T.C.
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SOSYAL BİLİMLER ENSTİTÜSÜ

DOKTORA TEZİ
MUHASEBE - FİNANSMAN ANABİLİM DALI
MUHASEBE - FİNANSMAN DOKTORA PROGRAMI

TEZ BAŞLIĞI
Essays on Central Bank Foreign Exchange Reserve Adequacy in Emerging Market Economies

Ömer ÇAYIRLI

Danışman
Prof. Dr. Hüseyin AKTAŞ

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YEMİN METNİ

Doktora tezi olarak sunduğum "Essays on Central Bank Foreign Exchange Reserve Adequacy in Emerging Market Economies" adlı çalışmanın, tarafımdan bilimsel ahlak ve geleneklere aykırı düşecek bir yardıma başvurmaksızın yazıldığını ve yararlandığım eserlerin bibliyografyada gösterilen eserlerden oluştuğunu, bunlara atıf yapılarak yararlanmış olduğumu belirtir ve bunu onurumla doğrularım.

09/09/2022

Ömer ÇAYIRLI

ÖZET

GELİŞMEKTE OLAN PİYASA EKONOMİLERİNDE MERKEZ BANKASI DÖVİZ REZERVİ YETERLİLİĞİ ÜZERİNE DENEMELER

IMF'nin ARA metriği kullanılarak hesaplanan aşırı rezervlerin GSYİH'ye oranının basit bir analizi, bazı gelişmekte olan (GO) ülkeler ARA metriğinin işaret ettiği seviyelere yakın düzeyde rezerv bulundurmasına karşın, diğer ülkelerin rezerv seviyelerinin önemli ölçüde farklılaştığını göstermektedir. Bu tezin ilk makalesi, GSYİH, geniş para ve ticaret dengesi ile 3 aylık ithalat tutarından oluşan bir metriğin merkez bankalarının rezerv tutma kararlarını büyük ölçüde yansıttığını göstermektedir. Bu ölçüt, IMF ARA metriğinin doğasında var olan ve bazı GO ülkeler için yeterli rezerv düzeyinin olduğundan fazla, diğerleri için ise olduğundan düşük tahmin edilmesi sorununu, en azından merkez bankalarının bakış açısından, hafifletmektedir.

GO ülkelerin gözlenen rezerv biriktirme davranışlarını açıklamaya yönelik çalışmalar oldukça fazla olmakla birlikte, döviz rezervlerinin aşırı olup olmadığına dair araştırmalar azdır. Bu tezin ikinci makalesi, çeşitli rezerv yeterlilik ölçütleri ve GO ülkeler dış borç piyasası kullanılarak piyasa tarafından yeterli görülen uluslararası rezervlerin seviyesini belirlemeye çalışmaktadır. Elde edilen sonuçlar, piyasa fiyatlamalarının IMF'nin ARA ölçütünün yeterli rezerv seviyesini önemli ölçüde fazla tahmin ettiği yönünde olduğunu göstermektedir. Daha da önemlisi, yeterli seviyelerin üzerinde rezerv biriktirmek, piyasa tarafından ödüllendirilmediği için optimal değildir. GO ülkeler için görece yüksek veya aşırı döviz rezervi tutmak, dış şokların olumsuz etkilerini sınırlamanın bir yoludur. Bununla birlikte, uluslararası rezervlerin istiflenmesi, küresel finansal istikrarı bozabilir ve rezerv otoritelerinin rezerv portföy yönetimine yönelik muhafazakar yaklaşımı göz önüne alındığında maliyetli olabilir. Bu tezin üçüncü makalesinde, GO ülkelerin aşırı rezerv tutma maliyetlerini en aza indirmelerine yardımcı olabilecek basit bir çerçeve geliştiriyoruz. Kredi takas sözleşmeleri, ani duruşlara bağlı koşullu alacaklar olarak karar kuralına dahil edilmektedir. Önerilen çerçeve, olumsuz koşullarda çok ihtiyaç duyulan dış likiditeyi sağlar ve sistematik riskten korunmak için küresel faktörlerle bağlantılı koşullu alacakları, ülkelere özgü riskten korunmak için karşılaştırılabilir ülkelerin dış borcuna dayalı kredi takas sözleşmelerinden oluşan bir portföyü içerecek şekilde genişletilebilir.

ABSTRACT

ESSAYS ON CENTRAL BANK FOREIGN EXCHANGE RESERVE ADEQUACY IN EMERGING MARKET ECONOMIES

A simple analysis of IMF's ARA metric implied excess reserves-to-GDP ratio suggests that despite some of the EM countries holding reserves close to ARA metric implied levels, some countries' holdings diverge to a great extent. The first essay of this thesis shows that GDP, broad money, and trade balance augmented with 3-month of imports reflect the reserve holding decisions of central banks to a great extent. This metric mitigates the inherent problem of the IMF's ARA metric to overestimate the adequate level of reserves for some EM countries while underestimating for others, at least from the central banks' perspective.

Although studies that attempt to explain the observed hoarding behavior of EMEs are abundant, research on whether the levels of foreign exchange reserves are excess or not is scarce. The second essay of this thesis attempts to identify the level of international reserves deemed adequate by the market using several reserve adequacy measures and the EM external debt market. The results suggest that the market assesses the IMF's ARA metric to overestimate the level of adequate reserves to a great extent. More importantly, hoarding reserves beyond adequate levels is not optimal since it is not rewarded by the market.

For EMEs, holding relatively high or excess foreign exchange reserves is a way of limiting the adverse impact of external shocks. However, hoarding of international reserves may be distortionary to global financial stability and may be costly given the conservative approach of reserve authorities to reserve portfolio management. In the third essay of this thesis, we develop a simple framework that may help EMEs minimize the costs associated with holding excess reserves. CDS contracts are incorporated into the decision rule as contingent claims linked to sudden stops. The suggested framework provides the much-needed external liquidity in bad states and can be extended to include contingent claims linked to global factors for hedging the systematic risk component while a portfolio of CDS contracts on the external debt of comparable countries can be used for hedging the idiosyncratic risk component.

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Ömer ÇAYIRLI
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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
AR	Autoregressive
ARA	Assessing Reserve Adequacy
AREAER	Annual Report on Exchange Arrangements and Exchange Restrictions (IMF)
CDS	Credit Default Swap
EM	Emerging Market
EME	Emerging Market Economies
FGLS	Feasible Generalized Least Squares
FX	Foreign Exchange
GDP	Gross Domestic Product
GFC	Global Financial Crisis
IFIs	International Financial Institutions
IIP	International Investment Position
IMF	International Monetary Fund
Max	Maximum
Min	Minimum
Obs	Observations
PSTR	Panel Smooth Transition Regression
PTR	Panel Threshold Regression
Std. Dev.	Standard Deviation
US	United States
VAR	Vector Autoregression
WB-GEM	World Bank Global Economic Monitor

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INTRODUCTION

This thesis focuses on the issues related to central bank reserve adequacy and consists of three essays. Although the essays study different sub-topics related to international reserve adequacy, they are closely related to each other. The first essay takes a critical approach to the metric-based reserve adequacy measures. The study starts with a discussion of reserve adequacy metrics and carries out a detailed analysis of IMF's ARA metric. Based on the identified problems with IMF's ARA metric, alternative reserve adequacy metrics that reflect the reserve holding decisions of the central banks is suggested. The second essay builds on the first essay and attempts to identify the level of international reserves deemed adequate by the market using several reserve adequacy measures and the emerging market (EM) external debt market. The results suggest that the market assesses the IMF's ARA metric to overestimate the level of adequate reserves to a great extent. More importantly, the study shows that hoarding reserves beyond adequate levels is not optimal since it is not rewarded by the market. Taking its motivation from the observation that the hoarding of international reserves may be distortionary to global financial stability and may be costly given the conservative approach of reserve authorities to reserve portfolio management, the third essay develops a simple framework that uses contingent claim portfolio(s) as a component of excess international reserves. The developed framework is focused on hedging the capital flow volatility and may help EMEs minimize the costs associated with holding excess reserves.

As a whole, this thesis analyzes different aspects of foreign exchange reserve adequacy and offers improvements to the current practices. The results of this study may be helpful to policymakers in their decisions regarding international reserve holdings as well as providing a new perspective to the literature.

ESSAY I

REVISITING THE METRIC-BASED RESERVE ADEQUACY MEASURES: A CRITICAL APPROACH

Abstract- IMF does not claim that the ARA metric is complete and measures reserve adequacy appropriately, instead sees it as a starting point for reserve adequacy analysis and emphasizes the importance of country-specific factors. A simple analysis of IMF's ARA metric implied excess reserves to GDP ratio suggests that despite some of the EM countries holding reserves close to ARA metric implied levels, some countries' holdings diverge to a great extent. This study shows that GDP, broad money, and trade balance augmented with 3-month of imports reflects the reserve holding decisions of central banks to a great extent. This metric mitigates the inherent problem of the IMF's ARA metric to overestimate the adequate level of reserves for some EM countries while underestimating for others, at least from the central banks' perspective.

Index Terms- Reserve Adequacy, Emerging Markets, International Reserves, Excess Reserves.

Jel Code(s)- E58

1.1. Introduction

IMF's Balance of Payments and International Investment Position Manual (IMF, 2009) defines reserve assets as *"external assets that are readily available to and controlled by monetary authorities for direct financing of payment imbalances, for indirectly regulating the magnitude of such imbalances through intervention in exchange markets to affect the currency exchange rate, and/or for other purposes."* Parallel to this definition, central banks hold foreign exchange reserves mainly for having the necessary liquidity for the balance of payments needs and increasing markets' confidence in monetary and foreign exchange policies. Reserves also serve the goal of limiting the effects of adverse external shocks on the domestic economy as well as providing a central bank the capacity to intervene in foreign exchange markets when needed.

For EM economies, holding relatively high or excess foreign exchange reserves has become a tool for mitigating the impact of adverse external shocks on the real economy. This stance became increasingly prevalent among EM countries after the currency crises era of the 1990s. According to IMF-International Financial Statistics data, by the end of 1989, EM economies possessed 18% (16% for ex-China) of world reserves including gold which stood at 1.15 trillion USD. As of 2021, world reserves increased to 18.8 trillion USD and 53% (31% ex-China) of this amount was held by EM economies.

The reserve accumulation trend is also evident in relative terms. Based on World Bank's Global Economic Monitor data, the total GDP of emerging and developing countries in current US dollars was 5,38 trillion in 1999 and the ratio of total reserves to GDP was 12.75%. As of 2019, this ratio increased to 23.83%, and at its peak, in 2009, it was 34.63%. Similarly, the import cover of foreign exchange reserves of emerging and developing countries increased from 1.80 months in 1999 to 4.56 months by the end of 2019.

This unprecedented reserve accumulation drew the attention of researchers and motivated studies on optimal reserves and reserve adequacy as well as the underlying causes and implications of this observed hoarding behavior (Aizenman and Jaewoo, 2008; Caballero and Panageas, 2008; Bastourre et al., 2009; Cheung and Sengupta, 2011, Jeanne and Rancière, 2011; Delatte and Fouquau, 2012; Cheng, 2015b; Arslan and Cantú, 2019; Cabezas and De Gregorio, 2019; Cheung et al., 2019; Fatum and Yetman, 2020 among others).

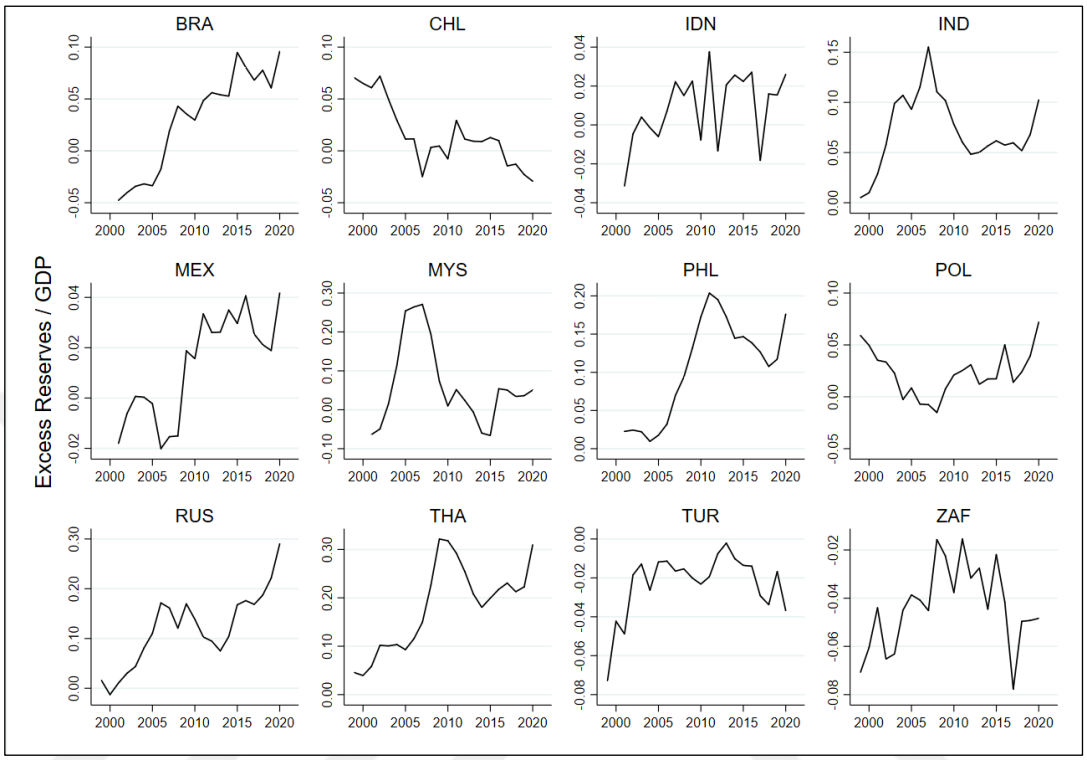
Earlier studies on optimal international reserves, (Heller, 1966; Hamada and Ueda, 1977; Frenkel and Jovanovic, 1981), focus on the precautionary motive and variability of the current account. This line of research models the reserve demand as a function of the opportunity cost of holding reserves, macroeconomic adjustment costs, and reserve volatility. Mostly starting with Feldstein (1999) and Wijnholds and Kapteyn (2001) focus turns to the variability of the capital account, mainly as a result of the crisis experience of EM economies in the 1990s. It can be easily argued that the IMF's increasingly used ARA metric, which is a product of a series of studies (IMF 2011a, 2011b, 2013a, 2013b, 2015, 2016), has its roots in these later studies.

IMF's ARA metric for measuring reserve adequacy is a hybrid tool based on various potential drains on foreign exchange reserves. ARA metric is hybrid in the sense that it is a weighted sum of short-term debt, exports, broad money, and other liabilities component of international investment position (IIP). IMF does not claim that the ARA metric is complete and measures reserve adequacy appropriately, instead sees it as a starting point for reserve adequacy analysis and emphasizes the importance of country-specific factors as discussed in IMF (2015). However, although it is postulated in this way, according to World Bank (2019), 36% of central banks already use the ARA metric as a measure of reserve adequacy and this ratio will likely increase in the coming years. This increased use of IMF's ARA metric is not surprising since it is headline data that is calculated and published by IMF, and which has the potential of becoming the anchor for reserve adequacy assessments of the market participants. Thus, although it is announced as an additional metric, it may force the central banks to target an acceptable ARA metric level comparable to their peers. On the other hand, given the lack of adjustments to generic sources of potential drains for country-specific factors, reserve adequacy decisions based on IMF's ARA metric may cause central banks to overshoot the optimal level and hold implicit excess reserves, or vice versa.

Undoubtedly, analyzing the existence of an overshooting/undershooting behavior as a result of targeting IMF's ARA metric implied level of reserves requires the estimation of optimal international reserve levels, which is not an easy task. However, a simple analysis of IMF's ARA metric implied excess reserves to GDP ratio suggests that despite some of the EM countries holding reserves close to ARA metric implied levels, some countries' holdings diverge to a great extent as depicted in Figure 1. Excess reserves, based on the IMF ARA metric, exceed 30% of GDP for

some countries at times while the mean value of the total reserves-to-GDP (RESGDP) ratio is 21%, which merits further investigation of this behavior (Table 1.1).

Figure 1.1: Ratio of IMF ARA Metric implied excess reserves to GDP for selected countries



Notes: Excess reserves are measured as the total reserves minus IMF ARA metric suggested reserves. The selected countries for representative purposes are Brazil (BRA), Chile (CHL), Indonesia (IDN), India (IND), Mexico (MEX), Malaysia (MYS), Philippines (PHL), Poland (POL), Russia (RUS), Thailand (THA, Türkiye (TUR), South Africa (ZAR).

Table 1.1: Descriptive statistics for total and excess reserves

Variable	Obs	Mean	Std. Dev.	Min	Max
Full Sample (24 Countries)					
TOTRES	527	170.72	524.79	0.07	3899.29
EXIMF	510	37.06	184.22	-1561.78	1382.18
RESGDP	503	0.21	0.11	0.00	0.54
EXIMFGDP	486	0.04	0.09	-0.18	0.32
Excluding China (23 Countries)					
TOTRES	509	81.00	112.55	0.07	630.63
EXIMF	492	24.29	61.01	-32.21	444.58
RESGDP	486	0.20	0.11	0.00	0.54
EXIMFGDP	469	0.04	0.09	-0.18	0.32

Notes: Please see Section 2 for data and variable selection. Also, refer to Table 1.2 for sample selection and Table A1.1 for variable explanations and data sources. The reason for providing an excluding-China analysis is its mean-distorting level of reserve accumulation within the sample period. China's reserve holdings increased from 2% of world reserves in 1989 to 7.5% in 1999 and exceeded 21% in 2021.

As IMF (2011a) points out, reserve accumulation tends to be costly and subject to diminishing returns. Similarly, holding inadequate reserves may also be costly since disorderly adjustments as a result of an adverse external shock may take a toll on the economy. Hence, given that there is a cost associated with both excess and inadequate reserves, for a central bank, it would not be a prudent decision to let actual reserves diverge from adequate levels to a great extent. However, as Figure 1.1 depicts, actual reserve holdings of central banks diverge remarkably from the adequate reserve levels implied by IMF's ARA metric. One of the possible explanations for this observed behavior may be that central banks do not put much emphasis on the costs that may arise as a result of holding inadequate or excess reserves. Another possible explanation, which this study focuses on, is that the IMF's ARA metric may not be an efficient tool for measuring the adequate level of reserves, particularly from a central bank perspective. In other words, IMF's ARA metric constituents may not be reflecting the underlying dynamics of the central bank decision-making process on reserve holdings. If this is the case, it can be easily argued that the ARA metric does not serve its purpose since one of the main motivations behind its development is the remark in IMF (2011a) that "current approaches to reserve adequacy do not appear to be followed closely by countries in their reserves holding decisions."

These observations lead to the main research question of this study: Does the ARA metric's approach to reserve adequacy generates an efficient measure? If not, what are the adjustments needed to transform the ARA metric into a tool that enables central banks and market participants to infer the level of adequate reserves more effectively?

The importance of these questions arises from the fact that when there is high uncertainty in adequate reserve estimations, it may cause central banks to choose to be on the safe side by holding an increased amount of reserves as observed in recent decades, particularly in EM countries. A higher level of foreign exchange reserves may be deemed to have a significant "excess" component. On the other hand, despite the level of reserves seeming to be at levels above adequate reserves implied by a metric or a set of metrics, a central bank's view on the level of adequate reserve levels may differ. Therefore, it is important to understand the behavior of central banks regarding reserve holding decisions. When there is a sustained and significant divergence from adequate reserve levels implied by a metric or set of metrics, it may be the case that the metric(s) are wrong, the central bank(s) are wrong, or both. Although it is not the

main focus of this study, a natural way of making a conclusion on this issue is to draw on the market's view.

The remainder of this study is structured as follows. Section 1.2 provides insights into the data and variable selection. Section 1.3 discusses reserve adequacy and analyzes IMF's ARA metric efficiency. A modified metric for reserve adequacy is developed in Section 1.4. Finally, Section 1.5 presents overall conclusions and suggestions for further research.

1.2. Data and Variable Selection

Our sample covers the period between 1999 and 2019. We carry out our analysis using both annual data and quarterly data. We would prefer to use quarterly data solely; however, we are forced to use annual data since quarterly observations are not available in IMF's ARA metric database. This is mostly a result of quarterly data availability on short-term debt on a remaining maturity basis. Table 1.2 provides the steps and the decision criteria in each of these steps that are used for finalizing the EM countries to be included in the sample. We are not in search of a balanced sample; hence we allow for late entry (early exit) into (out of) the sample but we do not allow for missing data in between.

Our main variables of interest are total reserves including gold (TOTRES), broad money (M2), short-term debt (STED), exports (EXP), imports (IMP), and other liabilities (OTHLIA) of IIP. Except for IMP, these variables are the main components of IMF's ARA metric along with the dummies for the exchange rate regime which are based on the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) dataset. In calculations of the IMF ARA metric, exchange rate regimes are classified into fixed and floating based on the AREAER data. Although we use the same classification for some analysis (FXREG), we also employ an additional exchange rate regime variable (FX) which reflects the scaled degree of float.[1] FX variable is employed since using a dummy variable based on a strict threshold as in IMF's ARA metric results in treating a regime with "no separate legal tender (category1)" and a regime with "other managed arrangement (category 8)" as having the same characteristics which is an overreaching assumption. Similarly, a managed float and a pure float are not the same in terms of their impact on foreign

[1] IMF defines float when a country's exchange rate regime is classified >=7 before 2008 whereas float is defined classifications >=9 from 2008 onwards. Before 2008, there were 8 available categories while, starting with 2008, number of categories in AREAER dataset is increased to 10.

exchange reserves. Employing the variable FX enables investigation of the impact of the degree of the float for reserve adequacy. This approach is similar to that of Wijnholds and Kapteyn (2001).

The variable FX is calculated using the historical foreign exchange regime classifications in IMF's AREAER database. Firstly, each category is assigned a numerical value from 1 to 8 (1 to 10 starting from 2008) based on the level of its float. For instance, "No separate legal tender" is assigned numerical value 1 whereas the "Independently floating" category receives numerical value 8. By taking the log of the division of the number of available categories in a given year by the numerical value assigned to a country regarding its exchange rate regime for the same year, the variable FX is calculated. Therefore, in a pure floating regime impact of the FX variable equals zero while it increases as an exchange rate regime converges to the "No separate legal tender" category. In other words, the FX variable takes values between 0 and 1, by construction. Table A1.1 in the Appendix contains the list of variables used in our analysis along with their explanations and sources.

Table 1.2: Sample selection details

Inclusion/Exclusion Procedure		Countries
# of countries classified as Emerging Market and Middle-Income Economies in IMF Fiscal Monitor, April 2022.	40	
# of countries excluded for not being in the IMF ARA Database.	5	Iran, Islamic Rep. (IRN), Kuwait (KWT), Oman (OMN), Qatar (QAT), Saudi Arabia (SAU)
# of countries excluded for not having any ARA metric calculations.	3	Algeria (DZA), Lebanon (LBN), United Arab Emirates (ARE).
# of countries excluded for missing ARA metric data in-between.	1	Argentina (ARG).
# of countries excluded for lack of GDP data in the World Bank Global Economic Monitor (WB-GEM) database.	4	Angola (AGO), Dominican Republic (DOM), Pakistan (PAK), Venezuela (VEN).
# of countries excluded for lack of REER data in the World Bank Global Economic Monitor (WB-GEM) database.	3	Belarus (BLR), Kazakhstan (KAZ), Sri Lanka (LKA).
Remaining countries in the sample	24	Brazil (BRA), Bulgaria (BGR), Chile (CHL), China, P.R. (CHN), Colombia (COL), Croatia (HRV), Ecuador (ECU), Egypt (EGY), Hungary (HUN), India (IND), Indonesia (IDN), Malaysia (MYS), Mexico (MEX), Morocco (MAR), Peru (PER), Philippines (PHL), Poland, Rep. of (POL), Romania (ROM), Russian Federation (RUS), South Africa (ZAF), Thailand (THA), Türkiye (TUR), Ukraine (UKR), Uruguay (URY).

