BANQUE DE FRANCE
EUROSYSTÈME

Climate-Related Natural Disasters and Exchange Rate Misalignment in Developing Countries

Thibault Lemaire

Banque de France & Université Paris 1 Panthéon - Sorbonne

Frontiers of Climate and Nature in Macroeconomics and Finance
October 24, 2022

The views expressed in these slides are mine and should not be interpreted as reflecting the views of Banque de France or the Eurosystem.

Motivation

- Climate-related natural disasters have recently had dramatic effects on developing countries' real sector and populations.
- Monetary and financial consequences have received much less attention, despite importance for macroeconomic stability.
- Context in which climate change will alter the frequency and intensity of these natural disasters while reducing income and adaptation capacity in developing countries.

Research Questions

- Do climate-related natural disasters affect RER misalignment in developing countries?
  - Empirical approach.
  - RER depreciation: higher imports, lower FDI, lower agricultural output/exports, etc.
  - RER appreciation: increased exports (diaspora effect), ODA, remittances, capital inflows (reconstruction), inflation (shortages), etc.

Contribution

- Empirical literature assessed mainly the real effects of natural disasters.
  - Output growth (Felbermayr and Gröschl, 2014), capital stock (Acevedo, 2016), trade flows (El Hadri et al., 2018, 2019), public finances (Acevedo, 2014; Klomp, 2017), household income (Arouri et al., 2015; Keerthiratne and Tol, 2018), religiosity (Sinding Bentzen, 2019).
  - Klomp (2019), Parker (2018): inflation, not exchange rate.

- Empirical literature assessed the effects of RER misalignment.
  - Behavioural approach (Edwards, 1989; ElBadawi, 1994; Clark and MacDonald, 1998). Fundamentals and external sustainability approaches have drawbacks (Noureldin, 2018).
  - Output growth (ElBadawi et al., 2012), export diversification (Sekkat, 2016), civil conflict (Ambaw and Sim, 2021).

- This paper:
  - Study the monetary and financial consequences of climate-related natural disasters in developing countries.
  - Country-specific estimations of RER misalignment over a long period (1960–2017).
  - Additional determinant of RER misalignment.

Data sources: RER Misalignment Index

Sample: 110 low- and middle-income countries, annual data, 1960–2017.

Block 1: Real exchange rate misalignment.

- REER (66 trading partners) from Bruegel dataset (Darvas, 2012).
- Determinants:
  - Commodity terms of trade from Gruss & Kebhaj (2019)
  - NFA (% GDP) from WDI
  - Productivity index ($\frac{nGDPpc_{i,t}}{nGDPpc_{OECD,t}}$) from WDI
  - Public consumption (% GDP) from PWT v9.1
  - Trade openness ($\frac{X+M}{Y}$) from PWT v9.1

RER Misalignment Construction

- Step 1: RER as a function of its fundamentals (commodity terms of trade, productivity differential with respect to OECD countries, trade openness, government consumption, net foreign assets and world interest rate).
  - $RER_{i,t} = \alpha_i + \mathbf{\Omega}\mathbf{X'}_{i,t} + \varepsilon_{i,t}$

- Step 2: Compute the Equilibrium RER.
  - $RER^{E}_{i,t} = \widehat{\delta_i} + \widehat{\mathbf{\Omega}}\overline{\overline{\mathbf{X'}}}_{i,t} = \overline{RER}_i + \widehat{\mathbf{\Omega}}\left(\overline{\overline{\mathbf{X'}}}_{i,t} - \overline{\mathbf{X'}}_i\right)$

- Step 3: Compute RER Misalignment.
  - $RER^{MIS}_{i,t} = RER_{i,t} - RER^{E}_{i,t} = \left(RER_{i,t} - \overline{RER}_i\right) - \widehat{\mathbf{\Omega}}\left(\overline{\overline{\mathbf{X'}}}_{i,t} - \overline{\mathbf{X'}}_i\right)$
  - $RER^{MIS}_{i,t} = \widehat{\mathbf{\Omega}}\widetilde{\mathbf{X'}}_{i,t} + \widehat{\varepsilon}_{i,t}$

Data sources: Climate-Related Natural Disasters (1)

Block 2.a.: Climate-related natural disasters.

- EM-DAT (event based): floods, droughts, extreme temperatures, landslides, storms and wildfires.
  - Occurence, total death, total affected
  - Intensity, from Parker (2018)

$$intensity_{i,t,k} = \begin{cases} \frac{\left[100 \times \frac{total\ death_{i,t,k} + 0.3 \times total\ affected_{i,t,k}}{population_{i,t}}\right]}{occurrences_{i,t,k}}, \text{ if } intensity > 0.1 \\ 0 \text{ otherwise} \end{cases} \quad (1)$$

$$intensity_{i,t} = \sum_{k \in K} intensity_{i,t,k} \quad (2)$$

  - Endogenous, measurement error due to selection criteria (Felbermayr and Gröschl, 2014):
    $p(disaster) = f(GDPpc)$

Data sources: Climate-Related Natural Disasters (2)

Block 2.b.: Climate-related natural disasters.

