The Empirics of Foreign Reserves

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February 2001

Forthcoming, *Open Economies Review*

Abstract

In this paper, we study the determinants of cross-country variation in the level of international reserves over 1981-95. Confirming intuition, trade openness is easily the most important variable. There is also some evidence that financial deepening is associated with an increase in the reserves ratio. Smaller and more volatile industrial countries hold larger reserves than their larger, less volatile counterparts. In addition, more indebted developing countries tend to have smaller reserve ratios. We view these results as establishing some interesting stylized facts that may be helpful in informing future theoretical modelling of reserves behavior.

Keywords: foreign reserves, openness, volatility, financial development, external debt.

JEL Codes: F3, F4.

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The 1990s international financial crises have led to a renewal of interest in the behavior of international reserves. For instance, it is noteworthy that those countries (Singapore, Taiwan) with the largest reserves holdings were the least affected by speculative pressures during the Asian crisis. In this paper, we seek to understand the empirical determinants of the cross-country variation in the level of international reserves. We view this as a natural first step in establishing some stylized facts concerning the country characteristics that influence the level of reserves.

Our approach is positive in approach: we study the cross-sectional variation in the actual level of reserves. As such, it may be the case that reserves policies are non-optimal so the estimated equations need not reflect the "ideal" sensitivity of reserves to the various determinants. In future work, structural estimation may make progress on this issue but a natural starting point is to establish some stylized facts, via reduced-form estimation. As is outlined in section 2, a large number of variables may be identified as influencing reserves and we take an eclectic approach in this paper by studying a wide range of potential determinants.

With respect to the previous literature on the determinants of international reserves, there was an explosion of empirical papers in the 1960s and early 1970s (see Kenen and Yudin 1965; Kelly 1970; Flanders 1971; Grubel 1971; Frenkel 1974). More recent studies are provided by Landell-Mills (1989) and Bordo and Eichengreen (1998). These papers typically study a much smaller number of countries and a much narrower set of explanatory variables than are considered in this paper. For instance, Bordo and Eichengreen (1998) is the closest to our study but it includes only twenty-one countries and considers only country size, trade openness and volatility measures as potential determinants of reserves. These authors emphasize higher-frequency data by considering a pool of annual data and study the absolute level of reserves rather than the reserve-GDP ratio.

Previewing our empirical results, we confirm intuition by finding that trade openness is easily the most important factor in explaining cross-country variation in reserves accumulation. However, there is also some evidence that financial development and, at least

among the industrial countries, country size and external volatility are associated with an increase in the reserves/GDP ratio. An interesting finding for developing countries is that there is a negative partial correlation between the level of external debt and reserves. We view these results as establishing some empirical relationships that may stimulate new theoretical modelling of reserves behavior.

The rest of the paper is organised as follows. In section 1, we describe and motivate the set of determinants examined in this paper. Section 2 reports summary data and analyses the regression results. Finally, concluding comments are offered in section 3.

1 Determinants of Reserves

The extant literature identifies a range of variables that may influence reserve holdings. Since there is no consensus theoretical model of reserves behavior, we take a broad approach and attempt to include a large number of these potential determinants in the empirical work. These are: output per capita; trade openness; country size; export volatility; financial development; capital controls; the exchange rate regime; an oil dummy; and external debt variables. In this section, we motivate the selection of these regressors and describe our empirical measures.

Output per capita is included as a general control variable for the level of development. GDP per capita is measured in 1990 constant US dollars and is taken from the IMF's *International Financial Statistics* (*IFS*) CD-ROM.

Trade openness is an obvious candidate. Reserves are the "financing option of last resort" in covering import demand, providing a natural link between trade openness and reserve levels. In measuring trade openness, the raw volume of trade is potentially suspect, since reserves policy and trade policy may be jointly determined. Accordingly, we employ the adjusted index constructed by Frankel and Romer (1999) that attempts to capture the natural (policy-free) level of trade openness by using the sum of the predicted bilateral trade shares from the geographical determinants in a gravity model.

We check for scale effects by including country size. If the absolute level of international

reserves matters in deterring speculators, a larger country may be able to survive with a lower reserves-GDP ratio. Country size is measured by population (in millions), since we already control for output per capita. External volatility provides a prudential motive to hold reserves. Volatility is measured as the standard deviation of the growth rate of export revenues, in current US dollars. By using current dollars, the measure captures both volume and price volatility in exports.