1.3. Reserve Adequacy

As IMF (2011a) emphasizes, a critical component of country insurance is the country's own reserve holdings. Although this is a widely accepted conjecture, assessing the adequate level of reserves is not an easy task. Still, central banks measure reserve adequacy in one way or another. According to the survey results from World Bank (2019), central banks most frequently use the import coverage method (78 percent) followed by the short-term external debt ratio (48 percent), broad money ratio (36 percent), and the IMF's ARA metric (36 percent). Moreover, 62 percent of 85 respondents to the World Bank survey reported using at least two metrics, and 40 percent employed at least three.

Three months of reserve cover of imports had traditionally been seen as a minimum level of comfort in terms of reserve adequacy (IMF, 2000). Nevertheless, the crude rule of thumb that reserves have to equal at least three months of imports lost much of its relevance as openness and external vulnerability are no longer merely defined in terms of trade shocks (Wijnholds and Kapteyn, 2001).

The ratio of reserves to short-term external debt received attention in attempts to find a simple benchmark that countries should satisfy to minimize their vulnerability (IMF, 2000). Using the ratio of reserves to short-term debt as a reserve adequacy measure was first proposed by Pablo Guidotti, the Deputy Finance Minister of Argentina, and is widely known as the Guidotti-Greenspan proposal. As noted in Greenspan (1999), the rule calls for the management of external assets and liabilities in such a way that usable foreign exchange reserves exceed scheduled amortizations of foreign currency debts (assuming no rollovers) during the following year. However, as Feldstein (1999) emphasizes, despite the unwillingness of foreign creditors to roll over existing loans may be the most probable danger, limiting short-term debt to less than the sum of foreign exchange reserves is not enough to ensure sufficient international liquidity since the magnitude of widespread capital flight by domestic residents and speculation by foreigners may pose the greater risk.

Regarding the effect of money supply on reserve adequacy, literature considered the importance of broad money, particularly in countries using pegged exchange rate regimes. Wijnholds and Kapteyn (2001) merged this view with the Guidotti-Greenspan proposal and developed a reserve adequacy measurement framework which can be represented as follows:

$$R_{ad} = \beta_1 STED + \beta_2 M_2 CR \tag{1.1}$$

According to this setting, adequate reserves (R_{ad}) can be calculated by summing 100% of short-term external debt (β_1 is set to 1) and adjusted money supply. Drain on reserves through money supply is calculated by assuming a range of β_2 coefficients based on the exchange rate regime, and the country risk index (*CR*) is used for incorporating varying riskiness across countries. To the author's knowledge, this is the first use of a such setting, and IMF's ARA metric is highly influenced by this approach. Including broad money in reserve adequacy estimation is supported by the findings of Obstfeld et al. (2010), which show that there has been a statistically robust and economically significant correlation of reserve levels (reserves/GDP) with financial openness (a measure of cross-border capital mobility), financial development (proxied by M2/GDP), and exchange rate policy (captured by peg indicators).

IMF's effort to develop a reserve adequacy measure that reflects potential drains on international reserves has its roots in these discussions. As emphasized by IMF (2016), the ARA metric was proposed by IMF as an additional metric against the backdrop of the traditional metrics. IMF ARA metric focuses on the precautionary aspect of holding reserves and attempts to develop a reserve adequacy assessment tool that aggregates information from a set of potential drains on international reserves. In the calculations of the metric, short-term debt, exports, broad money, and other liabilities of IIP are used as the set of potential drains while differentiating between fixed and floating exchange rate regimes. IMF (2016) notes that a key motivating factor for the work towards an additional metric was the experience of the past balance of payments crises, which were characterized by multiple channels of market pressure, suggesting the need for a metric encompassing a broad set of risks.

Table 1.3: Revised ARA Metric weights

	Short-term debt	**Other liabilities**	**Broad money**	**Exports**
Fixed Exchange Rate Regime	30%	20%	10%	10%
Floating Exchange Rate Regime	30%	15%	5%	5%

Notes: Revised weights used in the calculation of IMF ARA EM Metric. (IMF, 2016)

Short-term debt is almost a standard component in measuring reserve adequacy. As discussed earlier, broad money's importance and acceptance as a potential drain increased, particularly in the last two decades. On the other hand, including other

liabilities as a potential source of drain is relatively new. Moreover, using exports instead of imports represents a major departure from the conventional rules of thumb. IMF (2016) points out that the ARA metric does not include the current account deficit (or imports); because, to the extent that the current account deficit is financed by external liabilities, debt, and other portfolio inflows, it should raise either the short-term debt or other liabilities elements included in the metric or both. Although this reasoning has its own merits, replacing imports with exports is somewhat contradictory to the intuition behind reserve adequacy since exports do not represent a potential drain on reserves. Undoubtedly, loss of export income has important consequences for the external balance of an EM country; however, focusing solely on exports may be problematic since depending on the relationship between imports and exports, the net impact of a change in exports on reserves may vary. When the sensitivity of imports to exports is high, one would expect a relatively minor impact on foreign currency demand. In this case, using only the export component of external balance in reserve adequacy calculations will likely result in the overestimation of adequate reserves. On the other hand, when the sensitivity of imports to exports is low, a decline in exports may result in net increased demand for foreign assets. From a reserve adequacy perspective, the relationship between imports and exports as well as the sensitivity of the domestic economy to that of the rest of the world is important since central banks are known to develop their macroeconomic models and use estimations from these models in their decision-making process. Hence, it may be an overreaching assumption that central banks disregard the country-specific dynamics of external balance and focus solely on exports when assessing reserve adequacy.

In simple terms, determinants of exports and imports may be defined as follows:

$$EXP = f(REER, GDP_F) \tag{1.2}$$

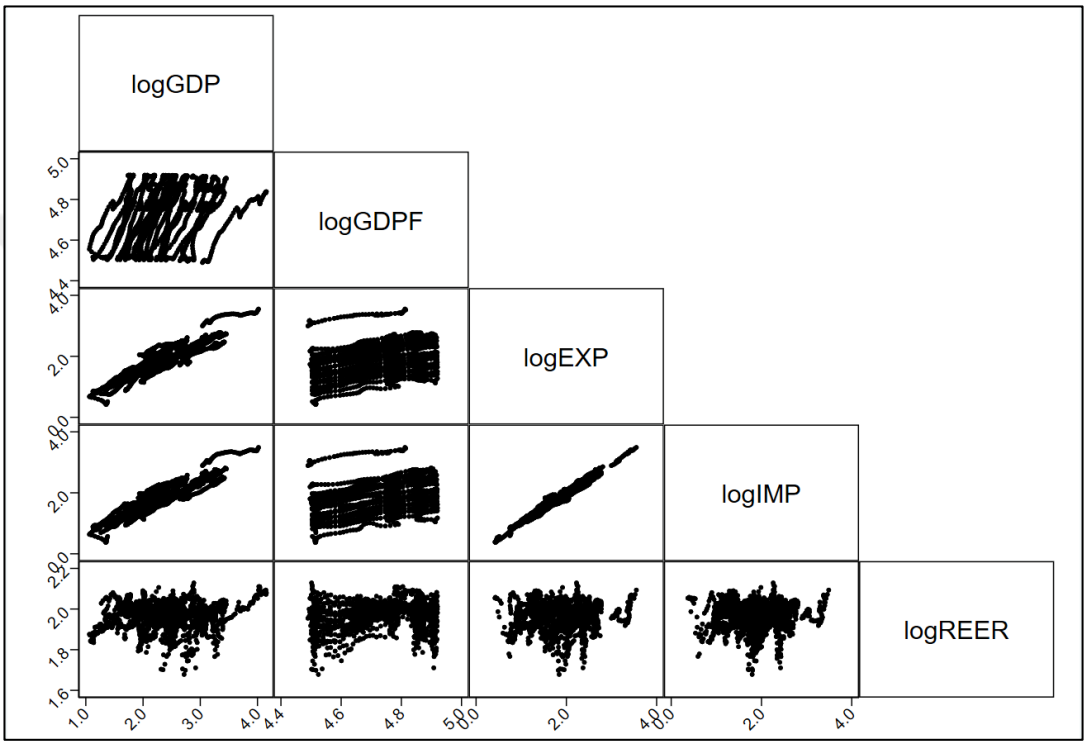
$$IMP = g(REER, GDP_D) \tag{1.3}$$

$$TB = h(REER, GDP_F, GDP_D) \tag{1.4}$$

where *EXP* represents exports, *IMP* denotes imports and *REER* is the real effective exchange rate. GDP_D is a given country's GDP. GDP_F represents world gross domestic product (GDP) minus GDP_D. Therefore, the trade balance (TB) of a country is a function of *REER*, GDP_F, and GDP_D in this simplistic setting. Whenever there is a strong relationship between domestic and foreign GDPs, it is obvious that exports and imports will likely move in a closely related pattern. On the other hand, the high

sensitivity of imports to exports may also be a result of import dependence on exports. In both cases, which are not mutually exclusive, the co-movement of imports and exports is unlikely to cause a significant enough change in the trade balance that would put notable pressure on the foreign exchange assets of an EM economy. Figure 1.2 provides insights into these dynamics. Particularly the discussed relationship between the imports and exports across the panel is evident.

Figure 1.2: Relationships among the variables related to external balance



Notes: Based on the quarterly observations over the full sample period.

Table 1.4 provides the correlations between relevant pairs of GDP_D, GDP_F, *IMP, and EXP* for the 24 EM countries over the full sample period (1999Q4-2021Q4), and for the two sub-periods determined based on the starting (2007Q2) and ending (2009Q1) quarters of the global financial crisis (GFC).[2] For the pre-GFC period, correlations between the variables are remarkably high with relatively low standard deviations. However, in the post-GFC period, there is a clear decline in the correlations as well as a significant increase in the divergence of correlations across countries. Nevertheless, correlations between imports and exports are still high after the GFC except for several countries (i.e., Colombia, South Africa, Türkiye, and Uruguay). Hence, using exports solely as a potential drain source on foreign exchange reserves may not be appropriate.

[2] Please see Cayirli et al. (2022) for a discussion regarding the determination of start and end dates for GFC.

A variable that reflects the inherent relationship between exports and imports may be more suitable. An obvious choice that would mitigate the problem of overestimation of adequate reserves as a result of highly correlated imports and exports is the trade balance. This is mostly because the trade balance reflects the net impact of external balance on the reserves whether exports and imports display a strong comovement or not.

Table 1.4: Correlations for exports, imports, domestic GDP, and foreign GDP

Country	1999Q4 - 2019Q4							1999Q4 - 2007Q2							2009Q2 - 2019Q4						
	Obs	GDP_D, GDP_F	Obs	GDP_D, IMP	Obs	GDP_F, EXP	Obs	EXP, IMP	Obs	GDP_D, GDP_F	Obs	GDP_D, IMP	Obs	GDP_F, EXP	Obs	EXP, IMP	Obs	GDP_D, GDP_F	Obs	GDP_D, IMP	Obs	GDP_F, EXP	Obs	EXP, IMP
BGR	82	0.976	82	0.965	82	0.993	89	0.965	31	0.997	31	0.990	31	0.994	31	0.999	44	0.821	44	0.888	44	0.990	51	0.965
BRA	82	0.886	82	0.977	82	0.957	89	0.971	31	0.869	31	0.986	31	0.990	31	0.928	44	-0.005	44	0.826	44	0.566	51	0.859
CHL	82	0.989	82	0.976	82	0.911	88	0.957	31	0.945	31	0.992	31	0.965	31	0.994	44	0.933	44	0.826	44	0.362	50	0.847
CHN	82	0.912	61	0.851	61	0.939	61	0.988	31	0.980	31	0.957	31	0.968	31	0.995	44	0.870	23	0.863	23	0.802	23	0.932
COL	82	0.951	82	0.989	82	0.908	89	0.985	31	0.923	31	0.977	31	0.954	31	0.989	44	0.563	44	0.913	44	0.317	51	0.793
ECU	78	0.982	78	0.918	78	0.959	89	0.985	27	0.974	27	0.984	27	0.978	31	0.954	44	0.935	44	0.447	44	0.701	51	0.912
EGY	72	0.915	26	0.787	26	0.509	36	0.606	21	0.817	21	0.847	21	0.803	31	0.734	44	0.444	0	n.a.	0	n.a.	0	n.a.
HRV	82	0.821	82	0.949	82	0.959	89	0.960	31	0.992	31	0.999	31	0.993	31	0.997	44	-0.220	44	0.366	44	0.888	51	0.922
HUN	82	0.885	82	0.987	82	0.955	89	0.994	31	0.970	31	0.979	31	0.995	31	0.999	44	0.649	44	0.934	44	0.902	51	0.980
IDN	82	0.967	82	0.972	82	0.968	89	0.989	31	0.980	31	0.942	31	0.953	31	0.987	44	0.963	44	0.820	44	0.745	51	0.936
IND	82	0.985	82	0.954	82	0.993	89	0.992	31	0.994	31	0.990	31	0.986	31	0.997	44	0.934	44	0.773	44	0.983	51	0.934
MAR	82	0.994	69	0.879	69	0.924	69	0.970	31	0.991	31	0.857	31	0.791	31	0.990	44	0.959	31	0.609	31	0.691	31	0.946
MEX	82	0.954	82	0.944	82	0.982	89	0.997	31	0.880	31	0.960	31	0.947	31	0.999	44	0.787	44	0.771	44	0.992	51	0.987
MYS	82	0.993	82	0.900	82	0.862	85	0.983	31	0.988	31	0.980	31	0.993	31	0.999	44	0.964	44	0.294	44	-0.122	47	0.897
PER	82	0.984	82	0.993	82	0.985	89	0.977	31	0.984	31	0.995	31	0.972	31	0.998	44	0.980	44	0.964	44	0.870	51	0.875
PHL	82	0.969	82	0.970	82	0.966	89	0.986	31	0.934	31	0.950	31	0.965	31	0.988	44	0.947	44	0.948	44	0.965	51	0.972
POL	82	0.970	81	0.889	81	0.949	81	0.990	31	0.984	31	0.960	31	0.964	31	0.998	44	0.853	43	0.409	43	0.773	43	0.982
ROM	82	0.959	82	0.986	82	0.985	89	0.976	31	0.985	31	0.985	31	0.975	31	0.989	44	0.816	44	0.953	44	0.978	51	0.967
RUS	82	0.884	82	0.998	82	0.881	89	0.990	31	0.983	31	0.999	31	0.982	31	0.988	44	0.151	44	0.989	44	0.256	51	0.961
THA	82	0.989	82	0.966	82	0.997	89	0.982	31	0.992	31	0.979	31	0.991	31	0.992	44	0.976	44	0.792	44	0.986	51	0.850
TUR	82	0.942	82	0.987	82	0.992	89	0.972	31	0.983	31	0.996	31	0.999	31	0.992	44	0.399	44	0.870	44	0.942	51	0.778
UKR	74	0.706	74	0.986	74	0.702	89	0.992	23	0.972	23	0.995	23	0.995	31	0.988	44	0.079	44	0.968	44	-0.033	51	0.973
URY	82	0.928	81	0.795	81	0.930	81	0.981	31	-0.217	31	-0.158	31	0.973	31	0.990	44	0.918	43	-0.256	43	0.129	43	0.817
ZAF	82	0.908	82	0.970	82	0.926	89	0.975	31	0.976	31	0.975	31	0.996	31	0.999	44	0.209	44	0.833	44	0.339	51	0.798
Median		0.957		0.968		0.956		0.982		0.980		0.980		0.976		0.992		0.837		0.826		0.773		0.932
Mean		0.935		0.941		0.922		0.965		0.912		0.922		0.963		0.978		0.663		0.730		0.653		0.908
Std Dev		0.066		0.061		0.108		0.077		0.245		0.233		0.053		0.054		0.369		0.298		0.354		0.067
Min		0.706		0.787		0.509		0.606		-0.217		-0.158		0.791		0.734		-0.220		-0.256		-0.122		0.778
Max		0.994		0.998		0.997		0.997		0.997		0.999		0.999		0.999		0.980		0.989		0.992		0.987

Table 1.5 reports correlations for total reserves and ARA metric components for the full sample and across exchange rate regimes. EXIMF, GDP, imports, and trade balance are included for explanatory purposes. EXIMF represents the difference between the total reserves and the IMF's ARA metric suggested adequate reserves. For the full sample, broad money, short-term debt, and exports are highly correlated mostly as a result of close-to-unit correlations in fixed exchange rate regimes. This observation alone should suffice to be concerned about the inclusion of all of these variables into the reserve adequacy metric(s).

Table 1.5: Correlations for total reserves, ARA Metric components, GDP, and trade balance

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Full sample (482 observations)										
TOTRES	(1)	1.00								
EXIMF	(2)	0.54	1.00							
GDP	(3)	0.95	0.31	1.00						
M2	(4)	0.94	0.22	0.97	1.00					
STED	(5)	0.94	0.28	0.97	0.97	1.00				
EXP	(6)	0.97	0.44	0.97	0.94	0.96	1.00			
OTHLIA	(7)	0.71	0.22	0.83	0.72	0.77	0.79	1.00		
IMP	(8)	0.96	0.41	0.97	0.94	0.96	0.99	0.80	1.00	
TB	(9)	0.76	0.49	0.66	0.67	0.64	0.74	0.50	0.67	1.00
Fixed exchange rate regime (151 observations)										
TOTRES	(1)	1.00								
EXIMF	(2)	0.52	1.00							
GDP	(3)	0.96	0.27	1.00						
M2	(4)	0.94	0.20	0.99	1.00					
STED	(5)	0.95	0.25	0.98	0.98	1.00				
EXP	(6)	0.99	0.42	0.98	0.96	0.97	1.00			
OTHLIA	(7)	0.87	0.17	0.94	0.91	0.92	0.92	1.00		
IMP	(8)	0.98	0.39	0.99	0.97	0.98	1.00	0.91	1.00	
TB	(9)	0.86	0.54	0.80	0.76	0.77	0.87	0.83	0.84	1.00
Floating exchange rate regime (331 observations)										
TOTRES	(1)	1.00								
EXIMF	(2)	0.91	1.00							
GDP	(3)	0.89	0.65	1.00						
M2	(4)	0.90	0.71	0.93	1.00					
STD	(5)	0.76	0.49	0.78	0.77	1.00				
EXP	(6)	0.84	0.64	0.82	0.74	0.82	1.00			
OTHLIA	(7)	0.80	0.52	0.91	0.79	0.72	0.78	1.00		
IMP	(8)	0.80	0.57	0.84	0.78	0.84	0.97	0.77	1.00	
TB	(9)	0.05	0.24	-0.19	-0.23	-0.16	0.01	-0.06	-0.22	1.00

Notes: Estimations are based on annual data provided in IMF ARA Database except for GDP data which is obtained for the World Bank's World Development Indicators Database.

Similar to the results from quarterly data, exports and imports also have high correlations both in fixed and floating exchange rate regimes. However, as one would expect, trade balance displays a completely different relationship with other variables across fixed and floating exchange rate regimes. While trade balance has somewhat high correlations with other variables in fixed exchange rate regimes that is not the case for floating exchange rate regimes in which it has a very low correlation with total reserves and negative or considerably low correlations with IMF's ARA metric components. Contrary to these observations, the differentiation made regarding exports in the fixed and floating exchange rate regimes by IMF's ARA metric is the 5% higher weight applied to exports in the reserve adequacy calculations (5% vs. 10% as in Table 1.3) for fixed exchange rate regimes.

EXIMF, which is the excess reserves calculated based on the ARA metric calculations and the actual reserve holdings, displays substantial correlations with the ARA metric components, particularly for the floating exchange rate regimes. This suggests that the weights applied to the ARA metric components are not in line with the views of the EM central banks.

A more important observation is the remarkably high correlation of GDP with total reserves and the constituents of the IMF's ARA metric, particularly broad money, short-term debt, and exports. It would not be an overreaching inference that GDP may be driving the changes in these three highly correlated variables. If that is the case, rather than using broad money, short-term debt, and exports, a metric based on the level of GDP or one that controls for the size of the economy using GDP may be more appropriate. We further analyze this issue in Section 1.3.1.

Table 1.6 provides fixed-effect linear panel regression results for both total reserves and excess reserves which are calculated based on IMF's adequate reserve estimations. Along with country effects, time effects are also employed. All reported t-statistics are based on robust standard errors based on Froot (1989), which extends the works of Huber (1967) and White (1980) to panel data estimation. Based on the estimation results provided in Table 1.6, not surprisingly, IMF's ARA metric components have explanatory power over the total reserve holdings of EM countries. But they are still statistically and economically significant determinants of excess reserves, particularly for floating exchange rate regimes. For the sub-sample that excludes China, none of the ARA metric components have a statistically significant relationship with excess reserves in fixed exchange rate regimes (Panel B, models 9

and 10). This is a result of the coefficient estimates obtained for models 3 and 4 in Panel B being close to the actual weights used in ARA metric calculations for fixed exchange rate regimes. However, for floating exchange rate regime estimations, that is not the case since broad money and short-term debt have explanatory power for excess reserves whether time fixed effects are used or not. In addition, while the coefficient estimates for short-term debt are close to the ARA metric weights in fixed exchange rate regimes, negative and significant coefficient estimates for floating exchange rate regimes are puzzling. These observations suggest that the differentiation made by the IMF's ARA metric across fixed and floating exchange rate regimes may not be sufficient and far from explaining the true dynamics of the central bank reserve holding decisions.

In studies focusing on other aspects of macroeconomic and financial dynamics in EM countries, reserve adequacy is usually proxied by the reserves-to-GDP ratio. This approach might be useful since it allows researchers to control the size of the economies. Also, it provides an easily calculable and understandable metric for assessing reserve adequacy. For instance, Frankel and Saravelos (2012) use 50 annual macroeconomic and financial variables to investigate whether leading indicators can help explain the cross-country incidence of the 2008–09 financial crisis. Their results suggest that the level of foreign exchange reserves (measured relative to GDP, external debt, imports, broad money, and short-term debt) in 2007 appears as a consistent and statistically significant leading indicator of who got hit by the 2008-09 crisis.

To investigate the relationship between the reserves-to-GDP ratio and ARA metric components, we scale all the variables by dividing them by the corresponding GDP figures and re-estimate the models in Table 1.6. The results of these estimations are provided in Table 1.7. Firstly, it should be noted that the explanatory power of ARA metric components, when controlled by the size of the economy, declines across all models in both panels A and B. Secondly, model 3 results both in panel A and panel B fail to reject the null hypothesis that all estimated coefficients are zero. This contradicts the estimation results based on the unscaled variables. Given these results and the correlation estimates provided in Table 1.5, further analysis of the impact of GDP on total reserve holdings and ARA metric components is needed.

