⇒ Does climate risk affect banks' capital structure adjustment?
⇒ What are the implications for speed and balance sheet adjustments?

Climate Risk and Bank Capital Structure

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Motivation

- Climate Risk refers to sources of uncertainty surrounding external environment (e.g., abnormal heat, El Niño, hurricane, etc.) and transition to a low carbon economy (*Barnett et al., RFS, 2020*).

- Difficulties in managing climate risks are attributed to the uncertain and endogenous future policy shocks that:
  - lead to an increase in regulatory costs and uncertainty [*Çolak et al., JFQA, 2017; Chen et al., JFQA, 2019*],
  - and thus, may affect bank regulatory capital decision [*Krueger et al., RFS, 2020*].

- Climate Risk as informal institutional environments (such as cultural values) may affect bank regulatory capital decision [*Krueger et al., RFS, 2020; Chen et al., JFQA, 2019*].

Objective & Research Question

1. Investigate whether *Climate Risk* may alter bank capital structure adjustment (‘*speed* and *mechanisms*’).
   - How Banks located in areas exposed to Climate Risk manage their *capital structure* and rebalance towards their *optimal capital levels*.
   - Does Climate Risk affect their *SoA* and *asymmetries* in adjustments *according to the sign of the capital gap*.
   - Examine importance of ***Physical*** *vs.* ***Regulatory*** Climate Risks.

2. Look into adjustment mechanisms: investigate growth rates in ***assets*** (RWA) and ***equity*** classes, *according to the sign of the capital gap*.

Climate Risk Exposure

- Following *Huynh et al.* (JCF, 2020), I use the country location of a bank's headquarter to determine its exposure to climate risk.

- According to NGFS (2020), the global financial sector faces mainly two types of climate change risks:

  (i) physical risk (e.g., abnormal temperature, floods, sea level),

  (ii) green transition risk (i.e., carbon-dioxide emissions, transition to a low-carbon economy).

Climate Risk Exposure

1) Physical risk index: *abnormally hot temperature*

- This takes into account the extreme weather conditions**.**
- Daily data is collected from the *IMF*/*WB:* constructed based on weather records from 15,900 stations covering the EU: ranging 01/01/1973 and 31/12/2021.

- *Bansal et al. (2014)* argue that long-run climate risk is captured by *abnormally hot* temperature. Following *Choi et al. (RFS, 2020)*, I decompose *local temperature* (*WM*) in 3-components: which account for ***predictable***, ***seasonal***, and ***abnormal*** *patterns*:

$$\text{Temperature}_{j,m} = \text{AvgTemp}_{j,m} + \text{MonTemp}_{j,m} + \boldsymbol{Ab}\mathbf{Temp}_{\boldsymbol{j,m}}$$

Climate Risk Exposure

2) **Transition risk:** *Carbon emission intensity*
   - Yearly data from the *IMF/WB is* constructed based on carbon disclosure reports + *Worldwide Governance Indicators*.
   - ***Carbon emission intensity***, total carbon emissions scaled by country's economy size:

$$\mathrm{CEI}_{j,t} = \frac{\mathrm{KtCO2e}_{j,t}}{GDP_{j,t}}$$

3) **Climate Risk-index:** *aggregated composite index*
   - The ***CR-index*** allocates country-year observations in quintiles according to these two characteristics: *Physical & Regulatory risks*.
   - It covers two equally-weighted dimensions of climate risk.
   - The index ranges from 2 to 20. The highest value representing the highest level of climate risk that a bank can be exposed to.

Capital measures

Observed regulatory capital levels

- Total capital adequacy ratio

  → [CAR, *ratio of total capital over total RWA*].

- *Robustness: Tier1 capital ratio*

  → *[Tier1RWA, ratio of capital Tier 1 over total RWA].*

I consider a dynamic setting where banks adjust to their target capital ratio at a certain adjustment speed.

Where we go from: *capital structure adjustment*

- Literature shows that banks set an ***optimal*** capital structure, which balances the costs/benefits of capital [Berger et al., 2008; Flannery and Rangan, 2008; Memmel and Raupach, 2010].
  - **but**, observed capital structures frequently *deviate* from the *targeted* (*optimal*) levels.
  - The existence of a ***wedge*** (+/– *gap*), between the observed and optimal capital, reflects variations in the ***speed*** at which banks adjust to the optimal capital structure.

- **Frictions** prevent banks to immediately adjust to their desired capital. However, bank's decision to adjust depends on the trade-off between *adjustment costs and costs of operating with suboptimal capital* [Flannery and Hankins, 2013].
  - **climate risk** may alter the tradeoff between the costs (or the benefits) of being off the capital target and the costs of adjusting back to the optimal capital structure.
  - We hypothesize that climate risk may affect regulatory capital via two possible channels: larger *expected distress costs* and *higher operating costs*.

Methodology: *capital adjustment model*

- The general partial adjustment model is given by [*Flannery and Rangan* (JFE, 2006), De *Jonghe and Öztekin* (JFI, 2015); *Gropp and Heider* (RF 2010)]:

$$\mathrm{CAR}_{ij,t} = \lambda \mathbf{CAR}^{*}_{\mathbf{ij,t-1}} + (1-\lambda)\mathrm{CAR}_{ij,t-1} + \varepsilon_{ij,t-1}$$

- I use this framework to model and estimate the target capital ratio:

$$\mathbf{CAR}^{*}_{\mathbf{ij},t} = \beta X_{ij,t-1} + \delta Y_{ij,t-1} + u_i + v_t$$

Following the literature [*Wintoki et al.* (JFE, 2012)], I include a number of covariates that fulfills two-conditions: (i) *exogeneity* and (ii) *explanatory power*, as determinants of target capital.

- Using *Blundell and Bond*'s (JE, 1998) GMM estimation, I use the following standard partial adjustment process:

$$\mathrm{CAR}_{ij,t} = (1-\lambda)\mathbf{CAR}_{\mathbf{ij,t-1}} + \lambda(\beta X_{ij,t-1} + \delta Y_{ij,t-1} + u_i + v_t) + \varepsilon_{ij,t-1}$$

The long-run effect of each explanatory variable, $X_{ij,t-1}$, is then given by: $\zeta = \beta/(1-\lambda)$.

