Real exchange rate and international reserves in the era of financial integration

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Outline

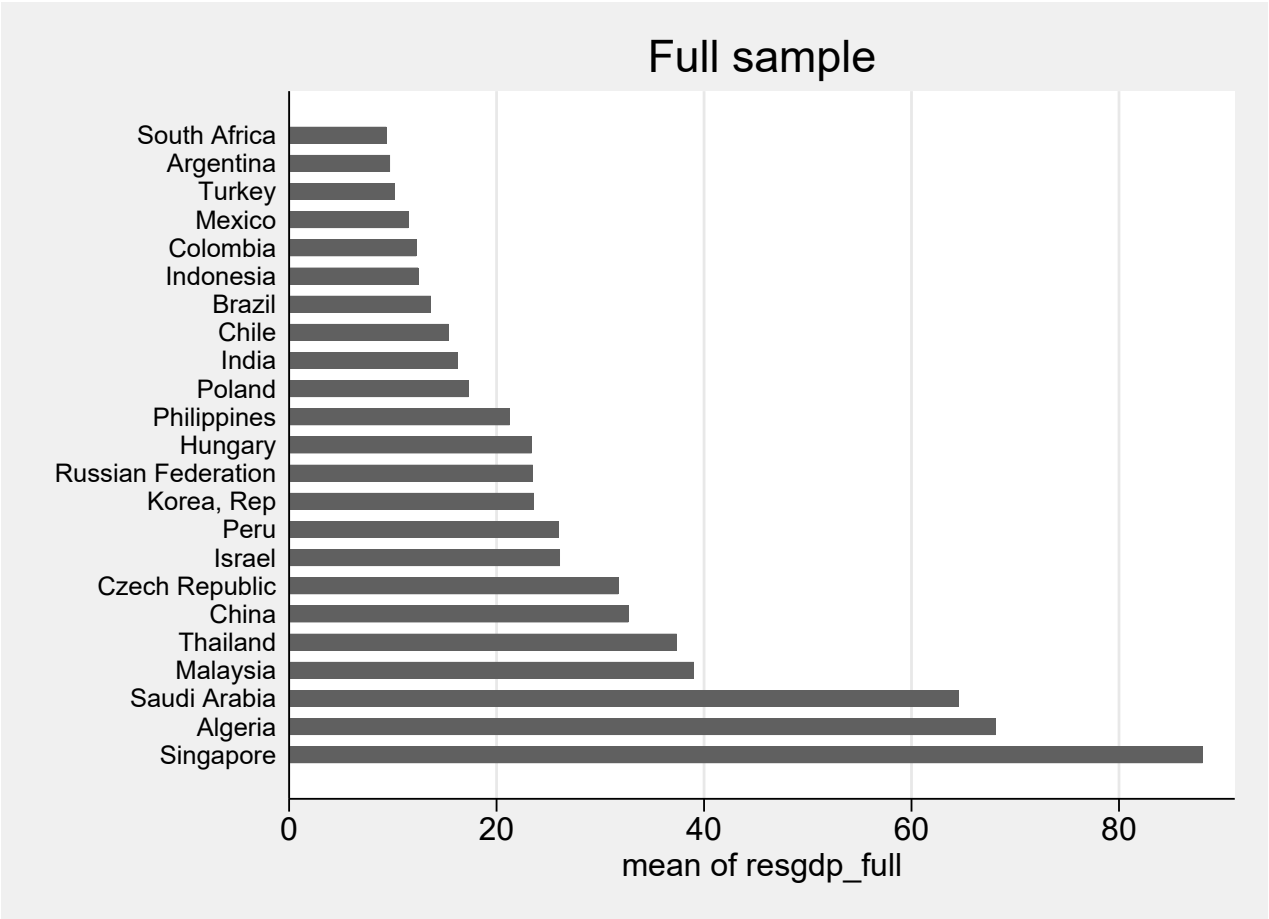
Research question

Motivation 1

- Holding of international reserves increased since the last 20 years
- Terms-of-trade shocks may provoke real exchange rate appreciation and volatility
- Self-insurance tool or buffer against external finance shocks (Buffer effect)
- The mitigation effect of international reserves can be affected by
  - Financial integration and financial openness is higher in the 2000s
  - Impact of the Great Financial Crisis and the Euro Crisis
  - Regional heterogeneity, Commodity exporters, Macro-prudential policies
- From which level of international reserves the buffer effect is observed?
- Do countries use international reserves as shield against the negative consequences of terms-of-trade shocks on the real exchange rate? Do countries use international reserves holdings as substitute to sound financial institutions?
- Do the level of financial openness matters for the buffer effect?
  - Focus on the financial institutions and financial openness in this paper

Research question

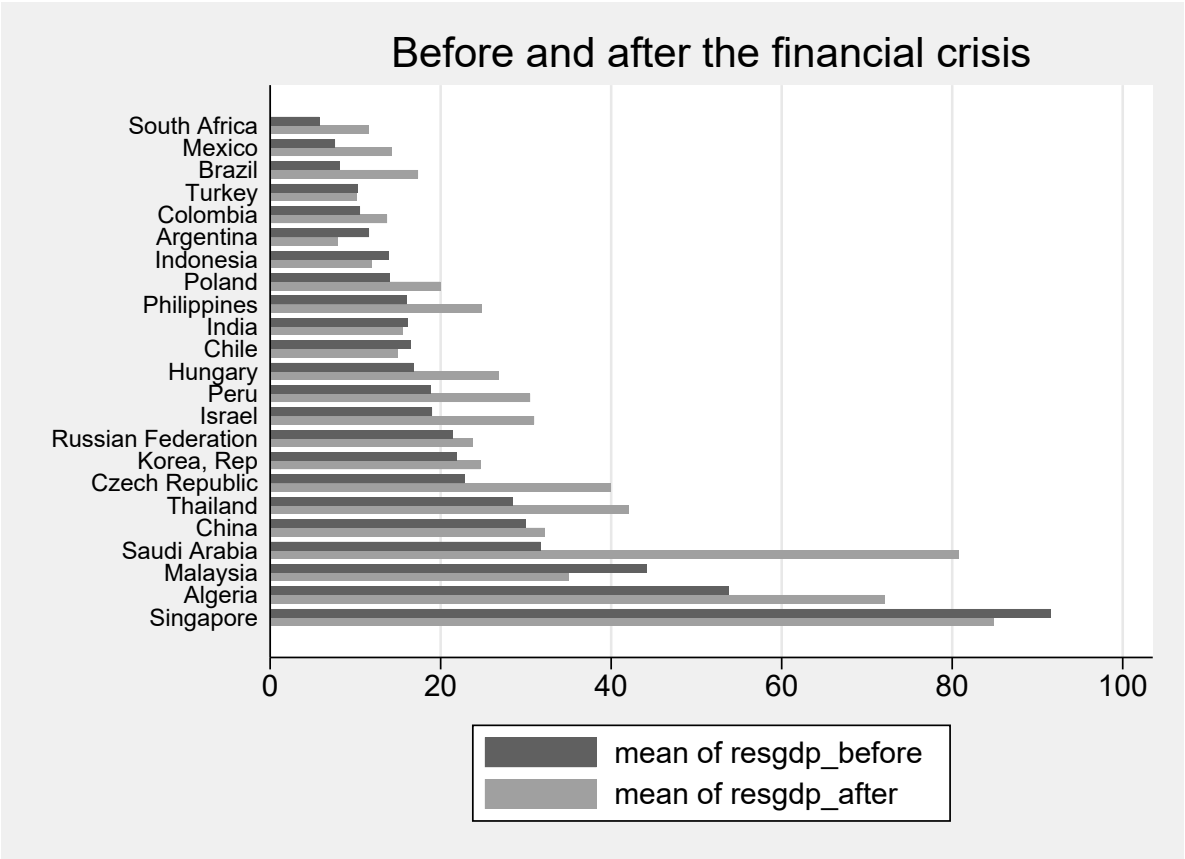
Figure 1. Large holders of international reserves as percent of GDP (full sample - 2001 to 2020)



Notes: we select a sample of emerging and developing economies as in Arslan and Cantù (2019). The mean value of international reserves holding are represented. Source: authors' calculations.

