WP/11/144

IMF Working Paper

International Reserve Adequacy in Central America

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INTERNATIONAL MONETARY FUND

 WP/11/144

IMF Working Paper

Western Hemisphere Department

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Authorized for distribution by David Vegara

June 2011

Abstract

Countries' absolute and relative international reserves adequacy has recently attracted considerable attention. The analysis has however concentrated on the largest and most advanced economies. We apply various methodologies for assessing reserve adequacy in Central America, taking into account the region's high degree of deposit dollarization. We find that reserve cover is low both in an absolute and relative sense, suggesting further reserve accumulation is an important policy option for reducing vulnerabilities.

JEL Classification Numbers: F31, F32, F37, F41

Keywords: Foreign reserves, balance of payments crises, financial dollarization

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[1] This paper greatly benefited from discussions with Luis Cubeddu, Rodolfo Luzio, Ola Melander, Marco Piñon, Miguel Savastano, seminar participants at the International Monetary Fund as well as the IMF Central American country teams. Alejandro Carrion-Menendez provided excellent research assistance. We are grateful to Bikas Joshi for giving us access to his panel data set used in the reserve demand regressions.

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I. INTRODUCTION

International reserve accumulation has recently grown rapidly, reaching 13 percent of global GDP in 2009, which represents a three-fold increase over ten years. During this time, emerging market holdings rose to 32 percent of GDP.[2] This extensive accumulation of foreign reserves has naturally prompted questions regarding what benefits countries have from international reserves holdings, and whether current levels can be justified on economic grounds.

One long-standing view of the rationale for holding international reserves is to insure against balance of payments shocks. Commonly used rules-of-thumb for reserve adequacy investigate whether international reserves cover some external commitments, e.g. three months of imports for countries with limited access to capital markets, or measures of potential capital flight, such as short-term external debt at residual maturity and current account deficits. Alternatively, the actual demand for international reserves has been studied using variants of the "buffer stock model", treating reserves as a resource for smoothing consumption in the face of sudden stops of external credit and the output falls that often accompany it (Frenkel and Jovanovic, 1981). This strand of literature typically finds that the size of reserve holdings is positively related to income volatility, openness and financial depth (Edwards, 1983, Flood and Marion, 2002, Obstfeld et al, 2008). Previous literature has also tried to find an "optimal" level of international reserves by weighing the aforementioned benefits of international reserves for mitigating falls in domestic consumption during balance of payments crises with the costs of holding reserves, such as the interest rate differential between long-term debt issued to finance reserves and the return on reserves (Jeanne and Rancière, 2006, Gonçalves, 2007, Valencia, 2010).

Using the above-mentioned frameworks, several authors have come to the conclusion that the recent reserve holdings of most emerging markets are hard to justify on economic grounds, and that other factors such as export-oriented growth strategies might be at play (Dooley et al, 2003). Recent evidence from Asia and Latin America suggests that the over-accumulation of international reserves in one country might then have prompted others to follow suit through an attempt to "keep up with the Joneses" (Cheung and Qian, 2009, Cheung and Sengupta, 2011).

Most research on the international reserve coverage has so far concentrated on large emerging markets and advanced economies. This paper instead focuses on small non-dollarized economies in Central America, i.e. Costa Rica, the Dominican Republic, Honduras, Guatemala and Nicaragua.[3] Our motivation to do so is two-fold. First, the aforementioned lack of studies on

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[2] 26 percent if China is excluded.

[3] El Salvador and Panama have been fully dollarized for the period we study and the notion of international reserves is hence not readily applicable to them. Belize belongs to Central America but was excluded due to its smaller size than the other economies in the sample.

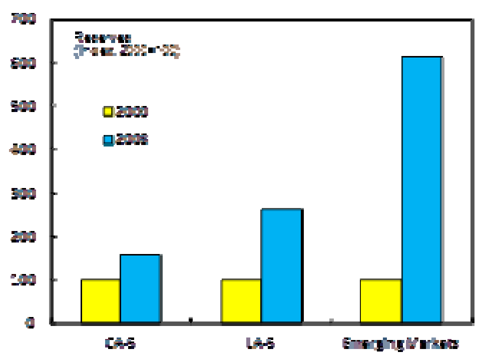
reserve coverage for the region, and smaller emerging markets in general.[4] Second, to shed light on the appropriateness of the different commonly used methods for assessing reserve adequacy for smaller and less financially integrated emerging markets than those previously studied, including the possible presence of "keeping up with the Joneses" effects.

Our focus region also displays other features which makes it an interesting testing ground for assessing reserve adequacy. Compared to some of their larger and more advanced emerging market peers, the Central American economies have relatively little short-term external debt, suggesting a smaller vulnerability along that dimension. On the other hand, the share of dollar-denominated deposits to total deposits is about 45 percent on average in the region, well above the levels of dollarization in the five largest economies in Latin America and other emerging markets. This gives rise to risks of large deposit withdrawals during crises which need to be taken into account when assessing reserve adequacy, but has achieved less attention in the literature.[5]

The rest of the paper is organized as follows. Section II investigates international reserve coverage using traditional rules-of-thumb. Section III presents results from reserve demand regressions. Section IV contains a model of optimal reserve coverage and its predictions. Section V concludes.

II. Rules-of-Thumb for Reserve Cover

Central America has increased its reserve cover in recent years, though the extensions of coverage were much smaller than that of other emerging markets.[6] While gross international reserves increased by over 50 percent during 2000–2008 in Central America, it jumped three-fold in the five largest Latin American economies and six-fold in a larger global sample of emerging markets, as seen from the figure to the right. In fact, the rules-of-thumb that follow suggest that Central America's reserve cover could be strengthened further.



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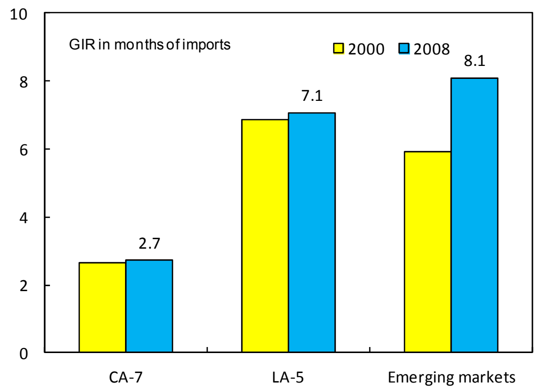
[4] An exception is Canales-Kriljenko (2008) who uses a version of the Jeanne and Rancière model to assess optimal reserve adequacy for the Dominican Republic.

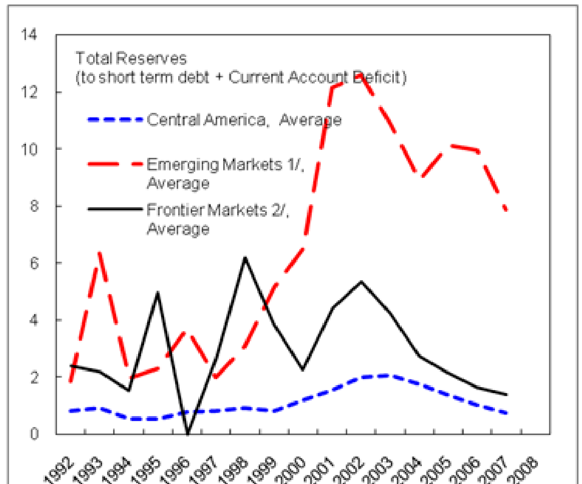
[5] Gonçalves (2007) is a notable exception.

