin crisis on hoarding of international reserves. These are generally derived from the conventional exchange rate market pressure (EMP) index (Eichengreen et al.,1996).[13]

- Institutions: Some of the recent literature argues that the quality of institutions could affect reserve demand holdings. Aizenmann and Marion, 2004 show that countries with weaker institutions may need hold more reserves in order to shore up confidence but note that weaker institutions may also be associated with fewer holdings of reserves as corrupt governments may use up reserves.[14] Cheung and Ito, 2009, finds that weaker institutions reduces reserves and argue that an economy with a good reputation of having less corruption would need lower reserves to demonstrate fundamental soundness.

A. Data and Modeling Strategy

A panel model with fixed effects covering 23 SIs using annual data spanning 1999-2010 is estimated. The sample is limited to SIs for which tourism plays an important role and for which data is available. Annual data are used. See Tables 1-2 for detailed description of country sample and regression variables. We then compare these findings with those from model with 45 EMs spanning the same period.

We consider a scaled measure of international reserves given by $r_{i,t} = R_{i,t}/GDP_{i,t}$ where $R_{i,t}$ is economy *i*'s holdings of international reserves and $GDP_{i,t}$ is economy *i*'s gross domestic product at time *t.* Both variables are measured in US dollars.

The baseline model is given by

$$r_{i,t} = \beta_0 + \beta_1 (Import/GDP)_{i,t} + \beta_3 (d(Broad\ money\ supply\ /GDP))_{i,t} + \beta_3 (Short-term\ debt\ / GDP)i,t + \beta 4\ NEER\ volatilityi,t + \beta 5\ CrisisDumi,t + t + \varepsilon it \quad (1)$$

for $i = 1,\ldots,N$ and $t = 1,\ldots T,$ where N and T design the cross-section and the time dimensions of the panel.[15] CrisisDum is a dummy variable that takes value of 1 if there is an

[12] Scaling international reserves facilitates comparison across countries of different sizes.

[13] We create an EMP dataset—see later for discussion on derivation.

[14] Countries with high discount rates, political instability or political corruption might find it optimal to hold smaller precautionary balances.

[15] The estimation methodology provides robust variances that give an accurate assessment of the sample-to-sample variability of the parameter estimates even when the model is misspecified regression. For more discussion on variance estimates that adjust for within-cluster correlation see Froot, 1980, Williams, 2000, and Wooldridge, 2002.

EMP crisis and 0 otherwise. *t* refers to the time dummies and ε_{it} is the error term. Alternative models consider the role of institutions, alternative variables to capture real earnings volatility (including export, tourism, and FDI volatility) and impact of trade openness and interest rate differential.

We undertake out-of-sample prediction to determine whether the estimated model fits average reserve growth and individual country holdings reasonably well. The model is estimated using panel data for SIs from 1999 to 2007 and the remaining years are used to compare out of sample forecasts with actual reserve buildups. This exercise is replicated for EMs.

We apply quantile regressions techniques in order to test and compare elasticities at different quantiles of the distribution of reserve holdings using the quantile regression method developed by Koenker and Basett, 1978.[16] To allow for different elasticities, we modify (1) as follows where γ is the weight given to the reserve policy. We assume that higher levels of reserve holdings are associated with higher γ, holding everything else constant. Each elasticity coefficient is a function γ but in equation (2), they are data driven (i.e., estimated from the data). We present the findings from the model including institutions as additional regressor and also test for the constant elasticity hypothesis.

$$r_{i,t} = \beta_0(\gamma) + \beta_1(\gamma)(\quad)_{i,t} + \beta_3(\gamma)(d(Broad\ money\ supply\ /GDP))_{i,t} + \beta_3(\gamma)(Short-term\ debt\ / GDP)i,t + \beta 4\,\gamma NEER\ volatilityi,t + \beta 5\,\gamma CrisisDumi,t + t + \varepsilon it \quad (2)$$

B. Empirical Results from Standard Panel OLS and Fixed Effects

The results from the panel regression for the OLS and fixed effects models are broadly in line with our priors (Table 3).[17] We focus on the baseline model--model 2 for SIs and 10 for EMs.[18]

Current account vulnerabilities are an important determinant of reserve holdings in both SIs and EMs. A one percent increase in the import-to-GDP ratio in SIs is associated with about 0.2 percent in increase in the reserve-to-GDP ratio. This finding is significant and robust in alternative model specifications. Alternative indicators of vulnerability to external shocks,

[16] The quantile regression makes it possible to estimate elasticities of the demand function at different points of the reserve holdings distribution, instead of running separate OLS regression for decomposed samples. The methodology is robust to outliers differentiating their effect from other observations. See Koenker and Hallock, 2001, for greater discussion of quantile regressions and how they help avoid Heckman-type sample selection bias.

[17] Unit root tests indicate that all the variables are stationary, with the exception of broad money-to-GDP ratio. These results are available upon request.

[18] We did not obtain significant results using interest rate differential therefore brevity these findings are not shown. For brevity, we do not report all the findings from the model specifications using the EM sample. These findings are available upon request from the author.

such as real GDP growth and trade openness, are also positive and significant impact (models 3 and 7, respectively).[19] Current account vulnerabilities also have a significant impact on reserve holdings in EMs (models 9-11). These findings are consistent with findings from other studies (e.g., Aizenman and Marion, 2003).

Capital account vulnerabilities have differing effects on SIs and EMs.

- The change in broad money-to-GDP ratio in general does not have a statistically significant impact on reserve holdings in SIs, with the exception of one specification where it is associated with a 0.1 percent increase in reserve holdings (model 3) and the OLS specification (model 1). In contrast, for EMs, the change in broad money-to-GDP ratio is an important significant determinant of reserve holdings. A one percent acceleration in this broad money ratio is associated with about 0.2 percent increase in reserve-to-GDP holdings suggesting that as EMs' financial systems deepen, they hold higher reserves (model 10).

- Short-term debt to GDP ratio has a negative and weakly significant effect on reserve holdings in SIs but this finding is not robust across all specifications. In contrast, this is positive and strongly significant for EMs. A one percent increase in short-term debt is associated with about 0.2 percent increase in short term debt. This negative relationship is similar to findings from the literature on the effect of net capital flows on reserve holdings in the 1980s in EMs (Choi et al., 2007). The literature has attributed this to finance current account deficits in the 1980s. The more familiar positive relationship which reflects in part "sudden stops: and the loss of access to international capital markets was observed much later.[20]

Greater exchange rate flexibility is associated with lower reserve holdings in SIs but has no statistically significant impact on EMs, except in the OLS specification. However, the macroeconomic impact is small. For example, a one percent increase in flexibility is generally associated with a 0.01 percent point increase in the reserve-to-GDP ratio in SIs.[21]

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[19] In some specifications for SIs, aid volatility (model 5) have a significant statistical impact but even here the economic impact is very limited—a one percent increase in volatility is associated with very small change in reserve holdings.

[20] In the 1990s, the sensitivity declined substantially reflecting the use of capital flows to finance domestic expenditures. In recent years however net capital flows have had a strong positive effect on reserve holdings in EMs suggesting that capital inflows have not just financed current account deficits but have also been used to build reserve buffers.

[21] Alternative model specifications considered the exchange rate dummy. This variable was insignificant for SIs likely reflecting the impact of "fear of floating" effects (i.e., de jure fixed exchange rate regimes). For EMs, neither the exchange rate volatility nor the dummy variable were significant (except in the OLS specification). This is broadly the same result as empirical literature on EMs.

Stronger government effectiveness is associated with higher reserve holdings in SIs but has no significant impact on EMs, with the exception of the OLS pooled specification (model 9). A one percent increase in government effectiveness is associated with a 0.3 percent increase in reserve holdings in SIs (model 8). These findings for SIs are in line with literature (e.g., Cheung and Ito, 2009) that stronger institutions lead to lower need for reserves to shore up confidence.

A comparison of reserve build-up during 2005-2010 with the model's forecasts suggests that reserves holdings have generally increased at a faster pace than suggested by evolving fundamentals (Figure 2). Using out-of-sample prediction since 2007, we find reserve holdings that were slightly higher than levels suggested by economic fundamentals. Similar to IMF, 2011a, we find that the regression model does not track all individual country holdings very well.[22] Precautionary motives explain on average about 30 percent of the variation, though there are differences both over time and across countries. Similar to the IMF, 2011a, we find that there may be additional motivations for holding reserves, which are not well captured by the purely precautionary elements of the model. This could reflect non-precautionary motives, or may reflect precautionary motives that have not been captured by the model (e.g., risk aversion). In addition, ad hoc factors such as currency swaps and increase in SDR allocations could have contributed in the raising reserves relative to the level that would be expected from the model.[23] [24]

C. Empirical Results from Quantile Regressions

The findings for the full sample (using pool of SIs and EMs) as well as subsamples of SIs and EMs are presented in Tables 4-6 (eqn 3-7).[25] The model is estimated at the 5th, 25th, 50th, 75th, and 95th quantiles.[26] The findings from comparison of the estimates from two quantiles (i.e., difference estimates) and tests for the constant elasticity hypothesis are presented in Tables 7-9 for the full sample as well as subsamples. Figures 3-5 present a complete picture of the change in the coefficient estimates as the quantiles increase for the full sample as well

[22] A number of SIs have had consistently lower reserve holdings than can be attributed to economic fundamentals (e.g., Belize, and Seychelles); some of these have managed to close these gaps in recent years. A few SIs (e.g., Mauritius) have large positive gaps. For EMs, the outliers are generally one-direction, that is, with rising gap during the latter part of the sample period with substantial holdings in excess for some countries. For brevity, comparisons for individual countries are not shown but are available upon request.

[23] The model is used for forecasting reserve holdings after 2007, however during the crisis period of 2008-10 the drivers of reserve changes may be different than in the previous period.

[24] Mutual insurance schemes in small island economies (for example the Caribbean Catastrophic Risk Insurance Facility) play an important role by providing mutual insurance against natural disasters. Future work could examine the impact of mutual insurance schemes and other contingent financial instruments.

[25] To facilitate a direct comparison, the findings from the pooled and fixed effects OLS regression are also shown in eqn 1-2.

[26] Since the estimation procedure requires some weight both below and have the chosen percentile, it is not possible to examine the 100th percentile.

as subsamples. The solid bold green line plots the point estimate from quantile regressions ranging from 0.05 to 0.95 percentile of the distribution and the shaded area around the solid line shows the 95th confidence interval constructed by the 1000 bootstrap replications. The straight dashed orange-red line represents the estimates from the OLS estimate and the dotted blue lines above and below that line show the borders of the 95th confidence interval.

Full sample findings suggest significant differences across distribution between countries on lower tails and those on the opposite end of the reserve distribution.