Research question

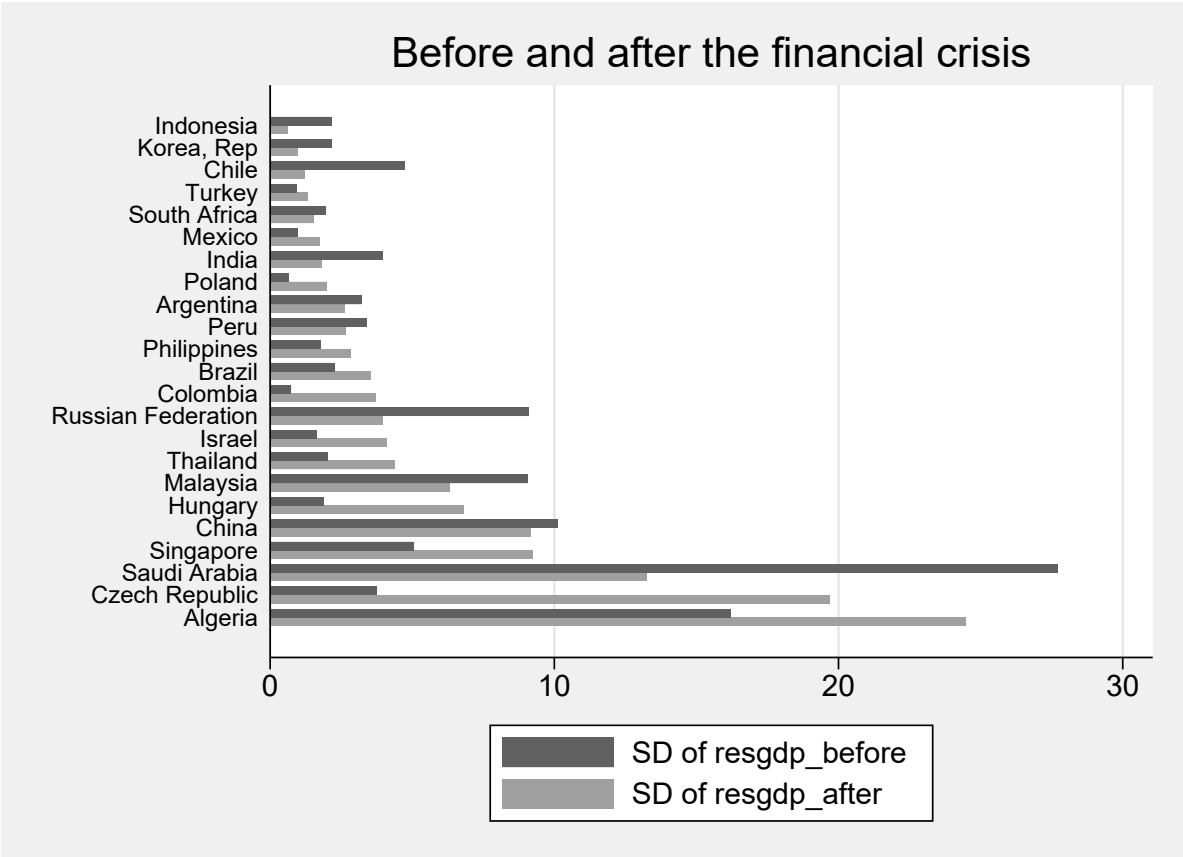
Figure 2. Large holders of international reserves as percent of GDP (before and after the GFC)



Notes: we select a sample of emerging and developing economies as in Arslan and Cantù (2019). We split the sample into two sub-periods, 2001-2007 and 2010-2020, to observe the consequences of the great financial crisis on reserves accumulation. Source: authors' calculations.

Research question

Figure 3. Large holders of international reserves as percent of GDP (before and after the GFC - standard deviation)



Notes: we select a sample of emerging and developing economies as in Arslan and Cantù (2019). We split the sample into two sub-periods, 2001-2007 and 2010-2020, to observe the consequences of the great financial crisis on reserves accumulation. Source: authors' calculations.

Motivation 2

- Holding of international reserves and the exchange rate adjustment in the literature (Aizenman and Riera-Crichton, 2006)
- Several empirical studies on the buffer effect of international reserves
- Some studies focus on the Latin-American countries (see, e.g., Aizenman et al., 2012) and commodity exporters (see, e.g., Al-Abri., 2013; Coudert et al., 2015)
- Good financial institutions may help to deal with the consequences of terms-of-trade shocks
- Central result: countries with a low development of their financial institutions may use the international reserves as a shield to deal with the negative consequences of terms-of-trade shocks on the real exchange rate
  - In line with Aizenman et al. (2012)

Research question

Literature 1

- Why do countries holds international reserves?
  - Seminal contribution of Aizenman and Lee (2007)
- Mercantilist motive $\longrightarrow$ weaken the domestic currency to promote exports
- Precautionary motive $\longrightarrow$ self-insurance against external financing shocks
- Hoarding reserve in times of plenty and selling them in rainy days
  - Very intuitive mechanism

Literature 2

- Time-varying motives: Delatte and Fouquau (2011); Ghosh et al. (2017)
  - Precautionary motive become more important after financial crises
- Large stock of reserves may act as a deterrent of speculation: Cabezas and De Gregorio (2019)
  - equivalent explanatory power for both motives
- Holding reserves is associated with depreciation, especially, when combined with capital control: Choi and Taylor (2022)
  - combined reserves and capital controls can affect the trade balance → mercantilist motive
  - reserves without controls can insure against crises → precautionary motive (independently of exchange rates)

Literature 3

- Do holding reserves help to mitigate the consequence of a terms of-trade shock on the real exchange rate?
  - Buffer effect, especially strong in emerging Asia (Aizenman and Riera-Crichton, 2006, 2008)
- Aizenman et al. (2012); Al-Abri (2013); Coudert et al. (2015); Adler et al. (2018); Aizenman and Jinjarak (2020)
  - Aizenman et al. (2012): commodity terms-of-trade shocks (role of institutions)
  - Al-Abri (2013): decomposition between FDI integration and portfolio integration (FDI helps to stabilize the price of no-tradables) $\longrightarrow$ financial integration as an alternative to holding international reserves
  - Coudert et al. (2012): terms-of-trade volatility matters the most during financial stress
  - Adler et al. (2018): asymmetries between falling and rising terms-of-trade (constraint on reserves accumulation during rainy days)
  - Aizenman and Jinjarak (2020): opportunity costs of holding reserves and interemporal gains (sizeable gains of hoarding in times of plenty)

