Foreign reserves as hedging instrument in the emerging countries

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Abstract

This work derives a model where foreign reserves are a monetary policy instrument to coordinate investment, short term and long term finance, all of them being exposed to volatility of foreign capital inflow. The model is able to explain why emerging markets in the last decade increased the stock of foreign reserves and simultaneously managed to raise GDP growth while leaving short term foreign debt and investment in net fixed capital nearly unchanged. The explanation depends crucially on two structural parameters newly introduced in this model, which account for the marginal cost of long term finance and for the competitiveness of the domestic industry. The approximated analytical solution of the model leads us to conclude that emerging countries generate the observed high ratios of reserves to short term foreign debt with the purpose of stabilising not the short term but the long term finance available to domestic firms.

Keywords: foreign reserves; short term foreign debt; long term finance; growth; investment.
JEL: F32; F36; F43; G32

1 Introduction

This study proposes a new approach to explain why emerging countries, especially those that exhibit high GDP growth rates, are responsible for massive accumulation of foreign reserves.

In the aftermath of the East Asian crisis, economists and international institutions argued that the stock of international reserves, in the absence of an international lender of last resort, is warranted as insurance against foreign short term debt withdrawal (Calvo, 1998; Feldstein, 1999). Radelet and Sachs (1998) pointed out that countries vulnerable to financial panic were those holding a stock of reserves noticeably lower than the amount of short term external debt. Both the Federal Reserve and the IMF, since then, have recommended that countries follow the so called Greenspan-Guidotti rule of thumb, according to which an adequate level of reserves should be equal to the stock of the short term external debt (Greenspan, 1999; Fisher, 2001). Several recent studies, however, have reported that the average demand for international reserves from emerging economies, which was comparable to developed countries in the 80s, has climbed since the 90s to reach levels never seen before, well above the coverage ratio recommended by the Greenspan-Guidotti rule. According to Rodrik (2006), the average reserves to short term debt ratio increased from around 0.9 in 1990 to around 3.7 in 2004. As section 2 of this study will document, such a ratio reached an average level above 7 in 2009.

Theoretical models explaining the stockpile of foreign reserves, in the approach of the precautionary (or self-insurance) view,[1] often describe emerging countries as financing long term investment with volatile short term foreign capital and building reserves to cushion the real output of the economy in the event of foreign capital outflow. The impact of a sudden stop (of foreign capital inflow) on the output varies from one model to another. For example, in Jeanne and Rancière (2006) and in Jeanne (2007) the sudden stop lasts one period, after which the output goes back to its long run growth path, whereas in Aizenman and Lee (2007), in Cheung and Qian (2007) and in Garcia and Soto (2004) the sudden stop forces a costly liquidation of the investment, thereby reducing the output.[2]

[1] Other explanations of reserves come from earlier models, surveyed in Flood and Marion (2002), and from the mercantilist view, by Dooley et al. (2003)

[2] Recent empirical studies on the effects of financial crises on output losses are Hutchison and Noy (2006), and Bordo et al. (2010). Other theoretical studies focus on the effect of capital outflows on the real exchange rate (Bar-Ilan and Marion, 2009; Kehoe and Ruhl, 2009) and on the determination of capital outflows as solutions of a general equilibrium framework

With the exception of Devereux and Sutherland (2009), who argue that holding fixed income nominal bonds and issuing claims on capital (FDI) achieves a considerable degree of international risk-sharing, the prevalent opinion is that the observed stocks of reserves are not optimally determined. Caballero and Panageas (2004, 2005) suggest that holding state contingent assets in a Central Bank's portfolio would be a more efficient self insuring policy. Greenwald and Stiglitz (2010) claim that the increasing reserve hoarding is responsible for global imbalances (as savings from emerging economies could be better employed to finance domestic and global growth instead of the US current account deficit). Jeanne (2007) points out that emerging countries less exposed to risks of the capital account crisis are those that accumulate more reserves.

The evidence summarised in section 2 of this study draws attention to some stylised facts suggesting that the extent of reserves, rather than being suboptimal, is still partially unexplained. Emerging countries in the last decade seem to have reduced their exposure to the risk of short term foreign capital outflow: BRIC countries, which are the biggest and fastest growing economies, have managed to double their average growth rates with little growth in new capital assets and short term foreign debt; similarly, smaller emerging economies have even managed to increase growth despite a lower level of investment in new capital assets and a lower short term foreign debt. Nevertheless, emerging countries - especially those growing more - have kept raising foreign reserves massively.

This paper contributes to the analysis of optimal reserves in the emerging countries by deriving the aforementioned stylised facts as the solution of a new model, which innovates the theoretical analysis in many respects. Firstly, foreign reserves are not conceived of as a tool to simply balance short term foreign capital, but as a monetary policy instrument to coordinate investment, short term and long term finance, all of them being exposed to volatility of foreign capital. Secondly, the model introduces two structural parameters whose value may depend on the degree of openness to global goods and financial markets. These parameters, which account for the competitiveness of the domestic industry and for the marginal cost of long term finance, are crucial for deriving numerical solutions. Thirdly, by using an approximated analytical solution, the model allows for a thorough sensitivity analysis of the determinants of the optimal reserves to short term foreign debt ratio and of its effects on the investment and financial structure. As a result, numerical simulations of the model are able to explain both the high GDP growth and the growing stock of reserves as the

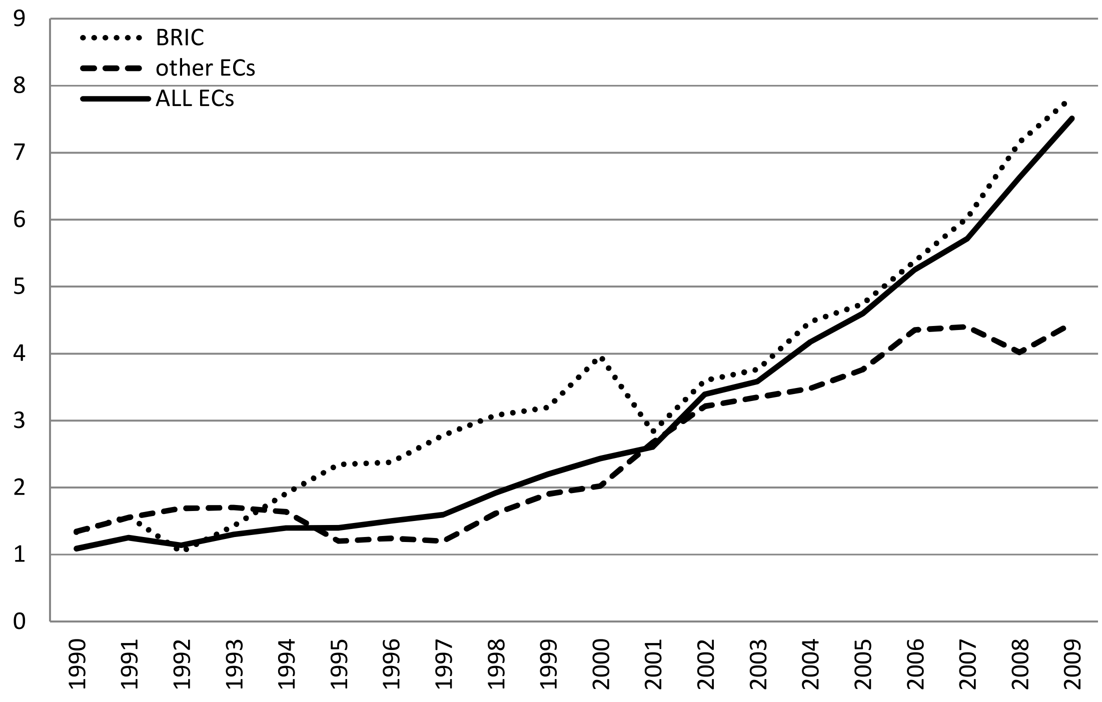
(Devereux and Sutherland, 2009; Alfaro and Kanczuk, 2009).

outcome of the same process of globalisation of the emerging economies.

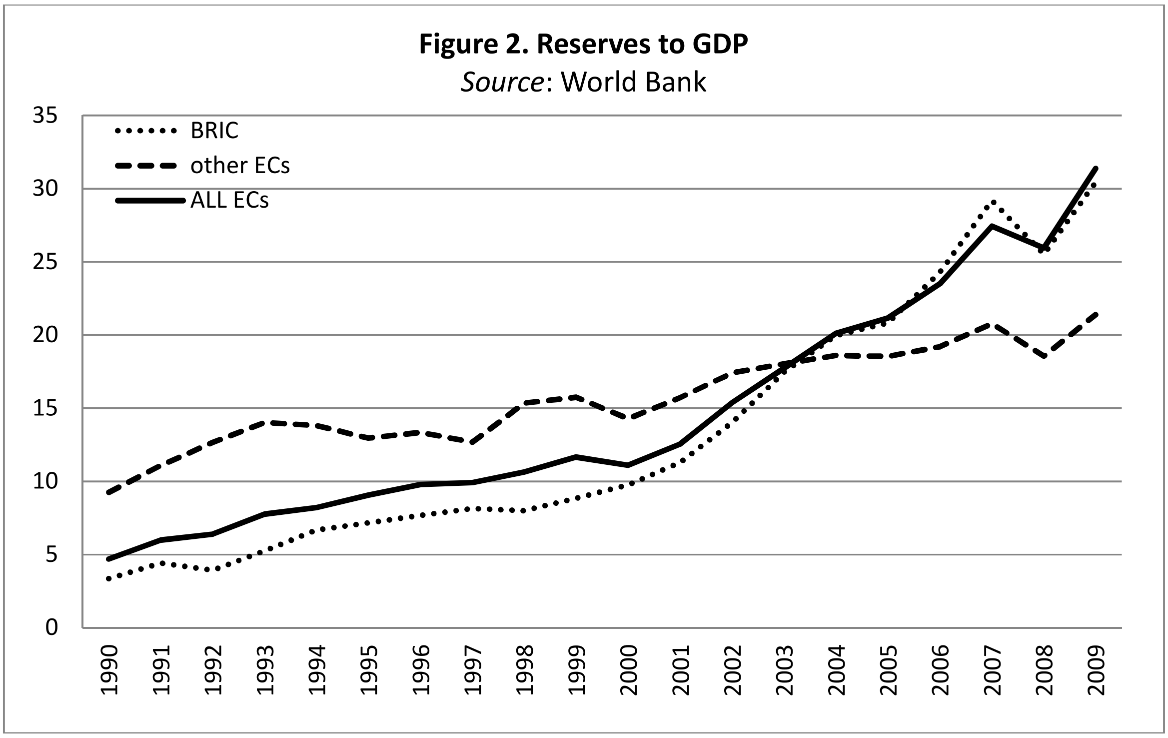
The remainder of the paper is organised as follows. In section 2, stylised facts are inferred from a descriptive analysis of the emerging countries. In section 3, the model is presented in the general formulation and the approximated analytical solution is derived. Section 4 comments on the properties of the optimal solution for reserves to short term foreign debt ratio and its effects on investment and long term finance and derives numerical solutions compatible with observed stylised facts. Section 5 concludes.

2. Evolution over time of emerging countries

Figure 1. Reserves to short term foreign debt ratio
Percent values. *Source*: World Bank



The empirical descriptive analysis of this section is based on a sample of 18 emerging countries distributed across Asia, Latin America and Africa from 1990 to 2009. The sample is split into two subsamples: the BRIC economies (Brazil, Russia, India and China), which in the last decade account for more than 60% of the sample's GDP, and the other 14 smaller economies (less than 40% of the sample's GDP).[3] Figures in this section report the evolution of variables for these two subsamples and for the weighted average of the full sample.



