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Does Climate Change Affect Bank Lending Behavior?

By *Caglayan Aslan, Erdem Bulut, Oguzhan Cepni, Muhammed Hasan Yilmaz*

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Does Climate Change Affect Bank Lending Behavior?

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Abstract

We examine how banks adjust credit supply in areas with higher exposure to climate risks by utilizing the province-level air pollution and loan growth data of a large emerging market, Turkey, following the Paris Agreement in 2015. Our results show that banks limit their credit extension to more polluted provinces in the post-agreement interval, implying that banks consider climate change-related risks and adjust their credit provisioning accordingly. Our baseline findings are intact against a myriad of robustness checks. We also find that the shift in the climate risk-credit provisioning nexus is asymmetric depending on the levels of air pollution.

JEL Codes: G21, G28, H23, Q53, Q54

Keywords: Air Pollution; Climate Change; Paris Agreement; Bank Loans; Financial Stability

1. Introduction and Related Literature

A growing body of research shows that climate change poses severe risks to the financial system (Nguyen et al., 2020; Javadi and Masum, 2021; Reghezza et al., 2021). Investors are increasingly viewing such risks as being already relevant and having a high potential to materialize (Ilhan et al., 2021a). As a result, accurate pricing of the risks posed by climate change becomes an increasingly critical component of financial stability. Policymakers acknowledge that climate change is a significant and immediate threat to society (Carney, 2015). The signing of the Paris Agreement (COP21) in December 2015 was a significant event since it committed countries responsible for 97% of global carbon emissions to taking action to limit warming to below 2°C. Consequently, the banking sector has become more aware of the need to protect the environment. More than thirty of the world's most prestigious banks have announced that they will no longer allocate funding to coal-related activities or coal power companies.[1]

Given banks' essential role in funding economic entities and analyzing the borrower riskiness in emerging markets, in this study, we investigate how the banking sector in Turkey considers climate risks in their credit allocation following the introduction of COP21. There exist two reasons for focusing on the Turkish banking sector. First, Turkey held off on ratifying the COP21, claiming that she should not be deemed a developed nation as a part of the agreement. Second, absent developed capital markets, the banking sector is the primary driver of the financial intermediation in Turkey.[2] This context entails the investigation of two conflicting hypotheses. First, not ratifying the COP21 by the Turkish government might encourage banks to lend more to polluted sectors while they are still legally able to do so.

[1] Accessed at https://apo.org.au/node/222196
[2] In the case of Turkey, banks are the main sources of external financing for economic agents, given that they are responsible for providing more than 95% of all outstanding loans to firms and households.

Second, due to persuasion, awareness and expectations channels, banks might still choose to price climate risks by cutting credit provisioning to polluting regions and industries following the global trends even if no ratification took place.

Our locational climate risk measure obtained via a confidential dataset is based on particulate matter (PM10), a term that refers to particles with diameters typically 10 micrometers or smaller. Put differently, PM10 is a proxy for air pollution and originates from emissions, atmospheric reactions, wildfires and landfills.[3,4] Climate risks that arise from air pollution might include (i) physical damages caused by catastrophic weather events, (ii) financial costs that are due to the new regulations that have been implemented, and (iii) financial loss incurred as a result of carbon-related litigation. Thus, we expect that firms located in high air pollution areas are more prone to climate risks, causing an increase in the level of uncertainty surrounding the company earnings and a decline in the firm value (Aretz and Bartram, 2010).