Outline

Empirical approach

- Annual data from 2001 to 2020 for a large macroeconomic panel, $n \times T = 110 \times 20 = 2200$
- Nonlinear panel regressions, country groups, panel threshold regressions
  - Variable are construct as in Aizenman and Riera-Crichton (2006)
  - Several robustness checks: commodities, after the GFC, macroprudential policies
  - Cross-sectional correlations
- Threshold variables: lagged level of international reserves, financial development indexes, financial openness index
- Financial markets and institutions efficiency, access and depth: Svirydzenka (2016)
- Understanding the interaction between the buffer effect of international reserves and financial integration

Methodology

Table 1. Selected variables in the financial development indexes

Category	Indicator
Financial Institutions	
Depth	Private-sector credit to GDP
	Pension fund assets to GDP
	Mutual fund assets to GDP
	Insurance premiums, life and non-life to GDP
Access	Bank branches per 100,000 adults
	ATMs per 100,000 adults
Efficiency	Net interest margin
	Lending-deposits spread
	Non-interest income to total income
	Overhead costs to total assets
	Return on assets
	Return on equity
Financial Markets	
Depth	Stock market capitalization to GDP
	Stocks traded to GDP
	International debt securities of government to GDP
	Total debt securities of financial corporations to GDP
	Total debt securities of non-financial corporations to GDP
Access	Percent of market capitalization outside of top 10 largest companies
	Total number of issuers of debt (domestic and external, corporations)
Efficiency	Stock market turnover ratio (stocks traded to capitalization)

Source: reproduced from Svirydzenka, 2016.

Methodology

- Along with panel regressions with interaction terms, we test the panel threshold regressions (Hansen, 1999; Aizenman and Riera-Crichton, 2006; Wang, 2015):

$$rer_{i,t} = \mu + \alpha_1 gdppk_{i,t} + \alpha_2 govexp_{i,t} + \alpha_3 etot_{i,t} + \alpha_4 res_{i,t-1} + \alpha_5 etot_{i,t} \times res_{i,t-1} + u_i + e_{i,t} \tag{1}$$

$$rer_{i,t} = \mu + \beta_1 gdppk_{i,t} + \beta_2 govexp_{i,t} + \beta_3 etot_{i,t} I\left(res_{i,t-1} \leq \gamma\right) + \beta_4 etot_{i,t} I\left(res_{i,t-1} > \gamma\right) + u_i + e_{i,t} \tag{2}$$

- Real effective exchange rate, rer; trade openness, to; terms-of-trade tot; effective terms-of-trade, $etot$; and international reserves, res. Controls: the GDP per capita, $gdppk$, and the government expenditures, $govexp$.
- The above equation (2) can be written as follows:

$$rer_{i,t} = \begin{cases} \mu + \beta_1 gdppk_{i,t} + \beta_2 govexp_{i,t} + \beta_3 etot_{i,t} + u_i + e_{i,t}, & res_{i,t-1} \leq \gamma, \\ \mu + \beta_1 gdppk_{i,t} + \beta_2 govexp_{i,t} + \beta_4 etot_{i,t} + u_i + e_{i,t}, & res_{i,t-1} > \gamma. \end{cases} \tag{3}$$

Methodology

- First step, the search is restricted to a certain interval of quantiles for the threshold variables to estimate the threshold value γ. The estimator value for the threshold is the value that minimize the residual sum of square, that is,

$$\widehat{\gamma} = \arg\min_{\gamma} S_1(\gamma) \tag{4}$$

- To test the true value of the threshold $\gamma = \gamma_0$, Hansen, 1999, proposes to form the confidence interval using the "no-rejection" method with likelihood-ratio (LR) statistics, as follows:

$$\mathrm{LR}_1(\gamma) = \frac{\{\mathrm{LR}_1(\gamma) - \mathrm{LR}_1(\widehat{\gamma})\}}{\widehat{\sigma}^2} \xrightarrow{\Pr} \xi \tag{5}$$

$$\Pr(x < \xi) = \left(1 - e^{\frac{-x}{2}}\right)^2$$

Methodology

- In a second step, we test the linear model versus the single threshold model:

$$H_0 : \beta_3 = \beta_4 \quad H_a : \beta_3 \neq \beta_4 \tag{6}$$

- The F statistics is constructed as:

$$F_1 = \left(S_0 - S_1(\hat{\gamma})\right) / \hat{\sigma}^2 \tag{7}$$

where, S_0, is the RSS for the model without threshold, S_1, is the RSS for the model with a specific threshold $\hat{\gamma}$, $\hat{\sigma}^2$ is the residual variance for a specific threshold. Under H_0, the threshold is not identified, and F_1 has nonstandard asymptotic distribution. Hansen, 1996, uses a bootstrapped likelihood ratio test (asymptotically valid).