The 1990s crises have highlighted the close relationship between domestic financial development and exposure to external crises (eg Goldfajn and Valdes 1997). To the extent that the liabilities of the domestic financial sector are partly denominated in foreign currency, financial deepening should be matched by an increase in international reserves. We measure financial depth by the M2/GDP ratio.[1] Population, export revenue and the M2/GDP ratio are taken from the *IFS* CD-ROM.

We include two policy variables in some of the specifications. One is the fraction of years during the sample period in which capital controls were in place. The other is the fraction of years in which a floating exchange rate regime is in place. The impact of capital controls is potentially ambiguous. On the one side, capital controls may reduce the risk of speculative attack, reducing the need to hold reserves as a bulwark against speculators. On the other, capital controls may prevent access to external credit sources, increasing the importance of reserves in financing external transactions. With respect to the exchange rate regime, fewer reserves are required, the weaker is the commitment to defend a given value for the exchange rate. The capital controls and exchange rate regime data are taken from Cottarelli and Giannini (1997), which is based on underlying IMF classifications. Although these are policy variables, we do not believe that decisions concerning capital controls and the exchange rate regime are strongly influenced by the endogenously-determined level of reserves over the long horizon studied in our cross-sectional approach.[2] Rather, any line of causation is more plausibly from these "meta" regime decisions to reserves behavior.

We also include a zero-one dummy variable to indicate countries that are heavily dependent on oil revenues. If we think of such countries as enjoying a temporarily high income

stream, it may wish to accumulate external assets, including liquid (reserve) holdings. The identification of oil countries is based on the IMF's *World Economic Outlook* classification.

Finally, we consider external debt indicators for a developing-country subsample. We examine total external debt, short-term debt and the ratio of short-term to total debt. Again, the relation between debt and reserves can go either way. Following Eaton and Gersovitz (1979), debt may serve as a substitute for reserves: if external transactions can be financed by debt, fewer reserves need be held. However, reserves may be required collateral in raising external debt. Moreover, the level of reserves may be important in stabilising the external debt market (especially at short maturities): if liquid assets are inadequate, rollover risk and the probability of creditor panics are increased (eg see Feldstein 1998). The debt variables are taken from the World Bank's *Global Development Finance* database.

2 Empirical Specification and Results

We estimate a cross-sectional specification, using data averaged over 1981-95. We focus on the cross-section, since we want to abstract from cyclical fluctuations in reserves (e.g. induced by boom-bust patterns in capital flows or speculative attacks) and many of the regressors have little time series variation.[3] The specification is[4]

$$\log\left(\frac{RES}{GDP}\right)_i = \alpha + \beta Z_i + u_i \tag{1}$$

where Z_i is the set of control variables. Estimation is by OLS, with heteroscedasticity-consistent standard errors.

The data set consists of 102 countries, listed in Table 1. (Not all variables are available for all countries, so the number of countries in each regression varies accordingly.) Figure 1 is a histogram of the reserves/GDP ratio, dividing countries into four groups. Group 1 contains the 48 countries with average reserves/GDP ratios below 5 percent; group 2 is the 33 countries with ratios between 5 and 10 percent; there are 15 countries with ratios between 10 and 20 percent in group 3; only six countries have ratios above 20 percent in group 4. Accordingly, the data clearly indicate considerable cross-country heterogeneity in

the reserves/GDP ratio.

Table 2 reports summary statistics and Table 3 the simple correlations between the (log) reserves/output ratio and the various determinants. GDP per capita (GDP-pc) and country size (Size) are transformed into logs; trade openness (Open), financial depth (FinDepth), total debt (Total Debt), short-term debt (ST Debt) and the ratio of short-term debt to total debt (ST Ratio) are measured as ratios; volatility (Volatility) is in percentage terms; capital controls (CAP) and the flexible exchange rate regime (Float) variables are respectively the fractions of years in which capital controls exist and a floating exchange rate regime is in place; finally, the oil dummy (Oil) is a zero-one dummy in which one denotes a country heavily dependent on oil revenues. In line with the theoretical discussion, the correlations are significantly positive with output per capita, trade openness, financial depth and the oil dummy and significantly negative with country size and the exchange rate flexibility dummy. The correlations are weaker with export volatility and the various debt variables.