- The main predictions of the buffer stock model hold best for countries that for countries at 50th quantile of reserve holdings (Table 4). Short-term debt has a significant and positive impact on reserve holdings, with the coefficient rising to its peak for countries at the 95th quantile. Change in broad money to GDP has a significant impact on reserves in all quantiles except countries located at the tails of the distribution. Exchange rate flexibility is only significant for countries at the 50th quantiles. Conversely, import-to-GDP ratio is strongly significant for all distribution levels except the 5th quantile where it is not significant. In addition, the size of the coefficient increases as move up the reserve distribution. Good government effectiveness has a significant effect on reserve holdings across all levels of distribution with the exception of countries at the 25th and 75th quantile. However, the sign differs—it has a positive effect on reserves for countries at the tails of the distribution but a negative effect particularly for 50th quantile.

- The majority of the graphs in Figure 3 illustrate the sensitivity of the coefficients as reserves move from one quantile to another. The estimates generally increase as move towards higher quantiles of the reserve holdings with some coefficients showing non-linear pattern (e.g., the u-shaped pattern for the government effectiveness coefficient).

- Table 7 confirms these results and shows that some of the interquantile estimates for the coefficients are not constant across the various quantiles of the reserve distribution particularly for import share and government effectiveness. F-test findings comparing quantile regressions also support the finding that there is significant difference in the magnitude and sign of coefficients between countries at the lower and upper end of the distribution (eqn 5 compares the 5th and 95th quantiles). However, it also shows significant differences even between the 5th and 25th quantile (eqn 1) and between the 75th and 95th quantile (eqn 4).

Overall findings from the quantile regression suggest that there are no significant differences between small islands across the reserve distribution (Table 8, F-test). Most of the charts in Figure 4 show little varying size and significant of the coefficients as move towards higher quantiles of the reserve holding distribution. Notwithstanding, there are some significant differences in the size of some of the coefficients particularly on exchange rate flexibility and

short-term debt (Table 8). In general, we find that short-term debt is strongly significant and has a large negative coefficient—reaching a peak (in absolute terms) at the 75th quantile (Table 5). Therefore, for countries with higher reserve holdings, an increase in short-term debt leads them to hold lower reserves than for countries at the lower end of the reserve distribution. Since most of their debt tends to be concessional, an increase in debt may not be associated with concerns about insurance against capital flight episodes. In addition, we find that broad money, which was not significant in the OLS fixed effects model, is significant for SIs, albeit weakly in the 25th and 50th quantile. Finally, the quality of government effectiveness has a negative and significant impact on reserve holdings for SIs, but these findings are obtained for countries at the 50th and 75th quantile. These findings suggest that economies with strong institutions tend to hold lower reserves.

In contrast for EMs the overall findings suggest that there are significant differences in the quantiles (Table 9, F-test). Most of the charts in Figure 5 show large variation in the size and significant of the coefficients as move towards higher quantiles of the reserve holding distribution. Table 9 shows that there are significant differences between the 25th and 50th as well as between 50th and 75th quantiles in elasticities of import share. In addition, there is a significant difference in the size and sign of coefficients of short-term debt and government effectiveness between the lower and upper tail of the reserve distribution. In general, we find that short-term debt has a significant and positive impact on reserve holdings, this rises reaching its peak at the 95th quantile (Table 6). These findings are in line with the precautionary view which suggests that countries with a large stock of short-term debt accumulate reserves to smoothen the adjustment process in case there is a crisis. Ghosh et al., 2012, find that the coefficient on short-term debt is large and statistically significant at the lower end of the distribution but smaller and/or insignificant for above-median reserve holders. Unlike SIs, we find that broad money is significant in all quartiles for the EMs except tail ends of the distribution. Unlike SIs, institutions have a positive and strongly significant effect on reserve holdings for EMs but these findings are obtained at the 5th, 75th, and 95th quantile tails of the distribution.

Overall these findings suggest that there could be important of unobservable factors that explain the demand for reserves, in particular the role of rollover risk and market sentiments. This finding is due to the stylized fact that the largest reserve holders in the sample, nations that are at the right hand of the distribution, are EMs. The finding on short-term debt is particularly insightful given SIs, on average, tend to hold higher levels of concessional debt and multilateral debt than EMs, with the size of the coefficient increasing with rising reserve holdings (Figure 6). For example, in 2009 whilst the median concessional debt to GDP was about 20 percent, it was about 84 percent for SIs with reserves at 75th percentile of reserve

distribution and about 11 percent for EMs.[27] However, within EMs there have been significant differences in the trends in the relationship between the share of concessional/ multilateral debt and reserve holdings which could be contributing to findings of non-constant elasticities.[28] Variables that capture the weight that countries attach to reserves could substantially help explain the difference in reserve holdings between SIs and EMs.

III. A New Metric For Small Islands

In this section, we develop a metric adapting the IMF (2011a, b) metric to better reflect country specificities of SIs.[29]

Small island developing states (SIs) tend to have unique features that make them more vulnerable to shocks than their larger counterparts raising the importance of maintaining adequate precautionary reserves as insurance against shocks. The literature has highlighted the role of higher trade openness[30] and export concentration in magnifying the impact of terms of trade shocks and greater susceptibility to natural disasters[31] in increasing income volatility.[32] SIs limited financial structures are an important dimension that also needs to be examined in particular how it affects resilience shocks. Although SIs tend to have high debt ratios, in general their debt tends to have a longer maturity, concessional and held by multilateral creditors. This debt structure suggests lower vulnerability to rollover risk and deleveraging. However, in the face of shocks, SIs that have short-term market debt could face great acceleration of deleveraging that is compounded by their more limited financial depth.

A number of combination metrics have been developed over the years to take into account the fact that reserves might be needed for all purposes at the same time.

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[27] Similarly, whilst the median multilateral debt was about 25 percent, for SIs it ranged from 22 percent for economies with less than 25th percentile of reserves to about 70 percent for those with higher than the 75th percentile.

[28] In the mid-2000s, EMs with higher share of multilateral debt had higher reserves, but the converse applied in 2009 and 1999.

[29] Also recognizing that structural conditions in these economies have evolved significantly, we examine sources of risk since 1999 unlike the IMF (2011a) metric which examine post 1990s.

[30] See Atkins et al., 2000; Easterly and Kraay, 2000; Jansen, 2004; Armstrong and Read, 1998.

[31] Rasmussen, 2004, and 2006, finds that SIs tend to have the highest frequency of natural disasters. The high debt ratios in a number of countries (particularly the Caribbean SIs) are partly attributed to reconstruction-costs related to natural disasters.

[32] LICs are similar to SIs in that they share have limited export diversification, however they are on average significantly less open than small economies. SIs are concentrated both in terms of their sectoral focus (relying mostly on tourism) and export source markets while many LICs tend to be commodity exporters.

- The most commonly-used rule of thumb is the extended Guidotti rule which covers short-term external debt plus the current account deficit. However, this metric has a number of limitations. In particular, the thresholds are arbitrary and lack theoretical or empirical backing (IMF, 2011; Wijnholds and Kapteyn, 2001). An additional shortcoming is that the metric does not take not into account potential for reserve loss arising from capital flight by residents.

- Wijnholds and Kapteyn, 2001, developed a composite metric for 21 large emerging market economies using sum of short-term external debt and broad money weighted by the country risk. The metric has a number of weaknesses: the thresholds are arbitrary and no clear benchmark is provided for some economies,[33] the use of standard deviations could have biased the results,[34] and since many countries do not have country risk data the metric has limited operational value.

- Lipschitz et al., 2006 developed a composite indicator using imports, broad money and foreign debt service for 38 developing countries and note that reserves tend to fall more than predicted by traditional thresholds. The metric has two main shortfalls: the thresholds are arbitrary and do not have empirical underpinning and changes in the structural conditions in an economy could affect response to extreme loss events.

Recognizing the various weaknesses of these combination metrics, the IMF (2011a, b) recently developed a benchmark that could be used for emerging market economies based on a two-stage "risk-weighted" approach.

- Stage 1 involves developing a metric that reflects the relative risk levels of different potential sources of balance of payments pressure, based on observed outflows during crisis episodes. Since crisis episodes are associated with pressures on the exchange rate and on official reserves, the IMF (2011a, b) suggests that a good measure of crisis periods could be obtained by examining changes in exchange rate, reserves which can be paid out in response to speculative pressure and changes in interest rate differential since interest rates can be raised to fend off an attack.

- Stage 2 applies risk-weighting by determining the reserve cover needed relative to this risk-weighted measure, based on empirical evidence. The following weights were proposed:

  Fixed: 10% exports + 10% M2 + 30% short-term debt+ 15% other portfolio liabilities

  Floating: 5% exports + 5% M2 + 30% short-term debt+ 10% other portfolio liabilities

[33] For example, there is no debt threshold for economies with fixed exchange rate regimes.

[34] As Flood and Marion, 2002, note if reserves are positively skewed, this measure can over-estimate the downward volatility of reserves.

Drawing on empirical estimate of the coverage of this metric against past episodes, they suggest coverage in the region of 100-150 percent of the metric.

Despite the innovations, the metric has a number of shortcomings. The sources of potential balance of payments risk and the thresholds developed are based on emerging market economies and do not reflect the vulnerabilities that many SIs face. Second, the operational applicability of the benchmark is largely limited to emerging market economies with reliable international investor position data (IIP).

A. Developing A Metric

Drawing on Eichengreen et al., 1996, we compute an EMP index to capture crisis events for SIs with some modification to reflect peculiarities of these islands. Since most SIs have more limited access to capital markets, and lack deep domestic markets, the interest channel tends to be weak. In addition, we do not have reliable interest rate data.[35] Second, the weighting and aggregation of the two variables is undertaken taking into account the exchange rate regime instead of the more typical regional averages. Since volatility of variables tends to be higher in SIs, the paper modifies the critical threshold used to demarcate periods as crisis episodes and periods of tranquility. The definition of the critical threshold in the literature has been arbitrarily defined. Eichengreen et al., 1996 and the IMF (2011a, b) pool all events for a country as a crisis event if the standard deviation from the EMP mean exceeds a threshold of 1.5 while Kaminsky and Reinhart, 1999; and Kaminsky et al., 1998 set this at 3. However, using these thresholds for SIs leaves only idiosyncratic large shocks since they tend to have very high volatility. We therefore modify this measure and set the threshold to 1.

