Optimal Holdings of International Reserves: Self-Insurance Against Sudden Stops

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Motivation

- Prior to the financial crisis, little was done to improve the resilience of EMs against Sudden Stops (SS), despite multiple official pronouncements about the need to find a new *Financial Architecture.*
- EM policymakers had strong incentives to self-insure by accumulating International Reserves (IRs).
- More recently, new instruments have been developed (FCLs, PLLs) but they are not widely used. As pointed out by Marino and Volz (2012):
  - Entry problem: Potential stigma of IMF involvement
  - Exit problem: graduation from precautionary agreements may signal country no longer qualifies and worsen financial conditions

Motivation

- Following substantial increase in IRs in several EMs following SS episodes throughout the 1990s raises two questions:
  - Are EMs over accumulating IRs?
  - Is this accumulation consistent with a self-insurance motive?

Related Literature

- Concept of holding international reserves for precautionary reasons is not new.
- Heller (1966).
  - Shocks to the trade balance
  - First to quantify optimal reserve levels for a large set of countries by weighting the adjustment costs resulting from external imbalances that cannot be met with reserves against the opportunity cost of holding reserves.
- Garcia and Soto (2004):
  - Larger amounts of IRs could imply that countries avoid costly liquidation of assets.
  - Reserves/ST liabilities affect probability of SS, however mechanism is not explicitly stated, indicators of external liabilities (factor that could be considered relevant in terms of providing a source of risk justifying the need to accumulate reserves) turn out not to be significant
  - Alternative *assumptions* about the costs of a crisis (from 5% to 15% of GDP)

Related Literature

- Jeanne and Ranciere (2006)
  - Model that incorporates the benefit of holding international reserves in sustaining domestic absorption in times of a SS
  - Expected costs of SS: Probability of SS exogenous to stock of reserves (probit model), cost of SS (sample average difference in the output growth rate in SS times relative to tranquil times).
  - Jeanne (2007) incorporates international reserves as a determinant of the probability of crises but finds no significant effect.
- Gonçalves (2007)
  - Include coverage of dollar deposit withdrawals during a SS as an additional element to consider at the time of choosing optimal reserves
  - does not incorporate a role for reserves either in affecting the probability of a Sudden Stop or the cost of a crisis.

Our approach

- Builds on this precautionary approach literature and makes the following contributions:
  - Endogenize both the probability of a SS *and* the costs of a crisis through empirical models linked to balance-sheet effects.
  - Provides a rationale for the inclusion of IRs in the determination of the probability of a SS as well as output costs, as they constitute an instrument that offsets potential balance-sheet effects stemming from large Domestic Liability Dollarization (DLD).
  - Instead of selecting parameters to calibrate a first order condition to match data on reserves and costs of crisis, we estimate empirical models of the probability of a SS and of costs using country specific data on their determinants
  - We then use FOC to put pieces together
  - However, as it will become clear later, assumptions need to be made regarding the level of precaution of policy makers (i.e., picking most conservative scenario).

The Model

- Assumption: CBs conservatively choose the stock of reserves (R) by balancing the expected cost of a SS against the opportunity cost of holding reserves.

- Reserves affect expected cost of a SS
  - Reduce the probability of a SS $P(SS = 1|R)$
  - Reduce the costs associated with SS $K(R|SS = 1)$

- Determinants of the probability of a crisis − including international reserves − are in and of themselves also determinants of the cost of a crisis.

The Model

- Formally, it is assumed the CBs seek to minimize a cost function of the form:

$$L(R) = \underbrace{P(SS = 1|R)K(R|SS = 1)}_{\text{Expected output cost of a SS}} + \underbrace{\rho R}_{\text{Opportunity cost of holding reserves}}$$

FOC: $P'K + K'P + \rho = 0$

Empirical Implementation

Probability of SS

- Calvo, Izquierdo and Mejia (2008) identify as key factors: DLD & Potential RER changes
- We consider the potential offsetting impact that IR could have on hazard caused by DLD: $NetDLD = DLD - R$
- Probit Model:

$$P(SS_t = 1) = \Phi\left(\alpha_0 + \alpha_1(1-\omega_{t-1}) + \alpha_2(NetDLD_{t-1}) + X\beta + \sum_i \eta_i time\_dum_i\right)$$

where:

- SS is defined à la CIM (2008)
- (*1-ω*): ΔRER that results from a stop in financing of CAD, a function of CAD/Z (where Z is the absorption of tradable goods)
- *X*: set of control variables (financial integration, TOT, Fiscal Balance, etc.)
- *time_dum:* yearly time dummies (capture changing external conditions)

- Sample: 110 countries (21 developed economies, and 89 developing countries) for the period 1992-2004.

Systemic Sudden Stops: Definition

- We look for measures of SS that reflect large and unexpected falls in capital inflows that coincide with with international financial turmoil.

- A 3S phase meets the following criteria:

  - Has at least one observation where the year-on-year fall in capital flows lies at least two standard deviations below its sample mean.

  - Phase ends once the change in capital flows is less than one standard deviation below its sample mean.

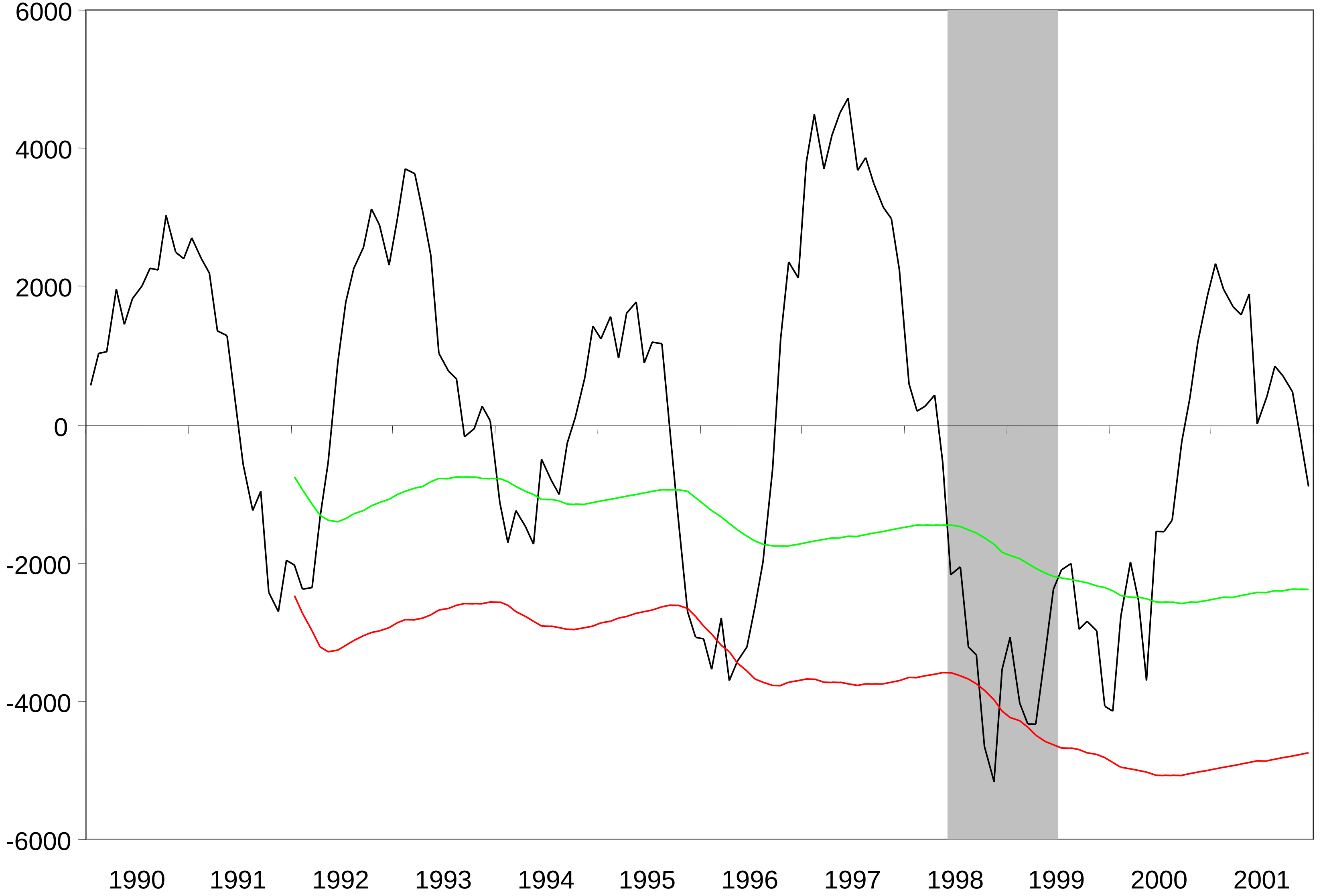
  - Phase starts the first time the change in capital flows falls one standard deviation below the mean (symmetry).