Table 1.6: Panel regressions for total and excess reserves with country and time fixed effects across currency regimes

Panel A: Full Sample	**TOTRES**						**EXIMF**					
	Full Sample		Fixed Exch. Rate		Floating Exch. Rate		Full Sample		Fixed Exch. Rate		Floating Exch. Rate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
M2	-0.01	-0.02	-0.02	-0.04***	0.18***	0.19***	-0.12***	-0.13***	-0.12***	-0.14***	0.13***	0.14***
	(-0.30)	(-0.80)	(-1.59)	(-4.43)	(6.59)	(7.54)	(-5.92)	(-6.04)	(-8.17)	(-15.77)	(4.80)	(5.60)
EXP	1.42***	1.57***	1.91***	2.06***	0.22**	0.20*	1.39***	1.54***	1.81***	1.96***	0.17*	0.15
	(3.18)	(3.48)	(7.11)	(9.65)	(2.48)	(1.76)	(3.20)	(3.53)	(6.73)	(9.18)	(1.93)	(1.31)
STED	0.33**	0.33**	0.27	0.30	-0.19	-0.28	0.02	0.00	-0.03	0.00	-0.49**	-0.58***
	(2.33)	(2.21)	(1.21)	(1.32)	(-0.95)	(-1.45)	(0.11)	(0.01)	(-0.12)	(0.01)	(-2.42)	(-2.98)
OTHLIA	-0.55	-0.52	-0.86***	-0.77***	0.08	0.01	-0.61	-0.60	-1.06	-0.97***	-0.07	-0.14*
	(-1.54)	(-1.42)	(-7.24)	(-6.71)	(1.01)	(0.10)	(-1.63)	(-1.52)	(-8.91)	(-8.45)	(-0.94)	-1.86
Country Fixed Effects	X	X	X	X	X	X	X	X	X	X	X	X
Time Fixed Effects		X		X		X		X		X		X
F Statistics	28431.22	n.a	9.44E+06	n.a	353.57	n.a	10117.89	n.a	2.83E+06	n.a	54.80	n.a
Prob	0.00	n.a	0.00	n.a	0.00	n.a	0.00	n.a	0.00	n.a	0.00	n.a
Within R-squared	0.83	0.85	0.89	0.91	0.87	0.89	0.65	0.68	0.79	0.83	0.60	0.64
# of observations	482	482	151	151	331	331	482	482	151	151	331	331
# of countries	24	24	14	14	20	20	24	24	14	14	20	20
Panel B: Excluding China	**TOTRES**						**EXIMF**					
	Full Sample		Fixed Exch. Rate		Floating Exch. Rate		Full Sample		Fixed Exch. Rate		Floating Exch. Rate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
M2	0.16***	0.16***	0.07**	0.08***			0.13***	0.13***	-0.03	-0.02		
	(8.55)	(9.26)	(2.66)	(4.16)			(5.37)	(5.96)	(-1.31)	(-0.81)		
EXP	0.20***	0.21**	0.12*	0.11**			0.12**	0.11	0.02	0.01		
	(3.22)	(2.39)	(1.96)	(2.23)			(2.20)	(1.61)	(0.38)	(0.29)		
STED	-0.06	-0.07	0.31***	0.31***			-0.42***	-0.46***	0.01	0.01		
	(-0.51)	(-0.58)	(8.92)	(8.26)			(-3.25)	(-3.49)	(0.27)	(0.37)		
OTHLIA	0.12**	0.11*	0.11**	0.08			-0.06	-0.08	-0.09*	-0.12*		
	(2.09)	(2.03)	(2.18)	(1.34)			(-1.01)	(-1.54)	(-1.92)	(-2.08)		
Country Fixed Effects	X	X	X	X			X	X	X	X		
Time Fixed Effects		X		X				X		X		
F Statistics	103.39	n.a	170.15	n.a			17.80	n.a	4.95	n.a		
Prob	0.00	n.a	0.00	n.a			0.00	n.a	0.01	n.a		
Within R-squared	0.86	0.87	0.83	0.86			0.55	0.57	0.20	0.35		
# of observations	465	465	134	134			465	465	134	134		
# of countries	23	23	13	13			23	23	13	13		

*Notes: t-statistics based on robust standard errors in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level. China is classified as a fixed exchange rate regime for the whole sample. Thus, results for the floating exchange rate regime are the same in both panels.*

Table 1.7: Panel regressions for total and excess reserves with country and time fixed effects across currency regimes

Panel A: Full Sample	**RESGDP**						**EXIMFGDP**					
	Full Sample		Fixed Exch. Rate		Floating Exch. Rate		Full Sample		Fixed Exch. Rate		Floating Exch. Rate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
M2GDP	0.16**	0.07	0.01	-0.02	0.24***	0.15**	0.07	-0.07	-0.09	-0.12	0.19***	0.10
	(2.42)	(0.85)	(0.14)	(-0.16)	(4.77)	(2.55)	(1.04)	(-0.77)	(-0.87)	(-0.92)	(3.79)	(1.72)
EXPGDP	0.23***	0.24***	0.28*	0.29	0.20**	0.19**	0.18**	0.19**	0.18	0.19	0.15*	0.14
	(3.55)	(3.52)	(1.81)	(1.52)	(2.43)	(2.32)	(2.25)	(2.33)	(1.16)	(1.00)	(1.83)	(1.71)
STEDGDP	0.03	-0.01	0.08	0.05	-0.02	-0.07	-0.26**	-0.31***	-0.22	-0.25	-0.32*	-0.37**
	(0.35)	(-0.11)	(0.38)	(0.20)	(-0.14)	(-0.46)	(-2.63)	(-2.99)	(-0.96)	(-0.95)	(-2.01)	(-2.35)
OTHLIAGDP	0.04	0.06	0.02	-0.01	0.05	0.09**	-0.09*	-0.08	-0.18**	-0.21**	-0.10*	-0.06
	(0.98)	(1.19)	(0.34)	(-0.13)	(1.00)	(2.23)	(-1.99)	(-1.34)	(-2.70)	(-2.79)	(-1.92)	(-1.58)
Country Fixed Effects	X	X	X	X	X	X	X	X	X	X	X	X
Time Fixed Effects		X		X		X		X		X		X
F Statistics	11.69	n.a	1.52	n.a	23.64	n.a	9.14	n.a	4.29	n.a	4.42	n.a
Prob	0.00	n.a	0.25	n.a	0.00	n.a	0.00	n.a	0.02	n.a	0.01	n.a
Within R-squared	0.26	0.33	0.11	0.27	0.37	0.45	0.15	0.25	0.22	0.36	0.31	0.39
# of observations	482	482	151	151	331	331	482	482	151	151	331	331
# of countries	24	24	14	14	20	20	24	24	14	14	20	20
Panel B: Excluding China	**RESGDP**						**EXIMFGDP**					
	Full Sample		Fixed Exch. Rate		Floating Exch. Rate		Full Sample		Fixed Exch. Rate		Floating Exch. Rate	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
M2GDP	0.22***	0.15**	0.15**	0.21			0.13**	0.01	0.05	0.11		
	(4.97)	(2.72)	(2.18)	(2.71)			(2.76)	(0.09)	(0.75)	(1.42)		
EXPGDP	0.18***	0.19***	0.10	0.05			0.13*	0.15*	0.00	-0.05		
	(3.32)	(3.37)	(0.82)	(0.41)			(1.83)	(1.90)	(-0.01)	(-0.34)		
STEDGDP	0.02	-0.01	-0.02	0.01			-0.27**	-0.31***	-0.32*	-0.29		
	(0.19)	(-0.12)	(-0.12)	(0.07)			(-2.66)	(-2.86)	(-1.80)	(-1.47)		
OTHLIAGDP	0.04	0.05	0.00	-0.04			-0.10*	-0.08	-0.20**	-0.24***		
	(0.79)	(0.99)	(0.07)	(-0.64)			(-2.04)	(-1.48)	(-2.69)	(-3.86)		
Country Fixed Effects	X	X	X	X			X	X	X	X		
Time Fixed Effects		X		X				X		X		
F Statistics	12.03	n.a	1.89	n.a			9.59	n.a	6.08	n.a		
Prob	0.00	n.a	0.18	n.a			0.00	n.a	0.01	n.a		
Within R-squared	0.34	0.38	0.18	0.41			0.19	0.26	0.24	0.45		
# of observations	465	465	134	134			465	465	134	134		
# of countries	23	23	13	13			23	23	13	13		

*Notes: t-statistics based on robust standard errors in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level. China is classified as a fixed exchange rate regime for the whole sample. Thus, results for the floating exchange rate regime are the same in both panels.*

1.3.1. Factor Analysis

The correlation dynamics provided in Table 1.5 suggest a relatively strong comovement of IMF ARA metric components. In addition, these variables are also highly correlated with the GDP. Undoubtedly, high correlations of the ARA metric components with GDP do not necessarily suggest that the GDP is the determinant of these variables. On the other hand, using highly correlated variables for assessing reserve adequacy may be problematic, and if there is a common factor that explains the variations in these variables, replacing these variables with this common factor might be a more appropriate approach. As Brown and Moore (2012) note, confirmatory factor analysis (CFA) is a useful tool for establishing the number and nature of factors that account for the variation and covariation among a set of variables and provides a more parsimonious understanding of the covariation among a variable set. Accordingly, an exploratory factor analysis of the IMF ARA metric components is carried out, and the results are provided in Table 1.8.

Factor analyses are done using the principal-component factors method across full sample and sub-samples based on exchange rate regimes. Sampling adequacy calculations are based on the Kaiser-Meyer-Olkin measure of sampling adequacy developed by Kaiser and Rice (1974). For all estimations, results suggest that a single factor captures a relatively high portion of common variance (between 83% and 96%). Except for the full sample that excludes China and floating exchange rate regimes, unique variances of the ARA metric components are mostly less than 10%. Correlations of the retained factor with GDP and IMF ARA metric components are provided in Table 1.9 across all estimations, which clearly shows that the single factor identified based on factor analysis exhibits a strong positive comovement with the GDP.

Table 1.8: Factor analysis results for IMF ARA Metric components

Full Sample (# of obs=485, retained factors=1)				**Full Sample ex. China (# of obs=468, retained factors=1)**			
	Factor 1				Factor 1		
Eigenvalue	3.58			Eigenvalue	3.39		
Variance Proportion	0.90			Variance Proportion	0.85		
	Factor Loadings	Unique Variance	Sample Adequacy		Factor Loadings	Unique Variance	Sample Adequacy
M2	0.96	0.07	0.79	M2	0.91	0.17	0.85
EXP	0.98	0.04	0.87	EXP	0.93	0.13	0.79
STED	0.98	0.04	0.76	STED	0.92	0.15	0.81
OTHLIA	0.86	0.26	0.89	OTHLIA	0.92	0.16	0.82
Fixed Exchange Rate Regime (# of obs=154, retained factors=1)				**Fixed Exchange Rate Regime ex. China (# of obs=137, retained factors=1)**			
	Factor 1				Factor 1		
Eigenvalue	3.83			Eigenvalue	3.69		
Variance Proportion	0.96			Variance Proportion	0.92		
	Factor Loadings	Unique Variance	Sample Adequacy		Factor Loadings	Unique Variance	Sample Adequacy
M2	0.99	0.03	0.83	M2	0.97	0.05	0.85
EXP	0.98	0.03	0.91	EXP	0.99	0.03	0.76
STED	0.99	0.02	0.79	STED	0.93	0.13	0.86
OTHLIA	0.96	0.08	0.96	OTHLIA	0.95	0.10	0.90
Floating Exchange Rate Regime (# of obs=331, retained factors=1)							
	Factor 1						
Eigenvalue	3.31						
Variance Proportion	0.83						
	Factor Loadings	Unique Variance	Sample Adequacy				
M2	0.91	0.17	0.83				
EXP	0.92	0.15	0.80				
STED	0.91	0.17	0.80				
OTHLIA	0.90	0.19	0.82				

Notes: Factor analysis is carried out using the principal-component factors method. Sampling adequacy calculations are based on the Kaiser-Meyer-Olkin measure of sampling adequacy. China is classified as a fixed exchange rate regime for the whole sample period. Hence, the results for the floating exchange rate regime are the same in both panels.

Table 1.9: Correlations of the retained factor with GDP and IMF ARA Metric components

	Including China			Excluding China		
	Full Sample	**Fixed**	**Floating**	**Full Sample**	**Fixed**	**Floating**
GDP	0.991	0.995	0.943	0.947	0.945	
M2	0.963	0.986	0.909	0.908	0.973	
EXP	0.978	0.983	0.920	0.934	0.985	
STED	0.980	0.989	0.910	0.921	0.935	
OTHLIA	0.860	0.958	0.902	0.918	0.949	
# of Obs.	485	154	331	468	137	

Notes: China is classified as a fixed exchange rate regime for the whole sample period. Hence, results for the floating exchange rate regime are not affected by the exclusion of China from the sample.

Analyses carried up to this point suggest that using the reserves-to-GDP ratio as a reserve adequacy measure may not be wrong. Obviously, GDP does not represent a potential drain on foreign assets from a reserve adequacy perspective. But it has a strong positive relationship with the potential drain sources based on the results of the factor analysis. Given the high correlations among the ARA metric components, replacing these variables with GDP may offer a parsimonious but efficient metric for measuring reserve adequacy. Hence, we explore the efficiency of GDP as a single factor for explaining the reserve holding decisions of central banks in the next section.

1.3.2. GDP and Total Reserves

When discussing the existing approaches to reserve adequacy, IMF (2011a) notes that although GDP is sometimes employed as an adequacy measure, it has little if any theoretical or empirical backing and its best use is simply as a scaling factor for cross-country analysis. Nevertheless, contrary to IMF's conviction that GDP has no role in the determination of adequate reserves, the analyses in Section 1.3.1 clearly show that IMF's ARA metric components display a considerably high correlation with a common factor which has a correlation with the GDP between 0.943 and 0.995. In addition, despite arguing that GDP's best use is simply as a scaling factor neither IMF (2011a) nor the ensuing IMF studies do not employ GDP as a variable or scaling factor. This study agrees that the use of GDP alone as an adequacy measure lacks theoretical backing. However, using highly correlated variables which are affected by an underlying factor is also problematic.

In order to set the ground for further analysis and preserve comparability, we estimate one-factor models in Table 1.10 as baseline regressions. Estimates are based

on quarterly data, and both country and year fixed effects are used in linear panel regressions. In general, results in Table 1.10 suggest that the explanatory power of GDP as a single factor is not much different than the multi-factor estimations provided in Table 1.6. However, results in Table 1.10 suggest a remarkable change in coefficient estimates for GDP from the pre-GFC period to the post-GFC period for both fixed and floating exchange rate regimes whether year fixed effects are employed or not. Besides this observation, we do not rely much on the results in Table 1.10 since further tests suggest problems related to both heteroscedasticity and cross-sectional dependence, in particular. We check for cross-sectional independence for total reserves and GDP using the method developed in Pesaran (2004) and Pesaran (2015). For the full sample period, pre-GFC and post-GFC test results suggest rejection of the null hypothesis of cross-section independence at the 1% level. However, there is a clear decline in mean cross-section correlations after the GFC; from 0.82 to 0.27 for total reserves and from 0.86 to 0.48 for GDP. As Baltagi et al. (2012) note, in the fixed n case and as $T \rightarrow \infty$, Breusch and Pagan's (1980) test can be applied to test for the cross-sectional dependence in panels. Breusch-Pagan LM test results also suggest cross-sectional dependence. We check for heteroscedasticity using the routine developed by Baum (2000) based on the modified Wald statistic discussed in Greene (2000). Test results suggest the existence of groupwise heteroscedasticity.

Regarding the relationship between GDP and total reserves, it can be argued that replacing the ARA metric components with GDP might be a viable option. However, given the results in Table 1.5 and Table 1.10, employing additional variables that capture the differing dynamics across exchange rate regimes is also needed. Based on the previous discussions, the trade balance is the first candidate as an additional variable. Another obvious candidate is the scaled version of broad money. Broad money is expected to capture the potential internal drains and the broad money channel of potential drains is closely related to sources of reserve accumulation. Gande and Parsley (2005) argue that the transmission channel is stronger through capital than through trade flow linkages and that the capital account is more important in the short run, while trade correlations are more important in the longer run. Tong and Wei (2010) find that liquidity shocks are more severe for emerging economies that have a higher pre-crisis exposure to foreign portfolio investments and foreign loans. Accordingly, accumulations that are mainly a result of current account surpluses might pose a different risk in terms of possible drains compared to accumulations that are

related to the financial account. An accumulation as a result of continued current account surpluses may be preferable since the country under consideration would be less vulnerable to risks arising from capital flow volatility and sudden stops. Furthermore, within the financial account, portfolio investments and foreign direct investments (FDI) have completely different volatility profiles, and the potential drain risks of these two sub-accounts are different to a great extent. Both portfolio investments and FDIs would mostly generate a drain on reserves mainly through money supply. Yet, the intensity of these drains is likely to be quite different. A country that is mostly financed through FDI compared to a country that is heavily financed through portfolio investments would likely face differing levels of demand for foreign currency in high-stress periods. In addition to these dynamics, the level of float for the currency is also important. In a pure float, a central bank will not intervene in foreign exchange markets and an increased demand for foreign currency from domestic agents or foreign agents (portfolio and FDI outflows) will be met in the market and will likely cause the domestic currency to depreciate, leading to a new equilibrium in the domestic economy. As the degree of float declines a central bank cannot stay neutral and needs to act against the pressures on the foreign exchange rate. Hence, broad money's impact as a potential drain will increase as the degree of float decreases. As mentioned before, IMF addresses this issue by using differentiated weights across fixed and floating exchange rate regimes. But this two-way classification is far from capturing the true dynamics. For instance, IMF's ARA metric assumes that the impact of broad money is the same for pure floats and managed floats. Also, the fixed exchange rate regime classification has 6 categories before 2008 and 8 categories afterward. Using an undifferentiated weight for all sub-categories of fixed exchange rate regime classification implicitly assumes that the broad money channel displays the same behavior for category 1 (no separate legal tender) and category 8 (other managed arrangement), which is again an overreaching assumption. Given these discussions, several alternative adequacy measures are developed in the next section and excess reserves are analyzed based on the estimations obtained from these metrics.

Table 1.10: Estimation results of single-factor models

1999Q4:2019Q4	Full Sample		Fixed Exchange Rate		Floating Exchange Rate	
GDP	0.27***	0.27***	0.27***	0.27***	0.18***	0.15***
	(25.72)	(30.50)	(205.73)	(101.36)	(18.42)	(14.51)
Country Fixed Effects	X	X	X	X	X	X
Year Fixed Effects		X		X		X
F Statistics	661.41	2.03E+05	42322.85	n.a	339.25	n.a
Prob	0.00	0.00	0.00	n.a	0.00	n.a
Within R-squared	0.79	0.79	0.80	0.83	0.75	0.78
# of observations	1,926	1,926	618	618	1,308	1,308
# of countries	24	24	16	16	20	20
1999Q4:2007Q2	**Full Sample**		**Fixed Exchange Rate**		**Floating Exchange Rate**	
GDP	0.48***	0.53***	0.61***	0.62***	0.27***	0.31**
	(5.32)	(6.27)	(308.70)	(179.86)	(3.03)	(2.72)
Country Fixed Effects	X	X	X	X	X	X
Year Fixed Effects		X		X		X
F Statistics	28.31	29.53	95294.26	3.85E+06	9.16	5.83
Prob	0.00	0.00	0.00	0.00	0.01	0.00
Within R-squared	0.80	0.83	0.99	0.99	0.45	0.50
# of observations	722	722	224	224	498	498
# of countries	24	24	13	13	20	20
2009Q2:2019Q4	**Full Sample**		**Fixed Exchange Rate**		**Floating Exchange Rate**	
GDP	0.06***	0.06***	0.06***	0.06***	0.08**	0.06*
	(19.00)	(14.34)	(41.48)	(12.94)	(2.43)	(1.88)
Country Fixed Effects	X	X	X	X	X	X
Year Fixed Effects		X		X		X
F Statistics	360.93	1409.80	1720.28	n.a	5.89	36.96
Prob	0.00	0.00	0.00	n.a	0.03	0.00
Within R-squared	0.17	0.20	0.17	0.26	0.27	0.44
# of observations	1036	1036	341	341	695	695
# of countries	24	24	13	13	19	19

*Notes: t-statistics based on robust standard errors in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level.*

1.4. Modified metrics for explaining reserve holding decisions of central banks

This section is focused on investigating modified metrics that perform better than the IMF's ARA metric in explaining EM central bank reserve holding decisions. Within this context, IMF's ARA metric cannot be deemed as a reserve adequacy measure since for a strong proposition like that the developed metric data should be augmented into other lines of research that use reserve adequacy measure(s) as explanatory variable(s) and evidence for its explanatory power should be provided. To the author's knowledge, currently, there is not any study that uses IMF's ARA metric as a measure of reserve adequacy. For instance, in EM sovereign bond spread studies,

it is almost a standard to employ the reserves-to-GDP ratio as a measure of reserve adequacy. One of the rare studies that do not proxy reserve adequacy with the reserves-to-GDP ratio is Bellas et al. (2010). They control for reserve adequacy through short-term debt/reserves, interest payments/reserves, and amortization/reserves variables. This is a "potential drains on reserves" approach. However, it is not complete in terms of sources of potential drains used in IMF's ARA metric.

Thus, for a metric to be accepted as an efficient measure of reserve adequacy, evidence of its explanatory power should be provided. This study does not aim to provide that evidence and leaves it for further research. On the other hand, it is still important to understand the reserve holding decision dynamics of central banks. One would expect a central bank to hold foreign exchange reserves close to the levels it deems adequate since diverging from adequate reserves by either holding excess or insufficient foreign exchange assets may translate to net positive costs for the EM countries. Hence, in general, actual reserve holdings of a central bank may be used to investigate the levels of reserves considered adequate from a central bank perspective.

Based on the discussion in Section 1.3, we explore the impact of GDP, M2, TB, and IMP on the reserve holding decisions of the central banks. In doing so, we estimate the models in Table 1.11 over the 2001Q4-2020Q1 using quarterly data and a balanced sample which is selected to maximize the observations available after balancing and consists of the following 11 countries: Brazil, Chile, Colombia, Hungary, Malaysia, Mexico, Philippines, Romania, South Africa, Thailand, and Türkiye.

As discussed in Section 1.2, test results suggest the existence of heteroscedasticity, cross-correlation, and autocorrelation. In addition, since we use a subsample in which the time dimension (74 quarters) is larger than the cross-sectional dimension (11 countries), using fixed-effect linear panel regressions may not be appropriate. Accordingly, in this section, we employ feasible generalized least squares (FGLS) estimation regressions for all models. As Bai et al. (2021) note, the generalized least squares model allows taking heteroskedasticity, and cross-sectional and serial correlations into account in the estimation. Based on the test results, we assume heteroscedasticity, cross-correlation, and panel-specific AR (1).

