

# IMPACT OF DISASTERS ON BANK LENDING TO MICRO-, SMALL-, AND MEDIUM ENTERPRISES - EVIDENCE FROM THE PHILIPPINES

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**ABSTRACT.** This paper examines the impact of disasters on MSME NPL rates and bank lending to micro, small, and medium enterprises (MSMEs) in the Philippines. Combining industry-level MSME bank lending data provided by the Bangko Sentral ng Pilipinas with country-level disaster data, the econometric analysis reveals that climate-related disasters affect bank types differently. Thrift Banks experience a greater decline in MSME NPL rates following emergency declarations than Rural and Cooperative Banks do. This may indicate that Thrift Banks benefit from a stronger mitigating effect of disaster relief policy responses than Rural and Cooperative Banks. The data also reveal that Universal and Commercial Banks do not significantly change their lending behaviour to MSMEs following disaster occurrences, which may be consistent with the large-bank barrier hypothesis. Furthermore, results show that Rural and Cooperative Banks significantly increase lending to MSMEs when GDP grows by 1%, whereas Thrift Banks and Universal and Commercial Banks decrease lending — suggesting counterintuitive and heterogeneous lending behaviour across bank types during periods of economic growth.

*Keywords.* Disasters, Bank Lending, MSMEs, Non-performing loans, Philippines, Financial resilience

*JEL Codes* G21, O11, G28, Q54, E58

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# 1 Introduction

Climate change and environmental degradation pose large macro-financial risks to the economy. Climate-related disasters not only eliminate people’s livelihoods and disrupt business operations, but also increase inequalities between and within countries (Hallegatte et al. 2014; Islam and Winkel 2017; Winsemius et al. 2015). Emerging markets and developing economies (EMDEs) are more often located in low-coastal areas that are prone to climate-related disasters than advanced economies are (Islam and Winkel 2017). Micro, small and medium enterprises (MSMEs) represent a vulnerable group that, especially in EMDEs, are often located in low-coastal rural areas with high disaster occurrence and more often experience financial exclusion, whereas larger firms are more often located in safer areas and have better access to finance (Islam and Winkel 2017; Berger and Udell 2002; Volz and Knaack 2023).

Firms exposed to disasters tend to require more finance than those with less exposure to build resilience and insure against disaster occurrences (Clò, David, and Segoni 2024; Kempa 2026). However, due to their low-margin and high-risk profile, MSMEs are more frequently confronted with financial exclusion than larger firms. It is widely documented that smaller firms face restricted access to finance due to information opacity and the perceived higher likelihood of default (Stiglitz and Weiss 1981; Berger and Udell 1998; Berger and Udell 2002).

In addition to these structural barriers, climate-related disasters may further exacerbate financial exclusion of MSMEs (Hallegatte et al. 2014; Volz and Knaack 2023; Clò, David, and Segoni 2024). This can result in a vicious cycle, in which vulnerable MSMEs receive insufficient finance to rebuild and insure themselves against climate-related disasters, potentially increasing their likelihood of financial distress and bankruptcy rates (Volz, Knaack, et al. 2020; Volz and Knaack 2023).

Since there is a lack of empirical evidence on the impact of disasters on bank lending to MSMEs, this paper uses data on MSMEs bank lending provided by Bangko Sentral ng Pilipinas (BSP) from 2014 to 2024 in combination with country-level disaster data provided by Dryden 2025 and macroeconomic variables from the International Monetary Fund (IMF), to empirically examine how disasters affect NPL rates and bank lending to MSMEs for the case of the Philippines. If disasters reduce bank lending to MSMEs and increase MSMEs’

NPL rates, this would indicate that climate-related disasters reinforce financial exclusion, thereby posing a challenge for achieving a just transition.

However, empirical results show a different dynamic. Thrift Banks (TBs) experience a decline in MSME NPL rates following emergency declarations and increasing number of people affected more so than Rural and Cooperative Banks (RCBs) do. This suggests that national and international policy responses after large disaster occurrences may support MSMEs in building financial resilience more so for TBs than for RCBs. Furthermore, larger banks, such as Universal and Commercial Banks (UKBs), do not exhibit any significant changes in lending behaviour to MSMEs nor in their MSME NPL rates after emergency declarations or increasing numbers of people affected by the disaster, which may potentially indicate stronger risk management of MSMEs and more diversified portfolios.

The empirical results show that emergency declarations of disasters, as well as the actual occurrence of a disaster measured in the number of total people affected, hit banks differently. The bank type, therefore, is a relevant factor contributing to how disasters affect lending and NPL rates of MSMEs.

Other results show that a 1% increase in GDP increases bank lending to MSMEs for RCBs, but decreases for TBs and UKBs. This is a counterintuitive result, as one might assume that GDP growth to increase lending to MSMEs across the whole financial system. That lending decreases for TBs and UKBs but increases for RCBs suggests that, again, the bank type plays a significant role in distributing much needed finance to MSMEs. Banks specifically made for financial inclusion of MSMEs, as RCBs are, will increase access to finance for MSMEs during economic booms whereas more commercially-oriented banks, such as TBs and UKBs, do the opposite.

Section 2 describes the data used. Section 3 sets out the hypotheses underlying the econometric analysis and explains the empirical model. Section 4 presents the econometric results, whilst robustness tests can be found in the Appendix. Section 5 concludes.

## 2 Data

By working with MSME level credit registry data provided by Bangko Sentral ng Pilipinas (BSP), merging it with disaster data collected by Dryden (2025) using the EM-DAT database, and adding macroeconomic variables obtained from the

International Monetary Fund (IMF), the impact of disasters on bank lending to MSMEs in the Philippines is being examined econometrically. First of all, a definition of MSMEs in the Philippine context is given.

Based on the Republic Act no. 9501, the Senate and House of Representatives of the Philippines in Congress have assembled the following definition for MSMEs:

| <b>Firm</b> | <b>Asset Size (inclusive of loans,<br/>exclusive of land)</b> | <b>Number of Employees</b> |
|-------------|---------------------------------------------------------------|----------------------------|
| Micro       | Up to Php 3,000,000                                           | Fewer than 10              |
| Small       | Php 3,000,001 – 15,000,000                                    | 10–99                      |
| Medium      | Php 15,000,001 – 100,000,000                                  | 100–199                    |

TABLE 1. Definition of MSMEs in the Philippines (Supreme Court 2008)

## 2.1 BSP data

The data set provided by the BSP illustrates the evolution of total bank lending in millions of Philippine pesos (Php) and non-performing loan (NPL) ratios between 2014Q1 to 2024Q4 for each MSME firm type in the Universal and Commercial Bank (UKB), Thrift Bank (TB), and Rural and Cooperative Bank (RCB) sector. UKBs and TBs have reported MSME-level bank lending data on a monthly basis, whereas RCBs have only done so on a quarterly basis. For this reason, the dataset has been adjusted to quarters.

UKBs are the largest institutions in the financial system of the Philippines and serve both households and corporations. Universal banks additionally exercise investment banking (Supreme Court 2001). Figure 1 shows that UKBs account for the largest volume of MSME lending, and that this lending is concentrated in medium enterprises, which receive a share far exceeding their weight in the MSME population.

TBs are consumer-focused institutions that are more likely to specialize in savings accounts. TBs include savings and mortgage banks, private development banks and stock savings and loan associations. They are set to encourage private enterprise, investment and savings among the public, while also providing capital and credit to Filipino entrepreneurs (Supreme Court 2001; Court 1995;

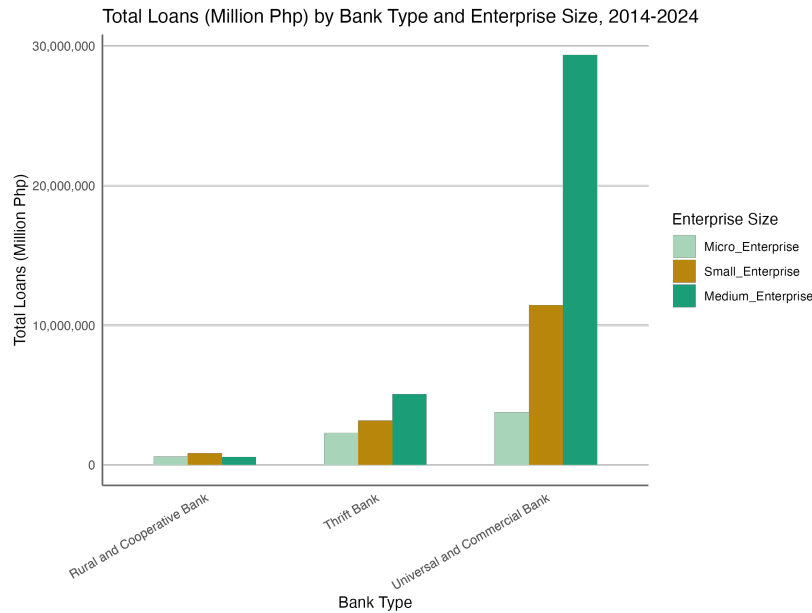


FIGURE 1. Total Loans (Million PHP) by Bank Type and Enterprise Size, 2014–2024

Earnest 2026). Although most loans are given to medium firms, a slightly more proportional share is distributed to small and micro firms as well (Figure 1).

RCBs support the basic financial needs of residents in rural areas, which ultimately are farmers and MSMEs. They are privately owned, but receive government support. Figure 1 shows that RCBs extend the smallest volume of MSME credit of the three groups, with small enterprises accounting for the largest portion. (Supreme Court 2001; Cana 2020)

Figure 2 shows the NPL rates from 2014Q1 to 2024Q4 by firm size and bank type, where NPL rates are defined as the ratio of non-performing loans to total outstanding loans. Two patterns stand out. First, rates differ systematically in level across bank types: for small enterprises, rates at RCBs and TBs exceed those at UKBs throughout the sample. Second, the bank types differ in their dynamics. UKBs record a steady decline in rates on loans to micro enterprises and broadly flat rates for medium enterprises, whereas TBs and RCBs show more movement: rates on loans to micro enterprises at TBs and RCBs remain roughly constant, rates for small enterprises at TBs rise over the period, and rates for medium enterprises at TBs follow a U-shaped path, declining until around 2018 before rising again. RCBs show similarly variable rates for medium enterprises.