- ifo GAME dataset (Felbermayr and Gröschl, 2014).
  - Measure physical intensity from primary meteorological and geophysical data
  - Negative effects on output are underestimated when using EMDAT
  - Limitations:
    - includes also geophysical natural disasters: cannot use their aggregate index
    - droughts identified using only precipitations
    - coverage ends in 2010

Data sources: Climate-Related Natural Disasters (3)

Block 2.c.: Climate-related natural disasters.

- I use primary meteorological datasets (monthly observations):
  - Land temperatures and precipitations: Matsuura and Willmott (2019).
  - Standardised Precipitation-Evapotranspiration Index (SPEI): Vicente-Serrano et al. (2010)
- To build alternative measures:

$$drought_{i,m,t} = \begin{cases} 1 \text{ if } SPEI_{i,x,t} \leq \mu_{SPEI_{i,m,1901-2018}} - \sigma_{SPEI_{i,m,1901-2018}} \text{ for } x \text{ in } [m, m-2] \\ 0 \text{ otherwise} \end{cases} \tag{3}$$

$$drought_{i,t} = \begin{cases} 1 \text{ if } \sum_{m=1}^{12} drought_{i,m,t} \geq 1 \\ 0 \text{ otherwise} \end{cases} \tag{4}$$

Data sources: Climate-Related Natural Disasters (4)

$$\textit{heat wave}_{i,m,t} = \begin{cases} 1 \text{ if } dtemp_{i,m,t} \geq \mu_{dtemp_{i,m,1900-2017}} + 2\sigma_{dtemp_{i,m,1900-2017}} \\ 0 \text{ otherwise} \end{cases} \tag{5}$$

$$\textit{cold wave}_{i,m,t} = \begin{cases} 1 \text{ if } dtemp_{i,m,t} \leq \mu_{dtemp_{i,m,1900-2017}} - 2\sigma_{dtemp_{i,m,1900-2017}} \\ 0 \text{ otherwise} \end{cases} \tag{6}$$

$$\textit{extreme precip}^{+}_{i,m,t} = \begin{cases} 1 \text{ if } dprecip_{i,m,t} \geq \mu_{dprecip_{i,m,1900-2017}} + \sigma_{dprecip_{i,m,1900-2017}} \\ 0 \text{ otherwise} \end{cases} \tag{7}$$

$$\textit{extreme precip}^{-}_{i,m,t} = \begin{cases} 1 \text{ if } dprecip_{i,m,t} \leq \mu_{dprecip_{i,m,1900-2017}} - \sigma_{dprecip_{i,m,1900-2017}} \\ 0 \text{ otherwise} \end{cases} \tag{8}$$

Data sources: Other Socio-Economic Variables

Block 3: Control variables, heterogeneity.

- Population: World Population Prospects (UNPD)
- Land area: WDI
- Annual food inflation (CPI, average): Parker (2018)
- Remittances: WB's Migration and Remittances Data dataset
- Capital Flows: IMF's Balance of Payments and International Investment Position Statistics database
  - Following Koepke and Paetzold (2020), an increase in net capital flows corresponds to capital outflows from country i:

$$\textit{Net Capital Flows}_{i,t} = \textit{Net Change in Assets}_{i,t} - \textit{Net Change in Liabilities}_{i,t} \quad (9)$$

Empirical Strategy

▷ Equation (10) allows to assess the effects of climate-related natural disasters on real exchange rate misalignment:

$$RER_{i,t}^{MIS} = \beta_0 + \beta_1 CRND_{i,t} + \mathbf{\Theta}\widetilde{\mathbf{X}'}_{i,t} + \delta_i + \gamma_t + \varepsilon_{i,t} \tag{10}$$

- Country i, year t, δ_i and γ_t are country and year fixed effects
- RER^{MIS}: Real exchange rate misalignment
- $CRND$: Occurrences of climate-related natural disasters, or alternative variable
- $\mathbf{X}'$: Vector containing cyclical components of fundamental RER determinants (commodity ToT, productivity differential with respect to OECD, trade openness, government consumption, and NFA).