Outline

Results

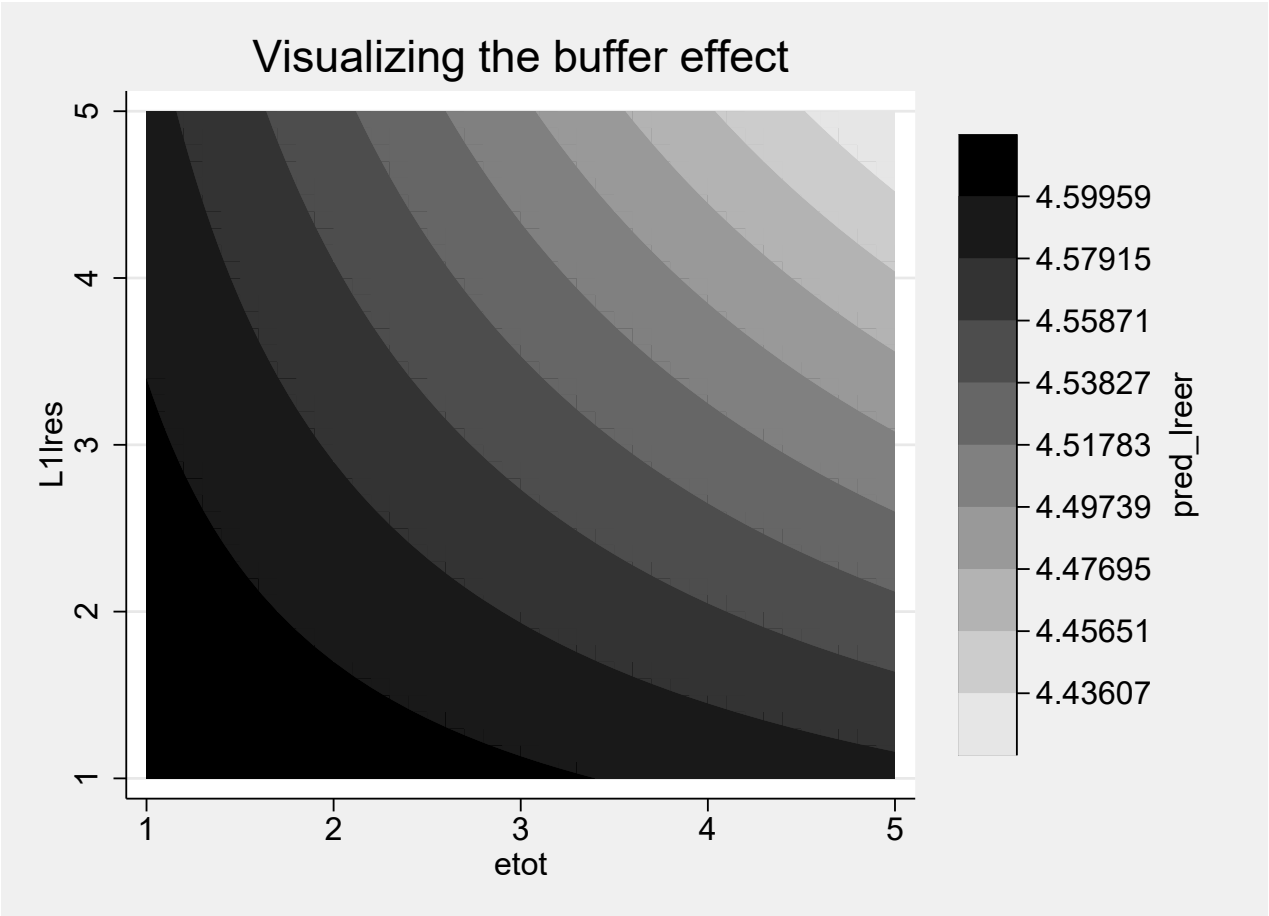
Table 2. Baseline nonlinear regression

	(1)
Variables	*rer*
gdppk	0.6589***
	(0.0725)
govexp	0.1435***
	(0.0292)
etot	0.0369***
	(0.0134)
L.res	0.0266***
	(0.0098)
etot × *L.res*	-0.0196***
	(0.0047)
Constant	1.1186***
	(0.3733)
Observations	1,900
Number of countries	100
Adjusted R-squared	0.4395
RMSE	0.1198

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L, stands for the lag operator. Source: author's estimates.

Results

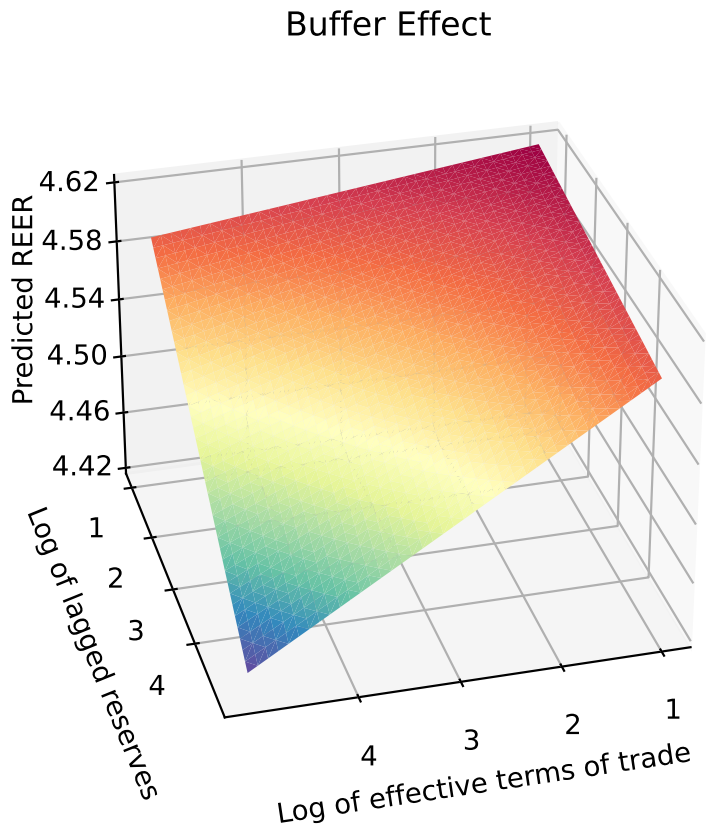
Figure 4. Contour plot for the buffer effect



Note: The lighter areas indicate that the buffer effect (i.e. the mitigation of real exchange rate appreciation after a terms-of-trade shock) is stronger when the level of reserves is higher. We include year-fixed effects in the regressions. The results are similar without the year-fixed effects. Source: authors' estimates.

Results

Figure 5. 3-D plot for the buffer effect



Note: The blue areas indicate that the buffer effect (i.e. the mitigation of real exchange rate appreciation after a terms-of-trade shock) is stronger when the level of reserves is higher. We include year-fixed effects in the regressions. The results are similar without the year-fixed effects. Source: authors' estimates.

Results

Table 3. Regional baseline regressions

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	*EAS* *rer*	*ECS* *rer*	*LCN* *rer*	*MEA* *rer*	*NAC* *rer*	*SAS* *rer*	*SSF* *rer*
gdppk	1.0095***	0.6223***	1.1065***	-0.4581*	0.7047	1.5699***	0.1675
	(0.1097)	(0.0757)	(0.2752)	(0.2510)	(0.6906)	(0.1093)	(0.1995)
govexp	0.3070***	0.1519***	0.1998***	-0.1076	-1.0568***	0.2116***	0.1245***
	(0.0639)	(0.0529)	(0.0664)	(0.1015)	(0.2320)	(0.0395)	(0.0415)
etot	0.3412***	0.0527***	0.0124	-0.1240	0.4374*	-0.0908*	0.0413**
	(0.1003)	(0.0136)	(0.0540)	(0.0919)	(0.2394)	(0.0549)	(0.0205)
L.res	0.0891***	-0.0103	0.1052***	-0.0425	-0.5427***	0.0529	0.0837***
	(0.0264)	(0.0087)	(0.0379)	(0.0274)	(0.0940)	(0.0427)	(0.0259)
etot × *L.res*	-0.1109***	-0.0175***	-0.0225	0.0184	-0.5321**	0.0185	-0.0229***
	(0.0323)	(0.0060)	(0.0196)	(0.0215)	(0.2160)	(0.0163)	(0.0073)
Constant	-1.1045**	1.0721**	-1.1372	7.3190***	4.4000	-2.3250***	3.4647***
	(0.4665)	(0.4366)	(1.2672)	(1.3201)	(3.2728)	(0.4312)	(0.8148)
Observations	247	760	323	114	38	95	304
Nb. of countries	13	40	17	6	2	5	16
R-squared	0.6595	0.3296	0.4721	0.3850	0.7476	0.7930	0.3839
RMSE	0.0933	0.0938	0.1378	0.0979	0.0614	0.0699	0.1474

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L, stands for the lag operator. Source: author's estimates.

Results

Table 4. The buffer effect for low levels of financial indicators (below Q3 for the financial indicator)

	(1)	(2)	(3)	(4)
Variables	*FD* *rer*	*FI* *rer*	*FM* *rer*	*KAOPEN* *rer*
gdppk	0.814***	0.815***	0.761***	0.961***
	(0.0949)	(0.0849)	(0.103)	(0.0729)
govexp	0.135***	0.133***	0.136***	0.140***
	(0.0295)	(0.0301)	(0.0343)	(0.0276)
etot	0.0453***	0.0418***	0.0473***	0.0379**
	(0.0161)	(0.0159)	(0.0161)	(0.0173)
L.res	0.0360***	0.0383***	0.0345***	0.0317***
	(0.0117)	(0.0126)	(0.0114)	(0.0113)
etot × *L.res*	-0.0231***	-0.0221***	-0.0229***	-0.0226***
	(0.00539)	(0.00535)	(0.00550)	(0.00535)
Constant	0.575	0.557	0.800	-0.161
	(0.449)	(0.403)	(0.489)	(0.335)
Observations	1,373	1,381	1,379	1,306
Nb. of countries	80	82	83	99
R-squared	0.4497	0.4559	0.4383	0.4310
RMSE	0.1303	0.1291	0.1291	0.1224

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L, stands for the lag operator. Source: author's estimates.