The regression results for the full sample are shown in Table 4. The dependent variables is the (log) reserves/GDP ratio. GDP per capita, in logs, is included as a general control variable in all the regressions in columns (1)-(10); trade openness is included in columns (2)-(10); the other regressors are added on an individual basis in columns (3)-(8); column (9) includes all the regressors; and column (10) drops country size, in view of its naturally strong negative correlation with trade openness. Column (1) reveals a significantly positive relation: richer countries accumulate larger reserve/GDP ratios. Trade openness is added to the specification in column (2).[5] The explanatory power of the regression sharply improves, with the adjusted R^2 rising from 0.063 to 0.275. Both GDP per capita and trade openness are individually significant. Indeed, trade openness is individually significant and its point estimate is quite stable across columns (2)-(10), with the exception of column (9) that includes all the explanatory variables, including country size. GDP per capita loses significance in those specifications that include variables such as financial depth which are highly correlated with the level of development.

In columns (3)-(10), the other regressors are much less important in terms of improving

overall explanatory power. In columns (3) and (9), country size enters negatively; its p-value is 0.105 in column (3) and 0.007 in column (9): larger countries hold fewer reserves. In the full sample, there is some evidence that higher reserves are correlated with financial deepening, which is significant in columns (5) and (9). There is no evidence that volatility, capital controls, the exchange rate regime or oil dependence independently influences the level of reserves. One explanation is that some of these variables are quite correlated with the level of GDP per capita, which is already included in the specification.

Table 5 examines the subset of industrial countries. Within this high-income sample, GDP per capita has no impact on variation in reserve/GDP ratios. The effect of openness is very similar to the full sample results: rich open economies have higher ratios than rich closed economies. The evidence on the negative impact of country size is also very similar to the full sample results. The evidence on financial depth is slightly weaker and again there is no evidence of an independent effect of capital controls or the exchange regime. (We do not include the oil dummy since none of the industrial countries is classified as being heavily oil dependent.) The main difference with respect to the full sample is that there is some evidence that export volatility has a positive impact on the reserve ratio: the volatility variables is individually significant in columns (4) and (9). This positive relation accords with the prudential motive signalled by theoretical considerations.

We restrict the sample to developing countries in Table 6. Not surprisingly, the results are very similar to those for the full sample. The main exception is that country size is not individually significant within the developing country subsample, suggesting that its negative role in the full sample is emanating from the very low reserves/GDP ratios of the largest industrial countries. (The average reserve/GDP ratio over 1981-95 for the US was only 0.8 percent and it was only 2.5 percent for Japan.)

In Table 7, we add external debt variables to the specification for those developing countries that appear in the World Bank's *Global Development Finance* database. In columns (1)-(3), we add total external debt as a ratio to GNP; in columns (4)-(6), we consider only the short-term debt ratio; finally, in columns (7)-(9), we include both total

external debt and the ratio of short-term debt to total debt. The results are quite consistent for the three different debt measures. Once we control for other variables, external debt has a significantly negative partial correlation with the reserves ratio. Moreover, it is clear from columns (7)-(9) that what matters is total external debt: holding fixed the total, the composition between short-term and long-term does not matter.[6] The fact that debt enters negatively is consistent with debt substituting for reserves as a means of financing external transactions or with a high debt implying a high opportunity cost to holding reserves.

3 Conclusions

In this paper, we have studied the determinants of cross-country variation in the level of international reserves over 1981-95. Predictably, trade openness is easily the most important variable: for example, the estimate in column (2) in Table 4 suggests that a one standard deviation increase in trade openness from its sample mean (e.g. from 22.9 percentage points to 41.4 percentage points) leads to a 44 percent increase in the reserves/GDP ratio (from its sample mean of 8.6 percentage points to 12.4 percentage points). There is also some evidence that financial deepening is associated with an increase in the reserves ratio. Smaller and more volatile industrial countries hold larger reserves than their larger, less volatile counterparts. In addition, more indebted developing countries tend to have smaller reserve ratios.

We view the partial correlations generated by this cross-sectional study as helpful in establishing some stylized facts concerning the cross-country variation in reserves accumulation. Such empirical correlations can inform theoretical work on the modelling of reserves behavior. However, it would be desirable to explore estimation of structural models to make further progress. In addition, it is reasonable to believe that the determinants of reserves are evolving: in the wake of the 1990s crises, growing prominence is likely to be given to the scale of short-term external liabilities in determining the appropriate level of reserves. Finally, another recent innovation that could be studied in future work is the growing role played by financial engineering (credit lines, swaps and other derivatives) as

a partial substitute for reserves in national liquidity management policies.