  - This phase coincides with a spike exceeding two standard deviations in aggregate spreads (EMBI)

- We work with monthly data (proxy nets out the trade balance from changes in international reserves).

- Sample: 110 countries (89 developing, 21 developed), spanning 1990-2004.

Sudden Stops: An Example



Reasoning behind Changes in RER at Time of Sudden Stop

- Our approach: shocks to the financing of the current account and effects over the real exchange rate (RER).

- Demand function for nontradables:

  - $h_t = \alpha + \beta\, rer_t + \delta\, z_t$ (Eq. 1)

  where *h* and *z* are (the log of) the demand for nontradables and tradables (RER=p*/p).

- Current account deficit (*CAD*):

  - $CAD_t = Z_t - Y^*_t + S_t$ (Eq. 2)

  where Y^* is output of tradables and *S* are factor payments, remittances abroad, etc.

Reasoning behind Changes in RER at Time of Sudden Stop (cont.)

- When CAD_t is driven down to zero, given Y and S:

$$\Delta CAD_t = \Delta Z_t \qquad \text{(Eq. 3)}$$

$$CAD_{t-1} / Z_{t-1} = -\Delta Z_t / Z_{t-1} \qquad \text{(Eq. 4)}$$

- Then, from Eqs. 1 and 4, and assuming that the supply of nontradables is constant, in equilibrium we find:

$$\Delta rer_t = (\delta / \beta)\, CAD_{t-1} / Z_{t-1} = (\delta / \beta)\,(1-\omega) \qquad \text{(Eq. 5)}$$

where $\omega = (Y^* - S^*)/Z$ = un-leveraged absorption ratio

- Also notice that lower β (lower elasticity of substitution between tradables and nontradables) implies bigger RER adjustment.

- This is not the <u>actual</u> change in the RER but the part of the total change that the country finds difficult to prevent.

Balance Sheet Effect: DLD Definition

- We construct a proxy for credit in foreign currency extended by the domestic banking system as a share of GDP (size of the burden matters, not share of total credit; difference with Arteta (2003), Edwards (2003))

- For developing countries, we add dollar deposits to bank borrowing in foreign currency, and assume currency matching of bank assets and liabilities due to regulatory measures

- For developed countries, it is actual BIS data on credit in foreign currency

Empirical Implementation

Probability of SS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
$(1-\omega)_{t-1}$	1.430***	1.925***	2.119***	2.391***	2.340***	2.301***	2.068***	1.974***	1.969***	1.967***	1.601**
	(0.529)	(0.720)	(0.721)	(0.738)	(0.737)	(0.745)	(0.727)	(0.738)	(0.738)	(0.740)	(0.800)
Net DLD_{t-1}	1.594***	3.404***	3.253***	3.203***	3.137***	3.126***	2.750***	2.547***	2.532***	2.504***	2.536***
	(0.513)	(0.850)	(0.945)	(0.921)	(0.922)	(0.924)	(0.882)	(0.879)	(0.879)	(0.883)	(0.897)
Portfolio Int_{t-1}		-5.221***	20.36***	19.19***	20.46***	19.53***	19.21***	16.56**	16.57**	16.37**	15.82**
		(1.536)	(6.926)	(6.734)	(7.031)	(7.115)	(6.963)	(6.726)	(6.734)	(6.770)	(6.804)
(Portfolio $Int_{t-1})^2$			-153.3***	-145.1***	-146.8***	-141.0***	-138.9***	-121.3***	-121.6***	-121.0**	-114.5**
			(50.420)	(49.240)	(49.910)	(49.620)	(48.840)	(46.770)	(46.880)	(47.130)	(47.120)
FDI Int_{t-1}				-0.181	-0.165	0.0346	-0.00724	0.0688	0.067	0.0738	-0.043
				(0.595)	(0.592)	(0.602)	(0.582)	(0.593)	(0.593)	(0.595)	(0.613)
$Developing_{t-1}$					0.323	0.308	0.344	0.391	0.384	0.443	0.268
					(0.455)	(0.457)	(0.431)	(0.432)	(0.431)	(0.452)	(0.500)
TOT $growth_{t-1}$						-0.258	-0.297	-0.602	-0.595	-0.58	-0.403
						(0.738)	(0.756)	(0.782)	(0.783)	(0.785)	(0.809)
(Gov. Balance/GDP)$_{t-1}$							-0.005	-0.005	-0.005	-0.005	-0.005
							(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
$LYS3_{t-1}$								0.097			
								(0.114)			
$LYS5_{t-1}$									0.060	0.061	0.059
									(0.074)	(0.074)	(0.076)
(M2/Reserves)$_{t-1}$										0.005	0.007
										(0.011)	(0.012)
(For. Debt/GDP)$_{t-1}$											0.000
											(0.000)
Constant	-3.281***	-3.456***	-3.824***	-3.708***	-4.008***	-4.036***	-3.886***	-4.023***	-4.032***	-4.114***	-3.877***
	(0.332)	(0.460)	(0.496)	(0.520)	(0.677)	(0.684)	(0.662)	(0.704)	(0.713)	(0.739)	(0.756)
Observations	1,101	951	951	941	941	922	868	814	814	813	677
# Countries	110	95	95	94	94	90	84	83	83	83	72

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Time dummies included in all regressions.