[6] International reserve holdings are defined in the standard way, i.e. as the sum of gold, SDR holdings, and foreign exchange. Since our analysis does not cover 2009, the exception al SDR allocation in that year does not affect this measure.



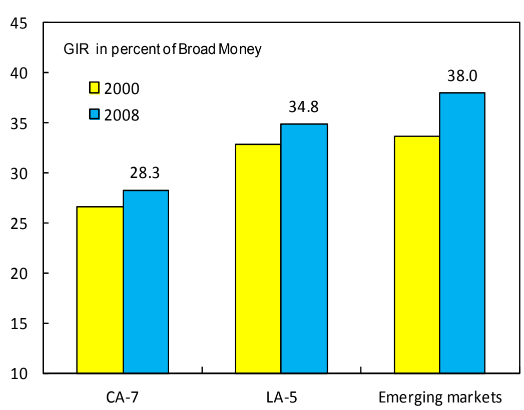
Maybe the most traditional rule of thumb, generally used for countries with limited access to capital markets, is that international reserves should equal three months of imports. As seen from the figure to the left, this level is barely reached by the Central American economies, but exceeded by a wide margin both by the larger economies in Latin America and the full sample of emerging markets.

Alternatively, the so-called Greenspan-Guidotti rule states that gross international reserves should cover short-term external debt measured on a residual maturity basis, i.e. public and private external debt maturing over the next 12 months (Greenspan, 1999). This rule is often extended to also take into account current account deficits to proxy for total external financing needs and give a more extensive picture of possible capital flight. As seen from the figure to the right, Central America falls short of the benchmark, despite their relatively modest external debt levels, and in contrast to other emerging markets.



Source: WEO, IFS.
/1 Includes countries covered by the JPMorgan EMBI index except Algeria and Brazil.
/2 Includes countries coeverd by the MSCI Barra Frontier Markets index.

Another often used rule of thumb is to compare international reserves to the stock of broad money, usually M2. While traditionally a cover of 5–20 percent of broad money has been considered adequate, more recently e.g. Obstfeld et al (2008) have argued that a sufficient "war chest" should cover up to 50%. Regardless of the precise level deemed appropriate, the figure to the left shows that Central America again are below comparators in this dimension. Moreover, one needs to take into account the relatively low level of financial intermediation in the region; in Central America, the ratio of broad money to GDP stands at roughly 40 percent, compared to an average of 70 percent for the larger sample of emerging economies.



Taken together, the above benchmarks suggest that Central America's reserve cover is on the low side both in an absolute sense, and compared to emerging market peers on the Latin American continent and elsewhere.

III. Reserve Demand Regressions

While the aim of the rules-of-thumb presented in the previous section is to give a benchmark regarding the adequacy of international reserves, another angle for analyzing international reserves is to try to explain what has motivated a country to accumulate a certain stock. Indirectly, this approach can also shed light on whether the time variation in international reserve coverage can be justified on accounts of changes in e.g. macroeconomic fundamentals, or whether there is excessive accumulation or run-down of reserves during certain time periods. This strand of literature has often used variants of the "buffer-stock model" (Frenkel and Jovanovic, 1981) that considers international reserves a resource for smoothing consumption in the face of sudden stops.

How much reserves a country demands naturally varies with its characteristics. Countries experiencing relatively higher income volatility over extended periods may opt for higher reserves holdings due to their larger utility from income insurance. As pointed out by Edwards, 1983, Flood and Marion, 2002, countries with fixed exchange rate regimes also need larger reserve holdings to defend the parities of their domestic currencies to the one they have pegged to. The secular move towards more exchange rate flexibility during the last decades should then ceteris paribus have resulted in lower international reserve holdings around the world, while in fact the opposite happened. One reason for reserve holdings to remain high is that *de facto* exchange rate flexibility could be lower than *de jure* measures, or that some countries classified as floaters hold international reserves to occasionally intervene in the foreign exchange market and influence their floating exchange rates.

Other factors argued to matter for reserve demand more directly correspond to balance-of-payments needs. Closely linked to the Greenspan-Guidotti rule, Radelet and Sachs (1998) argued that short-term foreign-currency debt is an important source of vulnerabilities, and hence a potentially important determinant of reserve demand. Calvo (1996) first suggested that a country's vulnerability to crisis should be measured by the size of its money supply, as it is a natural upper limit on the extent of possible asset withdrawal. Obstfeld et al (2008) further investigated the need to protect the domestic banking system and credit markets through international reserves. They argue that the rationale for holding reserves increases in more financially open economies, as risks multiply with the possible combination of currency mismatches and deposit withdrawals, both of those currently held in foreign currencies and through an increased demand for exchanging domestic deposits into hard currency. Given that domestic bond markets are often thin in emerging markets, international reserves are then argued to be one of the very few means of financing available to a government in times of crisis. Key variables for reserved demand would then be measures of financial depth and openness of the economy, which the authors investigate both in a theoretical model and an econometric analysis.

Reserve demand might also stem from other motives than economic fundamentals. Peer or "Joneses" effects are meant to capture that precautionary or mercantilist hoardings by one economy may induce competitive hoarding by other economies in the same region, as found by Cheung and Qian (2009). If a market is viewed as having inadequate reserve coverage compared to its peers, it might be more vulnerable to capital outflows by market participants in times of economic crisis.

We follow the methodology of Obstfeld et al (2008) and investigate reserve demand in a panel of 52 emerging economies for the period 1993-2008.More specifically, we estimate the following models:

$$Y_{it} = X_{it}^{'}\alpha + \delta D1_i + \gamma D1_i * J_{it-1} + \theta D2_{it} + \varepsilon_{it}, i = 1 \dots N; t = 1 \dots . T$$

where *i* denotes economies (N = 52) and *t* denotes time (T=16). $Y_{it}$is the reserves-to-GDP ratio of economy *i* at time *t*. $X_{it}^{'}$ is the vector of economic variables used to explain reserve demand. $D1_i$ is a dummy taking on the value one for Central American countries. $D2_{it}$ takes on the value one in years when country *i* experienced a crisis, defined as a reversal of the current account to GDP ratio by more than five percentage points. The presence of peer effects are investigated by defining "Joneses" variables for economy *i* as follows:

$$J_{it} = \sum_{i \neq k} Y_{kt}$$

where Y_{kt} is the reserves to GDP ratio of economy *k* at time *t*. For smaller countries, it is however not clear whether "size matters" and the relevant comparators are other smaller emerging markets or the largest countries in the region. To allow for both possibilities, we sum respectively over the other small emerging markets in the region, and only the five largest economies.[7] Following Cheung and Qian (2009), we lag the "Jones" variable to take into account lack of contemporaneous data on other countries' reserve levels.

In line with previous studies, we find that reserve demand is positively related to openness and GDP volatility, and negatively related to exchange rate flexibility. The largest effect on reserve demand comes from exchange rate flexibility; raising the period standard deviation of the nominal national currency/dollar exchange rate by one unit is associated with an decreased reserve/GDP ratio of about 25 percentage points. The effects of a one percentage point increase in the openness of the economy, defined as the ratio of exports and imports to GDP, or the FDI/GDP ratio have effects on the reserve to GDP ratio close to that size. Contrary to previous studies, we find no significant effect of financial depth on reserve demand.

