The Economic Footprint of Natural Disasters: Demand-side or supply-side forces?

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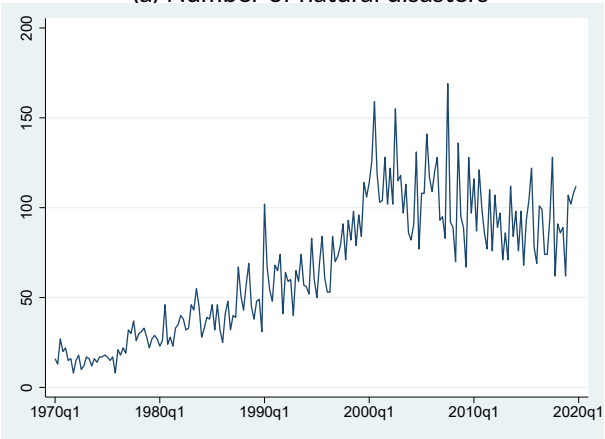
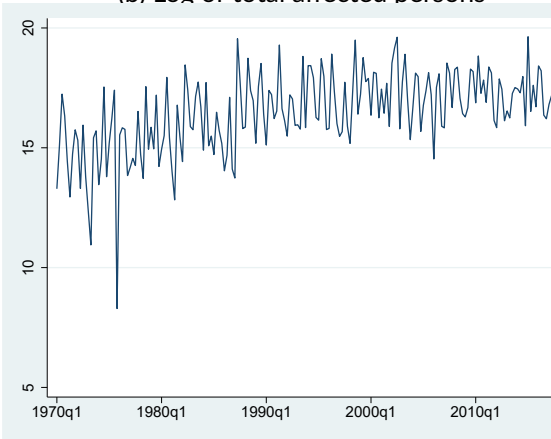
Motivation: Increasing importance of natural disasters

(a) Number of natural disasters



(b) Log of total affected persons



Source: EM-DAT. The number of total affected persons do not include the number of deaths. We count the disasters just at the start date. Period: 1970:Q1 - 2019:Q4.

Motivation

- Natural disasters pose significant physical risks, disrupting business cycles and hindering macroeconomic stability.
- These disasters impact the economy through both supply and demand channels.
- The relative importance of these channels is crucial for effective monetary policy

Outline of the paper

Research Question:

- Can we determine whether the impacts of natural disasters are more similar to demand-side shocks or supply-side shocks?
  - What are the implications for monetary policy (MP)?

Methodology: Mainly Empirical

- Country-quarterly (or yearly) data on climate-related disaster data from 3 sources + IFS data.
- Linear regressions to study the effects of natural disasters on inflation and GDP growth.

Results:

- The average natural disaster leaves a footprint similar to a supply shock: $\uparrow \pi$ & $\downarrow GDP$
- Large impacts for low-income countries.
- Persistent effects $\Rightarrow$ MP implications
- Heterogeneity in the economic footprint across different types of disasters.

Related Literature

- Natural disasters & GDP: [Dell et al. (2014); Botzen et al. (2019)]
  - Overall GDP: Level [Acevedo Mejia et al. (2019); Hsiang and Jina (2014)] & Growth [Cavallo et al. (2013); Felbermayr and Gröschl (2014)]
  - Potential GDP: [Parker (2023)]

    Incomplete recoveries [Cuaresma et al. (2007); Hallegatte and Dumas (2009)], financial frictions and bankruptcy [Uchida et al. (2015); Basker and Miranda (2017)], Human capital [Almond (2006); Vigdor (2008); Hornbeck (2012); Caruso and Miller (2015); Bier (2017)], innovation slow down [(Leiter et al., 2009; Noy and Strobl, 2022)].

- Natural disasters & Inflation: [Parker (2017); Mukherjee and Ouattara (2021); Kotz et al. (2023)]

- Natural disasters & supply and demand shocks: [Ciccarelli and Marotta (2024)]

Natural Disasters Data

Emergency Events Database (EM-DAT)

- quarterly data: 1990-2023.
- NNAT variable: Number of natural disasters
- Focus on 8 more frequent type of disasters: droughts, earthquakes, epidemics, extreme temperature, flood, mass movement, volcanic activity and wildfire.