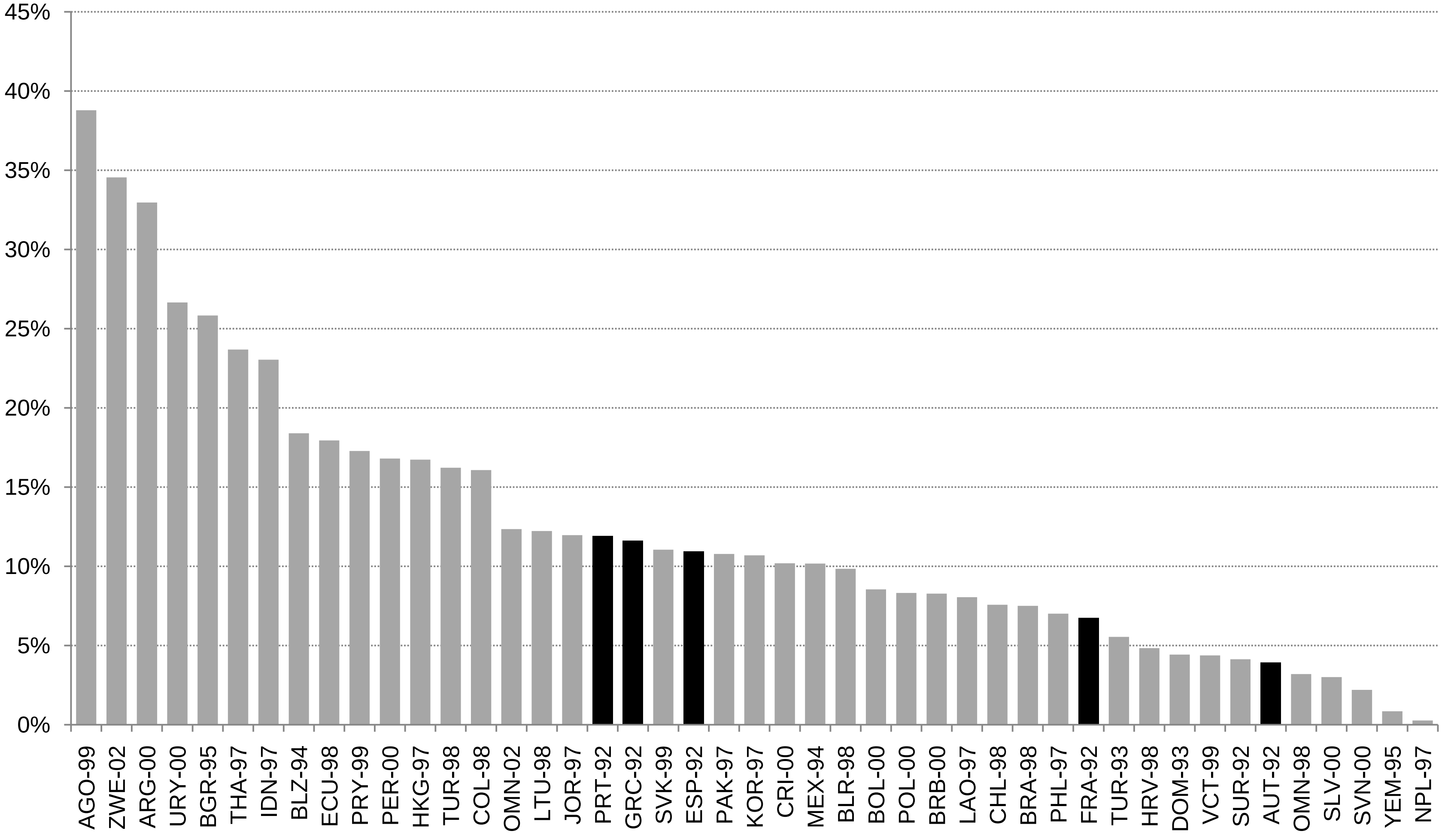
Empirical Implementation

Output Costs

Step 1: Definition of output costs ($K_{T,i}$)

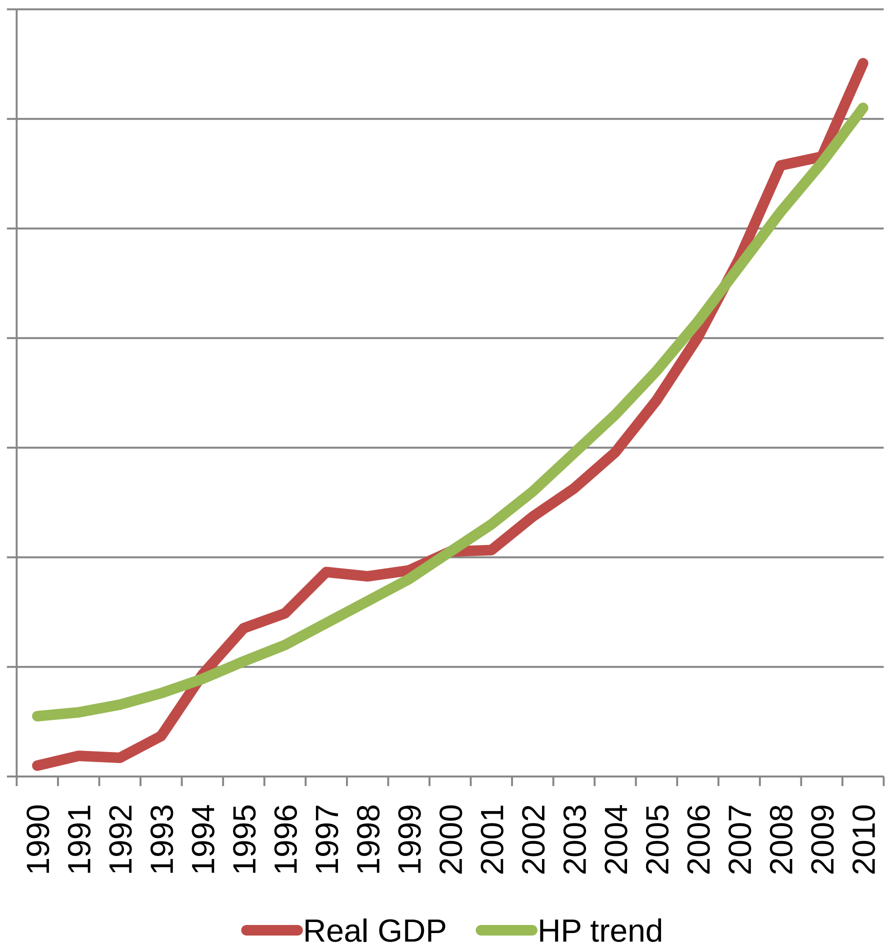
- For each country included in our Probit estimation, we compute the present discounted sum of any contiguous negative output gaps measured as the percentage difference between observed GDP and its corresponding HP trend.
  - Discount rate: 10%
  - HP Trend: 1980-2010
- For each episode, we denote T as the period immediately prior to GDP falls below trend.
- Filter episodes in which a Systemic Sudden Stop occurs in a 3-year window centered at T $[K(R|SS=1)]$

Output Costs of Sudden Stops



Note: Black bars indicate identified episodes in Developed countries.

