

1. Capital Flows at Risk²

1. While the past literature on the drivers of capital flows focused primarily on the contemporaneous relationship between capital flows and different factors, the Capital-Flows-at-Risk framework takes a forward-looking perspective on risks to capital flows by asking what global and domestic conditions today can tell us about the probability and the size of future capital flows. The approach applies quantile regressions to compute the entire probability distribution of future flows and considers the joint impact of different drivers on the predicted distribution. The risks to future flows are measured by the size (and changes) in the tails of the distribution.
2. The approach is similar in spirit to the Growth-at-Risk analysis, published in the *Global Financial Stability Report* previously (IMF 2017, 2018; see also Adrian, Boyarchenko, and Giannone (2018)). Since then it has been applied to capital flows for example in IMF (2018) and in Gelos and others (2019). The methodology builds on the analysis in Gelos and others (2019) and extends it to various types of portfolio flows.

Empirical Approach

3. Let $\bar{y}_{i,t:t+h}$ denote the average portfolio inflows to country i (in percent of GDP) in the quarters $t, t+1, \dots, t+h$, where t stands for current quarter. Our baseline regression is specified as follows:

$$\bar{y}_{i,t:t+h}^{\alpha} = \gamma_i^{\alpha} + \beta_1^{\alpha} Global_t + \beta_2^{\alpha} Domestic_{i,t-1} + \beta_3^{\alpha} TimeControls, \quad (1)$$

for $\alpha=0.05, 0.1, 0.15, \dots, 0.95$.

4. $Global_t$ is a vector of global “push” factors, $Domestic_{i,t}$ stands for country-specific factors in country i at time $t-1$, that have been considered as “pull” drivers in the literature. All domestic variables are lagged to limit potential for reverse causality. All regressions also include dummies for the pre-GFC, GFC (global financial crisis), and post-GFC periods and country fixed effects.

¹ This is an annex to Chapter 3 of the April 2020 *Global Financial Stability Report*. © 2020 International Monetary Fund.

² This section was prepared by Rohit Goel and Lucyna Górnicka.

5. The upper-script α stands for the percentile at which the regression is estimated. In a general quantile regression of a variable $\bar{y}_{t:t+h}$ on a vector of controls x_t , $\bar{y}_{t:t+h} = \delta^\alpha x_t$, the regression slope δ^α is chosen to minimize the quantile-weighted absolute value of errors:

$$\hat{\delta}^\alpha = \operatorname{argmin} \sum_{t=1}^{T-h} (\alpha \times 1_{\bar{y}_{t:t+h} > x_t \delta} |\bar{y}_{t:t+h} - x_t \delta| + (1 - \alpha) \times 1_{\bar{y}_{t:t+h} < x_t \delta} |\bar{y}_{t:t+h} - x_t \delta|) \quad (2)$$

where $1_{(\cdot)}$ denotes the indicator function. The predicted value from that regression is the percentile of $\bar{y}_{t:t+h}$ conditional on x_t . In this application, equation (1) is estimated for a range of percentiles from the 5th to the 95th percentile. Estimates are then used for a range of percentiles to construct an empirical distribution of predicted average portfolio flows.

6. To summarize the information from individual quantile regressions, the analysis distinguishes between the lower tail of the predicted distribution, median predicted flows and the upper tail of the distribution³: the average of coefficients from regressions for the 5th to 30th percentiles reflects impact of a variable on the *lower tail* of the conditional predicted distribution of future flows, the average of coefficients from regressions for the 40th to 60th percentiles—on *median flows*, and the average of coefficients from the regression for the 70th to 95th percentiles—on *upper tail* of the distribution.

7. Finally, in the Capital-Flows-at-Risk framework, risks to capital flows can be quantified by estimating the *size of outflows* that would be reached or exceeded for a given probability. This amount is called “capital flows at risk” (CaR), and—following the Growth-at-Risk literature—it is estimated it using the 5th percentile of the distribution.

Variants of the Model and Sample Description

8. The analysis considers different types of portfolio flows:

- *Total debt portfolio flows.* This part focuses on the drivers of aggregate debt portfolio flows, independently of the currency in which debt flows are denominated, and it is based on a sample of 37 emerging market economies (Online Annex Table 3.1.1).
- *Total debt portfolio flows versus equity portfolio flows.* Next, the drivers of debt flows and equity flows are analyzed based on a sample of the 18 emerging market economies with sufficiently liquid equity markets (Online Annex Table 3.1.1).
- *Local currency debt flows versus hard currency debt flows.* The analysis is based on a sample of 15 large economies for which sufficiently long data on local currency debt flows are

³ The overall results hold true even when only the coefficients of the extreme quantiles are considered, but averaging across quantiles gets an approximation of the shape of the distribution

available. Hard currency debt flows are calculated as the residual from the overall portfolio debt flows (Online Annex Table 3.1.1).

Online Annex Table 3.1.1. Sample Characteristics

	Total Debt Portfolio Flows	Debt versus Equity Portfolio Flows	Local Currency versus Hard Currency Debt Portfolio Flows
EMEA region	Bulgaria, Bosnia and Herzegovina, Belarus, Georgia, Hungary, Kazakhstan, North Macedonia, Poland, Romania, Russia, Serbia, Ukraine, Egypt, Morocco, Turkey, South Africa, Jordan, and Mauritius	Bulgaria, Hungary, Poland, Romania, Russia, Egypt, Turkey, and South Africa	Egypt, Hungary, Poland, Russia, Turkey, Ukraine, and South Africa
Asia and Pacific region	India, Indonesia, Republic of Korea, Malaysia, Philippines, and Thailand	India, Indonesia, Republic of Korea, Malaysia, Philippines, and Thailand	China, India, Indonesia, Korea, and Malaysia
Central and South America region	Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Guatemala, Jamaica, Mexico, Panama, Peru, El Salvador, Paraguay, and Uruguay	Brazil, Chile, Colombia, Mexico, and Peru	Brazil, Mexico, and Peru
Time period	1996:Q4–2019:Q1	1996:Q4–2019:Q1	2000:Q1–2019:Q1
Panel type	Unbalanced	Unbalanced	Unbalanced

Sources: Country sources; Haver Analytics; IMF Financial Flows Analytics database; and IMF staff calculations.
Note: EMEA = Europe, the Middle East, and Africa.