Our empirical approach is centered on using COP21 as a shock that increases bank awareness about firms' climate risks. We combine the province-level air pollution data and loan growth to investigate how banks change credit supply in provinces more exposed to air pollution since banks may update their perceptions of the climate risks associated with firms located in polluted areas following the COP21 shock. Our results show that banks limit their credit supply in more polluted provinces, implying that banks indeed consider risks related to climate change in the province and adjust their provisioning accordingly. A potential reason might be that the degree to which a company is affected by information asymmetry is amplified when there is prominent level of air pollution because banks may be unable to gauge the size of the additional costs appropriately. Hence, increased information asymmetry might lead banks

[3] Accessed at https://ww2.arb.ca.gov/resources/inhalable-particulate-matter-and-health

[4] In 2013, due to public pressure, China enacted the Clean Air Action, which necessitates cities to decrease PM10 levels by 10% compared to 2012 levels and mandates that the majority of cities construct monitoring systems for air pollutants and frequently report on the state of the air quality (Huang et al., 2021).

to cut credit supply in these areas. Our findings straddling different loan breakdowns' growth tendencies render further support to this presumption as the magnitude of the identified effect is stronger in commercial credits. Furthermore, we distinguish the loan allocation between bank ownership types: private and state-owned banks. Considering that private banks have a lower degree of government intervention and a stronger corporate governance structure, they might consider the climate risks when lending to polluted areas more. We find that the level of attention given to climate risks is not specific to private banks and is also followed by state banks.

Overall, our results are robust to a myriad of robustness checks, including modeling choices, data handling, endogeneity concerns, and internal validity analysis via placebo tests. In our subsequent estimations, we further utilize an empirical specification accommodating asymmetric effects which points out that the weakening of the association between climate risks and positive loan growth is found to be stronger among provinces with higher air pollution.

This study contributes to rapidly growing literature on climate change and the financial system. A sizable body of research shows that investors demand a premium to hold the shares of companies with extensive exposure to climate risk (Bolton and Kacperczyk, 2021; Ilhan et al., 2021b). Similarly, bonds issued by companies with high exposure to climate risk have lower expected returns in the future (Huynh and Xia, 2021). Fewer studies have examined how banks' understanding of climate risks affects their lending practices. Delis et al. (2019) analyze how well the climate risk is priced in syndicated loans after COP21 by using fossil fuel reserves data. Huang et al. (2019) find that loan default rates and financing costs rose for high-polluting firms after the Clear Air Action of 2013 in China. Some studies investigate how the loan prices react to the firm exposure to carbon risk via carbon emissions data (Kacperczyk and Peydró, 2021; Reghezza et al., 2021; Mueller and Sfrappini, 2022). Our study takes a more holistic approach by investigating how direct exposure to air pollution affects bank lending behavior after controlling the variables related to regional loan demand and bank characteristics.

The rest of the paper is organized as follows. Section 2 introduces empirical design and describes data sources. Section 3 presents empirical findings. Section 4 provides conclusive remarks.

2. Empirical Design and Data

To examine the relationship between climate risks and bank lending behavior, we utilize the following specification:

$$
\begin{aligned}
Loan\ Growth_{it} &= \beta_1 Post_t\ x\ Harmful\ Particles_{it} + \beta_2 Harmful\ Particles_{it} + \beta_3 Post_t \\
&\quad + \gamma X_{it} + \delta_i + \varepsilon_{it}
\end{aligned} \tag{1}
$$

where $Loan\ Growth$ is the annual logarithmic growth rate of total credits given in province i in year t. $Harmful\ Particles$ is the PM10. $Post$ is the dichotomous variable taking the value of one after the declaration of the COP21 in 2015, otherwise assuming the value of zero. The main coefficient β_1 is attached to the interaction term $Post\ x\ Harmful\ Particles$ measuring how the extent of association between province-level climate risks and banks' credit allocation activities shifts following the increasing awareness regarding environmental concerns via the announcement of COP21.

The vector of variables X_{it} controls for a variety of province-level banking industry-related and macroeconomic forces potentially driving the credit activities to remedy the omitted variable problem. Specifically, we account for the spatial asset quality of extended credits (NPL) (Mohaddes et al., 2017), spatial deposit funding ($Deposit\ Growth$) (Behr et al., 2017) and the presence of branching network ($Branching$) (Koetter et al., 2020). Furthermore, we construct control variables proxying macroeconomic outlook and economic development of provinces involving the growth of spatial value-added (GDP), the growth of spatial imports and exports volume ($Foreign\ Trade$) and the growth of total electricity consumption ($Electricity\ Consumption$).