Table 1.11: Feasible generalized least squares estimations

	TOTRES		
	(1)	(2)	(3)
GDP	0.08***	0.06***	0.05***
	(11.63)	(8.85)	(6.42)
M2	0.06***		
	(8.96)		
TB	0.07*	0.09**	
	(1.93)	(2.37)	
FXM2		0.04**	0.05**
		(2.01)	(2.20)
IMP			0.10***
			(3.66)
Constant	26.78**	137.62***	121.81***
	(1.97)	(3.81)	(4.37)
Wald Chi-sq	1142.30	209.67	402.72
Prob	0.00	0.00	0.00
# of observations	814	814	814
# of countries	11	11	11

*Notes: t-statistics in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level. All models are estimated with country-specific autocorrelation, heteroscedasticity, and cross-correlation assumptions based on quarterly data (2001Q4:2020Q1).*

Based on the result provided in Table 1.11, we form five reserve adequacy metrics in addition to the IMF's ARA metric. These metrics are given in the equations below:

$$RESOC1 = (GDP * 0.08) + (M2 * 0.06) + (TB * 0.07) \quad (1.5)$$

$$RESOC2 = (GDP * 0.06) + (FX * M2 * 0.04) + (TB * 0.09) \quad (1.6)$$

$$RESOC3 = (GDP * 0.05) + (FX * M2 * 0.05) + (IMP * 0.10) \quad (1.7)$$

$$RESOC4 = BASEIMP + RESOC1 \quad (1.8)$$

$$RESOC5 = BASEIMP + RESOC2 \quad (1.9)$$

where BASEIMP is the 3-month imports value based on the average of the last 4 quarters. Augmenting imports to the metrics in equations 1.5 and 1.6 follows from the fact that the import coverage method is still the most used (78 percent) reserve adequacy measure by the central banks according to World Bank (2019) survey data.

Using these equations, adequate reserve series are estimated for each country in the original 24-country sample. Then, implied excess reserves are calculated using the difference between actual reserves and the estimated adequate reserves. Since the coefficients in equations 1.5, 1.6, and 1.7 are obtained from a subsample of 11 countries using quarterly data, it is possible to observe the out-of-the-sample predictive power of the suggested reserve adequacy metrics.

Table 1.12 provides the summary statistics for these estimations. Results in the left panel in Table 1.12, which are based on levels, suggest that Equation 1.8 better reflects the determinants of the reserve holding decisions of central banks. This inference follows from the fact that EXOC4 in Table 1.12 has the smallest mean in the full sample, subsample excluding China, and for the 1.12 countries that are not included in the sample for the estimations in Table 1.11. Similar to the mean, EXOC4 also has the smallest standard deviations for all estimations.

Table 1.12: Summary Statistics for excess reserve alternatives

	Obs	Mean	Std. Dev.	Min	Max		Obs	Mean	Std. Dev.	Min	Max
Full Sample						**Full Sample**					
EXIMF	510	37.1	184.2	-1561.8	1382.2	EXIMFGDP	486	0.04	0.09	-0.18	0.32
EXOC1	503	62.6	222.3	-49.9	2010.2	EXOC1GDP	503	0.09	0.10	-0.09	0.40
EXOC2	503	118.2	391.3	-6.2	3124.1	EXOC2GDP	503	0.14	0.10	-0.06	0.45
EXOC3	503	107.4	373.6	-19.1	2988.7	EXOC3GDP	503	0.11	0.10	-0.09	0.41
EXOC4	503	19.9	166.6	-449.2	1480.2	EXOC4GDP	503	0.00	0.08	-0.19	0.26
EXOC5	503	75.5	315.4	-72.4	2594.0	EXOC5GDP	503	0.05	0.09	-0.16	0.34
Full Sample ex. China						**Full Sample ex. China**					
EXIMF	492	24.3	61.0	-32.2	444.6	EXIMFGDP	469	0.04	0.09	-0.18	0.32
EXOC1	486	28.3	55.0	-49.9	410.5	EXOC1GDP	486	0.08	0.10	-0.09	0.40
EXOC2	486	51.8	78.8	-6.2	499.8	EXOC2GDP	486	0.14	0.10	-0.06	0.45
EXOC3	486	44.1	75.0	-19.1	491.2	EXOC3GDP	486	0.11	0.09	-0.09	0.41
EXOC4	486	-1.3	44.1	-109.1	334.5	EXOC4GDP	486	-0.01	0.08	-0.19	0.26
EXOC5	486	22.2	58.7	-72.4	423.8	EXOC5GDP	486	0.04	0.08	-0.16	0.33
Out of Sample (12 Countries)						**Out of Sample (12 Countries)**					
EXIMF	248	30.9	75.7	-32.2	444.6	EXIMFGDP	236	0.03	0.09	-0.18	0.29
EXOC1	246	32.7	68.2	-21.4	410.5	EXOC1GDP	246	0.09	0.09	-0.09	0.40
EXOC2	246	54.6	95.7	-6.2	499.8	EXOC2GDP	246	0.14	0.10	-0.06	0.45
EXOC3	246	48.0	91.2	-10.3	491.2	EXOC3GDP	246	0.11	0.09	-0.09	0.40
EXOC4	246	6.2	52.4	-90.5	334.5	EXOC4GDP	246	0.00	0.09	-0.19	0.26
EXOC5	246	28.0	69.9	-25.5	423.8	EXOC5GDP	246	0.05	0.09	-0.16	0.31

The right panel in Table 1.12 provides the summary statistics for excess reserves after scaling by GDP. Again, EXOC4 has the lowest means and standard deviations for all estimations. In fact, mean excess reserves are zero for the full sample and out of the sample, which suggests that Equation 1.8 reflects the reserve holding decisions of the central banks to a great extent, particularly when scaled by GDP.

To further analyze the suggested metrics and compare them with the IMF's ARA metric, we estimate the models in tables 1.13A and 1.13B using annual data. The difference between Table 1.13A and 1.13B is the scaling of the variables by GDP in the latter.

The results in Table 1.13A suggest that RESOC4 better reflects the dynamics of the central banks' reserve holding decisions, particularly when China is excluded from the sample. IMF's ARA metric components still have a considerable explanatory power for the other metrics but given an R-squared of 0.07 for EXOC4 in the sample that excludes China, that is not the case for Equation 1.8. Similar observations are also true for the results provided in Table 1.13B. The main difference in Table 1.13B compared to Table 1.12B is that RESOC4 performs better in the full sample rather than the sample that excludes China.

Table 1.13A: Excess reserves and IMF ARA Metric components

	Full Sample					
	EXIMF	EXOC1	EXOC2	EXOC3	EXOC4	EXOC5
	(1)	(2)	(3)	(4)	(5)	(6)
M2	-0.12***	-0.09***	-0.03	-0.03	-0.09***	-0.03
	(-5.92)	(-4.58)	(-1.64)	(-1.51)	(-4.46)	(-1.54)
EXP	1.39	1.24***	1.29***	1.24***	1.03**	1.08**
	(3.20)	(2.84)	(2.94)	(2.79)	(2.31)	(2.41)
STED	0.02***	0.40**	0.44***	0.40***	0.33**	0.37**
	(0.11)	(2.77)	(3.09)	(2.80)	(2.29)	(2.64)
OTHLIA	-0.61	-0.62*	-0.60*	-0.60*	-0.63*	-0.61*
	(-1.63)	(-1.87)	(-1.77)	(-1.78)	(-1.94)	(-1.84)
F Statistics	10117.89	388.41	11035.53	9214.70	2733.64	5066.90
Prob	0.00	0.00	0.00	0.00	0.00	0.00
Within R-sq.	0.65	0.52	0.73	0.71	0.51	0.60
# of obs.	482	482	482	482	482	482
# of countries	24	24	24	24	24	24
	Full Sample ex. China					
	EXIMF	EXOC1	EXOC2	EXOC3	EXOC4	EXOC5
	(1)	(2)	(3)	(4)	(5)	(6)
M2	0.13***	0.04*	0.12***	0.12***	0.03	0.11***
	(5.37)	(1.84)	(5.38)	(5.52)	(1.47)	(4.97)
EXP	0.12**	0.10	0.12*	0.06	-0.12	-0.09
	(2.20)	(1.38)	(1.92)	(0.84)	(-1.45)	(-1.22)
STED	-0.42***	0.03	0.00	-0.03	0.00	-0.02
	(-3.25)	(0.17)	(0.02)	(-0.19)	(0.00)	(-0.15)
OTHLIA	-0.06	0.08	0.08	0.08	0.07	0.08
	(-1.01)	(1.08)	(1.29)	(1.27)	(0.94)	(1.13)
F Statistics	17.80	6.52	24.39	32.02	5.04	30.38
Prob	0.00	0.00	0.00	0.00	0.00	0.00
Within R-sq.	0.55	0.44	0.75	0.69	0.07	0.50
# of obs.	465	465	465	465	465	465
# of countries	23	23	23	23	23	23

*Notes: t-statistics based on robust standard errors in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level. 2) All models are estimated using annual data with country fixed effects.*

Table 1.13B: Excess reserves and IMF ARA metric components

	Full Sample					
	EXIMF GDP (1)	EXOC1 GDP (2)	EXOC2 GDP (3)	EXOC3 GDP (4)	EXOC4 GDP (5)	EXOC5 GDP (6)
M2GDP	0.07	0.10	0.15**	0.15**	0.10	0.15**
	(1.04)	(1.49)	(2.33)	(2.30)	(1.49)	(2.32)
EXPGDP	-0.26**	0.21***	0.20***	0.15**	0.04	0.02
	(-2.63)	(3.21)	(3.05)	(2.38)	(0.56)	(0.34)
STEDGDP	0.18**	0.04	0.05	0.03	0.02	0.03
	(2.25)	(0.44)	(0.55)	(0.34)	(0.17)	(0.26)
OTHLIAGDP	-0.09*	0.04	0.05	0.05	0.05	0.05
	(-1.99)	(0.96)	(0.99)	(1.05)	(1.02)	(1.06)
F Statistics	9.14	7.76	10.18	7.56	2.26	3.96
Prob	0.00	0.00	0.00	0.00	0.09	0.01
Within R-sq.	0.15	0.17	0.23	0.19	0.08	0.14
# of obs.	482	482	482	482	482	482
# of countries	24	24	24	24	24	24
	Full Sample ex. China					
	EXIMF GDP (1)	EXOC1 GDP (2)	EXOC2 GDP (3)	EXOC3 GDP (4)	EXOC4 GDP (5)	EXOC5 GDP (6)
M2GDP	0.13**	0.15***	0.20***	0.20***	0.16***	0.21***
	(2.76)	(3.60)	(4.66)	(4.57)	(3.52)	(4.61)
EXPGDP	0.13*	0.16***	0.15**	0.10*	-0.02	-0.03
	(1.83)	(2.89)	(2.71)	(1.93)	(-0.32)	(-0.57)
STEDGDP	-0.27**	0.02	0.03	0.02	0.00	0.01
	(-2.66)	(0.27)	(0.38)	(0.19)	(0.02)	(0.11)
OTHLIAGDP	-0.10*	0.04	0.04	0.04	0.04	0.04
	(-2.04)	(0.77)	(0.81)	(0.87)	(0.83)	(0.87)
F Statistics	9.59	7.47	10.91	9.46	6.32	10.85
Prob	0.00	0.00	0.00	0.00	0.00	0.00
Within R-sq.	0.19	0.23	0.30	0.27	0.15	0.23
# of obs.	465	465	465	465	465	465
# of countries	23	23	23	23	23	23

*Notes: t-statistics based on robust standard errors in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level. All models are estimated using annual data with country fixed effects.*

1.5. Conclusion

IMF's ARA metric for measuring reserve adequacy is a hybrid tool based on various potential drains on foreign exchange reserves. ARA metric is hybrid in the sense that it is a weighted sum of short-term debt, exports, broad money, and other liabilities component of international investment position (IIP). IMF does not claim that the ARA metric is complete and measures reserve adequacy appropriately, instead sees it as a starting point for reserve adequacy analysis and emphasizes the importance of country-specific factors as discussed in IMF (2015). However, although it is postulated in this way, according to World Bank (2019), 36% of central banks already

use the ARA metric as a measure of reserve adequacy and this ratio will likely increase in the coming years. A simple analysis of IMF's ARA metric implied excess reserves to GDP ratio suggests that despite some of the EM countries holding reserves close to ARA metric implied levels, some countries' holdings diverge to a great extent. Excess reserves, based on the IMF ARA metric, exceed 30% of GDP for some countries at times while the mean value of the total reserves-to-GDP (RESGDP) ratio is 21%, which merits further investigation of this behavior. One of the possible explanations for this observed behavior may be that central banks do not put much emphasis on the costs that may arise as a result of holding inadequate or excess reserves. Another possible explanation, which this study focuses on, is that the IMF's ARA metric may not be an efficient tool for measuring the adequate level of reserves, particularly from a central bank perspective.

The analyses in this study suggest that broad money, short-term debt, and exports are highly correlated mostly as a result of close-to-unit correlations in fixed exchange rate regimes for the full sample. In addition, the excess reserves calculated based on the ARA metric suggested adequate reserves display substantial correlations with the ARA metric components, particularly for the floating exchange rate regimes. This suggests that the weights applied to the ARA metric components are not in line with the views of the EM central banks. A more important observation is the remarkably high correlation of GDP with total reserves and the constituents of the IMF's ARA metric, particularly broad money, short-term debt, and exports, which suggests that GDP may be driving the changes in these three highly correlated variables which is confirmed by the principal component analysis provided in Section 1.3.1.

The analyses provided in Section 1.4 suggest that GDP, broad money, and trade balance augmented with 3-month of imports reflect the reserve holding decisions of central banks to a great extent. This metric mitigates the inherent problem of the IMF's ARA metric to overestimate the adequate level of reserves for some EM countries while underestimating for others, at least from the central banks' perspective. One would expect a central bank to hold foreign exchange reserves close to the levels it deems adequate since diverging from adequate reserves by either holding excess or insufficient foreign exchange assets may translate to net positive costs for the EM countries. Hence, in general, actual reserve holdings of a central bank may be used to investigate the levels of reserves considered adequate from a central bank perspective.

To the author’s knowledge, currently, there is not any study that uses IMF’s ARA metric directly as a measure of reserve adequacy. Within this context, IMF’s ARA metric cannot be deemed as a reserve adequacy measure since for a strong proposition like that the developed metric data should be augmented into other lines of research that use reserve adequacy measure(s) as explanatory variable(s) and evidence for its explanatory power should be provided. This study does not aim to provide that evidence and leaves it for further research.

ESSAY II

FOREIGN EXCHANGE RESERVE ADEQUACY, EXCESS RESERVES AND EMERGING MARKET SOVEREIGN BOND SPREADS

Abstract- Although studies that attempt to explain the observed hoarding behavior of EMEs are abundant, research on whether the levels of foreign exchange reserves are excess or not is scarce. This study attempts to identify the level of international reserves deemed adequate by the market using several reserve adequacy measures and the EM external debt market. The results suggest that the market assesses the IMF's ARA metric to overestimate the level of adequate reserves to a great extent. More importantly, hoarding reserves beyond adequate levels are not optimal since it is not rewarded by the market.

Index Terms- Reserve Adequacy, IMF ARA Metric, Excess Reserves, International Reserves, Emerging Market Sovereign Bond Market.

Jel Codes- F30, G12, G15

2.1. Introduction

The accumulation of foreign exchange reserves in emerging market (EM) countries since the late 1990s has been analyzed extensively. In attempts to explain the unprecedented surge in reserves, the literature draws upon various explanations. The analogy discussed in Machlup (1966) regarding "Mrs. Machlup's wardrobe" and "keeping up with Joneses effect" became one of those explanations. It suggests that the EM countries accumulate reserves to keep up with their peers and some studies find empirical evidence that supports this explanation (Cheung and Qian, 2009; Cheung and Sengupta, 2011; Pontines and Yongqiang, 2011; Cheung et al., 2019). Another line of research focuses on mercantilist vs. precautionary motives (Jo, 2011; Schröder, 2017; Cabezas and De Gregorio, 2019; Choi and Taylor, 2022 among others). In addition to these lines of research, there is a broad literature, as discussed in Section 2.2, that investigates the behavior of central banks from an optimality perspective.

Although studies that attempt to explain the observed hoarding behavior of EMEs are abundant, research on whether the levels of foreign exchange reserves are excess or not is scarce. This is mostly because of the missing theoretical framework for the optimal level of reserves. Jeanne and Rancière (2011) try to fill that gap and study the optimal level of international reserves for a small open economy seeking insurance against sudden stops in capital flows. They argue that the buildup of reserves in emerging market Asia can be explained only if one assumes a large anticipated output cost of sudden stops and a high level of risk aversion. However, as discussed in the first essay of this thesis, sudden stops in capital flows do not seem to be the only concern of central banks despite being an important area of concern.

Parallel to the difficulties in conferring on the optimal level of reserves, few studies focus directly on excess reserves. In one of those rare studies, Park and Estrada (2009) investigate the issue of whether developing Asia does have large and growing excess reserves. Using various measures of reserve adequacy, the study argues that developing Asia's foreign exchange reserves have in fact reached excessive levels. Ghosh et al. (2017) also observe that even after including generally accepted motives for holding reserves as well as allowing different motives to apply at different points in the reserves distribution, there remains a positive residual for the more recent years except when EMEs ran down reserves during the GFC. In a more recent study, Arslanalp et al. (2022), discuss the excess reserves based on the IMF's ARA metric

but do not employ them as an explanatory variable in estimations, probably as a result of the study's focus on dollar dominance. Although Arslanalp et al. (2022) base their deliberations on excess reserves on the IMF's ARA metric, there are some fundamental issues with the metric as discussed in the first essay of this thesis. Moreover, the results in the first essay of this thesis suggest that a reserve adequacy metric that includes the GDP, broad money, and trade balance along with 3-month of imports reflects the reserve holding decisions of central banks to a great extent and performs better than IMF's ARA metric in explaining the behavior of central banks.

The approach adopted in this study is that a reserve adequacy metric should reflect both the market's view and the behavior of central banks. Only a metric that better reconciles the view of the market on adequate reserves with the view of central banks has the potential to become a generally accepted reserve adequacy measure. This is important because, firstly, if the market does not price a supposedly relevant risk source then it is not relevant. Thus, if the market believes that the level of foreign exchange reserves is irrelevant beyond some point deemed adequate, then it would not price these excess reserves and reward the countries that hold excess reserves. Secondly, it is not optimal for a central bank to diverge from the "market-assessed adequate reserves" since holding excess or inadequate reserves paves the way for increased costs. For instance, Park and Estrada (2009) argue that excess reserves are welfare-reducing since the cost of holding an additional dollar of such reserves is, by definition, larger than the benefit. They emphasize that the larger the excess reserves, the larger will be the loss of national welfare which is in line with this study's motivation. The increase in the cost of holding excess reserves is closely related to the return differential on central bank reserve portfolios and the opportunity costs. The opportunity costs may arise as a result of higher returns to the foreign currency-denominated portfolios of the domestic private sector or simply as a result of costs associated with acquiring international reserves. On the other hand, holding inadequate foreign exchange reserves may have an adverse macroeconomic impact on the economy and/or may increase the cost of external debt issuance. Therefore, from both market and central bank perspectives, reconciliation on the level of adequate reserves is the optimal behavior. Since the pricing behavior in EM sovereign bond markets is closely related to the riskiness of a country and international reserves are often seen as a measure of a country's ability to repay its foreign currency-denominated debt, this

essay attempts to uncover the pricing dynamics regarding the excess reserves using the EM sovereign bond spread data.

In literature focusing on the EM sovereign bond spreads, the usual approach is running the following representative model on a panel data set of EMEs.

$$spread_{i,t} = \mu + \alpha_j \, G_{j,t} + \delta_k \, C_{i,k,t} \quad (2.1)$$

In Equation 2.1, $spread_{i,t}$ is the observed overall spread for the i^{th} country at time *t*, which indicate the total return of a dollar-denominated external bond of a country after controlling for the return on risk-free asset. $G_{j,t}$ represents the value of j^{th} global factor at time *t* whereas $C_{i,k,t}$ is the value of k^{th} country-specific factor for country *i* at time *t*. α_j and δ_k are factor sensitivities for global and country-specific factors, respectively.

Cayirli et al. (2022) employ also the specification in Equation 2.2 to analyze the dynamics related to the relative spreads.

$$divspread_{i,t} = \omega + \varphi_j \, G_{j,t} + \psi_k \, C_{i,k,t} \quad (2.2)$$

where the $divspread_{i,t}$ is the difference between $spread_{i,t}$ and $embig_t$, which represents the total return for the EM sovereign bond market.

Among the country-specific factors, using the reserves-to-GDP ratio is almost standard practice.[3] Since this study focuses on how holding excess reserves affects the external borrowing costs of EM countries, we employ excess reserves-to-GDP ratios calculated using various reserve adequacy measures in addition to the reserves-to-GDP ratio. In doing so, potential state-dependent and asymmetric dynamics are also explored. This approach is completely new to the literature and has the potential to help central banks and other reserve authorities to make a more informed decision on holding excess reserves.

The remainder of this study is structured as follows: Section 2.2 briefly discusses relevant literature. Section 2.3 explains the details of data and variable selection. Empirical methodology and results are provided in Section 2.4. Finally, Section 2.5 presents overall conclusions as well as suggestions for further research.

[3]In EM sovereign spread literature, one of the rare studies that do not proxy reserve adequacy with the reserves-to-GDP ratio in EM sovereign bond spread literature is Bellas et al. (2010). The study employs a potential drain on reserves approach and controls for reserve adequacy through three variables: short-term debt/reserves, interest payments/reserves, and amortization/reserves variables.

2.2. The Relevant Literature

In this section, we provide a brief discussion of the relevant literature with a focus on the studies that attempt to explain the international reserves hoarding behavior of central banks from different perspectives as well as the studies that focus on excess reserves. The studies that investigate potential nonlinear dynamics are also included in the discussions.

Durdu et al. (2009) analyze the rapid growth in foreign reserves as a response to sudden stops witnessed at the early stages of financial globalization using a stochastic intertemporal equilibrium framework in which precautionary foreign asset demand is driven by output variability, financial globalization, and sudden stop risk. The study's results suggest that financial globalization and sudden stop risk can explain the surge in reserves but output variability cannot. Delatte and Fouquau (2011) analyze the dynamics of the international reserve holdings by emerging economies. using a Panel Smooth Transition Regression (PSTR) model, they find evidence for the presence of nonlinear behavior in the demand for international reserves. They argue that the deterioration of the US's external position is the most relevant to explain the increase in the accumulation of foreign exchange reserves. Using a sample of 130 countries over the 1980-2008 period, Vujanovic (2011) studies the empirical determinants of foreign currency reserve holdings and argues that while changes in GDP, the exchange rate regime, exchange rate volatility, and financial openness can all have permanent one-off effects on the level of reserves, the levels of trade and domestic financial depth are robust determinates of the level of reserves in the long run. Focusing on the liquidity of reserves in over-the-counter international capital markets, Jung and Pyun (2016) propose a general equilibrium theory of international reserves determination. The study underscores the role of U.S. T-bonds as the liquid asset that facilitates trade, either through collateral or buffer stocks against the repatriation of foreign capital. In this setting, they argue that the sustained enhancement of reserve assets' liquidity may hold the key to understanding the observed reserve accumulation in EMEs. Ghosh et al. (2017) study the motives for the behavior of EMEs stockpiling international reserves and how these motives evolved. They argue that vulnerability to current account shocks was relatively important in the 1980s, but factors related to the magnitude of potential capital outflows gained importance as EMEs became more financially integrated. Results of the study also suggest that high-reserve holders, who tend to be more financially integrated, are

motivated by insurance against capital account rather than current account shocks and are more sensitive to the cost of holding reserves than are low-reserve holders. Nevertheless, they observe that even after including generally accepted motives for holding reserves as well as allowing different motives to apply at different points in the reserves distribution, there remains a positive residual for the more recent years except when EMEs ran down reserves during the GFC. Benecká and Komarek (2018) investigate the most important cross-country determinants of reserve holdings and evaluate their importance using Bayesian model averaging. Their results suggest that trade openness and the broad-money-to-GDP ratio are the key determinants of the level of reserves, financial development lowers the need for reserves, and the role of debt is limited.