Using this definition, we find that SIs have experienced about 30 episodes of exchange market pressure between 1999 and 2010 (Figure 7, Table 10). Countries have experienced, on average, one episode of EMP pressure, though a number have experienced two or more (e.g., Bahamas, Belize, Comoros, and Jamaica). The frequency of the pressure episodes for countries with flexible exchange rate regime seems to be rising but this could reflect the smaller sample set. About half of these episodes occurred during 2000, 2001, and 2008 which were periods of global pressure suggesting that, on average, these shocks are not idiosyncratic. However, for many countries (e.g., Grenada) the shocks were country-specific (e.g., driven by natural disasters). Some countries have experienced repeated consecutive periods of pressure. In the ensuing analysis, for the economies that experience repeated

[35] Kaminsky and Reinhart, 1999 and Kaminsky et al., 1998, exclude interest rates on the ground of data limitations while Tanner, 2001, has more theoretical objections to the insertion of what she sees as a response variable rather than an indicator. Other papers that use two-component assessment include Sachs et al., 1996, WEO, 2007, as well as Giron and Roper, 1977. Gigineishvili, 2011, notes that pass-through to small island economies is sluggish and attribute this to the fact that most islands tend to have some form of fixed exchange rate regime.

consecutive crisis, we consider the first year and assume that it was a prolonged multi-year crisis.[36]

Studies of individual crisis episodes show balance of payments pressure driven mainly by natural disasters and terms of trade shocks. About two-thirds of the crisis episodes were driven by terms of trade shocks and natural disasters (Figure 8). Natural disasters accounted for about two-thirds of crisis episodes in currency unions whilst terms of trade shocks account for nearly half of crisis episodes in fixed exchange rate regimes. Reflecting this, in most SIs, a crisis event is reflected in a sharp collapse in the current account but in a few cases (e.g., Dominican Republic) it was also reflected in an outflow in private investment.

High levels of public debt limited countries ability to adjust and contributed to twin cases of balance of payments and debt crisis (e.g., Seychelles). Figure 9 illustrates these developments in the case of Grenada and Dominican Republic. A major hurricane devastated Grenada in 2004—with damage exceeding 200 percent of GDP—resulting in collapse in tourism and agriculture. High debt levels limited access to international credit coupled with delays in delivery of pledged donor assistance contributed to emergence of huge financing need leading to a debt crisis.[37] IMF-supported programs in the Dominican Republic and Grenada helped cushion some of the impact of these adverse shocks. In the Dominican Republic, a financial crisis in 2003 led to a generalized loss of confidence and a major bailout that doubled public debt. Capital flight, as illustrated by outflow of private investment, was the primary drain.

This experience suggests the need for a metric that encompasses a broad set of risks. This also accords with evidence from cross-sectional regressions on determinants of reserve holdings for SIs. The potential sources of BOP pressure are broad money, short term debt and exports of goods and services.

- Unlike IMF (2011a, b) we do not consider other debt and liabilities stock due to the general low risk of outflow during crisis of this debt and lack of data. In general most of the SIs liabilities are long-term fixed-interest rate government liabilities and FDI-related liabilities. Most of the government liabilities are held by official creditors (generally not liquidated during periods of stress). There is also no evidence that the stock of FDI-owned by foreigners is sold during times of stress from examination of EMP crisis episodes and from the literature (e.g., IMF, 2011). Most SIs, like other developing countries, do not have data on other (debt and equity) liabilities stock.

[36] However, if there is a gap between crisis (e.g., crisis in 2001 and then in 2003) we include both periods.

[37] The government sought donor assistance but despite over US$150 million in pledge, only US$12 million was available.

- Like the IMF (2011a, b) paper we do not use imports particularly since some of this may be FDI-related and tend to be lumpy and endogenous to the amount of financing available. However, we examine exports of goods as well as services marking a departure from the IMF, 2011b, metric which focused on exports of goods. This is particularly important in SIs given their general reliance on one sector (mainly tourism) and market concentration (mostly Europe and the U.S.).

Based on these crisis events and identified potential sources of pressure, the changes are: *short-term debt on a remaining maturity basis,*[38] *broad money*,[39] and *exports of goods and services.* Figure 10 presents the distribution of the identified potential sources of pressure. For robustness, we also consider random weighting taking into account the probability of shocks that could affect small islands.[40] Similar to the IMF (2011a, b) paper, we use the 10th percentile as the threshold, adjusted for large outliers.[41] Experiences of countries with currency unions (e.g., ECCB countries), fixed and- flexible exchange rate regimes are assessed separately.

The metric is constructed as the simple sum of the potential changes taking into account country experiences and crisis events, and reported in absolute levels, as follows:

Table 1. 10th Percentile Flows During Exchange Market Pressure Events

Percent	Exports	Broad money	Short-term debt
Currency Union	12.4	12.6	75.9
Fixed	10.5	3.6	89.1
Floating	4.8	24.4	35.2

Source: Author's calculations

[38] The debt service liabilities in year t are short-term liabilities in year t and t+1.

[39] The IMF (2011a, b) metric uses broad money during event year compared to the average three years ahead. Using broad money relative to previous years has the added advantage of creating a framework that is operational since this data is available.

[40] Bootstrapping techniques are used to obtain 10,000 random observations for each of the three sources of pressure (export drain, debt service and broad money) and including the observations from the original sample taking into account likely risks that could affect small islands. This is important for two reasons: the time span of the analysis (12 annual data points) is relatively short and EMP events are not high frequency events. Second, the EMP crisis events are reflection of outcome and there were likely additional sources of pressure. Crisis episodes could have been avoided through preventive measures such as IMF financing, grants and remittances. To complement the analysis will therefore also develop distribution of risk that taking into account likely risks that could affect small states drawing on the literature (e.g., Barnichon, 2009, notes that on average a major hurricane hits a Caribbean country every 25 years implying a probability of 0.96 each year).

[41] We remove extreme outliers (e.g., Comoros short-term debt).

Reflecting very large uncertainty necessarily surrounding these estimates and the data distribution an additional buffer of 5 percent is added. A larger buffer of 25 percent is added for exports drains to fixed exchange regimes to taking into account the high probability terms of trade shocks, the higher volatility of export drains and findings from random weighted distribution using bootstrapping techniques. The proposed for the metrics as follows:

Currency union: 20% of exports + 20% of broad money + 80% of short-term debt

Fixed: 35% of exports + 10% of broad money + 95% of short-term debt

Floating: 10% of exports + 30% of broad money + 40% of short-term debt

The proposed metric is more stringent than the IMF, 2011, metric. It places more weight on exports and short-term debt than suggested by the IMF, 2011a, metric partly reflecting the higher vulnerability of small islands to terms of trade shock and the limited financial structures that could lead to accelerated deleveraging for countries that do have short term market debt. The proposed metric requires higher reserve holdings that the most stringent of the traditional metrics for most countries (Figure 11).[42] Based on end-2010, only 29 percent of the sample was within the proposed metric. However, the use of weights allows us to construct a representative metric for all countries but does not provide any information about what is the adequate threshold value for this metric. In the next section, we develop thresholds drawing on empirical analysis of the effect of the metric in reducing crisis probabilities.

B. Empirical Analysis to Determine Thresholds For the Metric

We estimate a binary logit model, linking our dependent variable (using the EMP variable which takes on value of unity for a crisis and zero otherwise) to the reserves/proposed metric to see how well it would perform in reducing crisis probabilities. We also assess the performance of this metric against other metrics.

In the baseline model, we estimate the performance of the reserve-to-proposed metric in reducing the probability of a crisis controlling for fiscal policy and institutional quality. To assess the performance of this metric against other metrics, we run alternative regressions using the other metrics in combination with our proposed metric and also separately our sample includes annual data for 21 SIs from 1999 to 2010.[43] The dependent variable is as described above. The explanatory variable in the baseline model, reserve-to-proposed metric

[42] Using the maximum of the traditional metric generates some outliers for example Dominican Republic and Mauritius would be expected to hold about 15 and 11 months of reserves, respectively on account of their high broad money supply if the traditional 20 percent threshold is used. Similarly, Sao Tome and Principe, and Vanuatu would be expected to hold over 200 months of reserves (not shown in chart) due to their high broad money levels.

[43] Includes Sri Lanka and excludes outliers (e.g., Comoros).

is actual reserves divided by reserve holdings implied by the metric. The alternative metrics considered are the three-month import coverage metric; broad money metric; Guidotti-Greenspan metric; maximum of the three traditional metrics and Lipschitz metric.[44] As before, reserves are deflated by holdings implied by the metrics. The control variables are government effectiveness and fiscal balance as a share of GDP. All the data, with the exception of institutions, are taken from the International Financial Statistics and World Economic Outlook databases. Institution data are taken from World Bank, Kaufmann and Kraay governance indicators.

C. Estimation Results

The ratio of reserves to the metric is strongly positively associated with a reduction in the probability of an EMP event (Figure 12). Higher reserve holding relative to the proposed metric significantly reduces the probability of an EMP event, with the reduction diminishing as the reserves ratio increases. Crisis probabilities rapidly tail off as the coverage reaches about 75-100 percent of the metric and this could be regarded as adequate for a typical country. The probability of a crisis for countries that hold about 75 percent of reserves implied by this metric is less than 2 percent.

The reserves-to-metric ratio performs markedly better in this estimation than any of the alternative traditional single or combined metrics—including import cover, short-term debt, broad money, the maximum of the traditional metrics (Table 11, models 1-6). Holding higher reserves-to-proposed metric significantly reduces the probability of a crisis. This finding is highly significant and robust to alternative model specifications including after controlling for other metrics. The reserve-to-Lischitz metric is the only metric that is strongly significant with no other controls (model 11) but it is weakly significant in the regression including the proposed reserve-to-metric ratio (model 5).[45]

Most countries hold reserves that would be adequate by the proposed metric (Figure 13). Based on end-2010 data, about 37 percent of the sample was within the proposed adequacy range, with roughly 32 percent with reserves above the range and about 42 percent with reserves below the range. Of the 14 countries with cover below 100 percent, six have currency unions and five have fixed exchange rate regimes.

Depending on country characteristics, vulnerabilities and degree of risk aversion, they may choose to hold a different level of reserves than implied by these thresholds. Though SIs tend to face broadly similar sources of pressure, differences in their risk appetite and vulnerability to shocks (including idiosyncratic shocks such as natural disasters) could necessitate higher

[44] Due to lack of data, we did not compare against the IMF (2011a, b) metric or the Wijnholds and Kapteyn, 2001, metric.

[45] In order to enable a meaningful comparison of the various adequacy measures the sample size is kept constant.

reserve holdings for some countries. For example, countries that have no short-term market debt may choose to place no weight on this variable.

IV. Conclusion

This paper revisits the determinants of reserve holdings using quantile regression and standard OLS techniques and finds that there are pronounced differences in cross-country preferences across the distribution of reserve holdings, partly driven by differences in debt holders. Our findings suggest that that there is a positive relationship between short-term debt and reserves for EMs reflecting insurance against deleveraging and rollover risk. For SIs, in general, reserves decrease as short-term debt rises and could reflect the higher share of concessional debt. Future work could investigate in more detail the debt-reserve dynamics. Whilst precautionary motives appear important in explaining the variation in reserve holdings there are additional reasons to hold reserves, which are not well captured by the purely precautionary elements of the model. F-tests comparing the inter-quantile differences could not reject the null that the models for the different quantiles of SIs reserve distribution were similar but this was rejected for EMs distribution suggesting that models explaining drivers of reserve holdings should take into account the country's reserve holdings.

The paper also develops a user-friendly operational metric than can be used to determine the level of reserves in SIs. The metric is a weighted function of broad money, short-term debt and exports. Empirical analysis suggests that holding about 75-100 percent of this metric reduces the probability of a crisis to less than 2 percent. Robustness analysis suggests that this metric performs better than others in reducing the probability of a crisis. There are some caveats. Country-specific factors need to be taken into account in determining the adequacy of reserve holdings.