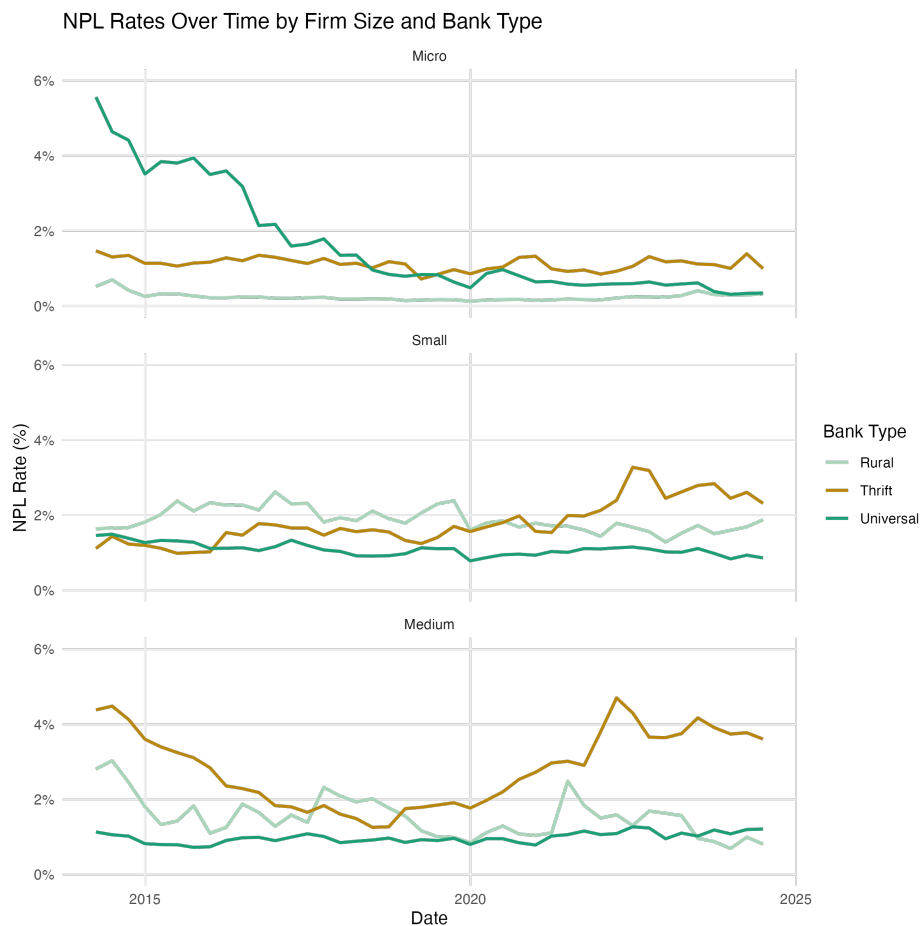


FIGURE 2. Non-Performing Loan Rates over time by Firm Size and Bank Type

## 2.2 Disaster data

The monthly, country-level disaster data of the Philippines was sourced from a dataset compiled by Dryden (2025) using the Emergency Events Database (EM-DAT). EM-DAT records an event as a disaster if at least one of the following criteria is met: 10 or more deaths, 100 or more people affected, the declaration of a state emergency or a call for international assistance (Delforge et al. 2025). The events recorded for the Philippines are predominantly hydrological and meteorological in origin — chiefly floods, tropical cyclones, and landslides — typically triggered by monsoonal rains, heavy rainfall, or low-pressure systems. Figure 3 shows that from 1990Q1 to 2024Q4, storms are by far the disaster type that causes the largest amount of people affected by it. Because the lending data are observed quarterly, the monthly disaster series is aggregated to quarterly frequency by rule.

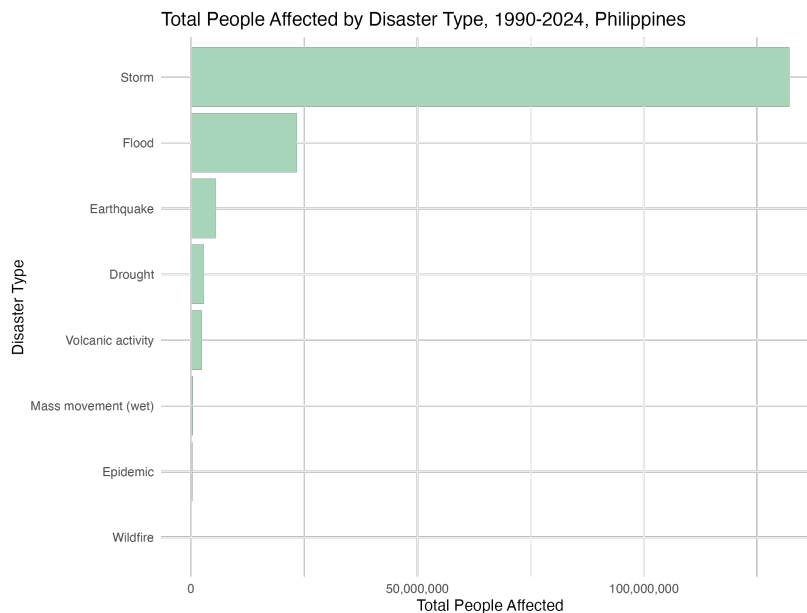


FIGURE 3. Total People Affected by Disaster Type, 1990–2024, Philippines

## 2.3 Macroeconomic data

Finally, several macro variables with a quarterly frequency have been sourced from different databases of the IMF. Gross Domestic Product (GDP), Import and Export data have been sourced from the national economic accounts dataset, and the inflation rate was calculated using the Consumer Price Index (CPI) dataset provided by the IMF. By aligning all macroeconomic datasets according to quarters, the final dataset enables the econometric examination of whether NPL rates of and total bank lending to MSMEs by UKBs, TBs, and RCBs are affected by disasters, controlling for several macroeconomic variables.

# 3 Methodology

## 3.1 Hypothesis

This paper empirically quantifies the impact of disasters on bank lending to MSMEs in the Philippines. Beyond the typical barriers MSMEs face in accessing finance, the increasing frequency of severe weather events raises the question of whether disasters compound these constraints. Disasters damage firm assets and disrupt or terminate business operations (Clò, David, and Segoni 2024; Kempa

2026), and rebuilding or insuring against such events imposes costs that many MSMEs cannot bear (Islam and Winkel 2017; Volz and Knaack 2023).

If firms affected by disasters are less able to meet their financial obligations, banks will experience deteriorating loan performance. Because loans are typically classified as non-performing after 90 days past due, any such deterioration should appear with a lag of at least one quarter. This yields the first hypothesis:

**H1: NPL rates on MSME loans increase in the quarters following disaster occurrences.**

Loan performance and credit lending volumes capture related but distinct dynamics. If banks respond to elevated credit risk by tightening supply, total lending to MSMEs should contract. That lending decrease after disasters due to higher credit risks is not an universal dynamic, it could also be the other way around. For instance, reconstruction demand, government-directed credit, and the restructuring of existing exposures may all raise recorded lending after a disaster (Ilabaca, Mann, and Mulder 2026; Mamonov, Ongena, and Pestova 2024). Since empirical evidence have primarily suggested lending to decrease after disaster occurrences, this is the hypothesis that is built here as well (Ilabaca, Mann, and Mulder 2026).

**H2: Total bank lending to MSMEs decreases following disaster occurrences.**

Taken together, evidence in favour of H1 and H2 would suggest that disasters raise the cost and reduce the availability of credit for MSMEs, leaving them less able to invest in resilience or obtain insurance — a pattern that, if persistent, may contribute to broader economic and financial instability (Islam and Winkel 2017; Kling et al. 2021; Volz and Knaack 2023).

## 3.2 Econometric Specification

The empirical analysis is organised around a single constraint imposed by the data: disaster exposure is measured at the country level, so at any date it takes the same value for all bank types. A specification containing a full set of time fixed effects therefore cannot identify the level effect of a disaster, since the disaster measure is collinear with the time dummies. Two complementary strategies follow from this.

The main specification is a two-way fixed effects (TWFE) panel model in which the disaster measure enters only through interactions with bank type. Its coefficients identify how the response of TBs and UKBs differs from that of RCBs, while unobserved heterogeneity across bank types and common time-varying shocks are absorbed by the fixed effects. This is the cleanest available design, but it is silent on the sign of the effect for any individual bank type.

Level effects, which are what H1 and H2 concern, require specifications without time fixed effects. A pooled OLS model with the same interaction structure as the TWFE model is estimated as a complement. Additionally, two other level effects - an aggregate time-series regression, and separate regressions by bank type - are estimated that are testing the robustness of the results in Section A.

### 3.2.1 Two-Way Fixed Effects (TWFE) Panel Model with Bank-Type Interactions

The Two-Way Fixed Effects (TWFE) Panel Model with interaction effects reflects the main econometric specification of this paper. This specification allows disaster and macroeconomic effects to vary across bank types through interaction terms, while controlling for unobserved heterogeneity across both bank types and time using industry  $\alpha_i$  and time  $\lambda_t$  fixed effects. It exploits the full panel structure of the data:

$$\begin{aligned}
 Y_{i,t} = & \alpha_i + \lambda_t + \sum_{j=1}^J \beta_j (Disaster_{t-k} \times Industry_j) \\
 & + \sum_{m=1}^M \sum_{j=1}^J \delta_{mj} (Macro_{m,t-k} \times Industry_j) + \varepsilon_{i,t}
 \end{aligned} \tag{3.1}$$

where  $Y_{i,t}$  is either the NPL rate or  $\log(Lending)$  for bank type  $i$  in quarter  $t$ ,  $\alpha_i$  are bank-type fixed effects, and  $\lambda_t$  are quarter fixed effects. RCBs are the omitted baseline category, so  $j \in \{TB, UKB\}$ .

The uninteracted terms  $Disaster_{t-k}$  and  $Macro_{m,t-k}$  do not appear in the equation. Both vary only over time and are therefore absorbed by  $\lambda_t$ ; including them would be redundant. The coefficients  $\beta_j$  consequently measure the response of bank type  $j$  relative to RCBs, not the absolute response of bank type  $j$ . A

negative  $\beta_{TB}$  in an NPL regression indicates that TB loan performance deteriorates less, or improves more, than that of RCBs following a disaster; it does not imply that TB NPL rates fall.

$\alpha_i$  captures industry fixed effects. Industry fixed effects can be understood as variations in bank size, level of lending, credit risk across bank types that are unobserved in the data but need to be accounted for.  $\alpha_i$  allows each bank type to have its own baseline and controls for that, which removes bias from omitted structural differences between bank types.

$\lambda_t$  captures time fixed effects. Time fixed effects  $\lambda_t$  control for all shocks that affect all banking industries simultaneously at a given point in time. For instance, macroeconomic cycles, national policy changes, monetary policy shifts, or countrywide disaster exposure trends that reflect a common shock affecting all banking institutions need to be removed from the data to avoid biases, using time fixed effects.

$Disaster_{t-k}$  represents the disaster shock variable, which is measured either by an emergency declaration indicator *Emergency* or the logarithm of the number of affected individuals  $\log(TotalAffected)$ , with lag structure  $k \in \{1, 2\}$ , for quarters.

The variable *Emergency* is constructed as an ordinal measure capturing the intensity of institutional responses to a disaster. It aggregates three binary indicators derived from the EM-DAT database: (i) whether the Office of US Foreign Disaster Assistance (OFDA) responded to the disaster, (ii) whether the affected country issued an international appeal for assistance, and (iii) whether a state of emergency was officially declared. (Delforge et al. 2025)

The variable takes values from 0 to 3. A value of 0 indicates that none of the three responses occurred, while values of 1, 2, and 3 indicate that one, two, or all three responses were triggered, respectively. As such, *Emergency* reflects the intensity of the policy and institutional response following a disaster. While this measure is interpreted as a proxy for disaster severity, it more precisely captures the extent to which a disaster prompted formal intervention and international support, which may also depend on country-specific institutional and political factors. (Dryden 2025)

$\log(TotalAffected)$  represents the total number of people affected by the disaster in logs. It sums up the number of people injured, number of people affected,

and the number of homeless people combined (Delforge et al. 2025). The difference between  $\log(TotalAffected)$  and  $Emergency$  is that  $\log(TotalAffected)$  reflects the known magnitude of a disaster after its occurrence, whereas  $Emergency$  signals the risk of a disaster after its occurrence, when information on its magnitude has not yet been determined. This variable also serves as a proxy to model disaster occurrences in the country.

$Industry_j$  is a categorical variable capturing the type of banking institution serving MSMEs, distinguishing between RCBs, TBs and UKBs, with RCBs representing the omitted baseline industry. This variable reflects structural differences across bank types in terms of scale, risk management capacity, portfolio diversification, and location. By interacting  $Industry_j$  with disaster variables, the model allows the impact of disasters on NPL rates and total bank lending to vary across bank types.

$Macro_{m,t-k}$  is a vector of lagged macroeconomic controls including  $\log(GDP)$ ,  $\log(Imports)$ ,  $\log(Exports)$ , and the inflation rate.  $\varepsilon_{i,t}$  is the error term.