Results

Table 5. The buffer effect for high levels of financial indicators (above Q3 for the financial indicator

	(1)	(2)	(3)	(4)
Variables	*FD* *rer*	*FI* *rer*	*FM* *rer*	*KAOPEN* *rer*
gdppk	0.125*	0.00404	0.353***	0.167**
	(0.0680)	(0.0630)	(0.0812)	(0.0831)
govexp	0.0678	-0.0169	0.172**	0.131***
	(0.0604)	(0.0527)	(0.0689)	(0.0478)
etot	-0.000934	0.0137	0.0245*	0.00407
	(0.0147)	(0.0143)	(0.0145)	(0.0139)
L.res	-0.0421***	-0.0475***	-0.0310**	-0.0441***
	(0.0113)	(0.00949)	(0.0155)	(0.0137)
etot × *L.lres*	0.00661	-0.00805	-0.0182***	-0.00304
	(0.00833)	(0.00705)	(0.00573)	(0.00672)
Constant	3.843***	4.729***	2.357***	3.542***
	(0.467)	(0.384)	(0.546)	(0.477)
Observations	527	519	521	594
Nb. of countries	34	35	36	100
R-squared	0.5389	0.5534	0.4817	0.7413
RMSE	0.0701	0.0703	0.0819	0.0788

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L, stands for the lag operator. Source: author's estimates.

Results

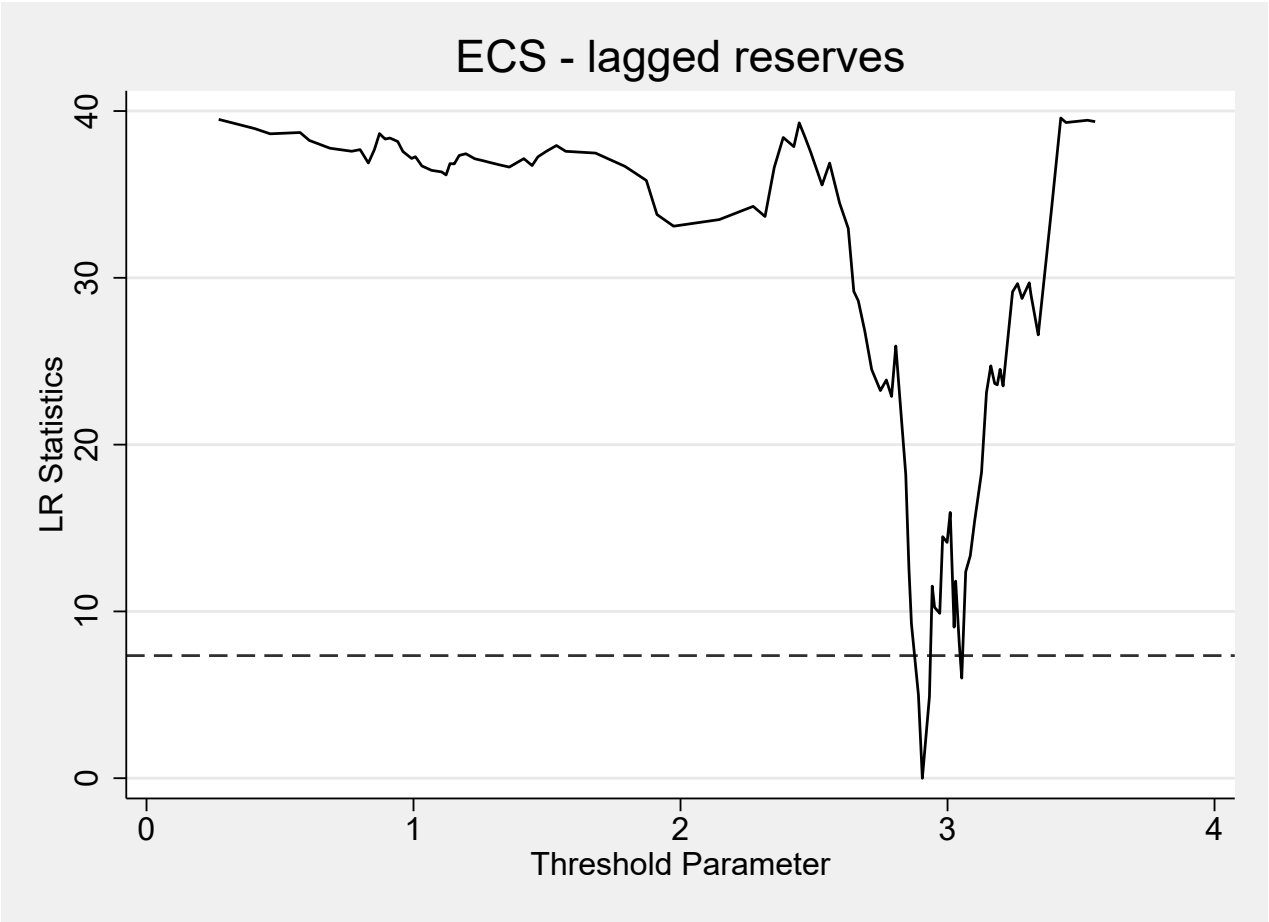
Table 6. Panel threshold regressions

	(1)	(2)	(3)	(4)	(5)
Variables	*FULL* *rer*	*EAS_SAS* *rer*	*ECS* *rer*	*LAC* *rer*	*MEA* *rer*
Estimated threshold	1.4260*	–	2.9058**	–	3.3463***
95% Confidence Interval	[1.2928; 1.4643]	–	[2.8780; 2.9323]	–	[3.2554; 3.3566]
gdppk	0.7004***	1.2468***	0.5618***	1.1271***	-0.2885
	(0.0523)	(0.0759)	(0.0603)	(0.2170)	(0.1931)
govexp	0.1498***	0.2434***	0.1790***	0.2500***	-0.0462
	(0.0209)	(0.0470)	(0.0420)	(0.0683)	(0.0732)
$etot.I\ (L.res \leq \gamma)$	0.0405***	-0.0265***	0.0353***	-0.0475***	-0.1378***
	(0.0106)	(0.0081)	(0.0066)	(0.0140)	(0.0223)
$etot.I\ (L.res > \gamma)$	-0.0237***	-0.2889***	-0.0208***	0.0084	-0.0217
	(0.0040)	(0.0844)	(0.0076)	(0.0315)	(0.0144)
Constant	0.9753***	-1.5495***	1.2702***	-1.0935	6.1917***
	(0.2520)	(0.3559)	(0.3449)	(1.0091)	(0.9715)
Observations	1,900	342	760	323	114
Observation below threshold	300	-	503	-	66
Number of countries	100	18	40	17	6
RMSE	0.120	0.0930	0.0922	0.139	0.0913

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L, stands for the lag operator. Source: author's estimates.