The level of total external debt as well as crisis dummies, have the expected positive sign but are not found to significantly affect reserve demand in a consistent manner, which is also in line with existing work (Obstfeld, 2008). Raising the short term debt to GDP ratio is however found to increase the reserve to GDP ratio by around three percentage points, suggesting that the

[7] Brazil, Chile, Colombia, Mexico and Peru.

maturity structure of debt matters. The "Jones" variables have the expected positive sign, suggesting that increased reserve accumulation by peers affect country i's reserve demand upwards. However, only the reserve levels in the large emerging markets seem to matter, in that an increase in the reserve to GDP ratio of the five largest economies in Latin America on average increases the reserve to GDP ratio of a Central American economy by half a percentage point the following year, but there is no significant effect of reserve accumulation in other Central American economies.

Taken together, Central America stands out as having lower reserve ratios after controlling for the standard demand drivers in the literature, as indicated by a significant, negative coefficient of a dummy for the region that can be interpreted as the reserve-to-GDP ratio on average being about two percentage points lower in Central America, after controlling for other relevant factors.

Table 1. Reserve Demand Regressions. Dependent Variable: GIR/GDP

Variable	Coefficient	T-stat.
Log (Population)	-0.008*	-1.97
Openness /1	0.117***	9.82
Exchange rate flexibility/2	-0.241*	-1.87
GDP volatility/3	0.101*	1.37
Central America dummy	-0.024*	-1.40
FDI/GDP	0.191***	2.90
Short term debt/GDP	0.031*	1.71
Jones2*CA dummy	0.004***	3.55

1/ Defined as (exports + imports)/GDP.
2/ Defined as the period standard deviation of the NCU/dollar exchange rate, over the period average.
3/ Defined as the period standard deviation of real GDP, over the period average.
4/ Defined as M2/GDP. ***, **, * denote results significant on the 1, 5 and 10% significance levels (one-sided t-tests).

All estimated coefficients, as well as different specifications and robustness checks, can be found in the Appendix.

IV. Models of Optimal Reserves

The econometric analysis in the previous section can be criticized for lacking microfoundations, i.e. not discussing whether actual reserve holdings are optimal from the perspective of rational utility-maximizing agents. This section hence focuses on reserve optimality from a consumption insurance perspective, balancing the benefits of holding reserves when sudden stops in external credit occur with the quasi-fiscal costs of doing so. However, the focus on external debt links this framework to the Greenspan-Guidotti rule and the reserve demand models in the previous section.

Although the early literature discussing reserve optimality emphasized vulnerabilities stemming from external short-term debt, recent works has widened the definition. As an important source of fragility in Central America as earlier mentioned is bank dollar deposits, we use Gonçalves (2007) dollar deposit extension of the Jeanne and Rancière (2006) framework for assessing the role of reserves for consumption insurance. As pointed out by Valencia (2010), another reason for accumulating precautionary reserves is to insure against volatile terms-of-trade developments. This option is however mainly relevant as a tool for revenue management for commodity exporters, which the Central American economies we focus on are not.[8]

The model features an intertemporal optimization problem of a small open economy hit by sudden stops in capital flows. Notice that this model does not study the role of reserves for actually reducing the likelihood or cost of a crisis, nor the effects on borrowing costs. These benefits are however typically found to be insignificant or only present at low reserve-to-GDP ratios, and hence the costs and benefits of holding reserves can thought to be well approximated by the model (Blanchard et al, 2010, Llaudes et al, 2010).

In the model, reserves are held to smooth consumption over time. This role of international reserves can be inferred from a few accounting relationships. First, note that real domestic absorption in an open economy can be written as the difference between real domestic output and the trade balance:

$$A_t = Y_t - TB_t \tag{1}$$

where the trade balance, in turn, can be written as

$$TB_t = -KA_t - IT_t + \Delta R_t \tag{2}$$

where KA_t is the financial account, IT_t is income and transfers from abroad, and $\Delta R_t = R_t - R_{t-1}$ is the change in reserves. Eqs. (1) and (2) can be combined to obtain an expression for decomposing domestic absorption into domestic output, the financial account, income from abroad, and accumulation or decumulation of reserves:

$$A_t = Y_t + KA_t + IT_t - \Delta R_t \tag{3}$$

A sudden stop is characterized by a cut of external credit, resulting in a sharp fall of the capital account KA_t, ceteris paribus inducing a fall in domestic absorption. If the sudden stop is accompanied by a fall in output, Y_t, the effects on domestic absorption will be amplified. Reserves can however be used to e.g. repay external debt that is not rolled over, alleviating the need to cut domestic absorption, and thus providing consumption insurance.

[8] In theory, commodity importers could naturally also use reserves to insure against terms-of-trade shocks, in practice they have less frequently been used against volatile commodity prices.

Based on a partial equilibrium framework, a main advantage of the model is that it has a closed form solution.[9] For simplicity, all variables in the model are scaled by GDP. The government welfare maximization problem results in first order conditions which can be manipulated to obtain the optimal level of reserves as a fixed fraction of the level of output, ρ:

$$\rho = \lambda + \gamma - \frac{p^{1/\sigma} - 1}{1 + \left(p^{1/\sigma} - 1\right)\left(1 - \delta - \pi\right)} \left(1 - \frac{r - g}{1 + g}\lambda - \left(\delta + \pi\right)\left(\lambda + \gamma\right)\right) \quad (4)$$

where

ρ =optimal reserves-to-output ratio

$\lambda = (\alpha (1-\varphi)\lambda_{DEP} + \lambda_{DEBT})$ sum of external debt λ_{DEBT}, defined as external debt coming due on a residual maturity basis over the next 12 months, and possible deposit withdrawals $\alpha(1-\varphi)\lambda_{DEP}$, i.e. deposit obligations not covered by banks' liquid foreign assets

φ = share of dollar deposits covered by banks' liquid foreign assets

α = share of dollar deposits backed by the government

γ = output cost of a crisis

σ = coefficient of relative risk aversion

δ = term premium

π = probability of crisis

r = risk-free interest rate

g = real growth rate of (potential) output

$p = 1 + \delta/[\pi(1-\delta-\pi)]$ is the liquidity premium generated by a crisis (if δ=0, p=1, i.e. domestic consumption is perfectly insured against the risk of a crisis)

To get the intuition behind this formula for the optimal reserve-to-GDP ratio, it is useful to examine an approximation to it, which can be obtained by setting $\delta + \pi = r - g = 0$ in equation (4), implying:

$$\rho = \lambda + \gamma - \left(1 - \left(1 + \frac{\delta}{\pi}\right)^{1/\sigma}\right) \quad (5)$$

This approximation illustrates that the optimal level of reserves increases one-for-one with the amount of short-term external debt λ and the output cost of a crisis γ, and declines with the opportunity cost of holding reserves (1+ δ/π).

If the term premium δ is equal to zero, then reserves should be optimally set to the level that perfectly smoothes the impact of a crisis on domestic consumption, i.e. λ + γ, the "full insurance" optimum. If the output cost of a crisis is zero (γ=0), then ρ = λ, or optimal reserves should equal short-term external debt. Otherwise, the optimal level of reserves also increases

[9] The full model can be found in the Appendix.

with the probability of a sudden stop, π, and the risk aversion parameter σ, and declines with the term premium, δ.