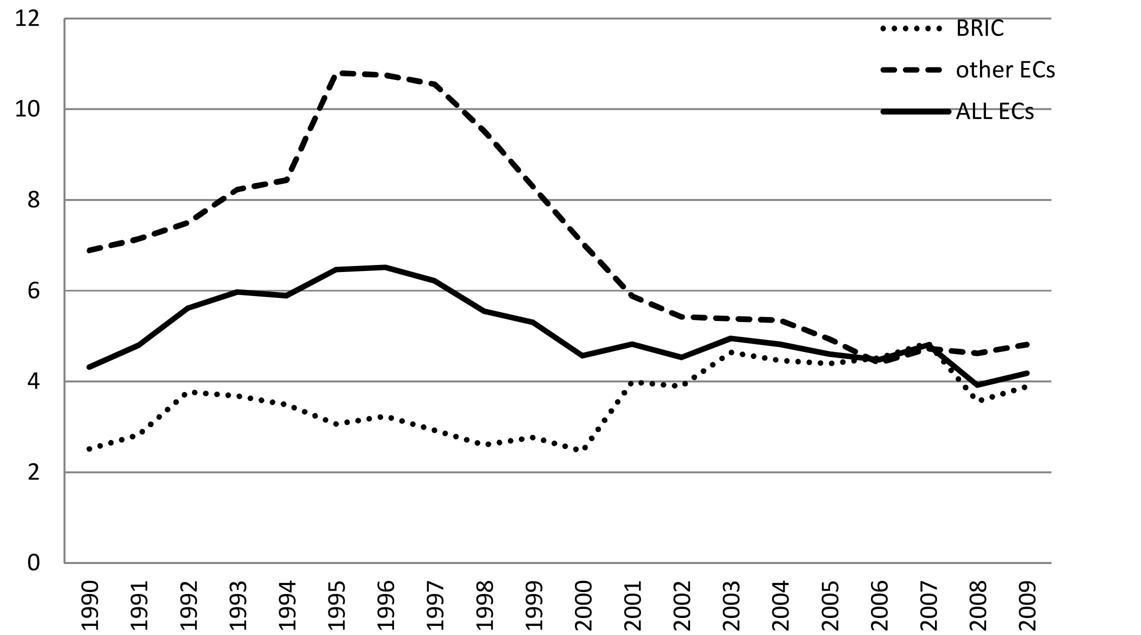
At the end of the 90s, leading institutions agreed on the policy guidance that holding reserves equal to short term debt was sufficient to counteract and prevent crises due to capital outflows (Greenspan, 1999, Fisher, 2001). However, as Figure 1 illustrates, the ratio of reserves to short term debt climbed from around 1 in 1990 to around 7.5 in 2009. The increasing level of this ratio was particularly pronounced in the group of bigger economies. Consistent with previous empirical studies (Aizenman and Lee, 2007; Devereux and Sutherland, 2009; Rodrik, 2006), Figures 2 indicates that the rise in the reserves to short term debt ratio is certainly due to the increasing demand for international reserves. This was around 5% of GDP in 1990 and rose constantly to around 30% in 2009, with the exception of difficult years (2000, 2008), when reserves were partially reduced.

The short term foreign debt (Figure 3) climbed during the 90s in the smaller countries group (from 6.9% in 1990 to 10.6% in 1997) and decreased after the Asian Crisis to reach values stably below 5% of GDP in the last five years. This performance, however, is smoother if we look at the full sample

[3] Due to policy coordination, South Africa nowadays is often considered a new member of the group of strongest emerging (BRICS) economies. In this paper, however, it is considered more homogeneous with the smaller emerging countries as its GDP accounts for about 2.6% of the sample.

weighted average level (continuous line), suggesting that the rising values of the aforementioned reserves to short term ratio can be explained more by the increasing demand for foreign reserves than by the decreasing level of the short term foreign debt. The stylised fact that the demand for reserves continued to increase even during periods where the short term debt decreased suggests that the Greenspan-Guidotti rule is not perceived as a sufficient recommendation to prevent new crises and that the short term debt is not the only variable to take into account when the foreign reserve policy is decided.

Figure 3. Short term foreign debt to GDP
Percent values. *Source*: World Bank



A strand of the economic literature emphasises that short term foreign debt is used up by emerging countries to finance long term investment projects (Chang and Velasco, 2001; Aizenman and Lee, 2007; Jeanne and Rancière, 2006; Jeanne, 2007). Assessing the overall effect of short term foreign debt on the level of investment is a difficult task. On the one hand, this source of finance, as it is cheaper than alternative sources (such as new equity capital or longer term debt), might contribute to increased investment; on the other hand, it makes domestic investment exposed to liquidity shocks due to foreign capital outflow, thereby inhibiting investment. Raising reserves as a buffer stock against capital outflows reduces the effects of liquidity shocks, but, as Greenwald and Stiglitz (2010) point out, is equivalent to channelling domestic saving away from the domestic investment. Empirical evidence seems to confirm that the effect of short term foreign debt on the level of investment is mixed. Rodrik (2006) and Aizenman (2005) already stated that increasing short term foreign debt in the 90s cannot be associated to increasing investment. In our sample, merely comparing the average values in the years 1990-99 and 2000-09, reported in Table 1, both the net investment (defined as gross fixed capital formation less depreciation) and the short term debt decreased in the smaller economies and increased for the BRIC countries.

Figure 4. Growth of GDP over 2 years

Percent values. *Source*: World bank

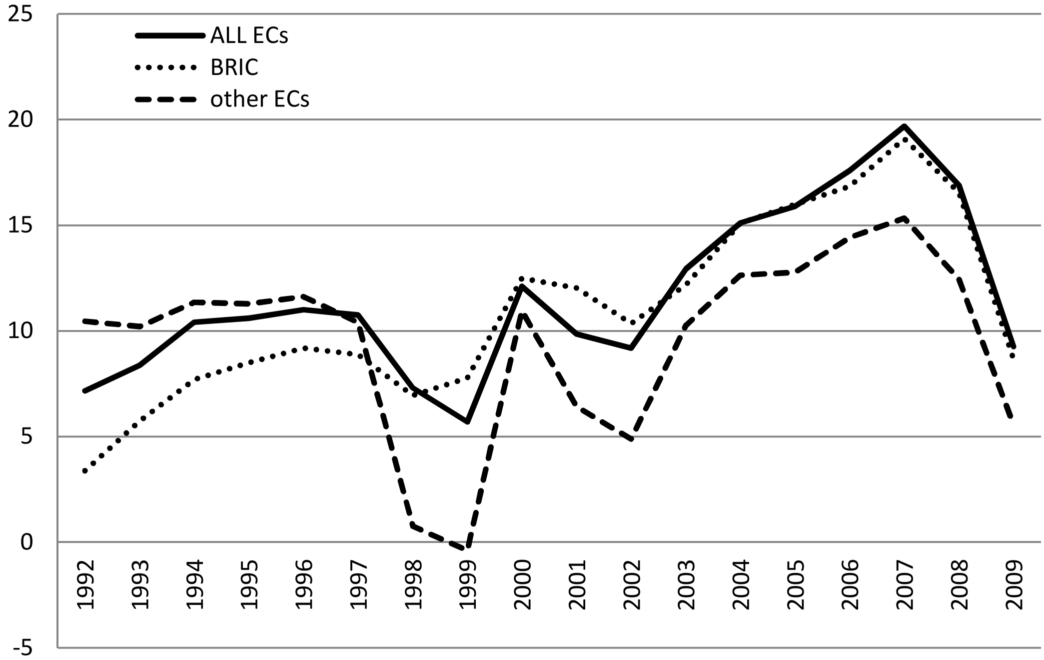


Figure 4 illustrates how the long term GDP growth (average on 2 years) increased sharply for 5 years from 2002 to 2007, to an extent that the growth in the net investment is not able to explain.[4] The average values reported in Table 1 confirm this result: 2 year growth rates doubled in the BRIC countries while the net investment increased by less than two percent of GDP, and increased in the smaller countries even though the net investment decreased.

[4] Variation in output unexplained by factors of productions are traditionally attributed to total factor productivity, which is, however, a residual, thus a `measure of our ignorance'. See Caselli (2005) and Sturgill (2009) for efforts to raise empirically the explanatory power of factors and factor shares.

Table 1 – Evolution of emerging economies: growth, investment, short term debt and reserves

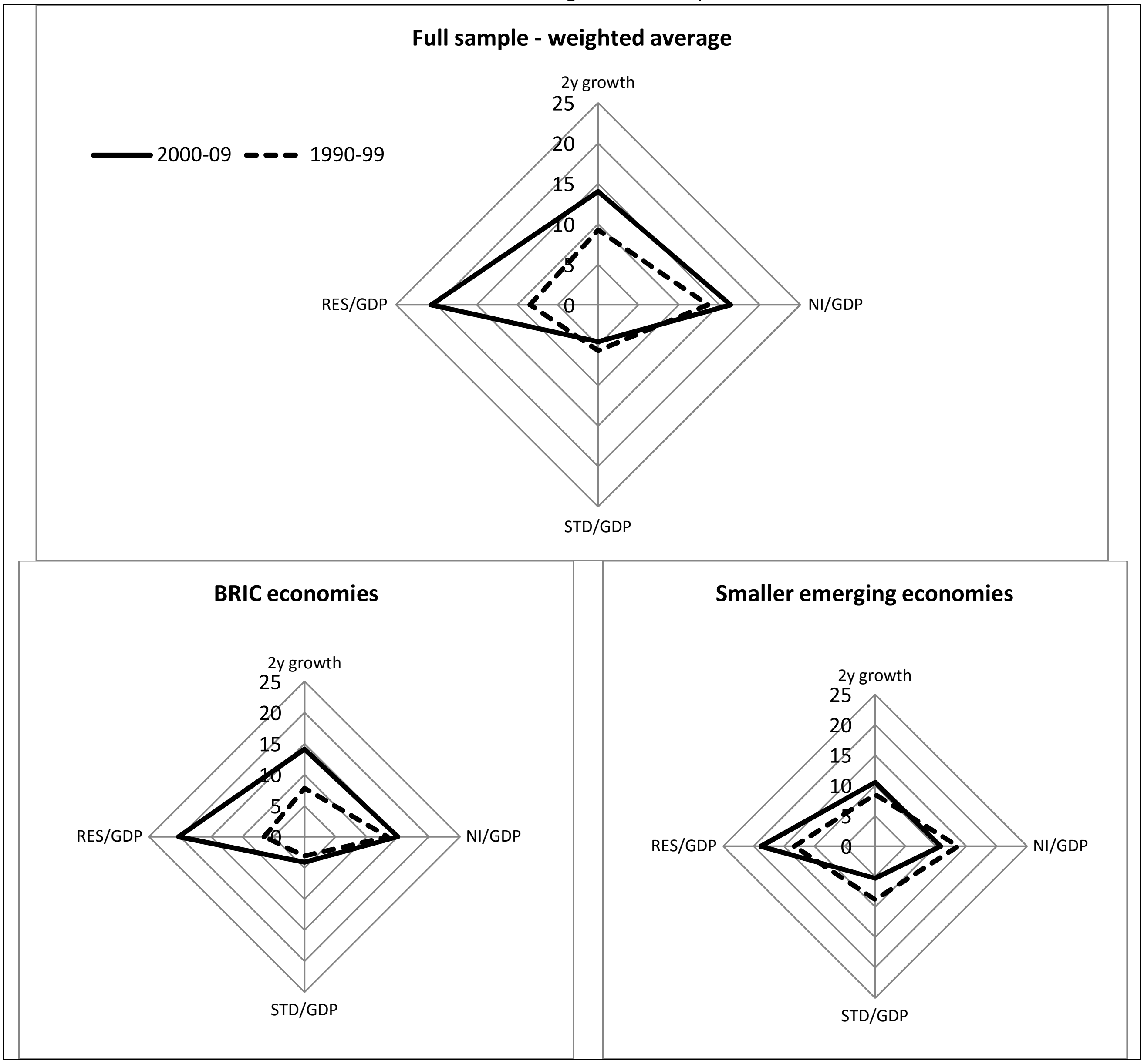
Average values based on World Bank data of 2 years GDP growth (2y growth), net (start up) investment in fixed capital assets over GDP (NI/GDP), stock of short term foreign debt over GDP (STD/GDP), stock of foreign reserves over GDP (RES/GDP), reserves to short term foreign debt ratio (RES/STD), corrected index of reserves to short term foreign debt ratio (RES/STD corr). NI is defined as gross fixed capital formation less depreciation; RES/STD corr is computed multiplying RES/SDT by the ratio of cumulative inflows of short term foreign debt to the cumulative sum of short term foreign debt and net equity inflows (setting 1990=1). Values refer to two different time periods (1990-99 and 2000-09) for each single country of the sample and for the following groups: Full sample (average values and weighted average values), BRIC economies and smaller economies.