### 3.2.2 Pooled OLS with Interaction Effects

The pooled OLS specification retains the interaction structure but omits the fixed effects, which allows the level effect of disasters on the baseline bank type to be estimated:

$$\begin{aligned}
 Y_{i,t} = & \alpha + \beta_0 Disaster_{t-k} + \sum_{j=1}^J \beta_j (Disaster_{t-k} \times Industry_j) \\
 & + \sum_{m=1}^M \gamma_m Macro_{m,t-k} + \sum_{m=1}^M \sum_{j=1}^J \delta_{mj} (Macro_{m,t-k} \times Industry_j) + \varepsilon_{i,t}
 \end{aligned} \tag{3.2}$$

Here  $\beta_0$  is the effect for RCBs and  $\beta_0 + \beta_j$  the effect for bank type  $j$ . This specification therefore tests H1 and H2 directly, at the cost of leaving unobserved heterogeneity and common time shocks uncontrolled. Comparing  $\beta_j$  across equations (3.1) and (3.2) also indicates how far the fixed effects alter the estimated heterogeneity.

### 3.3 Robustness Tests

To account for the robustness of the TWFE and pooled OLS models, other more general OLS specification, such as an aggregate OLS model as well as disaggregated per bank type are being run. Additionally, a robustness test for collinearity is run as well. The results of these tests are found in the Appendix section [A](#). In the following the OLS specifications are explained here.

#### 3.3.1 Aggregate OLS Specification

This regression equation tests the average effect of disasters on bank lending to and NPL rates of MSMEs across the entire banking system in the Philippines.

$$Y_t = \alpha + \beta_1 Disaster_{t-k} + \sum_{m=1}^M \gamma_m Macro_{m,t-k} + \varepsilon_t \quad (3.3)$$

#### 3.3.2 Bank-Type Time-Series Specifications

To examine heterogeneous effects across bank types, the baseline OLS specification is estimated separately for each bank type  $i \in \{RCB, TB, UKB\}$ :

$$Y_t^{(i)} = \alpha^{(i)} + \beta_1^{(i)} Disaster_{t-k} + \sum_{m=1}^M \gamma_m^{(i)} Macro_{m,t-k} + \varepsilon_t^{(i)} \quad (3.4)$$

This approach allows all coefficients to vary across bank types. It captures cross-sectional heterogeneity by estimating separate regressions for each bank type.

#### 3.3.3 Multicollinearity

A standard robustness test is run to test for multicollinearity between the macroeconomic variables through looking at the Variance Inflation Factors (VIF) that can be found in the Annex [A](#).

### 3.4 Data Overview

Table [2](#) below displays the summary statistics of the data variables used in the econometric analysis. NPL rates range from 0.86% to 3.25%. Bank lending range from  $e^{10.44} \approx 34,169$  to  $e^{14.09} \approx 1,313,000$  million Php. *Emergency* does not

exceed 2, and *TotalAffected* ranges from 202 to roughly 11.8 million people (5.31 to 16.28 in logs).

TABLE 2. Summary Statistics of First-Lag Variables under Observation

| Variable          | Min     | 1st Qu. | Median | Mean   | 3rd Qu. | Max    | NA's |
|-------------------|---------|---------|--------|--------|---------|--------|------|
| NPL_rate          | 0.8594  | 1.0605  | 1.3301 | 1.5008 | 1.7166  | 3.2462 | 0    |
| log_lending       | 10.44   | 10.95   | 12.45  | 12.35  | 13.78   | 14.09  | 0    |
| Emergency         | 0       | 0       | 0      | 0.521  | 1       | 2      | 9    |
| log_TotalAffected | 5.308   | 11.272  | 13.995 | 13.069 | 14.900  | 16.282 | 9    |
| log_GDP           | 28.87   | 29.03   | 29.14  | 29.12  | 29.22   | 29.34  | 3    |
| log_Import        | 27.63   | 27.97   | 28.19  | 28.12  | 28.31   | 28.37  | 3    |
| log_Export        | 27.47   | 27.67   | 27.88  | 27.83  | 27.96   | 28.03  | 3    |
| infla_rate        | -0.2944 | 0.2180  | 0.8244 | 0.8413 | 1.2606  | 2.1330 | 3    |

Notes: NA's indicate missing observations for each variable.

Before running regressions, it is crucial to check the general multicollinearity between the variables under observation. Table 3 below shows the correlation matrix of the relevant lag 1 variables used in the econometric model. High correlations among GDP, imports, and exports can be observed. However, these reflect common macroeconomic dynamics. The robustness testing for collinearity in section A will address these problems more precisely by running resuced-specification robustness checks. But for the general TWFE and OLS specifications, all the macroeconomic variables mentioned will be included in the models.

Table 3 displays the correlation between all the variables under observation, without differing across industries. Hence, correlations reflect only the variation over time. It becomes evident that emergencies are negatively correlated with NPL rates, but positively correlated with log lending. Furhtermore, emergencies are negatively correlated with GDP and exports, but positively correlated with imports and inflation.

Total Affected is positively correlated with NPL rates and log lending. Additionally, Total Affected is also positively correlated with GDP, imports, exports and inflation rates. Emergency and Total Affected show a positive correlation of 0.517, which indicates a moderate, positive relationship, but no multicollinearity.

TABLE 3. Correlation Matrix (First-Lag Variables)

| Variable       | NPL    | log_Lending | Emergency | Total_Affected | GDP    | Imports | Exports | Inflation |
|----------------|--------|-------------|-----------|----------------|--------|---------|---------|-----------|
| NPL            | 1.000  | -0.192      | -0.062    | 0.020          | -0.056 | -0.118  | -0.111  | 0.065     |
| log_Lending    | -0.192 | 1.000       | 0.008     | 0.005          | 0.052  | 0.055   | 0.054   | 0.007     |
| Emergency      | -0.062 | 0.008       | 1.000     | 0.517          | -0.065 | 0.022   | -0.028  | 0.258     |
| Total_Affected | 0.020  | 0.005       | 0.517     | 1.000          | 0.187  | 0.181   | 0.126   | 0.419     |
| GDP            | -0.056 | 0.052       | -0.065    | 0.187          | 1.000  | 0.951   | 0.960   | 0.373     |
| Imports        | -0.118 | 0.055       | 0.022     | 0.181          | 0.951  | 1.000   | 0.980   | 0.408     |
| Exports        | -0.111 | 0.054       | -0.028    | 0.126          | 0.960  | 0.980   | 1.000   | 0.395     |
| Inflation      | 0.065  | 0.007       | 0.258     | 0.419          | 0.373  | 0.408   | 0.395   | 1.000     |

*Notes:* Pearson correlation coefficients computed for first-lag variables. NPL and lending refer to lagged values. Macroeconomic variables include GDP, imports, exports, and inflation in log or rate terms. High correlations among GDP, imports, and exports reflect common macroeconomic dynamics.

## 4 Results

The results are presented in two steps. First, the two-way fixed effects (TWFE) model is discussed. Because it includes both bank type and time fixed effects, its coefficients identify how disasters and macroeconomic variables affect bank lending to and NPL rates of MSMEs differently across bank types relative to the RCB baseline. Simultaneously, it is absorbing unobserved heterogeneity common to all banks within each quarter. This design cannot, however, display the level effect of disasters for all bank types, since country-level shocks are absorbed by the time effects. The pooled OLS model, discussed after the TWFE model, omits the time fixed effects and therefore estimates these level effects directly, including the RCB baseline. The two specifications are thus complementary: the TWFE isolates cross-bank heterogeneity, while the pooled OLS recovers the absolute responses that can be used to respond to H1 and H2.

### 4.1 Two-Way Fixed Effects (TWFE) Panel Model moderated by Bank Types

Since the econometric specification includes two different disaster variables, the following two subsections will describe the results for the models run for each of the two disaster variables.

#### 4.1.1 TWFE with Disaster Variable Emergency Declarations

The reported coefficients for TBs and UKBs capture differential effects relative to RCBs, the omitted baseline category. As such, they reflect heterogeneous responses across bank types rather than absolute effects.

Table 4 presents TWFE estimates of the impact of emergency declarations on MSME NPL rates and log lending. When an emergency is being declared, then MSMEs' NPL rates decrease by 0.295% more so for TBs than for RCBs at a 5% statistically significant level, for a lag of 2 in Model 1. This result proves to be potentially robust, as similar dynamics hold for Model 2, when macroeconomic control variables are introduced. An emergency declaration decreases MSME NPL rates by 0.182% more so for TBs than for RCBs at a statistically significant level of 10% and a lag of 2 in Model 2.

TABLE 4. Fixed Effects: Impact of disaster emergency declarations on NPL rates and log lending of MSMEs

|                                          | NPL rates         |                    |                      |                      | Lending (log)    |                  |                      |                      |
|------------------------------------------|-------------------|--------------------|----------------------|----------------------|------------------|------------------|----------------------|----------------------|
|                                          | Model 1           |                    | Model 2              |                      | Model 3          |                  | Model 4              |                      |
|                                          | Lag 1             | Lag 2              | Lag 1                | Lag 2                | Lag 1            | Lag 2            | Lag 1                | Lag 2                |
| <i>Emergency Exposure × Industry</i>     |                   |                    |                      |                      |                  |                  |                      |                      |
| Thrift Bank                              | -0.161<br>(0.128) | -0.295*<br>(0.129) | -0.053<br>(0.086)    | -0.182<br>(0.091)    | 0.071<br>(0.063) | 0.087<br>(0.064) | 0.010<br>(0.031)     | 0.033<br>(0.032)     |
| Universal & Commercial Bank              | -0.043<br>(0.128) | -0.103<br>(0.129)  | 0.034<br>(0.086)     | -0.082<br>(0.091)    | 0.073<br>(0.063) | 0.062<br>(0.064) | 0.011<br>(0.031)     | 0.017<br>(0.032)     |
| <i>Macroeconomic Controls × Industry</i> |                   |                    |                      |                      |                  |                  |                      |                      |
| GDP × Thrift Bank                        |                   |                    | 13.499***<br>(1.479) | 13.249***<br>(1.654) |                  |                  | -5.600***<br>(0.530) | -5.546***<br>(0.582) |
| GDP × Universal & Commercial Bank        |                   |                    | 3.639*<br>(1.479)    | 3.334*<br>(1.654)    |                  |                  | -4.701***<br>(0.530) | -4.900***<br>(0.582) |
| Import × Thrift Bank                     |                   |                    | -3.528**<br>(1.172)  | -4.615***<br>(1.237) |                  |                  | 1.759***<br>(0.420)  | 1.827***<br>(0.436)  |
| Import × Universal & Commercial Bank     |                   |                    | -0.593<br>(1.172)    | -0.813<br>(1.237)    |                  |                  | 1.896***<br>(0.420)  | 1.955***<br>(0.436)  |
| Export × Thrift Bank                     |                   |                    | -4.300**<br>(1.569)  | -2.582<br>(1.672)    |                  |                  | 0.682<br>(0.562)     | 0.434<br>(0.589)     |
| Export × Universal & Commercial Bank     |                   |                    | -1.193<br>(1.569)    | -0.744<br>(1.672)    |                  |                  | 0.696<br>(0.562)     | 0.637<br>(0.589)     |
| Inflation × Thrift Bank                  |                   |                    | 0.263**<br>(0.078)   | 0.260**<br>(0.083)   |                  |                  | -0.105***<br>(0.028) | -0.092**<br>(0.029)  |
| Inflation × Universal & Commercial Bank  |                   |                    | -0.048<br>(0.078)    | 0.024<br>(0.083)     |                  |                  | -0.073*<br>(0.028)   | -0.072*<br>(0.029)   |
| Observations                             | 119               | 116                | 119                  | 116                  | 119              | 116              | 119                  | 116                  |
| Adjusted $R^2$                           | -0.538            | -0.467             | 0.439                | 0.409                | -0.538           | -0.534           | 0.706                | 0.687                |

*Notes:* Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Baseline industry category: Rural and Cooperative Banks (RCBs). GDP, Import, and Export are in logarithms. All models include two-way fixed effects (bank and time).