Corneli and Tarantino (2016) analyze the optimal portfolio choice of a risk-neutral sovereign that is subject to liquidity and productivity shocks. The main result of the study is that reserves and debt are complementary: Although raising debt increases the sovereign's exposure to liquidity and productivity crises, the contemporaneous accumulation of reserves mitigates the consequences of these crises on sovereign welfare. Hur and Kondo (2016) argue that reserve accumulation is an optimal response to an increase in foreign debt rollover risk. They argue that reserves are chosen to balance the opportunity cost of idle reserves due to reduced capital investment, the endogenous change in interest rate, and the overall lower likelihood of a crisis. Domanski et al. (2016) focus on the increased activity of EMEs in FX markets after the Global Financial Crisis. They note that the carrying costs of foreign reserves have risen in many countries since the GFC. The study also argues that the costs of running down foreign reserve buffers in terms of higher sovereign risk premia appear to be small, especially for countries that already enjoy strong credit ratings. Shousha (2017) argues that including international reserves as implicit collateral for external borrowing in a small open economy model subject to exogenous financial shocks can explain the observed behavior of EMEs that simultaneously hold very high levels of international reserves and foreign liabilities. The optimal policy suggested by the model implies that the government accumulates international reserves before a sudden stop, and there is a small depletion during it. The study emphasizes the stabilizing role of international reserves even if central banks do not use them. Bianchi et al. (2018) use a quantitative sovereign default model to study the optimal accumulation of international reserves and show that the optimal policy is to borrow and accumulate

reserves in good times to hedge against future increases in borrowing costs based on the model developed that features long-term debt, risk-free assets, and shocks to foreign creditors' stochastic discount factor. They argue that the model can account for significant holdings of international reserves, and the larger accumulation of both debt and reserves in periods of low spreads and high income. From an "excess reserves" perspective, these findings suggest that the accumulation of international reserves is temporary and simply a reflection of countries' precautionary motives. This is because the model recommends the optimal policy is to accumulate in good times only to spend in bad times. Hernández (2018) develops a quantitative model of sovereign default and international reserves to address the optimal portfolio choice of the government. The model features risk-neutral lenders and the government faces a rollover risk arising from coordination failures on the lenders' side. In this setting, higher reserve holdings preclude some of the risk of self-fulfilling debt crises in the future and reduce current sovereign spreads.

Among the studies that adopt a monetary perspective, Taguchi (2011) examines trends in monetary autonomy and their interactions with financial integration, currency regimes, and foreign reserves in emerging Asian and Latin American economies. The study finds that most of the accumulation of foreign reserves has contributed to retaining monetary autonomy in EM economies. However, as Aizenman and Hutchison (2012) note, it is interesting to see that despite the remarkable buildup of international reserves by emerging markets during the period before the financial crisis, countries relied primarily on exchange rate deprecation rather than reserve loss to absorb most of the exchange market pressure shock. They focus on the external balance sheet exposures and argue that small net exposure but large gross exposures with maturity and liquidity mismatches led to deeper exposure and adjustment for emerging markets. Aizenman et al. (2013) studies new metrics for measuring the trilemma aspects: exchange rate flexibility, monetary independence, and capital account openness, taking into account the substantial international reserve accumulation that has taken place since the 2000s. They find that despite the increasing importance of international reserves holding, the role of international reserves holding in the linear relationship among the trilemma policy goals is limited. Additionally, they note that it may be possible that the role of international reserves holding in the context of the trilemma is increasing since the beginning of the 2000s of financial globalization. Steiner (2013b) explains the increase in the foreign exchange holdings

of central banks with the liberalization of international capital markets. The study argues that changes in reserves are a form to manage net capital inflows which permit the central bank to preserve some leeway for an independent monetary and financial policy despite the classic policy trilemma. Aizenman and Ito (2014) note some asymmetrical effects on output losses and gains arising from the level of international reserves. They argue that while international reserves holding is found to increase output gains across the three types of crises, it does not have any negative or loss-reducing effect on output losses. Pina (2015) also adopts a monetary perspective for explaining the massive international reserves accumulation in developing economies. The study treats the accumulation as the outcome of a simple model in which the central bank smooths inflation and argues that central banks accumulate reserves to avoid large inflation during crises.

Steiner (2013a) focuses on the question of whether the central banks revise their reserve policy in the aftermath of financial crises. Analyzing data for emerging and developing countries covering the period 1970–2010, the study argues that currency crises induce a permanent increase of reserves and similar effects are observed in the aftermath of banking crises albeit with less robustness. Catão and Milesi-Ferretti (2014) examine the determinants of external crises, focusing on the role of foreign liabilities and their composition over the 1970–2011 period. They argue that international reserves reduce the likelihood of crisis more than other foreign asset holdings based on their results which suggest that crises tend to occur in countries with reserves lower than the mean by around 2% of GDP. Based on a theoretical model, Cheng (2015a) claims that either by deploying its foreign reserves to lend in foreign currency to the private sector or by increasing fiscal spending on domestic goods, countries can use foreign reserves to enhance their domestic economies' resilience to potential risks from balance sheet effects. The study contends that the policy tools suggest different amounts of minimum international reserves. In their study that analyzes the behavior of gross capital flows in 63 countries between 1991 and 2010, Alberola et al. (2016) find that larger stocks of international reserves are linked to higher gross inflows and lower gross outflows. More importantly, their results suggest that while accumulating reserves initially reduces the outflows, there are decreasing returns to scale which is clear evidence of nonlinear behavior in line with this study’s intuition.

Berkmen et al. (2012) argue that the value of international reserves may diminish sharply once they move above a threshold considered sufficient to guard against risks that suggest a nonlinear relationship. Their argument regarding the existence of nonlinearity is in line with the findings of Llaudes et al. (2010) that suggest although the reserves helped dampen the impact of the GFC on EMs up to a limit, the countries holding reserves in excess of the sum of short-term debt and the current account deficit enjoyed little additional benefit. Allegret and Allegret-Sallenave (2018) investigate the relationship between reserves holding and macroeconomic performance using a non-linear framework. They employ a threshold VAR model and show that output damages due to trade, monetary, and financial shocks tend to be mitigated when authorities hold reserves above a specific threshold. Kohlscheen (2020) studies the relationship between sovereign risk premia and foreign exchange reserves using a quantile regression framework. The results of the study suggest that foreign exchange reserves do not impact risk metrics during tranquil times or for countries at the lower end of the risk spectrum, but their significance starts to emerge as one moves towards higher risk observations.

The review of the literature suggests that although there is a broad literature on international reserve holdings, the benefits of holding excess reserves and potential nonlinearities regarding the response of markets to the changes in excess reserves are relatively unexplored subjects. In addition, the lack of studies that link the optimal reserves suggested by models and generally accepted metrics with the financial markets is also evident. This study attempts to fill that gap by investigating the sovereign market's response to excess reserve holdings calculated using various metrics both in a linear and nonlinear framework.

2.3. Data and Variable Selection

The sample used in empirical analyses covers the period between 1999:Q4 and 2019:Q4. It coincides with the period in which an unprecedented international reserve accumulation in EMEs took place. To study the potential impact of the GFC, we also use a post-GFC subsample that spans the 2009:Q2-2019:Q4 period. In determining the starting quarter of the post-GFC era, we follow Cayirli et al. (2022).

We choose the EM countries to be included in the sample based on the steps provided in Table 1. Missing data in-between is not allowed. However, late entry (early exit) into (out of) the sample is allowed.

Table 2.1: Sample selection details

Inclusion/Exclusion Criteria		Countries
# of Countries with more than one EMBI+ spread entry within the 1999:12 – 2019:12 sample period.	56	
# of Countries excluded for missing EMBI+ spread data in-between.	8	Belarus, Cote d'Ivoire, Croatia, Jordan, Morocco, Nigeria, Trinidad and Tobago, Tunisia.
# of Countries excluded for lack of GDP data.	13	Algeria, Angola, Belize, Dominican Republic, Gabon, Iraq, Lebanon, Namibia, Pakistan, Panama, Senegal, Venezuela, Zambia.
# of Countries excluded for lack of real effective exchange rate (REER) data.	8	Azerbaijan, El Salvador, Guatemala, Jamaica, Kazakhstan, Lithuania, Mongolia, Sri Lanka.
# of Countries excluded for lack of broad money (M2) data.	4	China, P.R., Ecuador, India, Vietnam
# of countries excluded for not being in the IMF ARA Database.	1	Ghana.
# of countries excluded for missing ARA metric data in-between.	1	Argentina.
Remaining countries in the sample	21	Brazil (BRA), Bulgaria (BGR), Chile (CHL), Colombia (COL), Costa Rica (CRI), Egypt Arab Rep. (EGY), Georgia (GEO), Hungary (HUN), Indonesia (IDN), Korea Rep. (KOR), Malaysia (MYS), Mexico (MEX), Peru (PER), Philippines (PHL), Poland, Rep. of (POL), Russian Federation (RUS), South Africa (ZAF), Thailand (THA), Türkiye (TUR), Ukraine (UKR), Uruguay (URY).

Notes: EMBI+ spread, GDP, and REER data are obtained from WB-GEM whereas the balance of payments and broad money-related data are obtained from the International Monetary Fund-International Financial Statistics Database (IMF-IFS). Please see Table A2.1 in the Appendix for further details on the variables.

Parallel to our motivation, EM sovereign spread (SPREAD) on external debt is employed as the dependent variable. J.P. Morgan EMBI+ spread for a given country, which is obtained from World Bank Global Economic Monitor Database (WB-GEM), is used as the proxy for EM sovereign spread. The developing markets EMBI+ spread (EMBIG) from WB-GEM proxies the emerging and developing countries' dollar-denominated external debt market excess return. For each country, divergence from the market (DIVSPREAD) is calculated as the difference between the individual country's spread and the corresponding EMBIG spread.

As explanatory variables, both country-specific variables and global factors are employed. Global factors included in our study are Bank for International Settlements

(BIS) global liquidity indicator (BISGL), CBOE Volatility Index (VIX), TED spread (TED), U.S. 10-year Treasury Bond yield (US10Y), and IMF's commodity price index (PCPS). BISGL reflects the global liquidity conditions and may affect both the overall spreads and relative spreads. In sovereign spread studies, it is customary to use the VIX as a proxy for global risk aversion. The inclusion of TED is to control the price of credit risk. US10Y is used to capture global economic conditions and expectations. Undoubtedly, using the difference between long-term yield and short-term yield may better reflect the global economic conditions and expectations. However, mainly due to the high correlation between the short end of the yield curve and TED, using solely the US10Y as an explanatory variable is an acceptable compromise. The external balance of EM countries may be influenced by the changes in commodity prices and PCPS is employed as a global factor to capture this impact.

Aside from the variables related to the reserve adequacy and excess reserves, ratios of external debt, current account, and financial account to GDP as well as real effective exchange rate (REER) and commodity terms of trade (CTOT) are included in the subset of country-specific explanatory variables. External debt-to-GDP (DEBTGDP) captures information regarding the indebtedness of an EME while current account-to-GDP (CAGDP) and financial account-to-GDP (FAGDP) are employed to control for the impact of the changes in the external balance. As Cayirli et al. (2022) discuss, REER is rich in information content and their results suggest that it is one of the consistent determinants of EM sovereign spreads. Accordingly, we include REER as a country-specific explanatory variable although it may be simply a proxy for other variables that directly affect the pricing behavior in the EM sovereign bond markets. As Hilscher and Nosbusch (2010) discuss, a deterioration in terms of trade is likely to have an adverse impact on net exports, and vice versa. Thereby, CTOT is closely related to the ability of a country to accumulate net foreign assets and contrary to the current account which conveys information on the current state of external balance, CTOT contains information on the future path.

In addition to reserves-to-GDP (RESGDP), excess reserves are calculated using the adequate reserve levels by IMF's ARA metric and the two adequacy metrics (RESOC4 and RESOC5) explored in the first essay of this thesis are employed in the empirical analyses. Quarterly data for the IMF's ARA metric is not available and it is not possible to generate the quarterly metrics since the IMF uses its own estimates for some of the drain sources included in the metric. Accordingly, the excess reserves

based on the IMF's ARA metric are calculated as the difference between the value of international reserves at the end of each quarter and the value of IMF's ARA metric at the end of the previous year.

Table A2.1 in the Appendix contains the list of variables used in this study along with their explanations and sources. The summary statistics and the simple correlations are provided in Table A2.2 and Table A2.3, respectively.

2.4. Research Setting and Empirical Results

Before proceeding with our analysis, we check for cross-sectional dependence of country-specific variables using the approach developed in Pesaran (2004) and Pesaran (2015). The null hypothesis of cross-section independence is rejected at the 1% significance level for all variables. Accordingly, we test for unit root using the methodology developed by Im et al. (2003), which takes cross-sectional dependence into account. In doing so, we let the optimal lag length (up to 4) be selected based on Akaike Information Criterion (AIC). The alternative hypothesis for Im et al. (2003) is that some panels are stationary while the null hypothesis is all panels contain unit roots. Among the country-specific variables, the null hypothesis is rejected for SPREAD, DIVSPREAD, FAGDP, CTOT, and REER at the 5% significance level. For CAGDP, the null hypothesis is rejected at the 10% significance level while test results for RESGDP and DEBTGDP suggest that all panels contain unit roots. Augmented Dickey-Fuller tests based on Dickey and Fuller (1979) are run for the subset of global factors with constant and no trend. Lag selection for the tests is made according to the suggestion of AIC. The results suggest that the null hypothesis of the variable containing a unit root is rejected only for TED at the 5% significance level.

Using the methodology of Kao (1999), cointegration tests are carried out across the full sample. The null hypothesis is no cointegration and the alternative hypothesis is all panels being cointegrated. For models based on equations (2.1) and (2.2) specifications, null hypotheses are rejected at the 1% level.

Serial correlation tests are carried out using the routine developed by Wursten (2018) based on Born and Breitung (2016). The null hypothesis of no serial correlation up to order 4 is rejected at the 1% significance level for both equation (2.1) and equation (2.2) specifications. Since the test requires the residuals to include the fixed effect, global factors are excluded in tests for autocorrelation. Tests for heteroscedasticity are conducted using the routine developed by Baum (2000) based

on the modified Wald statistic discussed in Greene (2000). Test results suggest the existence of groupwise heteroscedasticity.

2.4.1. Baseline Regressions

To set the ground for further analysis, we provide and briefly discuss the estimation results for baseline regressions in this section. Based on the diagnostic tests, we choose to estimate baseline linear regression models using the specifications provided in equations (1) and (2) with country fixed effects and panel-specific AR(1) autocorrelation structure along with the assumption that the disturbances are heteroscedastic and contemporaneously correlated across panels. The estimation results for the full sample period and the post-GFC era are provided in tables 2 and 3, respectively.

For the full sample period, estimation results suggest the excess reserves-to-GDP variables and the usual proxy for reserve adequacy, RESGDP, are consistently significant determinants of EM sovereign spreads. The estimated signs are negative which suggests that increases in reserve adequacy decrease both the overall and relative spreads, and vice versa. Among the country-specific variables, DEBTGDP and REER are the other economically and statistically significant determinants of the EM sovereign spreads. Global risk aversion, long-term U.S. yield, and commodity prices are the global factors that have a significant impact on EM sovereign spreads.

The estimation results in Table 2.3 suggest that there has not been a significant shift in the impact of reserve adequacy on the EM sovereign spreads both in terms of statistical significance and magnitude. REER is still a consistent and significant determinant, but external indebtedness seems to have lost some of its explanatory power in the post-GFC era. Regarding the global factors, VIX is still relevant but only for overall spreads. On the other hand, global liquidity proxied by BISGL seems to have become a prominent determinant of relative spreads which is the most striking difference from the full sample period.

Table 2.2: Baseline regression results for the full sample (1999:Q4-2019:Q4)

	(1) SPREAD	(2) SPREAD	(3) SPREAD	(4) SPREAD	(5) DIV SPREAD	(6) DIV SPREAD	(7) DIV SPREAD	(8) DIV SPREAD
RESGDP	-11.26***				-13.93***			
	(-6.77)				(-6.06)			
EXIMFGD_		-12.73***				-12.81***		
		(-5.05)				(-4.67)		
EXOC4GD_			-8.81***				-12.17***	
			(-4.81)				(-4.54)	
EXOC5GD_				-9.16***				-12.41***
				(-4.92)				(-4.58)
DEBTGDP	4.90***	3.30***	2.40***	2.52***	5.65***	4.12***	3.59***	3.68***
	(4.46)	(3.30)	(2.95)	(3.07)	(3.98)	(3.12)	(3.61)	(3.68)
CAGDP	4.91	2.52	-5.00	-4.61	8.89*	3.86	-0.84	-0.57
	(1.00)	(0.49)	(-1.19)	(-1.09)	(1.65)	(0.70)	(-0.17)	(-0.12)
FAGDP	3.20	4.18	5.28*	5.17*	3.01	4.53	4.77	4.73
	(1.02)	(1.36)	(1.69)	(1.65)	(1.01)	(1.57)	(1.55)	(1.53)
CTOT	-2.48	-4.11	6.98**	6.94**	0.15	-1.82	9.25***	9.22***
	(-0.72)	(-1.08)	(2.21)	(2.20)	(0.04)	(-0.43)	(2.69)	(2.68)
REER	-5.52***	-5.38***	-5.49***	-5.47***	-4.49***	-4.65***	-4.38***	-4.33***
	(-6.96)	(-6.59)	(-6.15)	(-6.06)	(-5.00)	(-5.06)	(-4.31)	(-4.24)
VIX	5.20***	5.15***	5.09***	5.05***	-1.96***	-1.70**	-1.36**	-1.40**
	(5.11)	(5.03)	(4.73)	(4.70)	(-2.73)	(-2.41)	(-2.01)	(-2.06)
BISGL	-4.56	-3.15	-0.54	-0.56	1.28	1.80	2.59	2.61
	(-1.98)	(-1.30)	(-0.22)	(-0.23)	(0.60)	(0.78)	(1.29)	(1.29)
TED	-12.60	-8.80	-21.18	-21.27	4.70	10.65	-0.92	-1.07
	(-0.64)	(-0.45)	(-1.04)	(-1.05)	(0.37)	(0.86)	(-0.08)	(-0.10)
US10Y	-25.23**	-24.84**	-33.82***	-34.67***	-20.07**	-13.73	-19.60**	-20.16**
	(-2.22)	(-2.09)	(-2.66)	(-2.72)	(-2.09)	(-1.41)	(-2.04)	(-2.10)
PCPS	-1.23***	-1.34***	-1.34***	-1.31***	1.07***	0.90**	0.87**	0.88**
	(-2.77)	(-2.94)	(-2.98)	(-2.93)	(2.78)	(2.26)	(2.36)	(2.40)
Wald Chi-	262.98	205.81	201.65	203.52	95.32	63.40	75.32	75.73
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R-squared	0.33	0.34	0.29	0.29	0.11	0.13	0.10	0.10
# of obs.	1,367	1,335	1,184	1,184	1,367	1,335	1,184	1,184
# of countries	21	21	20	20	21	21	20	20

*Notes: z-scores based on robust standard errors are in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level.*

Table 2.3: Baseline regression results for the post-GFC subsample (2009:Q2-2019:Q4)

	(1) SPREAD	(2) SPREAD	(3) SPREAD	(4) SPREAD	(5) DIV SPREAD	(6) DIV SPREAD	(7) DIV SPREAD	(8) DIV SPREAD
RESGDP	-10.85***				-11.46***			
	(-3.30)				(-3.29)			
EXIMFGD		-11.89***				-12.28***		
		(-3.05)				(-3.15)		
EXOC4G			-12.04***				-12.36***	
			(-3.75)				(-3.55)	
EXOC5G				-12.54***				-12.61***
				(-3.79)				(-3.55)
DEBTGDP	4.04*	3.30	4.41**	4.54**	5.05**	4.18*	5.31***	5.38***
	(1.93)	(1.55)	(2.27)	(2.28)	(2.33)	(1.89)	(2.64)	(2.62)
CAGDP	-10.25	-11.83*	-9.19	-8.35	-5.91	-7.86	-5.66	-5.00
	(-1.53)	(-1.78)	(-1.44)	(-1.29)	(-0.87)	(-1.18)	(-0.89)	(-0.78)
FAGDP	8.88**	8.39**	8.21*	8.06*	6.94	6.57	6.53	6.46
	(2.03)	(2.02)	(1.84)	(1.81)	(1.62)	(1.62)	(1.50)	(1.48)
CTOT	1.10	-1.02	1.49	1.25	2.87	1.34	3.87	3.69
	(0.20)	(-0.18)	(0.27)	(0.23)	(0.54)	(0.25)	(0.72)	(0.69)
REER	-4.18***	-4.35***	-4.79***	-4.81***	-3.94***	-4.09***	-4.59***	-4.59***
	(-3.36)	(-3.53)	(-3.18)	(-3.18)	(-3.22)	(-3.32)	(-3.00)	(-3.00)
VIX	1.69*	1.86**	1.81**	1.77*	-1.32*	-1.10	-1.20	-1.22*
	(1.90)	(2.13)	(1.97)	(1.95)	(-1.87)	(-1.58)	(-1.63)	(-1.67)
BISGL	0.00	-0.16	1.17	1.20	6.25**	7.00**	6.46**	6.54**
	(0.00)	(-0.04)	(0.34)	(0.34)	(2.18)	(2.04)	(2.24)	(2.25)
TED	46.68	35.86	44.08	44.10	28.17	18.23	18.99	19.39
	(0.86)	(0.67)	(0.78)	(0.79)	(0.68)	(0.44)	(0.43)	(0.44)
US10Y	-8.23	-11.15	-5.38	-5.68	-11.11	-13.10	-8.08	-8.32
	(-0.50)	(-0.65)	(-0.33)	(-0.35)	(-0.85)	(-0.94)	(-0.60)	(-0.62)
PCPS	-0.87	-1.07*	-0.68	-0.69	0.56	0.43	0.68	0.68
	(-1.47)	(-1.68)	(-1.14)	(-1.16)	(1.12)	(0.79)	(1.30)	(1.29)
Wald Chi-	80.45	66.75	83.53	84.55	39.09	25.14	40.02	39.83
Prob	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
R-squared	0.22	0.27	0.24	0.24	0.09	0.11	0.10	0.10
# of obs.	744	744	709	709	744	744	709	709
# of countries	19	19	18	18	19	19	18	18

*Notes: z-scores based on correlated panel-corrected standard errors are in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level.*

2.4.2. Threshold Regressions

In this section, to examine whether holding excess reserves makes a difference in terms of the market's pricing of EM sovereign debt, we carry out fixed-effect panel threshold regressions using a 12-country balanced subsample that covers the 2001:Q4-2018:Q4 period. The countries included in the subsample are Brazil (BRA), Chile (CHL), Colombia (COL), Hungary (HUN), Malaysia (MYS), Mexico (MEX), Philippines (PHL), Russian Federation (RUS), South Africa (ZAF), Türkiye (TUR), Ukraine (UKR), and Uruguay (URY). We estimate the baseline regressions for the balanced subsample and provide the results in Table A2.4 in the appendix to preserve comparability. The results for the post-GFC period are also provided in Table A2.5.