Our World in Data

- Annual data: 1900-2022.
- DR variable: Death rates.
- It is a measure of physical risk (Ciccarelli and Marotta, 2024).

Baker et al. (2020) Dataset

- Annual data: 1970-2021
- NAT variable: 1 to 4 based on quarterly disasters.
- Mainly high income countries.

Natural Disasters Data

Variables	Obs	N	Mean	S.D.	Minimum	Maximum
Number of natural disasters - Quarterly frequency						
Drought	9948	115	0,02	0,14	0,00	2,00
Earthquake	9947	115	0,05	0,28	0,00	4,00
Epidemic	9948	115	0,05	0,24	0,00	4,00
Extreme Temperature	9948	115	0,04	0,20	0,00	2,00
Flood	9926	115	0,23	0,60	0,00	5,00
Mass Movement	9948	115	0,03	0,21	0,00	5,00
Storm	9916	115	0,17	0,59	0,00	5,00
Wildfire	9948	115	0,02	0,18	0,00	4,00
Death rates - Annual frequency						
Drought	4650	122	0,00	0,05	0,00	3,32
Earthquake	4633	122	0,03	0,33	0,00	9,50
Volcanic activity	4648	122	0,00	0,04	0,00	2,74
Flood	4649	122	0,06	0,32	0,00	8,46
Storm	4643	122	0,06	0,47	0,00	9,65
Landslide	4647	122	0,02	0,16	0,00	5,57
Extreme Temperature	4639	122	0,03	0,33	0,00	9,97

Source: EM-DAT, Our World in Data, Own elaboration. N: number of countries. S.D.: Standard deviation. We keep $NNAT_{it} < 6$, $DR_{it} < 10$.

Economic Data

IFS Data from IMF: quarterly and annual data from AE & EME on

- Real GDP
- Consumer Price Index (CPI)

Main Indicators:

- Annual real GDP growth
- Real GDP cycle (HP filter to real GDP)
- Annual and quarterly inflation

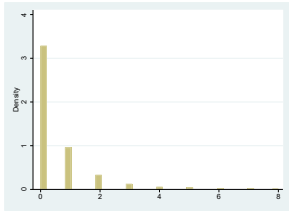
Sample Period: 1970:Q1 to 2019:Q4 (excluding COVID-19 period)

Data: Descriptive statistics

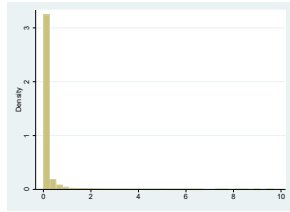
Variables	Obs	N	Mean	S.D.	Minimum	Maximum
Annual frequency						
π_{it} (%)	1296	115	8,19	9,89	-5,70	67,35
NAT_{it}	1296	30	0,24	0,62	0,00	4,00
DR_{it}	4607	122	0,20	0,74	0,00	9,66
$RGDPG_{it}$ (%)	5026	79	3,07	3,04	-13,70	13,56
Quarterly frequency						
π_{it} (%)	9885	115	1,25	1,89	-5,73	20,06
$NNAT_{it}$	9885	115	0,59	1,16	0,00	8,00
$GDPC_{it}$ (%)	2320	46	0,18	1,82	-11,30	10,18

Source: Baker et al. (2020), EM-DAT, Our World in Data, International Financial Statistics (IFS), IMF. Own elaboration. N: number of countries. S.D.: Standard deviation. We omit observations with extreme values: For annual inflation, we keep -10% $\leq \pi_{it} \leq$ 70%. For quarterly inflation, we keep -6% $\geq \pi_{it} \leq$ 25%. For the number of total natural disaster, we keep $NNAT_{it} < 9$. We keep -0.20% $\leq MPS_{it} \leq$ 0.20%, $DR_{it} \leq 10$, -15% $\leq RGDPG_{it} \leq$ 15%, -12% $\leq GDPC_{it} \leq$ 12%.