1990-99	2y growth	NI/GDP	STD/GDP	RES/GDP	RES/STD	RES/STD corr
Full sample (average)	8.36	13.56	7.31	11.62	1.590	1.302
Full sample (weighted av.)	9.26	13.60	5.67	8.38	1.478	1.115
BRIC	7.84	13.37	3.09	6.50	2.106	1.476
Smaller Economies	8.51	13.61	8.81	13.29	1.508	1.188
Argentina	9.41	5.59	7.66	6.48	0.846	0.645
Brazil	5.11	7.00	5.17	5.55	1.075	0.736
Chile	13.43	10.73	7.15	21.57	3.018	2.168
China	22.44	22.92	2.77	11.41	4.113	4.070
Colombia	5.32	8.19	5.34	11.60	2.172	2.120
Egypt, Arab Rep.	9.04	12.13	5.38	22.95	4.267	4.925
Indonesia	12.78	11.30	13.39	10.76	0.804	0.776
India	11.94	12.73	1.68	5.64	3.350	1.575
Morocco	4.45	25.96	2.66	12.62	4.744	6.415
Mexico	6.74	12.41	7.83	5.59	0.714	0.451
Malaysia	14.56	7.77	8.68	30.83	3.552	4.010
Pakistan	7.90	26.78	5.37	3.46	0.643	0.476
Peru	8.66	8.66	13.53	14.33	1.059	1.037
Philippines	6.35	11.89	9.55	11.82	1.238	1.152
Russian Federation	-8.13	10.84	2.78	2.79	1.004	0.995
Thailand	9.18	9.20	19.72	21.16	1.073	1.028
Turkey	7.53	30.05	8.48	7.10	0.837	0.761
South Africa	3.80	9.91	4.36	3.04	0.696	-0.713

2000-09	2y growth	NI/GDP	STD/GDP	RES/GDP	RES/STD	RES/STD corr
Full sample (average)	11.31	11.70	5.26	19.22	3.657	1.978
Full sample (weighted av.)	14.05	16.39	4.57	20.96	4.589	2.432
BRIC	14.08	15.00	4.07	20.23	4.976	2.634
Smaller Economies	10.52	10.76	5.26	18.78	3.572	1.885
Argentina	8.29	7.38	11.85	12.61	1.065	1.135
Brazil	7.06	5.59	3.50	9.02	2.574	0.979
Chile	8.04	8.85	8.03	16.87	2.100	1.206
China	22.01	28.68	4.90	32.26	6.588	4.619
Colombia	8.43	8.20	3.17	10.36	3.267	2.555
Egypt, Arab Rep.	9.98	12.12	2.15	19.37	9.004	10.453
Indonesia	32.30	8.74	6.82	14.06	2.063	2.389
India	14.98	18.11	1.77	16.95	9.599	2.226
Morocco	10.05	19.03	2.63	26.35	10.012	7.459
Mexico	4.29	17.06	1.87	8.34	4.467	1.327
Malaysia	10.10	9.00	8.95	44.00	4.918	4.509
Pakistan	9.69	13.93	1.42	9.11	6.407	2.076
Peru	11.29	6.84	4.57	19.72	4.315	3.280
Philippines	9.58	9.71	5.88	21.48	3.654	2.069
Russian Federation	12.30	7.64	4.80	22.87	4.767	4.006
Thailand	8.96	6.70	9.37	33.68	3.596	1.670
Turkey	8.37	16.31	7.36	10.93	1.485	1.193
South Africa	7.97	6.81	5.56	8.68	1.561	0.310

Figure 5 - Evolution of emerging economies

Source: World bank, average values reported in Table 1



Overall, the empirical descriptive analysis of this section allows us to establish the following stylised facts: firstly, the stock of reserves grows independently from short term foreign debt; secondly, there is not a clear relation between short term foreign debt and investment in new capital assets; thirdly, countries have been able to grow considerably in the last decade even though the investment in new capital assets has not changed to a relevant extent; fourthly, massive reserves accumulation, rather than causing underinvestment and slowing down the economy, seem to have grown so has GDP. These stylised facts are summarised in Figure 5, which illustrates the development of the economies based on mean values of the variables considered in this section over the last two decades.

While the evidence presented in this section seems to contrast with existing explanations of the rationale for (and consequence of) reserve accumulation, the next section finds a theoretical explanation which makes all the aforementioned stylised facts consistent with each other.

3 Reserves, investment and finance

This section builds the theoretical model explaining the relation between growth, investment, short term foreign debt and foreign reserves, based on the characteristics of both the good industry and the financial market, and derives an analytical approximated solution.

3.1 General Model

For simplicity, we assume that all firms are identical and that population size is equal to 1. Therefore the model describes a single firm but all variables involved denote national aggregate quantities. As in previous studies on the role of reserves, we assume that liquidity shock may force underinvestment, reducing second period output. As our focus is on developing countries, we assume that domestic long term investment of the firm is financed by (i) *cash flow* from preexisting assets, (ii) *short term finance* from banks and (iii) *long term finance*, from any sources (long term debt from banks, bonds, new equities, capital venture, etc.). Short term finance depends on two components: supply of foreign short term credit and supply of domestic credit. We assume that domestic credit is cheaper but scarce (for simplicity, interest rate is zero), whereas the cost of foreign short term credit is higher and constant ($r > 0$). We also set the interest rate on foreign reserves equal to zero, therefore r also represents the spread between the low yield on liquid reserve assets and the cost of external borrowing (Baker and Walentin, 2001; Rodrik, 2006; Stiglitz, 2006). Demand for short term credit to finance the investment is perfectly elastic, as the long term finance is more expensive. We assume that raising long term finance is costly and the cost increases with the quantity.

Table 2 – The time line

	Time 0	Time 1	Time 2
EXOGENOUS VARIABLES	Investment in net capital assets (K) raising funds from short term foreign debt (D_0) and pre-existing sources (V).	Shock to short term foreign capital (ε).	
ENDOGENOUS VARIABLES		Short term finance available (D_1) determined by ε and h^*	Return on output Service of finance Net profit π
DECISIONS	Central bank's reserves policy h*	Firm's variable investment and long term finance I*, B*	

The time line is summarised in Table 2. Investment starts at time 0 with a new fixed (start up) capital factor, K, and is completed at time 1 with a variable component, I. The variable investment I includes payment to all factors which are different from the initial fixed capital (intangible capital, human capital, workers, capital replacement, etc.)

Physical output is realised at time 2 and given by

$$f(K,I) = \omega K^{\alpha} I^{\beta}. \tag{1}$$

We adopt the conventional (but unnecessary) assumption of constant return to scale: $\alpha + \beta = 1$. For simplicity, we assume that at time 0 the only source of short term finance is from foreigners, and the amount is given by D_0. Time 0's start up capital is thus

$$K = D_0 + V, \tag{2}$$

where V is cash flow from preexisting assets. Time 1's investment is financed with (domestic and foreign) short term finance, D_1, and long term finance, B:

$$I = D_1 + B. \tag{3}$$

At time 1, the firm must service the previous period's debt (principal and interests) and renewal of foreign debt is hit by a multiplicative shock ε, distributed as a normal $N(1, \sigma^2)$; therefore, available funds from foreigners are given by $D_0(\varepsilon - 1 - r)$; the firm at time 1 also raises short term debt from domestic credit, ΔDC. The latter is determined by the monetary policy. Recalling that change in money supply is the sum of changes in domestic credit and foreign reserves, i.e. $\Delta M = \Delta DC + \Delta R$, we assume that the central bank at time 1 fulfills the following simple rules:

1. *Precautionary policy*: the proportion of foreign reserves to private foreign short term capital inflow is constant (h) if the net capital inflow is positive ($\varepsilon > 0$), zero otherwise;

2. *Sterilisation of foreign currency operations*: if the net capital inflow is non negative at time 1, money supply is unchanged ($\Delta M = 0$ if $\varepsilon \geq 0$);

3. *Expansionary policy during a crisis*: if the net capital inflow is negative at time 1, new money is issued in proportion h of the net capital outflow ($\Delta M = -hD_0\varepsilon$ if $\varepsilon < 0$).

From the aforementioned rules, reserves at times 0 and 1 are given, respectively, by

$$R_0 = hD_0 \tag{4}$$

and

$$R_1 = \begin{cases} hD_0\varepsilon & \text{if } \varepsilon \geq 0 \\ 0 & \text{if } \varepsilon < 0 \end{cases}, \tag{5}$$

whereas domestic credit at time 1 is given by

$$\Delta DC = -hD_0(\varepsilon - 1). \tag{6}$$

Summing up domestic and foreign credit yields the total short term finance available to the firm at time 1:

$$D_1 = D_0[h + (1 - h)\varepsilon - (1 + r)]. \tag{7}$$

At time 2 the output is sold at price θ and revenues are given by $F(K, I) = \theta f(K, I)$. We make the assumption that a negative relation (even very small) exists between time 2's output price and time 1's capital inflow:

$$\theta = \eta(\varepsilon - 1) + 1 \tag{8}$$

with $\eta < 0$. The coefficient η captures the intensity of this relation and accounts for the competitiveness of the product's industry in this small open economy. The more the industry is exposed to local and global competition, the more any additional foreign capital inflow is likely to be related to a downwards shift in the supply curve. Marginal cost reduction could be due to the birth of new firms, to lower market power of previous existing companies, to lower power of trade unions. More competition, thus, leads to a lower final output price.

The cost of long term finance is a growing function of the total amount. To keep the analysis as simple as possible, we model this cost as an exponential function:

$$C(B) = sB^{1+\delta}, \tag{9}$$

where s is a scale parameter and the coefficient δ accounts for the cost that the firm has to pay to increase long term finance. δ takes positive values and is expected to be lower in more globalised emerging economies with a more developed financial market.