Deriving Capital Deviation

- Hence, the time-varying capital deviation is derived as follows:

    - $\boldsymbol{Reg}\mathbf{Gap}_{\boldsymbol{ij,t-1}}$[*required adjustment* at t–1]= $\widehat{\mathbf{CAR}}^{*}_{\boldsymbol{i,t}} - \mathrm{CAR}_{i,t-1}$,

- Controlling for asymmetric reactions:

    - $\boldsymbol{Reg}\mathbf{Gap}^{+}_{\boldsymbol{ij,t-1}}$: downward adjustment → *decrease in capital* or *increase in assets.*
    - $\boldsymbol{Reg}\mathbf{Gap}^{-}_{\boldsymbol{ij,t-1}}$: upward adjustment → *increase in capital* or *decrease in assets.*

Effects of Climate Risk on Speed of Adjustment

- Determinants of the SoA.
  - I allow for the *time-varying* SoA, specified by *Climate Risk* that could affect the SoA [Berger et al. (2008), Oztekin and Flannery (2015)]:

$$\lambda_{ij,t} = \lambda_0 + \Lambda \boldsymbol{Z}_{\mathbf{ij,t-1}}$$

- Investigate *whether or not Climate Risk* ($Z_{ij,t-1}$) affects the SoA.
  - Baseline model: pooled OLS regressions:

$$\Delta CAR_{ij,t} = (\lambda_0 + \Lambda \boldsymbol{Z}_{\mathbf{ij,t-1}}) \times \boldsymbol{Reg}\mathbf{Gap}_{\boldsymbol{ij,t-1}} + \varepsilon_{i,t}$$

$$Z_{ij,t\text{-}1} = \begin{cases} \text{AbTemp} \\ \text{LogCO2} \\ \text{CR}-\text{index} \end{cases} \quad \textit{and} \quad \Delta CAR_{ij,t} = \{\textit{Capital Adequacy Ratio}$$