To take into account the importance of dollar deposits, we follow Gonçalves in assuming that the optimal level of foreign reserves should also cover a significant fraction of foreign currency deposits' withdrawal from the banking sector. Lacking country-specific information for government backing of foreign currency deposits, we use Gonçalves value of 30%, referring to the 2001 Uruguay crisis. But unlike Gonçalves we do not distinguish between the government's coverage of resident and non-resident deposits, due to lack of data regarding this split for the countries we study. To give an upper bound on the interval in which reserve coverage can be considered optimal according to the model, we also present results for the case when the government fully insures all dollar deposits.

We also stick with the original Jeanne and Rancière model in not taking into account valuation effects on international reserves through possible depreciation of the real exchange rate. While Gonçalves argue that by increasing foreign currency liabilities such a depreciation likely leads to further drops in consumption, and thus a higher marginal benefit of holding reserves, Jeanne and Rancière have shown that the optimal level of foreign reserves is not significantly affected by the real exchange rate. In a model with depreciation, the same amount of foreign reserves provides more insurance in terms of domestic consumption buffer when the economy faces a sudden stop, i.e. the marginal benefit of foreign reserves goes down, and these two effects offset each other.

A. Parameters

To compare the results for Central America with relevant peers, i.e. small- to middle-sized emerging markets for which data is available, we perform the exercises in this section for Armenia, Bolivia, Bulgaria, Costa Rica, the Dominican Republic, Guatemala, Honduras, Nicaragua, Paraguay, Romania and Uruguay.

Table 2 Non-country Specific Model Parameters

Term premium, δ	1.5%
Risk-free rate, *r*	5%
Coefficient of relative risk aversion, σ	2
Deposit coverage, α	30-100%

The non-country specific model parameters are common to the Jeanne and Rancière and Gonçalves' papers and relatively standard. The risk aversion parameter is set at 2, a standard estimate in the business cycle literature. The risk-free short-term dollar interest rate is set at 5 percent, roughly corresponding to the average U.S. 3-month Treasury bill rate over the last decades. The term premium is assumed to be 1.5 percent, close to the average difference between the yield on 10-year U.S. treasury bills and the federal funds rate over the same period. Country-specific debt levels λ , potential output growth rates *g,* and estimated output losses γ are available from the author upon request. Regarding the calculated probabilities of crisis π, Jeanne and Rancière uses a cross-country probit model to arrive at an estimate of 10.2%, i.e. that the average emerging market experiences a crisis every ten years. For countries experiencing crisis during the two decades for which we have data, we used the implied probability (e.g. one crisis during this period would result in a probability of 5%), while the Jeanne and Rancière estimate was used for the remaining countries. We discuss the importance of this and other parameters for the results later in the sensitivity analysis section.

B. Results

This section discusses actual reserve-to-GDP ratios versus the optimal levels spelled out by the Jeanne and Rancière model, as well as the Gonçalves model, with 30% and full government backing of dollar deposits, respectively. For the Jeanne and Rancière model, data was available to calculate optimal level of reserves for the period 1993–2008. Results for the Gonçalves model could only be obtained for 2003-2008, the longest time period for which we could get data on dollar deposits and private banks' liquid foreign assets. Notice that due to lags in data publication for short-term external debt, we cannot cover the 2009 crisis, when several of the countries in our sample used considerable amounts of their foreign reserves to meet balance of payments needs, and numbers on actual reserves should be considered as upper bounds.

Optimal reserve levels according to the Jeanne and Rancière model vary widely across time and countries, as seen from the time series plots in the Appendix. While some countries, such as Armenia, show very little time series variation in their optimal reserves over the time period under study, others, such as Bulgaria, display dramatic variation. Moreover, while the optimal levels of reserves are steadily declining for some countries, e.g. Bolivia, Honduras and Nicaragua, the model predicts increasing need for reserves in other countries such as Armenia, Bulgaria, Costa Rica and Romania.[10]

Figures in Table 2 below refer to time averages for the period 2003-2008, to avoid results being contaminated by outliers. As seen from the Table, actual reserve levels are in many cases close to, but typically exceeding, those spelled out by the Jeanne and Rancière model, and especially so for the more financially integrated emerging markets in the sample, e.g. Costa Rica, Dominican Republic, Bulgaria, Romania and Uruguay.

As earlier discussed, the assumptions of the model will lead to it always prescribing low reserve levels for countries with short-term low external debt levels such as Guatemala, Honduras, and Bolivia.[11] The discrepancy between actual and optimal reserves is especially striking for Bolivia.

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[10] Romania has had a currency board for much of the period under study, which has implications for optimal reserve coverage: it is mainly included for its similarity in terms of macroeconomic characteristics to the Central American sample.

[11] Notice however that while all of Guatemala's public external debt is long-term, short-term external debt in 2009 constituted 90 percent of banks' external debt (in the form of credit lines with foreign banks) and 40 percent of non-financial private sector external debt.

As earlier mentioned, Bolivia's current high level of international reserves is usually acknowledged to be a result of the recent natural resource boom and associated insurance motives against terms-of-trade shocks, together with few alternatives for investing the export revenues but to accumulate international reserves (Valencia, 2010).

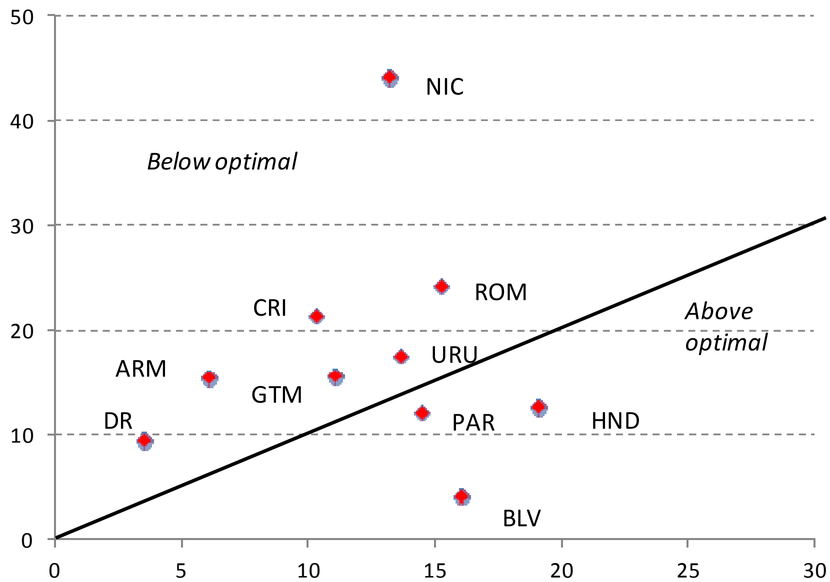
Table 3. Actual vs. Optimal Reserves (% of GDP), Time Averages 2003–08

	Actual	Jeanne and Rancière	Gonçalves (no depreciation effects)	
			30% guarantee	Full guarantee
Costa Rica	10.2	8.2	14.8	21.6
Dom. Republic	3.4	4.9	5.8	9.6
Guatemala	11.0	6.4	8.7	15.8
Honduras	19.1	7.3	7.9	12.7
Nicaragua	13.2	17.7	21.7	44.4
Armenia	6.0	13.8	14.4	15.6
Bolivia	16	2.5	2.7	4.3
Bulgaria	28.9	24.9	…	…
Paraguay	14.4	11.3	11.7	12.3
Romania	15.2	16.7	19.0	24.4
Uruguay	13.6	11.3	12.8	17.7

Source: Author's estimates.