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Tables and Figures

Appendix Table 1. Country List

Country	Small island developing states	Emerging markets	Country	Small island developing states	Emerging markets
Albania	0	1	Macedonia, FYR	0	1
Antigua and Barbuda	1	0	Malaysia	0	1
Argentina	0	1	Maldives	1	0
Bahamas, The	1	0	Mauritius	1	0
Barbados	1	0	Mexico	0	1
Belarus	0	1	Morocco	0	1
Belize	1	0	Namibia	0	1
Bosnia & Herzegovina	0	1	Pakistan	0	1
Botswana	0	1	Panama	0	1
Brazil	0	1	Paraguay	0	1
Bulgaria	0	1	Peru	0	1
Cape Verde	1	0	Philippines	0	1
Chile	0	1	Poland	0	1
China,P.R.: Mainland	0	1	Romania	0	1
Colombia	0	1	Samoa	1	0
Comoros	1	0	São Tomé & Príncipe	1	0
Costa Rica	0	1	Serbia, Republic of	0	1
Croatia	0	1	Seychelles	1	0
Dominica	1	0	Solomon Islands	1	0
Dominican Republic	1	0	South Africa	0	1
Egypt	0	1	Sri Lanka	1	0
El Salvador	0	1	St. Kitts and Nevis	1	0
Estonia	0	1	St. Lucia	1	0
Fiji	1	0	St. Vincent & Grens.	1	0
Grenada	1	0	Suriname	0	1
Guatemala	0	1	Swaziland	0	1
Hungary	0	1	Syrian Arab Republic	0	1
India	0	1	Thailand	0	1
Indonesia	0	1	Tonga	1	0
Jamaica	0	1	Tunisia	0	1
Jordan	1	0	Turkey	0	1
Latvia	0	1	Ukraine	0	1
Lebanon	0	1	Uruguay	0	1
Lithuania	0	1	Vanuatu	1	0

Appendix Table 2. Description of Variables

Table A1. Description of Variables 1/

Variables	Rationale	Variable Description	Data Source
Reserves	Dependent variable	Stock of reserves as a share of GDP	WEO, IMF
Export volatility 2/	Proxy for real earnings volatility, captures current account vulnerability	Volatility of real exports receipts of goods and services (G&S) weighted by the share of exports in GDP. This is computed on annual basis by taking standard deviation of quarterly real exports of G&S data during the year and weighting it by the share of exports of G&S in GDP that year.	IFS, IMF
Tourism volatility	Proxy for real earnings volatility, captures current account vulnerability	Volatility of real travel receipts. This is computed on annual basis by taking standard deviation of quarterly real travel receipts data during the year.	IFS, IMF
Remittance volatility	Proxy for real earnings volatility, captures current account vulnerability	Volatility of real remittance receipts. This is computed on annual basis by taking standard deviation of quarterly real remittance receipts data during the year.	IFS, IMF
Aid volatility	Proxy for real earnings volatility, captures current account vulnerability	Volatility of real aid receipts. This is computed on annual basis by taking standard deviation of quarterly real aid receipts data during the year.	IFS, IMF
GDP pc growth	Proxy for real earnings growth	Real GDP per capita growth.	WEO, IMF
Import-to-GDP	Proxy for current account vulnerability	Imports as a share of GDP	WEO, IMF
Openness	Proxy for current account vulnerability	Imports plus exports as a share of GDP	WEO, IMF
Debt-to-GDP	Proxy for capital account vulnerability	Short-term debt as a share of GDP	WEO, IMF
Money-to-GDP	Proxy for financial depth; captures capital account vulnerability	Broad money as a share of GDP	WEO, IMF
Interest rate	Proxy for the opportunity cost of holdign reserves	Interest differential with the US. This is computed by taking the US interest rate corresponding to the definition use for the national interest rate (deposit, t-bill rate, money market)	WEO and IFS, IMF
Government Effectiveness	Proxy for institutions	Proxy for institutions, focusing on governance	World Bank, Kaufmann and Kraay governance indicators
NEER volatility	Exchange rate flexibility	Volatility of the nominal effective exchange rate. This is computed on annual basisis by taking the standard deviation of monthly nominal effective exchange rate	IMF
Exchange rate dummy	Exchange rate effect	Is 1 if flexible; 0 otherwise.	AREAR, IMF
Crisis dummy	Crisis effects	Is 1 if crisis; 0 otherwise. Constructed using EMP.	Author estimates

1/ All data are on annual basis though computation of volatlity variables used data of higher frequency.
2/ For sensitivity, we also considered unweighted real exports of G&S and real exports of goods only.

Appendix Table 3. SIs and EMs: Reserve Demand Regressions 1/

	Small island economies								Emerging market economies		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Dependent variable: Reserve-to-GDP										
Regressors	OLS Pooled	OLS Fixed Effects							OLS Pooled	OLS Fixed Effects	
d(Broad money/GDP)	0.2016**	0.0689	0.1282**	-0.02565	-0.05002	0.0444	0.0579	0.0644	0.3319**	0.1768***	0.1771***
	(0.086)	(0.055)	(0.054)	(0.151)	(0.152)	(0.135)	(0.056)	(0.057)	(0.166)	(0.061)	(0.060)
Import-to-GDP	0.0512*	0.1855***	0.1713***	0.17998***	0.17826***	0.2027***		0.1756***	0.1824***	0.2075**	0.2089**
	(0.026)	(0.050)	(0.044)	(0.038)	(0.038)	(0.041)		(0.039)	(0.026)	(0.084)	(0.084)
NEER volatility	-0.0056***	-0.0049***	-0.0045**	-0.00664**	-0.00736**	-0.0072**	-0.0052***	-0.0046***	-0.0021***	-0.0002	-0.0002
	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Short-term debt	-0.3998***	-0.1515*	-0.1410*	-0.29964	-0.25111	-0.2786	-0.1302	-0.1680*	0.1358***	0.1536**	0.1520**
	(0.092)	(0.087)	(0.076)	(0.190)	(0.173)	(0.161)	(0.082)	(0.086)	(0.033)	(0.066)	(0.066)
Crisis Dummy	-0.0168	-0.0157**	-0.0169**	-0.02246**	-0.02787**	-0.0282**	-0.0168**	-0.0132	0.0364	-0.0072	-0.0081
	(0.013)	(0.007)	(0.007)	(0.010)	(0.010)	(0.009)	(0.007)	(0.008)	(0.033)	(0.008)	(0.008)
Real GDP growth per capita			0.2067***								
			(0.067)								
Tourism volatility				0.00004							
				(0.000)							
Aid volatility					0.00003*						
					(0.000)						
Export Volatility						-0.0033					
						(0.003)					
Openness							0.1385***				
							(0.033)				
Government Effectiveness								0.0290***			0.0139
								(0.010)			(0.020)
Constant	0.1235***	0.0869***	0.0916***	0.06203	0.06915	0.0672	0.0617*	0.0040	0.0691**	0.0956*	0.0531
	(0.017)	(0.027)	(0.025)	(0.045)	(0.050)	(0.049)	(0.030)	(0.038)	(0.030)	(0.050)	(0.080)
Observations	247	247	247	96	96	96	247	247	482	482	482
R-squared	0.2217	0.3082	0.3266	0.27212	0.26718	0.3099	0.3315	0.3440	0.2248	0.2947	0.2967
Number of panels		23	23	11	11	11	23	23		44	44

Robust standard errors in pare

*** p<0.01, ** p<0.05, * p<0.1

1/ Time dummies included

Appendix Table 4. Full Sample: OLS and Quantile Regression Results 1/

	Full sample (Small islands and Emerging Market Economies)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Reserve-to-GDP						
Regressors	OLS Pooled 2/	OLS Fixed Effects	Quantile				
			5th	25th	50th	75th	95th
d(Broad money/GDP)	0.2945**	0.1451***	0.1311	0.3050***	0.3263***	0.3316*	0.0925
	(0.117)	(0.042)	(0.080)	(0.115)	(0.102)	(0.183)	(0.230)
Import-to-GDP	0.0888***	0.1498***	0.0036	0.0709***	0.0833***	0.1299***	0.1350**
	(0.021)	(0.044)	(0.016)	(0.019)	(0.027)	(0.024)	(0.057)
NEER volatility	-0.0019**	-0.0004	-0.0023	-0.0019	-0.0025**	-0.0013	-0.0023
	(0.001)	(0.000)	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)
Short-term debt	0.1716***	0.1434**	0.1037***	0.1130***	0.1492***	0.2097***	0.2446***
	(0.030)	(0.064)	(0.019)	(0.034)	(0.049)	(0.036)	(0.069)
Crisis Dummy	0.0080	-0.0116*	-0.0136	-0.0098	-0.0052	-0.0062	0.1541
	(0.020)	(0.006)	(0.014)	(0.008)	(0.018)	(0.012)	(0.136)
Government Effectiveness	0.0075	0.0207*	0.0147**	-0.0093	-0.0205**	-0.0097	0.0649***
	(0.007)	(0.011)	(0.006)	(0.006)	(0.009)	(0.011)	(0.023)
Constant	0.0714***	0.0000	-0.0080	0.0742***	0.1392***	0.1350***	-0.0229
	(0.025)	(0.038)	(0.022)	(0.021)	(0.032)	(0.036)	(0.072)
Observations	729	729	729	729	729	729	729
R-squared	0.1865	0.2635					
Number of panels		67					

Robust standard errors in pare
*** p<0.01, ** p<0.05, * p<0.1
1/ Time dummies included
2/ Robust standard errors

Appendix Table 5. SIs Sample: OLS and Quantile Regression Results 1/

	Small islands						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Reserve-to-GDP						
Regressors	OLS Pooled 2/	OLS Fixed Effects	Quantile				
			5th	25th	50th	75th	95th
d(Broad money/GDP)	0.2241***	0.0644	0.2546	0.2654*	0.2410*	0.2533	0.1347
	(0.086)	(0.057)	(0.166)	(0.147)	(0.141)	(0.174)	(0.129)
Import-to-GDP	0.0645**	0.1756***	0.0569	0.1066**	0.0600	0.0800***	0.0683**
	(0.026)	(0.039)	(0.039)	(0.050)	(0.040)	(0.024)	(0.035)
NEER volatility	-0.0063***	-0.0046***	-0.0026	-0.0058**	-0.0061**	-0.0070***	-0.0101***
	(0.001)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)	(0.003)
Short-term debt	-0.3902***	-0.1680*	-0.2780**	-0.3627**	-0.3165**	-0.5757***	-0.4561***
	(0.091)	(0.086)	(0.132)	(0.149)	(0.158)	(0.095)	(0.132)
Crisis Dummy	-0.0171	-0.0132	-0.0281	-0.0126	-0.0249	-0.0259	-0.0009
	(0.012)	(0.008)	(0.022)	(0.014)	(0.025)	(0.018)	(0.025)
Government Effectiveness	-0.0124*	0.0290***	-0.0059	-0.0073	-0.0271**	-0.0140*	-0.0136
	(0.007)	(0.010)	(0.009)	(0.012)	(0.012)	(0.007)	(0.008)
Constant	0.1543***	0.0040	0.0854	0.1154*	0.2375***	0.2456***	0.3668***
	(0.024)	(0.038)	(0.054)	(0.059)	(0.044)	(0.029)	(0.045)
Observations	247	247	247	247	247	247	247
R-squared	0.2402	0.3440					
Number of panels		23					