That MSMEs' NPL rates decrease more so for TBs than for RCBs 2 quarters after an emergency declaration is an unexpected result. RCBs are primarily engaged with rural MSMEs and farmers, hence, RCBs should be more concerned with securing resilience of MSMEs after disaster occurrences than TBs do. The

result seems counterintuitive, as it indicates that TBs tend to receive more government support after disaster occurrences than RCBs do, although RCBs' clients might be more severely affected than TBs' are.

No statistically significant effects are observed for UKBs, suggesting that larger and more diversified banks are less sensitive to disaster-related emergency declarations. Furthermore, emergency declarations do not exhibit any statistically significant impact on dependent variable lending for either TBs or UKBs, as Models 3 and 4 show. This makes sense in so far that emergency declarations reflect policy responses that are presumably tight to government-backed funding that do not intersect with the private banking sector, hence lending for TBs and UKBs is not affected by it.

However, macroeconomic variables emerge as key drivers of MSME lending and NPL rates. When GDP grows by 1%, then MSMEs' NPL rate increase by 0.13249% more so for TBs than for RCBs with a lag of 2 at a statistically significant level of 0.1%, as Model 2 in Table 4 shows. Simultaneously, a 1% increase in GDP decreases lending to MSMEs by 0.05546% more so for TBs than for RCBs for a lag of 2, at a statistically significant level of 0.1%, as Model 4 in Table 4 shows.

These dynamics hold in the UKB sector as well. A 1% increase in GDP increases MSMEs' NPL rates by 0.0334% more so for UKBs than for RCBs at a statistically significant level of 5% with a lag of 2. Additionally, a 1% increase in GDP decreases lending to MSMEs in the UKB sector by 0.049% more so than for RCBs at a statistically significant level of 0.1%.

These results show that during phases of economic expansion, TBs and UKBs tend to reduce lending to MSMEs more so than RCBs do. This result seems to be counterintuitive, as one might presumably assume that economic expansions support lending activities to high-risk firms, as banks can afford it more so during booms than recessions, especially larger banks that are highly liquid. That TBs and UKBs tend to reduce lending to MSMEs during economic expansions more so than RCBs do might reflect larger banks' choice to substitute MSME loans with larger, more profitable corporations, a sign of further financial exclusion of MSMEs.

Similarly, increases in import volumes are associated with lower NPL rates and higher lending in TBs relative to RCBs at a 0.1% statistically significant

level, consistent with stronger domestic demand conditions that support MSME performance as Table 4 shows. UKBs also exhibit increased lending in response to higher imports in relation to RCBs at a 0.1% statistically significant level, though effects on NPL rates remain insignificant.

Inflation shows a strong and consistent effect on TBs relative to RCBs too. A 1% increase in inflation rates increases MSME NPL rates in the TB sector by 0.26% more than for RCBs with a lag of 2, at a statistically significant level of 1% as Table 4 shows. Furthermore, a 1% increase in inflation rates decreases lending by 9.2% more so for TBs than for RCBs with a lag of 2 at a statistically significant level of 1%. This suggests that inflationary pressures deteriorate borrower quality and induce a contraction in credit supply for TBs more so than for RCBs after 2 quarters. For UKBs, inflation significantly reduces lending at a 5% statistically significant level, but does not have a statistically significant impact on NPL rates.

Taken together, the findings indicate that policy response to disasters, measured as the declaration of an emergency, are associated with a modest reduction in MSME NPL rates in the TB sector relative to RCBs, particularly with a 2-quarter lag. However, emergency declarations do not significantly induce changes in lending behavior for any bank type. Hence, policy support may improve loan performance of MSMEs in the TB sector without stimulating additional credit supply with a 2-quarter lag.

Overall, the results highlight that the effects of disaster-related policy responses are existent, though limited and heterogeneous across bank types, while macroeconomic conditions—particularly GDP, trade, and inflation—play a more central role in shaping MSME credit risk and lending dynamics. A particularly outstanding suggests that TBs and UKBs reduce lending more so than RCBs do, when GDP grows by 1%, which is a counterintuitive result.

#### 4.1.2 TWFE with Disaster Variable $\log(\text{Total Affected})$

Table 5 reports TWFE estimates for the impact of disaster variable  $\log(\text{Total Affected})$ , on MSME NPL rates and lending. Results show that for Model 1, a 1% increase in Total Affected is associated with an increase of 0.00058% in NPL rates in the TB sector relative to RCBs, significant at the 10% level with a 1-quarter lag. However, once macroeconomic controls are included, the coefficient turns negative and is significant at the 10% level with a 2-quarter lag. This result

is similar to the result seen in Table 4. Hence, the larger the disaster, the more NPL rates in the TB sector reduce with a 2-quarter lag, relative to RCBs.

TABLE 5. Fixed Effects: Stepwise Estimates of Disaster Exposure (log Total Affected) and Industry Heterogeneity on Bank Outcomes

|                                                 | NPL Rate         |                  |                      |                      | Log Lending        |                   |                      |                      |
|-------------------------------------------------|------------------|------------------|----------------------|----------------------|--------------------|-------------------|----------------------|----------------------|
|                                                 | Model 1          |                  | Model 2              |                      | Model 3            |                   | Model 4              |                      |
|                                                 | Lag 1            | Lag 2            | Lag 1                | Lag 2                | Lag 1              | Lag 2             | Lag 1                | Lag 2                |
| <i>Total Affected</i> × <i>Industry</i>         |                  |                  |                      |                      |                    |                   |                      |                      |
| Thrift Bank                                     | 0.058<br>(0.032) | 0.028<br>(0.034) | -0.018<br>(0.023)    | -0.043<br>(0.024)    | -0.031*<br>(0.016) | -0.024<br>(0.016) | 0.005<br>(0.008)     | 0.010<br>(0.009)     |
| Universal & Commercial Bank                     | 0.014<br>(0.032) | 0.002<br>(0.034) | -0.002<br>(0.023)    | -0.010<br>(0.024)    | -0.016<br>(0.016)  | -0.014<br>(0.016) | 0.007<br>(0.008)     | 0.006<br>(0.009)     |
| <i>Macroeconomic Controls</i> × <i>Industry</i> |                  |                  |                      |                      |                    |                   |                      |                      |
| GDP × Thrift Bank                               |                  |                  | 13.936***<br>(1.488) | 14.732***<br>(1.665) |                    |                   | -5.739***<br>(0.529) | -5.846***<br>(0.583) |
| GDP × Universal & Commercial Bank               |                  |                  | 3.620*<br>(1.488)    | 3.814*<br>(1.665)    |                    |                   | -4.858***<br>(0.529) | -5.057***<br>(0.583) |
| Import × Thrift Bank                            |                  |                  | -3.521**<br>(1.161)  | -4.794***<br>(1.227) |                    |                   | 1.734***<br>(0.413)  | 1.840***<br>(0.430)  |
| Import × Universal & Commercial Bank            |                  |                  | -0.449<br>(1.161)    | -0.994<br>(1.227)    |                    |                   | 1.865***<br>(0.413)  | 1.953***<br>(0.430)  |
| Export × Thrift Bank                            |                  |                  | -4.599**<br>(1.665)  | -3.303<br>(1.778)    |                    |                   | 0.803<br>(0.592)     | 0.610<br>(0.622)     |
| Export × Universal & Commercial Bank            |                  |                  | -1.362<br>(1.665)    | -0.816<br>(1.778)    |                    |                   | 0.839<br>(0.592)     | 0.741<br>(0.622)     |
| Inflation × Thrift Bank                         |                  |                  | 0.275**<br>(0.081)   | 0.267**<br>(0.086)   |                    |                   | -0.109***<br>(0.029) | -0.095**<br>(0.030)  |
| Inflation × Universal & Commercial Bank         |                  |                  | -0.038<br>(0.081)    | 0.014<br>(0.086)     |                    |                   | -0.079**<br>(0.029)  | -0.075*<br>(0.030)   |
| Observations                                    | 119              | 116              | 119                  | 116                  | 119                | 116               | 119                  | 116                  |
| Adjusted $R^2$                                  | -0.502           | -0.557           | 0.436                | 0.405                | -0.494             | -0.530            | 0.709                | 0.688                |

*Notes:* Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Baseline industry category: Rural and Cooperative Banks (RCBs). All models include bank and quarter fixed effects. GDP, Import and Export are in logarithms.

For lending, Model 3 shows that a 1% increase in Total Affected reduces lending by 0.031% more for TBs than for RCBs with a lag of 1, at the 5% statistically significant level. However, this effect disappears in Model 4 once macroeconomic controls are introduced, implying that the initial relationship is potentially driven by broader economic conditions rather than the disaster itself, as Table 5 suggests.

Again, like in section 4.1.1. macroeconomic variables emerge as strong and consistent predictors of MSME lending and NPL rates. A 1% increase in GDP is associated with an increase of approximately 0.139% in NPL rates for TBs relative to RCBs, significant at the 0.1% level with a lag of 1. For UKBs, the same increase in GDP is associated with an increase of approximately 0.036 % in NPL rates, significant at the 5% level with a lag of 1. Similarly as results show in section 4.1.1. phases of economic expansion increases MSMEs NPL rates in the TB and UKB sector more so than for RCBs.

Moreover, GDP growth is associated with lower lending for both TBs and UKBs too. A 1% increase in GDP leads to a 5.6% decrease in lending for TBs relative to RCBs with a lag of 1 at a statistically significant level of 0.1%. A 1% increase in GDP leads to a 4.7% decrease in lending for UKBs relative to RCBs with a lag of 1 at a statistically significant level of 0.1%, as Table 5 shows.

Taken together, the results suggest that the transmission of disaster shocks, measured in  $\log(\text{Total Affected})$  will decrease MSME NPL rates with a 2-quarter lag for TBs more than for RCBs. However, like in the previous section, macroeconomic conditions emerge as dominant drivers of variation for both NPL rates and lending to MSMEs. The broader economic environment thus plays a crucial role in shaping credit risk and lending behaviour to MSMEs, which is heterogeneous across bank types. This pattern is particularly pronounced for TBs, which exhibit greater sensitivity to macroeconomic fluctuations than UKBs, suggesting that bank type is a relevant source of heterogeneity in how MSME lending and NPL rates respond to macroeconomic conditions.

## 4.2 Level results through Pooled OLS with Interaction Effects

While the TWFE models reveal heterogeneous effects across bank types, they do not reflect on any direct effects of RCBs, as the baseline industry is absorbed into the fixed effects. To recover RCB-level estimates and enable comparison across all 3 bank types, pooled OLS regressions with interaction effects are run and discussed in the following. Tables 6 and 7 report these estimates for emergency declarations and  $\log(\text{Total Affected})$ , respectively.

For TBs, emergency declarations are associated with a reduction in NPL rates at a 2 quarter lag, significant at the 5% level, as Table 6 suggests. No significant effects are found for RCBs or UKBs under either disaster measure.

Macroeconomic variables remain the dominant drivers of variation in both NPL rates and lending, though their effects differ across bank types. For RCBs, a 1% increase in GDP is associated with a decline of approximately 0.028% in NPL rates with 1 lag, significant at the 5% level, and an increase in lending of 3.117% and 3.120% at lags 1 and 2 respectively, significant at the 0.1% level, as Table 6 suggests. Increasing import volumes, by contrast, reduce RCB lending to MSMEs, with a 1% increase in imports associated with a 0.952% and 1.094% decrease in lending at lags 1 and 2, significant at the 1% level.