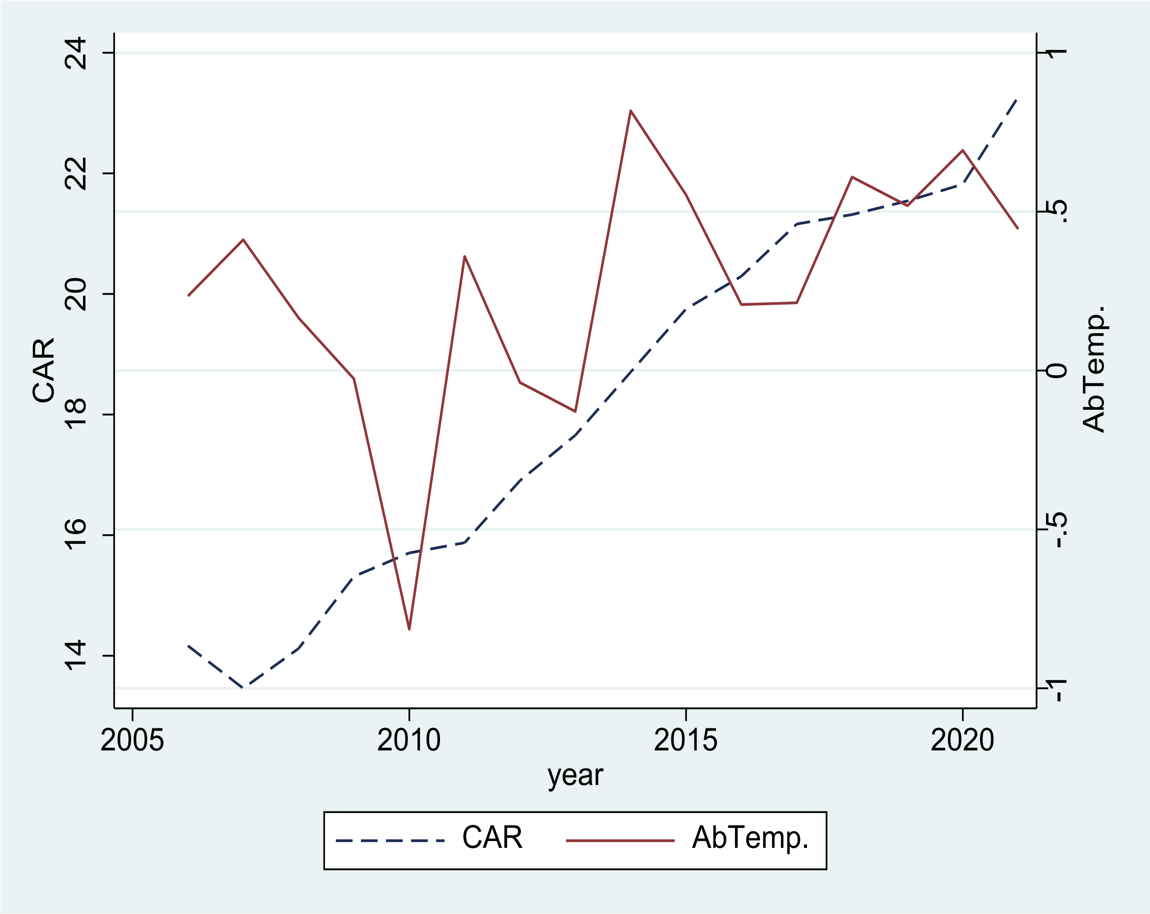
Data

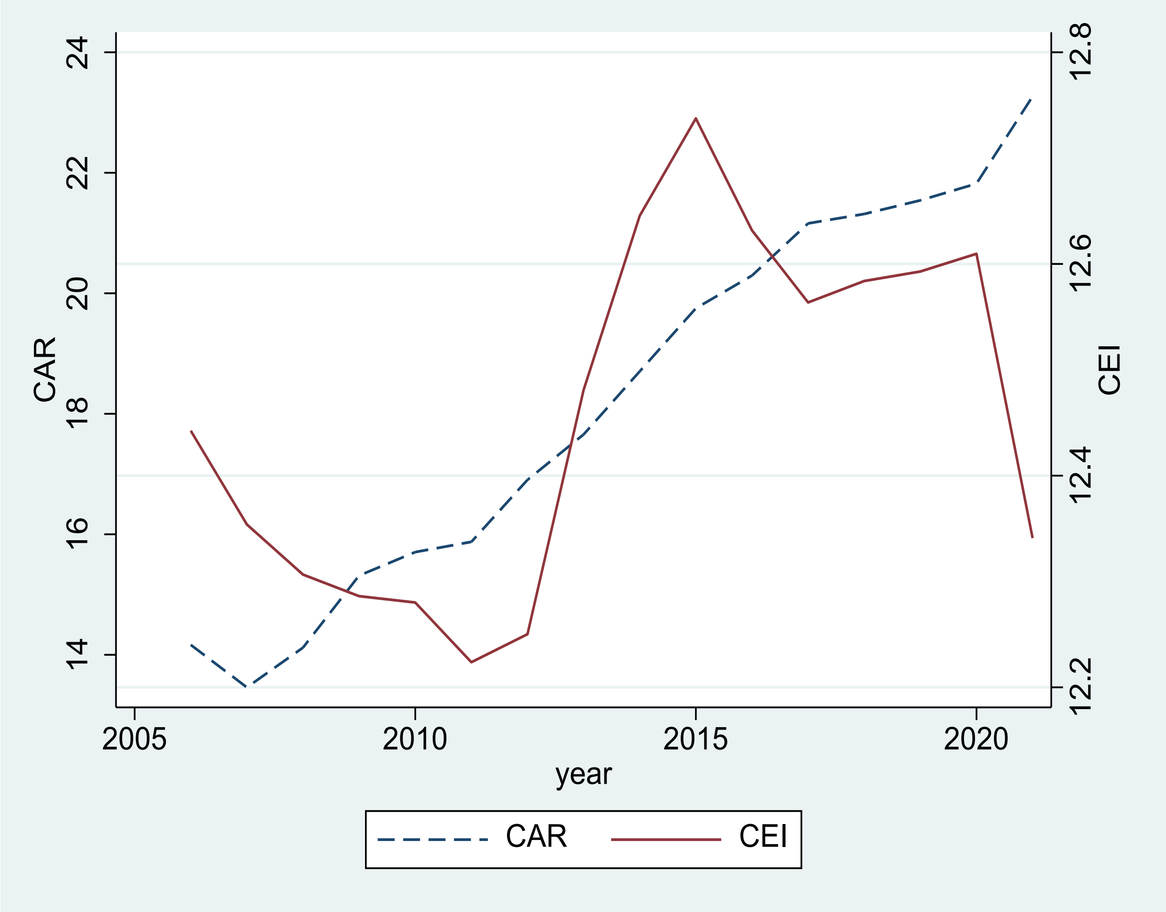
Table 1. Distribution of European banks and representativeness of the final sample

Country	Banks	Observations	Specialisation: Commercial bank	Savings bank	Cooperative bank	Investment bank	Others	Listed	non-listed
Albania	14	86	11	2	0	1	0	0	14
Austria	166	1132	53	30	64	3	16	14	152
Belarus	36	239	33	3	0	0	0	6	30
Belgium	31	268	23	6	2	0	0	0	31
BiH	26	178	24		1	1		17	9
Bulgaria	30	220	28	2	0	0	0	8	22
Croatia	28	223	26	1	1	0	0	8	20
Cyprus	37	241	35	0	1	1	0	4	33
Czech	28	282	23	0	4	1	0	3	25
Denmark	86	779	44	31	6	0	5	35	51
Estonia	12	101	10	0	0	2	0	0	12
Finland	155	788	29	9	114	1	2	9	146
France	135	1102	41	11	75	3	5	20	115
Germany	1319	10030	67	375	823	24	30	14	1305
Greece	17	175	13	0	2	2		11	6
Hungary	33	215	28	0	0	0	5	8	25
Iceland	8	58	3	4	0	1	0	3	5
Ireland	25	200	18	0	0	6	1	5	20
Italy	400	3023	100	15	265	18	2	48	352
Latvia	23	157	23	0	0	0	0	0	23
Liechtenstein	1	7	1	0	0	0	0	0	1
Lithuania	9	92	8	1	0	0	0	3	6
Luxembourg	42	308	36	3	2	1	0	0	42
Malta	15	85	11	1	1	2	0	5	10
Monaco	0	0	0	0	0	0	0	0	0
Montenegro	10	62	10	0	0	0	0	7	3
Netherlands	31	309	25	0	2	3	1	3	28
Norway	160	1245	31	123	0	2	4	61	99
Poland	163	1034	90	3	66	0	4	30	133
Portugal	40	326	24	5	5	6	0	0	40
Romania	32	215	27	4	1	0	0	7	25
Russia	782	4494	759	4	2	17	2	93	689
Serbia	27	199	24	1	0	0	0	3	24
Slovakia	14	123	9	3	0	0	2	4	10
Slovenia	21	207	18	2	1	0	0	3	18
Spain	90	653	41	12	35	2	0	13	77
Sweden	106	652	45	52	0	3	6	11	95
Switzerland	117	585	96	14	4	2	1	9	108
Turkey	98	896	97	0	1	0	0	47	51
UK	156	1086	96	1	0	13	45	7	149
Ukraine	83	431	78	5	1	0	0	34	49
Total	4,606	32,506	2,158	723	1,479	115	131	553	4,053

- Sample: 4,606 European banks [39 countries]:
  - *79% of them are Commercial & Cooperative banks.*
  - *12% of them are listed.*
  - *32,506 year-bank observations.*
- Period: 2005–2021.
- Prov*iders*:
  - *Financial data (annual-basis*):
    Bloomberg, Thomsen-Reuters, Eikon & SNL.
  - *Data on the environmental profile per country (daily-basis):*
    World Bank/IMF (Climate Change Knowledge Portal).
    Worldwide Governance Indicators.