To consider time-invariant province-level forces, we augment the empirical specification with province fixed effects (δ_i) and ε_{it} represents stochastic error term. We employ province-level clustered standard errors for the inference. Variable definitions and summary statistics are demonstrated in Table 1.

[**Insert Table 1 Here**]

In the first stage of sample composition, we collect the PM10 data for individual provinces at the NUTS-3 level from the Republic of Turkey Ministry of Environment, Urbanization and Climate Change. The following stage entails merging with the FinTurk database of Banking Regulation and Supervision Agency of Turkey (BRSA) via province names. This data source monitors the main aggregated banking outcomes such as credits, deposits, non-performing loans and branching activities at the NUTS-3 level. We maintain observations covering 78 provinces of Turkey (out of 81) after the merging process. Provincial macroeconomic controls are taken from the Turkish Statistical Institute (TurkStat) database. We designate sample interval to cover the period of 2010 to 2019. The beginning date of the sample is determined based on the availability of confidential PM10 data, whereas we also discard the recent episode to insulate empirical analysis from the disruptive effect of the Covid-19 pandemic on credit activities.

3. Empirical Results

In Table 2, we present the baseline empirical findings. Column (1) describes the plain specification, whilst columns (2) and (3) add provincial banking and macro controls, respectively. It is seen that climate risks proxied by $Harmful\ Particles$ are positively correlated with financial intermediation activities. However, the interaction term $Post\ x\ Harmful\ Particles$ carries a negative and significant coefficient validating that the aforementioned association has been weakened in the post-COP21 agreement period, potentially with the rising awareness about climate concerns. In other words, banks have become more hesitant in extending credits to localities causing prominent externalities to the environment. This finding is in line with the prior literature showing that climate risks increasingly interact with the organizational decisions and policies of banks (Nguyen et al., 2020; Javadi and Masum, 2021; Reghezza et al., 2021).

The direction of relationships regarding other controls is compatible with ex-ante predictions. Provincial credit risk is negatively correlated with credit activities, whereas stable deposit funding is positively related to credit activities. The boost in economic activity measured by the GDP growth rate and the trend in electricity consumption are also positively relevant to credit activities. We further analyze whether baseline findings are driven by the ownership type of banks. To this end, in columns (4) and (5), we restrict provincial banking aggregates for privately-owned and state-owned bank groups to repeat the estimations. In both cases, the interaction term $Post\ x\ Harmful\ Particles$ has still negative and significant coefficients implying that the attention to climate risks is not specific to private banks and is also embraced by state-owned banks.

[**Insert Table 2 Here**]

The potential underlying mechanism might be that firms in high pollution locations are more susceptible to carbon-related credit risk because they have less clarity about their future cash flows and capacity to repay the debt, leading to limited access to external financing via bank loans. To formally test this, we utilize the baseline specification and predict the growth in different loan breakdowns, separately (Table 3). Although the interaction coefficient is negative and significant in both consumer and commercial loans, the magnitude of the effect is slightly higher in the latter case rendering support to the argument that loan provisioning to firms could potentially facilitate the climate risk concerns.

[**Insert Table 3 Here**]

We perform a myriad of robustness analyses (Table 4). In rows (1) and (2), we follow alternative techniques for inference by using two-way (province-year) and region-level (26 regions at NUTS-2 level) clustering of standard errors. In row (3), we exclude provinces having average highest and lowest loan balances over the sample period.[5] In row (4), we use lagged values of covariates to remedy simultaneity issues. In row (5), we replace the dependent variable with winsorized version (at 1^{st} and 99^{th} percentiles) to account for the distorting effects of outliers. In row (6), we use the entropy balancing method to alleviate potential endogeneity concerns (Hainmueller, 2012).[6] In rows (7) and (8), we perform placebo estimations by distorting the adoption date of COP21 in the form of pseudo $Post$ variables taking the value of one after 2013 and after 2017, respectively. As expected, the interaction coefficients turn out to be insignificant suggesting the internal validity of our quasi-experimental design. In row (9),

[5] In this context, we discard eight provinces (three largest and five smallest) from our estimations. We also perform sensitivity analysis by excluding individual provinces one-by-one. We thank an anonymous reviewer for this suggestion.