Peru 2000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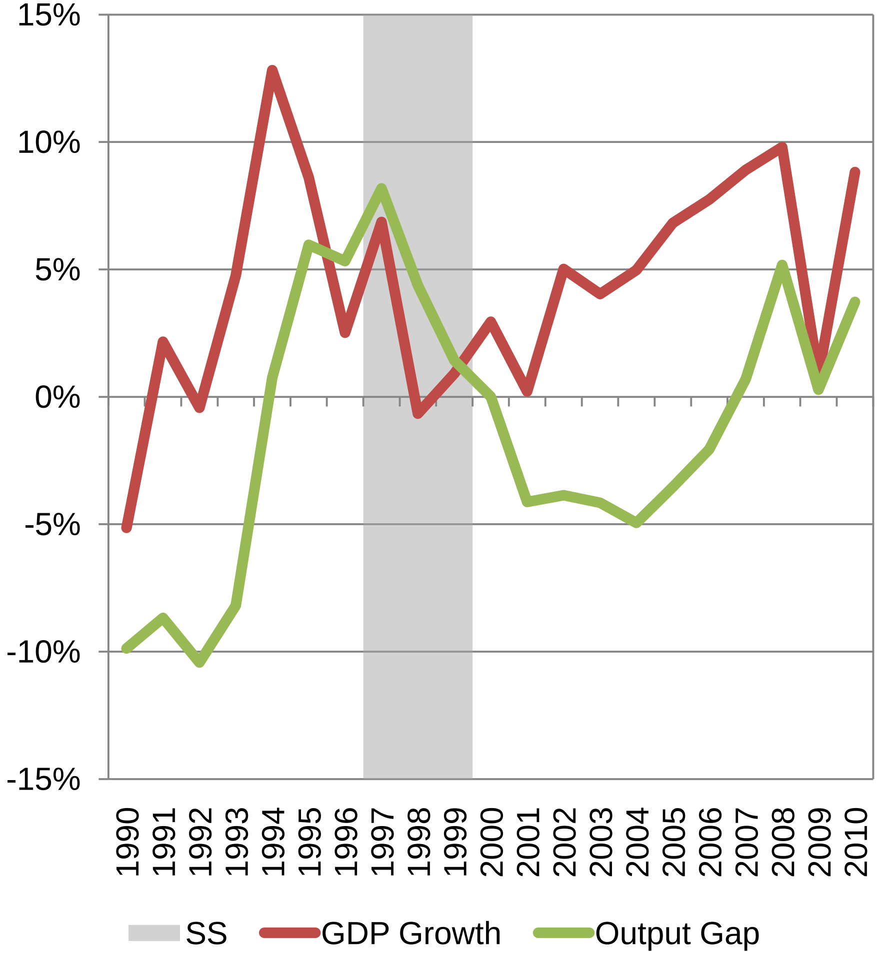
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SS
GDP Growth
Output Gap

Empirical Implementation
Output Costs

<u>Step 2</u>: Estimation of output cost functions

- No easy task: Policy responses affect output dynamics during crisis
  - Endogeneity issues.
- To the extent that investor predictions are right in the sense that the factors describing the vulnerability to a SS are valid, then these same factors could be a good predictor of the size of a crisis.
  - Ability of governments to respond to the crisis will depend on pre-existing vulnerabilities and the size of the shock
- Note that *Net DLD* and Fiscal Balance proxy the ability to conduct counter-cyclical monetary and fiscal policies during crisis.

Empirical Implementation
Output Costs

<u>Step 2</u>: Estimation of output cost functions

- We estimate functions of the form:

$$K_{T,i} = \phi_0 + \phi_1\left(1-\omega_{T,i}\right) + \phi_2\left(NetDLD_{T,i}\right) + X_{T,i}\gamma + \sigma ShockSize + \varepsilon_{T,i}$$

where *ShockSize* is change in the aggregate spreads before and after each Systemic Sudden Stop associated with a fall in output.

- <u>Aggregate</u> spreads to capture changes in international liquidity
- EMs: EMBI spread / DMs: Average European Sov. Spreads over German bonds.

Empirical Implementation
Output Costs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$(1\text{-}\omega)_T$	-0.188	-0.223	-0.222	-0.200	-0.195	-0.197	-0.229	-0.254
	(0.137)	(0.175)	(0.178)	(0.180)	(0.187)	(0.187)	(0.190)	(0.200)
Net DLD_T	0.150**	0.177***	0.176**	0.171**	0.171**	0.173**	0.171**	0.168*
	(0.062)	(0.063)	(0.065)	(0.070)	(0.074)	(0.074)	(0.079)	(0.089)
$(\text{Gov. Balance/GDP})_T$	-0.884***	-0.976***	-1.003***	-0.951**	-0.945**	-0.945**	-0.981**	-0.876**
	(0.209)	(0.199)	(0.329)	(0.413)	(0.437)	(0.430)	(0.402)	(0.412)
Portfolio Int_T		0.673**	0.697*	0.816*	0.807	0.811	0.922*	0.960*
		(0.308)	(0.390)	(0.427)	(0.488)	(0.489)	(0.486)	(0.494)
FDI Int_T			-0.011	-0.047	-0.048	-0.047	-0.057	-0.083
			(0.084)	(0.094)	(0.099)	(0.098)	(0.090)	(0.100)
TOT $growth_T$				0.111	0.114	0.111	0.121	0.229
				(0.193)	(0.194)	(0.197)	(0.201)	(0.228)
$LYS3_T$					-0.005			
					(0.018)			
$LYS5_T$						-0.002	-0.001	0.005
						(0.011)	(0.012)	(0.013)
$(\text{M2/Reserves})_T$							-0.002	-0.003
							(0.002)	(0.002)
$(\text{For. Debt/GDP})_T$								2.44E-05
								(0.000)
Shock Size	0.006*	0.008**	0.008**	0.009**	0.009*	0.009*	0.008*	0.009*
	(0.003)	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Constant	0.049**	0.007	0.006	0.009	0.020	0.015	0.031	0.020
	(0.024)	(0.036)	(0.037)	(0.034)	(0.066)	(0.071)	(0.074)	(0.086)
Observations	37	35	35	34	33	33	33	31
R-squared	0.41	0.46	0.46	0.47	0.46	0.46	0.47	0.52

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Empirical Implementation

Opportunity Cost of Holding Reserves

- Average of JP Morgan’s EMBI+ sovereign spread.

- *Rationale*: government can choose between paying back debt (in which case it foregoes interest payments at the ongoing public bond rate), or holding reserves (in which case it earns the risk free rate).

Optimal Reserves

- With empirical estimates of $P(SS=1|R)$, $K(R|SS=1)$ and ρ, FOC condition becomes:

$$\frac{\alpha_2}{\sqrt{2\pi}} e^{-A^2/2} B + \phi_2 \int_{-\infty}^{A} \frac{1}{\sqrt{2\pi}} e^{-t^2/2} dt + \rho = 0$$

with:

$$A = \alpha_0 + \alpha_1 (1-\omega) + \alpha_2 (NetDLD) + X\beta + \overline{\eta}$$

$$B = \phi_0 + \phi_1 \left(1 - \omega_{T,i}\right) + \phi_2 NetDLD_{T,i} + X_{T,i}\gamma + \sigma ShockSize$$

$$NetDLD = DLD - R^*$$

where:

$\overline{\eta}$ is the estimated coefficient of the time dummy that the policymaker believes reflects global financial conditions

R^* is the optimal level of reserves

Optimal Reserves

- Although country-specific variables used in both Probit and output costs estimations can be chosen for each point in time, a decision that remains to be made relates to the size of the shock for which countries will insure when deciding on their optimal reserve level.