Variables Description

9. In each specification, the dependent variable is gross portfolio inflows, that is, net nonresident purchases of emerging market (EM) debt instruments. Portfolio flows data are measured in US dollars, scaled by GDP in US dollars.⁴ The time horizon is a total of three quarters—including the current quarter and two quarters ahead.

10. The independent variables capture the various external and domestic drivers (“push and pull” factors) that have been established in the capital flows literature.⁵ In our preferred specification, push factors include⁶:

- 1) the VIX index, as a proxy for the global risk appetite
- 2) market interest rates captured through the US 10-year Treasury yields⁷
- 3) the US dollar (measured by the DXY dollar index).

⁴ China is excluded from this analysis because of its unique country characteristics, including its size relative to the rest of EMs.

⁵ The specification broadly mirrors the work done in Gelos and others 2019, where a broad range of additional explanatory variables were also tested.

⁶ For the hard currency vs local currency capital flows at risk analysis, variables #7 and #8 are not included given the constraints on the degrees of freedom and the smaller sample size.

⁷ In the empirical literature, the change in US 10-year Treasury yields is commonly used to analyze the determinants of capital flows. The predictive content for *future* capital flows, however, is better captured by the *level* of 10-year yields. The 10-year yield is de-trended using a Hodrick-Prescott filter to remove the secular downward trend observed over the past 35 years. The de-trended variable can be interpreted as a cyclical measure of US interest rates, with yields generally rising during economic expansions and falling during contractions.

11. A specification where the three push factors are replaced with a global Financial Conditions Index (FCI) is considered. On the domestic side, the variables are:

- 4) a ratio of short-term external debt foreign reserves, as a proxy for external balance sheet vulnerabilities
- 5) year-over-year real GDP growth rate
- 6) financial market depth index, capturing the level of development and liquidity of the domestic financial markets
- 7) capital account openness, measuring the severity of restrictions on cross-border capital transactions
- 8) GDP growth per capita, a measure of economic development and domestic wealth.⁸

Data Sources

12. The data on debt and equity portfolio inflows are from the IMF's Financial Flow Analytics database. The time series of VIX, US 10-year treasury yields and the DXY index come from the Federal Reserve Bank of St. Louis database, Federal Reserve Economic Data (FRED). The GDP growth rates, short-term external debt to reserves ratio, financial market depth index and the global financial conditions index all come from the IMF (see Svirydzhenka 2016 for a description of the financial market depth index). The Chinn-Ito index is used as a measure of capital account openness. GDP per capita figures are sourced from the World Bank and the local currency capital flows are from Haver Analytics and country sources. Hard currency capital flow data is then approximated as a residual from the Balance of Payments Portfolio Debt Flows.

Results

13. *Aggregate debt portfolio flows and debt portfolio flows versus equity portfolio flows (Figure 3.6).* Panels 1 and 2 of Figure 3.6 show the average coefficients from the subsets of quantile regressions based on the sample of 37 countries. Panels 3–6 show the average coefficients from regressions for debt and for equity portfolio flows, based on a smaller sample of 18 economies, for which a meaningful comparison of the two types of portfolio flows was possible. The absolute values of coefficients are reported in all the panels, but the results regarding debt versus equity portfolio flows also hold when looking at the standardized coefficients—reported in Online Annex Figure 3.1, panel 1.

14. Panel 1 reports average coefficients on the global FCI index when only the global FCI is included as a measure of global factors in equation (1). All other panels in Figure 3.5 present results from regressions that include the VIX index, the DXY index, and the US 10-year

⁸ In principle, a lower GDP per capita should be associated with higher average flows (since capital should be expected to flow to capital-scarce countries) but other effects are conceivable—for example, differences in GDP per capita are also correlated with differences in financial and institutional development.

Treasury yield instead of the global FCI. Online Annex Table 3.1.2 shows detailed results from the quantile regressions.

Online Annex Table 3.1.2. Quantile Regressions Estimation Results: Debt and Equity Portfolio Flows