Acknowledgements

We thank an anonymous referee, Michael Bleaney and Giovanni Lombardo. Lane is grateful to the Social Science Research Council of the Royal Irish Academy, the TCD Provost's Academic Development Fund, TCD Berkeley Fellowship and the TCD Arts and Social Sciences Benefactions Fund for financial support. This work is part of a research network on 'The Analysis of International Capital Markets: Understanding Europe's Role in the Global Economy', funded by the European Commission under the Research Training Network Programme (Contract No. HPRN-CT-1999-00067).

Notes

[1]This is a standard measure of financial development and has the advantage of being widely available.

[2]See Grilli and Milesi-Ferretti (1995) and Ghosh et al (1995) respectively for empirical studies of capital controls and exchange rate regime decisions. Of course, during crisis episodes, a collapse of an exchange rate peg is associated with a loss of reserves but such short-term correlations should wash out in the fifteen-year averaged data that we study.

[3]The lack of time-series variation would make fixed-effects panel estimation uninformative.

[4]The log specification is intended to reduce the role of the countries with extremely high reserve-GDP ratios (see Figure 1). A levels specification gives quite similar results.

[5]Very similar results are obtained if the trade openness ratio is entered in log form.

[6]The rise of private sector financing in the 1990s and the role played by short-term debt in the Tequila and Asian crises suggests that provisioning against short-term debt may increase over time.

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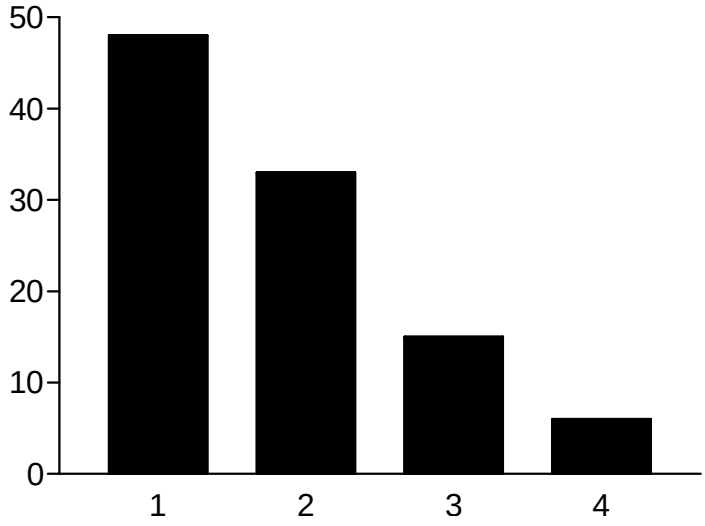

Figure 1: Histogram of RES/GDP ratio. Category 1 is ratio of less than 5%; 2 less than 10%; 3 between 10%-20%; 4 greater than 20%.

Table 1: Country List

Algeria	El Salvador	Madagascar	Saudi Arabia
Argentina	Ethiopia	Malawi	Seychelles
Australia	Finland	Malaysia	Sierra Leone
Austria	France	Mali	Singapore
Bahrain	Gabon	Malta	South Africa
Bangladesh	Gambia	Mauritania	Spain
Barbados	Germany	Mauritius	Sri Lanka
Belgium	Greecce	Mexico	Sweden
Benin	Guatemala	Morocco	Swaziland
Bolivia	Guinea-Bissau	Mozambique	Tanzania
Botswana	Guyana	Myanmar	Thailand
Brazil	Haiti	Nepal	Togo
Burundi	Honduras	Netherlands	Trinidad/Tobago
Canada	Hungary	New Zealand	Tunisia
Cent. Afr. Rep.	Iceland	Niger	Turkey
Chad	India	Norway	Uganda
Chile	Indonesia	Oman	UAE
China	Ireland	Pakistan	UK
Colombia	Israel	Panama	USA
Costa Rica	Italy	Papua NG	Uruguay
Cyprus	Jamaica	Paraguay	Venezuela
Denmark	Japan	Peru	Zaire
Djibouti	Jordan	Philippines	Zambia
Dom. Rep.	Kenya	Poland	Zimbabwe
Ecuador	Korea	Portugal	
Egypt	Kuwait	Rwanda	