Evolution of bank capital and climate risks over time: 2006–2021





Partial Adjustment Model of Bank Capital

Panel A. A partial adjustment model of bank capital

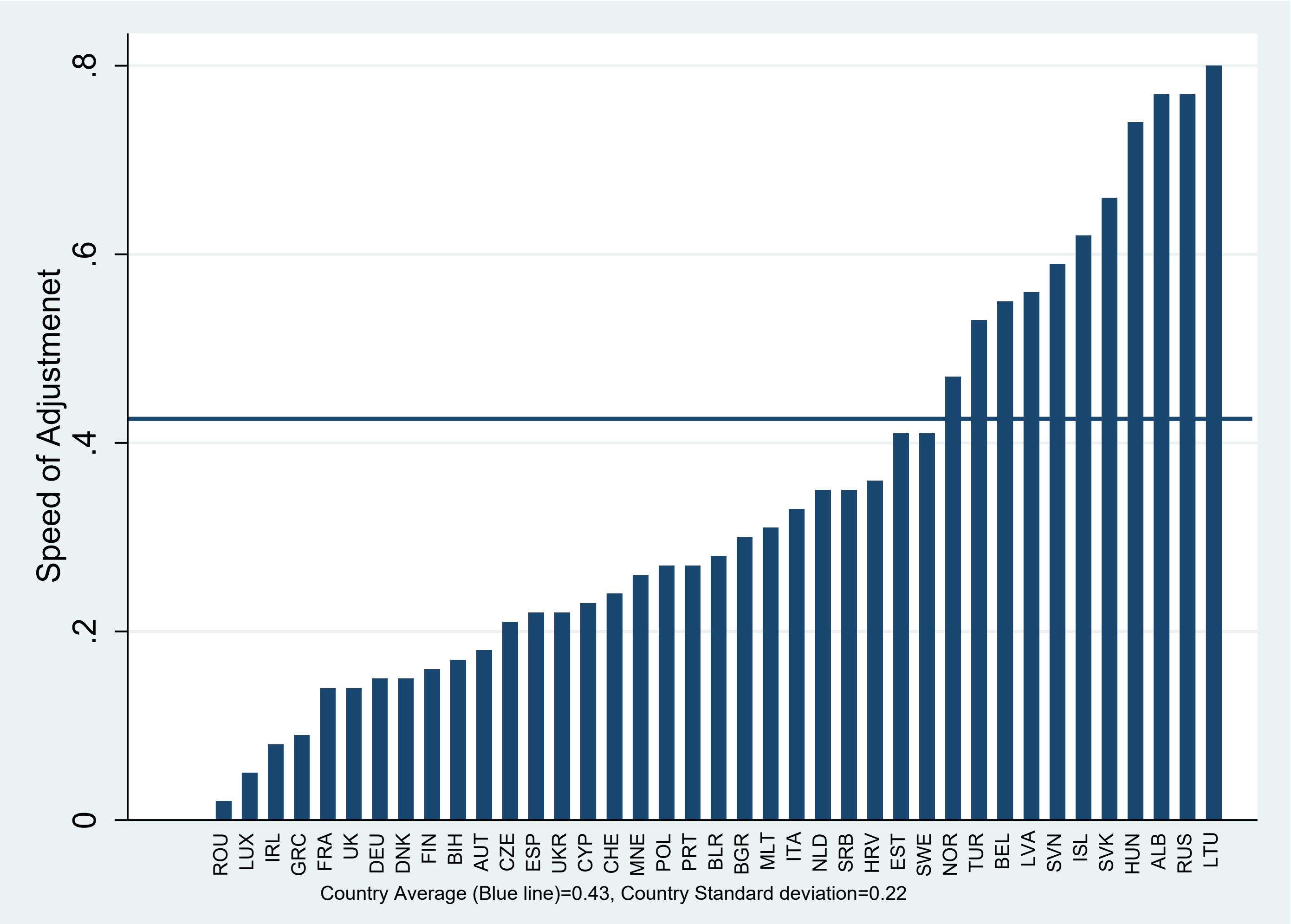
Dependent	Coefficients for the observed capital adequacy ratio (1)	Coefficients for the target ratio (2)
CAR_{t-1}	**0.517*****	**λ=0.483**
	(0.0266)	
$Size_{t-1}$	-0.557***	1.153***
	(0.0443)	
$Funding_{t-1}$	-0.757**	1.567**
	(0.324)	
$Credit\_Risk_{t-1}$	0.133*	0.275*
	(0.238)	
$Liquidity_{t-1}$	-0.033***	0.069***
	(0.004)	
$Tangibility_{t-1}$	-0.337	0.698
	(3.286)	
$Efficiency_{t-1}$	-0.004*	0.008*
	(0.002)	
RoA_{t-1}	-2.136	4.422
	(5.159)	
$Diversification_{t-1}$	-0.019*	0.040*
	(0.065)	
$Listed_{t-1}$	0.090*	0.186*
	(0.011)	
$AbTemp_{t-1}$	0.215**	0.445**
	(0.024)	
CEI_{t-1}	0.033*	0.068*
	(0.320)	
$PostCOP215_{t-1}$	0.033**	0.068**
	(0.029)	
$Log(surface)_{t-1}$	-0.005*	-0.006*
	(0.001)	
ΔGDP_{t-1}	-0.065**	0.136**
	(0.033)	
Constant	18.670***	
	(1.272)	
Observations	32,506	
Bank Fixed Effects	Yes	
Year Fixed Effects	Yes	
Number of Banks	4,606	
Number of Countries	40	
Hansen test (p-value)	0.201	
AR2 test (p-value)	0.378	

Panel B. Deriving capital deveiationA partial adjustment model of bank capital

Variable	N	Mean	SD	p5	p25	p50	p75	p95
Target total capital adequacy ratio								
Target CAR (%)	32506	20.23	7.745	12.420	15.540	18.080	21.930	39.360
Deviation from the target								
Capital Gap: *RegGap* (%)	32506	0.590	4.359	-5.200	-0.824	0.595	2.037	6.209
Capital Shortfall: *RegShortfall* (%)	20146	2.579	3.361	0.159	0.766	1.620	3.043	8.158
Capital Surplus: *RegSurplus* (%)	12345	-2.654	3.824	-9.545	-3.824	-1.392	-0.570	-0.022

- Economically, this SoA (λ) corresponds with half-live of: 1.10 year.
- 1.10 year is the time required for banks to halve the '***RegGap***' between their actual capital ratio and their target.