Dependent Variable: Gross Debt Portfolio Inflows (Sample of 37 Economies)											
	Percentile										
	5	10	20	30	40	50	60	70	80	90	95
FCI	-0.09 (0.07)	-0.09** (0.04)	-0.05 (0.03)	-0.02 (0.04)	-0.02 (0.03)	-0.04 (0.04)	-0.08* (0.05)	-0.11** (0.05)	-0.07 (0.07)	-0.10 (0.10)	-0.07 (0.12)
VIX	-0.013 (0.01)	-0.018* (0.01)	-0.016** (0.01)	-0.014** (0.01)	-0.014** (0.01)	-0.017** (0.01)	-0.02*** (0.01)	-0.022*** (0.01)	-0.025*** (0.01)	-0.014 (0.02)	-0.020 (0.02)
U.S. 10-Year Yield	-0.10 (0.19)	-0.21* (0.12)	-0.25** (0.11)	-0.24** (0.11)	-0.24** (0.11)	-0.28** (0.13)	-0.30** (0.14)	-0.38** (0.15)	-0.38** (0.19)	-0.21 (0.27)	-0.40 (0.33)
DXY	-0.01 (0.01)	-0.01 (0.01)	-0.01 (0.01)	-0.016** (0.01)	-0.015* (0.01)	-0.018** (0.01)	-0.020** (0.01)	-0.025** (0.01)	-0.028** (0.01)	-0.048** (0.02)	-0.073*** (0.02)
Dependent Variable: Gross Debt Portfolio Inflows (Sample of 18 Economies)											
	Percentile										
	5	10	20	30	40	50	60	70	80	90	95
VIX	-0.017 (0.02)	-0.019 (0.01)	-0.008 (0.01)	-0.008 (0.01)	-0.017 (0.01)	-0.017* (0.01)	-0.020* (0.01)	-0.023* (0.01)	-0.026** (0.01)	-0.029* (0.02)	-0.024 (0.03)
U.S. 10-Year Yield	-0.64*** (0.25)	-0.54*** (0.19)	-0.52*** (0.17)	-0.40*** (0.15)	-0.42** (0.17)	-0.39* (0.20)	-0.41* (0.22)	-0.3 (0.23)	-0.3 (0.22)	-0.2 (0.33)	0 (0.35)
DXY	-0.03** (0.02)	-0.03*** (0.01)	-0.029*** (0.01)	-0.032*** (0.01)	-0.037*** (0.01)	-0.034*** (0.01)	-0.035*** (0.01)	-0.032** (0.02)	-0.028* (0.01)	-0.036* (0.02)	-0.055*** (0.02)
Short-term FX	-0.82** (0.29)	-0.59*** (0.15)	-0.58*** (0.15)	-0.23 (0.14)	-0.03 (0.14)	0.04 (0.18)	0.07 (0.18)	0.23 (0.22)	0.30 (0.23)	0.57 (0.28)	0.86 (0.37)
Financial Markets Depth	1.47 (0.02)	1.93 (0.02)	2.51** (0.02)	2.62** (0.01)	2.24 (0.01)	2.45 (0.01)	3.78** (0.01)	4.42*** (0.01)	4.36*** (0.01)	4.51*** (0.02)	5.21** (0.02)
Dependent Variable: Gross Equity Portfolio Inflows (Sample of 18 Economies)											
	Percentile										
	5	10	20	30	40	50	60	70	80	90	95
VIX	-0.004 (0.009)	-0.002 (0.006)	-0.002 (0.003)	-0.004 (0.003)	-0.004 (0.003)	-0.008*** (0.003)	-0.007** (0.004)	-0.009*** (0.003)	-0.011** (0.004)	-0.011 (0.009)	-0.015 (0.013)
U.S. 10-Year Yield	-0.2 (0.14)	-0.1 (0.12)	-0.1 (0.08)	-0.1 (0.06)	-0.1 (0.06)	-0.1 (0.07)	-0.11* (0.07)	-0.13** (0.06)	-0.17*** (0.06)	-0.26*** (0.08)	-0.21* (0.13)
DXY	-0.005 (0.01)	-0.005 (0.01)	-0.006 (0.00)	-0.006 (0.00)	-0.008* (0.00)	-0.007 (0.00)	-0.009* (0.01)	-0.009* (0.00)	-0.011* (0.01)	-0.009 (0.01)	-0.004 (0.01)
Short-term FX	-0.08 (0.10)	0.19 (0.11)	0.11** (0.07)	0.09* (0.07)	0.04 (0.07)	0.06 (0.08)	0.14 (0.08)	0.20 (0.06)	0.17 (0.08)	0.39 (0.13)	0.43 (0.17)
Financial Markets Depth	0.07 (0.01)	-0.08 (0.01)	0.17 (0.00)	0.30 (0.00)	0.22 (0.00)	0.60 (0.00)	1.13* (0.00)	1.39** (0.00)	1.90** (0.00)	2.54** (0.01)	3.49** (0.01)

Sources: Haver Analytics; IMF, Assessing Reserve Adequacy database; IMF, Financial Flows Analytics database; IMF, International Financial Statistics database; World Bank estimates; and IMF staff calculations.

Note: DXY = U.S. Dollar Index; FCI = Financial Conditions Index; VIX = Chicago Board Options Exchange Volatility Index.

15. *Comparison between local currency and hard currency portfolio debt flows* (Figure 3.6): Panels 1–3 show the average coefficients from the subsets of quantile regressions for local and hard currency debt portfolio flows (as defined above) based on the sample of 15 countries. The results are based on regressions that include VIX index, the DXY index, and the U.S. 10-year Treasury yield instead of the global FCI. Panel 4 shows the average coefficients on the global FCI index when only the global FCI is included as a measure of global factors in equation (1). Online Annex Table 3.1.3 shows detailed results from the quantile regressions. Standardized coefficients are reported in Online Annex Figure 3.1.1, panel 2.

Online Annex Table 3.1.3. Quantile Regressions Estimation Results: Hard and Local Currency Debt Portfolio Flows

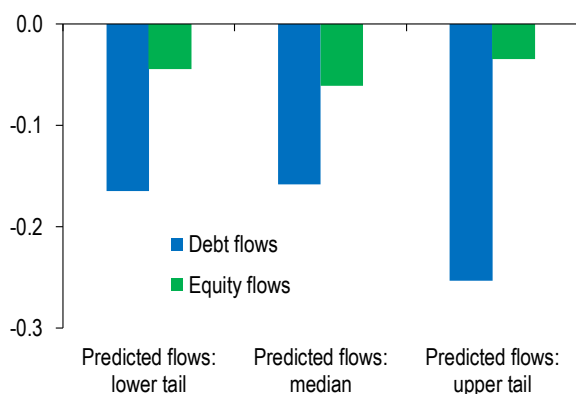
Dependent Variable: Gross Hard Currency Debt Portfolio Inflows (Sample of 15 Economies)											
	Percentile										
	5	10	20	30	40	50	60	70	80	90	95
Short-term FX	-0.22	-0.18	0.01	0.02	-0.01	-0.03	-0.03	0.05	-0.09	0.03	-0.13
Debt to Reserves	(0.05)	(0.06)	(0.05)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.07)
Domestic Growth	0.04	0.01	0.00	0.01	0.00	0.01	0.01	0.03	0.01	0.04	-0.02
	(4.44)	(0.44)	(0.29)	(0.25)	(0.31)	(0.27)	(0.30)	(0.33)	(0.40)	(46.50)	(100.55)
Financial Markets	0.61	1.55	3.14	3.57*	3.41**	4.01**	3.71*	3.59**	3.03***	2.39	3.73**
Depth	(0.33)	(0.34)	(0.40)	(0.41)	(0.44)	(0.51)	(0.55)	(0.50)	(0.33)	(0.31)	(0.88)
Global FCI	-0.02	-0.06	-0.05	-0.04	-0.07	-0.04	-0.01	-0.03	-0.06	-0.07	-0.14
	(0.14)	(0.09)	(0.07)	(0.08)	(0.10)	(0.09)	(0.11)	(0.12)	(0.16)	(0.26)	(0.23)
Dependent Variable: Gross Local Currency Debt Portfolio Inflows (Sample of 15 Economies)											
	Percentile										
	5	10	20	30	40	50	60	70	80	90	95
Short-term FX	-0.50***	-0.39**	-0.74**	-0.60	-0.46	-0.32	-0.17	0.20	0.10	0.34	0.54
Debt to Reserves	(0.02)	(0.03)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)	(0.06)	(0.07)	(0.06)
Domestic Growth	0.07***	0.04	0.02	0.00	0.01	0.01	0.04*	0.05	0.03	0.05	0.06
	(2.50)	(3.17)	(0.22)	(0.26)	(0.33)	(0.45)	(0.57)	(0.61)	(0.72)	(29.68)	(78.51)
Financial Markets	2.39	3.10	2.69*	3.02	2.77	4.31	4.07	5.63*	6.07*	6.15**	7.01**
Depth	(0.16)	(0.20)	(0.29)	(0.41)	(0.83)	(0.80)	(0.87)	(1.02)	(0.84)	(1.23)	(0.99)
Global FCI	-0.08	0.00	-0.11	-0.03	-0.01	-0.02	-0.04	-0.09	-0.07	-0.12	-0.01
	(0.22)	(0.18)	(0.11)	(0.09)	(0.08)	(0.07)	(0.09)	(0.09)	(0.09)	(0.13)	(0.15)