- Policymakers may face uncertainty in choosing amongst different specifications of the probability of a SS and the SS cost function.

- To tackle both issues, we follow Hansen and Sargent (1998), and assume that the policymaker implements a robust policy by minimizing the objective function for the most conservative model

Optimal Reserves

- Model uncertainty: each model is defined as a triplet of a Probit equation, a cost function and a particular size of the external shock.

- We calculate optimal reserves for each combination of Probit estimations and estimated cost functions, assuming the maximum size of the external shock in both cases
- For Probit, we take the maximum estimated coefficient of the set of time dummies (1999). For cost equations, we use the maximum shock size observed in the sample (1999)

  - Specifications with non-significant controls are excluded.

- Most parsimonious turns out to yield the larger optimal reserve level
  - Probability of SS: NetDLD, 1- ω
  - Output costs of SS: NetDLD and the fiscal balance

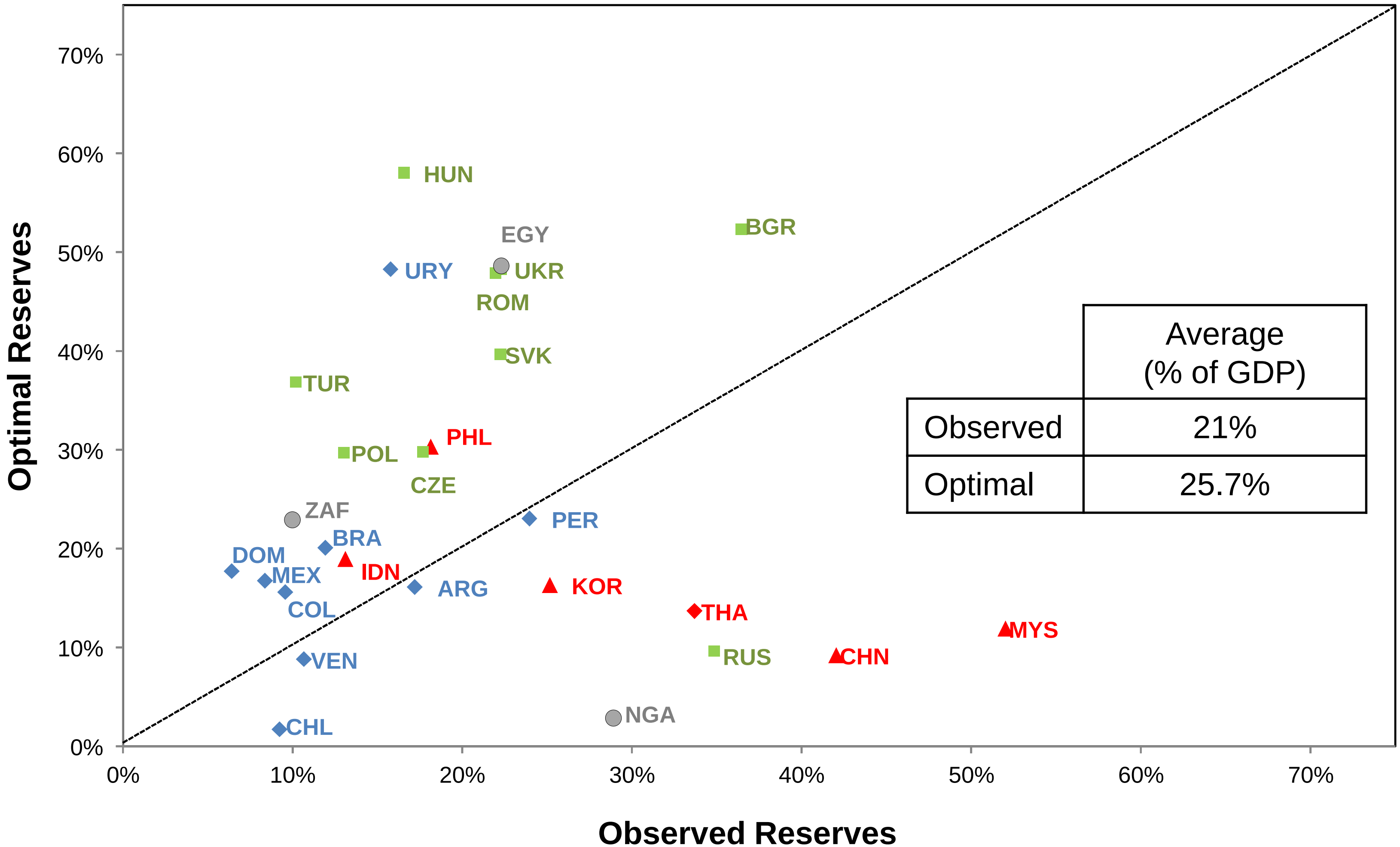
Sample of Countries

- We calculate the optimal level of international reserves as of 2007 for a set of 27 Emerging Economies.
  - Focus on economies that belong to JP Morgan's EM Bond Index.
  - Assessing how well prepared they were to withstand the 2008/2009 global financial crisis.

Emerging Asia (6)	**Latin America (9)**	**Emerging Europe (9)**	**Other Emerging (3)**
China	Argentina	Bulgaria	Egypt
Indonesia	Brazil	Czech Republic	Nigeria
Korea	Chile	Hungary	South Africa
Malaysia	Colombia	Poland	
Philippines	Dominican Rep.	Romania	
Thailand	Mexico	Russia	
	Peru	Slovakia	
	Uruguay	Turkey	
	Venezuela	Ukraine	

Optimal vs. Observed Reserves

(as of 2007, % of GDP)