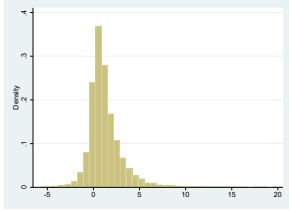
Descriptive statistics of disasters Data



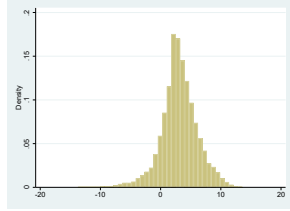
(a) Number of natural disasters



(b) Death rate



(c) Quarterly inflation



(d) Annual GDP growth

Note: It reports the histograms of the number of natural disasters and the death rates for the 1970 - 2019 period at quarterly and annual frequency, respectively. Source: EM-DAT, Our World in Data.

Empirical strategy

- Main Assumption: natural disaster is exogenous (at least in the short-run)
- Natural disasters $\Rightarrow$ Inflation and economy activity equilibrium effects
- Negative effects on GDP: either if natural disasters effects are similar to demand or supply shock
  1. Supply channels: Capital, labor and output losses
  2. Demand channels: Income channel, financial channels
- **Economic Footprint** of natural disasters is observed on inflation behavior
  1. If supply channels more relevant: $\uparrow \pi$
  2. If demand channels more relevant: $\downarrow \pi$

Empirical Model

$$Y_{it} = \mu + \alpha_i + \omega_t + \beta_0 Y_{it-1} + \beta_1 X_{it} + CTRL_{it} + \epsilon_{it},$$

- Y_{it}: GDP growth, output gap or Inflation,
- X_{it}: natural disasters variable
- Control variables:
  - α_i: Country fixed effects, controls for time-invariant characteristics of each country.
  - ω_t: Time-fixed effects: controls for global trends
  - $CTRL_{it}$: Y_{it-1} capturing the dynamic nature of the data, MP shocks to control MP response.

Results: GDP growth

↑ 1 in NNAT ⇒ ↓ real GDP growth by around 12 basis points

	All (1)	Drought (2)	Earthquake (3)	Epidemic (4)	Ext. temp. (5)	Flood (6)	Mass M. (7)	Storm (8)	Wildfire (9)
$RGDPG_{it-1}$	0.894***	0.896***	0.897***	0.895***	0.895***	0.897***	0.896***	0.895***	0.894***
	(0.00528)	(0.00518)	(0.00575)	(0.00522)	(0.00517)	(0.00517)	(0.00507)	(0.00514)	(0.00514)
$NNAT_{it}$	-0.117***	-1.079***	-1.828***	-1.185***	-0.647***	0.0116	0.0214	0.0124	-0.558***
	(0.0248)	(0.252)	(0.178)	(0.191)	(0.134)	(0.0435)	(0.164)	(0.0437)	(0.216)
Observations	4,933	5,026	5,026	5,026	5,026	5,003	5,026	4,992	5,026
N	79	79	79	79	79	79	79	79	79
F test (ρ-value)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: Table reports regression results using the number of natural disasters ($NNAT_{it}$) using EM-DAT. It uses information at quarterly frequency for the 1970:Q1-2019:Q4 period. $RGDP_{it}$: annual real GDP growth. Ext. temp: extreme temperatures. Mass M: mass movements. Standard errors are in parentheses. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991). This estimation includes country fixed effects.