Sources: Haver Analytics; IMF, Assessing Reserve Adequacy database; IMF, Financial Flows Analytics database; IMF, International Financial Statistics database; World Bank estimates; and IMF staff calculations.

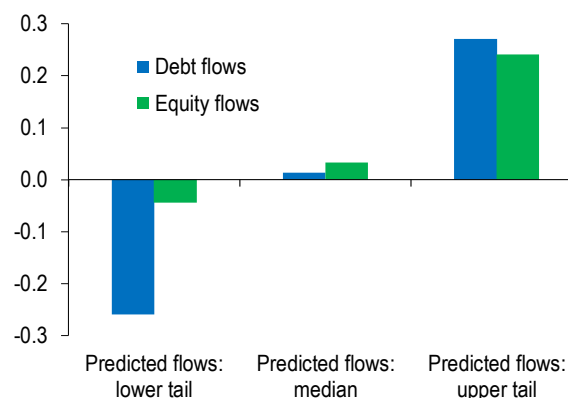
Note: DXY = U.S. Dollar Index; FCI = Financial Conditions Index; VIX = Chicago Board Options Exchange Volatility Index.

Online Annex Figure 3.1.1. Standardized Coefficients in Quantile Regressions: Debt versus Equity Portfolio Flows

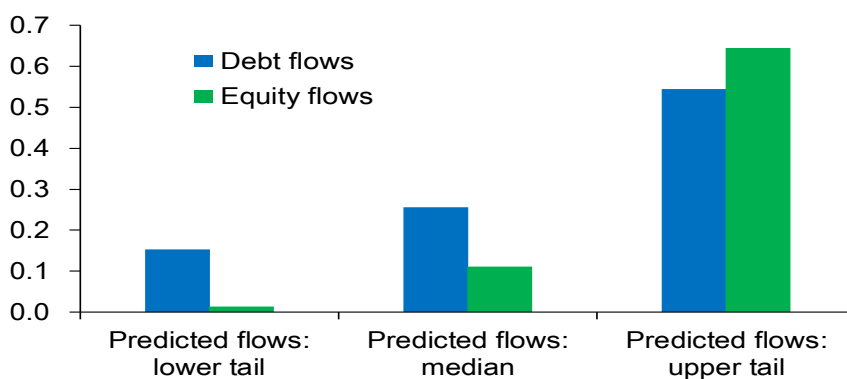
1. Standardized Coefficients on the US Dollar DXY Index from Quantile Regressions of Near-Term Debt and Equity Portfolio Flows



2. Standardized Coefficients on the Ratio of Short-term Foreign Currency Debt to Reserves from Quantile Regressions of Near-Term Debt and Equity Portfolio Flows



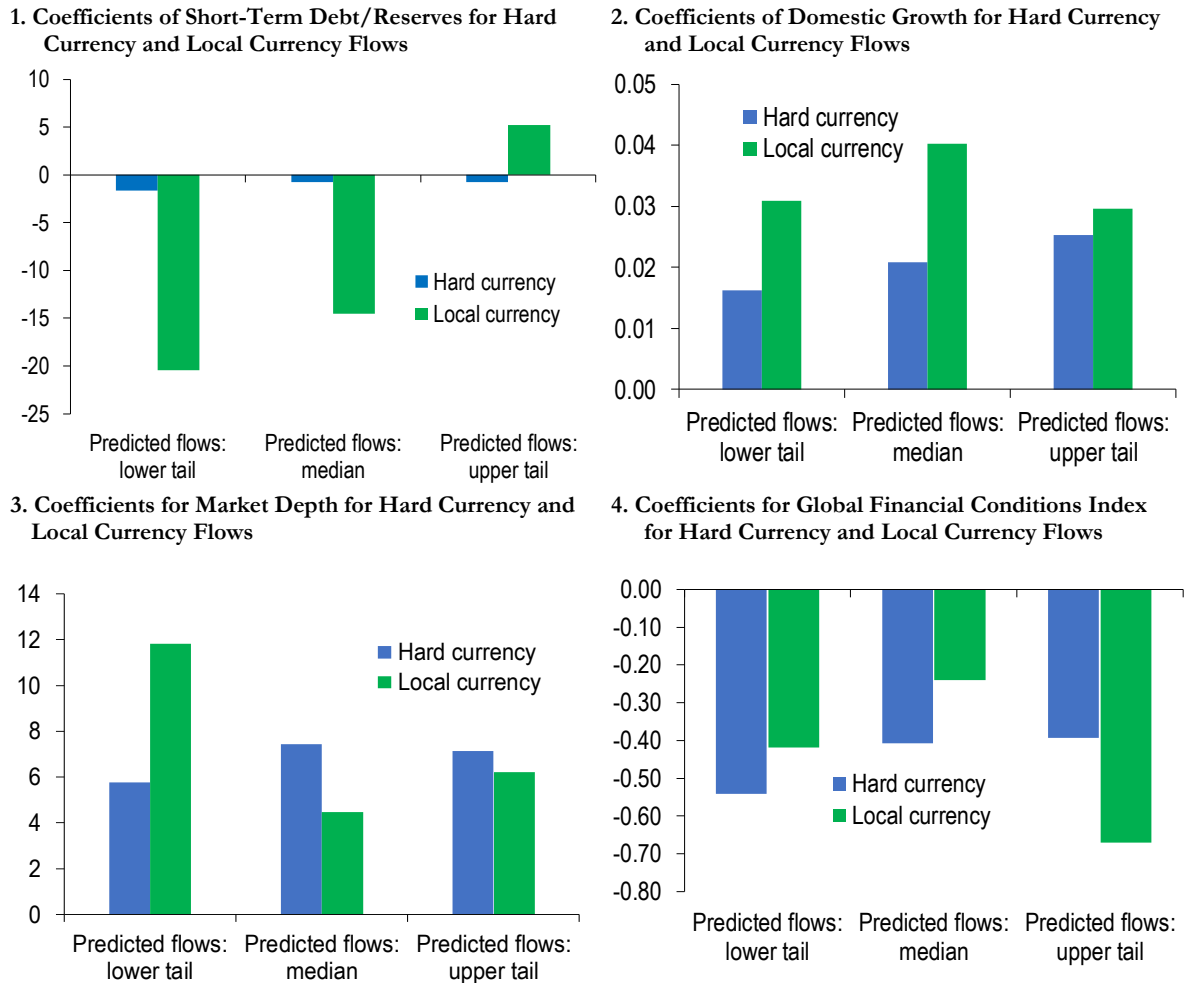
3. Standardized Coefficients on the Depth of Domestic Financial Markets Index from Quantile Regressions of Near-Term Debt and Equity Portfolio Flows