TABLE 6. OLS: Stepwise Estimates of Emergency Exposure and Industry Heterogeneity on NPL Rates and Log Lending

|                                          | NPL Rates         |                    |                      |                      | Log Lending       |                   |                      |                      |
|------------------------------------------|-------------------|--------------------|----------------------|----------------------|-------------------|-------------------|----------------------|----------------------|
|                                          | Model 1           |                    | Model 2              |                      | Model 1           |                   | Model 2              |                      |
|                                          | Lag 1             | Lag 2              | Lag 1                | Lag 2                | Lag 1             | Lag 2             | Lag 1                | Lag 2                |
| <i>Emergency Exposure × Industry</i>     |                   |                    |                      |                      |                   |                   |                      |                      |
| Rural and Cooperative Bank (Baseline)    | 0.008<br>(0.092)  | 0.088<br>(0.092)   | -0.057<br>(0.068)    | 0.046<br>(0.072)     | -0.038<br>(0.044) | -0.040<br>(0.044) | 0.009<br>(0.025)     | -0.001<br>(0.025)    |
| Thrift Bank                              | -0.162<br>(0.130) | -0.292*<br>(0.130) | -0.073<br>(0.095)    | -0.174<br>(0.102)    | 0.019<br>(0.062)  | 0.061<br>(0.062)  | -0.006<br>(0.035)    | 0.036<br>(0.035)     |
| Universal & Commercial Bank              | -0.043<br>(0.130) | -0.099<br>(0.130)  | 0.014<br>(0.095)     | -0.075<br>(0.102)    | 0.021<br>(0.062)  | 0.036<br>(0.062)  | -0.004<br>(0.035)    | 0.020<br>(0.035)     |
| <i>Macroeconomic Controls × Industry</i> |                   |                    |                      |                      |                   |                   |                      |                      |
| <b>RCB Baseline Effects:</b>             |                   |                    |                      |                      |                   |                   |                      |                      |
| GDP                                      |                   |                    | -2.781*<br>(1.192)   | -2.190<br>(1.328)    |                   |                   | 3.117***<br>(0.434)  | 3.120***<br>(0.451)  |
| Import                                   |                   |                    | 0.179<br>(0.927)     | 0.704<br>(0.981)     |                   |                   | -0.952**<br>(0.338)  | -1.094**<br>(0.333)  |
| Export                                   |                   |                    | 0.617<br>(1.243)     | -0.335<br>(1.330)    |                   |                   | -0.153<br>(0.453)    | 0.079<br>(0.452)     |
| Inflation                                |                   |                    | 0.069<br>(0.062)     | 0.022<br>(0.066)     |                   |                   | 0.032<br>(0.023)     | 0.025<br>(0.022)     |
| GDP × Thrift Bank                        |                   |                    | 12.997***<br>(1.620) | 12.454***<br>(1.831) |                   |                   | -6.198***<br>(0.590) | -5.982***<br>(0.622) |
| GDP × Universal & Commercial Bank        |                   |                    | 3.137<br>(1.620)     | 2.539<br>(1.831)     |                   |                   | -5.298***<br>(0.590) | -5.336***<br>(0.622) |
| Import × Thrift Bank                     |                   |                    | -3.440**<br>(1.309)  | -4.546**<br>(1.387)  |                   |                   | 1.864***<br>(0.477)  | 1.865***<br>(0.471)  |
| Import × Universal & Commercial Bank     |                   |                    | -0.504<br>(1.309)    | -0.744<br>(1.387)    |                   |                   | 2.001***<br>(0.477)  | 1.992***<br>(0.471)  |
| Export × Thrift Bank                     |                   |                    | -4.129*<br>(1.750)   | -2.200<br>(1.870)    |                   |                   | 0.886<br>(0.638)     | 0.644<br>(0.635)     |
| Export × Universal & Commercial Bank     |                   |                    | -1.022<br>(1.750)    | -0.361<br>(1.870)    |                   |                   | 0.900<br>(0.638)     | 0.847<br>(0.635)     |
| Inflation × Thrift Bank                  |                   |                    | 0.282**<br>(0.086)   | 0.261**<br>(0.093)   |                   |                   | -0.081*<br>(0.031)   | -0.091**<br>(0.032)  |
| Inflation × Universal & Commercial Bank  |                   |                    | -0.028<br>(0.086)    | 0.025<br>(0.093)     |                   |                   | -0.050<br>(0.031)    | -0.072*<br>(0.032)   |
| Observations                             | 119               | 110                | 110                  | 98                   | 119               | 116               | 119                  | 116                  |
| Adjusted $R^2$                           | 0.636             | 0.639              | 0.840                | 0.820                | 0.981             | 0.981             | 0.995                | 0.995                |

*Notes:* Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Baseline industry category: Rural and Cooperative Banks (RCB). GDP, Import and Export are in log terms.

TBs exhibit a very different pattern. A 1% increase in GDP is associated with an increase of approximately 0.107% in NPL rates and a decrease of 3.081% in lending, both significant at the 0.1% level for a lag of 1 (Table 7). Inflation further raises NPL rates and reduces lending for TBs, while increasing imports are associated with lower NPL rates and higher lending.

UKBs show a similar pattern when it comes to NPL rates and lending during GDP growth. A 1% increase in GDP increases MSME NPL rates by 0.356% at a statistically significant level of 10%, whereas lending decreases by 2.181% at a statistically significant level of 0.1% for a lag of 1 (Table 7).

TABLE 7. OLS: Stepwise Estimates of Disaster Exposure (Log Total Affected) and Industry Heterogeneity on NPL Rates and Lending

|                                          | NPL Rates         |                   |                      |                      | Log Lending       |                   |                      |                      |
|------------------------------------------|-------------------|-------------------|----------------------|----------------------|-------------------|-------------------|----------------------|----------------------|
|                                          | Model 1           |                   | Model 2              |                      | Model 1           |                   | Model 2              |                      |
|                                          | Lag 1             | Lag 2             | Lag 1                | Lag 2                | Lag 1             | Lag 2             | Lag 1                | Lag 2                |
| <i>Log Total Affected × Industry</i>     |                   |                   |                      |                      |                   |                   |                      |                      |
| Rural and Cooperative Bank (Baseline)    | -0.019<br>(0.023) | -0.001<br>(0.024) | -0.006<br>(0.019)    | 0.010<br>(0.019)     | 0.020<br>(0.011)  | 0.014<br>(0.011)  | 0.000<br>(0.006)     | -0.002<br>(0.007)    |
| Thrift Bank                              | 0.058<br>(0.033)  | 0.027<br>(0.033)  | -0.014<br>(0.026)    | -0.044<br>(0.027)    | -0.008<br>(0.016) | -0.012<br>(0.016) | 0.009<br>(0.009)     | 0.007<br>(0.009)     |
| Universal & Commercial Bank              | 0.014<br>(0.033)  | 0.002<br>(0.033)  | 0.002<br>(0.026)     | -0.011<br>(0.027)    | 0.007<br>(0.016)  | -0.002<br>(0.016) | 0.010<br>(0.009)     | 0.003<br>(0.009)     |
| <i>Macroeconomic Controls × Industry</i> |                   |                   |                      |                      |                   |                   |                      |                      |
| <b>RCB Baseline Effects:</b>             |                   |                   |                      |                      |                   |                   |                      |                      |
| GDP                                      |                   |                   | -2.425*<br>(1.214)   | -2.549<br>(1.335)    |                   |                   | 3.077***<br>(0.426)  | 3.159***<br>(0.456)  |
| Import                                   |                   |                   | 0.042<br>(0.932)     | 0.758<br>(0.971)     |                   |                   | -0.921**<br>(0.327)  | -1.073**<br>(0.332)  |
| Export                                   |                   |                   | 0.570<br>(1.343)     | -0.175<br>(1.410)    |                   |                   | -0.168<br>(0.471)    | 0.027<br>(0.482)     |
| Inflation                                |                   |                   | 0.061<br>(0.065)     | 0.021<br>(0.068)     |                   |                   | 0.034<br>(0.023)     | 0.027<br>(0.023)     |
| GDP × Thrift Bank                        |                   |                   | 13.270***<br>(1.658) | 13.954***<br>(1.838) |                   |                   | -6.263***<br>(0.582) | -6.302***<br>(0.628) |
| GDP × Universal & Commercial Bank        |                   |                   | 2.952<br>(1.658)     | 3.036<br>(1.838)     |                   |                   | -5.382***<br>(0.582) | -5.514***<br>(0.628) |
| Import × Thrift Bank                     |                   |                   | -3.546**<br>(1.317)  | -4.694***<br>(1.373) |                   |                   | 1.714***<br>(0.462)  | 1.899***<br>(0.469)  |
| Import × Universal & Commercial Bank     |                   |                   | -0.474<br>(1.317)    | -0.894<br>(1.373)    |                   |                   | 1.845***<br>(0.462)  | 2.011***<br>(0.469)  |
| Export × Thrift Bank                     |                   |                   | -4.187*<br>(1.879)   | -2.970<br>(1.986)    |                   |                   | 1.126<br>(0.659)     | 0.805<br>(0.678)     |
| Export × Universal & Commercial Bank     |                   |                   | -0.951<br>(1.879)    | -0.483<br>(1.986)    |                   |                   | 1.162<br>(0.659)     | 0.937<br>(0.678)     |
| Inflation × Thrift Bank                  |                   |                   | 0.289**<br>(0.092)   | 0.271**<br>(0.096)   |                   |                   | -0.098**<br>(0.032)  | -0.093**<br>(0.033)  |
| Inflation × Universal & Commercial Bank  |                   |                   | -0.024<br>(0.092)    | 0.018<br>(0.096)     |                   |                   | -0.068*<br>(0.032)   | -0.073*<br>(0.033)   |
| Observations                             | 119               | 116               | 119                  | 116                  | 119               | 116               | 119                  | 116                  |
| Adjusted $R^2$                           | 0.637             | 0.624             | 0.834                | 0.819                | 0.981             | 0.981             | 0.995                | 0.995                |

*Notes:* Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Baseline industry category: Rural and Cooperative Banks (RCB). GDP, Import and Export are in log terms. Disaster exposure is measured as the log of total affected persons.

The divergence between RCBs, TBs and UKBs during economic booms is the most striking finding of this analysis. While TBs tighten lending and experience rising NPL rates as GDP grows, RCBs expand lending and see declining NPL rates — precisely the opposite dynamic. This suggests that the two bank types serve MSMEs for fundamentally different purposes and under different lending frameworks.

RCBs are predominantly located in rural areas and function as developmental institutions closely tied to local governments (Berger, Klapper, and Udell 2001; Volz 2010). Their mandate explicitly targets financial inclusion of MSMEs and

agricultural firms in rural Philippines, and their lending is largely relationship-based, drawing on soft information rather than standardised credit assessments. This institutional orientation explains why RCBs expand MSME credit during economic booms rather than reallocating capital elsewhere.

TBs and UKBs, by contrast, are larger institutions engaged in more standardised forms of lending, which formally restricts credit access for MSMEs due to information opacity and risk aversion (Berger, Klapper, and Udell 2001; Mkhaiber and Werner 2021; Berger and Udell 2002; Stiglitz and Weiss 1981). During economic booms, these banks may divert capital toward larger, lower-risk borrowers, effectively crowding out MSME lending. The rising NPL rates observed for TBs during such periods may reflect the residual MSME portfolio becoming relatively riskier as the composition of borrowers shifts.