If both dollar deposits and short-term external debt are taken into account, actual reserves are lower than optimal reserves for the majority of the countries in Central America, even if the government only backs a third of deposits not covered by banks' liquid foreign assets. In the extreme case of full dollar deposit insurance, Honduras is the only country in the Central America region whose reserves are still higher than the optimal levels, as further shown by Figure 1 below.

Figure 1. Optimal Versus Actual Reserve Levels



X-axis: Actual reserve-to-GDP ratio. Y-axis: Optimal reserve-to-GDP ratio according to the Goncalves model with full insurance

Source: Author's calculations. Refers to time averages for the years 2003-2008.

C. Sensitivity analysis

This section shows how the level of optimal reserves depends on the calibrated parameters. For expositional clarity, graphs in this section refer to results from the Jeanne and Rancière model for Costa Rica and the year 2008. Another country, or including also dollar deposits, would have given similar pictures but of course different levels.

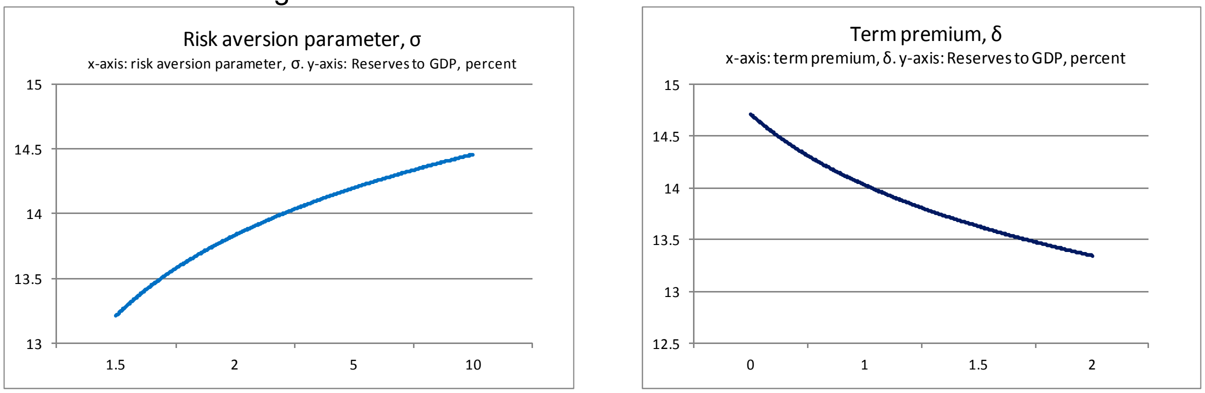
Risk aversion parameter, σ

Higher risk aversion increases the value of consumption insurance and hence the level of optimal reserves. Increasing σ from 2 to 5, for example, on average increases the average optimal reserve to GDP ratio by about 4 percent for our sample. For the Central American economies, the increase is somewhat larger, around 5 percent on average.

Term premium, δ, and lower risk free rate, r

A lower term premium decreases the opportunity cost of holding reserves, and thus pushes up the optimal reserve-to-GDP ratio. If the the term premium were to fall 150 basis points from 1.5 to 0, the average optimal reserve-to-GDP ratio would increase by almost 7 percent. Again, the increase is larger for the Central American economies, over 8 percent. Varying the risk-free rate has similar effects.

Figure 2. Risk Aversion Parameter and Term Premium



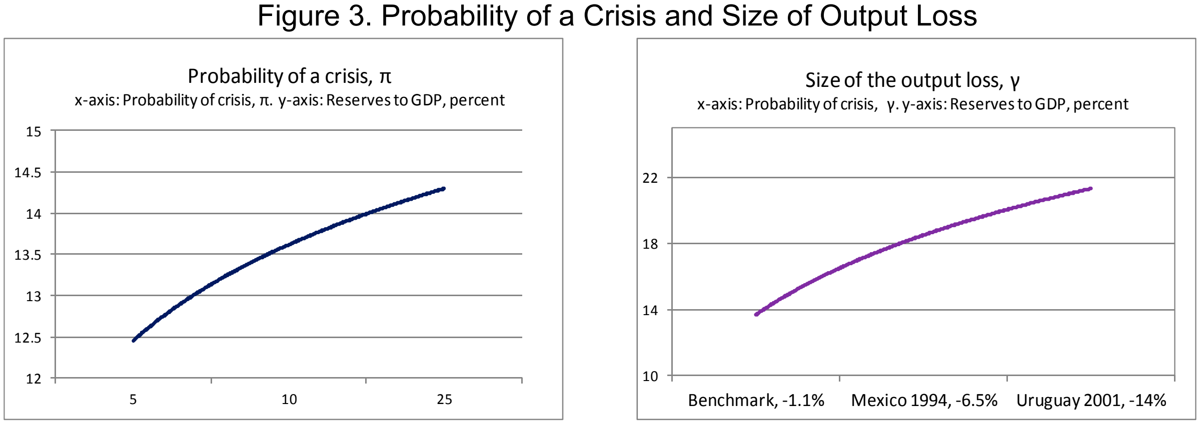
Probability of a crisis, π

A higher probability of a crisis increases the marginal benefit of reserves in the case of a sudden stop. If the crisis probability estimated by Jeanne and Rancière, 10.2 percent were to fall by half to 5 percent, this would lower the average reserves-to-GDP ratio by close to 11 percent. Given that the Central American economies have relatively low crisis probabilities compared to other economies in the sample in the benchmark parameterization, lowering the crisis probability to 5 percent would decrease their optimal reserve-to-GDP ratio by less, around 8 percent.

Size of output loss, γ

With a greater output loss, the need for consumption insurance naturally increases and with it the optimal reserve-to-GDP ratio. If the countries studied were to experience an output drop the size of Mexico's in 1994, -6.5 percent, the average increase in the optimal reserve-to-GDP ratio would be almost 70 percent for the Central American economies versus 40 percent for the full sample. If the same group of countries had a similarly sized output loss as Uruguay in 2001, -14 percent, the optimal reserve-to-GDP ratio would in fact double, i.e. increase by 104 percent, for the Central American economies and increase by 68 percent for the full sample. and. This striking result, which is in contrast to the findings in e.g. Gonçalves (2007), is due to the fact that the Central American economies have not experienced such dramatic output losses during the period we study, and the effects of increases in the output loss parameter are quite dramatic.

Figure 3. Probability of a Crisis and Size of Output Loss



V. Concluding Remarks

This paper applies a host of methods to discuss adequacy and demand drivers for international reserves in Central America and a comparator group of emerging markets. Our results show that the region scores relatively low on traditional reserve benchmarks such as reserves to months of imports or short-term external debt and current account positions. We also find that after controlling for determinants of reserve demand commonly found in the literature, such as openness of the economy, exchange rate flexibility, financial depth and external debt stocks in a panel data framework with a large sample of emerging markets, Central America stands out as having significantly lower reserve-to-GDP ratios. We however find evidence of a "keeping up with the Joneses" effects, i.e. that the Central American countries in our sample take into account the reserve accumulation of the large emerging markets in Latin America when making policy decisions.