The firm enters time 1 with the given stock of capital K and with available short term finance D_1 and chooses investment I (and thereby the amount of long term finance B) to maximise net expected profits (assuming discount rate equal to 1 for simplicity):

$$\pi = \theta f(K, I) - I - D_0 \varepsilon r - C(B). \tag{10}$$

The first order condition for this problem is:

$$\theta f_I = 1 + C_B, \tag{11}$$

where f_I and C_B are the first derivatives of (1) and (9), respectively, with respect to I and B.[5]

The Central Bank acts in the general interest of the economy and chooses optimal h by maximising the expected profit of the firm subject to available information at time 0, when the future foreign capital inflow is still uncertain:

$$\max_h E_0 \pi(D_1(\varepsilon, h)). \tag{12}$$

Based on the result of Froot, Scharfstein, and Stein (1993)[6], the non-closed form solution to (12) is given by the following formula:

$$h^* = 1 + \frac{\eta}{D_0} \frac{E_0\left[\frac{-f_I C_{BB}}{\theta f_{II} - C_{BB}}\right]}{E_0\left[\frac{-\theta f_{II} C_{BB}}{\theta f_{II} - C_{BB}}\right]}, \tag{13}$$

where f_{II} and C_{BB} are second derivatives of (1) and (9).

The informational content of the formula for the optimal solution (13) does not allow one to derive easily evident implications on the relationship between parameters involved in the reserve policy decision. Expression (13) shows clearly that the reserve policy depends on the parameter η, capturing the relation between return on investment and foreign capital fluctuations. The closer to zero η is, the lower the reserves to short term debt ratio, h, which is equal to 1 (the value of the Greenspan-Guidotti rule) when there is no relation between capital inflow and return on investment. Clearly, the decision on reserves is also dependent on the second moment of the shock to capital inflow (ε), which is included in the second derivatives f_{II} and C_{DD}. However, (13) does not show exactly how the volatility of the shock (σ), the competitiveness parameter (η) and the short term foreign credit available at the date when the decision on reserves is taken (D_0) affect the decision on

[5] At time 1, D_1 is given, hence $\frac{dB}{dI} = 1$.

[6] See Froot, Scharfstein, and Stein (1993), note 18 pag.1639. The proof is based on a result by Rubinstein (1976).

optimal reserves. Moreover, as reserves in this model is a tool to coordinate financing and investing policy, more information would also be desirable on how reserves depend on the parameters affecting investment and cost function (and the concavity of the payoff function), as well as on how investment, short term and long term finance are in turn affected by reserve policy. The next subsection makes this issue clearer.

3.2 Locally approximated solution

Equations (3), (11) and (13) constitute an unsolved system of three equations with three unknowns: I, B, h. Solving this system of equations would lead to expressing the three unknowns as functions of the random variable, ε. The system can be easily solved as a local approximation, after a second order Taylor expansion of the investment and equity cost functions, (1) and (9) respectively, around the expected levels of the investment, $\bar{I}$, and equity, $\bar{B}$.

After the second order Taylor expansion, the expected revenue and cost functions defined above take the following quadratic forms:

$$f(I) = \frac{a}{2}I^2 + bI + k, \tag{14}$$

with $a = f_{II}(\bar{I}) < 0$, $b = f_I(\bar{I}) - \bar{I}f_{II}(\bar{I}) > 0$ and $k = f(\bar{I}) - \bar{I}f_I(\bar{I}) + \frac{1}{2}\bar{I}^2 f_{II}(\bar{I})$, where $f_I = aI + b$, $f_{II} = a$;

$$C(B) = \frac{c}{2}B^2 + dB + w, \tag{15}$$

with $c = C_{BB}(\bar{B}) > 0$, $d = C_B(\bar{B}) - \bar{B}C_{BB}(\bar{B}) > 0$ and $w = C(\bar{B}) - \bar{B}C_B(\bar{B}) + \frac{1}{2}\bar{B}^2 C_{BB}(\bar{B})$, where $C_B = d + cB$ and $C_{BB} = c$.

Substituting (14) and (15) into the expected profit function (10), time 1's f.o.c. simplifies to

$$\theta(aI + b) = 1 + d + cB. \tag{16}$$

Combining (16) with time 1's budget constraint (from (3) and (7)),

$$I = B + D_0[h + (1-h)\varepsilon - (1+r)],$$

we can derive the optimal investment and long term finance as functions of the shock to capital inflow, ε, and the optimal reserves to debt ratio, h:

$$I^*(h,\varepsilon) = \frac{(1+d) - \theta b - cD_0[h + (1-h)\varepsilon - (1+r)]}{(\theta a - c)} \tag{17}$$

and

$$B^*(h,\varepsilon) = \frac{(1+d)-\theta b-\theta a D_0[h+(1-h)\varepsilon-(1+r)]}{(\theta a-c)}. \tag{18}$$

From a second order Taylor expansion of the two expected terms of equation (13) around $\varepsilon = 1$, after substituting for the approximated functions' derivatives, f_I, f_{II}, and C_{DD}, and for the optimal investment (equation (17)) into the expression for f_I, one can derive the reserves to short term foreign debt ratio:

$$h^* = 1 + \frac{\eta}{D_0}\frac{[1+d-\frac{bc}{a}+cD_0 r][(a-c)^2+3a^2\eta^2\sigma^2]}{(a-c)[(a-c)^2+3ac\eta^2\sigma^2]}. \tag{19}$$

Expression (19), unlike expression (13), displays the exact relationships between the parameters involved in the determination of the optimal ratio. Substituting expression (19) into equations (17) and (18) yields the analytical solutions for investment and long term finance levels as functions of the shock to capital inflow, ε.

4 Explaining the evidence

With the approximated analytical solution it is possible to derive, firstly, some general proposition about the determinants of the optimal ratio of reserves to short term foreign debt, secondly, the effects of reserves accumulation on the firm's investment and finance decisions and, thirdly, the effects on all variables of some changes in the parameters accounting for openness to global markets.

The model is calibrated to mimic observed average data reported in Table 1. Figures throughout this section refer to the full sample's weighted average values only, whereas Table 3 in subsection 4.3 also refers to average values of the subsamples (BRIC and smaller countries). In calibrating the model, we take as given time 0 data, i.e. the values of the fixed investment ($K = NI/GDP$) and short term foreign debt ($D_0 = STD/GDP$), and we infer the values of the parameters η, σ and δ compatible with observed long period (2 years) growth and reserves to GDP ratio. We also assume that the elasticity and scale parameters of the investment function are fixed and take standard values, although the factors involved (K, I) are not defined in a standard way. The fixed capital share (NI in Table 1) is, thus, $\alpha = 0.25$ and the variable investment's share is $\beta = 0.75$.[7]

[7] Estimates of physical product elasticity calculation in emerging countries are in Kehoe and Ruhl (2009).

The parameters multiplying the investment function (ω) and the cost of long term finance function (s), are set constant throughout all numerical simulations.[8] We also set a constant value of the interest rate on foreign short term debt, $r = 0.1$ (consistent with Rodrik, 2006, and Stiglitz, 2006).

4.1 Optimal reserves to short term foreign debt

This subsection derives and discusses some properties of the optimal reserves to short term foreign debt ratio implied by the approximated analytical solution (proofs of the propositions are in the appendix).

Proposition 1 *The optimal reserves to short term foreign debt ratio, h^*, is a decreasing function of the parameter η for any σ^2 lower than the critical value $\sigma^{*2} = \frac{-(a-c)^2}{3\eta^2 ac}$.*

Proof. The sign of the ratio as a function of η is given by the sign of the factor multiplying the ratio $\frac{\eta}{D_0}$ of the RHS in equation (19). The expression $[(a-c)^2 + 3a^2\eta^2\sigma^2]$ on the numerator is always positive as it is a sum of squares. The expression $(a-c)$ in the denominator is always negative by the definitions of the parameters in (14) and (15). The expression $[1 + d - \frac{bc}{a} + cD_0 r]$ in the numerator is positive for values of parameters a, b, c and d consistent with the elasticity of the product to the variable investment calculated in $\bar{I}$, $e_I = \frac{a\bar{I}^2 + b\bar{I}}{\frac{a}{2}\bar{I}^2 + b\bar{I} + k}$. This can be seen by taking the expectations at time 0 of the optimal investment level from equation (17): the expected level of investment is $\bar{I}^e = \frac{(1+d)-b+cD_0 r}{(a-c)}$; the expression $[1 + d - \frac{bc}{a} + cD_0 r]$ is hence positive if $\bar{I}^e(c-a) - b < -\frac{bc}{a}$, i.e. $\bar{I}^e < -\frac{b}{a} = \hat{I}$. This upper bound condition to the expected investment is not binding for values of the parameters consistent with a positive elasticity of the product to the investment: substituting $\bar{I} = \hat{I}$ into the expression for e_I, it turns out that $e_I = 0$. Hence, the ratio that multiplies the parameter η is negative whenever the expression $((a-c)^2 + 3ac\eta^2\sigma^2)$ in the denominator is positive, i.e. whenever $\sigma^2 < \sigma^{*2} = \frac{-(a-c)^2}{3\eta^2 ac}$.

This proposition confirms the general result (equation (13)) that the higher the correlation between return on investment and foreign capital inflow, the lower the optimal ratio h^*, but it also adds a limit: if the volatility of the foreign capital inflow is too high, no clear monotonic relation can be computed between the ratio h^* and competitiveness parameter η. The maximum critical value of the variance, σ^{*2}, depends on the concavity of the profit function, expressed by the parameters a and c, and on the absolute value of the competitiveness parameter, η. However, with the very small values of the competitiveness parameter examined in this section, the upper bound volatility is virtually infinite, thus the decreasing relation is always verified.

[8] Constant ω is equivalent to assuming unchanged total factor productivity through time. This is obviously an unrealistic assumption, but methodologically helpful to focus on the potential effects of the structural parameters, η and δ.

Figure 6 – h* as function of η

Simulations based on weighted average values of the sample reported in Table 1.

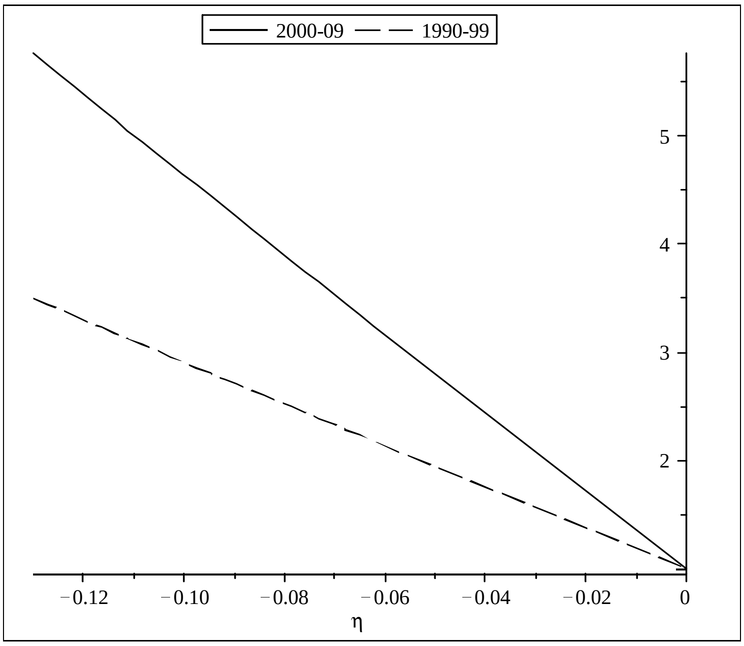


Figure 6 illustrates the aforementioned relation for our sample, based on 1990-99 (dashed line) and on 2000-09 data (continuous line). The higher sensitivity of the optimal ratio for the 2000-09 period depends mainly on the lower value assigned to the marginal cost of the long term finance (i.e. lower δ, which affects the values of c and d in the approximated solution (19)) to be consistent with the average value of the long period growth.[9] In both lines, the closer to zero the value of η is, the closer the optimal ratio h^* is to the Greenspan-Guidotti rule. When the relation between return on investment and foreign short term debt is negative, the policy of offsetting outflows of short term foreign credit with newly generated domestic credit (by selling reserves) is not sufficient, as the investment needs to raise more finance. Ratios higher than one, therefore, are needed to prevent the firm from rising an extra amount of longer term finance. Generally speaking, *the firm maximising its expected profit from a concave profit function is not concerned with hedging against the short term finance fluctuations, but it is rather concerned with hedging against the risk of rising long term finance in connection with its investment opportunity*.