[6] Initially, we decompose the sample observation into two groups depending on the median value of $Harmful\ Particles$. In the following step, we re-weight the sample to induce covariate balance by equating the mean, variance and skewness of covariates' empirical distribution across groups with high and low exposure to climate risks. Consequently, we estimate the equation (1) with entropy-balanced sample by utilizing the weights created in the prior step.

we replace the main dependent variable with the change in loan-to-deposit ratio. In row (10), we augment additional region-level controls including consumer inflation, unemployment rate and income inequality.

[**Insert Table 4 Here**]

In the last part of the empirical analysis, we investigate the asymmetric impact of climate risks on provincial credit provisioning. In Table 5, we utilize the fixed effects panel threshold regression method (Hansen, 1999) and estimate the regime-dependent model predicting loan growth for pre- and post-2015 incrementally, while the realized values of $Harmful\ Particles$ serve as threshold variable separating the regimes. We observe that the degree of association between climate externalities and loan outcomes is positive and significantly stronger in high pollution regime. On the other hand, this relationship is significantly reversed in the post-2015 period.

[**Insert Table 5 Here**]

4. Conclusion

In this paper, we aim to provide empirical evidence that climate risks affect the lending decision of an emerging country's banking sector. Although Turkey did not sign the COP21, our results show that it has a persuasion impact on the banking sector, leading banks to reduce the amount of lending to polluted areas, which highlights the update of beliefs about climate risks. Put differently, our results suggest that COP21 has the potential to influence banks' preferences for sustainable financing and raise awareness of the financial risks linked with climate change. Given that banks have an essential role in funding firms and in addition to the fact that banks are well-informed economic actors, we find that the banking sector in Turkey views climate risks as a relevant risk factor and incorporates it in their credit allocation decisions following the introduction of COP21.

Overall, financial institutions need to be aware of the possible risks concerning climate transition by including such risks in their risk management practices. Given that central banks and bank regulators are responsible for preserving financial stability, they should include monitoring of climate change-related financial risks into prudential supervision to protect the financial system's resilience. Our results reiterate the importance of this issue by demonstrating that the climate-related risks indeed interact with bank lending policies.

Since the climate risk is anticipated to affect all stages of the credit cycle, the banking sector should incorporate climate risk indicators into the credit risk management process to step towards both effective risk management and a carbon-neutral future. To further mitigate climate risk and decarbonize their credits, the banking sector should speed up product innovation and offer more green-lending options to compensate for the emissions they fund. Furthermore, for future research, it would be interesting to separate climate risks into physical and transition risk parts using a more detailed measure of climate risks, which might allow distinguishing whether banking sector lending behavior changes according to the different types of climate risk exposure.

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Table 1: Variable Definitions and Summary Statistics

Panel A: Variable Definitions

Variables	Definitions	Data Sources
$Loan\ Growth_{it}$	The growth rate of total loans extended in province i at year t	BRSA FinTurk
$Harmful\ Particles_{it}$	Particulate matter (PM10) which is a term that refers to particles with diameters that are typically 10 micrometers or smaller (/100)	Republic of Turkey Ministry of Environment, Urbanization and Climate Change
$Post_t$	A binary variable taking the value of one aftermath the COP21 in 2015, otherwise assuming the value of zero	Authors' Calculations
NPL_{it}	The ratio of non-performing loans to total loans in province i at year t (*100)	BRSA FinTurk
$Deposit\ Growth_{it}$	The growth rate of total deposits maintained in province i at year t	BRSA FinTurk
$Branching_{it}$	The growth rate of number of operational bank branches in province i at year t	BRSA FinTurk
GDP_{it}	The growth rate of gross domestic product in province i at year t	TurkStat
$Foreign\ Trade_{it}$	The growth rate of foreign trade volume (exports and imports) in province i at year t	TurkStat
$Electricity\ Consumption_{it}$	The growth rate of total electricity consumption (megawatt hour) in province i at year t	TurkStat