Taken together, these results underscore that bank type is not merely a control variable but a substantive determinant of how macroeconomic conditions transmit to MSME credit outcomes. Financial inclusion policies targeting MSMEs must account for this heterogeneity, particularly to prevent divestment from vulnerable borrowers during periods of broader economic expansion.

## 5 Conclusion

This paper examined whether climate-related disasters have a statistically significant effect on MSME NPL rates and bank lending behaviour. Theory and empirical studies both suggest that access to finance is commonly restricted for MSMEs due to their opaque credit records. This paper further investigates how climate-related disasters may pose an additional barrier to MSME access to finance — finance that is needed both to build resilience against natural disasters and to secure the green finance required for a transition to a sustainable future.

By combining MSME lending data across bank types with country-level disaster data and macroeconomic controls over 2014–2024, this paper finds evidence from the Philippines that disasters do affect MSME NPL rates and bank lending behaviour. However, this effect differs across bank types. Emergency declarations decrease MSME NPL rates more for TBs than for RCBs with a 2-quarter lag, at a statistically significant level of 10%, as Table 4 shows. This result strengthens to the 1% significance level when trade-related macroeconomic variables are excluded from the model, as the robustness specification in Table 17 shows. Since

emergency declarations reflect formal policy and institutional responses to large disasters, these results suggest that such responses can be beneficial for MSMEs in the medium term, and that their benefits accrue more to commercially-oriented TBs than to development-oriented RCBs.

Furthermore, Table 5 shows that MSME NPL rates decrease more for TBs than for RCBs when the total number of people affected increases by 1%, with a 2-quarter lag, at a statistically significant level of 10%. This suggests that larger disasters in magnitude reduce credit stress in the TB sector relative to RCBs, possibly reflecting stronger policy support or faster recovery channels for commercially-oriented banks following large-scale disaster events.

A further relevant finding concerns how macroeconomic conditions shape bank lending and MSME NPL rates. As Tables 6 and 7 show, TBs and UKBs reduce lending to MSMEs when GDP grows by 1%, significant at the 0.1% level, while RCBs — consistent with their mandate to support access to finance for MSMEs and rural farmers — increase it under the same conditions. This counterintuitive divergence suggests that commercially-oriented banks withdraw from MSME lending during economic booms while development-oriented banks expand it, underscoring the crucial role of bank type in determining MSME access to finance during periods of economic expansion.

The main finding of the relationship between disasters and MSME NPL rates should be interpreted with caution. Two limitations bound these findings. First, because disaster exposure is measured at the national level, the design cannot exploit the geographic concentration of Philippine disasters and identifies effects only from variation in severity rather than from a comparison of exposed and unexposed regions. Second, with only three bank types observed over 44 quarters, the sample is too short for unit-root and panel-robust diagnostics to be conclusive. A subnational design matching regional disaster exposure to regional lending would provide substantially stronger identification and is the natural next step.

Taken together, the findings suggest that bank types are differently affected by disaster-related policy responses and GDP growth. Contrary to the initial hypothesis, MSME NPL rates decrease rather than increase following disaster occurrences, indicating that well-intentioned policy responses can be beneficial for MSMEs in the medium term. These findings lend support to scaling up Inclusive Green Finance (IGF) policies that could aid MSMEs in accessing the finance

needed to build resilience against disasters and transition towards a sustainable future.

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## A Robustness Tests

### A.1 Aggregate OLS Specification

The baseline OLS regressions are first estimated using the disaster variable Emergency and aggregate MSME NPL rates and lending across all bank types (Table 8). The disaster variable is then replaced with log(Total Affected) to capture disaster intensity, and the same specifications are re-estimated (Table 9).

As Table 8 and Table 9 suggest, disasters do not affect MSME NPL rates nor lending at a statistically significant level in its aggregate terms. Macroeconomic variables, by contrast, are strong and consistent predictors of both MSME lending and NPL rates. A 1% increase in GDP is associated with an increase of approximately 0.000182 percentage points in aggregate MSME NPL rates, significant at the 1% level across both lags in Table 8 and at the 0.1% level in Table 9. This result is counterintuitive, as one may assume NPL rates to fall during

TABLE 8. Aggregate OLS Specification with disaster variable "Emergency"

|                               | NPL Rate              |                       |                        |                       | Log Lending        |                    |                      |                      |
|-------------------------------|-----------------------|-----------------------|------------------------|-----------------------|--------------------|--------------------|----------------------|----------------------|
|                               | (1) No Controls       |                       | (2) With Controls      |                       | (3) No Controls    |                    | (4) With Controls    |                      |
|                               | Lag 1                 | Lag 2                 | Lag 1                  | Lag 2                 | Lag 1              | Lag 2              | Lag 1                | Lag 2                |
| <i>Emergency Exposure</i>     |                       |                       |                        |                       |                    |                    |                      |                      |
| Emergency                     | -0.00053<br>(0.00043) | -0.00038<br>(0.00041) | -0.00053<br>(0.00033)  | -0.00039<br>(0.00034) | 0.0168<br>(0.0332) | 0.0397<br>(0.0321) | -0.0087<br>(0.0252)  | 0.0232<br>(0.0251)   |
| <i>Macroeconomic Controls</i> |                       |                       |                        |                       |                    |                    |                      |                      |
| GDP (log)                     |                       |                       | 0.0182**<br>(0.00557)  | 0.0185**<br>(0.00589) |                    |                    | -2.250***<br>(0.421) | -2.226***<br>(0.438) |
| Import (log)                  |                       |                       | -0.00917*<br>(0.00469) | -0.00774<br>(0.00459) |                    |                    | 0.967*<br>(0.354)    | 0.806*<br>(0.341)    |
| Export (log)                  |                       |                       | -0.00827<br>(0.00626)  | -0.00920<br>(0.00615) |                    |                    | 0.739<br>(0.473)     | 0.898<br>(0.457)     |
| Inflation                     |                       |                       | 0.00087**<br>(0.00030) | 0.00082*<br>(0.00031) |                    |                    | -0.0171<br>(0.0229)  | -0.0474*<br>(0.0229) |
| Observations                  | 39                    | 38                    | 37                     | 36                    | 39                 | 38                 | 37                   | 36                   |
| Adjusted $R^2$                | 0.012                 | -0.004                | 0.504                  | 0.455                 | 0.013              | 0.014              | 0.498                | 0.518                |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . All regressions use quarterly aggregated banking data. Lagged macro variables are included where indicated.

economic booms. This procyclical pattern in credit risk suggests that during periods of economic expansion, MSME loan portfolios deteriorate in quality, which may reflect looser lending standards or adverse selection during booms.

Furthermore, GDP is negatively associated with aggregate MSME lending, with a 1% increase in GDP associated with approximately a 2.250% to 2.387% decrease in lending volumes, significant at the 0.1% level across both lags as Table 8 and 9 show. This countercyclical pattern suggests that banks reduce MSME lending during economic booms, possibly redirecting capital toward larger or less risky borrowers.

Higher import volumes are associated with lower NPL rates, significant at the 10% level for a lag of 1. Simultaneously, imports are positively associated with lending volumes, significant at the 5% level across both lags as Table 8 suggests. This may reflect that import-intensive periods coincide with stronger MSME activity, reducing credit risk while stimulating demand for credit. Export volumes show a similar positive association with lending, significant at the 5% level at a lag of 1, though no significant effect on NPL rates is observed as Table 9 suggests.

Inflation is positively associated with MSME NPL rates, significant at the 1% level for a lag of 1 and 5% for a lag of 2, consistent with the view that rising

prices erode MSME debt servicing capacity as Table 8 shows. On the other hand, inflation is negatively associated with lending at a lag of 2, significant at the 5% level, suggesting that sustained price pressures eventually constrain MSME credit supply.

TABLE 9. Aggregate OLS Specification with disaster variable "Total Affected"

|                               | NPL Rate             |                      |                        |                        | Log Lending          |                       |                      |                      |
|-------------------------------|----------------------|----------------------|------------------------|------------------------|----------------------|-----------------------|----------------------|----------------------|
|                               | (1) No Controls      |                      | (2) With Controls      |                        | (3) No Controls      |                       | (4) With Controls    |                      |
|                               | Lag 1                | Lag 2                | Lag 1                  | Lag 2                  | Lag 1                | Lag 2                 | Lag 1                | Lag 2                |
| <i>Total Affected</i>         |                      |                      |                        |                        |                      |                       |                      |                      |
| Log Total Affected            | 0.00000<br>(0.00011) | 0.00003<br>(0.00010) | -0.00006<br>(0.00009)  | -0.00005<br>(0.00009)  | 0.00514<br>(0.00838) | -0.00394<br>(0.00826) | 0.01001<br>(0.00669) | 0.00346<br>(0.00675) |
| <i>Macroeconomic Controls</i> |                      |                      |                        |                        |                      |                       |                      |                      |
| GDP (log)                     |                      |                      | 0.0205***<br>(0.00580) | 0.0210***<br>(0.00599) |                      |                       | -2.362***<br>(0.413) | -2.387***<br>(0.443) |
| Import (log)                  |                      |                      | -0.0104*<br>(0.00479)  | -0.00863<br>(0.00460)  |                      |                       | 0.825*<br>(0.341)    | 0.853*<br>(0.340)    |
| Export (log)                  |                      |                      | -0.00823<br>(0.00675)  | -0.00968<br>(0.00663)  |                      |                       | 1.000*<br>(0.481)    | 0.940<br>(0.490)     |
| Inflation                     |                      |                      | 0.00084*<br>(0.00033)  | 0.00078*<br>(0.00032)  |                      |                       | -0.0336<br>(0.0236)  | -0.0455<br>(0.0237)  |
| Observations                  | 39                   | 38                   | 37                     | 36                     | 39                   | 38                    | 37                   | 36                   |
| Adjusted $R^2$                | -0.026               | -0.025               | 0.473                  | 0.437                  | -0.016               | -0.021                | 0.527                | 0.509                |

*Notes:* Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . All regressions use quarterly aggregated banking data. Lagged macro variables are included where indicated.

The absence of significant disaster effects at the aggregate level may reflect heterogeneity across bank types that cancels out in aggregation. Banks differ substantially in balance sheet structure, geographic exposure, and lending strategy, and these differences may generate opposing responses to disaster shocks that are obscured when data are pooled. The following section therefore disaggregates the analysis across bank categories to examine whether disasters affect MSME NPL rates or lending volumes differentially across RCBs, TBs, and UKBs.

## A.2 Cross-Sectional OLS by Bank Type

The following section presents the same model specifications as in the previous section, but estimated on separate datasets for each bank type rather than on aggregated MSME data, allowing for heterogeneous responses to disaster exposure across bank types.

### A.2.1 Rural and Cooperative Banks

Tables 10 and 11 present the results for RCBs, distinguishing between emergency exposure and number of total people affected. Across both specifications, there is no statistically significant evidence that either disaster variable affects MSME NPL rates or lending by RCBs. Coefficients on both Emergency and Total Affected are small in magnitude and remain statistically insignificant across both lags, indicating that disasters do not significantly affect MSME NPL rates and lending to MSMEs in the RCB sector.