We also investigate t optimal reserve-to-GDP ratios using the framework developed by Jeanne and Rancière (2006) and Gonçalves (2007), and again find that the actual reserve levels in Central America in many cases are lower than those prescribed by the model as optimal insurance against sudden stop of credit and withdrawal in part of dollar deposits.

The costs of reserve accumulation, such as the relatively low return on international reserves, quasi-fiscal costs stemming from sterilization operations, and the potential valuation losses associated with exchange rate movements, are non-negligible. Taken together, the results in this paper however suggest that further reserve accumulation is an important policy option for the economies in Central America. But it is however neither an uncomplicated nor the only alternative. First, it is important that further reserve accumulation is not seen as compromising the inflation targeting credibility of the countries that have committed to such regimes. The results from the reserve demand regressions also suggest that the need to accumulate foreign reserves could be mitigated by e.g. allowing for higher exchange rate flexibility and by bringing down short-term external debt. Moreover, several of the Central American countries studied swiftly accessed liquidity support from the IMF during the crisis. Given the increasing flexibility of IMF lending facilities and the usually temporary need for increased reserve coverage in times of heightened uncertainty, multilateral reserve pools not only remain the cheapest, but also in other respects an attractive means to obtain international reserves.

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Appendix 1: Data Sources

Variable	Source
Stylized facts	
International reserves	IFS, International Financial Statistics
Broad money (M2)	IFS, International Financial Statistics
GDP, real and nominal	World Economic Outlook Database
Current account deficit	World Economic Outlook Database
Private short-term foreign currency debt	Global Development Finance Database
Public short-term foreign currency debt	Global Development Finance Database
Foreign currency deposits	Global Development Finance Database
Total deposits	IFS, International Financial Statistics
Imports	World Economic Outlook Database
Exports	World Economic Outlook Database
CPIS portfolio investment	IFS, International Financial Statistics
Regression analysis	
Population	World Economic Outlook Database
Nominal effective exchange rate	IFS, International Financial Statistics
FDI	World Economic Outlook Database
Exports	World Economic Outlook Database
External debt	Global Development Finance Database
Optimal reserves models	
Banks' liquid foreign assets	National authorities
Reserve reqs. on FX deposits	National authorities
SDR Holdings	IFS, International Financial Statistics

Appendix 2: Results from Reserve Demand Regressions

Reserve demand regressions. Dependent variable: GIR/GDP

Variable	Coefficient/T-stat					
Population (log)	-0.009**	-0.013***	-0.008*	-0.010**	-0.005***	-0.008*
	(-1.96)	(-2.73)	(-1.86)	(-2.29)	(-2.36)	(-1.97
Openness	0.043***	0.0.031 ***	0.108 ***	0.103	0.127***	0.117***
	(6..15)	(4.60)	(9.62)	(8.79)	(12.35)	(9.82)
Exchange rate volatility	-.235**	-0.449 ***	-0.401 *-	0.206*	-0.181*	-0. 241*
	(-3.24)	(-3.74)	(-4.60)	(-1.70)	(-1.75)	(-1.87)
GDP volatility	0.073**	0.591*	0.0391	0.1 31	0.090	0. 101*
	(2.36)	(1.81)	(1.21)	(1.46)	(1.20)	(1. 37)
Financial depth	-0.0003	-0.0001*	-0.0001*	-0.000*	-0.000*	-0.000*
	-(0.93)	(-0.90)	(-0.29)	(-1.20)	(-1. 24)	(-.1.87)
Central America dummy	-0.0122*	-0. 134***	-0.028*	-0.029	-0.045*	-0.024
	(-1.74)	(--3.29)	(-1.54)	(-1.51)	(-1.74)	(-1.40)
Jones1* CA dummy/5	0.004	0.003	0.001	0.005	0.002	0.001
	(1.08)	(0.93)	(0.39)	(1.03)	(0.60)	(0.28)
Jones2*CA dummy/6	0.008***	0.006***	0.004***	0.004***	0.006***	0.004***
	(5.15)	(3.68)	(2.74)	(3.17)	(4.29)	(3.55)
FDI/GDP		0.36***	0.165***	0.190***	0.332***	0.191***
		(4.65)	(2.57)	(2.95)	(3.17)	(2.90)
Total debt/GDP			0.009*	0.006		
			(1.76)	(1.12)		
Short term debt/GDP					0.039**	0.031*
					(2.26)	(1.71)
Crisis dummy					0.004	0.94
					(1.08)	(0.69)

1/ Defined as (exports + imports)/GDP. 2/ Defined as the period standard deviation of the NCU/dollar exchange rate, over the period average. 3/ Defined as the period standard deviation of real GDP, over the period average. 4/ Defined as M2/GDP. ***, **, * denote results significant on the 1, 5 and 10% significance levels (one-sided t-tests). Robust standard errors in parentheses. Refers to the time period 1993-2008 and a panel of 52 emerging markets. 5/Average of other CA economies in sample. 6/Average of LA-5 economies.

Appendix 3: The Jeanne and Ranciere (2006) Model

Consider a small open economy in discrete time, t = 0,1, 2…There is one single good, consumed both domestically and abroad. The only source of uncertainty in the model is the risk of a sudden stop, i.e. an exogeneous loss of access to credit.

The domestic economy consists of a private sector and a government, where the former is modeled as representative consumer subject to the budget constraint

$$C_t = Y_t + L_t - (1 + r_t)L_{t-1} + Z_t \quad (1)$$

Where Y_t is domestic output, L_t is the foreign debt of the representative consumer, and Z_t is a transfer from the government. The interest rate r_t is constant, and the representative consumer does not default on her external debt.

Output and private external debt both grow at the same constant rate *g*, until the sudden stop occurs. In a sudden stop, debt cannot be rollovered and output falls by a fraction γ below its long-run growth path or potential growth rate. The consumer is assumed only to hold short-term external debt, and L_t hence falls to zero in a the sudden stop. After the sudden stop, L_t stays at zero, and output resumes it long-run growth rate.

The probability of a sudden stop occurs with probability π in each period. After the sudden stop, all uncertainty is resolved, and the economy resumes growing at $g < r$. For simplicity, only one sudden stop is assumed, although the results can be extended to multiple occurances.

Denote with the superscripts *b, d,* and *a* the periods *before*, *during* and *after* the sudden stop. Denoting by λ the level of private external debt as share of ouput in the pre-sudden stop period, the following set of equations sum up the assumptions so far:

$$Y_t^b = Y_t^a = (1+g)^t Y_0, Y_t^d = (1-\gamma)(1+g)^t Y_0 \quad (2)$$

$$L_t^b = \lambda(1+g)^t Y_0, L_t^d = L_t^a = 0, \quad (3)$$

where as earlier mentioned λ is the level of private external debt as a share of output in the pre-sudden stop period.

Unlike the private sector, the government can issue a long-term security that does not have to be repaid in a sudden stop. This security is a bond that yields one unit of the single good every period leading up to the sudden stop, and zero theerafter. The life expectancy of the bond is 1/ π and thus falls with the probability of a suddens stop to occur.