Sources: Bloomberg Finance L.P.; Haver Analytics; IMF, Assessing Reserve Adequacy database; IMF, Financial Flows Analytics database; IMF, International Financial Statistics database; Institute of International Finance; World Bank estimates; and IMF staff calculations.

Note: The *lower tail* corresponds to average coefficients on explanatory variables from regressions for low percentiles (5th, 10th, 20th and 30th), *median flows*—to average coefficients from regressions for middle percentiles (40th, 50th, 60th), *upper tail*—to average coefficients for upper percentiles (70th, 80th, 90th, 95th).

Online Annex Figure 3.1.2. Standardized Coefficients in Quantile Regressions: Local versus Hard Debt Portfolio Flows



Sources: Bloomberg Finance L.P.; Haver Analytics; IMF, International Financial Statistics database; IMF, Financial Flows Analytics database; IMF, Assessing Reserve Adequacy databases; Institute of International Finance; World Bank estimates; and IMF staff calculations.
 Note: The *lower tail* corresponds to average coefficients on explanatory variables from regressions for low percentiles (5th, 10th, 20th and 30th), *median flows*—to average coefficients from regressions for middle percentiles (40th, 50th, 60th), *upper tail*—to average coefficients for upper percentiles (70th, 80th, 90th, 95th).

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2. Local Currency Bond Yield Valuation⁹

16. The pricing of EM sovereign debt securities is determined by the country-specific fundamentals, external financial conditions but is also influenced by the global investors' risk appetite. The risk appetite becomes especially relevant during periods of stress (González-Hermosillo, 2008), as it could interact with domestic vulnerabilities to amplify the impact on borrowers with weaker fundamentals. For instance, as discussed in October 2018 GFSR, countries with high external debt were disproportionately impacted by a sharp rise in the US dollar during April-September 2018.

Framework and Data

17. A fundamentals-based asset valuation model for EM local currency yields—also considered as the funding costs on the local currency debt—is constructed based on both domestic fundamentals and external financial conditions. The model is similar to the asset valuation model for EM hard currency spreads (Online Annex, GFSR October 2019). The model covers 21 emerging and frontier markets, with quarterly data spanning back to December 2001.¹⁰ However, the time span is uneven, as countries entered the GBI-EM Index in different years (Online Annex Table 3.1.4). The data on local currency bond yields is sourced from Bloomberg based on the JP Morgan indices.

18. Given the data limitations, it is difficult to build reliable country-specific models, especially for countries with short data, the analysis focuses on panel estimation. An OLS model is estimated using an unbalanced panel. The local currency bond yields are regressed on domestic fundamental factors and external financial conditions, as follows:

$$Yield_{it} = c + \sum_{k=0}^K Fundamental_{kit} * \beta_k + \sum_{j=0}^J GlobalRiskAppetite_t * \alpha_j * Rating_j$$

where

- i (from 1 to 21) is the number of countries in the sample
- k (from 1 to 7) is the number of fundamental factors (outlined below)
- j (from 1 to 2) is the number of ratings (IG and HY)

and the fundamental determinants of the sovereign spreads are:

- Domestic Real GDP growth – 1 year forward consensus forecasts
- Domestic CPI Inflation – 1 year forward consensus forecasts
- Current Account Balance (percent of GDP)
- External Debt (percent of GDP)
- Foreign Currency Reserves (percent of GDP)

⁹ This section is authored by Rohit Goel.

¹⁰ All countries present in the JP Morgan GBI-EM Index are considered in the sample, with the exception of Argentina.

- External Real GDP growth – 1 year forward consensus forecasts
- US Dollar Index (DXY Index)
- Foreign Investors as a proportion of total ownership

The global risk appetite factor is proxied by the US BBB corporate spread.¹¹ It is also worth noting that *Rating* is a dummy variable corresponding to whether its an IG-rated country or a HY-rated country. It is not an interaction term.

Online Annex Table 3.1.4. Country Coverage and the Dates at which Yield Data Start

Asia Pacific		Western Hemisphere		EMEA	
Country	Date From	Country	Date From	Country	Date From
India	Dec-01	Brazil	Mar-02	Poland	Mar-01
Thailand	Dec-01	Mexico	Mar-02	Hungary	Dec-01
Malaysia	Dec-01	Colombia	Mar-03	South Africa	Dec-01
Indonesia	Mar-03	Peru	Dec-06	Czech Republic	Dec-01
China	Mar-04	Chile	Sep-10	Turkey	Jun-04
Philippines	Dec-10	Uruguay	Jun-17	Russia	Mar-05
		Dominican Republic	Jun-17	Romania	Mar-13
				Nigeria	Mar-18

Sources: Bloomberg Finance L.P.; JP Morgan Chase & Co., and IMF staff calculations.