DR variable

Results: GDP growth

Heterogeneous effects across disasters

	All	Drought	Earthquake	Epidemic	Ext. temp.	Flood	Mass M.	Storm	Wildfire
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
$RGDPG_{it-1}$	0.894***	0.896***	0.897***	0.895***	0.895***	0.897***	0.896***	0.895***	0.894***
	(0.00528)	(0.00518)	(0.00575)	(0.00522)	(0.00517)	(0.00517)	(0.00507)	(0.00514)	(0.00514)
$NNAT_{it}$	-0.117***	-1.079***	-1.828***	-1.185***	-0.647***	0.0116	0.0214	0.0124	-0.558***
	(0.0248)	(0.252)	(0.178)	(0.191)	(0.134)	(0.0435)	(0.164)	(0.0437)	(0.216)
Observations	4,933	5,026	5,026	5,026	5,026	5,003	5,026	4,992	5,026
N	79	79	79	79	79	79	79	79	79
F test (ρ-value)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Note: Table reports regression results using the number of natural disasters ($NNAT_{it}$) using EM-DAT. It uses information at quarterly frequency for the 1970:Q1-2019:Q4 period. $RGDP_{it}$: annual real GDP growth. Ext. temp: extreme temperatures. Mass M: mass movements. Standard errors are in parentheses. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991).

DR variable

Results: Output Gap

↑ 1 in NNAT ⇒ ↓ Output Gap by around 2.76%

	All (1)	Drought (2)	Earthquake (3)	Epidemic (4)	Ext. temp. (5)	Flood (6)	Storm (7)
$GDPC_{it-1}$	0.927***	0.929***	0.927***	0.931***	0.925***	0.926***	0.927***
	(0.00604)	(0.00603)	(0.00605)	(0.00605)	(0.00604)	(0.00603)	(0.00602)
$NNAT_{it}$	-0.0276***	-0.0184	0.0343	-0.101**	-0.0155	-0.0487***	-0.0249*
	(0.00810)	(0.0622)	(0.0329)	(0.0476)	(0.0398)	(0.0150)	(0.0136)
Observations	2,320	2,326	2,326	2,326	2,326	2,322	2,318
N	46	46	46	46	46	46	46
F test (ρ-value)	0	0	0	0	0	0	0

Table reports regression results using quarterly information of real GDP cycle ($GDPC_{it}$) and the number of natural disasters ($NNAT_{it}$). Standard errors are in parentheses. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991).

Results on inflation

↑ 1 in NNAT ⇒ ↑ quarterly inflation by around 7.4 basis points.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
π_{it-1}							0.257***	0.243***
							(0.0106)	(0.0118)
$NNAT_{it}$	0.0744***	0.0426**	0.0775***	-0.196***	-0.142***	-0.156***	0.0202	-0.00591
	(0.0164)	(0.0204)	(0.0156)	(0.0189)	(0.0225)	(0.0182)	(0.0150)	(0.0174)
$\pi_{i-1} \times NNAT_{it}$				0.220***	0.146***	0.191***		0.0160**
				(0.00841)	(0.00808)	(0.00816)		(0.00788)
Observations	9,885	9,885	9,853	9,885	9,885	9,853	9,885	9,885
F test (ρ-value)	6.75e-07	0.00472	4.54e-06	0	0	0	0	0
N	115	115	115	115	115	115	115	115
Country FE	No	Yes	No	No	Yes	No	Yes	Yes
Time FE	No	No	Yes	No	No	Yes	No	No

Table reports regression results using the number of natural disasters ($NNAT_{it}$) using EM-DAT. It uses information at quarterly frequency for the 1970:Q1-2019:Q4 period. π_{it}: quarterly inflation. Standard errors are in parentheses. MPS_{it}: monetary policy shock. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method for columns 1-6: OLS. Estimation method for columns 7-8: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991).

DR variable NAT variable

Results on inflation

However, the state dependent dimension is much more important.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
π_{it-1}							0.257***	0.243***
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$NNAT_{it}$	0.0744***	0.0426**	0.0775***	-0.196***	-0.142***	-0.156***	0.0202	-0.00591
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$\pi_{i-1} \times NNAT_{it}$				0.220***	0.146***	0.191***		0.0160**
				(0.00841)	(0.00808)	(0.00816)		(0.00788)
Observations	9,885	9,885	9,853	9,885	9,885	9,853	9,885	9,885
F test (ρ-value)	6.75e-07	0.00472	4.54e-06	0	0	0	0	0
N	115	115	115	115	115	115	115	115
Country FE	No	Yes	No	No	Yes	No	Yes	Yes
Time FE	No	No	Yes	No	No	Yes	No	No

Table reports regression results using the number of natural disasters ($NNAT_{it}$) using EM-DAT. It uses information at quarterly frequency for the 1970:Q1-2019:Q4 period. π_{it}: quarterly inflation. Standard errors are in parentheses. MPS_{it}: monetary policy shock. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method for columns 1-6: OLS. Estimation method for columns 7-8: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991).