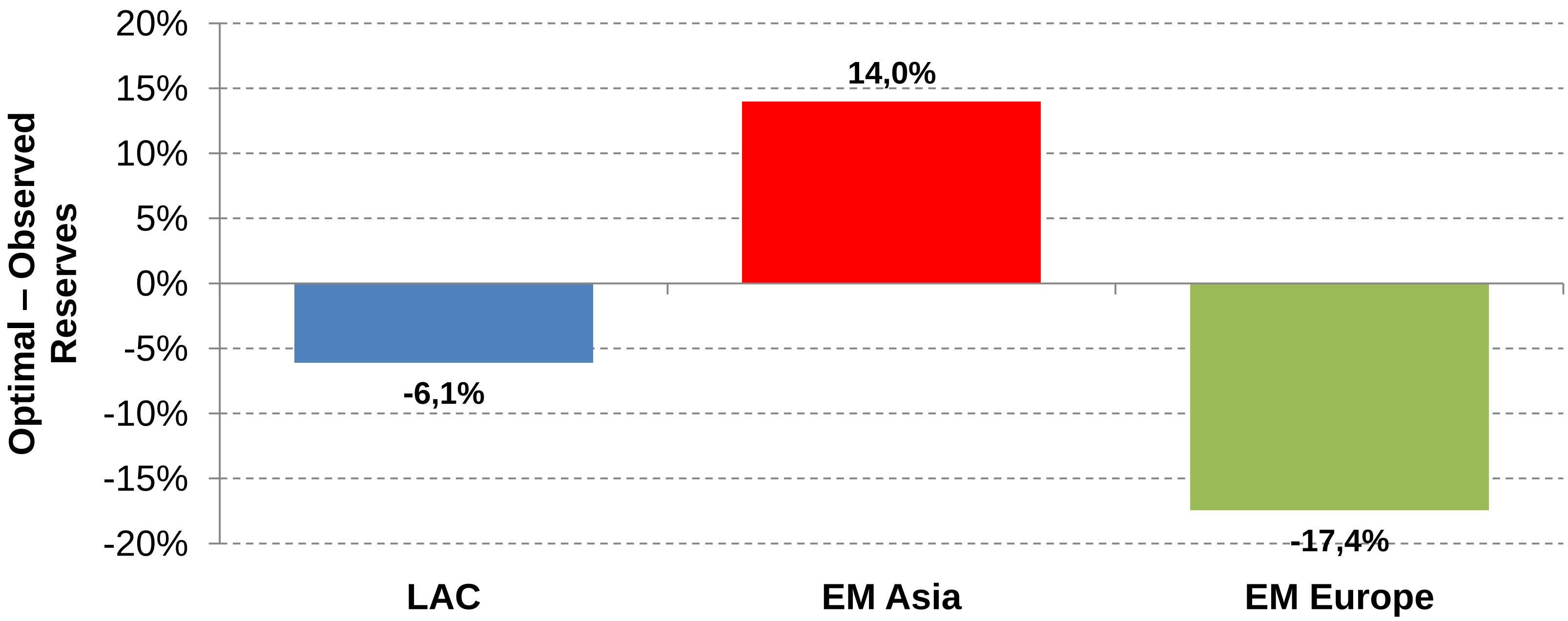


	Average (% of GDP)
Observed	21%
Optimal	25.7%

Out of 27, only 10 display higher-than-optimal reserves.

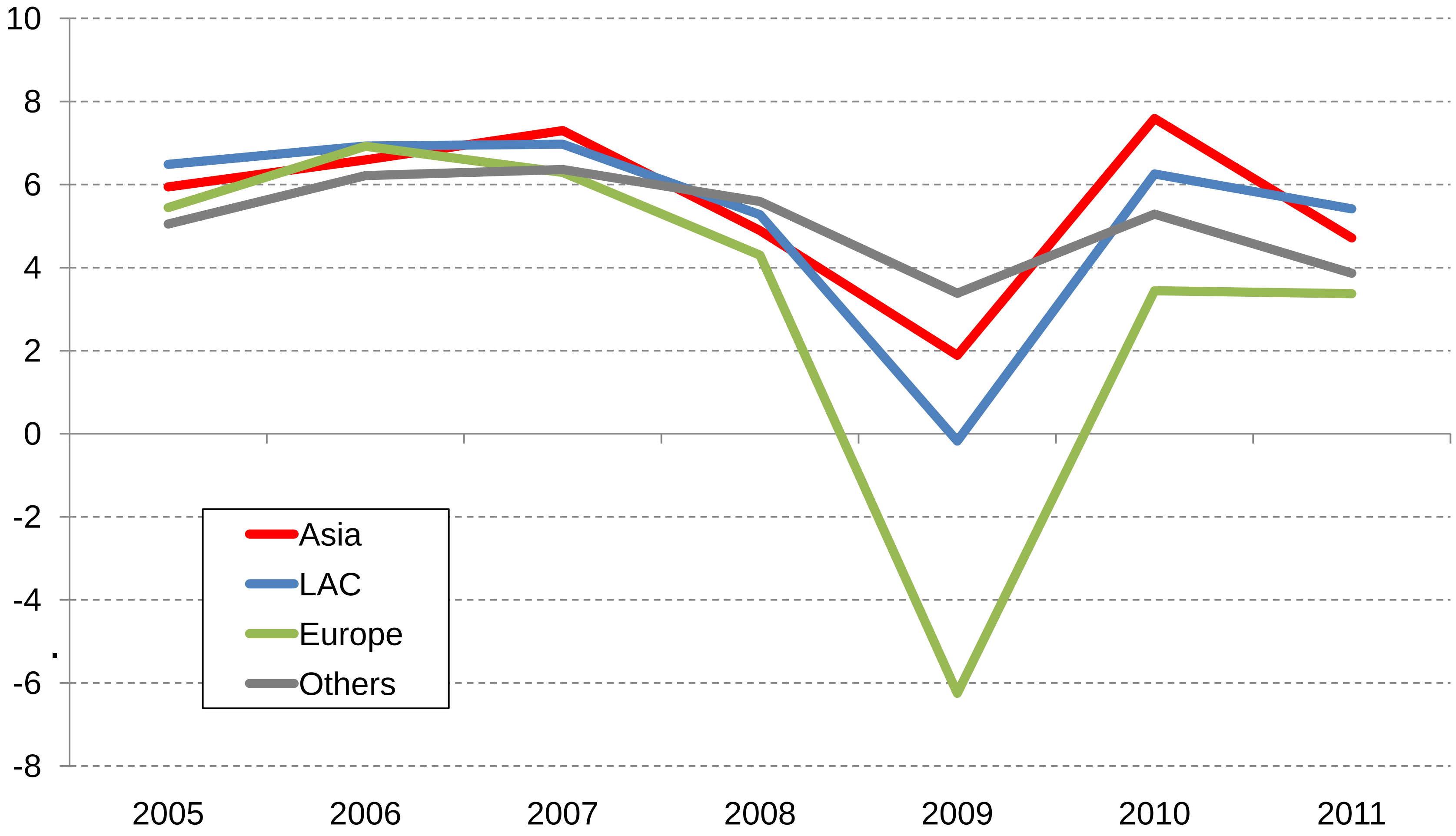
Optimal vs. Observed Reserves

(as of 2007, % of GDP)



- Overall, these results suggest that, on average, LAC and Asian countries were better positioned in 2007 to weather Sudden Stops relative to Eastern European economies.
- Results are consistent with the relative performance of these economies in the aftermath of the 2008 US financial crisis, after which LAC and East Asia came out relatively unscathed, while Eastern Europe fell into deep recession.

GDP growth



Source: WB- WDI

Explaining Deviations from Optimal

- Low self-insurance levels in Eastern European Countries
  - Presence of the European Union (EU) as a de-facto lender of last resort could have mitigated the perceived need for self-insurance.
- Oil exporters (Nigeria and Russia) display higher than optimal reserves
  - Reserve accumulation as mechanism to save proceeds of oil for inter-temporal smoothing of consumption of oil resources across generations.
- To analyze whether deviations of observed reserves from precautionary-motive optimal reserves are in any way associated with alternative motives, we run regressions of reserve deviations (observed minus optimal reserves) against measures of:

Perceived lender of last resort comfort	- % of EU foreign bank lending in domestic credit to the private sector - No access to IMF financing (ARG, VEN)
Relevance of oil production	Oil trade balance as a share of GDP
Mercantilist approach	Deviations of the REER from its 5-year MA

Explaining Deviations from Optimal

	(1)	(2)	(3)
Oil Balance/GDP	0.696***	0.674***	0.738***
	(0.226)	(0.269)	(0.239)
EU Foreign Bank Lending	-0.175**	-0.184**	-0.174**
	(0.068)	(0.071)	(0.069)
REER Gap		0.252	
		(0.331)	
No Access to ILOR			-0.0402
			(0.066)
Constant	0.0215	0.0741	0.0241
	(0.053)	(0.066)	(0.056)
Observations	27	23	27
R-squared	0.312	0.322	0.314