Table 2: Summary Statistics

	RES-pc	GDP-pc	Open	Size	Volatility	FinDepth
Mean	553.88	5457.76	22.90	36.90	0.19	0.44
StDev	1134.53	6859.63	18.51	123.00	0.13	0.24
Max	8390.49	26586.86	98.14	101.00	0.79	1.44
Min	2.42	133.06	2.30	0.06	0.07	0.05
	Total Debt	ST Debt	ST Ratio	CAP	Float	Oil
Mean	81.50	10.80	14.13	0.68	0.49	0.08
StDev	72.20	13.30	10.16	0.41	0.42	0.27
Max	494.80	99.20	63.31	1.00	1.00	1.00
Min	11.60	0.29	1.37	0.00	0.00	0.00

See text for definitions of variables and data sources.

Table 3: Correlations

GDP-pc	0.21
Open	0.50
Size	-0.38
Volatility	0.03
FinDepth	0.37
Total Debt	-0.16
ST Debt	-0.08
ST Ratio	0.30
CAP	-0.05
Float	-0.21
Oil	0.14

Correlations with (log) reserves-GDP ratio. See text for definitions of variables and data sources.

Table 4: Full Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
c	-4.2	-4.3	-2.3	-4.2	-3.9	-3.8	-3.6	-4.2	1.02	-3.03
	(0.41)	(.37)	(1.2)	(.41)	(.36)	(.53)	(.51)	(.37)	(.62)	(.59)
gdp-pc	0.16	0.105	0.113	0.102	0.03	0.05	0.046	0.086	-0.098	-0.055
	(.055)	(.05)	(.049)	(.049)	(.053)	(.063)	(.059)	(.05)	(.068)	(.069)
open		0.024	0.016	0.024	0.021	0.027	0.025	0.023	0.005	0.021
		(.005)	(.007)	(.005)	(.005)	(.005)	(.006)	(.005)	(.009)	(.006)
size			-0.114						-0.23	
			(.07)						(.08)	
volatility				-0.064					-0.39	-0.38
				(.9)					(1.22)	(1.48)
findepth					0.644				1.38	0.763
					(.38)				(.53)	(.51)
cap						-0.112			-0.14	-0.075
						(.246)			(.25)	(.25)
fix							-0.3		-0.15	-0.23
							(.269)		(.25)	(.26)
oil								0.48	0.43	0.51
								(.275)	(.43)	(.42)
adj.R^2	0.063	0.275	0.289	0.264	0.253	0.273	0.288	0.285	0.327	0.274
SE	0.91	0.8	0.79	0.81	0.78	0.81	0.8	0.79	0.77	0.8
N	102	102	102	101	97	78	78	102	76	76

Dependent variable is (log) reserves-GDP ratio. OLS estimation with robust standard errors. Standard errors are in parentheses. See text for definitions of variables and data sources.

Table 5: Industrial Country Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
c	-0.01 (3.3)	-0.5 (2.8)	2.59 (2.9)	-3.25 (2.96)	-0.94 (2.81)	-1.8 (3.07)	-0.66 (2.74)	1.9 (5.1)	-4.4 (3.02)
gdp-pc	-0.31 (.35)	-0.324 (.302)	-0.293 (.292)	-0.092 (.31)	-0.311 (.285)	-0.2 (.32)	-0.288 (.29)	-0.144 (.35)	0.012 (.3)
open		0.031 (.012)	0.019 (.01)	0.028 (.011)	0.032 (.012)	0.03 (.011)	0.028 (.014)	0.009 (.009)	0.026 (.011)
size			-0.19 (.11)					-0.27 (.15)	
volatility				4.3 (1.5)				1.21 (2.69)	3.9 (1.7)
findepth					0.485 (.528)			1.2 (.69)	0.305 (.533)
cap						0.34 (.32)		-0.024 (.3)	0.281 (.341)
fix							-0.212 (.344)	-0.285 (.283)	-0.09 (.28)
adj.R^2	-0.013	0.336	0.446	0.487	0.323	0.336	0.314	0.534	0.426
SE	0.68	0.55	0.5	0.48	0.556	0.551	0.56	0.46	0.51
N	22	22	22	22	22	22	22	22	22

Dependent variable is (log) reserves-GDP ratio. OLS estimation with robust standard errors. Standard errors are in parentheses. See text for definitions of variables and data sources.