DR variable | NAT variable | 2nd order

Results on inflation & Types of natural disasters

Heterogeneous effects:

- (droughts, earthquakes, epidemics, floods, mass movements) $\Rightarrow\uparrow \pi$
- (extreme temperatures, storms and wildfires) $\Rightarrow\downarrow \pi$

	Drought (1)	Earthquake (2)	Epidemic (3)	Ext. temp. (4)	Flood (5)	Mass M. (6)	Storm (7)	Wildfire (8)
π_{it-1}	0.253***	0.288***	0.267***	0.257***	0.259***	0.255***	0.245***	0.247***
	(0.0106)	(0.0105)	(0.0105)	(0.0106)	(0.0106)	(0.0105)	(0.0106)	(0.0106)
$NNAT_{it}$	0.208**	0.262***	0.337***	-0.0784	0.102***	0.127*	-0.131***	-0.159*
	(0.102)	(0.0590)	(0.0648)	(0.0756)	(0.0262)	(0.0716)	(0.0283)	(0.0824)
Observations	9,948	9,947	9,948	9,948	9,926	9,948	9,916	9,948
N	115	115	115	115	115	115	115	115
F test (ρ-value)	0	0	0	0	0	0	0	0

Table reports regression results using the number of each type of natural disasters ($NNAT_{it}$) using EM-DAT. It uses information at quarterly frequency for the 1970:Q1-2019:Q4 period. π_{it}: quarterly inflation. Standard errors are in parentheses. MPS_{it}: monetary policy shock. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991).

Discussion

- Our results
  - On average natural disasters effects on the economy are akin to negative supply shocks

    Natural disaster $\Rightarrow \uparrow$ Inflation & $\downarrow$ economic activity
  - Inflation state dependence is important.
  - The economic footprint varies across types of disasters.

- Implications of our findings about natural disasters
  - **Supply side footprint:** Create a trade-off between inflation and output gap for MP

    Natural disaster $\Rightarrow \uparrow$ uncertainty in MP strategy and complicate communication strategies increasing uncertainty in monetary policy and complicating communication strategies.
  - **State-dependence & heterogeneity**: Non-linear effects

    Natural disaster $\Rightarrow$ unpredictability in forecasts, potentially leading to inappropriate policy decisions.

Conclusions

- Robust evidence that physical risks from natural disasters act as negative supply shocks.
- We find evidence of compounding and non-linear effects of natural disaster shocks.
- Implications for MP: Physical risk amplifies the trade-off between inflation management and economic activity.
- Need for further normative research to build a resilient policy framework in the face of climate risk and higher uncertainty.

Gracias!

Appendix

Results on GDP growth

Table: Regression Results for all and by type of natural disaster

	All (1)	Drought (2)	Earthquake (3)	Volcanic act. (4)	Floods (5)	Storms (6)	Landslide (7)	Ext. temp. (8)
$RGDPG_{it-1}$	0.505***	0.497***	0.491***	0.494***	0.488***	0.503***	0.471***	0.485***
	(0.0179)	(0.0178)	(0.0177)	(0.0177)	(0.0175)	(0.0177)	(0.0175)	(0.0177)
DR_{it}	-1.390***	87.30*	0.107	-6.279***	1.488**	-1.182***	29.96***	2.560***
	(0.180)	(45.99)	(0.485)	(1.072)	(0.600)	(0.104)	(2.347)	(0.693)
Observations	1,607	1,621	1,620	1,621	1,621	1,620	1,621	1,610
N	86	86	86	86	86	86	86	86
F test (ρ-value)	0	0	0	0	0	0	0	0

Table reports regression results using the death rates for all and by each natural disaster type (DR_{it}) as our exogenous variable. It uses annual information for the 1970-2019 period. $GDPG_{it}$: the annual real GDP growth is our endogenous variable. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991).