Dependent Variable:	RER Misalignment			
	(1)	(2)	(3)	(4)
Climate-Related Natural Disaster Occurrence	0.015***		0.015***	
	(0.004)		(0.004)	
Climate-Related Natural Disaster Intensity		0.008***		0.008***
		(0.003)		(0.003)
Commodity Terms of Trade[a]	0.004	-0.143		
	(0.322)	(0.477)		
Productivity[a]	0.621***	-0.166		
	(0.189)	(0.305)		
Net Foreign Assets[a]	0.193***	0.034		
	(0.039)	(0.039)		
Public Consumption[a]	1.931***	0.385		
	(0.363)	(0.564)		
Trade Openness[a]	-0.592***	-0.343*		
	(0.115)	(0.188)		
Constant	0.381***	0.225*	0.390***	0.227*
	(0.079)	(0.120)	(0.079)	(0.120)
Country Fixed Effects	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y
Observations	4536	2375	4536	2375
Number of Countries	110	107	110	107

Note: [a] Cyclical component of the variable. Standard errors in parentheses. A positive RER misalignment corresponds to an overvalued RER. * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

Dependent Variable:	RER Misalignment					
Disaster Variable Source	ifoGAME		SPEI	University of Delaware		
Disaster Variable	Wind Speed	Drought	Drought	Heat Wave	Rainfall^{-}	Cold Wave
	(1)	(2)	(3)	(4)	(5)	(6)
Climate-Related Natural Disaster	0.001**	0.107***	0.027**	-0.026*	0.375	0.038**
	(0.001)	(0.032)	(0.014)	(0.016)	(0.413)	(0.018)
Commodity Terms of Trade[a]	0.678	0.324	-0.013	-0.006	0.003	-0.013
	(0.453)	(0.429)	(0.324)	(0.324)	(0.324)	(0.324)
Productivity[a]	0.833***	0.668***	0.623***	0.604***	0.615***	0.611***
	(0.235)	(0.217)	(0.191)	(0.191)	(0.191)	(0.191)
Net Foreign Assets[a]	0.201***	0.198***	0.196***	0.196***	0.194***	0.196***
	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)	(0.039)
Public Consumption[a]	2.451***	2.315***	2.025***	2.050***	2.037***	2.043***
	(0.452)	(0.426)	(0.376)	(0.376)	(0.376)	(0.376)
Trade Openness[a]	-0.690***	-0.698***	-0.640***	-0.643***	-0.643***	-0.638***
	(0.134)	(0.129)	(0.124)	(0.124)	(0.124)	(0.124)
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	2794	2888	4386	4386	4386	4386
Number of Countries	107	106	105	105	105	105

Note: [a] Cyclical component of the variable. Standard errors in parentheses. A positive RER misalignment corresponds to an overvalued RER. Constant included but not reported. * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

Dependent Variable:	RER Misalignment					
Disaster Variable Source	ifoGAME			SPEI		U. Delaware
Disaster Variable	Precipitation Deviations (1)	Precipitation Deviations (abs.) (2)	Temperature Deviations (3)	Drought (3 month) (4)	Drought (12 month) (5)	Rainfalls^{+} (6)
Climate-Related Natural Disaster	0.002	-0.002	-0.003	0.033**	0.032**	-0.015
	(0.007)	(0.002)	(0.002)	(0.014)	(0.014)	(0.014)
Commodity Terms of Trade[a]	0.389	0.686	0.691	0.005	-0.005	0.005
	(0.430)	(0.454)	(0.454)	(0.324)	(0.324)	(0.324)
Productivity[a]	0.671***	0.866***	0.868***	0.620***	0.630***	0.609***
	(0.217)	(0.236)	(0.236)	(0.191)	(0.191)	(0.191)
Net Foreign Assets[a]	0.197***	0.102*	0.102*	0.197***	0.193***	0.194***
	(0.039)	(0.054)	(0.053)	(0.039)	(0.039)	(0.039)
Public Consumption[a]	2.329***	2.547***	2.538***	2.009***	2.015***	2.031***
	(0.427)	(0.454)	(0.454)	(0.376)	(0.376)	(0.376)
Trade Openness[a]	-0.701***	-0.694***	-0.695***	-0.640***	-0.638***	-0.642***
	(0.129)	(0.134)	(0.134)	(0.124)	(0.124)	(0.124)
Country Fixed Effects	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y
Observations	2888	2774	2774	4386	4386	4386
Number of Countries	106	106	106	105	105	105

Note: [a] Cyclical component of the variable. Standard errors in parentheses. A positive RER misalignment corresponds to an overvalued RER. Constant included but not reported. * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

Dependent Variable:	RER Misalignment						
	Low-Income Countries (1)	Middle-Income Countries (2)	Occasional Disasters (3)	Disaster-Prone Countries (4)	Large Countries (5)	Smallest Countries (6)	Small Island Developing States (7)
Climate-Related Natural Disaster Occurrence	0.001 (0.005)	0.017*** (0.005)	-0.024 (0.017)	0.014*** (0.004)	0.023** (0.009)	0.013*** (0.004)	0.013*** (0.004)
Climate-Related Natural Disaster $\times \mathbb{1}_{\text{Large Country}}$					-0.010 (0.010)		
Climate-Related Natural Disaster $\times \mathbb{1}_{\text{Small Country}}$						0.041*** (0.016)	
Climate-Related Natural Disaster $\times \mathbb{1}_{\text{SIDS}}$							0.051*** (0.018)
RER^{MIS} determin.[a]	Y	Y	Y	Y	Y	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y
Observations	1473	3063	1805	2731	4536	4536	4536
Number of Countries	50	85	52	58	110	110	110