Table 6: Developing Country Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
c	-5.3	-4.9	-3.8	-4.8	-4.6	-4.3	-4.4	-4.8	-0.46	-3.3
	(.56)	(.52)	(1.5)	(.53)	(.49)	(.84)	(.79)	(.64)	(1.9)	(.88)
gdp-pc	0.329	0.219	0.214	0.21	0.145	0.163	0.181	0.188	0.006	0.045
	(.081)	(.081)	(.08)	(.08)	(.079)	(.113)	(.114)	(.1)	(.12)	(.13)
open		0.021	0.016	0.021	0.014	0.024	0.021	0.021	0.0015	0.014
		(.005)	(.008)	(.005)	(.006)	(.006)	(.007)	(.005)	(.015)	(.009)
size			-0.063						-0.17	
			(.082)						(.11)	
volatility				-0.414					-0.473	-0.672
				(.838)					(1.15)	(1.31)
findepth					1.03				1.71	1.22
					(.533)				(1.03)	(.91)
cap						-0.38			-0.37	-0.38
						(.29)			(.35)	(.33)
fix							-0.367		-0.23	-0.37
							(.341)		(.35)	(.37)
oil								0.262	0.256	0.256
								(.348)	(.511)	(.516)
adj.R^2	0.161	0.299	0.295	0.29	0.29	0.304	0.296	0.295	0.302	0.292
SE	0.92	0.84	0.84	0.846	0.815	0.871	0.875	0.84	0.864	0.87
N	80	80	80	79	75	56	56	80	54	54

Dependent variable is (log) reserves-GDP ratio. OLS estimation with robust standard errors. Standard errors are in parentheses. See text for definitions of variables and data sources.

Table 7: Debt Sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
c	-4.1	2.8	-2.3	-4.3	-0.23	-3.5	-4.3	1.5	-2
	(0.8)	(2.5)	(1.0)	(.63)	(1.94)	(.88)	(0.8)	(2.5)	(1)
gdp-pc	0.11	-0.13	1.29	0.142	0.075	0.14	0.167	-0.005	0.12
	(0.11)	(0.93)	(.10)	(.096)	(.121)	(.15)	(.132)	(.15)	(.17)
Open	0.019	-.01	0.292	0.019	-0.0031	0.012	0.02	-0.003	0.015
	(.006)	(.02)	(.152)	(.006)	(.017)	(.01)	(.0065)	(.018)	(.01)
Size		-0.275			-0.18			-0.23	
		(.14)			(.12)			(.13)	
Volatility		-0.237	-0.73		-0.23	-0.57		-0.24	-0.63
		(1.42)	(1.6)		(1.4)	(1.6)		(1.47)	(1.63)
FinDepth		1.61	0.8		1.67	1.1		1.91	1.39
		(1.12)	(.9)		(1.11)	(.89)		(1.01)	(.82)
CAP		-0.12	-0.18		-0.27	-0.31		-0.17	-0.23
		(.34)	(.33)		(.34)	(.32)		(.35)	(.31)
Float		-0.32	-0.51		-0.42	-0.56		-0.34	-0.49
		(.35)	(.37)		(.37)	(.38)		(.35)	(.35)
Oil		0.006	0.1		-0.039	-0.01		-0.074	-0.03
		(.6)	(.64)		(.63)	(.67)		(.63)	(.67)
Total Debt	-0.142	-0.93	-0.78				-0.14	-1	-0.9
	(.167)	(.37)	(.39)				(.18)	(.34)	(.37)
ST Debt				-1.1	-4.8	-4.9			
				(1.0)	(2.2)	(2.3)			
ST Ratio							-1.2	-2.1	-2.9
							(1.6)	(1.9)	(1.9)
adj.R^2	0.168	0.201	0.227	0.182	0.254	0.234	0.168	0.29	0.259
SE	0.84	10.92	0.85	0.835	0.835	0.843	0.842	0.81	0.83
N	69	48	48	69	48	48	69	48	48

Dependent variable is (log) reserves-GDP ratio. OLS estimation with robust standard errors. Standard errors are in parentheses. See text for definitions of variables and data sources.