Robust standard errors in pare
*** p<0.01, ** p<0.05, * p<0.1
1/ Time dummies included
2/ Robust standard errors

Appendix Table 6. EM Sample: OLS and Quantile Regression Results 1/

	Emerging Markets						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Dependent variable: Reserve-to-GDP						
Regressors	OLS Pooled 2/	OLS Fixed Effects	Quantile				
			5th	25th	50th	75th	95th
d(Broad money/GDP)	0.3640**	0.1771***	0.1389	0.2520**	0.3670**	0.4393**	0.2764
	(0.166)	(0.060)	(0.116)	(0.119)	(0.160)	(0.196)	(0.390)
Import-to-GDP	0.1820***	0.2089**	0.0370	0.0841***	0.1831***	0.2499***	0.1483***
	(0.025)	(0.084)	(0.032)	(0.025)	(0.034)	(0.044)	(0.052)
NEER volatility	-0.0019***	-0.0002	-0.0027	-0.0011	-0.0015*	-0.0014	-0.0029
	(0.001)	(0.000)	(0.002)	(0.001)	(0.001)	(0.001)	(0.003)
Short-term debt	0.1262***	0.1520**	0.0647	0.1369***	0.1178***	0.1609***	0.2708***
	(0.038)	(0.066)	(0.046)	(0.029)	(0.045)	(0.035)	(0.084)
Crisis Dummy	0.0294	-0.0081	0.0141	-0.0045	0.0155	0.0027	0.2137
	(0.032)	(0.008)	(0.015)	(0.021)	(0.021)	(0.021)	(0.180)
Government Effectiveness	0.0296***	0.0139	0.0258***	-0.0122	0.0019	0.0298**	0.1952***
	(0.011)	(0.020)	(0.007)	(0.009)	(0.013)	(0.013)	(0.063)
Constant	-0.0177	0.0531	-0.0420	0.0721***	0.0380	-0.0272	-0.3102
	(0.037)	(0.080)	(0.028)	(0.022)	(0.044)	(0.041)	(0.248)
Observations	482	482	482	482	482	482	482
R-squared	0.2392	0.2967					
Number of panels		44					

Robust standard errors in pare
*** p<0.01, ** p<0.05, * p<0.1
1/ Time dummies included
2/ Robust standard errors

Appendix Table 7. Full Sample: Inter-quantile Regression Results 1/

	Full sample (Small islands and Emerging Market Economies)				
	(1)	(2)	(3)	(4)	(5)
Regressors	Quantile				
	5th-25th	25th-50th	50th-75th	75th-95th	5th-95th
d(Broad money/GDP)	-0.1738	-0.0212	-0.0053	0.2391	0.0386
	(0.124)	(0.105)	(0.132)	(0.274)	(0.292)
Import-to-GDP	-0.0673***	-0.0124	0.0465*	-0.0052	-0.1314**
	(0.020)	(0.020)	(0.027)	(0.071)	(0.076)
NEER volatility	-0.0004	0.0007	-0.0012	0.0010	0.0000
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
Short-term debt	-0.0093	-0.0362	-0.0601*	-0.0348	-0.1409**
	(0.027)	(0.034)	(0.036)	(0.057)	(0.063)
Crisis Dummy	-0.004	-0.0046	0.0011	-0.1603	-0.1677
	(0.013)	(0.014)	(0.016)	(0.131)	(0.136)
Government Effectiveness	0.0241***	0.0111*	-0.0108	-0.0746***	-0.0502**
	(0.006)	(0.006)	(0.008)	(0.026)	(0.029)
Memo					
Observations	729	729	729	729	729
F-test 3/	1.78**	0.62	1.01	1.64**	2.49***
Prob>F	0.03	0.87	0.44	0.05	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
1/ Time dummies included
2/ Robust standard errors
3/ F-test with null hypothesis that the quantiles mentioned are equal

Appendix Table 8. SIs: Inter-quantile Regression Results 1/

	Small islands				
	(1)	(2)	(3)	(4)	(5)
Regressors	Quantile				
	5th-25th	25th-50th	50th-75th	75th-95th	5th-95th
d(Broad money/GDP)	-0.0107	0.0243	-0.0123	0.1187	0.1200
	(0.153)	(0.119)	(0.108)	(0.147)	(0.204)
Import-to-GDP	-0.0496	0.0465	-0.0199	0.0117	-0.0114
	(0.058)	(0.044)	(0.038)	(0.038)	(0.061)
NEER volatility	0.0032	0.0003	0.0008	0.0031	0.0075**
	(0.002)	(0.002)	(0.002)	(0.003)	(0.004)
Short-term debt	0.0847	-0.0462	0.2592**	-0.1195	0.1781
	(0.175)	(0.140)	(0.129)	(0.152)	(0.202)
Crisis Dummy	-0.0156	0.0122	0.0010	-0.0250	-0.0270
	(0.023)	(0.017)	(0.018)	(0.023)	(0.030)
Government Effectiveness	0.0013	0.0198**	-0.011	-0.0004	0.0077
	(0.010)	(0.010)	(0.010)	(0.009)	(0.012)
Memo					
Observations	247	247	247	247	247
F-test 3/	0.37	0.79	0.77	0.81	0.78
Prob>F	0.99	0.69	0.72	0.67	0.71

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
1/ Time dummies included
2/ Robust standard errors
3/ F-test with null hypothesis that the quantiles mentioned are equal

Appendix Table 9. EM: Inter-quantile Regression Results 1/

	Emerging Market Economies				
	(1)	(2)	(3)	(4)	(5)
Regressors	Quantile				
	5th-25th	25th-50th	50th-75th	75th-95th	5th-95th
d(Broad money/GDP)	-0.1131	-0.0115	-0.0723	0.1629	-0.1376
	(0.160)	(0.135)	(0.160)	(0.368)	(0.391)
Import-to-GDP	-0.0471	-0.0990***	-0.0668**	0.1016	-0.1113
	(0.031)	(0.027)	(0.033)	(0.080)	(0.086)
NEER volatility	-0.0016	0.0004	-0.0002	0.0015	0.0002
	(0.002)	(0.001)	(0.001)	(0.003)	(0.004)
Short-term debt	-0.0722*	0.0191	-0.0431	-0.1099	-0.2061**
	(0.038)	(0.036)	(0.038)	(0.073)	(0.082)
Crisis Dummy	0.0186	-0.0200	0.0128	-0.2110	-0.1996
	(0.018)	(0.019)	(0.025)	(0.137)	(0.144)
Government Effectiveness	0.0380***	-0.0141	-0.0279	-0.1653***	-0.1694***
	(0.009)	(0.009)	(0.011)	(0.057)	(0.060)
Memo					
Observations	482	482	482	482	482
F-test 3/	2.14***	1.50*	0.99	1.53**	2.69***
Prob>F	0.01	0.1	0.47	0.08	0.00

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
1/ Time dummies included
2/ Robust standard errors
3/ F-test with null hypothesis that the quantiles mentioned are equal

Appendix Table 10. SIs: Episodes of Exchange Market Pressure

(EMP = 1 if crisis episode; 0 otherwise)

Country	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Antigua and Barbuda	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bahamas, The	0.00	1.00	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00
Barbados	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Belize	0.00	0.00	0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Cape Verde	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...
Comoros	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Dominica	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
Dominican Republic	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fiji	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Grenada	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
Jamaica	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Maldives	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mauritius	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	1.00	0.00	0.00
Samoa	...	...	...	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
São Tomé & Príncipe	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	...	...	...
Seychelles	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
Solomon Islands	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sri Lanka	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
St. Kitts and Nevis	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
St. Lucia	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00
St. Vincent & Grens.	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tonga	1.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Vanuatu	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00

Source: Author's estimates

Appendix Table 11. Comparison on Various Reserve Adequacy Metrics: Logit Regression

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Independent variables	EMP events											
Reserves/metric$_{t-1}$	-3.771***	-3.833***	-4.565**	-3.797***	0.700	-3.986***	-2.812**					
	(1.361)	(1.404)	(1.926)	(1.446)	(2.665)	(1.378)	(1.178)					
Fiscal balance-to-GDP$_{t-1}$	0.0379*	0.0370*	0.0390*	0.0374*	0.0495**	0.0396*						
	(0.0203)	(0.0204)	(0.0207)	(0.0219)	(0.0237)	(0.0205)						
Government effectiveness$_{t-1}$	0.813	0.789	0.972	0.811	1.863	0.557						
	(1.435)	(1.435)	(1.466)	(1.432)	(1.561)	(1.536)						
Reserves/(CA deficit + s.term debt metric)$_{t-1}$		0.0385						0.0215				
		(0.148)						(0.0816)				
Reserves/broad money metric$_{t-1}$			0.421						-0.934*			
			(0.704)						(0.547)			
Reserves/ imports metric$_{t-1}$				-0.0832						0.500		
				(1.548)						(1.062)		
Reserves/Lipschitz metric$_{t-1}$					-5.279*						-2.771**	
					(3.119)						(1.143)	
Reserves/Maxmetric$_{t-1}$						-0.529						-0.268
						(0.502)						(0.389)
Constant	-1.358	-1.335	-1.611	-1.360	-2.038	-0.792	-0.689	-2.113***	-1.088*	-1.975***	-0.583	-2.007***
	(1.687)	(1.685)	(1.748)	(1.684)	(1.734)	(1.836)	(0.579)	(0.263)	(0.589)	(0.345)	(0.614)	(0.272)
Observations	164	164	164	164	164	164	164	164	164	164	164	164