Although the PSTR model proposed by Gonzalez et al. (2005) which is updated in Gonzalez et al. (2017) has become popular in recent years, we choose to employ the panel threshold regression (PTR) model developed in Hansen (1999). As Gonzalez et al. (2017) discuss, the PSTR model is a nonlinear panel model that generalizes the PTR model by allowing the regression coefficients to change smoothly when moving from one "extreme" regime or state to another. The rationale of Gonzalez et al. (2005) in proposing the PSTR model is the PTR model's implication that the different groups of observations can be clearly distinguished from each other based on the value of the threshold variable alone although that may not always be feasible. In this essay, the PTR model is preferred because we are not interested in gradual changes in the coefficients. As depicted in Figure 1, the changes in excess-reserves-to-GDP ratios do not always exhibit smooth or gradual transitions. Using PSTR given the volatility of excess reserves would imply that the available information to the market participants is gradually incorporated into the EM external debt prices, which may be an overreaching assumption from a market efficiency perspective.

Accordingly, we estimate the specifications in equations (2.3) and (2.4).

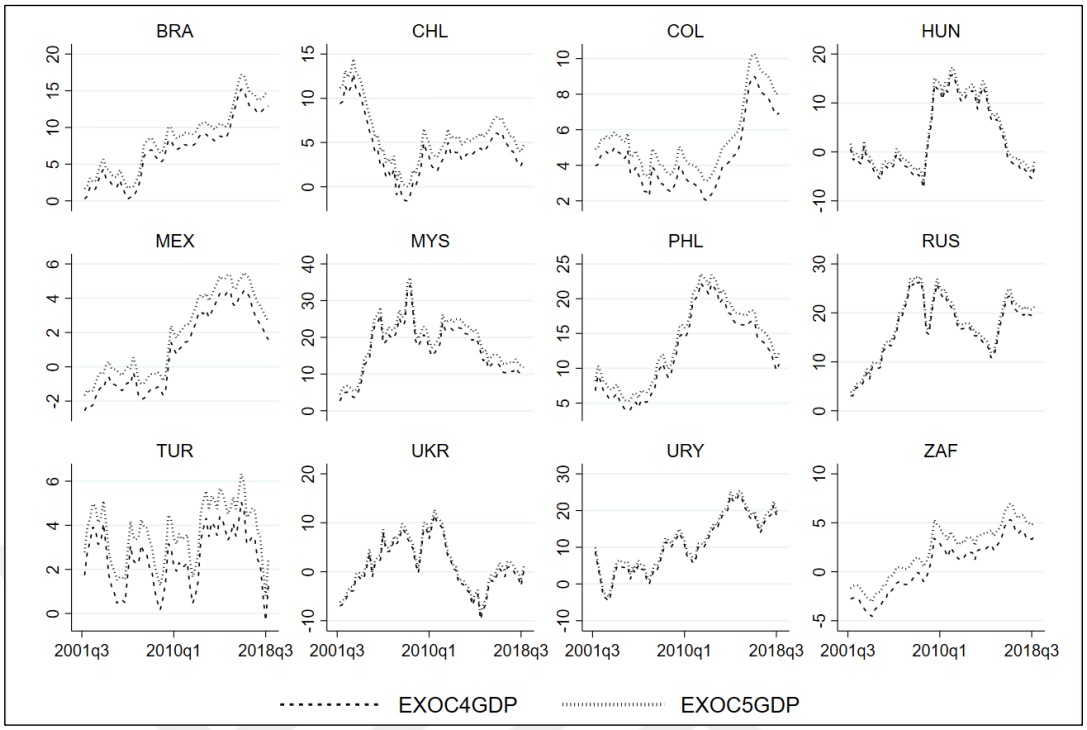
$$spread_{i,t} = \begin{cases} \mu + \gamma_j^1 \, K_{j,t} + \alpha_j \, G_{j,t} + \delta_k \, C_{i,k,t} + v_{i,t} & if \; K_{j,t} \leq \tau \\ \mu + \gamma_j^2 \, K_{j,t} + \alpha_j \, G_{j,t} + \delta_k \, C_{i,k,t} + v_{i,t} & if \; K_{j,t} > \tau \end{cases} \tag{2.3}$$

$$divspread_{i,t} = \begin{cases} \omega + \theta_j^1 \, K_{j,t} + \varphi_j \, G_{j,t} + \psi_k \, C_{i,k,t} + u_{i,t} & if \; K_{j,t} \leq \tau \\ \omega + \theta_j^2 \, K_{j,t} + \varphi_j \, G_{j,t} + \psi_k \, C_{i,k,t} + u_{i,t} & if \; K_{j,t} > \tau \end{cases} \tag{2.4}$$

K is the set of reserve adequacy proxies (REGDP, EXIMFGDP, EXOC4GDP, and EXOC5GDP) that are also employed as threshold variables in the corresponding estimations. τ is the endogenously determined value for the threshold variable. $G_{j,t}$ is the observed value of j^{th} global factor at time *t* whereas $C_{i,k,t}$ represents the k^{th} state-invariant country-specific variable for i^{th} country at time *t*. Equations (2.3) and (2.4) are single-threshold (two-state) representations; however, they can be extended to double-threshold (three-state) models.[4]

[4] Although we do not report, we also run three-state panel threshold regressions. In those estimations, the second threshold effect is statistically significant at 5% level only for the model (3) and only for the full balanced subsample period.

Figure 2.1: Excess reserves-to-GDP for balanced sample countries



Notes: Excess reserves are measured as the total reserves minus RESOC4 and RESOC5 suggested reserves.

The estimation results for the fixed-effect panel threshold regressions are provided in Table 2.4 and Table 2.5. Regarding the impact of global factors on the EM sovereign spreads, the fixed-effect PTR estimation results in Table 2.4 suggest that the VIX is relevant for the overall spreads but does not affect the relative spreads. On the other hand, the reverse is true for global liquidity. The statistically significant and positive coefficient estimate for BISGL in DIVSPREAD models suggests that the divergence in the EM sovereign spreads increases as the global liquidity conditions improve, and vice versa. In other words, global liquidity's impact on the EM sovereign spreads is not uniform. This is also the case for commodity prices. In line with baseline regression estimates in Table 2.2, external debt and real effective exchange rate are identified as consistent determinants of the EM sovereign spreads. The financial account also seems to have bearing on the EM sovereign bond pricing behavior in the 12-country subsample in a nonlinear setting.

Table 2.4: Fixed-effect panel threshold estimation results (2001:Q4 - 2018:Q4)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SPREAD	SPREAD	SPREAD	SPREAD	DIV SPREAD	DIV SPREAD	DIV SPREAD	DIV SPREAD
Threshold Variable	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP
Threshold Level	8.73	-16.89	-5.92	-5.16	8.73	-16.89	-5.92	-5.16
Threshold Effect F-Stat Prob	0.01	0.00	0.00	0.00	0.01	0.00	0.00	0.00
STATE #1								
	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP
	31.61**	-44.74***	-115.42***	-131.01***	28.58*	-44.98***	-114.48***	-129.92***
	(2.32)	(-4.72)	(-4.30)	(-4.80)	(2.19)	(-4.73)	(-4.66)	(-5.22)
STATE #2								
	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP
	-1.56	-1.78	-1.97	-2.19	-1.12	-1.11	-1.26	-1.42
	(-0.57)	(-1.13)	(-0.97)	(-1.06)	(-0.46)	(-0.67)	(-0.70)	(-0.78)
INVARIANT								
DEBTGDP	7.29***	6.32***	6.85***	6.90***	7.63***	6.76***	7.21***	7.25***
	(4.54)	(5.46)	(4.74)	(4.68)	(4.83)	(6.72)	(5.04)	(4.98)
CAGDP	-16.92*	-14.26	-16.21	-16.11	-15.78	-13.28	-15.00	-14.94
	(-1.83)	(-1.26)	(-1.69)	(-1.68)	(-1.64)	(-1.16)	(-1.52)	(-1.51)
FAGDP	18.17**	17.06**	18.43**	18.39**	17.77**	16.34**	17.74**	17.72**
	(2.41)	(2.67)	(2.89)	(2.86)	(2.24)	(2.48)	(2.66)	(2.64)
CTOT	4.65	3.46	2.90	2.83	5.24	4.22	3.55	3.49
	(1.42)	(0.92)	(0.87)	(0.85)	(1.66)	(1.11)	(0.95)	(0.93)
REER	-6.05***	-4.17***	-4.62***	-4.57***	-5.88***	-4.12***	-4.61***	-4.57***
	(-5.73)	(-3.73)	(-3.61)	(-3.59)	(-5.05)	(-3.86)	(-3.65)	(-3.63)
VIX	10.80***	10.87***	10.90***	10.88***	-1.53	-1.48	-1.46	-1.47
	(6.67)	(6.15)	(6.35)	(6.37)	(-0.93)	(-0.84)	(-0.83)	(-0.84)
BISGL	-2.97	-3.90**	-2.11	-2.14	6.77***	5.91***	7.74***	7.71***
	(-1.62)	(-2.66)	(-0.99)	(-1.01)	(3.94)	(4.16)	(3.70)	(3.71)
TED	-11.69	1.29	-22.80	-21.75	-14.97	-3.62	-26.89	-25.82
	(-0.77)	(0.09)	(-1.19)	(-1.14)	(-0.98)	(-0.25)	(-1.40)	(-1.35)
US10Y	-1.21	14.91	5.93	5.42	-5.73	8.84	0.04	-0.29
	(-0.07)	(1.37)	(0.31)	(0.28)	(-0.35)	(0.78)	(0.00)	(-0.02)
PCPS	0.54*	0.11	0.03	0.03	1.94***	1.53***	1.45***	1.45***
	(1.80)	(0.35)	(0.10)	(0.12)	(6.29)	(5.01)	(5.35)	(5.41)
F Statistics	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Prob	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Within R-sq.	0.48	0.52	0.51	0.51	0.38	0.45	0.44	0.44
# of obs.	828	828	828	828	828	828	828	828
# of countries	12	12	12	12	12	12	12	12

*Notes: t-statistics based on robust standard errors are in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level.*

For all models in Table 2.4, the threshold effect is statistically significant at the 1% significance level based on 500 bootstrap replications. The coefficient estimates for reserve adequacy proxies are not statistically different than zero in the high state. On the other hand, all of the excess reserve measures have economically and statistically significant coefficient estimates in the low state. The coefficient estimate

for RESGDP in the low state is also statistically significant but the positive sign on the estimated coefficient is not in line with a priori expectations.

The considerable difference between the endogenously determined threshold levels of excess reserves based on the IMF ARA metric and the metrics developed in the first essay of this thesis is striking. Since the excess reserve proxies are found to be relevant only when they are in the low state (when the reserves are deemed inadequate by the market), the levels of the endogenously identified thresholds convey important information regarding the market's view on the appropriateness of reserve adequacy measures. A threshold level of -16.9% of GDP for excess reserves based on the IMF ARA metric suggests that the market participants believe the metric overestimates the level of adequate reserves to a great extent. On the other hand, the threshold levels for EXOC4GDP and EXOC5GDP are closer to zero. Hence, these metrics also overestimate the level of adequate reserves albeit to a lesser extent compared to IMF's ARA metric.

For the post-GFC period, the global risk aversion proxied by VIX is still significantly different than zero only in the regressions that use the overall spread as the dependent variable. This observation suggests that VIX is more relevant for the EM sovereign debt market risk rather than individual country relative spreads. The results for the global liquidity in the post-GFC era are mixed and not as consistent as the results for the full sample period. The threshold regression estimates also suggest that the TED spread gains prominence as an idiosyncratic global factor after the GFC while the same is true for US10Y but as a factor that affects both overall and relative spreads. As is the case for the full sample period, the commodity prices have an economically and statistically significant impact on the relative spreads rather than the overall spreads. Regarding the country-specific factors, DEBTGDP and REER maintain explanatory power which was also evidenced in the preceding results.

In the post-GFC era, the market's pricing behavior of EM external sovereign debt based on reserve adequacy is virtually unchanged aside from the increase in the coefficient estimates. The levels of endogenously determined thresholds are also similar to the ones estimated for the full sample period. Therefore, it may be argued that although the market does not reward the EM countries for holding excess reserves it penalizes the countries that have inadequate reserves. The results in Table 2.4 and Table 2.5 suggest that the cost of holding inadequate international reserves has been amplified after the GFC.

Table 2.5: Fixed-effect panel threshold estimation results (2009:Q2 - 2018:Q4)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	SPREAD	SPREAD	SPREAD	SPREAD	DIV SPREAD	DIV SPREAD	DIV SPREAD	DIV SPREAD
Threshold Variable	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP
Threshold Level	8.73	-18.26	-6.58	-5.54	8.73	-18.26	-6.58	-5.54
Threshold Effect F-Stat Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
STATE #1								
	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP
	107.62**	-82.03***	-186.13***	-207.08***	101.70**	-81.58***	-184.27***	-204.84***
	(2.91)	(-75.25)	(-23.32)	(-20.62)	(2.64)	(-105.56)	(-23.47)	(-20.80)
STATE #2								
	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP	RES GDP	EXIMF GDP	EXOC4 GDP	EXOC5 GDP
	-9.81	-3.09	-3.59	-3.93	-10.91	-3.60**	-4.88	-5.14
	(-1.19)	(-1.65)	(-0.60)	(-0.64)	(0.19)	(-2.41)	(-0.91)	(-0.92)
INVARIANT								
DEBTGDP	10.67***	3.76***	7.39*	7.57*	11.20**	4.07***	8.06**	8.22**
	(2.29)	(3.13)	(2.08)	(2.06)	(2.51)	(3.99)	(2.46)	(2.42)
CAGDP	4.32	-7.78	-0.74	-0.42	7.24	-5.15	2.33	2.60
	(0.83)	(-1.23)	(-0.21)	(-0.11)	(1.46)	(-0.78)	(0.74)	(0.80)
FAGDP	14.75*	9.31*	10.65*	10.75*	13.03	7.69	8.88	8.99
	(1.81)	(2.03)	(2.00)	(1.98)	(1.58)	(1.68)	(1.64)	(1.63)
CTOT	-2.16	-2.45	0.62	0.45	-2.50	-2.69	0.23	0.08
	(-0.37)	(-0.64)	(0.16)	(0.11)	(-0.43)	(-0.74)	(0.07)	(0.02)
REER	-4.84***	-4.53***	-3.78***	-3.77***	-4.23***	-3.93***	-3.07***	-3.07***
	(-6.63)	(-5.48)	(-4.17)	(-4.13)	(-6.52)	(-4.78)	(-4.12)	(-4.10)
VIX	4.67***	2.46***	4.02***	4.02***	0.32	-1.85***	-0.30	-0.31
	(3.41)	(4.07)	(4.60)	(4.65)	(0.23)	(-3.24)	(-0.34)	(-0.35)
BISGL	-1.37	4.02*	0.81	0.73	1.78	7.11***	3.79*	3.72*
	(-0.40)	(1.82)	(0.38)	(0.33)	(0.56)	(3.41)	(1.91)	(1.82)
TED	-110.57	20.22	-12.28	-14.86	-176.48**	-44.34*	-80.03**	-82.23**
	(-1.46)	(0.87)	(-0.36)	(-0.43)	(-2.28)	(-2.00)	(-2.23)	(-2.22)
US10Y	-46.57**	-23.45***	-30.58**	-30.94**	-38.15**	-14.42**	-22.33*	-22.59*
	(-2.95)	(-3.56)	(-2.63)	(-2.65)	(-2.50)	(-2.32)	(-2.03)	(-2.04)
PCPS	1.57*	0.89	0.88	0.89	2.17**	1.48**	1.48**	1.49**
	(2.03)	(1.72)	(1.74)	(1.75)	(2.79)	(2.98)	(2.95)	(2.94)
F Statistics	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Prob	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Within R-sq.	0.47	0.69	0.65	0.64	0.45	0.69	0.64	0.63
# of obs.	468	468	468	468	468	468	468	468
# of countries	12	12	12	12	12	12	12	12

*Notes: t-statistics based on robust standard errors are in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level.*

The overall conclusions based on the results obtained from PTR estimations are twofold. Firstly, the market's assessment of the adequate level of international reserves and the levels suggested by the IMF's ARA metric differs considerably. More specifically, the EM sovereign market participants believe that the IMF's ARA metric overestimates the level of adequate reserves by a high margin. Secondly, the pricing

behavior of the EM sovereign bond market suggests that holding excess reserves is not optimal from a cost of external debt perspective. The EMEs are rewarded for reserve accumulation by the market, in terms of external debt costs, only when the reserves are in the inadequate region. As the international reserves reach adequate levels, there are no additional benefits to reserve accumulation. The results also suggest that holding inadequate reserves is costly. Below the adequate level of international reserves, the declines have a considerably high impact on the cost of external debt.

2.5. Conclusion

In the first essay of this thesis, it is found that both RESOC4 and RESOC5 as reserve adequacy metrics reflect the international reserve holding decisions of central banks to a great extent. The former of these metrics utilize GDP, broad money, and trade balance in addition to 3-month imports for calculating the adequate reserves while the latter scales broad money with the degree of exchange rate float. Based on the results, both are argued to better explain central banks' behavior than the IMF's ARA metric. This argument is clearly supported by the results based on the PTR estimations in this essay. Despite IMF's motivation noted in IMF (2011a) that originates from the observation that the current approaches to reserve adequacy do not appear to be followed closely by countries in their reserves holding decisions, IMF's ARA metric is not successful in explaining the international reserve holding decision of the EM central banks as shown in the first essay of this thesis. Moreover, this essay shows that the ARA metric also does not reflect the market's perception of adequate reserves. For the EM external debt market, international reserves are deemed to be inadequate only at levels around 17% below the ARA metric suggested adequate reserves. This is clear evidence of the overestimation of adequate reserves from a market's perspective. Since the market participants are the ones that take the risks and seek acceptable returns given these risks, it is natural to accept the market's assessment of the appropriateness of any reserve adequacy measure. Regarding the adequacy measures developed in the first essay, RESOC4 and RESOC5, it can be argued that they are not only successful in explaining the behavior of EM central banks, but they also reflect the market's assessment of risks arising from reserve adequacy better than the IMF's ARA metric. This conclusion follows from the observation that these metrics have considerably lower endogenously determined threshold levels compared to the IMF's ARA metric.

The approach adopted in this study is that a reserve adequacy metric should reflect both the market's view and the behavior of central banks. Only a metric that better reconciles the view of the market on adequate reserves with the view of central banks has the potential to become a generally accepted reserve adequacy measure. This is important because, firstly, if the market does not price a supposedly relevant risk source then it is not relevant. Secondly, it is not optimal for a central bank to diverge from the "market-assessed adequate reserves" since holding excess or inadequate reserves would translate into increased costs. RESOC4 and RESOC5 are not perfect but, based on the estimation results, they are promising measures of reserve adequacy measures.

Along with the conclusions regarding the performance and appropriateness of three reserve adequacy measures, the main result of this study is that the observed hoarding behavior of central banks is not optimal from the market's perspective. This follows from the results that suggest that the market does not reward the EM countries for holding international reserves beyond the levels deemed adequate. Holding inadequate reserves is penalized by the market heavily as the considerably high and negative coefficient estimates on excess reserve proxies. This also means that increases in international reserves are also rewarded by the market when a country's reserve holdings are deemed to be inadequate. However, this reward is only available up to the point where the international reserve holdings reach the adequate level.

ESSAY III

HEDGING SUDDEN STOPS: CONTINGENT CLAIMS AS A POLICY TOOL AGAINST CAPITAL FLOW VOLATILITY

Abstract- For EMEs, holding relatively high or excess foreign exchange reserves is a way of limiting the adverse impact of external shocks. However, hoarding of international reserves may be distortionary to global financial stability and may be costly given the conservative approach of reserve authorities to reserve portfolio management. In this study, we develop a simple framework that may help EMEs minimize the costs associated with holding excess reserves. CDS contracts are incorporated into the decision rule as contingent claims linked to sudden stops. The suggested framework provides the much-needed external liquidity in bad states and can be extended to include contingent claims linked to global factors for hedging the systematic risk component while a portfolio of CDS contracts on the external debt of comparable countries can be used for hedging the idiosyncratic risk component.

Index Terms- Sudden Stops, Capital Flow Volatility, Contingent Claims, International Reserves, Emerging Markets.

Jel Codes- F30, G12, G15

3.1. Introduction

For emerging market countries, holding relatively high or excess foreign exchange reserves is increasingly seen as a way of limiting the impact of external shocks on their economies. As Feldstein (1999) argues, a country that has substantial international liquidity, large foreign currency reserves, and a ready source of foreign currency loans is less likely to be the object of a currency attack which in turn will enable a country to make more orderly financial adjustments; however, the challenge is to find ways to increase liquidity at a reasonable cost.

IMF (2011a) underscores that reserve accumulation tends to be costly, subject to diminishing returns, and is potentially distortionary to both the domestic and global economy. Therefore, since holding excess reserves is highly likely to result in increased costs, the question that has to be answered is when the decision to hold excess reserves is given, how central banks can reduce the costs associated with this decision. One way to accomplish this is by earning increased returns from the reserve portfolio. Indeed, given the current tools available it is possibly the only way. Consequently, parallel to the unprecedented accumulation of reserves in the last two decades, the central banks, either through sovereign wealth funds (SWFs) or directly, started to expand their investment universes and invest in asset classes that have higher returns but also higher risks than the traditional asset classes of reserve portfolios. Nevertheless, the change has been slow as a result of the conservative approach to reserve management by central banks, and the GFC didn't help either. According to survey results discussed by World Bank (2021), despite most institutions having small allocations to nontraditional asset classes such as corporate bonds, emerging market bonds, covered bonds, mortgage-backed securities, or equities, asset classes with high liquidity and low risk continue to be the most frequently used instruments in central bank portfolios. Hence, it is not an overreaching argument to state that expanded investment universes are hardly a solution to cope with the costs arising from holding excess reserves unless there is a drastic change in central banks' conservative approach to reserve management. Moreover, as long as central banks' priorities are safety and liquidity, whenever there are signs of volatility in global financial markets it should not be surprising to see central banks shifting their portfolio allocations into asset classes they consider to be safer and more liquid. It is even likely that expanded investment universes might increase the overall costs of holding reserves in the long term, particularly when there are aggressive shifts towards safer and more liquid asset

classes during episodes of global market turmoil. Pihlman and Hoorn (2010) analyze the behavior of central banks during the GFC and argue that central banks put pressure on the banking sector by pulling out at least $500 billion of deposits and other investments to avoid default risk. So, the portfolio shifts of central banks during crisis episodes not only have the potential to increase costs to central banks but also to impact global financial stability adversely.

In this study, we focus on developing an alternative policy tool that may help a given EME in containing the adverse effects of volatile capital flows and increase the level of independence in monetary policy implementation while minimizing the costs related to foreign exchange reserve holdings without impairing the confidence of domestic and international investors. The adopted approach is based on hedging the capital volatility by using contingent claims and despite being related to the approach of Caballero and Panegas (2005) and Caballero and Panegas (2008), this study takes its motivation from Black (1997). Fischer S. Black envisions a world in which firms would have equity and debt and other kinds of liabilities and they would buy puts with a face value equal to the value of their debt so as to make the debt more or less riskless and would eliminate bankruptcy and default and that sort of complication. Although the focus of Black (1997) is on firms, there is no reason why this should not apply to sovereign countries as well. But two main issues should be dealt with when developing such a framework to be used as a hedging tool against capital flow volatility. First, there needs to be a decision rule that guides EM reserve authorities in determining to hold the excess reserves either as traditional foreign exchange assets or contingent claim portfolio(s). Secondly, such a framework should also minimize the potential adverse impact of moral hazard concerns. Accordingly, this essay focuses on these two critical components.