Note: [a] Cyclical component of the RER misalignment determinants. A positive RER misalignment corresponds to an overvalued RER. Low-income countries: below p33. Disaster-prone: above median. Large: above median. Smallest: below p25. Constant included but not reported. Standard errors in parentheses. * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

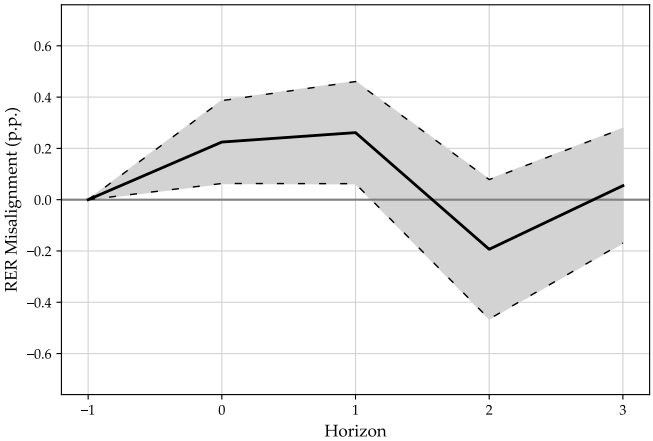
Empirical Strategy: Dynamic Approach

- Equation (11) allows to assess the effects of climate-related natural disasters on real exchange rate misalignment over time, using the Local Projections (Jordà, 2005).
- Separately estimated for horizons $h = 0, 1, ..., 3$:

$$RER^{MIS}_{i,t+h} = \alpha^h_0 + \theta^h CRND_{i,t} + \beta^h \sum_{p=1}^{h} CRND_{i,t+p} + \mathbf{\Phi}\widetilde{\mathbf{X}'}_{i,t} + \delta^h_i + \gamma^h_t + \varepsilon^h_{i,t} \qquad (11)$$

- RER^{MIS}: Real exchange rate misalignment
- $CRND$: Occurrences of climate-related natural disasters, or alternative variable
- $\mathbf{X}'$: Vector containing cyclical components of fundamental RER determinants (commodity ToT, productivity differential with respect to OECD, trade openness, government consumption, and NFA), one lag of dependent and explanatory variables.

Results: Local Projections



Note: RER misalignment response to a climate-related natural disaster. Standard errors are clustered at the country level.

Dependent Variable:	RER Misalignment								
Dependent Variable:	Food Inflation (1)	Food Inflation (2)	RER Misalign. (3)	Remittances (4)	RER Misalig. (5)	RER Misalign. (6)	Net Capital Flows (7)	RER Misalign. (8)	RER Misalign. (9)
CRND Occurrence	0.166 (0.383)			0.627*** (0.043)		0.011** (0.004)	-0.699*** (0.096)		0.003 (0.005)
Food Inflation			-0.001*** (0.000)						
Remittances					0.010*** (0.002)	0.008*** (0.002)			
Net Capital Flows								-0.005*** (0.001)	-0.005*** (0.001)
CRND Intensity		2.270*** (0.447)							
Constant	-86.825*** (6.046)	-99.228*** (9.945)	0.229*** (0.064)	-0.655 (0.568)	0.364*** (0.052)	0.355*** (0.052)	3.268 (8.095)	0.488 (0.348)	0.489 (0.348)
RER^{MIS} determin.[a]	N	N	Y	N	Y	Y	N	Y	Y
Country Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y
Observations	2141	1314	2036	3894	3421	3411	3505	3050	3050
Number of Countries	105	103	103	112	110	110	110	109	109

Note: [a] Cyclical component of the RER misalignment determinants. A positive RER misalignment corresponds to an overvalued RER. An increase in net capital flows corresponds to net acquisition of assets or a net decrease in liabilities (see Koepke and Paetzold, 2020). Net capital flows and remittances are expressed in billions of USD. Standard errors in parentheses. * Significant at the 10 percent level, ** significant at the 5 percent level, *** significant at the 1 percent level.

Conclusion

- Climate-related natural disasters lead to RER overvaluations in developing countries: one occurrence leads to a 0.015 unit increase in the RER misalignment index.
- This effect tends to increase when using measures of natural disasters based on climatic data.
- Effect mostly explained by middle-income countries, small countries, and small island developing states.
- Remittances and net capital flows act as transmission channels.