Panel B: Summary Statistics

Variables	Obs.	Mean	Std. Dev.	Median	P5	P95
Loan Growth	702	0.1951	0.1048	0.1802	0.0548	0.4115
Harmful Particles	702	0.5727	0.2141	0.5468	0.2602	0.9468
NPL	702	3.5313	1.2721	3.2926	1.9594	5.8573
Deposit Growth	702	0.1603	0.0636	0.1609	0.0592	0.2633
Branching	702	0.0245	0.0438	0.0183	-0.0388	0.1042
GDP	702	0.0484	0.0467	0.0477	-0.0232	0.1231
Foreign Trade	700	0.0388	0.4897	0.0181	-0.4953	0.5856
Electricity Consumption	702	0.0495	0.0854	0.0433	-0.0804	0.1858

Notes: This table reports variable definitions, data sources and summary statistics of the sample. Our sample involves the annual observations of 78 provinces over the period 2010-2019.

Table 2: Baseline Results

	(1) Loan Growth	(2) Loan Growth	(3) Loan Growth	(4) Loan Growth	(5) Loan Growth
Post x Harmful Particles	-0.088***	-0.077***	-0.073***	-0.051*	-0.084**
	(0.024)	(0.025)	(0.024)	(0.027)	(0.034)
Harmful Particles	0.143***	0.112***	0.092**	0.083*	0.104**
	(0.045)	(0.041)	(0.039)	(0.049)	(0.044)
Post	-0.049***	-0.043**	-0.035*	-0.069***	0.010
	(0.016)	(0.018)	(0.018)	(0.018)	(0.022)
NPL		-0.035***	-0.030***	-0.027***	-0.034***
		(0.004)	(0.003)	(0.003)	(0.007)
Deposit Growth		0.385***	0.326***	0.189**	0.294***
		(0.062)	(0.067)	(0.076)	(0.068)
Branching		-0.082	-0.069	0.188	-0.164
		(0.117)	(0.0112)	(0.113)	(0.117)
GDP			0.536***	0.565***	0.515***
			(0.089)	(0.089)	(0.107)
Foreign Trade			0.010	0.011	0.009
			(0.007)	(0.007)	(0.008)
Electricity Consumption			0.069**	0.059	0.102**
			(0.034)	(0.040)	(0.042)
Obs.	702	702	700	700	700
Bank Type	All	All	All	Private	State
Banking Controls	No	Yes	Yes	Yes	Yes
Macro Controls	No	No	Yes	Yes	Yes
Province FE	Yes	Yes	Yes	Yes	Yes
Adj. R^2	0.256	0.368	0.428	0.593	0.196

Notes: This table presents the estimation results of the baseline model specified in Equation (1). The sample includes the observations of 78 provinces over the period 2010-2019. In all columns, the dependent variable is the annual logarithmic growth of province-level total loans. Column (1) is the parsimonious specification, while column (2) involves province-level banking controls (NPL, $Deposit\ Growth$, $Branching$). Column (3) further augments the specification with province-level macroeconomic controls (GDP, $Foreign\ Trade$, $Electricity\ Consumption$). Columns (4) and (5) repeat the saturated specification for province-level lending activities of private and state bank groups respectively. The main independent variable is $Post\ x\ Harmful\ Particles$ interaction term. In all columns, we control for province fixed effects. Detailed variable definitions are available in Table 1. Standard errors clustered at the province level are reported in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Table 3: Loan Breakdown

	(1) Consumer Loan Growth	(2) Commercial Loan Growth
Post x Harmful Particles	-0.049**	-0.095***
	(0.019)	(0.034)
Obs.	700	700
Banking Controls	Yes	Yes
Macro Controls	Yes	Yes
Province FE	Yes	Yes
Adj. R^2	0.472	0.363