Return

Results on Inflation

Table: Inflation: Regression Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
π_{it-1}							0.517***	0.497***
							(0.0108)	(0.0117)
NAT_{it}	0.756*	0.445	0.763*	-4.982***	-4.443***	-4.302***	4.023***	0.131
	(0.440)	(0.523)	(0.410)	(0.617)	(0.694)	(0.586)	(0.363)	(0.384)
π_{i-1} NAT_{it}				0.642***	0.474***	0.568***		0.131***
				(0.0511)	(0.0463)	(0.0490)		(0.0251)
Observations	1,296	1,296	1,296	1,296	1,296	1,296	1,296	1,296
F test (ρ-value)	0.0857	0.0155	0.0633	0	0	0	0	0
N	30	30	30	30	30	30	30	30
Country FE	No	Yes	No	No	Yes	No	Yes	Yes
Time FE	No	No	Yes	No	No	Yes	No	No

Table reports regression results using the natural disaster shock (NAT_{it}) of Baker et al. (2020). It uses information at annual frequency for the 2004-2019 period. π_{it}: annual inflation. Standard errors are in parentheses. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method for columns 1-6: OLS. Estimation method for columns 7-8: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991). This estimation includes country fixed effects.

Return

Results on Inflation

Table: Regression Results - Death rates

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
π_{it-1}							0.323***	0.328***
							(0.00807)	(0.00794)
DR_{it}	0.356*	0.648***	0.330*	-2.081***	-2.458***	-1.561***	1.587***	2.968***
	(0.187)	(0.196)	(0.171)	(0.249)	(0.264)	(0.231)	(0.391)	(0.429)
π_{i-1} DR_{it}				0.292***	0.367***	0.226***		-0.0652***
				(0.0203)	(0.0218)	(0.0189)		(0.0243)
Observations	4,607	4,607	4,607	4,607	4,607	4,607	4,607	4,607
F test (ρ-value)	0.0564	0.000954	0.0539	0	0	0	0	0
N	122	122	122	122	122	122	122	122

Table reports regression results using the death rates (DR_{it}) as our endogenous variable. It uses information at annual frequency for the 1970-2019 period. π_{it}: annual inflation. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method for columns 1-6: OLS. Estimation method for columns 7-8: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991). This estimation includes country fixed effects.

Return

Inflation second order effects

Table: Regression Results - second order effects

	All	Drought	Earthquake	Volcanic act.	Floods	Storms	Landslide	Ext. temp.
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(7)
π_{it-1}	0.323***	0.322***	0.320***	0.302***	0.315***	0.324***	0.309***	0.315***
	(0.00796)	(0.00801)	(0.00791)	(0.00799)	(0.00791)	(0.00805)	(0.00797)	(0.00798)
DR_{it}	7.677***	-199.9***	15.82***	376.4***	-6.371***	12.00***	-10.99***	-2.588
	(0.923)	(25.99)	(1.800)	(36.94)	(1.575)	(1.671)	(3.946)	(2.634)
DR_{it}^2	-1.094***	61.71***	-2.063***	-144.0***	1.021***	-1.655***	2.975***	0.312
	(0.135)	(8.099)	(0.246)	(14.12)	(0.239)	(0.231)	(0.864)	(0.354)
Observations	4,607	4,650	4,633	4,648	4,649	4,643	4,647	4,639
N	122	122	122	122	122	122	122	122
F test (ρ-value)	0	0	0	0	0	0	0	0

Table reports regression results using the death rates (DR_{it}) as our endogenous variable by different natural disasters type. It uses information at annual frequency for the 1970-2019 period. π_{it}: annual inflation. MPS_{it}: monetary policy shock. N: number of countries. *** Statistically significant at 1%, ** statistically significant at 5%, * statistically significant at 10%. Estimation method: Generalized Method of Moments (GMM) estimator of Arellano and Bond (1991). This estimation includes country fixed effects.

Return

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