¹¹ The US BBB corporate spread is a price-based measure meant to capture external factors pertaining to both economic fundamentals and other drivers, such as significant political events. As a market-based measure, the BBB US corporate spread can itself be misaligned.

3. Sensitivity and Determinants

19. The final model has an adjusted R^2 of almost 70 percent, with most variables both economically and statistically significant. The analysis shows that strong fundamentals tend to reduce funding costs, while elevated vulnerabilities and lower buffers tend to have the opposite effect (Online Annex Table 3.1.5).¹² High *inflation* increases local currency bond yields, while better *growth* prospects contribute to lower yields. Higher *external debt* and lower *foreign exchange reserves* are associated with higher local currency yields. Lower-rated bond issuers are found to be more vulnerable to swings in *global investor risk appetite* than higher-rated issuers—with the results being consistent with the hard currency spread analysis done in GFSR October 2019. Finally, higher *foreign participation* also helps reduce the local currency yields (as in Ebeke and Lu 2014).

Online Annex Table 3.1.5. Estimation Results for the Local Currency Bond Yields

	Coefficient	Std Error	T-Stat	P-val	
(Intercept)	4.06	1.22	3.32	0.00	
Domestic GDP Growth	-0.09	0.04	-2.25	0.02	**
Domestic Inflation	0.82	0.04	22.59	0.00	***
External Growth	0.76	0.16	4.70	0.00	***
Current Account Balance	-0.02	0.02	-0.93	0.35	
External Debt	0.01	0.00	6.74	0.00	***
FX Reserves	-0.07	0.01	-8.43	0.00	***
Dollar	-0.03	0.01	-3.24	0.00	***
Foreign Ownership	-1.18	0.58	-2.03	0.04	**
Risk Appetite (IG)	0.00	0.00	4.13	0.00	***
Risk Appetite (HY)	0.01	0.00	8.59	0.00	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Total Sum of Squares: 11499

Residual Sum of Squares: 3694.9

R-Squared: 0.67869

Adj. R-Squared: 0.67537

F-statistic: 204.464 on 10 and 968 DF, p-value: < 2.22e-16

F-statistic: 151.065 on 10 and 855 DF, p-value: < 2.22e-16

Unbalanced Panel: n = 64, T = 8-19, N = 979

Sources: Bloomberg Finance L.P.; Consensus Economics; Haver Analytics; IMF, World Economic Outlook database; JP Morgan Chase & Co.; Serkan and Tsuda (2014); and IMF staff calculations.

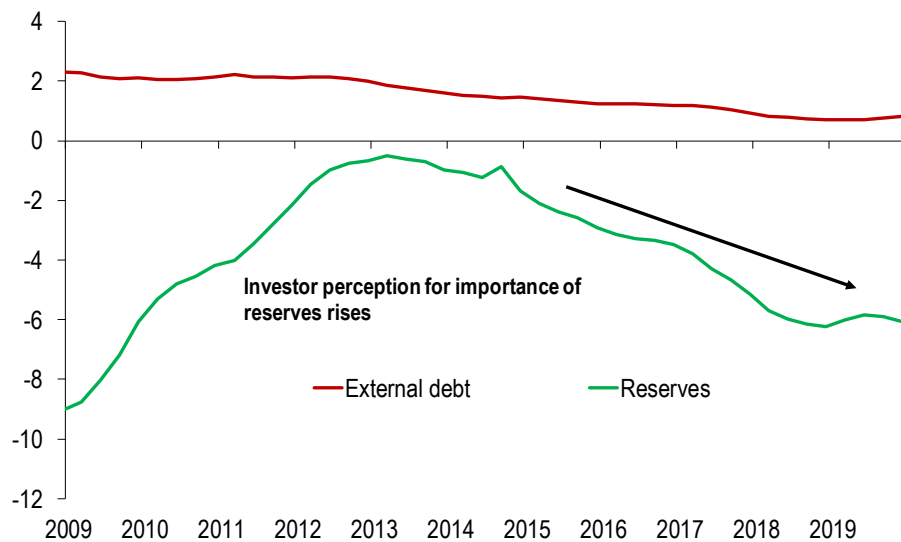
20. Rolling regressions are also run using the same specification, but using time windows of 24 quarters, to understand how the respective sensitivities have changed over time. The analysis highlights that the coefficients on reserves/GDP is rising steadily over the last few years. Every

¹² See Piljak, 2013; Baldacci and Kumar (2010); and Jaramillo and Weber (2013).

percentage point rise in reserves/GDP is equivalent to 9 bps decline in funding costs now, compared to only 2 bps reduction during taper tantrum (Online Annex Figure 3.1.3). On the other hand, the coefficient for external debt has moderated somewhat over the last few years as the search for yield has intensified.¹³

Online Annex Figure 3.1.3. Determinants of EM Local Currency Bond Yields

Sensitivity of LC Yields to Reserves/GDP and External Debt to Exports
(Coefficient; rolling 24 quarter regression)



Sources: Bloomberg Finance L.P.; Haver Analytics; Institute of International Finance; and Fund staff calculations.

Calculating the Extent of Mispricing

21. The model results can be used to calculate mispricing in two ways:

- **Proportion of countries which are overvalued (Online Annex Figure 3.1.4, panel 1):**
This is calculated separately for IG and HY country buckets—weighed by GDP and unweighted. Lower-rated issuers appear to be more overvalued than higher-rated issuers. This includes one-half of the lowest-rated issuers, when weighted by GDP, compared to only 10 percent of higher rated issuers that are estimated to be overvalued.¹⁴
- **Median overvaluation, in basis points (Online Annex Figure 3.1.4, panel 2):**
Overvaluation is defined as model implied yield—market yield. Staff analysis suggests that median yield on emerging market local currency bonds is overvalued relative to these countries’ economic fundamentals and external financial conditions, driven in part by the

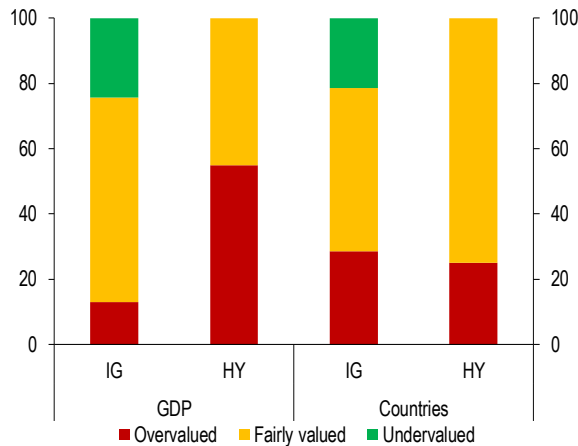
¹³ This might also be reflective of lengthening of maturities by the investors.