[9] See subsection 4.3 and Table 2 for a more detailed explanation.

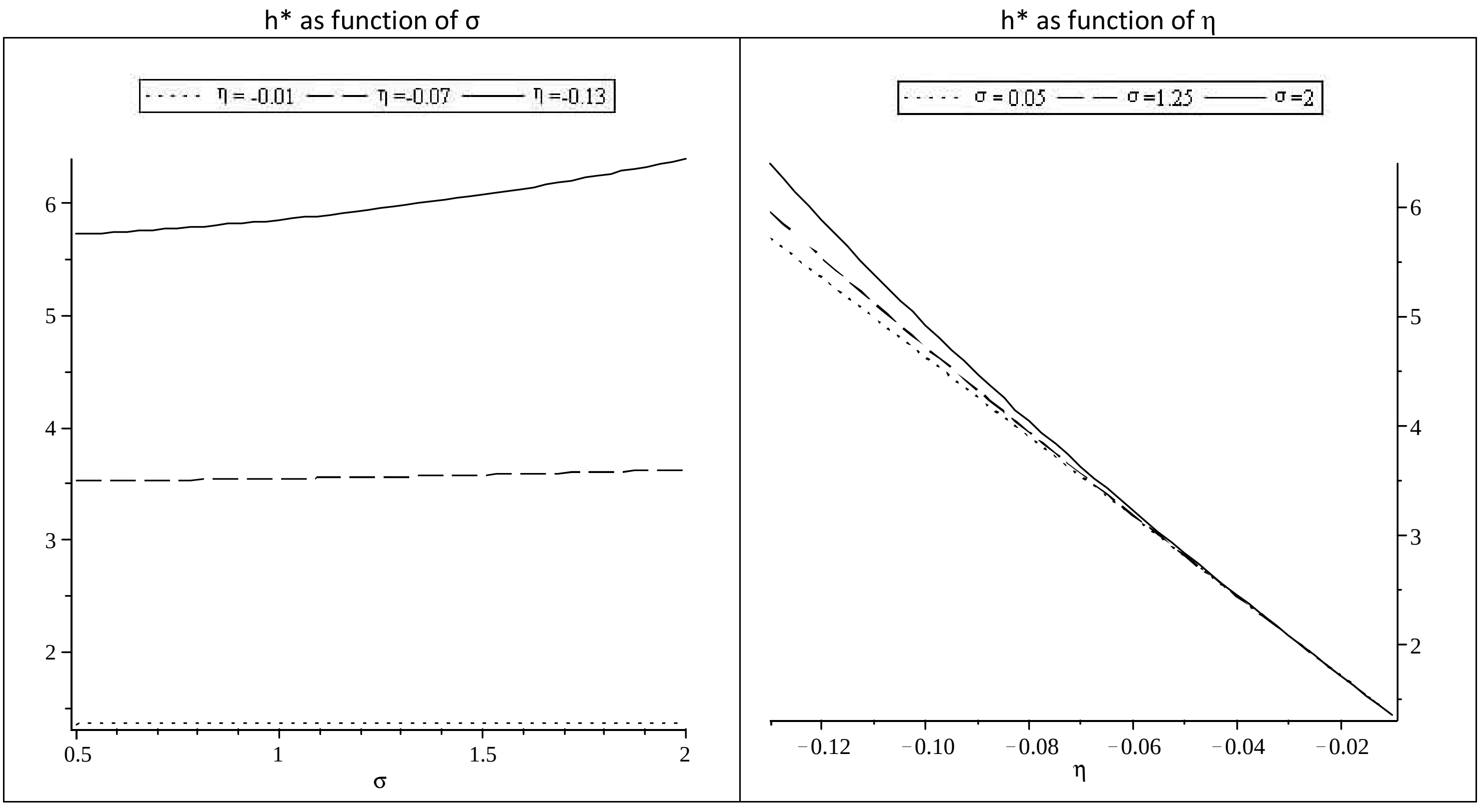
Proposition 2 *Provided that* $\sigma^2 < \sigma^{*2}$*, given any* $\eta < 0$*, the higher the variance of the shock to short term foreign debt,* σ^2*, the higher the reserves to short term foreign debt ratio,* h^**.*

Proof. Everything else being constant, a higher variance, σ^2, increases the value of the numerator of expression (19), as $3a^2\eta^2\sigma^2 > 0$, while decreasing the value of the denominator, as $3ac\eta^2\sigma^2 < 0$. Hence, for any value of $\eta < 0$, the higher the variance, σ^2, the higher the value of h^*.

This proposition is illustrated in Figure 7, where h^* is expressed either as a function of the volatility parameter, σ, setting three different levels of η (-0.01,-0.07,-0.13), or as a function of the competitiveness parameter, η, setting three different values of σ (0.5, 1.25, 2). Clearly, the closer the value of η is to zero, the lower the sensitivity of h^* is to rising volatility. As the values of η considered in the context of the emerging economies are very low, a change in volatility has a negligible impact on the choice of reserves, variable investment, and long term finance.

Figure 7 – Irrelevance of the variance (σ)

Simulations based on weighted average values of the sample during years 2000-09 reported in Table 1 (δ=0.4, D_0=4.57, K=16.39)



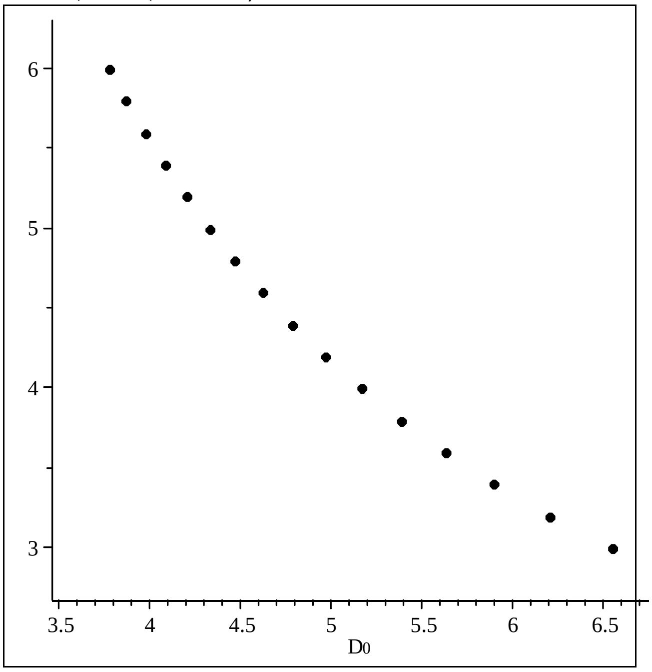
The irrelevance of the variance is a not intuitive result: more volatile short term foreign capital inflows have generated worries and justified raising reserves with a precautionary motive. However, according to this model, in line with Radelet and Sachs (1998) and Rodrik (2006), the fact that foreign short term capital is volatile justifies the one-to-one ratio suggested by the Greenspan-Guidotti rule only, but does not explain rationally the higher ratios observed in recent years.

Proposition 3 *For any* $\eta < 0$*, the optimal ratio* h^* *is a decreasing function of the short term foreign debt,* D_0.

Proof. From equation (19) the factors containing D_0 can be insulated: $\frac{[1+d-\frac{bc}{a}+cD_0r]}{D_0} = \frac{\left(1+d-\frac{bc}{a}\right)}{D_0} + cr$. This expression is positive (see proof of Proposition 1) and is lower as D_0 is higher. Hence, the value of h^* is closer to 1 as D_0 is higher, for any value of η.

Figure 8 - h* as function of D_0

Simulations based on weighted average values of the sample during years 2000-09 reported in Table 1 (η=-0.1; σ=0.7; δ=0.4, K=16.39)



This is another counterintuitive result: common wisdom (and the Greenspan-Guidotti rule) associates more foreign debt to more reserves. Evidence reported in section 2, however, suggests that this link is not confirmed and that reserves grow independently from short term foreign debt. Proposition 3 allows us to explain the aforementioned evidence: the simple presence of short term foreign debt in a country justifies an equal quantity of reserves, but not more. This model, by contrast, deals with situations where countries hold higher ratios as they need to hedge against long term costly finance. When short term finance rises, the gap between investment and long term finance becomes lower, as does the marginal cost of long term finance. Hence, the incentive to substitute extra short term finance with extra long term finance is lower and the reserves to short term foreign debt ratio approaches the level recommended by the Greenspan-Guidotti rule.

Figure 8 illustrates this relationship by simulating optimal solutions of the model for different values of D_0, *ceteris paribus*. The figure reports single point solutions for h^*, as for every value of D_0 all parameters of the local approximated analytical solution around the expected investment ($\bar{I}$) and long term finance ($\bar{B}$) are recalculated.

4.2 Effects of the shock to short term foreign debt

Based on the optimal ratio (19), this section discusses the model's implications about the effect of a shock to short term foreign debt on optimal decisions about investment (17) and long term finance (18), as well as on the short term finance available to the firm (7).

Figure 9 illustrates two examples taken from weighted average values of the emerging countries in the two decades examined in section 2. The values expected at time zero (i.e. the points corresponding to $\varepsilon = 1$) are also reported in bold characters in Table 3, Panels A and B. The figure illustrates how reserve policy coordinates investment, short term and long term finance. As the return on investment is negatively related to the shock to foreign capital inflow ($\eta < 0$), the variable investment decreases with ε. The short term finance at time 1 is also a decreasing function of the shock ε, for reserves to short term ratios higher than one. More exactly, the higher h is, the higher the slope of the short term finance function is (it would be a flat line for $h = 1$ recommended by the Greenspan-Guidotti rule). The optimal ratio, therefore, makes it possible to generate short term finance when the foreign capital inflow slows down ($\varepsilon < 1$) and more investment is needed, and to reduce it when capital inflow increases ($\varepsilon > 1$) and investment slows down. The result of the optimal ratio is to fully stabilise (to a virtually flat line) the long term finance function around its expected level. The different levels of the expected variable investment (and therefore long term finance) at time 1 in the years 1990-99 and 2000-09 are due to changes in the cost of long term finance, as we will see in the next subsection. A lower cost of long term finance is an incentive to increase the variable investment, given the fixed (start up) capital factor and the expected foreign capital inflow.

Figure 9 – Investment, short term finance and long term finance as functions of the shock to capital inflow (optimal solutions)

Simulations based on weighted average values of the sample reported in Table 1.