Notes: This table presents the estimation results of the baseline model specified in Equation (1) for consumer and commercial loans, separately. The sample includes the observations of 78 provinces over the period 2010-2019. In both columns, the dependent variable is the annual logarithmic growth of province-level total loans. In both columns, we add province-level banking (NPL, $Deposit\ Growth$, $Branching$) and macroeconomic (GDP, $Foreign\ Trade$, $Electricity\ Consumption$) controls. The main independent variable is $Post\ x\ Harmful\ Particles$ interaction term. In both columns, we control for province fixed effects. Detailed variable definitions are available in Table 1. Standard errors clustered at the province level are reported in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Table 4: Robustness Checks

	(1) Coefficient (Post x Harmful Particles)	(2) S. E.	(3) Obs.
(1) Two-way S. E. clustering	-0.073**	(0.026)	700
(2) S. E. clustered at region level	-0.073***	(0.023)	700
(3) Excluding certain provinces	-0.072**	(0.027)	630
(4) Lagged control variables	-0.045*	(0.023)	544
(5) Data winsorization	-0.069***	(0.022)	700
(6) Entropy balancing	-0.080**	(0.036)	700
(7) Placebo estimation	-0.020	(0.028)	700
(8) Placebo estimation	-0.046	(0.034)	700
(9) Dependent variable: Δ(Loan-to-Deposit Ratio)	-0.120**	(0.045)	700
(10) Inclusion of other regional forces	-0.061**	(0.025)	700

Notes: This table presents the estimation results of robustness checks for the specification presented in column (3) of Table 2. Columns (1), (2) and (3) report the coefficient attached to interaction term $Post\ x\ Harmful\ Particles$, standard error and number of observations, respectively. In rows (1) and (2), we cluster standard errors at province-year and region levels. In row (3), we exclude the provinces maintaining largest (three provinces are dropped) and smallest loan balances (five provinces are dropped) in performing estimations. In row (4), we use lagged control variables to alleviate simultaneity issues. In row (5), we utilize winsorized version of dependent variable (at 1^{st} and 99^{th} percentiles) to negate potential effects of outliers. In row (6), we repeat the baseline estimations with entropy-balanced sample to remedy endogeneity issues. In rows (7) and (8), we perform placebo estimations assuming that the timing of COP21 coincides with years 2013 and 2017, respectively. Row (9) replaces the dependent variable with the change in loan-to-deposit ratio. In row (10), we control for additional regional factors including inflation, unemployment rate and Gini coefficient. In all rows, we control for province fixed effects. Detailed variable definitions are available in Table 1. Unless stated otherwise, standard errors clustered at the province level are reported in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

Table 5: Panel Threshold Regression Results

	(1) Loan Growth (Year < 2015)	(2) Loan Growth (Year ≥ 2015)
Harmful Particles (High Pollution Regime)	0.179***	-0.064**
	(0.060)	(0.027)
Harmful Particles (Low Pollution Regime)	0.019	0.036
	(0.073)	(0.025)
Obs.	310	390
Banking Controls	Yes	Yes
Macro Controls	Yes	Yes
Province FE	Yes	Yes
Overall R^2	0.259	0.320

Notes: This table presents the estimation results of the fixed effects panel threshold regression model. In column (1), observations belonging to pre-2015 period are retained to disentangle the sample into high and low pollution regime based on lagged values of $Harmful\ Particles$ in line with Hansen (1999) and Wang (2015). In column (2), we follow the same procedure for the observations belonging to post-2015 period. Both columns involve province-level banking controls (NPL, $Deposit\ Growth$, $Branching$) and macroeconomic controls (GDP, $Foreign\ Trade$, $Electricity\ Consumption$) as well as province fixed effects. Detailed variable definitions are available in Table 1. Robust standard errors are reported in parentheses. ***, **, and * denote statistical significance at 1%, 5%, and 10% levels, respectively.

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