Before a sudden stop, the price of the security is equal to the sum of the present discounted value of the unit of good it pays in the next period (with certainty) and the expected market value of the security,

$$P = \frac{1}{1+r+\delta}[1 + (1 - \pi)P] \qquad (4)$$

which, after solving for P and assuming the the price of the security is constant before the sudden stop and zero thereafter, and that there is a positive term premium δ[12], becomes

$$P = \frac{1}{1+r+\delta} \qquad (5)$$

The long-term sercurity is used to finaance a stock of international reserves

$$R_t = PN_t \qquad (6)$$

Where N_t is the number of securities issued by the government in period *t*. Given that the government is assumed unable to issue any long-term security during the sudden stop, all reserves must be accumulated prior to that time.

Substitute N_t and N_{t-1} from the government's budget constraint using (6)

$$Z_t + R_t + N_{t-1} = P(N_t - N_{t-1}) + (1 + r)R_{t-1} \qquad (7)$$

to get an expression for the transfer before the sudden stop

$$Z_t^b = -\left(\frac{1}{P} - r\right)R_{t-1} = -(\delta + \pi)R_{t-1}. \qquad (8)$$

The transfer is negative, i.e. the government taxes the representative consumer in order to pay for reserve holdings, and this cost is proportional to the sum of the term premium and the probability of a sudden stop.

In the event of a suddent stop, the government transfers the remaining reserves net of the last payment on the long-term bond) to help the consumer pay the external debt that cannot be rolled over,

$$Z_t^d = (1 - \delta - \pi)R_{t-1} \qquad (9)$$

---

[12] The term premium does not include the default premium; it is instead included in the sudden stop probability π.

The assumption $\delta + \pi < 1$ ensures that this transfer is positive. After the sudden stop the government becomes inactive: R_t, N_t, and Z_t equal zero.

Use eqs. (8) and (9) to substitute Z_t from eq. 4 to obtain expressions for the level of domestic consumption before, during and after the sudden stop,

$$C_t^b = Y_t^b + L_t^b - (1+r)L_{t-1}^b - (\delta + \pi)R_{t-1} \quad (10)$$

$$C_t^d = (1-\gamma)Y_t^b - (1+r)L_{t-1}^b + (1-\delta-\pi)R_{t-1} \quad (11)$$

$$C_t^a = Y_t^a \quad (12)$$

From eqs. (11) and (12) the trade-off involved in choosing the optimal level of reserves is clear, as well as the consumption insurance role played by reserves. By increasing R_{t-1}, consumption can be increased during the sudden stop, but lowers it if no sudden stop occurs.

The model is closed by assuming that the government maximizes the welfare of the representative consumer

$$U_t = \sum_{s=0,\dots,+\infty}(1+r)^{-s}\, u(C_{t+s}) \quad (14)$$

Where the utility function is characterized by constant relative risk aversion (CRRA)

$$u(C) = \frac{C^{1-\sigma}-1}{1-\sigma} \quad (15)$$

The governement chooses the level of reserves R_t so as to maximize U_t in each period *t* before the sudden stop. The optimal level of reserves in period *t* mazimizes the expected utility of period $t + 1$ consumption

$$R_t = \arg\max\ (1-\pi)u(C_{t+1}^b) + \pi u(C_{t+1}^d) \quad (16)$$

and C_{t+1}^b and C_{t+1}^d given by eqs. (10) and (11).

The first-order condition is given by

$$\pi(1-\delta-\pi) = (1-\pi)(\delta+\pi)u'\left(C_{t+1}^b\right) \quad (17)$$

The left-hand side of eq. (17) is given by the product of the probability of the occurrence of a sudden stop and the marginal benefit of reserves in the event of a sudden stop, which is equal to the probability of no sudden stop times the marginal cost of holding reserves.

The above first-order condition can be manipulated to obtain a closed-form expression for the optimal level of reserves. Denote by p_t the marginal rate of subsitution between consumption in the respective states of sudden stop and no sudden stop, or the liquidity premium of reserves in the event of a suddent stop

$$p_t \equiv \frac{u'(C_t^d)}{u'(C_t^b)} \tag{18}$$

According to the first order condition (17), when reserves are set optimal this marginal rate of subsitution should be constant and equal to

$$p \equiv \frac{1-\pi}{\pi}\frac{\delta+\pi}{1-\delta-\pi} = 1 + \frac{\delta}{\pi(1-\delta-\pi)} \tag{19}$$

If the term premium δ is equal to zero, then p is equal to 1, implying that domesticconsumption is perfectly insured against the risk of a suddens stop, $C_t^d = C_t^a$. If the term premium is strictly positive, then $p > 1$, and domestic consumption lower in a sudden stop.

Use the first-order condition $(C_t^d) - \sigma \quad = p(C_t^b)^{-\sigma}$ and the expressions for C_t^d and C_t^b to show that the optimal level of reserves during normal times is a fixed level of output:

$$R_t = \rho Y_{t+1}^b \tag{20}$$

By using eq. (20), toghether with eqs. (2) and (3), together with the first order condition and the expressions for C_t^d and C_t^b, one can solve for the optimal-reserve-to-GDP ratio ρ:

$$\rho = \lambda + \gamma - \frac{p^{1/\sigma}-1}{1+\left(p^{1/\sigma}-1\right)}\left(1 - \frac{r-g}{1+g}\right)\lambda - (\delta + \pi)(\lambda + \gamma) \tag{21}$$

A good approximation to the exact formula, in the range of parameter values considered in the calibration, can be obtained by setting $\delta + \pi = r - g = 0$ in the last term of eq. (21)

$$\rho = \lambda + \gamma - (1 - p^{1/\sigma}) \tag{22}$$

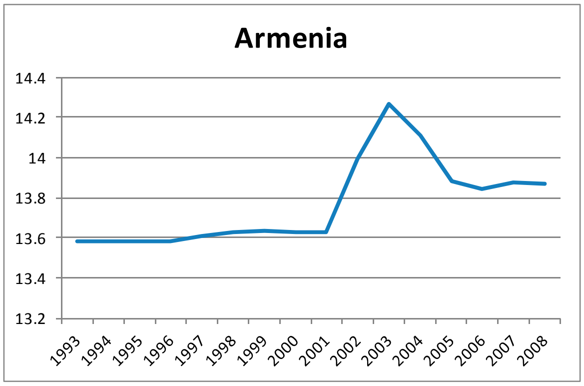
This approximate formula shows that the optimal level of reserves is increasing one for one with the amount of short-term debt and the output cost of a sudden stop. As noted earlier, if the term premium is equal to zero, then p is equal to one, and reserves should be set to the level that perfectly smoothes the impact of the sudden stop on domestic consumption, $\rho = \lambda + \gamma$. The optimal level of reserves falls with an increase in ρ, which in turn could be caused by a decrease in the probability of a sudden stop, π, or an increase in the term premium δ. An increase in the risk aversion parameter σ decreases $p^{1/\sigma}$ and raises the optimal level of reserves.