Results

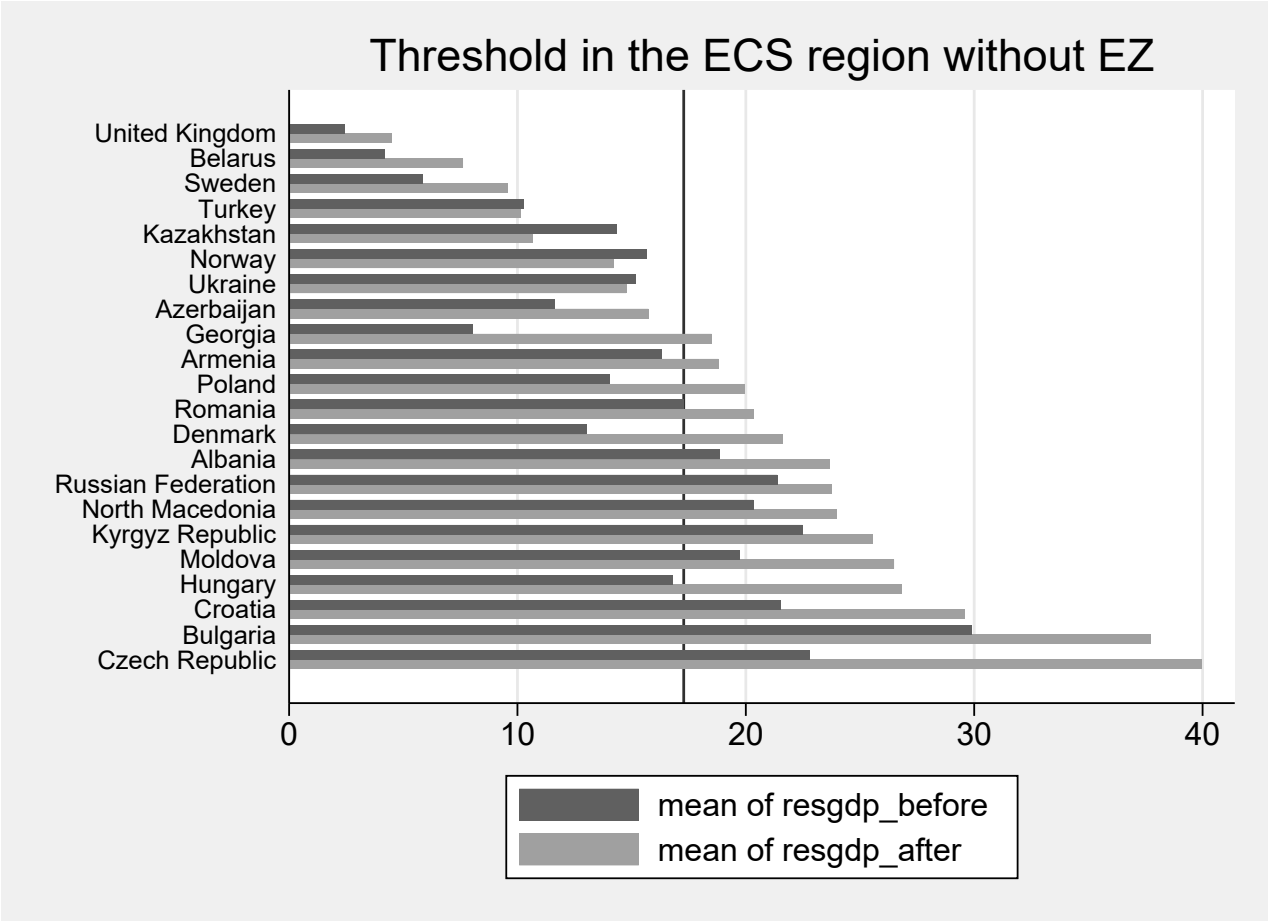
Figure 6. Construction of the confidence interval in the threshold model – ECS region



Notes: the estimation for the threshold value is the point where LR statistics is equal to zero. We obtain a value of 2.91 for the threshold. This value corresponds to a value of 17.28 percent for the reserves-to-GDP ratio ($\ln(1 + 100 \times x) = 2.9058 \Leftrightarrow x = 0.1728$). When the LR curve crosses the horizontal line for the first time, the lower limit of the CI is obtained. When the LR curve crosses the horizontal line for the second time, the upper limit of the CI is obtained. Source: authors' estimations.

Results

Figure 7. Threshold effect in the ECS region



Notes: we use a selection of emerging and developing ECS countries to compare the value of the threshold (17.28% of GDP) found in this region with the evolution of international reserves holding (mean value) before and after the great financial crisis. Source: authors' estimations.

Results

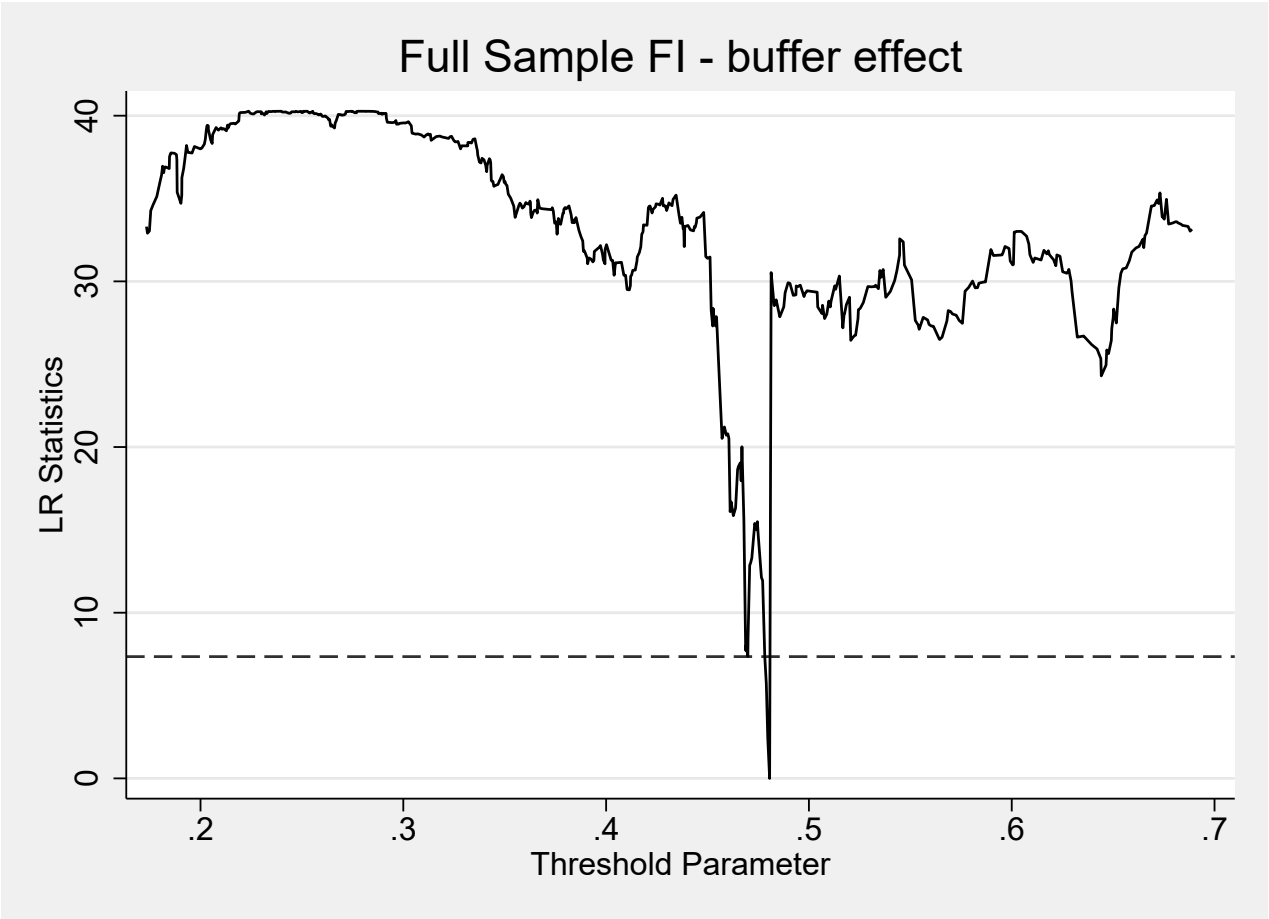
Table 7. Panel threshold regressions and financial development