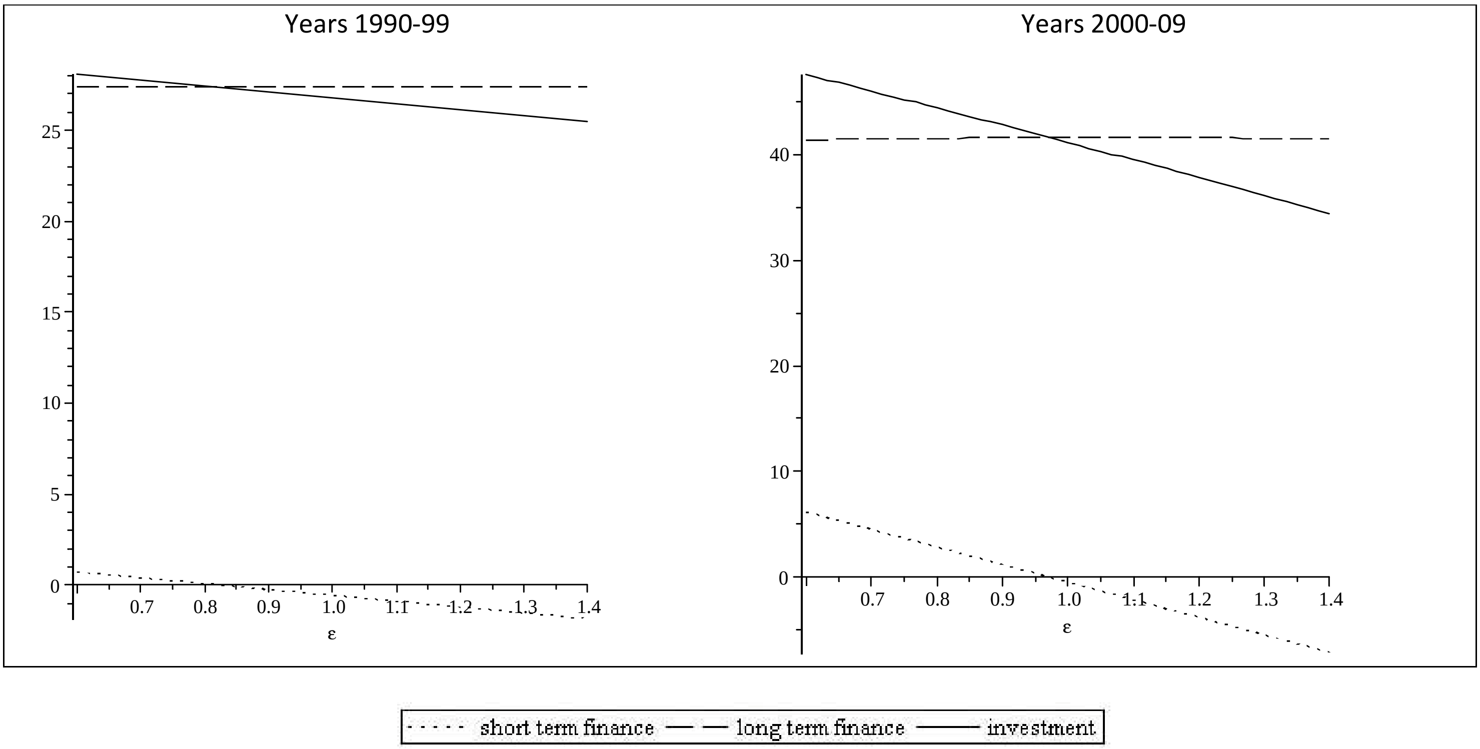


Figure 10 – Investment, short term finance and long term finance with different reserve ratios

Simulations based on weighted average values of the sample during years 2000-09 reported in Table 1.

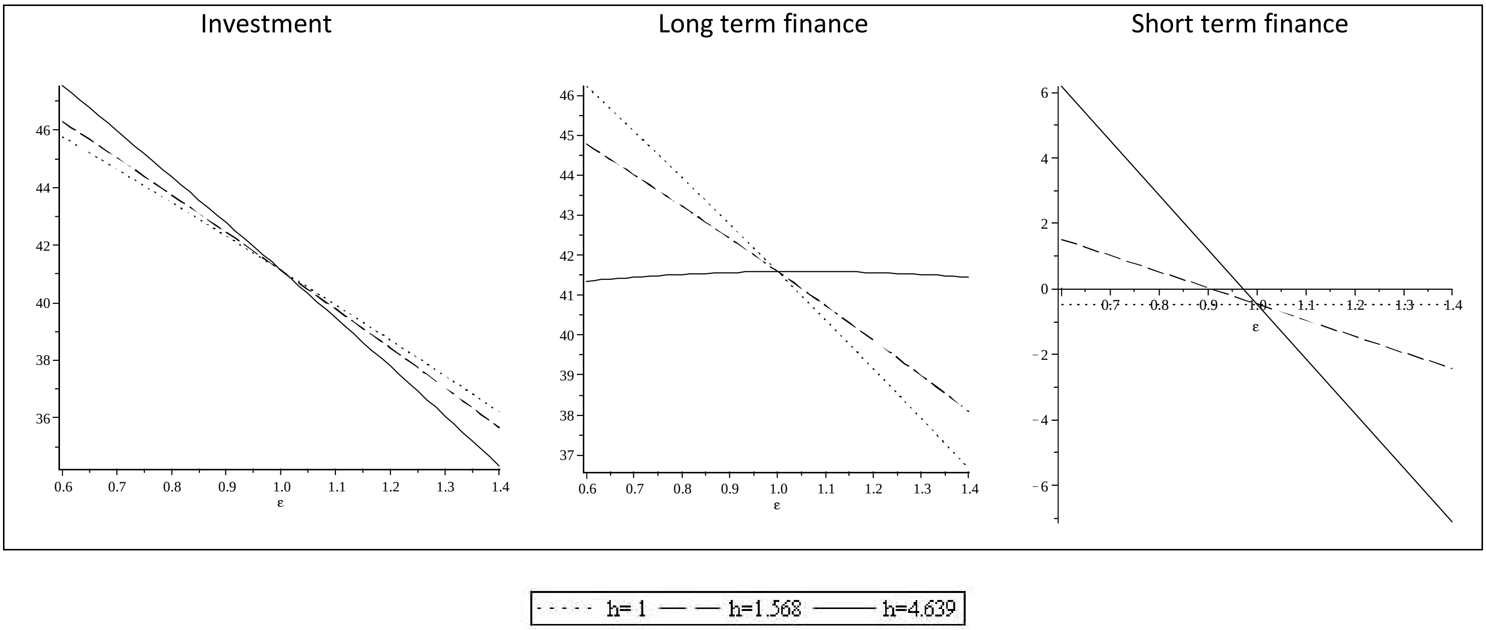


Figure 10 compares firm's investment, short term and long term finance in the period 2000-09, with three alternative values of the reserves to short term foreign debt ratio, h. The Greenspan-Guidotti rule ($h = 1$) implies full stabilisation of short term finance available to the firm, lower variability of the investment but much higher variability of the more expensive long term finance. The ratio of reserves to short term foreign debt that was optimal in the 1990-99 period ($h = 1.568$) would still imply a considerable variability of the long term finance in the 2000-09 period. By contrast, the optimal ratio in 2000-09 ($h^* = 4.639$), based on changed values of the parameters of the industry (lower η) and the financial market (lower δ), generates higher fluctuations in the short term finance, higher sensitivity of the investment to foreign capital inflow, but nearly full stabilisation of the long term finance function. This result confirms, again, that the purpose of reserve policy is to stabilise not the short term finance, but the longer term finance available to the investment. The Greenspan-Guidotti rule is not an optimal solution because it simply stabilises short term finance.

4.3 Effects of globalisation

The solution of the model presented in section 3 depends on three parameters, which account for the marginal cost of long term finance, δ, the competitiveness of the domestic industry, η, and the volatility of the foreign short term capital, σ. Their changing value can be associated to the process of globalisation. As the volatility parameter is irrelevant for values of η that are sufficiently low (from proposition 2), this subsection examines the effects of changing values of δ and η, all other parameters being held constant. Comparison is made, again, between years 1990-99 and 2000-09 average values. All panels in Table 3 take time 0 data from Table 1, i.e. the values of the fixed investment (NI) and short term foreign debt (STD), and compute solutions for the values of η from -0.01 to -0.13 and δ from 0.34 to 0.58. Each solution implies values for time 0's optimal reserves to short term foreign debt ratio and for time 1's expected variable investment, total investment, long term finance, average cost of long term finance, long period (2 years) growth. Bold characters are values of the 2 years growth and the optimal ratio h^* compatible with those observed in our sample (Table 1).

The purpose of the simulations is simply to focus on the potential capacity of the structural parameters newly introduced in this model and representative of changing openness to global markets (η and δ) to account for the stylised facts observed in section 2. The numerical exercises, thus, should not be considered as appropriate estimates of the values of the two mentioned parameters: this could be the object of further work.

Numerical results reported in Table 3 suggest that lower cost of long term finance could explain, *ceteris paribus*, how BRIC economies, in the last decade, have managed to double their average growth rates with little increase in new capital assets and short term foreign debt, as well as how smaller economies have managed to increase growth despite a lower level of investment in new capital assets and a lower short term foreign debt. The value of δ compatible with the observed growth rates goes from 0.5 to 0.4 in the weighted average sample (panels A-B), from 0.56 to 0.38 in the BRIC subsample (panels C-D), from 0.53 to 0.4 in the smaller countries subsample (panels E-F). This change implies that the average cost of long term finance declines, in all countries, from 26% to 22% (recall that the cost of short term foreign debt, r, is set equal to 10%) while the quantity of long term finance increases (from 27.4% to 41.5% of GDP). Simulations imply a relevant difference between subsamples: while the declining average cost is a common trend in both subsamples (from 29% to 21% in BRIC economies, from 28% to 20% in smaller countries), this is associated to almost a double quantity of long term finance in the BRIC economies and a more modest change (one fifth higher) in the smaller economies. Adding the net start up investment (given by data) and the variable investment (found as optimal solution) yields the total investment, which increases in all numerical simulations (+56% in BRIC and +7% in smaller economies, +42% on average) as a pure result of the decreasing cost of long term finance.

Lower values of δ are not able, alone, to account for the observed increased ratios of reserves to short term foreign debt ratios, h^*. In principle, lowering the cost of long term finance should even induce reduction of the stock of reserves, as it reduces the incentive to substitute extra short term finance with extra long term finance. Reserves, however, rise, because a lower value of δ also boosts the expected level of variable investment, which in turn requires a higher expected level of long term finance. Considering the full sample, the average ratio h^* was 1.478 in 1990-99, which corresponds to $\delta = 0.5$ and η between -0.02 and -0.03 in panel A. From panel B, it can be verified that lowering δ and holding η constant would imply a ratio increasing to a value between 1.72 and 2.081 only. The observed value, however, is 4.589 and is consistent with η around -0.1. Similarly, the values of η implied the subsamples go from -0.04 to -0.1 for the BRIC economies and from -0.045 to -0.11 for the smaller economies.

Table 3. Optimal solutions for different values of parameters

Numerical simulation of the solution of the model when the cost of external finance rises (δ from 0.34 to 0.58) and when the correlation between return on investment and short term foreign capital inflow rises (η from -0.01 to -0.13). Values of the short term foreign debt (STD) and the net (start up) investment (NI) are set equal to average values reported in Table 1. Panels from A to F report numerical results for different samples (Full sample, BRIC economies and smaller economies) in two different time periods (1990-99 and 2000-09). All Panels report solutions for optimal ratios of reserves to short term foreign debt ratio (h*) and for the expected values of the following variables: variable investment (VI), total investment (TI), long term finance (LTF), interest on short term foreign debt (Int. on STD), average cost of long term finance (AC on LTF), 2 years GDP growth (2y GDP growth). Other parameters of the model are set constant as follows: short term foreign debt volatility, σ=0.7; interest rate on short term foreign debt, r=0.1; scale parameters of the investment function, ω=2.2, and of the long term finance cost function, s=0.05; share of fixed capital (NI), α=0.25, and of other factors (VI), β=0.75.