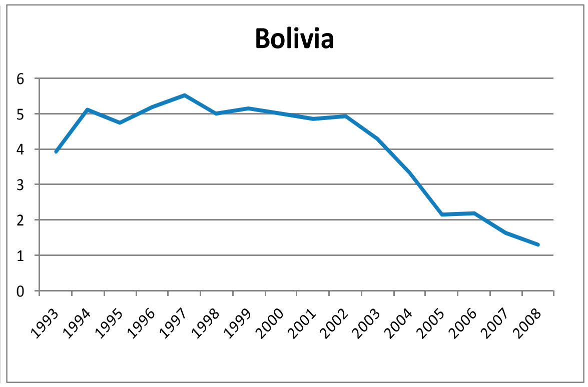
Note that in this model, the optimal level of reserves could be lower and higher than the Greenspan-Guidotti rule, which states that the ratio of reserves to short-term debt should be equal to one, i.e.

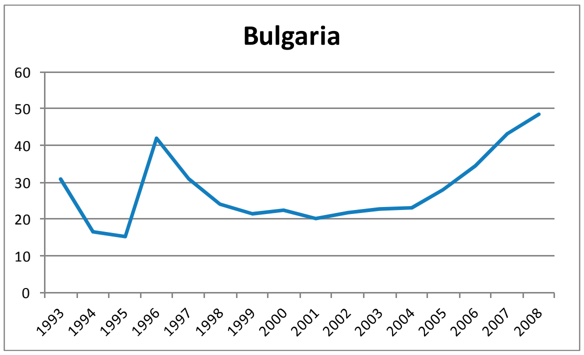
$$\rho = \lambda$$

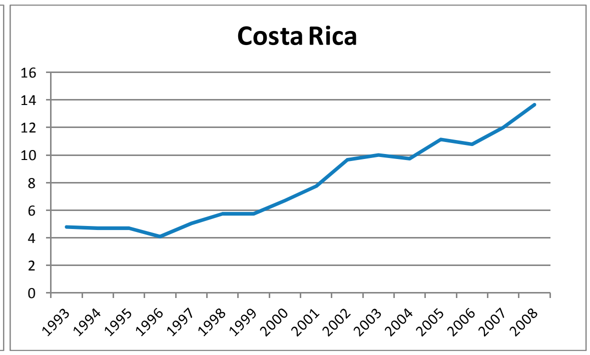
which means that consumption is perfectly smoothed in a sudden stop if there is no output cost. As shown by equation (22), the optimal level of reserved spelled out by the model could be higher or lower than this rule. As captured by γ, the optimal level could be higher since reserves smooth the impact of the output loss. On the other hand the optimal level could be lower, due to the cost of reserves captured by $(1 - p^{1/\sigma})$.

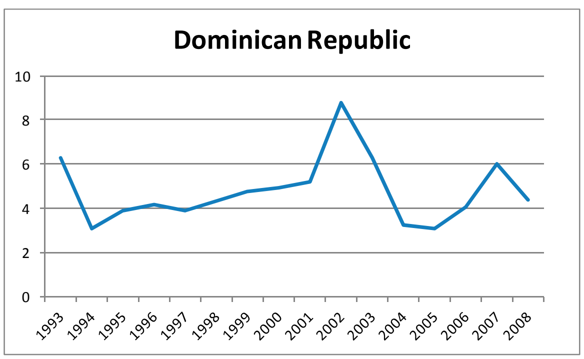
Appendix 4. Optimal Reserves According to the Jeanne and Rancière (2006) Model

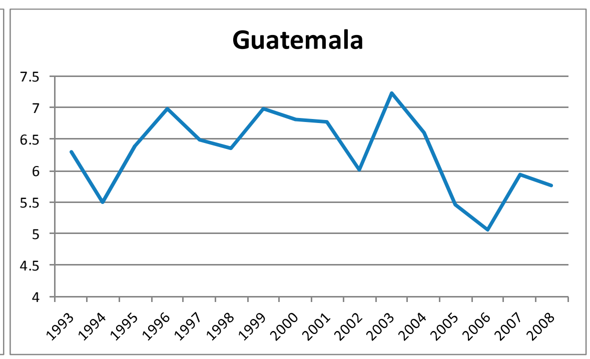


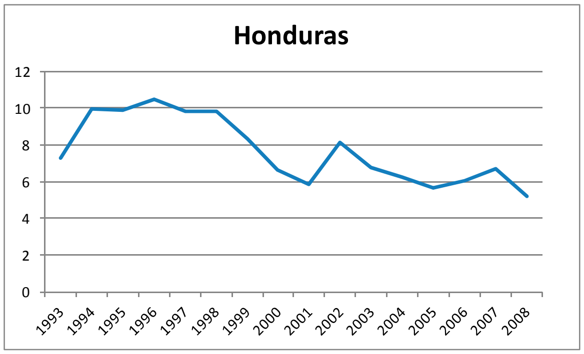








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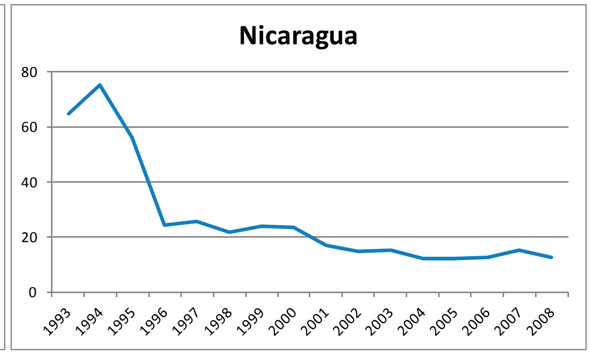
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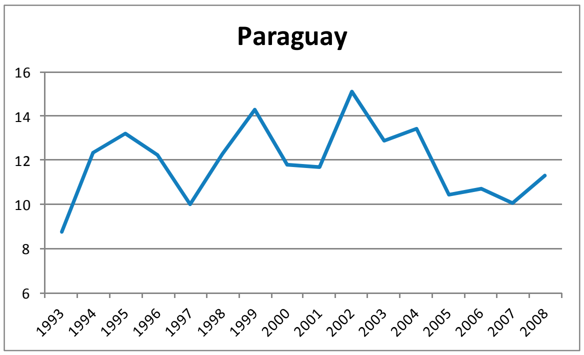
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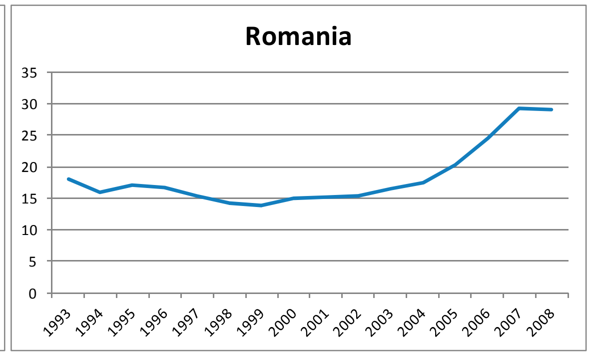
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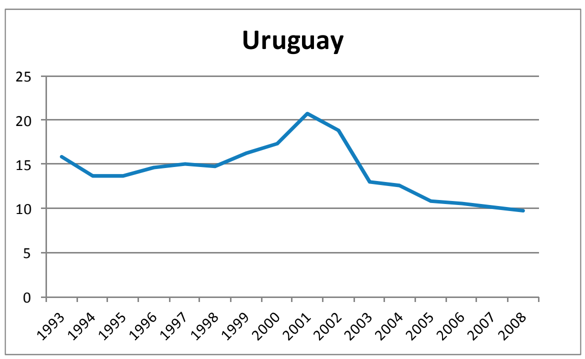
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