¹⁴ The trend is similar in the hard currency emerging market bonds (refer GFSR October 2019).

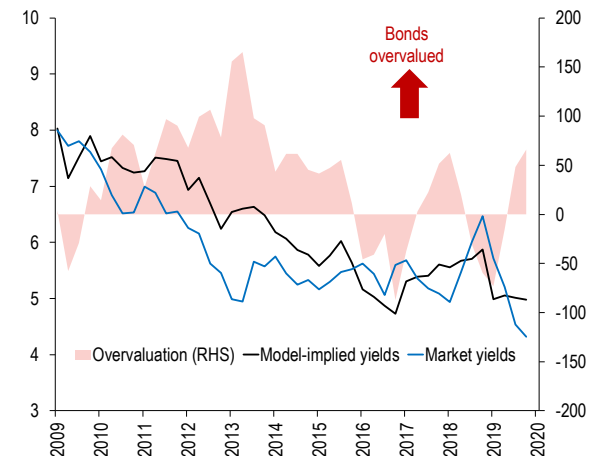
large decline in local currency bonds yields in 2019. The extent of overvaluation is similar to the 2018 emerging market bond sell-off episode, though much less than before the taper tantrum.¹⁵

Online Annex Figure 3.1.4. Extent of Mispricing between Market Yields and Fundamental-Implied Yields

1. Overvaluation per Different Rating Buckets (Percent of total GDP / countries)



2. Local Currency Bond Yields versus Model-Implied Residuals (Basis points on the right scale)



Sources: Bloomberg Finance L.P.; Haver Analytics; IMF, World Economic Outlook database; JPMorgan Chase & Co; and IMF staff calculations.

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¹⁵ Nonetheless, there is considerable variation across countries, with bonds in about a third of countries estimated to be overvalued, and bonds in about 15 percent of countries estimated to be undervalued.

Jaramillo, L., and Michelle Tejada. 2011. “Sovereign Credit Ratings and Spreads in Emerging Markets: Does Investment Grade Matter?” IMF Working Paper 11/44, International Monetary Fund, Washington, DC.

Piljak, Vanja. 2013. “Bond Markets Co-Movement Dynamics and Macroeconomic Factors: Evidence from Emerging and Frontier Markets.” *Emerging Markets Review* 17 (C): 29–43.

4. Foreign Participation, Financial Depth and Volatility of Yields¹⁶

22. The goal of the analysis is twofold: to assess whether (1) foreign participation in local currency debt market is associated with higher volatility of yield after it hits a threshold, and (2) domestic financial market depth can help countries lower volatility.

Sample

23. The analysis has an unbalanced panel from 18 economies in the sample: Brazil, Chile, China, Colombia, Czech Republic, Hungary, Indonesia, India, Mexico, Malaysia, Peru, Philippines, Poland, Romania, Russia, Thailand, Turkey, and South Africa. The sample period is 2004:Q2–2017:Q4. Note that results below are not driven by a specific country in the sample.

Variable and Data Description

24. The *dependent variable* is the volatility of government bond yield. Volatility is calculated as the logarithm of the standard deviation of weekly changes in the yield for each quarter to capture the within country-quarter volatility of the government bond yields, as in Ebeke and Kyobe (2014).

25. There are two main (explanatory) variables of interest: foreign participation in local currency debt market and financial depth. The data for foreign participation in the local currency debt market comes from the quarterly dataset by Arslanalp and Tsuda (2014, updated). The analysis uses the ratio of foreign participation in local currency debt market as a share of international reserves. Data on reserves is from the IFS database. To explore if foreign participation as a share of reserves increases the volatility after it exceeds a level, a dummy variable for the foreign participation is defined, which takes 1 after a threshold. However, the analysis also aims to isolate the threshold effect from, if any, the linear effect of foreign participation on volatility. To do this, foreign participation to reserves ratio as a continuous variable is included in regressions to capture its separate effects on volatility. The analysis uses lagged variables for the foreign participation, as with Ebeke and Kyobe (2014), but results are very similar both qualitatively and quantitatively if contemporaneous values are used instead.

¹⁶ This section is authored by Dimitris Drakopoulos and Can Sever.

26. Financial markets depth is from the financial development database by Sahay and others (2015), which has annual data until 2017. It incorporates information from stock market capitalization, stocks traded, international debt securities by the government, total debt securities of nonfinancial corporations, and total debt securities of financial corporations as shares of GDP. The analysis also tests results using a proxy for financial institutions depth from the same dataset. It is an index consisting of private sector credit, pension fund assets, mutual fund assets and insurance premiums as share of GDP (Online Annex Table 3.1.6).

Online Annex Table 3.1.6. Definitions of Financial Institutions and Financial Markets Depth Variables

	FINANCIAL INSTITUTIONS	FINANCIAL MARKETS
DEPTH	1. Private-sector credit (% of GDP) 2. Pension fund assets (% of GDP) 3. Mutual fund assets (% of GDP) 4. Insurance premiums, life and non-life (% of GDP)	1. Stock market capitalization to GDP 2. Stocks traded to GDP 3. International debt securities government (% of GDP) 4. Total debt securities of nonfinancial corporations (% of GDP) 5. Total debt securities of financial corporations (% of GDP)

Sources: Sahay and others (2015).

Baseline Model Specification

27. The analysis also controls for current account balance, external debt and government debt as shares of GDP (from WEO database)(from Haver) which are at annual frequency. Other control variables, inflation (change in the CPI), the exchange rate vis-à-vis USD, reserves as a share of GDP and growth rate of GDP from IFS database are at quarterly frequency. The analysis also includes turnover in FX market from triennial central bank surveys by the BIS. Results are robust to dropping any of these control variables. Country and quarter fixed effects are used to control for unobservable time-invariant features at the country-level, and year-specific shocks that are common across all EMs such as developments in the US rates.

