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

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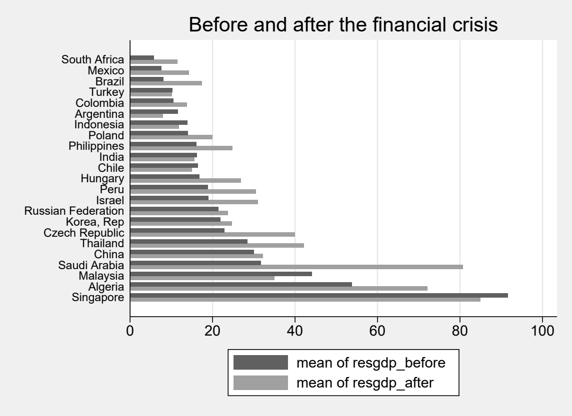
Outline

Research question

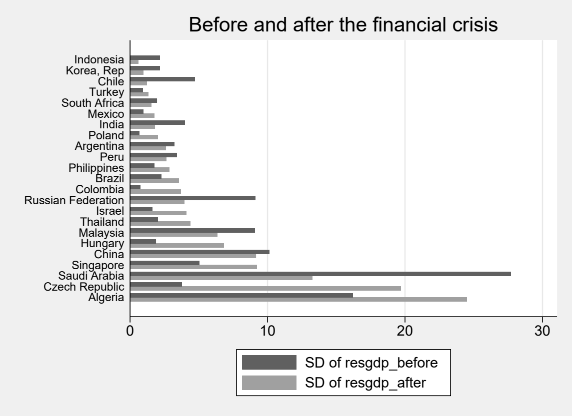
Figure 1. Large holders of international reserves as percent of GDP (before and after the GFC)



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



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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 buffer/mitigation effect of international reserves can be affected by
  - Financial integration and financial openness is higher in the 2000s
  - Impact of the Global Financial Crisis (Dominguez et al. 2012: ***reserves bounce back***) and the Euro Crisis
  - Regional heterogeneity, Commodity exporters, Macro-prudential policies
- Do countries use international reserves as shield against the negative consequences of terms-of-trade shocks on the real exchange rate? From which level of international reserves the buffer effect is observed? (Aizenman and Lee, 2007)
- Do countries use international reserves holdings as substitute to sound financial institutions? (Dominguez, 2010)
- Do the level of financial openness matters for the buffer effect?
  - Complementarity between capital controls and international reserves; see Steiner (2017), Cezar and Monnet (2023)

Research question

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 → weaken the domestic currency to promote exports
- Precautionary motive → self-insurance against external financing shocks
- Hoarding reserve in times of plenty and selling them in rainy days
  - Very intuitive mechanism

Research question

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)

Research question

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 non-tradable) → 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

1. Research question

2. Methodology

3. Results

Methodology

Empirical approach

- Annual data from 2001 to 2020 for a medium-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

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

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

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

- 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:

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

Outline

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Results

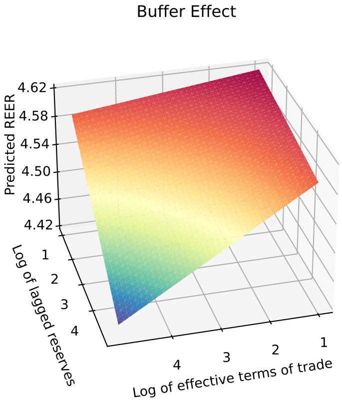
Table 1. Baseline nonlinear regression

	(1)
Variables	*rer*
gdppk	0.6589***
	(0.0725)
govexp	0.1435***
	(0.0292)
etot	0.0369***
	(0.0134)
L.res	0.0266***
	(0.0098)
$etot \times L.res$	**-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.

Results

Figure 3. 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. The results are very similar when we use lagged or present values for all the explanatory variables.

Results

Table 2. 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)
$etot \times L.res$	**-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.

Results

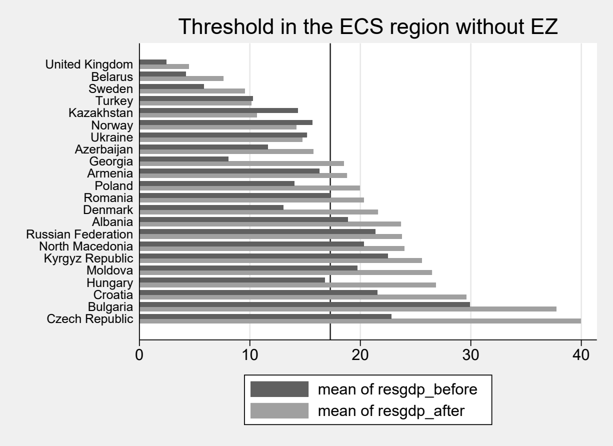
Table 3. Panel threshold regressions

	(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. One important advantage of this approach is to test the statistical significance of the threshold values. Determining whether thresholds are statistically significant when thresholds are chosen in an ad hoc manner is difficult.

Results

Figure 4. Threshold effect in the 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** ($\ln(1 + 100 \times x) = 2.9058 \Leftrightarrow x = 0.1728$). 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 global financial crisis.

Results

Table 4. 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. **When you have an interaction term between two variables, the marginal effects can be visualized in a 3-D plane, but when you have an interaction term between three variables, it is no longer possible to visualize the interaction, as we live in a world with three dimensions of space.**

Results

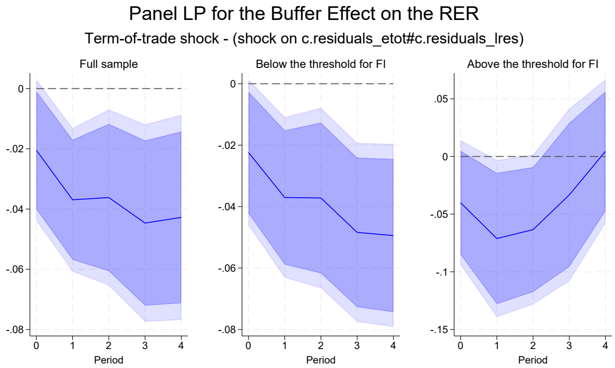
Table 5. Panel threshold regression and financial openness

	(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.

Results (Identification of the causality)

Figure 5. Panel LP for the buffer effect on the RER



Notes: **We construct two residual variables for lres and etot by running OLS regressions with country-fixed effects. We regress the variation of these variables on the real exchange rate.** In the left panel, the unit shock is on the full sample. In the center panel, we use the data below the previously identified threshold for the financial institution development. In the right panel, we use the data above the previously identified threshold for the financial institution development. Bootstrapped standard errors. 90%, 95% confidence intervals in dark and light blue, respectively.

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
- Policy recommendations: First-best, developing sound financial institutions; Second-best, holding internal reserves as a self-insurance tool against external finance shocks