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

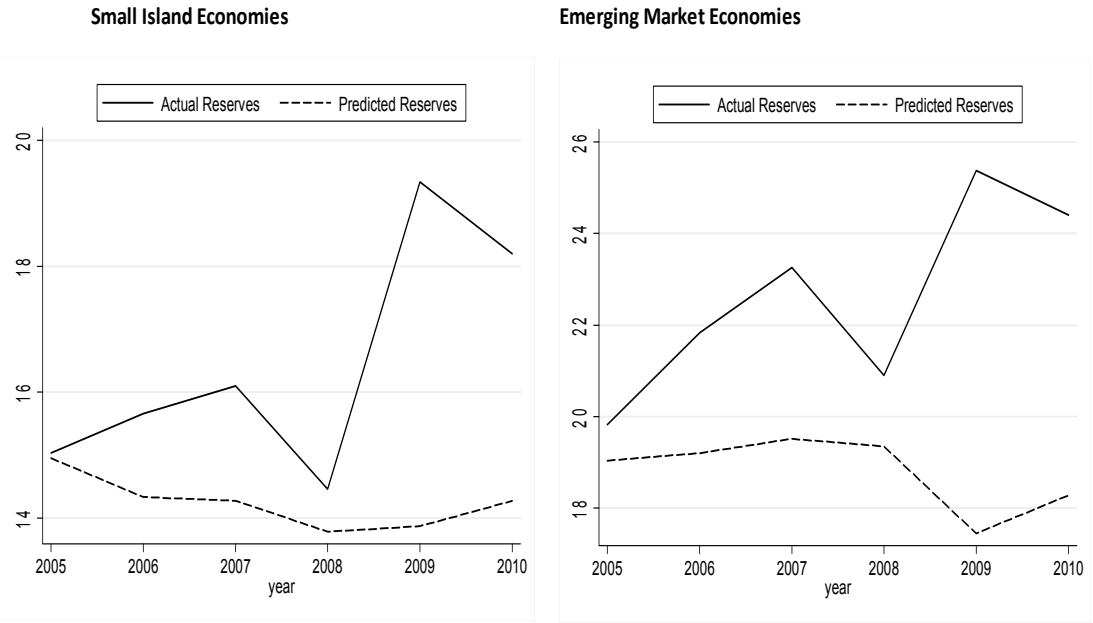
Source: Staff estimates
1/ "Maxmetric" equals the maximum of 100 percent of short-term debt, 20 percent of broad money, and three months of imports

Figure 1. EM and SIs: Traditional Metrics, 2000-2010 1/

Source: WEO estimates and Author's estimates

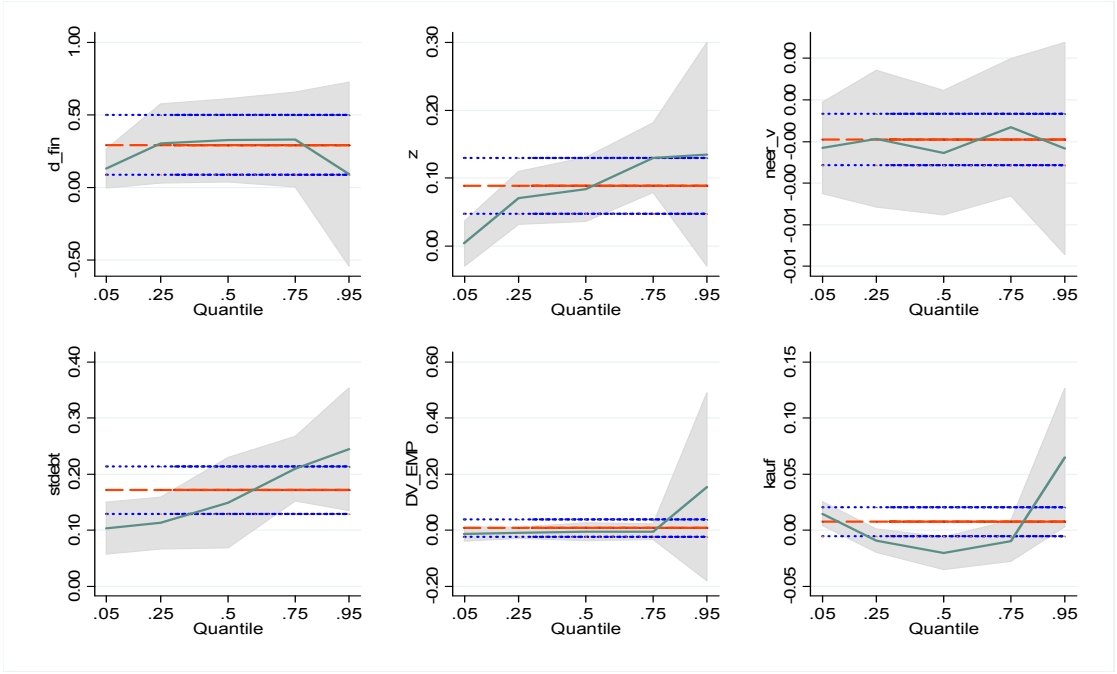
1/ The maximum of the traditional approach is the largest value from various traditional metrics.

Figure 2. Sample Mean: Actual and Predicted Reserves, 2007-2010 [1/]
(In percent of GDP)



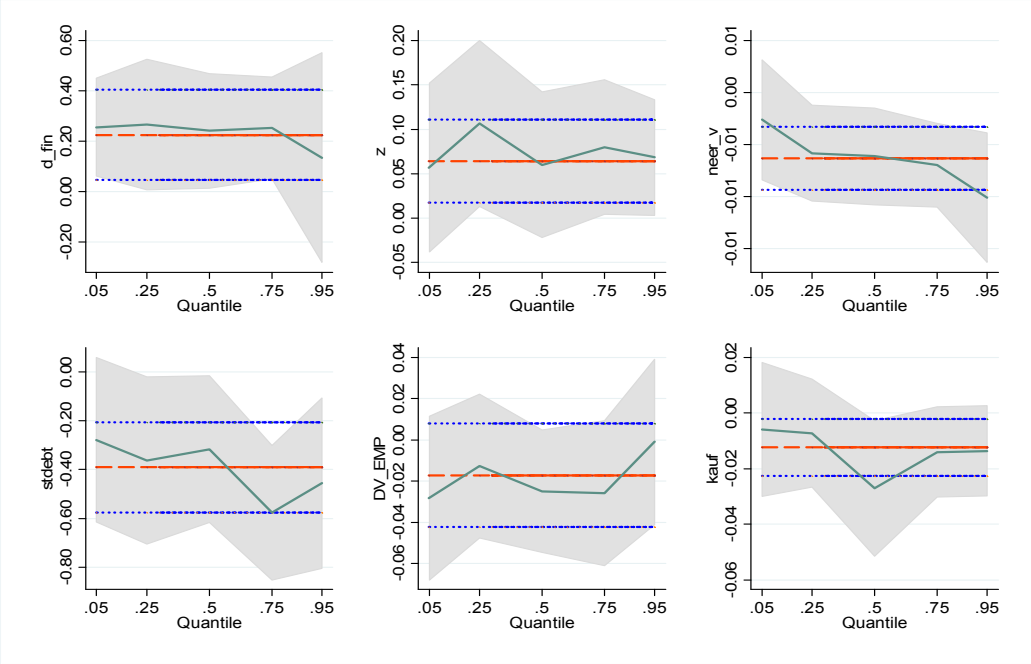
Source: Author's estimates
1/ Out of sample prediction of baseline model (2 and 10) from Table A3.

Figure 3. Full Sample: Comparison of OLS and Quantile Regression Coefficient Estimate