Country-specific Adjustment Speeds (λ_j)



Code	Country	SOA	Code	Country	SOA
			BLR	Belarus	0.28
			BGR	Bulgaria	0.30
ROU	Romania	0.02	MLT	Malta	0.31
LUX	Luxembourg	0.05	ITA	Italy	0.33
IRL	Ireland	0.08	NLD	Netherlands	0.35
GRC	Greece	0.09	SRB	Serbia	0.35
UK	UK	0.14	HRV	Croatia	0.36
FRA	France	0.14	SWE	Sweden	0.41
DNK	Denmark	0.15	EST	Estonia	0.41
DEU	Germany	0.15	NOR	Norway	0.47
FIN	Finland	0.16	TUR	Turkey	0.53
BIH	BiH	0.17	BEL	Belgium	0.55
AUT	Austria	0.18	LVA	Latvia	0.56
CZE	Czech	0.21	SVN	Slovenia	0.59
ESP	Spain	0.22	ISL	Iceland	0.62
UKR	Ukraine	0.22	SVK	Slovakia	0.66
CYP	Cyprus	0.23	HUN	Hungary	0.74
CHE	Switzerland	0.24	ALB	Albania	0.77
MNE	Montenegro	0.26	RUS	Russia	0.77
PRT	Portugal	0.27	LTU	Lithuania	0.80
POL	Poland	0.27			

Determinants of speed of adjustment (SoA) to target regulatory capital structure: *effects of Climate Risk (abnormally hot temperature and CO2 emission) on the SoA*

	(1) ΔCAR	(2) ΔCAR	(3) ΔCAR	(4) ΔCAR	(5) ΔCAR
RegGap	0.413***	0.415***	0.409***	0.411***	0.408***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)
RegGap#**AbTemp**$_{t-1}$		**0.042*****		**0.040*****	
		(0.007)		(0.007)	
RegGap#**LogCO2**$_{t-1}$			**0.020*****	**0.018*****	
			(0.006)	(0.006)	
RegGap#**CR-index**$_{t-1}$					**0.038*****
					(0.006)
Observations	32,506	32,506	32,506	32,506	32,506
Number of Banks	4,606	4,606	4,606	4,606	4,606
Adjusted R-squared	0.346	0.348	0.347	0.349	0.349
Clustered SE	Bank	Bank	Bank	Bank	Bank

Economically, a one standard deviation increases in: **AbTemp**(2), **LogCO2**(3) and **CR-index**(5) increases the average SoA by: 0.042, 0.02 and 0.38 (compared to a baseline adjustment speed, $\widehat{\boldsymbol{\lambda_0}}$, of 0.415, 0.409 and 0.408) and explains 20%, 10% and 19% of the observed cross-country standard deviation in the SoA (0.22), leasing to a significantly higher half-life.

Effects of Climate Risk on SoA: *additional results*

	Normal growth: 2<Gr(GDP)<4	Normal growth: 0.10<Gr(TA)<0.15	Commercial & Saving banks	Commercial banks only	No crisis	WLS	Alternative capital ratio: Tier 1RWA
	ΔCAR	ΔCAR	ΔCAR	ΔCAR	ΔCAR	ΔCAR	
Panel A: Abnormally hot temperature and CO2							
	(1a)	(2a)	(3a)	(4a)	(5a)	(6a)	(7a)
RegGap	0.428***	0.397***	0.419***	0.425***	0.411***	0.392***	0.435***
	(0.011)	(0.009)	(0.007)	(0.008)	(0.007)	(0.018)	(0.007)
RegGap#**AbTemp**$_{t-1}$	0.028***	0.046***	0.052***	0.049***	0.041***	0.040***	0.030***
	(0.011)	(0.008)	(0.008)	(0.010)	(0.007)	(0.013)	(0.008)
RegGap#**LogCO2**$_{t-1}$	0.024**	0.009	0.020***	0.022***	0.019***	-0.012	0.027***
	(0.009)	(0.008)	(0.006)	(0.006)	(0.006)	(0.018)	(0.006)
Observations	10,277	24,622	25,010	14,887	31,175	32,506	30,140
Number of Banks	3,806	4,397	3,637	2,158	3,410	4,606	4,606
Adjusted R-squared	0.349	0.329	0.355	0.369	0.349	0.330	0.362
Clustered SE	Bank	Bank	Bank	Bank	Bank	Bank	Bank
Panel B: Aggregated climate risk-index							
	(1b)	(2b)	(3b)	(4b)	(5b)	(6a)	(7b)
RegGap	0.425***	0.394***	0.414***	0.419***	0.408***	0.428***	0.433***
	(0.011)	(0.008)	(0.007)	(0.008)	(0.007)	(0.014)	(0.007)
RegGap#**CR-index**$_{t-1}$	0.032***	0.033***	0.044***	0.046***	0.038***	0.038***	0.039***
	(0.011)	(0.008)	(0.007)	(0.008)	(0.006)	(0.013)	(0.007)
Observations	10,277	24,622	25,010	14,887	31,175	32,506	30,140
Number of Banks	3,806	4,387	3,637	2,158	3,410	4,606	4,606
Adjusted R-squared	0.349	0.328	0.354	0.369	0.349	0.329	0.362
Clustered SE	Bank	Bank	Bank	Bank	Bank	Bank	Bank

Baseline results

- Exposure to climate risk is directly associated roles with the dynamics of bank capital.
  - Findings suggest that banks are sensitive to adjusting their capital faster: ***19% faster***, when they are highly exposed to both climate-related hazards.