The remainder of this study is as follows. The motivation of the study is discussed in Section 3.2. A simple model for using contingent claims as a policy tool against capital flow volatility is developed in Section 3.3. Issues related to the implementation of the framework including moral hazard are discussed in Section 3.4. The study concludes and offers potential areas for further research in Section 3.5.

3.2. Motivation

Broner et al. (2013) analyze the behavior of international capital flows by foreign and domestic agents over the business cycle and during financial crises. Their results suggest that gross capital flows are very large and volatile, pro-cyclical, and

total gross flows collapse during crises. Alberola et al. (2016) also focus on the behavior of gross capital flows and analyze a quarterly database consisting of 63 countries over the 1991–2010 period. They find that capital flows are pro-cyclical and that country-specific variables are less important in explaining gross domestic outflows than global factors. Ghosh et al. (2016) investigate when the capital flow surges to emerging markets with open capital accounts end gracefully or in some form of crisis. They argue that global factors are a major determinant of how surges end but policy responses of EMEs also matter.

Aizenman and Marion (2004) find that greater vulnerability to exogenous shocks increases reserve holdings. Obstfeld et al. (2010) show that there has been a statistically robust and economically significant correlation of reserve levels (reserves/GDP) with financial openness (a measure of cross-border capital mobility), financial development (proxied by M2/GDP), and exchange rate policy. Allegret and Allegret-Sallenave (2018) claim that holding a sizeable stock of reserves may strengthen their ability to resist disturbances resulting from recurrent capital flows instability. Reinhart and Reinhart (2008) note that when global capital flows in, the preference for relatively stable exchange rates often necessitates accumulating reserves. However, for true floating exchange rate regimes, reserve accumulation through direct intervention should not be an option. Alternatively, foreign exchange buying auctions may be used for accumulating reserves but at its core, these are also interventions to the foreign exchange market and inevitably affect the exchange rate which is contradictory to the motivation behind having a floating exchange regime. Reserve accumulation also impacts domestic liquidity. Consequently, decisions on whether to sterilize or not as well as the level of sterilization, if sterilization is the chosen option, should accompany the decision to accumulate international reserves. As Akdogan (2020) notes, the consequences of an intervention vary depending on whether it is sterilized or unsterilized since buying of foreign reserves in unsterilized intervention causes an expansionary policy that results in an initial jump in exchange rates with a depreciation of the domestic currency while the result of expansionary foreign exchange operation is offset by contractionary monetary policy in the case of sterilized intervention. Fratzscher et al. (2019) focus on sterilized interventions and find that intervention stabilizes exchange rates in more than 80 percent of cases in narrow-band regimes. On the other hand, their results suggest that the baseline success rate is around 60 percent in floating exchange rate regimes. This study does not intend

to explore the effectiveness of sterilized or unsterilized interventions. Instead, the costs associated with reserve accumulation through sterilized interventions are of interest to this study and they are an integral part of the decision rule developed in Section 3, which is based on the excess reserve cost function. More importantly, the conclusions are still relevant even if the excess reserve accumulation is not sterilized at all.

Summers (2000) emphasizes that sound financial systems can contribute enormously to economic development around the world, and the flow of capital across international borders can confer enormous benefits but there is the potential for massive accidents. These potentially massive accidents are generally financial crises that are triggered by capital flow reversals. Calvo et al. (2006) report two types of regularities that are robust across emerging markets crisis: sudden stops of capital flows and phoenix miracles. Sudden stops are of interest to us. A sudden stop is, first and foremost, a credit event (Calvo, 2006). As Bianchi and Mendoza (2020) emphasize, sudden stops are financial crises defined by a large, sudden current-account reversal and they occur in both advanced and emerging economies and result in deep recessions, collapsing asset prices, and real exchange-rate depreciations. The study reviews the stylized facts of sudden stops and identifies 58 sudden stop events worldwide using annual data for 35 EMEs and 23 advanced economies (AE) that covers the 1979-2016 period.

For the crisis that took place in the 1990s, Calvo and Mendoza (2000) point to three commonalities: financial vulnerability, economic collapse, and contagion. The study notes that these crises were preceded by an unprecedented surge in portfolio capital inflows that started in 1989, each country that suffered a sudden stop of capital inflows also experienced a sharp economic downturn and a surge in unemployment, regardless of whether the currency remained stable or suffered a devaluation, crises started as country specific events but quickly spread across financial markets within the same region and across the world. According to Calvo et al. (2006) sudden stops display a large degree of temporal bunching, suggesting that global capital market turmoil acts as a coordinating factor external to emerging markets; however, even though the initial shock is exogenous to the economy, whether it materializes into a sudden stop depends on domestic financial vulnerabilities. In a related study, Tong and Wei (2010) analyze the effects of the composition of capital flows. Their findings suggest that liquidity shocks are more severe for EMEs that have a higher pre-crisis exposure to foreign portfolio investments and foreign loans.

Sudden stops generally coincide with episodes in which a country's access to international markets becomes limited. This may be a result of the reluctance of the demand side, supply side, or both. The reluctance of the demand side is a result of increased costs of foreign borrowing during these episodes. On the other hand, the supply side's concerns mostly arise from the increased perception of the riskiness of a country or a group of countries. In this context, using contingent claim portfolios as a policy tool against capital flow volatility has the potential to offer improvement for access to international financial markets during increased volatility periods whether its source is global or mostly confined to a single country.

Obstfeld et al. (2010) stress that a primary reason for a central bank to hold reserves is to protect the domestic banking sector, and domestic credit markets more broadly, while limiting external currency depreciation. They note that the need for such protection increases given the multiplication of risks in more financially open economies, where potential currency mismatches and a combination of internal drains (runs from bank deposits to currency) and external drains (flight to foreign currency or banks) can place extraordinary demands on a central bank's foreign exchange reserves. Although the literature is largely in agreement regarding both the necessity and the benefits of holding foreign exchange reserves, the cost of reserves is still controversial to some extent. Heller (1966) defines the differential between the social yield on capital invested and the yield on liquid international reserves as the appropriate concept of the opportunity cost of holding liquid international reserves. Ben-Bassat and Gottlieb (1992) conclude that when the opportunity cost is estimated according to its theoretical definition, that is, as the difference between the real return on capital and reserves, opportunity cost plays an important role in determining the demand for reserves. But, Aizenman and Marion (2004) argue that most empirical studies have been unable to find a significant effect of opportunity cost on demand for reserves.

According to Flood and Marion (2001), once the capital gains on foreign-currency reserves arising from exchange rates are taken into account, the opportunity cost of holding reserves is negligible. However, Higgins and Klitgaard (2004) note that the reserve purchases generally result in lost interest income for a central bank and expose it to potentially large capital losses should the currency eventually strengthen against reserve currencies. Taking a different approach, Rodrik (2006) focuses on the social cost of reserves and shows that these costs amount to around 1 percentage point

of GDP annually for developing nations taken as a whole. The approach of Rodrik (2006) to the cost of international reserves is similar to Heller (1966) since the study notes that central banks hold their foreign exchange reserves mostly in the form of low-yielding short-term securities and each dollar of reserves that a country invests in these assets comes at an opportunity cost that equals the cost of external borrowing for that economy; therefore, the spread between the yield on liquid reserve assets and the external cost of funds represents the social cost of self-insurance.

Yeyati (2008) calls attention to a potentially benign effect of reserve accumulation for self-insurance purposes. The study argues that the cost of reserves may be considerably overstated when the resulting lower spreads on the service costs of the stock of sovereign debt that usually accompanies the increases in reserves are ignored. Bianchi et al. (2018) study the optimal accumulation of international reserves in a quantitative model of sovereign default with long-term debt and a risk-free asset. They argue that while keeping higher levels of reserves provides a hedge against rollover risk, it is costly because using reserves to pay down debt allows the government to reduce sovereign spreads. This argument is similar to the one raised by Rodrik (2006). On the other hand, Kohlscheen (2020) finds that the cost of holding FX reserves is not attenuated by any meaningful reduction in risk premia as long as sovereign risk and yields are low while FX reserves do reduce risk spreads in a clear and significant way under adverse circumstances.

The approach adopted in this study to the cost of reserves is somewhat different from the one prevalent in the literature. As discussed above, the social cost of reserves defined as the spread between the yield on liquid reserve assets and the external cost of funds is a widely used measure. Instead of using a straightforward cost measure, particularly for excess reserves, this study also takes the costs associated with sterilized reserve accumulation into account. In addition, the difference between the total rate of return that the domestic private sector earns from foreign currency-denominated investments and the central bank reserve portfolio's total rate of return is incorporated into the cost equation as the opportunity cost. Out of these two cost measures, the higher one becomes the effective cost of international reserves for the decision rule developed in the next section.

3.3. A Simple Model

Black (1997) envisions a world in which firms would have equity and debt and other kinds of liabilities and they would buy puts with a face value equal to the value

of their debt so as to make the debt more or less riskless and would eliminate bankruptcy and default and that sort of complication. Although our motivation is different than that of Fisher Black's, we see no reason why this should not apply to sovereign countries as well. We are not willing to go as far as Black (1997) and suggest making a country's debt virtually riskless while we believe that a country can and should use contingent claim portfolios to reduce its vulnerability to volatile capital flows. Hence, we focus on deriving a policy rule that may help countries to avoid the adverse effects of the volatile capital flows while enabling greater independence in implementing both monetary and foreign exchange rate policies.

To the author's knowledge, Caballero and Panegas (2005) is the first study in the literature that recommends the use of a contingent claim framework. The study argues that it is essential to find non-emerging-market-specific assets that are correlated to sudden stops and suggest that the S&P 500's implied volatility index is an example of such assets. The reasoning they put forth for this argument is that external insurance is hard to obtain because sudden stops often come together with distress in emerging market investors themselves. The study builds on a representative agent economy with a benevolent government that seeks to maximize the expected present value of utility from consumption. A strong assumption of the study is that the world capital markets do not accept contracts contingent on variables endogenous to these economies since they have limited connections and understanding of emerging market economies. Specialists, defined as the investors that have developed some expertise and connections in the country and can engage in more information-intensive contracts, are an integral part of the developed model. Countries are allowed to sign contracts with specialists that are contingent on country-specific variables, and this paves the way for the study's suggestion that it is essential to find non-emerging-market-specific assets since the natural insurers (specialists) are also often in distress during sudden stop episodes. The study notes that the introduction of specialists allows for incorporating short-term borrowing, the availability of which can be reversed instantaneously in a manner that is largely unrelated to country-specific state variables, into the model. Another important aspect of the model is that the international reserves are capped in the sense that if the reserves exceed a given level, the country rather consumes them instead of using them to further smooth sudden stops. This is because the strength of the other financial constraint in the model, the inability to pledge a significant share of future income, raises the opportunity cost of storing reserves

enough to make it optimal to remain somewhat unprotected against these sudden stops. The contingent claim in the model is constructed as a contract that resembles a digital option that pays 1 if the traded asset exhibits a jump above a pre-determined price and 0 otherwise.

Caballero and Panegas (2008) is a highly modified version of Caballero and Panegas (2005). Although the latter is primarily focused on jump risk, the former deals with both diffusive and jump risk hedging in addition to paying more attention to the financial aspects of the research question.[5] Still, Caballero and Panegas (2008) argue that there are substantial fluctuations in the likelihood of a sudden stop that are correlated with persistent external variables, which offer hedging possibilities free of moral hazard or emerging-market-specific informational concerns. Possibly as a result of concerns regarding inherent moral hazard issues, the study exemplifies the potential hedging instruments with factors mostly of global nature such as the price of commodities, the high yield spread (HY), the volatility index (VIX) indicators of US, and other developed regions activity.

Longstaff et al. 2007 provide evidence that supports the focus of Caballero and Panegas (2008) on global factors. The study carries a principal component analysis of 26 countries' CDS spreads, and the results suggest that the principal source of variation across almost all sovereign credit spreads is very highly correlated with the US market as measured by US market returns or by the VIX index. Pan and Singleton (2008) also find a strong relationship between sovereign credit spreads and the VIX index. However, we are skeptical of these results. For instance, Longstaff et al. (2007)'s overlapping data period covers 2004:M10 - 2007:M5 whereas the maximum length of the period is 2000:M10 - 2007:M5 when all the observations are used. These periods are mostly devoid of single-country or clustered crisis episodes. In a recent study, Cayirli et al. (2022) analyze the determinants of EM sovereign spreads in state-dependent and asymmetric settings while making the distinction between systematic and idiosyncratic global factors. Their findings suggest that VIX is more of a systematic nature while global liquidity mostly acts as an idiosyncratic response-generating factor. Their results also provide evidence for both state-dependent and

[5] Lee (2009), which adopts an option pricing approach to international reserves, argues that a diffusion process, which is often used in the literature on reserves, is a good approximation when trade flows are the main source of risks to external liquidity; however, the risk of a sharp reversal in financial flows, which is probably better described as a jump risk, has become more prominent with increased integration of financial markets.

asymmetric behaviors. Therefore, using contingent claim portfolios linked to the global factor is not straightforward and requires conditional behavior to be taken into account.

Our approach is different from both Caballero and Panegas (2005) and Caballero and Panegas (2008) mainly in two aspects. Firstly, we make the distinction between minimum reserves and excess reserves. For any country, the cost of holding an adequate (minimum) level of reserves should be irrelevant. This is because the international reserves are not held just for limiting the effects of adverse external shocks on the domestic economy but also to provide the necessary liquidity for the balance of payments needs and increase markets' confidence in monetary and foreign exchange policies as well as providing a central bank the capacity to intervene in foreign exchange markets. Accordingly, the costs associated with the adequate or minimum level of reserves are in essence semi-fixed costs for a country that is at least partially integrated with the rest of the world. Secondly, after making the distinction between the minimum and excess reserves, our approach develops a simple decision rule based on the cost of excess reserves instead of focusing on consumption or aggregate demand. Theoretically, if a country holds an adequate level of reserves, these reserves should act as a buffer for external adjustment and the impact of events like sudden stops on consumption should be negligible. If not, it is highly likely that the adequate level of reserves is not determined appropriately. Also, it may be the case that the international reserve stock is not used effectively as a buffer for external adjustment.

Assume a central bank decides to hold excess reserves and it has to hold noncontingent foreign exchange assets for minimum reserves but can hold either foreign exchange assets or a credit default swap (CDS) portfolio as excess reserves. Then, we can define the total foreign exchange position (R) of the central bank as the sum of the minimum reserves (R_{min}), excess foreign exchange reserves ($R_{ex,fx}$), and an excess CDS position ($R_{ex,CDS}$).

$$R = R_{min} + R_{ex} \tag{3.1}$$

$$R = R_{min} + R_{ex,fx} + R_{ex,CDS} \tag{3.2}$$

Assume that there are two possible drains on reserves: internal drain and external drain. We use broad money, M2, as a proxy for the internal drain and short-

term external debt (STED) as a proxy for the external drain. The minimum reserves are determined by Equation 3.3 in this setting.[6]

$$R_{min} = \beta_1 M2 + \beta_2 STED \quad (3.3)$$

Although Equation 3.3 is simplified in terms of potential drains, it is in line with the suggestion of Summers (2000), which argues that countries should reduce their vulnerabilities to liquidity/rollover risk and balance-sheet risk and foreign reserves need to be compared to meaningful measures of liabilities that can become a claim against a country's reserves. We can rewrite equation 3.2 by substituting equation 3.3 for R_{min}:

$$R = \beta_1 M2 + \beta_2 STED + R_{ex,fx} + R_{ex,CDS} \quad (3.4)$$

In Equation 3.4, β_1 represents the ratio of broad money that can be expected to become a claim against reserves (internal drain). β_2 is the coverage ratio for short-term external debt (external drain). Note that M2 is determined by the broad money multiplier (η) and the monetary base (MB).

Also, assume that the central bank builds excess reserve position either through sterilized intervention in foreign exchange markets or by buying sovereign credit default swaps. Then, the total cost of excess reserves has three components: Costs arising from the sterilized acquisition of excess foreign exchange reserves, alternative costs as a result of the difference between the returns to the reserve portfolio and the expected return on the private sector's foreign investments, and CDS premium. Hence, in this setting we can write the one-period total cost equation for excess reserves as follows:

$$C_{ex} = R_{ex,fx} \frac{[\max(r_{dmm}, r_{pv}) - r_{cb}]}{(1+r_f)} + R_{ex,CDS} S_0 \quad (3.5)$$

where C_{ex} is the total one-period cost of excess reserves, r_f is the risk-free rate, r_{dmm} is the domestic money market rate, r_{pv} is the expected total rate of return the private sector earns by investing in foreign assets, r_{cb} is the expected total rate of return on central bank reserve portfolio, and S_0 is the one period spread on sovereign CDS at $t=0$, which is also paid at $t=0$.

Equation 3.5 follows from the fact that in foreign currency terms, the cost of excess reserves acquired through sterilized interventions is $((MB_{wos}–MB_{ws})\ e_{d,f}\ r_{dmm})$ where $(MB_{wos}–MB_{ws})$ is the difference between the monetary base without sterilization

[6] Equation 3.3 was first introduced by (Wijnholds & Kapteyn, 2001).

and with sterilization, $e_{d,f}$ is exchange rate defined as the domestic currency per foreign currency (i.e. BRL/USD). Also note that, $R_{ex,fx} = (MB_{wos} – MB_{ws})\, e_{d,f}$.

Taking the total derivative of the cost equation under independence assumptions, we have:

$$dC_{ex} = \frac{[\max(r_{dmm}, r_{pv}) - r_{cb}]}{(1+r_f)} dR_{ex,fx} + S_0\, dR_{ex,CDS} \tag{3.6}$$

Equation 3.6 suggests that for a given level of cost,

$$-\frac{dR_{ex,fx}}{dR_{ex,CDS}} = \frac{S_0}{[\max(r_{dmm}, r_{pv}) - r_{cb}]/(1+r_f)} \tag{3.7}$$

If utility derived from holding one unit of excess foreign exchange position was equal to holding one unit of nominal CDS position, we could use Equation 3.7 to assess the relative attractiveness of acquiring either foreign exchange or CDS. However, the cash-generating power of a nominal CDS position is not equal to that of the same amount of foreign exchange. Let the level of the CDS premium given an external shock to the economy be $\bar{S}$, and external shock to the economy to take place instantaneously. Then, cash generated by a unit of CDS position upon unwinding at $\bar{S}$ is $(\bar{S} - S_0)dR_{ex,CDS}$, and Equation 3.8 should hold for the cash-generating power of a foreign exchange position and contingent claim portfolio to be equal:

$$dR_{ex,fx} = -dR_{ex,CDS}(\bar{S} - S_0) \tag{3.8}$$

Substituting the right-hand side (RHS) of Equation 3.8 into Equation 3.7 yields Equation 3.9 after arrangements.

$$\frac{(\bar{S} - S_0)}{S_0} = \frac{(1+r_f)}{[\max(r_{dmm}, r_{pv}) - r_{cb}]} \tag{3.9}$$

The left-hand side (LHS) of Equation 3.9 is the expected percentage change in CDS spread given an external shock to the economy while the RHS represents the reciprocal of the present value of acquisition/opportunity costs. Equation 3.9 suggests that the total cost of excess reserves is unchanged when a unit of nominal CDS position is replaced by the same amount of foreign exchange holdings. Therefore, for minimizing the marginal cost of acquiring additional excess reserves, the decision rule should be clear;

$$dR_{ex} = \begin{cases} dR_{ex,CDS}, & if\ \frac{(\bar{S} - S_0)}{S_0} > \frac{(1+r_f)}{[\max(r_{dmm}, r_{pv}) - r_{cb}]} \\ dR_{ex,fx}, & if\ \frac{(\bar{S} - S_0)}{S_0} < \frac{(1+r_f)}{[\max(r_{dmm}, r_{pv}) - r_{cb}]} \end{cases} \tag{3.10}$$

Given Equation 3.10, the decision to acquire a CDS position does not depend directly on the initial level of CDS premiums. Rather than the initial level, the expected percentage increase in CDS spread given an external shock should be compared with the level implied by the current level of r_f and r_{dmm} as well as expected returns on private investment and reserve portfolio.

As would be expected, for holding a portfolio of CDS instead of traditional foreign exchange assets, the required instantaneous expected change in CDS spreads decreases as the net cost of holding an excess reserve portfolio in traditional foreign exchange assets increases. The net cost of holding a foreign exchange portfolio may increase as a result of increasing the domestic money market rate or decreasing returns to the central bank reserve portfolio. Net cost increase may also be the case when the expected total rate of return the private sector earns by investing in foreign markets increases while expected returns to the central bank reserve portfolio do not increase by the same amount, for ($\Delta r_{dmm} < \Delta r_{pv}$).

Although Equation 3.10 is based on a one-period investment horizon, it also suggests that the decision to hold either noncontingent assets or contingent claim portfolio(s) as excess reserves is not a one-time decision. To achieve cost efficiency, the inequality in Equation 3.10 should be evaluated continuously since the changes in $\bar{S}$, S_0, r_{dmm}, r_{pv}, and $r_f$may alter the optimality of holding a given excess reserve position.

The simple model developed in this section has the potential to help reserve authorities to relax the constraints on their decisions to hold excess reserves in a cost-effective way. However, it is not devoid of complexities on the implementation front. These potential complexities are discussed in the next section.

3.4. Model Implementation

In this study, we use a country's own sovereign credit default swap contracts instead of the put options discussed in Black (1997), which are basically the same. As Duffie (1999) stresses, the classic credit swap can be thought of as an insurance contract in which the insured party pays an insurance premium in return for coverage against a loss that may occur because of a credit event.

In one of the earlier studies on foreign exchange reserves, Heller (1966) defines two qualities that international means of payments should possess: they must be acceptable at all times to foreign economic units for payment of financial obligations,

and their value-expressed in foreign units of account-should be known with certainty. Following this definition, the study identifies three types of assets that qualify under this definition: official holdings of gold, convertible foreign exchange, and the IMF gold tranche position. A CDS portfolio is not an accepted foreign economic unit of payment in usual terms. Nevertheless, a CDS portfolio has cash-generating power which also possesses the much-desired property that it increases as the proceeds become more needed. In addition, CDS contracts are written mostly on reserve currencies, and at any point in time, their value expressed in foreign units of account is known. Therefore, it can be argued that CDS portfolio(s) possesses the required qualities to be used as a component of the excess international reserve portfolios.

The literature on using contingent claims as a tool against capital flow volatility focuses on assets linked to global factors. This approach has the potential to provide insurance against the systematic risks EMEs face. However, numerous scenarios in which the sudden stops are the case for only a group of countries, or a single country can be discussed. Also, the severity of stops may differ across the EMEs. Moreover, the state-dependent correlation structure of sovereign spreads with global factors is always an issue whether it is supported by historical data or not, which makes global factors imperfect hedges against the capital flow volatility of a given country. A better way to construct contingent claim portfolios for hedging capital flow volatility may be to dissociate the risk into systematic and idiosyncratic components. For the systematic component using a contingent claim portfolio that consists of contracts linked to global factors is viable. The more challenging task is hedging the idiosyncratic component.