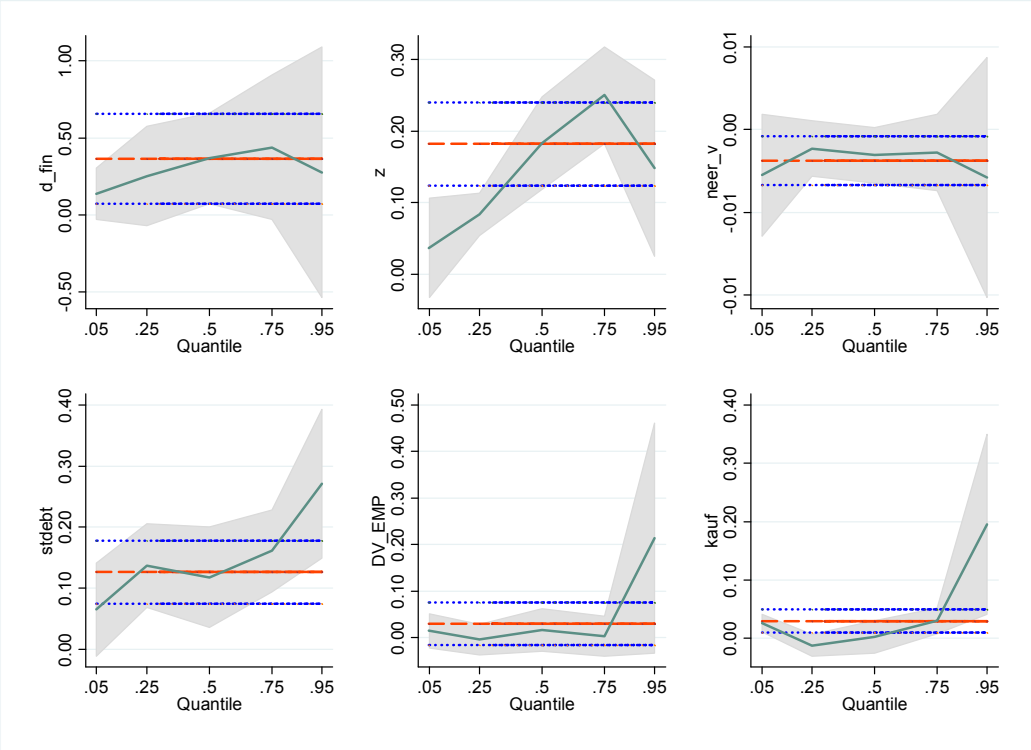
Source: Author's estimates

Figure 4. SIs: Comparison of OLS and Quantile Regression Coefficient Estimates



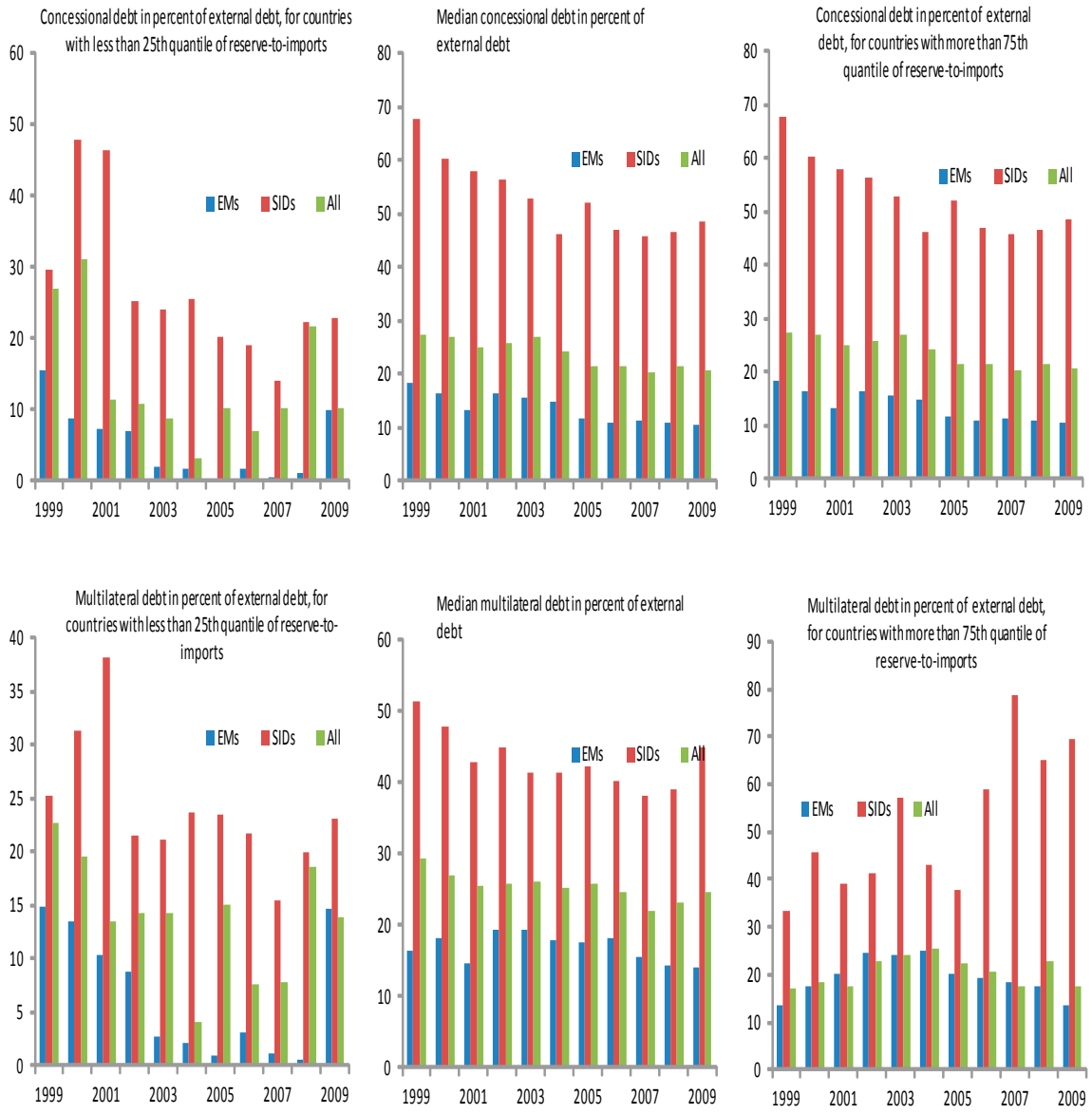
Source: Author's estimates

Figure 5. EM: Comparison of OLS and Quantile Regression Coefficient Estimates



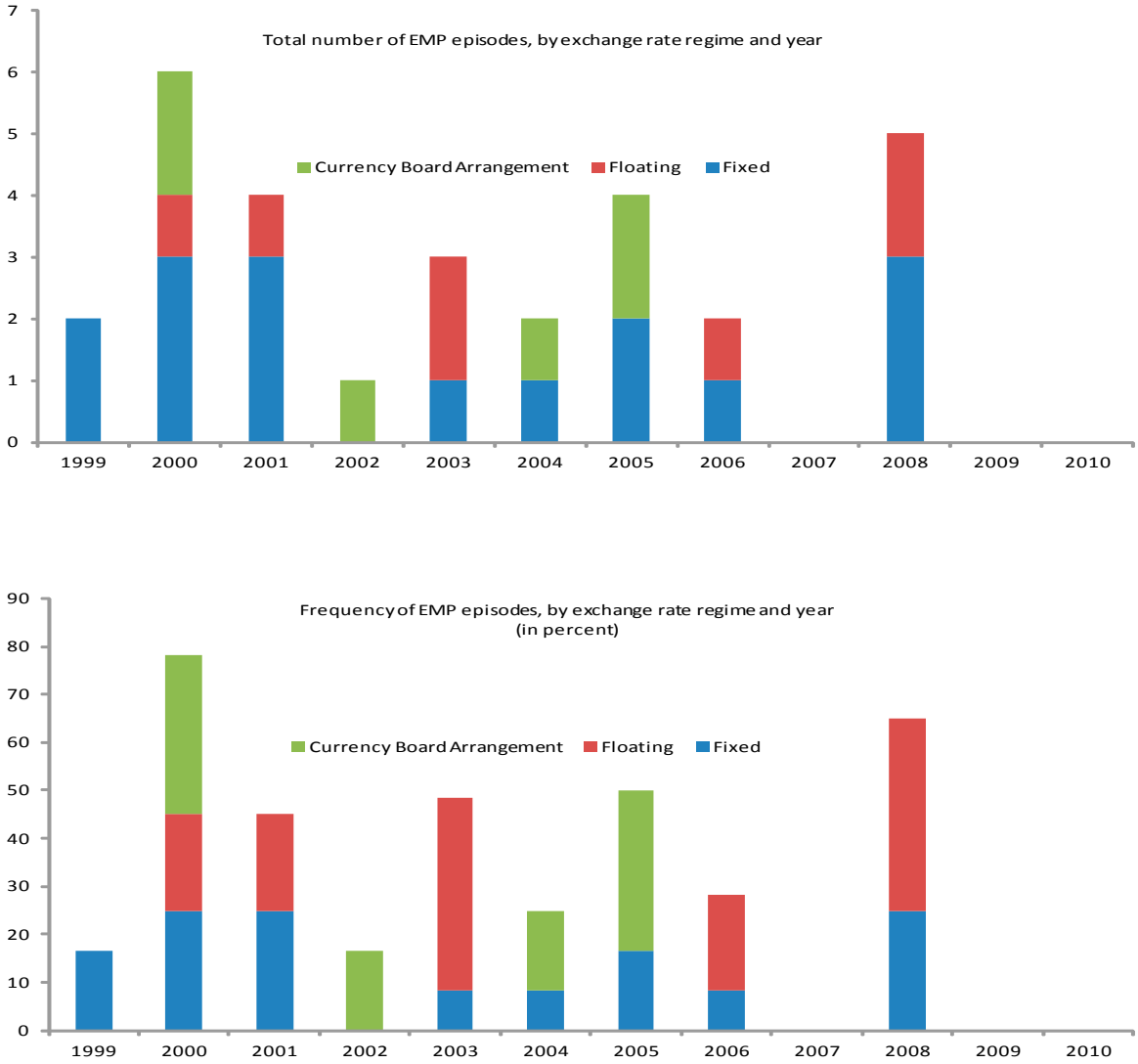
Source: Author's estimates

Figure 6. EM and SIs: Concessional and Multilateral Debt, 1999-2009



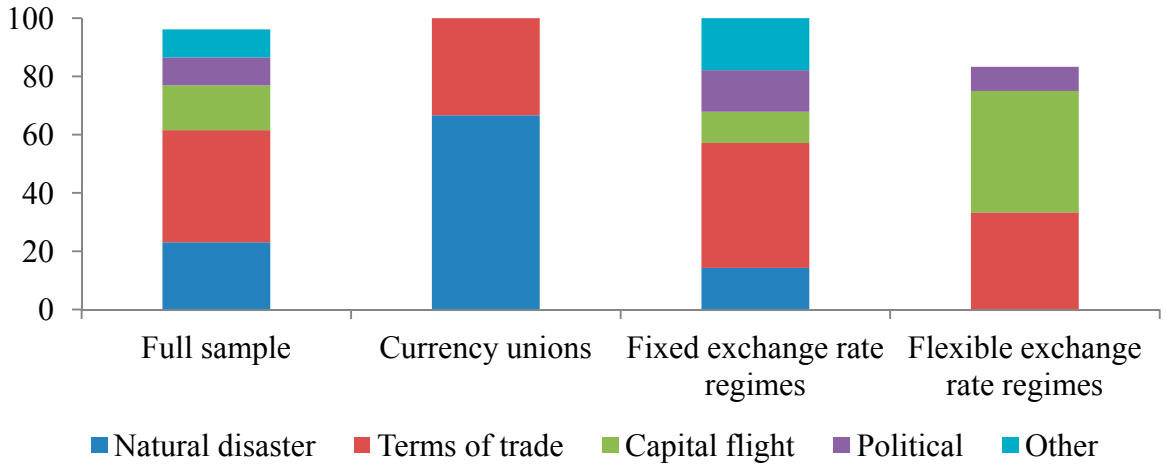
Source: IFS

Figure 7. SIs: Exchange Market Pressure Crisis Episodes



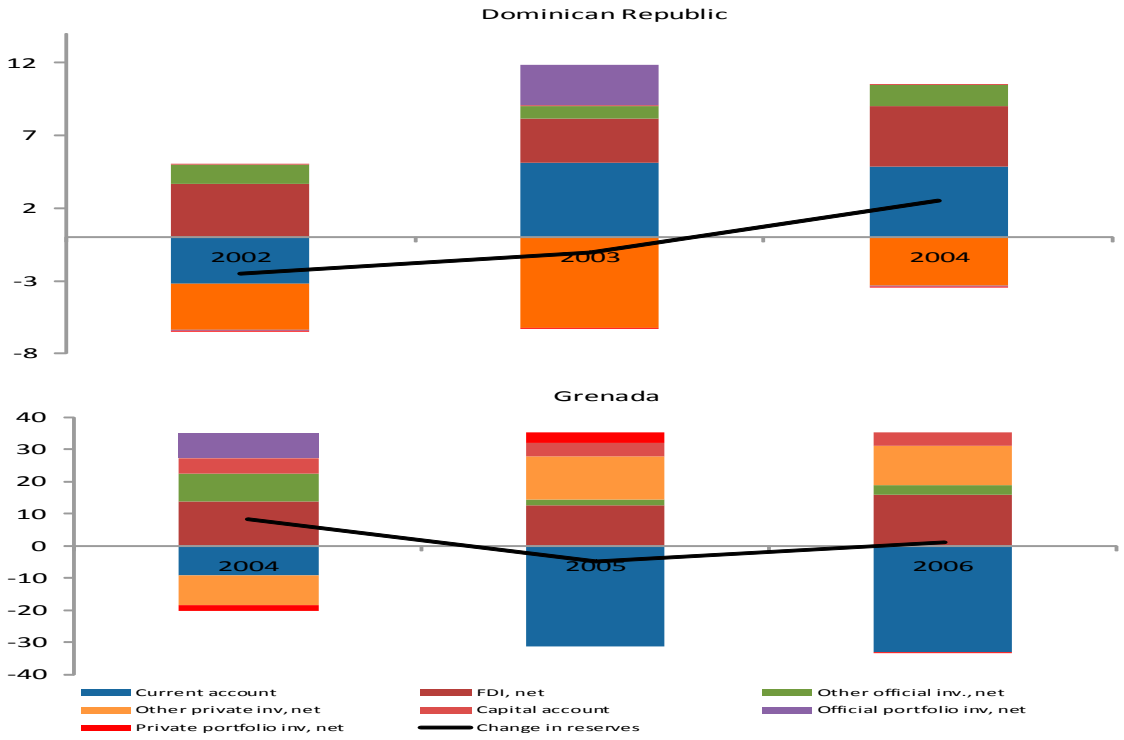
Source: Author's calculations

Figure 8. SIs: Exchange Market Pressure Crisis Episodes Triggers (in percent of total)