Panel A. Full sample - Weighted average – Years 1990-99

RES to STD (h*) η δ	**0.34**	**0.36**	**0.38**	**0.4**	**0.42**	**0.44**	**0.46**	**0.48**	**0.5**	**0.52**	**0.54**	**0.56**	**0.58**
-0.01	1.300	1.284	1.268	1.253	1.239	1.225	1.212	1.200	1.189	1.179	1.169	1.159	1.151
-0.02	1.600	1.567	1.536	1.506	1.478	1.451	1.425	1.401	**1.378**	1.357	1.337	1.319	1.302
-0.03	1.901	1.852	1.805	1.760	1.717	1.676	1.638	1.602	**1.568**	1.536	1.506	1.479	1.453
-0.04	2.202	2.137	2.074	2.014	1.956	1.902	1.851	1.803	1.758	1.715	1.676	1.639	1.604
-0.05	2.504	2.422	2.343	2.268	2.197	2.129	2.065	2.005	1.948	1.895	1.845	1.799	1.755
-0.06	2.807	2.709	2.614	2.524	2.438	2.356	2.279	2.207	2.139	2.075	2.015	1.959	1.907
-0.07	3.112	2.996	2.886	2.780	2.680	2.584	2.494	2.410	2.330	2.256	2.186	2.121	2.060
-0.08	3.418	3.285	3.159	3.038	2.923	2.813	2.711	2.614	2.522	2.437	2.357	2.282	2.213
-0.09	3.725	3.576	3.433	3.297	3.167	3.044	2.928	2.818	2.716	2.619	2.529	2.445	2.366
-0.1	4.035	3.869	3.709	3.557	3.412	3.275	3.146	3.024	2.910	2.802	2.702	2.608	2.521
-0.11	4.346	4.163	3.987	3.819	3.659	3.508	3.365	3.231	3.105	2.986	2.876	2.772	2.676
-0.12	4.660	4.459	4.267	4.083	3.908	3.743	3.586	3.439	3.301	3.172	3.050	2.937	2.831
-0.13	4.977	4.758	4.549	4.349	4.159	3.979	3.809	3.649	3.499	3.358	3.226	3.103	2.988
TI/GDP	56.12	53.80	51.58	49.46	47.44	45.52	43.72	42.01	40.41	38.91	37.51	36.20	34.97
NI/GDP	13.60	13.60	13.60	13.60	13.60	13.60	13.60	13.60	13.60	13.60	13.60	13.60	13.60
STD/GDP	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67	5.67
VI/GDP	42.52	40.20	37.98	35.86	33.84	31.92	30.12	28.41	26.81	25.31	23.91	22.60	21.37
LTF/GDP	43.09	40.77	38.55	36.42	34.40	32.49	30.68	28.98	27.38	25.88	24.48	23.16	21.94
Int. on STD/GDP	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57	-0.57
AC of LTF	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
2y GDP growth	14.23	13.65	13.06	12.45	11.83	11.22	10.60	9.98	**9.37**	8.77	8.17	7.59	7.02

Panel B. Full sample - Weighted average – Years 2000-99

Res to STD (h*) η δ	**0.34**	**0.36**	**0.38**	**0.4**	**0.42**	**0.44**	**0.46**	**0.48**	**0.5**	**0.52**	**0.54**	**0.56**	**0.58**
-0.01	1.432	1.407	1.383	1.360	1.339	1.318	1.299	1.281	1.265	1.249	1.235	1.221	1.209
-0.02	1.863	1.813	1.766	1.720	1.677	1.637	1.599	1.563	1.530	1.499	1.470	1.443	1.417
-0.03	2.296	2.221	2.149	2.081	2.017	1.956	1.899	1.845	1.795	1.748	1.705	1.664	1.626
-0.04	2.729	2.629	2.533	2.443	2.356	2.275	2.199	2.128	2.061	1.998	1.940	1.886	1.836
-0.05	3.164	3.038	2.919	2.805	2.697	2.596	2.500	2.411	2.327	2.249	2.176	2.108	2.045
-0.06	3.600	3.449	3.305	3.168	3.039	2.917	2.802	2.695	2.594	2.500	2.413	2.331	2.255
-0.07	4.037	3.861	3.693	3.533	3.382	3.239	3.105	2.979	2.862	2.752	2.650	2.555	2.466
-0.08	4.477	4.276	4.083	3.900	3.727	3.563	3.409	3.266	3.131	3.005	2.888	2.779	2.678
-0.09	4.920	4.692	4.475	4.268	4.073	3.888	3.715	3.553	3.401	3.259	3.127	3.004	2.890
-0.1	5.365	5.111	4.869	**4.639**	4.421	4.216	4.023	3.842	3.673	3.515	3.368	3.231	3.104
-0.11	5.813	5.533	5.266	5.012	4.771	4.545	4.332	4.132	3.946	3.771	3.609	3.458	3.318
-0.12	6.264	5.958	5.665	5.387	5.124	4.876	4.643	4.424	4.220	4.030	3.852	3.687	3.534
-0.13	6.719	6.386	6.068	5.765	5.479	5.209	4.956	4.719	4.497	4.290	4.097	3.917	3.750
TI/GDP	65.69	62.83	60.11	57.52	55.07	52.76	50.58	48.55	46.64	44.86	43.20	41.66	40.22
NI/GDP	16.39	16.39	16.39	16.39	16.39	16.39	16.39	16.39	16.39	16.39	16.39	16.39	16.39
STD/GDP	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57	4.57
VI/GDP	49.30	46.44	43.72	41.13	38.68	36.37	34.19	32.16	30.25	28.47	26.81	25.27	23.83
LTF/GDP	49.75	46.90	44.18	41.59	39.14	36.83	34.65	32.61	30.71	28.93	27.27	25.73	24.29
Int. on STD/GDP	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46
AC of LTF	0.19	0.20	0.21	0.22	0.23	0.24	0.26	0.27	0.28	0.29	0.30	0.31	0.32
2y GDP growth	16.67	15.92	15.15	**14.37**	13.59	12.80	12.01	11.23	10.46	9.70	8.96	8.23	7.52

Panel C. BRIC Economies – Years 1990-99

Res to STD (h*) η \ δ	0.34	0.36	0.38	0.4	0.42	0.44	0.46	0.48	0.5	0.52	0.54	0.56	0.58
-0.01	1.544	1.514	1.486	1.459	1.434	1.409	1.386	1.365	1.345	1.325	1.308	1.291	1.275
-0.02	2.088	2.029	1.973	1.919	1.868	1.819	1.773	1.730	1.689	1.651	1.615	1.582	1.551
-0.03	2.633	2.545	2.460	2.379	2.302	2.229	2.160	2.095	2.034	1.977	1.924	1.873	1.827
-0.04	3.179	3.061	2.948	2.840	2.737	2.640	2.548	2.461	2.380	2.304	2.232	**2.165**	2.103
-0.05	3.726	3.579	3.438	3.302	3.174	3.052	2.937	2.828	2.727	2.631	2.541	2.458	2.380
-0.06	4.276	4.099	3.929	3.766	3.612	3.465	3.327	3.196	3.074	2.959	2.852	2.751	2.657
-0.07	4.828	4.620	4.422	4.232	4.051	3.880	3.718	3.566	3.423	3.288	3.163	3.045	2.935
-0.08	5.382	5.145	4.917	4.699	4.492	4.296	4.111	3.937	3.773	3.619	3.475	3.340	3.215
-0.09	5.940	5.672	5.415	5.169	4.936	4.715	4.506	4.309	4.124	3.951	3.789	3.637	3.495
-0.1	6.501	6.202	5.916	5.642	5.382	5.136	4.903	4.684	4.478	4.284	4.104	3.935	3.777
-0.11	7.065	6.736	6.420	6.118	5.831	5.559	5.302	5.060	4.833	4.620	4.420	4.234	4.060
-0.12	7.634	7.274	6.927	6.597	6.283	5.985	5.704	5.439	5.191	4.957	4.739	4.535	4.345
-0.13	8.208	7.816	7.439	7.080	6.738	6.414	6.109	5.821	5.550	5.297	5.060	4.838	4.631
TI/GDP	55.37	53.10	50.93	48.85	46.87	44.99	43.22	41.55	39.98	38.51	37.13	35.84	34.64
NI/GDP	13.37	13.37	13.37	13.37	13.37	13.37	13.37	13.37	13.37	13.37	13.37	13.37	13.37
STD/GDP	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09	3.09
VI/GDP	42.00	39.73	37.56	35.48	33.50	31.62	29.85	28.18	26.61	25.14	23.76	22.47	21.27
LTF/GDP	42.31	40.04	37.86	35.79	33.81	31.93	30.16	28.49	26.92	25.45	24.07	22.78	21.58
Int. on STD/GDP	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31	-0.31
AC of LTF	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
2y GDP growth	14.04	13.47	12.90	12.31	11.71	11.11	10.50	9.90	9.31	8.72	8.14	**7.58**	7.03

Panel D. BRIC Economies – Years 2000-99

Res to STD (h*) η \ δ	0.34	0.36	0.38	0.4	0.42	0.44	0.46	0.48	0.5	0.52	0.54	0.56	0.58
-0.01	1.452	1.427	1.402	1.379	1.357	1.336	1.317	1.298	1.281	1.265	1.250	1.236	1.223
-0.02	1.904	1.853	1.805	1.758	1.715	1.673	1.634	1.597	1.563	1.530	1.500	1.472	1.446
-0.03	2.357	2.281	2.208	2.138	2.072	2.010	1.951	1.896	1.844	1.796	1.751	1.709	1.669
-0.04	2.811	2.709	2.612	2.519	2.431	2.348	2.269	2.196	2.126	2.062	2.002	1.945	1.893
-0.05	3.266	3.139	3.017	2.900	2.790	2.686	2.588	2.496	2.409	2.328	2.253	2.183	2.117
-0.06	3.723	3.570	3.423	3.283	3.151	3.026	2.908	2.797	2.693	2.596	2.505	2.420	2.341
-0.07	4.181	4.002	3.831	3.668	3.513	3.366	3.228	3.099	2.977	2.864	2.758	2.659	2.567
-0.08	4.642	4.437	4.241	4.054	3.876	3.708	3.550	3.402	3.263	3.133	3.012	2.898	2.793
-0.09	5.106	4.874	4.652	4.441	4.241	4.052	3.874	3.707	3.550	3.403	3.266	3.139	3.020
-0.1	5.572	5.314	**5.067**	4.832	4.609	4.398	4.199	4.013	3.838	3.675	3.523	3.380	3.248
-0.11	6.041	5.756	5.484	5.224	4.978	4.746	4.527	4.321	4.128	3.948	3.780	3.623	3.477
-0.12	6.514	6.202	5.904	5.620	5.350	5.096	4.856	4.631	4.420	4.223	4.039	3.867	3.707
-0.13	6.991	6.651	6.327	6.018	5.725	5.448	5.188	4.943	4.714	4.499	4.299	4.113	3.939
TI/GDP	60.98	58.40	55.93	53.57	51.34	49.22	47.23	45.36	43.61	41.97	40.44	39.01	37.68
NI/GDP	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
STD/GDP	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07	4.07
VI/GDP	45.98	43.40	40.93	38.57	36.34	34.22	32.23	30.36	28.61	26.97	25.44	24.01	22.68
LTF/GDP	46.39	43.81	41.33	38.98	36.74	34.63	32.64	30.77	29.02	27.38	25.85	24.42	23.09
Int. on STD/GDP	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41	-0.41
AC of LTF	0.18	0.19	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30	0.31
2y GDP growth	15.47	14.81	**14.13**	13.44	12.74	12.04	11.34	10.64	9.95	9.27	8.60	7.95	7.32