In the simple model developed in the previous section, a country's own CDS contracts are used to represent the contingent claim portfolio. However, the moral hazard problem accompanies the decision to use a country's own CDS contracts as a component of the excess international reserve portfolio. First of all, EMEs may not be able to find counterparties that are willing to sell CDS contracts written on their own debt. This issue may be circumvented by exchange-traded contracts or by international financial institutions (IFIs) acting as a counterparty only to distribute the insured risks to the willing market participants. The former option is not feasible since the CDS contracts are traded over the counter while the latter only requires the willingness of IFIs as a facilitator. Caballero and Panegas (2008) also suggest that the involvement of IFIs may facilitate the adoption of hedging strategies against capital flow volatility.

Even if the IFIs are involved in the process and the primary necessary condition of finding a counterparty for holding contingent claim portfolios is satisfied, the moral hazard is still an issue. For dealing with the moral hazard problem, it is of uttermost importance for an EME to have a rule-based framework as well as a transparency pledge. Having a rule-based framework ensures that the contingent claim portfolios are built and managed prudently. Within such a framework, limiting the share of contracts written on its own debt is essential. The ratio of the nominal amount of the CDS portfolio to the external debt is a natural way of doing so. On the other hand, transparency, particularly on the size of the CDS portfolio, will enable the markets to price the risks related to the moral hazard problem. In an efficient market, the market participants can easily price the CDS contracts such that they reflect not only the fundamental risks relevant to these products but also the moral hazard risks. If this approach is implemented effectively, there is no reason to believe that an EME will have the motivation to default on its own debt just to collect the proceeds from its contingent claim portfolio. Undoubtedly, there may be skeptics arguing that it is unacceptable for a country to carry a portfolio of contingent claims linked to its own external debt. Although the simple decision rule for holding either foreign exchange assets or contingent claim portfolio(s) as a hedge against capital flow volatility has been developed using a country's own CDS contracts, this is only a baseline scenario to simplify the issue at hand. A portfolio of CDS contracts written on the external debt of other comparable countries may easily be used to hedge the idiosyncratic component.

Accordingly, it may be argued that the involvement of IFIs in enabling the EMEs to build contingent claim portfolios and acting as an agent that ensures the EMEs adhere to the rule-based framework as well as transparency is essential to the successful implementation of the suggested framework. In their decisions to facilitate such a framework, the IFIs should also contemplate the potential gains regarding global financial stability.

3.5. Conclusion

For emerging market countries, holding relatively high or excess foreign exchange reserves is a way of limiting the impact of external shocks on their economies. However, increasing the size of the international reserves may be costly given the conservative approach of reserve authorities to reserve portfolio management. In this study, we develop a simple decision rule that may help EMEs

minimize the costs associated with holding excess reserves. Putting aside the countries that accumulate reserves with mercantilist motives, the excess reserves serve mostly as insurance against the volatility of capital flows. Taking this motive into consideration, CDS contracts are incorporated into the decision rule as contingent claims linked to the sudden stops EMEs face. Although CDS contracts written on an EMEs own external debt have been used for simplicity, the suggested framework may be extended to include contingent claims linked to global factors for hedging the systematic risk component while a portfolio of CDS contracts written on the external debt of comparable countries can be used for hedging the idiosyncratic risk component.

The reason for suggesting a framework in which an EME may hold a contingent claim portfolio is that it enables a country to manage the cost of holding reserves more effectively and provides much-needed external liquidity in bad states. However, the approach is unorthodox and may receive criticism from skeptics, particularly regarding the inherent moral hazard issues. To alleviate these concerns, a rule-based framework and a transparency pledge is our suggestion. We also believe that the involvement of IFIs to facilitate the implementation of strategies aimed at hedging the risks associated with capital flow volatility may be needed. Since the risks to global financial stability increase with the size of excess international reserves and potentially aggressive shifts to safer and more liquid assets during market turmoils, being part of such a framework should be a straightforward decision for the IFIs.

For further research on the issue, we encourage studies that extend our approach to a framework that dissociates the risks into systematic and idiosyncratic components to build contingent portfolios that have the potential to manage these risks effectively. Another suggested area for research is both a theoretical and empirical analysis of expected change in the sovereign spreads given an external shock since it is a crucial component of the decision rule developed in this study.

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Appendix

Table A1.1: Variables, data sources, and explanations

Variable	Short Name	Data Source	Interval*	Variable/Data Explanation
Adequate Reserves	*ARAEM*	IMF-ARA	Annual	IMF's reserves adequacy calculations.
GDP	*GDP*	WB-GEM	Quarterly	GDP in current U.S. Dollars, seasonally adjusted. Calculated as the sum of the current quarter value plus the sum of the previous 3 quarters. Series code: NYGDPMKTPSACD.
Total reserves	*TOTRES*	IMF-IFS	Quarterly	International Reserves and Liquidity, Liquidity, Total Reserves, of which: Gold at Market Price, US Dollar. Series code: RAFA_MV_USD
Exports	*EXP*	IMF-BOP/IIP	Quarterly	Balance of Payments, Current Account, Goods and Services, Credit, US Dollars. Calculated as the sum of the current quarter value plus the sum of the previous 3 quarters. Series Code: BXGS_BP6_USD.
Imports	*IMP*	IMF-BOP/IIP	Quarterly	Balance of Payments, Current Account, Goods and Services, Debit, US Dollars. Series Code: BMGS_BP6_USD. Calculated as the sum of the current quarter value plus the sum of the previous 3 quarters.
Trade Balance	*TB*		Quarterly	Calculated as the difference between EXP and IMP.
Real Effective Exchange Rate	*REER*	WB-GEM	Monthly	Nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs. Series Code: REER
Broad Money	*M2*	IMF-IFS	Quarterly	Monetary, Broad Money, Domestic Currency. Converted to USD using the end-of-quarter exchange rate.
Short-term Debt	*STED*	IMF-ARA	Annual	Total external debt, short-term debt on a remaining maturity basis.
Other Liabilities	*OTHLIA*	IMF-ARA	Annual	For the ARAEM metric, other liabilities are defined as portfolio liabilities plus other investment liabilities less short-term debt at remaining maturity.
Foreign Exchange Regime	*FXREG*	IMF-AREAER	Annual	Annual report on exchange arrangements and exchange restrictions. Defined float when a country's exchange rate regime is classified >=7 before 2008 whereas float is defined classifications >=9 from 2008 onwards.
Degree of Float	*FX*		Annual	Calculated as the log of the division of the number of available categories in a given year by the numerical value assigned to a country regarding its exchange rate regime for the same year. Takes values between 0 and 1.

Notes: *For data that monthly original interval, corresponding end-of-period values are used to generate quarterly and annual series. To preserve consistency, in annual estimations), the data from IMF ARA Database is used for broad money(M2), exports (EXP), and imports (IMP).*

Table A2.1: Variables, data sources, and explanations

Variable	Short Name	Data Source	Interval*	Variable/Data Explanation
EMBI+ Country Spread	*SPREAD*	WB-GEM	Monthly	J.P. Morgan Emerging Markets Bond Index (EMBI+). Series code: EMBIG
EMBI+ Developing Countries Spread	*EMBIG*	WB-GEM	Monthly	J.P. Morgan Emerging Markets Bond Index (EMBI+). Series code: EMBIG
Relative spread	*DIVSPREAD*	Author's calculations		Calculated as the divergence from the market (spread minus EMBIG for each observation)
GDP	*GDP*	WB-GEM	Quarterly	GDP in current U.S. Dollars, seasonally adjusted. Calculated as the sum of the current quarter value plus the sum of the previous 3 quarters. Series code: NYGDPMKTPSACD.
Total reserves	*RES*	IMF-IFS	Quarterly	International Reserves and Liquidity, Liquidity, Total Reserves, of which: Gold at Market Price, US Dollar. Series code: RAFA_MV_USD
External Debt	*DEBT*	Joint BIS-IMF-OECD-WB Statistics on External Debt	Quarterly	Sum of cross-border loans from BIS reporting banks (Line 1), total multilateral loans (Line 6), insured export credit exposures (Line 9), SDR allocation (Line 11), international debt securities, and all maturities (Line 16).
Current Account and Capital Account	*CA*	IMF-IFS	Quarterly	Balance of Payments, Total Current + Capital Account, US Dollar. Series Code: BTCC_BP6_USD. Calculated as the sum of the current quarter value plus the sum of the previous 3 quarters.
Financial Account	*FA*	IMF-IFS	Quarterly	Supplementary Items, Financial Account, Net (Excluding Exceptional Financing), US Dollars. Calculated as the sum of the current quarter value plus the sum of the previous 3 quarters. Series Code: BFXF_BP6_USD.
Commodity Terms of Trade	*CTOT*	IMF-Commodity Terms of Trade Database	Monthly	Commodity Net Export Price Index, Individual Commodities Weighted by Ratio of Net Exports to GDP. Series Code: XM_GDP
Real Effective Exchange Rate	*REER*	WB-GEM	Monthly	Nominal effective exchange rate (a measure of the value of a currency against a weighted average of several foreign currencies) divided by a price deflator or index of costs. Series Code: REER
VIX	*VIX*	CBOE	Daily	Chicago Board Options Exchange's CBOE Volatility Index
BIS Global Liquidity Indicator	*BISGL*	BIS	Quarterly	Bank for International Settlements, all currencies, all countries, cross-border & local in FCY, Percentage of GDP.
TED Spread	*TED*	Federal Reserve Bank of St. Louis	Quarterly	TED Spread, Percent, Quarterly, Not Seasonally Adjusted. Series Code: TEDRATE
U.S. 10-year Bond Yield	*US10Y*	Federal Reserve Bank of St. Louis	Monthly	U.S. 10-Year Treasury Constant Maturity Rate. Series Code: GS10

Table A2.1 Continued: Variables, data sources, and explanations

Variable	Short Name	Data Source	Interval*	Variable/Data Explanation
Commodity Price Index	*PCPS*	IMF-Primary Commodity Price System	Quarterly	All commodity price index, 2016=100, includes both fuel and non-fuel price indices. Series Code: PALLFNF
IMF's ARA metric	*ARAEM*	IMF ARA Database	Annual	IMF's ARA metric calculations for each country
Exports	*EXP*	IMF Balance of Payments Statistics	Quarterly	Current Account, Goods and Services, Credit, US Dollars. Series code: BXGS_BP6_USD. Calculated as the sum of the current quarter value plus the sum of previous 3 quarters.
Imports	*IMP*	IMF Balance of Payments Statistics	Quarterly	Current Account, Goods and Services, Debit, US Dollars. Series code: BMGS_BP6_USD. Calculated as the sum of the current quarter value plus the sum of previous 3 quarters.
Trade balance	*TB*	Author's calculations	Quarterly	Calculated as the difference between EXP and IMP.
Broad money	*M2*	IMF-IFS	Quarterly	Broad Money, Domestic Currency, Monetary and Financial Statistics. Converted to US Dollars using the end-of-period exchange rate.
Degree of float	*FX*	IMF AREAER Database	Annual	Each category is assigned a numerical value from 1 to 8 (1 to 10 starting from 2008) based on the level of its float. FX is calculated by dividing the number of available categories in a given year by the numerical value assigned to a country regarding its exchange rate regime for the same year.
Degree of float	*FXLOG*	Author's calculations	Annual	Calculated as the log of the variable FX. Takes values strictly in the (0,1) range.
Reserve adequacy metric 4	*RESOC4*	Author's calculations	Quarterly	3-months of imports plus (GDP*0.08)+ (M2*0.06)+ (TB*0.07).
Reserve adequacy metric 5	*RESOC5*	Author's calculations	Quarterly	3-months of imports plus (GDP*0.06)+ (FXLOG*M2*0.04)+ (TB*0.09)

Notes: For data that have daily or monthly original interval, corresponding end-of-quarter values are used to generate quarterly series.

Table A2.2: Summary Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
SPREAD	1,431	300.77	293.26	14.00	3,863.00
DIVSPREAD	1,431	-111.89	273.98	-849.59	3,451.82
EMBIDEV	1,701	414.56	172.74	159.95	892.35
VIX	1,701	19.57	7.75	9.51	44.14
BISGL	1,701	46.09	7.41	33.66	66.98
TED	1,701	0.46	0.42	0.13	3.15
US10Y	1,701	3.43	1.24	1.62	6.28
PCPS	1,701	116.06	40.57	48.82	189.52
RES	1,701	78.04	107.16	0.12	569.03
RESGDP	1,689	19.51	10.12	3.67	59.14
DEBTGDP	1,689	30.94	13.63	9.50	103.17
CAGDP	1,640	-0.86	5.36	-27.70	20.96
FAGDP	1,640	-2.58	5.66	-44.56	24.68
CTOT	1,701	99.94	3.21	82.21	110.73
REER	1,685	93.53	13.06	47.65	134.47
GDP	1,689	417.51	508.62	2.90	2,645.66
EXP	1,656	133.24	146.72	0.55	733.29
IMP	1,656	126.41	131.89	1.09	675.07
TB	1,656	6.82	30.15	-68.88	172.54
M2	1,484	296.54	433.25	0.35	2,516.51
FX	1,701	1.39	0.83	1.00	5.00
FXLOG	1,701	0.10	0.16	0.00	0.70
FXLOGM2	1,484	15.77	25.79	0.00	195.11
ARAEM	1,613	59.94	70.18	0.36	378.04
RESOC4	1,439	48.16	48.88	0.39	234.45
RESOC5	1,439	41.57	41.20	0.37	191.11
EXIMF	1,613	21.43	51.85	-48.13	374.40
EXOC4	1,439	39.59	72.62	-19.42	442.16
EXOC5	1,439	46.18	79.15	-15.05	456.94
EXIMFGDP	1,612	3.77	8.52	-46.27	35.32
EXOC4GDP	1,439	7.33	8.42	-9.73	34.23
EXOC5GDP	1,439	8.69	8.59	- 8.85	36.33

Table A2.3: Correlation Matrix

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
SPREAD	(1)	1																			
DIVSPREAD	(2)	0.86	1																		
EMBIDEV	(3)	0.38	-0.15	1																	
VIX	(4)	0.31	0.00	0.59	1																
BISGL	(5)	-0.09	0.13	-0.41	0.22	1															
TED	(6)	0.04	0.06	-0.04	0.39	0.55	1														
US10Y	(7)	-0.05	-0.09	0.06	0.03	0.42	0.17	1													
PCPS	(8)	-0.14	0.15	-0.53	0.01	0.28	0.19	-0.45	1												
RESGDP	(9)	-0.24	-0.19	-0.12	-0.03	0.03	-0.01	-0.15	0.18	1											
DEBTGDP	(10)	0.13	0.15	-0.01	-0.03	-0.03	-0.03	-0.04	-0.03	0.28	1										
CAGDP	(11)	-0.11	-0.14	0.04	-0.05	-0.03	-0.10	0.15	-0.17	0.35	-0.08	1									
FAGDP	(12)	0.11	0.02	0.17	-0.04	-0.24	-0.21	-0.02	-0.25	0.09	-0.07	0.78	1								
CTOT	(13)	-0.02	0.06	-0.14	-0.05	0.07	-0.02	-0.09	0.10	-0.07	0.10	-0.16	-0.08	1							
REER	(14)	-0.29	-0.19	-0.21	0.03	0.23	0.10	-0.02	0.34	0.21	-0.05	-0.07	-0.13	0.24	1						
EXIMF	(15)	-0.11	-0.07	-0.08	-0.03	-0.02	0.01	-0.17	0.14	0.29	-0.33	0.24	0.17	-0.16	-0.01	1					
EXOC4	(16)	-0.08	-0.03	-0.09	-0.04	-0.05	-0.02	-0.20	0.18	0.25	-0.34	0.22	0.18	-0.12	-0.06	0.95	1				
EXOC5	(17)	-0.08	-0.03	-0.09	-0.04	-0.05	-0.02	-0.21	0.18	0.22	-0.36	0.21	0.18	-0.12	-0.08	0.95	1.00	1			
EXIMFGDP	(18)	-0.34	-0.29	-0.14	0.00	0.10	0.07	-0.11	0.20	0.65	-0.03	0.29	0.04	-0.16	0.22	0.53	0.41	0.39	1		
EXOC4GDP	(19)	-0.23	-0.18	-0.12	-0.02	0.00	-0.02	-0.20	0.22	0.82	0.08	0.33	0.11	-0.17	0.17	0.53	0.50	0.48	0.84	1	
EXOC5GDP	(20)	-0.25	-0.20	-0.12	-0.03	0.00	-0.03	-0.20	0.22	0.83	0.08	0.34	0.12	-0.17	0.16	0.52	0.50	0.48	0.84	1.00	1

Table A2.4: Baseline regression results for the balanced subsample (2001:Q4-2018:Q4)

	(1) SPREAD	(2) SPREAD	(3) SPREAD	(4) SPREAD	(5) DIV SPREAD	(6) DIV SPREAD	(7) DIV SPREAD	(8) DIV SPREAD
RESGDP	-8.01***				-9.32***			
	(-3.29)				(-3.49)			
EXIMFGDP		-10.93***				-12.09***		
		(-3.85)				(-3.99)		
EXOC4GDP			-9.73***				-11.89***	
			(-3.41)				(-3.62)	
EXOC5GDP				-10.26***				-12.23***
				(-3.53)				(-3.66)
DEBTGDP	2.17***	1.42	1.63*	1.74**	3.24***	2.92**	3.09***	3.22***
	(2.66)	(1.39)	(1.89)	(1.99)	(3.60)	(2.33)	(3.16)	(3.22)
CAGDP	0.87	-1.74	-0.91	-0.30	3.54	-0.01	2.08	2.33
	(0.12)	(-0.26)	(-0.14)	(-0.04)	(0.44)	(0.00)	(0.28)	(0.31)
FAGDP	8.21**	7.65*	7.77*	7.58*	6.84*	6.68*	6.28	6.17
	(2.06)	(1.94)	(1.92)	(1.87)	(1.69)	(1.74)	(1.54)	(1.51)
CTOT	10.90***	8.83**	10.45***	10.39***	10.61***	8.93**	10.55***	10.51***
	(3.26)	(2.43)	(3.01)	(2.97)	(2.83)	(2.23)	(2.75)	(2.72)
REER	-6.43***	-6.17***	-6.58***	-6.55***	-5.14***	-4.77***	-5.06***	-5.02***
	(-6.32)	(-5.76)	(-6.24)	(-6.17)	(-4.60)	(-4.07)	(-4.44)	(-4.37)
VIX	5.05***	4.82***	4.82***	4.76***	-1.32	-1.19	-1.36	-1.39*
	(4.33)	(4.17)	(4.17)	(4.13)	(-1.58)	(-1.41)	(-1.62)	(-1.66)
BISGL	-2.61	-2.42	-2.83	-2.91	2.00	2.47	1.80	1.77
	(-0.95)	(-0.81)	(-0.99)	(-1.01)	(0.88)	(0.94)	(0.76)	(0.74)
TED	-20.52	-17.84	-21.43	-21.80	-0.17	2.79	-1.55	-1.87
	(-1.00)	(-0.88)	(-1.06)	(-1.08)	(-0.01)	(0.19)	(-0.11)	(-0.13)
US10Y	-38.12***	-38.84***	-39.56***	-40.85***	-19.76*	-18.73*	-21.19*	-21.88*
	(-2.57)	(-2.60)	(-2.68)	(-2.76)	(-1.76)	(-1.60)	(-1.86)	(-1.91)
PCPS	-1.14**	-1.26**	-1.13**	-1.09**	0.94**	0.90*	1.01**	1.03**
	(-2.42)	(-2.43)	(-2.29)	(-2.20)	(2.26)	(1.91)	(2.34)	(2.38)
Wald Chi-sq	200.79	158.75	187.01	189.28	85.36	47.51	75.25	75.30
Prob	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
R-sq.	0.28	0.29	0.28	0.28	0.10	0.11	0.10	0.10
# of obs.	828	828	828	828	828	828	828	828
# of countries	12	12	12	12	12	12	12	12

*Notes: z-scores based on correlated panel-corrected standard errors are in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level.*

Table A2.5: Baseline regression results for the balanced subsample (2009:Q2-2018:Q4)

	(1) SPREAD	(2) SPREAD	(3) SPREAD	(4) SPREAD	(5) DIV SPREAD	(6) DIV SPREAD	(7) DIV SPREAD	(8) DIV SPREAD
RESGDP	-8.80**				-9.77**			
	(-2.07)				(-2.29)			
EXIMFGDP		-15.03***				-15.66***		
		(-3.14)				(-3.21)		
EXOC4GDP			-11.53***				-12.75***	
			(-2.86)				(-2.94)	
EXOC5GDP				-12.49***				-13.50***
				(-2.97)				(-3.01)
DEBTGDP	4.77**	4.96**	4.59**	4.84**	5.79***	6.20**	5.92***	6.15***
	(2.29)	(2.15)	(2.23)	(2.26)	(2.64)	(2.53)	(2.67)	(2.67)
CAGDP	0.81	-0.96	-0.47	0.60	3.43	1.27	1.51	2.53
	(0.06)	(-0.08)	(-0.04)	(0.06)	(0.27)	(0.11)	(0.14)	(0.24)
FAGDP	11.73*	10.52*	11.10*	10.80*	10.05*	8.66*	9.30	9.06
	(1.95)	(1.84)	(1.87)	(1.82)	(1.69)	(1.53)	(1.59)	(1.55)
CTOT	6.38	1.71	6.39	6.15	5.24	2.04	6.18	5.99
	(0.90)	(0.22)	(0.88)	(0.84)	(0.71)	(0.26)	(0.83)	(0.80)
REER	-7.19***	-6.70***	-6.83***	-6.85***	-6.42***	-6.03***	-5.98***	-5.99***
	(-3.73)	(-3.35)	(-3.43)	(-3.43)	(-3.34)	(-2.98)	(-3.01)	(-2.99)
VIX	1.33	1.53	1.29	1.23	-1.49	-1.25	-1.47	-1.52
	(1.07)	(1.30)	(1.08)	(1.03)	(-1.36)	(-1.19)	(-1.36)	(-1.40)
BISGL	-1.72	-1.23	-2.33	-2.42	3.33	4.67	3.17	3.19
	(-0.41)	(-0.26)	(-0.53)	(-0.55)	(0.87)	(1.02)	(0.77)	(0.77)
TED	44.01	29.94	40.79	41.19	6.68	-2.72	4.64	5.36
	(0.59)	(0.42)	(0.57)	(0.58)	(0.10)	(-0.04)	(0.07)	(0.08)
US10Y	-17.45	-21.08	-18.65	-19.66	-15.48	-19.10	-16.83	-17.78
	(-0.80)	(-0.94)	(-0.86)	(-0.90)	(-0.78)	(-0.92)	(-0.84)	(-0.88)
PCPS	0.07	-0.21	-0.13	-0.15	1.25*	1.03	1.13	1.14
	(0.09)	(-0.26)	(-0.17)	(-0.18)	(1.73)	(1.33)	(1.50)	(1.50)
Wald Chi-sq	52.73	51.86	53.08	53.69	26.81	22.76	25.55	25.58
Prob	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01
R-sq.	0.21	0.29	0.22	0.22	0.12	0.15	0.12	0.12
# of obs.	468	468	468	468	468	468	468	468
# of countries	12	12	12	12	12	12	12	12

*Notes: z-scores based on correlated panel-corrected standard errors are in parentheses; * significant at 10% level; ** significant at 5% level; *** significant at 1% level.*