The specification is as follows:

$$\begin{aligned}
 Volatility_{ct} = & \alpha_1 Threshold(Foreign Participation)_{ct-1} + \alpha_2 Financial Markets Depth_{ct} \\
 & + \theta Controls_{ct} + \mu_c + \theta_t + e_{ct}
 \end{aligned}
 \tag{3}$$

where c is country, t is quarter, μ_c and θ_t stand for country and quarter fixed effects.

$Threshold(Foreign Participation)_{ct-1}$ is the dummy variable which takes 1 for values of the ratio of foreign participation to reserves above a level, and 0 otherwise. $Controls_{ct}$ include several domestic variables, as well as the ratio of foreign participation to reserves, as mentioned before. The coefficient estimate α_1 must be positive if foreign participation is associated with higher volatility after a threshold, and α_2 to be negative if financial markets depth helps countries decrease volatility.

Estimation Results

28. Online Annex Table 3.1.7 illustrates the results. The analysis starts the search for the level of the threshold effect from very low levels of foreign participation. The results suggest that the threshold dummy becomes statistically significant only after the foreign participation to reserves ratio exceeds 40 percent. First 3 columns show that although it is positive, α_1 is not statistically significant when the dummy is defined using 37, 38, and 39 percent levels, respectively. However, as the fourth column shows, it becomes statistically significant (at 5 percent level) starting from the 40 percent level. The point estimates suggest that as the foreign participation exceeds 40 percent, the volatility increases by 15 percent. Results hold and are statistically significant for the 41, 42, and 43 percent thresholds in columns 5, 6 and 7, respectively. It is important to note that the ratio of foreign participation to reserves (continuous variable itself) has statistically insignificant coefficients throughout regressions. Thus, the only statistically significant effect of foreign participation on volatility arises from the threshold effect.

29. The analysis also finds strong evidence for the effect of financial depth on volatility. In first 7 columns, financial markets depth has statistically significant (at 1 percent level) coefficients. The coefficient estimates in column 4 suggests that one standard deviation increase (0.21) in the financial markets depth in the sample is associated with 20.6 percent decrease in volatility. The last column shows that results are also robust to using financial institutions depth, instead of financial markets depth.

Online Annex Table 3.1.7. Estimation

The dummy for the threshold takes 1 after the ratio of foreign participation to reserves exceeds								
Variable (percent)	37	38	39	40	41	42	43	40
Threshold	0.009	0.06	0.09	0.147**	0.163**	0.205***	0.188**	0.152*
Dummy	-0.063	-0.066	-0.067	-0.068	-0.07	-0.074	-0.074	-0.08
Financial Markets Depth	-1.051***	-1.029***	-1.015***	-0.980***	-0.969***	-0.967***	-0.980***	
Financial Institutions Depth	-0.358	-0.3564	-0.355	-0.353	-0.351	-0.349	-0.348	-1.165**
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Quarter F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	741	741	741	741	741	741	741	741
R Squared	0.606	0.606	0.607	0.608	0.609	0.61	0.609	0.605

Source: IMF staff calculations.

Note: The estimation is based on equation (3) using quarterly data from 18 emerging markets from 2004:Q2–2017:Q4. Dependent variable is the logarithm of the volatility of yield. The threshold dummy is defined using different thresholds of foreign participation in local currency bond markets to reserves ratio. Control variables are lagged value of foreign participation to reserve ratio; and current account balance, external debt, government debt, inflation, reserves, exchange rate against US dollars, and turnover in the foreign exchange market. Control variables, and country and quarter fixed effects are included in all regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

30. Finally, we test for a slope effect of foreign participation on volatility after it reaches to 40 percent threshold as found above. We add an interaction between the threshold dummy for foreign participation and the ratio of foreign holdings to reserves into equation (3) above. Although interpretation of the alternative model is different, Table 3.1.8 shows that previous finding that foreign participation increases volatility after 40 percent threshold stays the same. The first distinction in this model is that foreign participation to reserves has a (statistically significant) decreasing effect on volatility when it is below 40 percent threshold. However, if it is above 40 percent, it increases volatility comparing the coefficient estimates of the ratio and the interaction term (column 3 and 4). The second implication from this model is that as the foreign participation keeps increasing above 40 percent, the effect of volatility becomes stronger. The effect of financial market depth on volatility stays similar.

Online Annex Table 3.1.8. Alternative Model

Variable	Threshold Dummy	The Ratio of Foreign Participation to Reserves	Threshold Dummy x Foreign Participation to Reserves	Financial Markets Depth
	-0.266 (0.163)	-1.047** (0.416)	1.120*** (0.424)	-0.939*** (0.348)

Source: IMF staff calculations.

Note: IMF staff calculations. R-squared is 0.612. Number of observations is 741. The estimation is based on quarterly data from 18 emerging markets from 2004:Q2–2017:Q4. Dependent variable is the logarithm of the volatility of yield. The threshold dummy is defined using the 40 percent threshold of foreign participation in local currency bond markets to reserves ratio. Control variables are lagged value of foreign participation to reserve ratio; and current account balance, external debt, government debt, inflation, reserves, exchange rate against USD, and turnover in the foreign exchange market. Control variables, and country and quarter fixed effects are included in all regressions. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

References

Arslanalp, Serkan, and Takahiro Tsuda. 2014. “Tracking Global Demand for Emerging Market Sovereign Debt.” IMF Working Paper WP/14/39, International Monetary Fund, Washington, DC.

5. List of Countries Includes in Selected Figure of Chapter 3

31. Figure 3.2, panel 1, includes a sample of 20 emerging markets and 20 frontier markets. Emerging markets include Argentina, Brazil, Bulgaria, Chile, Colombia, Czech Republic, India, Indonesia, Israel, Korea, Malaysia, Mexico, Morocco, Peru, Philippines, Poland, Russia, South Africa, Turkey, and United Arab Emirates. Frontier markets include Angola, Belarus, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Ghana, Guatemala, Jamaica, Jordan, Mongolia, Mozambique, Namibia, Nigeria, Pakistan, Paraguay, Sri Lanka, and Tanzania.