- Users of EU foreign lending are prone to holding lower amounts of reserves relative to optimal levels
- Oil producers tend to hoard more reserves than those deemed optimal from a precautionary standpoint
- No evidence for mercantilist motive

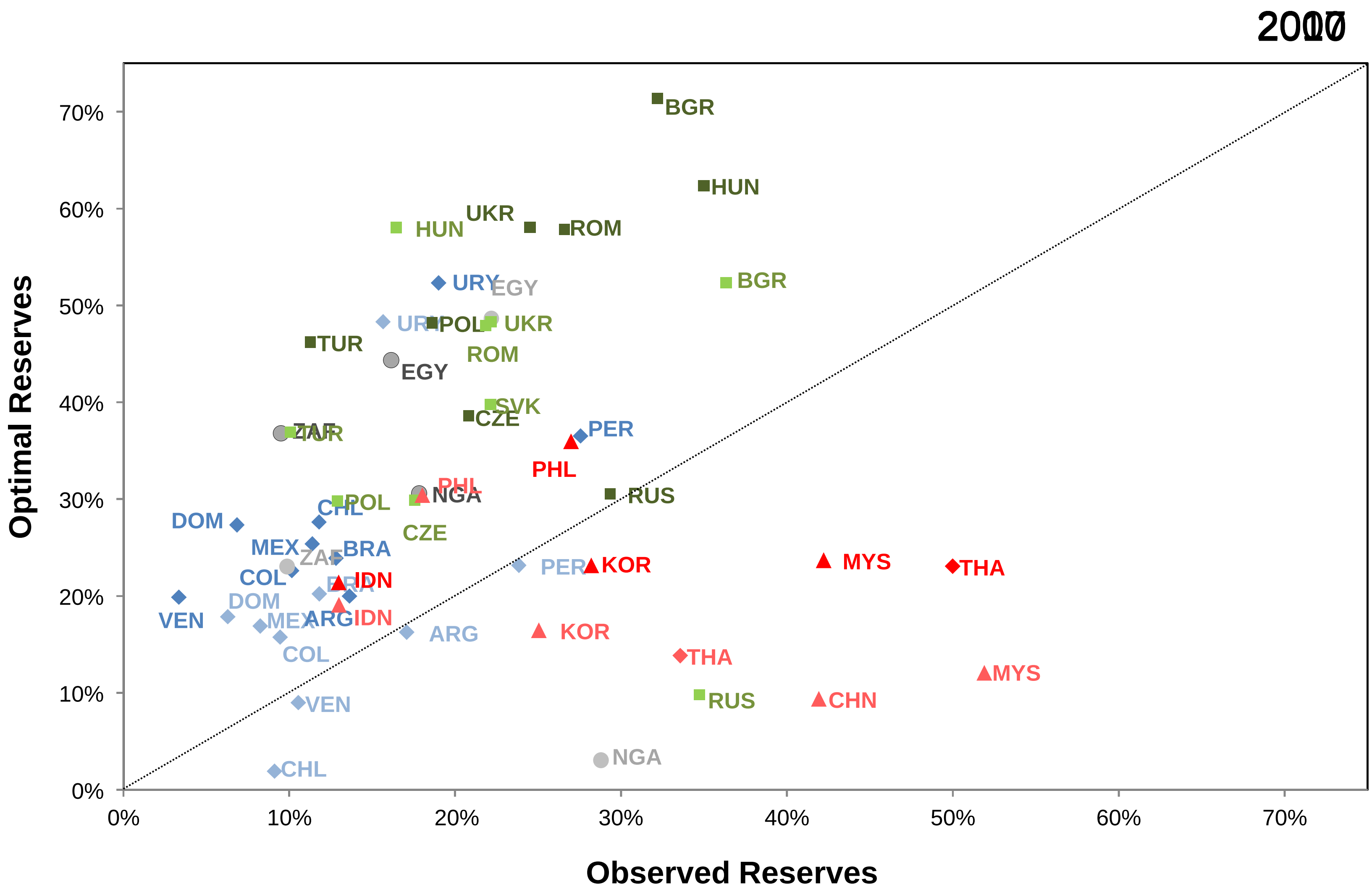
Optimal Reserves: where do we stand?

- How about more recent estimates of optimal reserves?

- Extend the assessment of international reserves adequacy to 2010 for same set of countries
  - China and Slovakia are not included in this exercise due to lack of data