- Results are consistent with the view that:
  - banks with the rising awareness about climate concerns are more likely to take proactive actions (*Nguyen and Phan, 2020*),
  - and also with *Reghezza et al. (2021)*, who argue that climate risk interacts with the organizational decisions and policies of banks, notably capital decisions.

Effects of Climate Risk on SoA: *heterogeneity*

pre- and post- COP21 & for banks under regulatory pressures

Table 4A: Relationship between SoA and climate risk: effect of COP21 and regulatory pressures

	Pre- vs. Post- the Paris Agreement (COP21)			Regulatory pressures		
	(1) ΔCAR	(2) ΔCAR	(3) ΔCAR	(4) ΔCAR	(5) ΔCAR	(6) ΔCAR
RegGap	0.343***	0.355***	0.341***	0.423***	0.422***	0.418***
	(0.010)	(0.013)	(0.012)	(0.007)	(0.007)	(0.007)
RegGap#**Post2015**	**0.100*** **	**0.078*** **	**0.089*** **			
	(0.012)	(0.014)	(0.013)			
RegGap#$AbTemp_{t-1}$		0.023**			0.041***	
		(0.011)			(0.007)	
RegGap#$LogCO2_{t-1}$		-0.010			0.020***	
		(0.011)			(0.006)	
RegGap#CR-$index_{t-1}$			-0.003			0.042***
			(0.012)			(0.006)
RegGap#$AbTemp_{t-1}$#**Post2015**		**-0.004**				
		(0.016)				
RegGap#$LogCO2_{t-1}$#**Post2015**		**0.031*** **				
		(0.012)				
RegGap#CR-$index_{t-1}$#**Post2015**			**0.033** **			
			(0.014)			
RegGap#**RegPressure**				**-0.222*** **	**-0.264*** **	**-0.239*** **
				(0.035)	(0.033)	(0.031)
RegGap#$AbTemp_{t-1}$#**RegPressure**					**-0.056**	
					(0.058)	
RegGap#$LogCO2_{t-1}$#**RegPressure**					**0.050** **	
					(0.024)	
RegGap#CR-$index_{t-1}$# **RegPressure**						**0.005**
						(0.041)
Observations	32,506	32,506	32,506	32,506	32,506	32,506
Adjusted R-squared	0.350	0.351	0.351	0.350	0.354	0.354
Clustered SE	Bank	Bank	Bank	Bank	Bank	Bank

Table 4B: implied adjustment speeds

Panel A: AbTemp

	AbTemp=-1	AbTemp=0	AbTemp=1
Pre2015	0.332	0.355	0.378
Post2015	0.414	0.433	0.452
WellCapitalized	0.381	0.422	0.463
RegPressure	0.173	0.158	0.143

Panel B: LogCO2

	LogCO2=-1	LogCO2=0	LogCO2: 1
Pre2015	0.365	0.355	0.345
Post2015	0.412	0.433	0.454
WellCapitalized	0.402	0.422	0.422
RegPressure	0.088	0.158	0.228

Panel C: CR-index

	CR-index=-1	CR-index=0	CR-index=1
Pre2015	0.344	0.341	0.338
Post2015	0.400	0.430	0.460
WellCapitalized	0.376	0.418	0.460
RegPressure	0.132	0.179	0.226

More results: *source of heterogeneity*

- Findings indicate that banks (highly exposed to climate risk) adjust faster during the **post-Paris Agreement** (COP21), with the rising awareness about the climate-related hazards.

- Banks holding small regulatory capital buffers (under **regulatory pressure**) boost their adjustment when they exposed to carbon pollution.

Balance Sheet Adjustment Mechanisms

How do deviations from the target *&* exposure to climate risk
affect a bank's asset and liability composition?

- We investigate *growth rates* (ΔBS) in *assets* classes and types of *equity*, according to the sign of the $\boldsymbol{Reg}\mathbf{Gap}_{\boldsymbol{ij,t-1}}$ (*controlling for potential asymmetric reactions*).

  1. Growth in: *Tier1 Capital.*
  2. Growth in: *Total Assets, Loans & RWA.*

$$\Delta Mechanism_{ij.t} = \lambda_0 + \beta_0 \text{CR–index}_{ij,t-1} + (\lambda_1 + \beta_1 \boldsymbol{CR\text{–}index_{ij,t-1}})\boldsymbol{RegGap^{+}_{ij,t-1}} \\ +(\lambda_2 + \beta_2 \boldsymbol{CR\text{–}index_{ij,t-1}})\boldsymbol{RegGap^{-}_{ij,t-1}} + \delta V_{\text{ij,t}-1} + \text{u}_\text{i} + \text{v}_\text{t} + \varepsilon_{i,t}$$