TABLE 10. OLS Specification with disaster variable "Emergency" for RCBs

|                               | NPL Rate           |                    |                      |                     | Log Lending         |                     |                     |                      |
|-------------------------------|--------------------|--------------------|----------------------|---------------------|---------------------|---------------------|---------------------|----------------------|
|                               | (1) No Controls    |                    | (2) With Controls    |                     | (3) No Controls     |                     | (4) With Controls   |                      |
|                               | Lag 1              | Lag 2              | Lag 1                | Lag 2               | Lag 1               | Lag 2               | Lag 1               | Lag 2                |
| <i>Emergency Exposure</i>     |                    |                    |                      |                     |                     |                     |                     |                      |
| Emergency                     | 0.0077<br>(0.0604) | 0.0875<br>(0.0550) | -0.0566<br>(0.0374)  | 0.0463<br>(0.0336)  | -0.0381<br>(0.0529) | -0.0401<br>(0.0534) | 0.0087<br>(0.0199)  | -0.0008<br>(0.0203)  |
| <i>Macroeconomic Controls</i> |                    |                    |                      |                     |                     |                     |                     |                      |
| GDP (log)                     |                    |                    | -2.781***<br>(0.653) | -2.190**<br>(0.617) |                     |                     | 3.117***<br>(0.347) | 3.120***<br>(0.372)  |
| Import (log)                  |                    |                    | 0.179<br>(0.508)     | 0.704<br>(0.456)    |                     |                     | -0.952**<br>(0.270) | -1.094***<br>(0.275) |
| Export (log)                  |                    |                    | 0.617<br>(0.681)     | -0.335<br>(0.618)   |                     |                     | -0.153<br>(0.362)   | 0.079<br>(0.373)     |
| Inflation                     |                    |                    | 0.069<br>(0.034)     | 0.022<br>(0.031)    |                     |                     | 0.032<br>(0.018)    | 0.025<br>(0.018)     |
| Observations                  | 40                 | 38                 | 40                   | 38                  | 40                  | 38                  | 40                  | 38                   |
| Adjusted $R^2$                | -0.027             | 0.040              | 0.685                | 0.709               | -0.013              | -0.012              | 0.885               | 0.882                |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Columns (1)–(2) and (5)–(6) report baseline models without controls. Columns (3)–(4) and (7)–(8) include macroeconomic controls. GDP, Import, and Export are in logarithms.

However, the macroeconomic control variable GDP emerges as a significant driver of variation in both NPL rates and lending by RCBs for both disaster variables, as Tables 10 and 11 suggest. If GDP grows by 1%, then MSME NPL rates will decrease by 0.0278% and lending to MSMEs will increase by 3.12% after 1 quarter, at a statistically significant level of 0.1% (Table 10).

Higher GDP is associated with lower NPL rates and higher MSME lending in subsequent periods, suggesting that improvements in economic activity strengthen MSME's performance while simultaneously increasing lending to them in the RCB sector.

TABLE 11. OLS Specification with disaster variable "Total Affected" for RCBs

|                                  | NPL Rate            |                     |                     |                      | Log Lending        |                    |                     |                      |
|----------------------------------|---------------------|---------------------|---------------------|----------------------|--------------------|--------------------|---------------------|----------------------|
|                                  | (1) No Controls     |                     | (2) With Controls   |                      | (3) No Controls    |                    | (4) With Controls   |                      |
|                                  | Lag 1               | Lag 2               | Lag 1               | Lag 2                | Lag 1              | Lag 2              | Lag 1               | Lag 2                |
| <i>Total Affected Population</i> |                     |                     |                     |                      |                    |                    |                     |                      |
| Log Total Affected               | -0.0189<br>(0.0150) | -0.0010<br>(0.0144) | -0.0062<br>(0.0102) | 0.0102<br>(0.0090)   | 0.0201<br>(0.0130) | 0.0145<br>(0.0134) | 0.0001<br>(0.0053)  | -0.0021<br>(0.0054)  |
| <i>Macroeconomic Controls</i>    |                     |                     |                     |                      |                    |                    |                     |                      |
| GDP (log)                        |                     |                     | -2.425**<br>(0.672) | -2.549***<br>(0.625) |                    |                    | 3.077***<br>(0.348) | 3.159***<br>(0.373)  |
| Import (log)                     |                     |                     | 0.042<br>(0.516)    | 0.758<br>(0.455)     |                    |                    | -0.921**<br>(0.267) | -1.073***<br>(0.271) |
| Export (log)                     |                     |                     | 0.570<br>(0.743)    | -0.175<br>(0.660)    |                    |                    | -0.168<br>(0.385)   | 0.027<br>(0.394)     |
| Inflation                        |                     |                     | 0.061<br>(0.036)    | 0.021<br>(0.032)     |                    |                    | 0.034<br>(0.019)    | 0.027<br>(0.019)     |
| Observations                     | 40                  | 38                  | 40                  | 38                   | 40                 | 38                 | 40                  | 38                   |
| Adjusted $R^2$                   | 0.015               | -0.028              | 0.667               | 0.704                | 0.035              | 0.005              | 0.885               | 0.882                |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Columns (1)–(2) and (5)–(6) report baseline models without controls. Columns (3)–(4) and (7)–(8) include macroeconomic controls. GDP, Import, and Export are in logarithms.

Overall, results suggest that MSME NPL rates and lending in the RCB sector are primarily driven by macroeconomic conditions rather than disaster exposure. Unlike the aggregate specification, where GDP growth increases MSME NPL rates and decreases lending to MSMEs, RCBs experience decreasing MSME NPL rates and increased lending when GDP grows by 1%. This indicates that during times of economic expansion, RCBs - a banking sector specifically trained to financially include MSMEs in rural areas will increase their lending volumes and act in a procyclical way. This indicates heterogeneity in lending behaviour across bank types and becomes more evident in the following subsections.

### A.2.2 Thrift Banks

Tables 12 and 13 present the results for TBs, distinguishing between emergency exposure and number of total people affected. Similarly to results in the RCB sector, there is no statistically significant evidence that disaster exposure affects either MSME NPL rates or MSME lending in the TB sector, when one runs a simple OLS regression.

However, as both Tables 12 and 13 show, macroeconomic variables are significantly predicting changes in MSME NPL rates and lending in the TB sector. GDP is highly significant in Model 2 and 4 in both Table 12 and 13. However, it

TABLE 12. OLS Specification with disaster variable "Emergency" for TBs

|                               | NPL Rate            |                     |                        |                        | Log Lending        |                    |                        |                        |
|-------------------------------|---------------------|---------------------|------------------------|------------------------|--------------------|--------------------|------------------------|------------------------|
|                               | (1) No Controls     |                     | (2) With Controls      |                        | (3) No Controls    |                    | (4) With Controls      |                        |
|                               | Lag 1               | Lag 2               | Lag 1                  | Lag 2                  | Lag 1              | Lag 2              | Lag 1                  | Lag 2                  |
| <i>Emergency Events</i>       |                     |                     |                        |                        |                    |                    |                        |                        |
| Emergency                     | -0.1541<br>(0.1425) | -0.2040<br>(0.1452) | -0.1296<br>(0.1046)    | -0.1281<br>(0.1176)    | 0.0191<br>(0.0417) | 0.0605<br>(0.0415) | -0.0055<br>(0.0263)    | 0.0364<br>(0.0275)     |
| <i>Macroeconomic Controls</i> |                     |                     |                        |                        |                    |                    |                        |                        |
| GDP (log)                     |                     |                     | 10.2161***<br>(1.7455) | 10.2642***<br>(2.0505) |                    |                    | -3.0809***<br>(0.4382) | -2.8618***<br>(0.4791) |
| Import (log)                  |                     |                     | -3.2603*<br>(1.4690)   | -3.8426*<br>(1.5952)   |                    |                    | 0.9118*<br>(0.3688)    | 0.7710*<br>(0.3727)    |
| Export (log)                  |                     |                     | -3.5122*<br>(1.9608)   | -2.5346<br>(2.1384)    |                    |                    | 0.7333<br>(0.4922)     | 0.7227<br>(0.4997)     |
| Inflation                     |                     |                     | 0.3511***<br>(0.0948)  | 0.2831*<br>(0.1071)    |                    |                    | -0.0499*<br>(0.0238)   | -0.0663*<br>(0.0250)   |
| Observations                  | 41                  | 40                  | 41                     | 40                     | 41                 | 40                 | 41                     | 40                     |
| Adjusted $R^2$                | 0.004               | 0.025               | 0.544                  | 0.489                  | -0.021             | 0.029              | 0.655                  | 0.659                  |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Columns (1)–(2) and (5)–(6) report baseline models without controls. Columns (3)–(4) and (7)–(8) include macroeconomic controls. GDP, Import, and Export are in logarithms.

TABLE 13. OLS Specification with disaster variable "Total Affected" for TBs

|                                  | NPL Rate           |                    |                        |                        | Log Lending         |                     |                        |                        |
|----------------------------------|--------------------|--------------------|------------------------|------------------------|---------------------|---------------------|------------------------|------------------------|
|                                  | (1) No Controls    |                    | (2) With Controls      |                        | (3) No Controls     |                     | (4) With Controls      |                        |
|                                  | Lag 1              | Lag 2              | Lag 1                  | Lag 2                  | Lag 1               | Lag 2               | Lag 1                  | Lag 2                  |
| <i>Total Affected Population</i> |                    |                    |                        |                        |                     |                     |                        |                        |
| Log Total Affected               | 0.0390<br>(0.0360) | 0.0262<br>(0.0374) | -0.0197<br>(0.0290)    | -0.0338<br>(0.0313)    | -0.0081<br>(0.0105) | -0.0125<br>(0.0106) | 0.0089<br>(0.0070)     | 0.0071<br>(0.0074)     |
| <i>Macroeconomic Controls</i>    |                    |                    |                        |                        |                     |                     |                        |                        |
| GDP (log)                        |                    |                    | 10.8432***<br>(1.7912) | 11.4052***<br>(2.0536) |                     |                     | -3.1854***<br>(0.4330) | -3.1435***<br>(0.4856) |
| Import (log)                     |                    |                    | -3.5041*<br>(1.4783)   | -3.9363*<br>(1.5755)   |                     |                     | 0.7933*<br>(0.3574)    | 0.8253*<br>(0.3726)    |
| Export (log)                     |                    |                    | -3.6178*<br>(2.0856)   | -3.1450<br>(2.2709)    |                     |                     | 0.9587*<br>(0.5042)    | 0.8322<br>(0.5370)     |
| Inflation                        |                    |                    | 0.3499**<br>(0.1022)   | 0.2920*<br>(0.1101)    |                     |                     | -0.0640*<br>(0.0247)   | -0.0655*<br>(0.0260)   |
| Observations                     | 40                 | 39                 | 40                     | 39                     | 40                  | 39                  | 40                     | 39                     |
| Adjusted $R^2$                   | 0.004              | -0.014             | 0.530                  | 0.489                  | -0.010              | 0.010               | 0.670                  | 0.651                  |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Columns (1)–(2) and (5)–(6) report baseline models without controls. Columns (3)–(4) and (7)–(8) include macroeconomic controls. GDP, Import, and Export are in logarithms.

comes with counterintuitive results, where GDP growth is positively associated with MSME NPL rates and negatively associated with MSME lending. This suggests that, unlike RCBs, TBs reduce MSME lending during periods of stronger economic activity while simultaneously experiencing higher credit risk. This pattern is consistent with a portfolio reallocation or risk-tightening channel rather than a standard procyclical lending response.

Overall, the simple, cross-sectional OLS regression analysis for TBs show that disasters do not have a statistically significant effect on MSME NPL rates and lending. It is GDP growth that induces changes in TBs' lending behaviour and MSME NPL rates. Though one may assume that lending increases during economic booms, the results show that TBs reduce lending to MSMEs when GDP grows by 1%, which is a counterintuitive result.

### A.2.3 Universal and Commercial Banks

Tables 14 and 15 present the results for UKBs, distinguishing between emergency exposure and disaster intensity measured by the total number of people affected. Like results in the RCB and TB sector have already shown, disaster exposure does not significantly affect MSME NPL rates or MSME lending in the UKB sector for the cross-sectional OLS regression model either.