Panel E. Smaller Emerging Economies – Years 1990-99

Res to STD (h*) η δ	**0.34**	**0.36**	**0.38**	**0.4**	**0.42**	**0.44**	**0.46**	**0.48**	**0.5**	**0.52**	**0.54**	**0.56**	**0.58**
-0.01	1.193	1.182	1.172	1.163	1.153	1.145	1.136	1.129	1.121	1.114	1.108	1.102	1.096
-0.02	1.386	1.365	1.345	1.325	1.307	1.289	1.273	1.257	1.243	1.229	1.216	1.204	1.193
-0.03	1.579	1.548	1.517	1.488	1.460	1.434	1.409	1.386	1.364	1.344	1.324	1.306	1.290
-0.04	1.773	1.731	1.690	1.651	1.614	1.579	1.546	1.515	1.486	**1.459**	**1.433**	1.409	1.386
-0.05	1.967	1.914	1.863	1.815	1.769	1.725	1.683	1.644	1.608	**1.574**	**1.541**	1.511	1.483
-0.06	2.162	2.098	2.037	1.979	1.923	1.871	1.821	1.774	1.730	1.689	1.650	1.614	1.581
-0.07	2.358	2.283	2.212	2.144	2.079	2.017	1.959	1.904	1.853	1.805	1.760	1.718	1.678
-0.08	2.555	2.469	2.387	2.309	2.235	2.164	2.098	2.035	1.976	1.921	1.869	1.821	1.776
-0.09	2.752	2.656	2.564	2.475	2.392	2.312	2.237	2.166	2.100	2.038	1.980	1.925	1.874
-0.1	2.951	2.844	2.741	2.643	2.549	2.461	2.377	2.298	2.225	2.155	2.090	2.030	1.973
-0.11	3.152	3.033	2.920	2.811	2.708	2.610	2.518	2.431	2.350	2.273	2.202	2.135	2.072
-0.12	3.354	3.224	3.099	2.981	2.868	2.761	2.660	2.565	2.476	2.392	2.314	2.240	2.172
-0.13	3.557	3.416	3.281	3.151	3.029	2.912	2.803	2.699	2.602	2.511	2.426	2.347	2.272
TI/GDP	56.09	53.76	51.53	49.40	47.38	45.45	43.64	41.93	40.33	38.82	37.41	36.09	34.86
NI/GDP	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61	13.61
STD/GDP	8.81	8.81	8.81	8.81	8.81	8.81	8.81	8.81	8.81	8.81	8.81	8.81	8.81
VI/GDP	42.48	40.15	37.92	35.79	33.77	31.84	30.03	28.32	26.72	25.21	23.80	22.48	21.25
LTF/GDP	43.36	41.04	38.80	36.67	34.65	32.73	30.91	29.20	27.60	26.09	24.68	23.36	22.13
Int. on STD/GDP	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88	-0.88
AC of LTF	0.18	0.19	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.28	0.29	0.30
2y GDP growth	14.22	13.64	13.04	12.43	11.81	11.19	10.57	9.95	9.33	**8.72**	**8.12**	7.53	6.96

Panel F. Smaller Emerging Economies – Years 2000-99

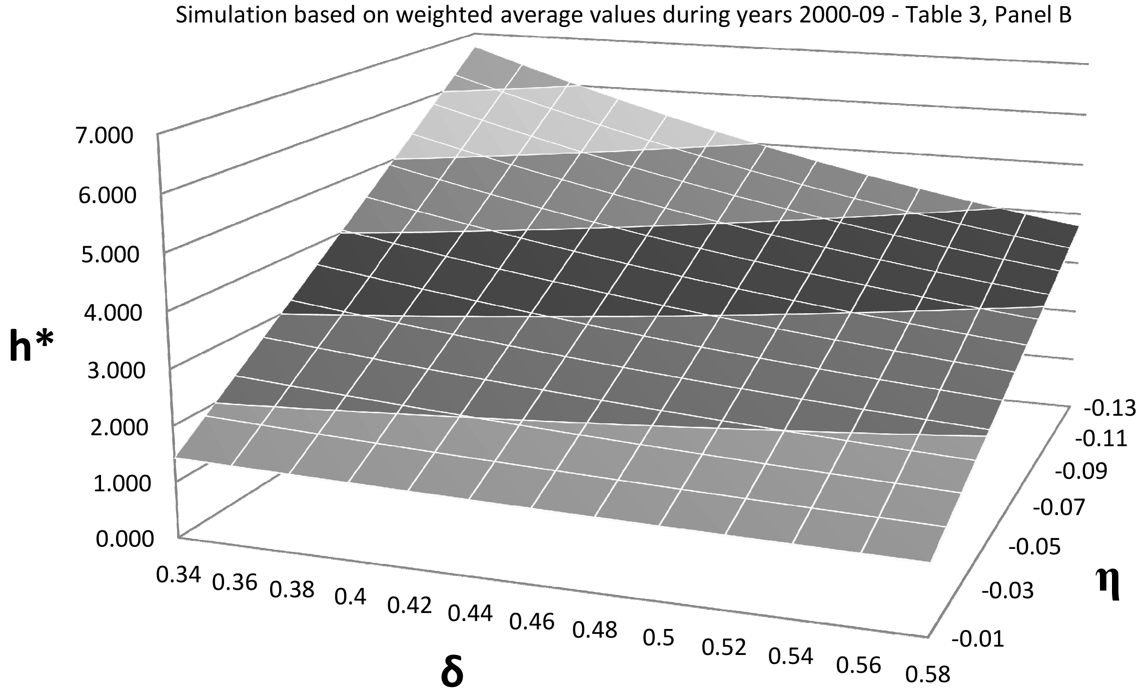
Res to STD (h*) η δ	**0.34**	**0.36**	**0.38**	**0.4**	**0.42**	**0.44**	**0.46**	**0.48**	**0.5**	**0.52**	**0.54**	**0.56**	**0.58**
-0.01	1.268	1.255	1.242	1.229	1.217	1.206	1.195	1.185	1.175	1.166	1.157	1.149	1.142
-0.02	1.537	1.510	1.484	1.459	1.435	1.412	1.390	1.370	1.350	1.332	1.315	1.299	1.284
-0.03	1.806	1.765	1.726	1.689	1.653	1.618	1.586	1.555	1.526	1.499	1.473	1.448	1.426
-0.04	2.075	2.021	1.969	1.919	1.871	1.825	1.782	1.741	1.702	1.665	1.631	1.598	1.568
-0.05	2.345	2.278	2.212	2.150	2.090	2.032	1.978	1.927	1.878	1.832	1.789	1.749	1.711
-0.06	2.617	2.535	2.457	2.381	2.309	2.240	2.175	2.113	2.055	2.000	1.948	1.899	1.853
-0.07	2.889	2.794	2.702	2.614	2.529	2.449	2.373	2.300	2.232	2.168	2.107	2.050	1.997
-0.08	3.163	3.053	2.948	2.847	2.751	2.658	2.571	2.488	2.410	2.336	2.267	2.202	2.141
-0.09	3.438	3.315	3.196	3.082	2.973	2.869	2.771	2.677	2.589	2.506	2.428	2.354	2.285
-0.1	3.715	3.577	3.445	3.318	3.197	3.081	2.971	2.867	2.769	2.676	2.589	2.507	2.430
-0.11	3.994	3.842	3.696	**3.556**	3.422	3.294	3.173	3.058	2.950	2.847	2.751	2.661	2.576
-0.12	4.274	4.108	3.949	3.795	3.648	3.508	3.376	3.250	3.132	3.020	2.915	2.816	2.723
-0.13	4.558	4.377	4.203	4.036	3.877	3.725	3.580	3.444	3.315	3.193	3.079	2.971	2.871
TI/GDP	46.04	44.27	42.55	40.91	39.34	37.84	36.42	35.07	33.80	32.60	31.47	30.40	29.41
NI/GDP	10.76	10.76	10.76	10.76	10.76	10.76	10.76	10.76	10.76	10.76	10.76	10.76	10.76
STD/GDP	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26	5.26
VI/GDP	35.28	33.51	31.79	30.15	28.58	27.08	25.66	24.31	23.04	21.84	20.71	19.64	18.65
LTF/GDP	35.81	34.03	32.32	30.68	29.10	27.61	26.18	24.84	23.56	22.36	21.23	20.17	19.17
Int. on STD/GDP	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53	-0.53
AC of LTF	0.17	0.18	0.19	0.20	0.21	0.22	0.22	0.23	0.24	0.25	0.26	0.27	0.28
2y GDP growth	11.64	11.22	10.80	**10.36**	9.91	9.46	9.01	8.55	8.10	7.65	7.21	6.77	6.35

Numerical simulations, thus, suggest that the increasing level of reserves to short term foreign debt ratios are mainly explained by the increasing competitiveness of the domestic industry, which implies a negative relation (although weak) between capital inflow and output price. The higher (in absolute value) this relation is, the higher the extent of the unpredictable fluctuations of the most expensive sources of finance associated to net foreign capital inflow, thus the higher is the stock of reserves needed to stabilise expensive finance around its expected level. While affecting unexpected fluctuations of the examined variables, competitiveness of domestic industry does not affect expected levels, which are only determined by δ, as Table 3 clearly shows.

The determination of the value of h^* as a function of the two parameters δ and η examined in this subsection is synthesised in Figure 11, taking data from 2000-09 full sample's simulated solutions (panel B of Table 3). It can be observed that the optimal ratio h^* is a decreasing function of the marginal cost of long term finance, δ, and an increasing function of the competitiveness of the domestic industry (decreasing function of η), and that its sensitiveness on the level of δ is lower when η is closer to zero.

Figure 11. Optimal reserves to short term debt ratio

Simulation based on weighted average values during years 2000-09 - Table 3, Panel B



5 Conclusion

Traditional models explaining stockpiles of foreign reserves describe emerging countries as financing long term investment with volatile short term foreign capital and building reserves to cushion the real output of the economy in the event of foreign capital outflow. Foreign reserves, in that they channel domestic saving away from financing domestic investment, are often seen as causing high social costs or underinvestment in the emerging economies (Rodrik, 2006, Greenwald and Stiglitz, 2010). However, in the last decade, emerging economies kept short term foreign debt and investment in net fixed capital nearly unchanged (or even reduced them), but increased reserves disproportionately and simultaneously managed to increase GDP growth. This work has constructed a model that is able to explain how both the high GDP growth and the growing stock of reserves are the result of the same process of globalisation of the emerging economies.

The model is built on the assumption that short term finance, which depends on foreign capital inflow and domestic monetary policy, is volatile but cheaper, whereas long term private finance is more costly and the cost increases with quantity. A variable component of the investment is decided, and simultaneously long term finance is raised, once the available short term finance is known with certainty. The optimal solution depends crucially on two structural parameters newly introduced in this model and representative of the openness of the emerging countries to global markets: they account for the marginal cost of long term finance and for the competitiveness of the domestic industry.

An approximated analytical solution of the model has been derived and has established that Central Banks of the emerging countries hold foreign reserves with the purpose of stabilising not the short term but the long term finance available to the firm around its expected level. To this purpose, a one-to-one Greenspan-Guidotti rule is not sufficient: emerging economies rationally accumulate higher ratios of reserves to short term foreign debt.

Numerical simulations of the model have explained the rising level of reserves in connection with rising GDP growth as the consequence of two simultaneous changes in the aforementioned structural parameters: a falling cost of long term finance and increasing competitiveness of the domestic industry. Both changes could be ascribed to the higher openness of the emerging economies to global goods and financial markets.

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