	(1)	(2)	(3)	(4)	(5)
Variables	*FD* *rer*	*FI* *rer*	*FM* *rer*	*FM − ECS* *rer*	*FMD − ECS* *rer*
Estimated threshold	–	0.4806**	–	0.0217***	0.0256***
95% Confidence Interval	–	[0.479; 0.4814]	–	[0.0210; 0.0220]	[0.0166; 0.0282]
gdppk	0.6930***	0.7113***	0.7140***	0.6172***	0.5944***
	(0.0552)	(0.0548)	(0.0552)	(0.0633)	(0.0633)
gov	0.1470***	0.1538***	0.1441***	0.1521***	0.1587***
	(0.0218)	(0.0217)	(0.0218)	(0.0409)	(0.0409)
$etot \times L.res.I\ (L2.k \leq \gamma)$	0.0035	-0.0096***	-0.0044***	-0.0135***	-0.0121***
	(0.0034)	(0.0014)	(0.0015)	(0.0030)	(0.0028)
$etot \times L.res.I\ (L2.k > \gamma)$	-0.0089***	0.0078***	-0.0145***	0.0144***	0.0129***
	(0.0014)	(0.0029)	(0.0022)	(0.0027)	(0.0025)
Constant	1.0207***	0.9178***	0.9325***	1.0763***	1.1718***
	(0.2654)	(0.2637)	(0.2651)	(0.3554)	(0.3552)
Observations	1,800	1,800	1,800	720	720
Observation below threshold	-	1180	-	122	123
Number of countries	100	100	100	42	42
RMSE	0.117	0.116	0.117	0.0866	0.0866

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L, $L2$, are the first and second lag operators, respectively. Source: author's estimates.

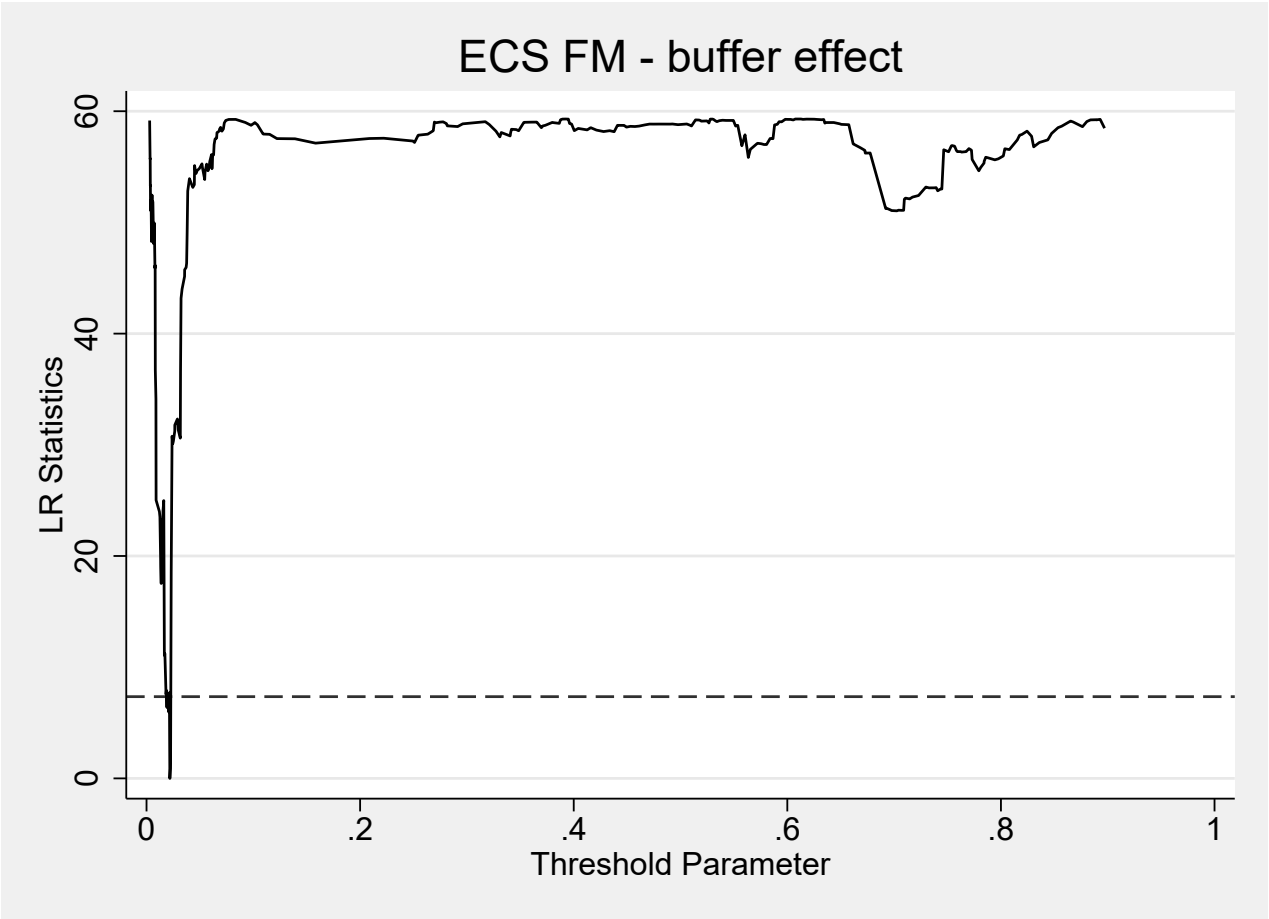
Results

Figure 8. Construction of the confidence interval in the threshold model – FI



Notes: the estimation for the threshold value is the point where LR statistics is equal to zero. When the LR curve crosses the horizontal line for the first time, the lower limit of the CI is obtained. When the LR curve crosses the horizontal line for the second time, the upper limit of the CI is obtained.
Source: authors' estimations.