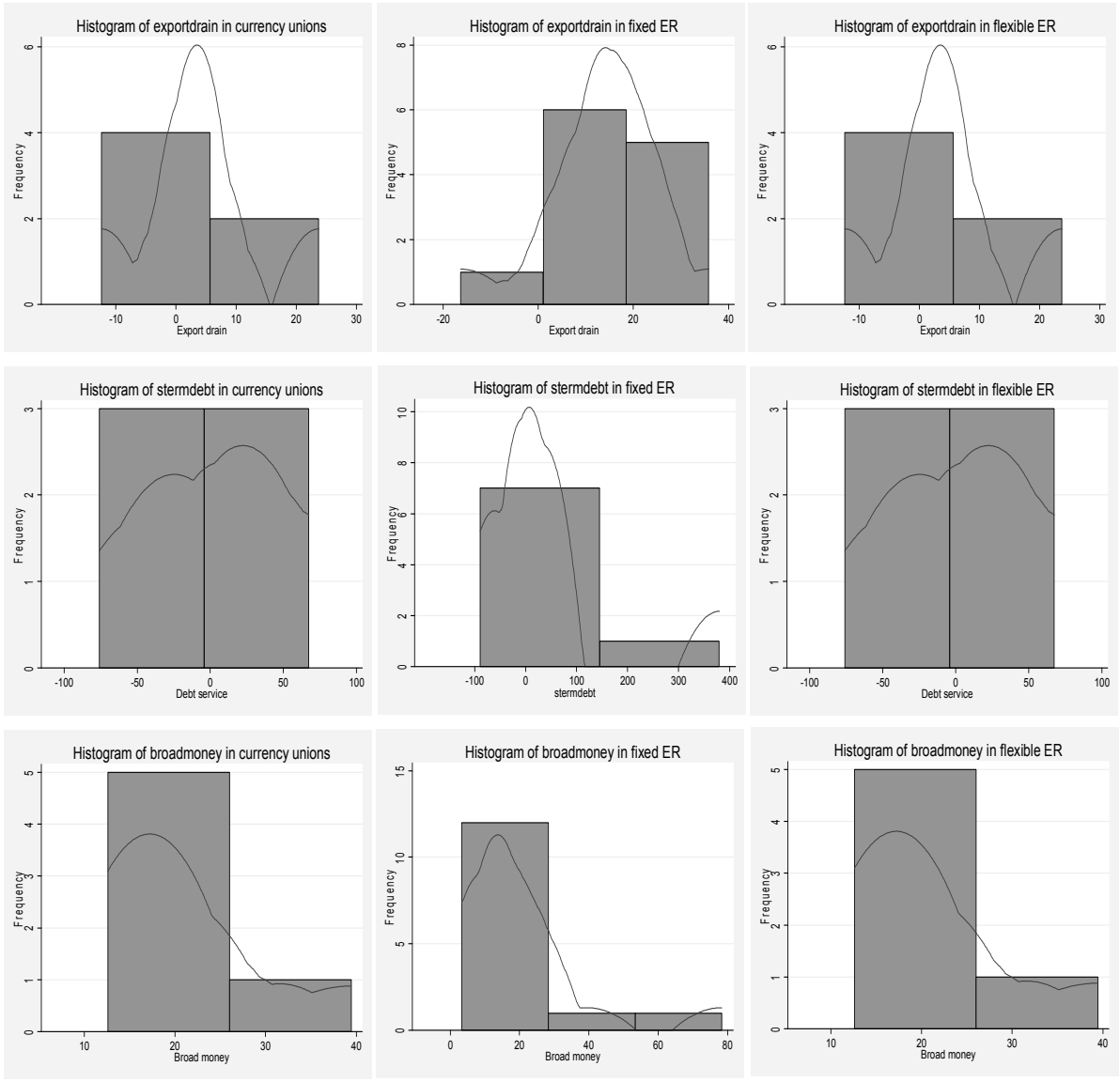
Source: IMF Article IV Consultation Reports (various), IMF Recent Economic Developments (various) and Author's estimates

Figure 9. The Dominican Republic and Grenada: Balance of Payments Flows In Crisis Events (in percent of GDP)



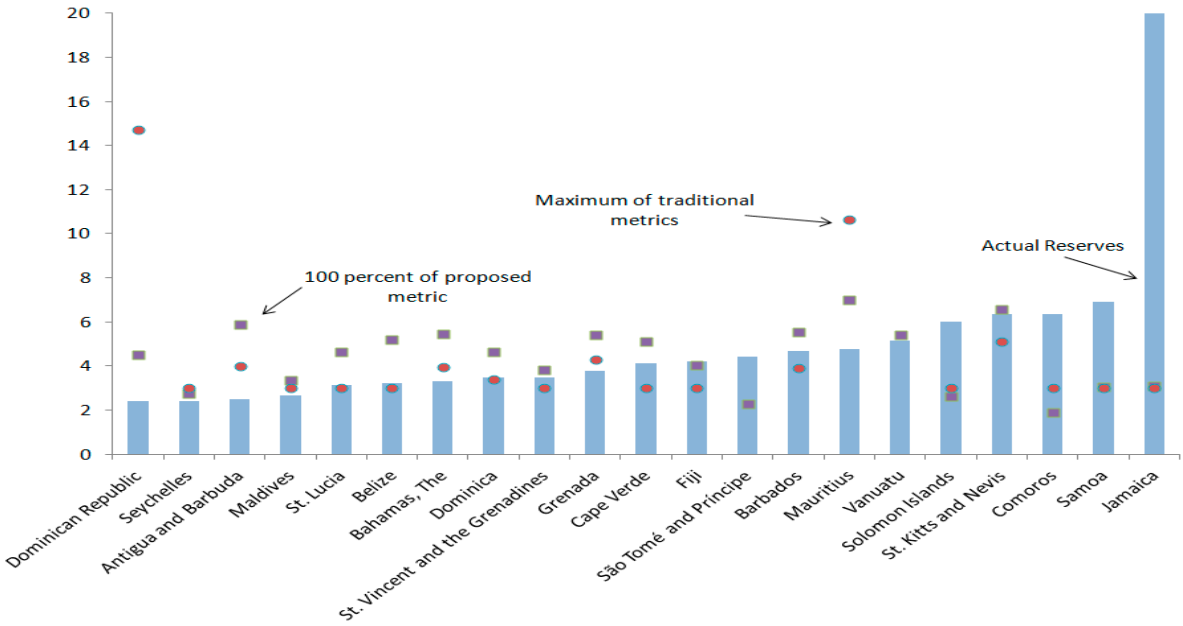
Source: WEO and Author's calculations

Figure 10. Distribution of Export, Broad Money, and Short-Term Debt



Source: Author's calculations

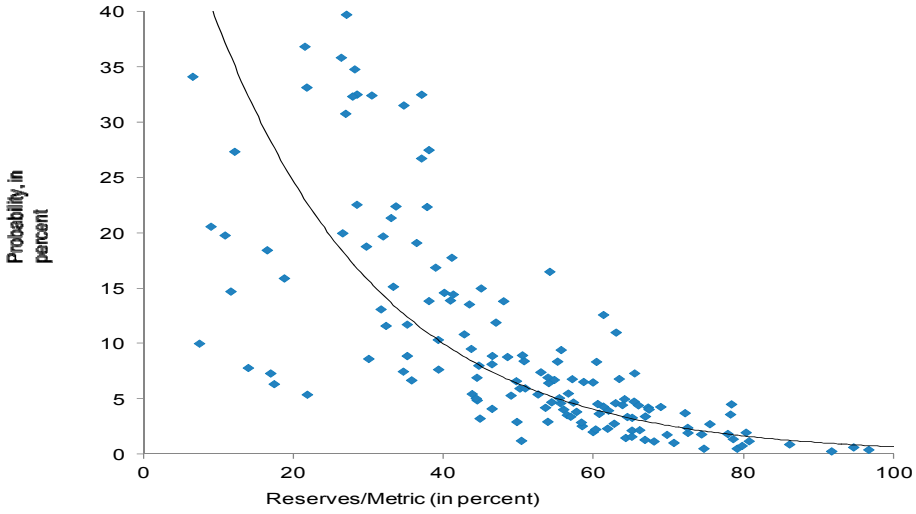
Figure 11. New Metric vs. Maximum of Traditional Metrics
(in months of imports)



Source: WEO and author estimates

Figure 12. EMP Event Probability[1]/

(taking into account primary balance)

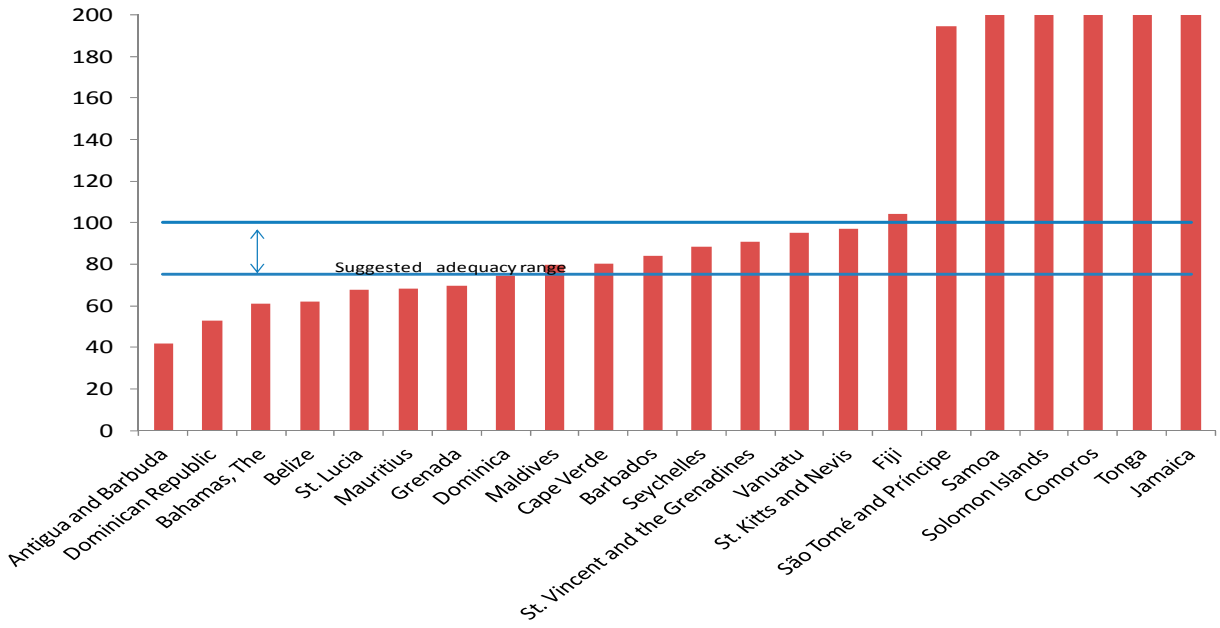


Source: Author's calculations

1/ For brevity, we display up to the 40 percent probability of a crisis.

Figure 13. Reserves Against Risk-Weighted Metric

(reserves as percent of metric, 2010)



Source: WEO and staff calculations