Balance Sheet Adjustment Mechanisms: *main results*

Climate risk and capital adequacy ratio adjustment

	(1) ΔTier1	(2) ΔLoans	(3) ΔAssets	(4) ΔRWA	(5) ΔTier1	(6) ΔLoans	(7) ΔAssets	(8) ΔRWA
$RegGap^{+}_{ij,t-1}$	0.875***	0.235	-0.278**	-0.307*	0.600***	0.337*	-0.160**	-0.423*
	(0.220)	(0.295)	(0.211)	(0.303)	(0.227)	(0.301)	(0.215)	(0.299)
$RegGap^{-}_{ij,t-1}$	0.676***	-0.830***	-0.426**	-0.105*	0.887***	-0.628**	-0.291**	0.098*
	(0.209)	(0.272)	(0.206)	(0.240)	(0.209)	(0.272)	(0.206)	(0.243)
$RegGap^{+}_{ij,t-1}$**#CR-index**$_{t-1}$	-0.050	-0.047	-0.002	-0.166***	-0.013	-0.042	-0.006	-0.140***
	(0.032)	(0.045)	(0.033)	(0.046)	(0.032)	(0.046)	(0.033)	(0.045)
$RegGap^{-}_{ij,t-1}$**#CR-index**$_{t-1}$	-0.073**	0.031	0.011	-0.267***	-0.093***	0.004	-0.011	-0.302***
	(0.032)	(0.044)	(0.031)	(0.039)	(0.032)	(0.044)	(0.031)	(0.039)
CR-index$_{t-1}$	-0.140**	-0.044*	0.176**	-0.060**	-1.132***	-1.077***	-1.074***	-1.411***
	(0.076)	(0.092)	(0.079)	(0.093)	(0.118)	(0.144)	(0.110)	(0.134)
LLProvisions$_{t-1}$					-11.051	-19.182	-16.307**	-4.217
					(8.349)	(12.575)	(8.103)	(9.698)
Deposit$_{t-1}$					15.653***	7.256**	9.201***	18.637***
					(2.382)	(3.191)	(2.726)	(2.975)
ΔGDP$_{t-1}$					-0.268***	-0.003	-0.386***	-0.326***
					(0.093)	(0.109)	(0.083)	(0.101)
Credit-to-GDP$_{t-1}$					0.011	-0.106***	-0.079***	-0.027
					(0.014)	(0.018)	(0.013)	(0.017)
InterTrade$_{t-1}$					0.217***	0.173***	0.222***	0.147***
					(0.028)	(0.039)	(0.029)	(0.037)
OilRent$_{t-1}$					-2.512***	-1.948***	-1.863***	-0.891***
					(0.149)	(0.230)	(0.163)	(0.200)
Constant	5.126***	3.675***	3.210***	3.205***	-15.541***	4.791	-2.345	-9.376**
	(0.499)	(0.594)	(0.439)	(0.587)	(3.283)	(4.238)	(3.372)	(4.418)
Observations	28,881	32,489	32,506	30,142	28,252	31,819	31,823	29,511
Number of Banks	4,365	4,603	4,606	4,432	4,274	4,512	4,512	4,341
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.090	0.056	0.087	0.112	0.192	0.161	0.175	0.171

Balance Sheet Adjustment Mechanisms

Climate risk and capital adequacy ratio adjustment: effect of the COP21

	Pre-COP21				Post-COP21			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	ΔTier1	ΔLoans	ΔAssets	ΔRWA	ΔTier1	ΔLoans	ΔAssets	ΔRWA
$RegGap^{+}_{ij,t-1}$	2.883***	1.088*	0.239	-0.489	0.388	0.111	-0.679**	-0.631
	(0.461)	(0.643)	(0.361)	(0.707)	(0.359)	(0.440)	(0.304)	(0.434)
$RegGap^{-}_{ij,t-1}$	-0.765	-0.279	0.232	-1.084**	1.411***	-0.983**	-0.347	0.100
	(0.495)	(0.485)	(0.397)	(0.470)	(0.284)	(0.384)	(0.279)	(0.317)
$RegGap^{+}_{ij,t-1}$#**CR-index$_{t-1}$**	**-0.237*** **	**-0.182***	-0.088	-0.173	0.019	0.000	0.070	**-0.184***
	(0.088)	(0.111)	(0.066)	(0.118)	(0.048)	(0.064)	(0.044)	(0.062)
$RegGap^{-}_{ij,t-1}$#**CR-index$_{t-1}$**	**0.325*** **	-0.068	**-0.145***	-0.124	**-0.164*** **	0.050	-0.003	**-0.340*** **
	(0.111)	(0.091)	(0.078)	(0.082)	(0.040)	(0.056)	(0.039)	(0.046)
CR-index$_{t-1}$	-1.431***	-1.682***	-1.452***	-1.475***	-0.617***	-0.847***	-1.094***	-1.461***
	(0.330)	(0.316)	(0.225)	(0.324)	(0.131)	(0.179)	(0.129)	(0.159)
LLProvisions$_{t-1}$	-9.825	-59.461**	-37.678**	-38.889	-10.761	-8.708	-8.028	-0.096
	(32.329)	(24.856)	(19.008)	(28.011)	(8.699)	(13.890)	(8.367)	(10.894)
Deposit$_{t-1}$	0.752	10.275	20.664***	8.904	16.595***	-2.587	2.351	18.621***
	(6.069)	(7.090)	(4.971)	(6.220)	(3.153)	(4.964)	(4.129)	(4.129)
ΔGDP$_{t-1}$	0.763***	0.874***	0.554***	0.608***	-0.443***	-0.497***	-0.665***	-0.650***
	(0.196)	(0.175)	(0.112)	(0.157)	(0.133)	(0.156)	(0.125)	(0.152)
Credit-to-GDP$_{t-1}$	0.097**	-0.127***	-0.026	-0.041	0.098***	-0.056**	-0.053**	0.018
	(0.039)	(0.027)	(0.020)	(0.033)	(0.020)	(0.025)	(0.021)	(0.022)
InterTrade$_{t-1}$	0.421***	0.377***	0.256***	0.194***	0.293***	0.260***	0.314***	0.293***
	(0.071)	(0.070)	(0.045)	(0.063)	(0.044)	(0.062)	(0.043)	(0.050)
OilRent$_{t-1}$	-1.257*	-1.617**	-0.357	-1.308**	-2.090***	-1.890***	-1.969***	-0.702***
	(0.677)	(0.718)	(0.579)	(0.600)	(0.163)	(0.276)	(0.186)	(0.234)
Constant	-39.026***	-19.442**	-24.680***	-10.719	-33.916***	-2.312	-6.806	-25.080***
	(8.420)	(8.030)	(5.327)	(7.597)	(4.817)	(6.713)	(5.020)	(5.949)
Observations	7,022	8,791	8,792	7,642	21,230	23,028	23,031	21,869
Number of Banks	4,274	4,512	4,512	4,341	4,274	4,512	4,512	4,341
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.118	0.124	0.124	0.163	0.098	0.050	0.065	0.191

Climate Risk & Adjustment Channels

- **Overcapitalization** banks exposed to climate hazards adjust via **expanding RWA** (*substituting safer assets for risker ones*), but not their assets and lending.