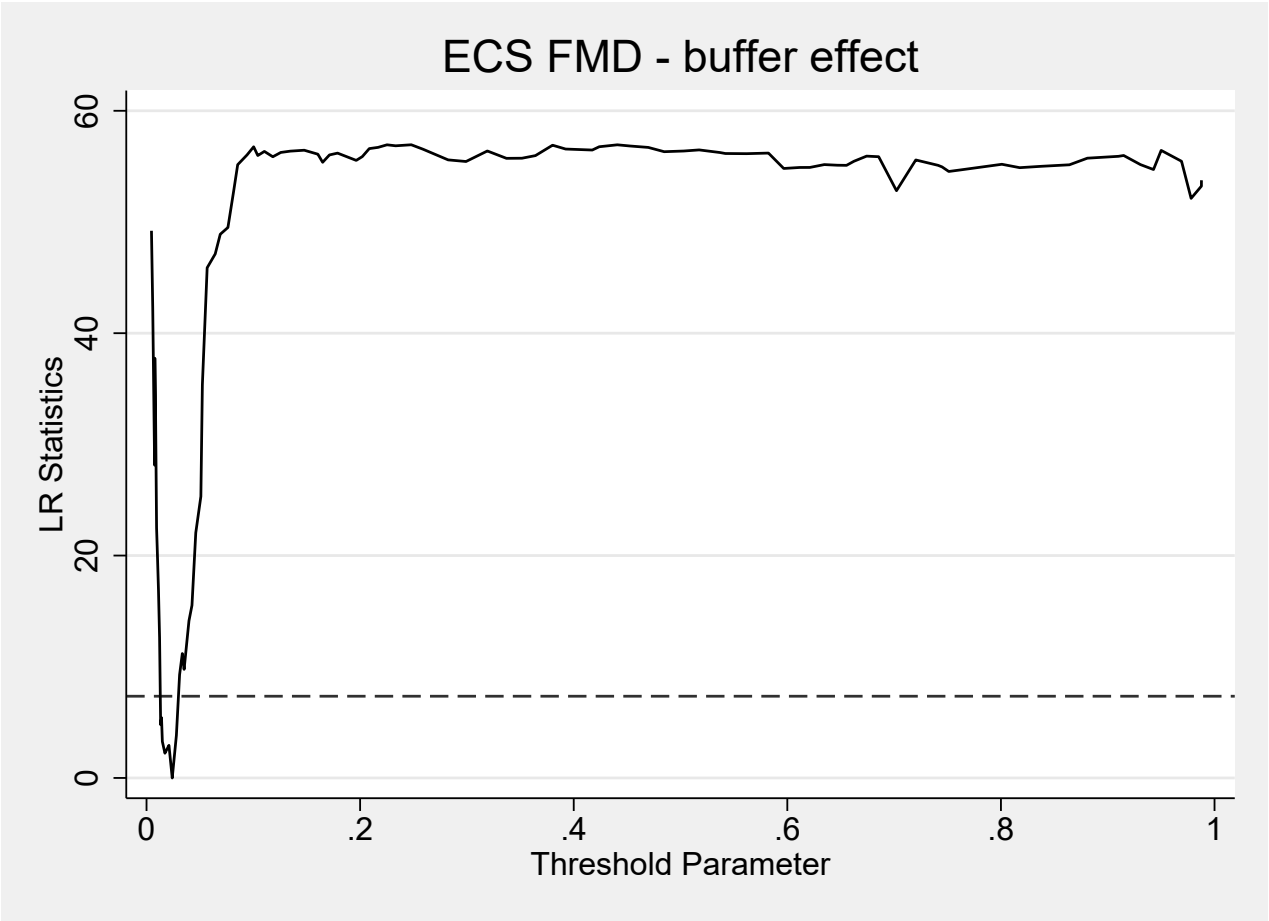
Figure 9. Construction of the confidence interval in the threshold model – FM, region ECS



Notes: the estimation for the threshold value is the point where LR statistics is equal to zero. When the LR curve crosses the horizontal line for the first time, the lower limit of the CI is obtained. When the LR curve crosses the horizontal line for the second time, the upper limit of the CI is obtained.
Source: authors' estimations.

Results

Figure 10. Construction of the confidence interval in the threshold model – FMD, region ECS



Notes: the estimation for the threshold value is the point where LR statistics is equal to zero. When the LR curve crosses the horizontal line for the first time, the lower limit of the CI is obtained. When the LR curve crosses the horizontal line for the second time, the upper limit of the CI is obtained.
Source: authors' estimations.

Results

Table 8. Panel threshold regression and financial openness

	(1)
Variables	$KAOPEN$ *rer*
Estimated threshold 1	-0.1144**
95% Confidence Interval	[-0.1333; -0.1097]
Estimated threshold 2	0.2058**
95% Confidence Interval	[0.1921; 0.2073]
$gdppk$	0.7404***
	(0.0570)
$govexp$	0.1441***
	(0.0225)
$etot \times L.res.I\left(L2.KAOPEN \leq \gamma_1\right)$	-0.0046***
	(0.0017)
$etot \times L.res.I\left(\gamma_1 < L2.KAOPEN \leq \gamma_2\right)$	-0.0235***
	(0.0024)
$etot \times L.res.I\left(L2.KAOPEN > \gamma_2\right)$	-0.0042*
	(0.0022)
$Constant$	0.8047**
	(0.2659)
Observations	1,764
Observation below threshold 1	870
Observation above threshold 2	825
Number of countries	98
RMSE	0.116

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L, $L2$, are the first and second lag operators, respectively. Source: author's estimates.

Results (robustness)

Table 9. Before and after the Great Financial Crisis

	(1)	(2)	(3)
Variables	*FI − after GFC rer*	*before GFC rer*	*after GFC rer*
Estimated threshold	0.4807**		
95% Confidence Interval	[0.4798; 0.4821]		
gdppk	0.6241***	0.9524***	0.5712***
	(0.0778)	(0.1460)	(0.1549)
govexp	0.0578**	0.0245	0.0605
	(0.0272)	(0.0426)	(0.0447)
etot		0.0074	0.0288**
		(0.0260)	(0.0133)
$L1.res$		0.0068	0.0052
		(0.0174)	(0.0110)
$etot \times L.res$		-0.0162*	-0.0153***
		(0.0098)	(0.0051)
$etot \times L.res.I\,(L2.FI \leq \gamma)$	-0.0083***		
	(0.0016)		
$etot \times L.res.I\,(L2.FI > \gamma)$	0.0098***		
	(0.0029)		
Constant	1.6149***	0.0593	1.8404**
	(0.3674)	(0.6918)	(0.8013)
Observations	1200	700	1,200
RMSE	0.0894	0.0884	0.0909

Note: bootstrapped standard errors in parentheses where 10,000 replications have been used. Fixed effects are included, but not shown. The symbols ***, **, * indicates statistical significance at the one, five and ten percent respectively. L and $L2$, stands for the lag operator. Source: authors' estimates.

Final thoughts

Key takeaways

- Assessing the buffer effect of international reserves in an era of high financial integration
- Understanding the consequences of holding international reserves
  - Buffer effect of international reserves is confirmed for a large macroeconomic sample
  - In Europe and Central Asia, the buffer effect is observed only above a threshold of 17 percent
  - Only observed in countries and periods where the development of financial institutions is low
  - More powerful in countries with intermediary levels of financial openness
- During the 2000 and 2010 decades, high international financial integration has not led to the reduction in reserve holdings
  - International reserve as a substitute to sound financial institutions
  - Development of sound financial institutions may be viewed as an alternative policy
- Possible extensions:
  - Consider monetary policy and macro-prudential policy
  - Understanding the consequences of the GFC and the euro crisis
  - Exploring the threshold effects in the common factors