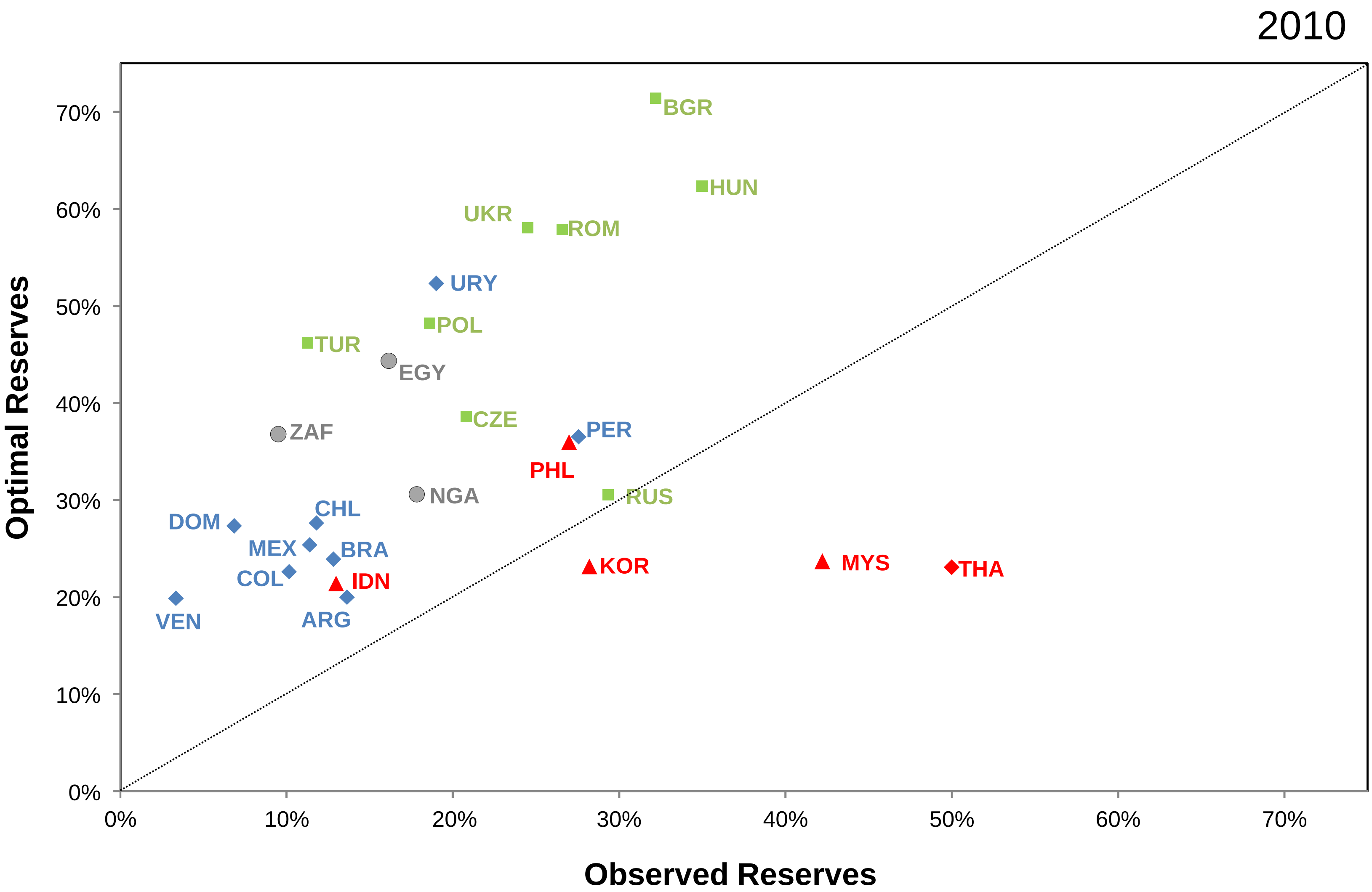
Optimal vs. Observed Reserves

(2007 vs. 2010, % of GDP)



Optimal vs. Observed Reserves

(as of 2010, % of GDP)

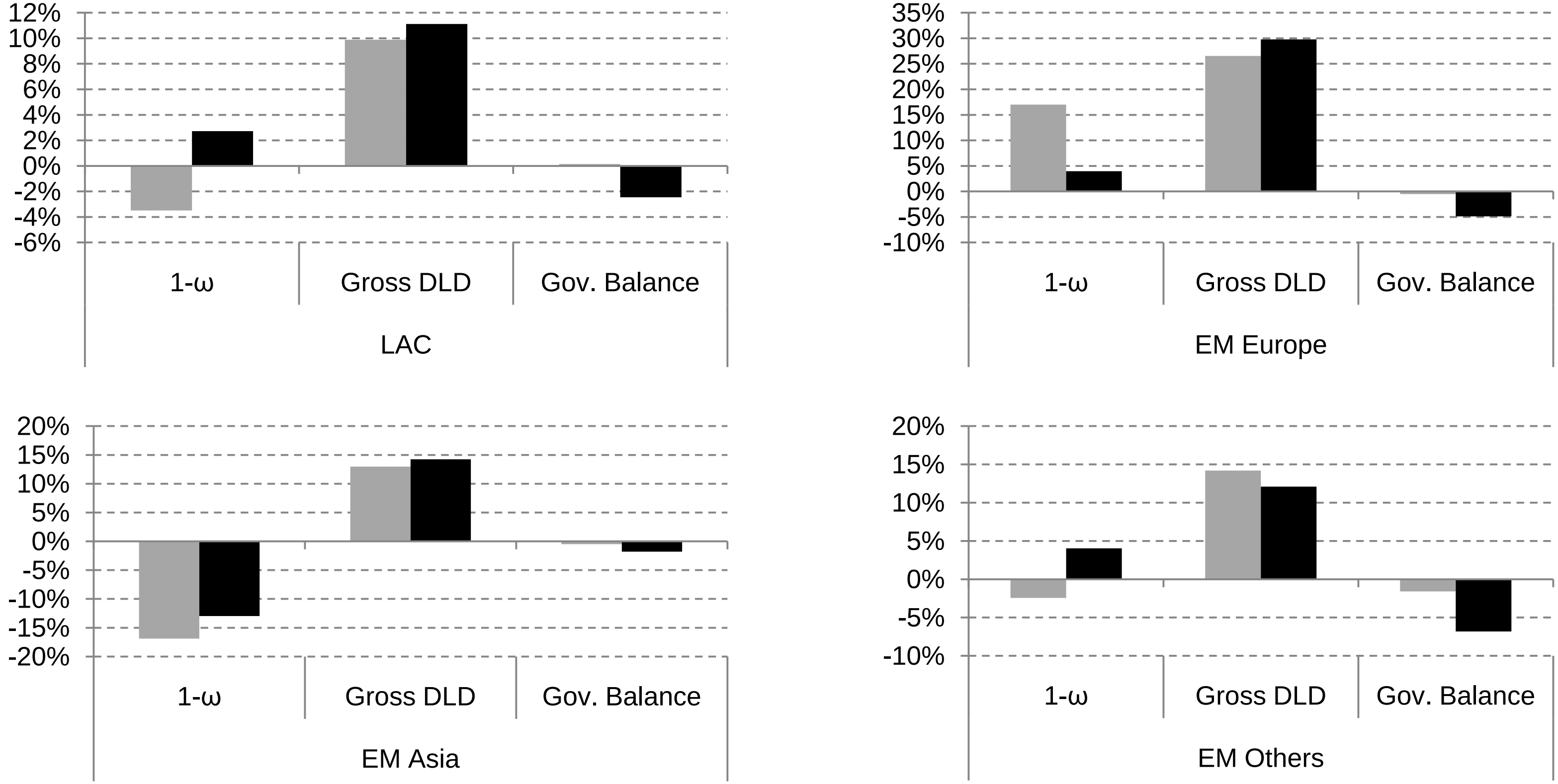


Optimal Reserves: where do we stand?

- Unlike results for 2007, we find that with the exception of Korea, Malaysia and Thailand, all other countries in our sample display lower-than-optimal reserves.

- While observed reserves remain relatively constant on average, the stock of optimal reserves has increased.
  - Change in risk factors (1- ω , Gross DLD and the government budget balance).

Risk factors between 2007 and 2010



- LAC and Asia: All risk factors have increased.
- LAC: CAB has changed from positive to negative, while the average Gov. Balance has deteriorated
- Europe: observed reduction in the CAD relative to the absorption of tradable goods (or 1- ω in our model) is more than compensated by the deterioration of the Gov. Balance and the increase in Gross DLD.

Optimal Reserves: where do we stand?

- Effects of the global financial crisis have not yet dissipated completely.
- Most countries implemented significant countercyclical fiscal policies that, in most cases, have not been fully reverted.
- Lower post-crisis growth in developed economies and the consequent weaker external demand has contributed to a deterioration of current accounts in EMs.
- If this global setting were to remain in the medium term:
  - need to improve fiscal positions
  - increase access to liquidity (either through reserve accumulation and/or by securing access to international resources)

Conclusions

- Under robust policy choices, <u>average</u> observed reserves holdings on the eve of the financial crisis were not distant from optimal reserve holdings prescribed by the model (w/o calibration).

  - Reserve over-accumulation in EMs was not obvious

  - Currency mismatches, current account deficits, fiscal balance are taken into account by policymakers in determining the level of International Reserves

Conclusions

- Discrepancies from the standpoint of <u>individual</u> economies point to:
  - Need to adjust stock of reserves by access to alternative sources of liquidity (FCLs, private credit lines to the banking system, etc).
  - Particularly important after 2008. Multilateral institutions, particularly the IMF, have taken a more active role as Lenders of Last Resort via provision of Flexible Credit Lines (FCL), which should be added to a country's stock of international reserves.
  - In financial centers (like Uruguay), foreign banks may hold large levels of reserves to meet potential dollar deposit withdrawals, which could be included in measures of total foreign currency reserves.
  - Existence of other motives for reserve accumulation.

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