- However, **undercapitalized**banks exposed to climate risk exhibit a lower responsiveness in adjustment mechanisms and favor the adjustments via a strong **decrease of the RWA** (*swapping risker assets for safer ones*) to boost the adequacy capital ratio.

- Overall, external recapitalization is limited, banks exposed to climate concerns (*especially after the Paris Agreement*) rely on reshuffling their risk-weighted assets as well as reallocating their assets to reach a different level.

Robustness checks

- **Alternative regression specifications** for the baseline model:
  (i) *OLS regression*, to investigate how much of complexity is explained by bank FE (*Laeven et al., 2015*),
  (ii) *WLS method*, to correct for country representation (*Baum 2006*),
  (iii) *GMM approach*, to address the *possible* endogeneity issues (*Correa and Goldberg, 2020*),
  (iv) *3-years interval averaged data*, to correct standard-errors (*Moulton, 1990*).

- **Alternative measures of**: complexity (*business proxy*), systemic risk (*probability-of-default and tail-beta*), and control for microprudential regulations (*capital stringency and supervisory power*).

- **Alternative sample selection criteria** to correct for sample selection bias:
  (i) *Small* vs. *Large* banks,
  (ii) *Listed* banks,
  (iii) The most *Under*- and *Over*-capitalized banks,
  (iv) *Pre* vs. *Post* COP21 subperiods,
  (v) Excluding the *top five* carbon-based economies.

- **Alternative definitions of the exogenous shocks**:
  - Excluding the Covid-19 crisis period.

⇒ *Results remain robust under all these tests.*

Robustness Checks: Non-linearities in the speed of adjustment: asymmetric response to climate risk

	(1) ΔCAR	(2) ΔCAR	(3) ΔCAR
$RegGap^{+}_{ij,t-1}$	0.414***	0.252***	0.299***
	(0.008)	(0.051)	(0.024)
$RegGap^{-}_{ij,t-1}$	0.411***	0.209***	0.300***
	(0.009)	(0.064)	(0.023)
$RegGap^{+}_{ij,t-1}$#**AbTemp**$_{t-1}$		**0.095*****	
		(0.019)	
$RegGap^{-}_{ij,t-1}$#**AbTemp**$_{t-1}$		**0.074*****	
		(0.024)	
$RegGap^{+}_{ij,t-1}$#**LogCO2**$_{t-1}$		**0.010****	
		(0.004)	
$RegGap^{-}_{ij,t-1}$#**LogCO2**$_{t-1}$		**0.014*****	
		(0.005)	
$RegGap^{+}_{ij,t-1}$#**CR-index**$_{t-1}$			**0.018*****
			(0.004)
$RegGap^{-}_{ij,t-1}$#**CR-index**$_{t-1}$			**0.018*****
			(0.004)
Observations	32,506	32,506	32,506
Adjusted R-squared	0.331	0.334	0.334

Robustness Checks: additional evidence on the non-linearities in the speed of adjustment:

	Small banks: Assets<$10millions	Large banks: Assets≥$10millions	Listed banks	The most under- and overcapitalised banks	Pre COP21	Post COP1	Covid-19 crisis excluded	Excluding top 5 carbon-based economies
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	ΔCAR	ΔCAR	ΔCAR	ΔCAR	ΔCAR	ΔCAR	ΔCAR	ΔCAR
$RegGap^{+}_{ij,t-1}$	0.423***	0.353***	0.487***	0.405***	0.313***	0.449***	0.411***	0.417***
	(0.009)	(0.016)	(0.017)	(0.008)	(0.016)	(0.010)	(0.008)	(0.013)
$RegGap^{-}_{ij,t-1}$	0.415***	0.324***	0.458***	0.408***	0.379***	0.412***	0.414***	0.393***
	(0.009)	(0.034)	(0.025)	(0.009)	(0.017)	(0.010)	(0.009)	(0.020)
$RegGap^{+}_{ij,t-1}$**#CR-index**$_{t-1}$	**0.030*****	**0.036****	**0.085*****	**0.042*****	**-0.015**	**0.017**	**0.043*****	**0.029****
	(0.010)	(0.017)	(0.017)	(0.009)	(0.015)	(0.012)	(0.009)	(0.013)
$RegGap^{-}_{ij,t-1}$**#CR-index**$_{t-1}$	**0.041*****	**-0.033**	**0.047***	**0.038*****	**0.008**	**0.041*****	**0.039*****	**0.002***
	(0.009)	(0.027)	(0.024)	(0.008)	(0.021)	(0.009)	(0.009)	(0.010)
Observations	25,220	7,284	5,016	12,983	19,167	13,339	30,125	15,643
Adjusted R-squared	0.352	0.243	0.375	0.413	0.297	0.349	0.289	0.298

Wrap Up

- Banks exposed to Climate Risk adjust **faster** to their **regulatory capital**, compared with the other peers.
  - *These banks might be more reluctant to change their capital base and* ***prefer sharper downsizing*** *or* ***faster expansion*** *of RWA to adjust.*
  - *This is more predominant during the post- Paris Agreement (COP21) period.*

- Under regulatory pressures banks exposed to greater Climate Risk (both Physical *&* Regulatory) adjust **faster** to their optimal capital structure,
  - *however*, stressed banks exposed either to Physical risk *or* Regulatory risk are **slower** in adjusting to their target.

Conclusion

- *Findings argue that climate risk is an important factor in understanding the organizational decisions and policies of banks, notably capital decisions*

- *Our findings contribute to the discussion about the climate-related regulatory capital requirements → the BCE climate-related regulatory capital requirements.*

- ***Limitation**: our results only cover the main two types of climate change risks that global financial sector is facing, according to NGFS (2020), and thereby do not have have to be seen as that the other typologies of climate-change are useless in banking.*