TABLE 14. OLS Specification with disaster variable "Emergency" for UKBs

|                               | NPL Rate            |                     |                     |                     | Log Lending        |                    |                        |                        |
|-------------------------------|---------------------|---------------------|---------------------|---------------------|--------------------|--------------------|------------------------|------------------------|
|                               | (1) No Controls     |                     | (2) With Controls   |                     | (3) No Controls    |                    | (4) With Controls      |                        |
|                               | Lag 1               | Lag 2               | Lag 1               | Lag 2               | Lag 1              | Lag 2              | Lag 1                  | Lag 2                  |
| <i>Emergency Events</i>       |                     |                     |                     |                     |                    |                    |                        |                        |
| Emergency                     | -0.0355<br>(0.0321) | -0.0120<br>(0.0294) | -0.0423<br>(0.0254) | -0.0286<br>(0.0245) | 0.0211<br>(0.0366) | 0.0362<br>(0.0352) | -0.0039<br>(0.0257)    | 0.0199<br>(0.0253)     |
| <i>Macroeconomic Controls</i> |                     |                     |                     |                     |                    |                    |                        |                        |
| GDP (log)                     |                     |                     | 0.3560<br>(0.4236)  | 0.3493<br>(0.4267)  |                    |                    | -2.1813***<br>(0.4285) | -2.2162***<br>(0.4407) |
| Import (log)                  |                     |                     | -0.3250<br>(0.3565) | -0.0403<br>(0.3320) |                    |                    | 1.0491**<br>(0.3606)   | 0.8985**<br>(0.3428)   |
| Export (log)                  |                     |                     | -0.4049<br>(0.4758) | -0.6965<br>(0.4450) |                    |                    | 0.7477<br>(0.4813)     | 0.9263<br>(0.4595)     |
| Inflation                     |                     |                     | 0.0406<br>(0.0230)  | 0.0471*<br>(0.0223) |                    |                    | -0.0185<br>(0.0233)    | -0.0473*<br>(0.0230)   |
| Observations                  | 39                  | 38                  | 39                  | 38                  | 39                 | 38                 | 39                     | 38                     |
| Adjusted $R^2$                | 0.006               | -0.022              | 0.472               | 0.434               | -0.017             | 0.002              | 0.574                  | 0.588                  |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . GDP, Import, and Export are in logarithms. Emergency variables are lagged indicators.

Here again, GDP plays a significant role in shaping MSME lending and NPL rates. GDP is consistently negative and highly statistically significant in the lending regressions, indicating that UKBs reduce MSME lending during periods of stronger economic activity. At the same time, GDP has no statistically significant effect on NPL rates, which is different from the results in the TB and RCB sector.

Furthermore, if import volumes grow by 1%, then MSME lending increases by 1.491% after 1 quarter in the UKB sector, at a statistically significant level of 5%. Export and inflation rates show weak statistically significant results, where increasing export volumes increase and inflation rates decrease lending to MSMEs.

Overall, the UKB results indicate that MSME credit supply is primarily driven by macroeconomic conditions rather than disaster exposure. However, GDP growth does have a statistically significant affect on MSME NPL rates in the UKB sector, but they do significantly decrease lending to MSMEs, which is a counterintuitive result.

TABLE 15. OLS Specification with disaster variable "Total Affected" for UKBs

|                                  | NPL Rate            |                    |                     |                     | Log Lending        |                     |                      |                      |
|----------------------------------|---------------------|--------------------|---------------------|---------------------|--------------------|---------------------|----------------------|----------------------|
|                                  | (1) No Controls     |                    | (2) With Controls   |                     | (3) No Controls    |                     | (4) With Controls    |                      |
|                                  | Lag 1               | Lag 2              | Lag 1               | Lag 2               | Lag 1              | Lag 2               | Lag 1                | Lag 2                |
| <i>Total Affected Population</i> |                     |                    |                     |                     |                    |                     |                      |                      |
| log Total Affected               | -0.0044<br>(0.0082) | 0.0005<br>(0.0074) | -0.0040<br>(0.0072) | -0.0007<br>(0.0066) | 0.0070<br>(0.0092) | -0.0024<br>(0.0090) | 0.0100<br>(0.0068)   | 0.0030<br>(0.0068)   |
| <i>Macroeconomic Controls</i>    |                     |                    |                     |                     |                    |                     |                      |                      |
| GDP (log)                        |                     |                    | 0.527<br>(0.443)    | 0.487<br>(0.436)    |                    |                     | -2.305***<br>(0.420) | -2.355***<br>(0.444) |
| Import (log)                     |                     |                    | -0.432<br>(0.366)   | -0.137<br>(0.334)   |                    |                     | 0.924**<br>(0.347)   | 0.938**<br>(0.341)   |
| Export (log)                     |                     |                    | -0.381<br>(0.516)   | -0.658<br>(0.482)   |                    |                     | 0.994*<br>(0.489)    | 0.964<br>(0.491)     |
| Inflation                        |                     |                    | 0.037<br>(0.025)    | 0.040<br>(0.023)    |                    |                     | -0.034<br>(0.024)    | -0.046<br>(0.024)    |
| Observations                     | 39                  | 38                 | 39                  | 38                  | 39                 | 38                  | 39                   | 38                   |
| Adjusted $R^2$                   | -0.019              | -0.027             | 0.434               | 0.411               | -0.011             | -0.025              | 0.599                | 0.583                |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . GDP, Import, Export, and Total Affected are in logarithms. Models include Emergency exposure and macroeconomic controls where specified.

### A.3 Multicollinearity

Because GDP, imports, and exports tend to move together over the business cycle, including them simultaneously risks multicollinearity, which inflates standard errors and destabilises individual coefficient estimates. Table 16 shows that Variance inflation factors (VIFs) confirm this concern: imports and exports return VIFs of 27.2 and 31.0 respectively, far above the conventional threshold of 10, while GDP is also elevated at 12.6. Inflation, by contrast, is unproblematic (VIF = 1.19).

TABLE 16. Variance Inflation Factors, Macroeconomic Controls

| Variable    | VIF   |
|-------------|-------|
| log GDP     | 12.55 |
| log Imports | 27.19 |
| log Exports | 30.10 |
| Inflation   | 1.19  |

*Notes:* VIFs from an OLS regression of the NPL rate on the four macroeconomic controls. Values above 10 conventionally indicate problematic multicollinearity.

The 3 trade-cycle variables therefore cannot be separately identified and should be interpreted as a single collinear block rather than as distinct channels. To assess whether this affects the results, the main specifications are re-estimated retaining only GDP and inflation as macroeconomic controls (Tables 17 and 18).

As Table 17 shows, the reduced specification strengthens the main disaster result. MSME NPL rates decrease by 0.344 percentage points more for TBs than for RCBs with a 2-quarter lag, significant at the 1% level — compared to 0.182 at only 10% significance in the full model. Additionally, emergency declarations are associated with an increase in lending to MSMEs of approximately 0.072% more for TBs than for RCBs at a 1-quarter lag (significant at 10%), rising to 0.089% at a 2-quarter lag (significant at 5%). That lending significantly increases to MSMEs more so for TBs than for RCBs after emergency declarations shows that specific banks do react to large disaster occurrences.

UKBs also show a marginally significant lending effect following emergency declarations, with lending increasing by 0.077% and 0.079% more for UKBs than for RCBs at 1- and 2-quarter lags respectively, both significant at the 10% level.

TABLE 17. TWFE: Emergency Exposure and Bank-Type Heterogeneity, Reduced Macro Set

|                                                             | NPL Rate            |                     | Lending (log)        |                      |
|-------------------------------------------------------------|---------------------|---------------------|----------------------|----------------------|
|                                                             | Lag 1               | Lag 2               | Lag 1                | Lag 2                |
| <i>Emergency Exposure <math>\times</math> Bank Type</i>     |                     |                     |                      |                      |
| Thrift Bank                                                 | -0.192<br>(0.116)   | -0.344**<br>(0.118) | 0.072<br>(0.043)     | 0.089*<br>(0.043)    |
| Universal & Commercial Bank                                 | -0.016<br>(0.116)   | -0.106<br>(0.118)   | 0.077<br>(0.043)     | 0.079<br>(0.043)     |
| <i>Macroeconomic Controls <math>\times</math> Bank Type</i> |                     |                     |                      |                      |
| GDP $\times$ Thrift Bank                                    | 2.179***<br>(0.599) | 2.152**<br>(0.627)  | -1.815***<br>(0.222) | -1.914***<br>(0.231) |
| GDP $\times$ Universal Bank                                 | 0.929<br>(0.599)    | 0.894<br>(0.627)    | -0.681**<br>(0.222)  | -0.789**<br>(0.231)  |
| Inflation $\times$ Thrift Bank                              | 0.221*<br>(0.110)   | 0.243*<br>(0.112)   | -0.099*<br>(0.041)   | -0.086*<br>(0.041)   |
| Inflation $\times$ Universal Bank                           | -0.027<br>(0.110)   | 0.022<br>(0.112)    | -0.065<br>(0.041)    | -0.066<br>(0.041)    |
| Observations                                                | 119                 | 116                 | 119                  | 116                  |
| Adjusted $R^2$                                              | -0.120              | -0.075              | 0.373                | 0.375                |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Baseline bank type: RCBs; coefficients are relative to this baseline. All models include two-way (bank and time) fixed effects. GDP is in logs; inflation is a rate.

TABLE 18. TWFE: Total Affected and Bank-Type Heterogeneity, Reduced Macro Set

|                                                             | NPL Rate            |                     | Lending (log)        |                      |
|-------------------------------------------------------------|---------------------|---------------------|----------------------|----------------------|
|                                                             | Lag 1               | Lag 2               | Lag 1                | Lag 2                |
| <i>log Total Affected <math>\times</math> Bank Type</i>     |                     |                     |                      |                      |
| Thrift Bank                                                 | 0.016<br>(0.031)    | -0.015<br>(0.033)   | -0.003<br>(0.012)    | 0.003<br>(0.012)     |
| Universal & Commercial Bank                                 | 0.009<br>(0.031)    | -0.006<br>(0.033)   | -0.003<br>(0.012)    | -0.002<br>(0.012)    |
| <i>Macroeconomic Controls <math>\times</math> Bank Type</i> |                     |                     |                      |                      |
| GDP $\times$ Thrift Bank                                    | 2.354***<br>(0.599) | 2.540***<br>(0.652) | -1.898***<br>(0.223) | -2.011***<br>(0.234) |
| GDP $\times$ Universal Bank                                 | 0.972<br>(0.599)    | 0.989<br>(0.652)    | -0.768***<br>(0.223) | -0.869***<br>(0.234) |
| Inflation $\times$ Thrift Bank                              | 0.142<br>(0.114)    | 0.154<br>(0.120)    | -0.071<br>(0.043)    | -0.062<br>(0.043)    |
| Inflation $\times$ Universal Bank                           | -0.049<br>(0.114)   | -0.004<br>(0.120)   | -0.037<br>(0.043)    | -0.038<br>(0.043)    |
| Observations                                                | 119                 | 116                 | 119                  | 116                  |
| Adjusted $R^2$                                              | -0.170              | -0.211              | 0.338                | 0.331                |

Notes: Standard errors in parentheses. \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ ,  $p < 0.1$ . Baseline bank type: RCBs; reported coefficients are differences relative to this baseline. All models include two-way (bank and time) fixed effects. GDP is in logs; inflation is a rate.

Whilst in the full model specification no statistically significant effect was observed for UKBs, this reduced macro set shows that UKBs do react to emergency declarations by increasing lending to MSMEs.

Emergency declarations do have a statistically significant effect on MSME NPL rates and lending in both the TB and UKB sector, however, the disaster variable log Total Affected does not show any significance, as Table 18 displays.

Counterintuitive GDP effects also emerge in Tables 17 and 18. A 1% increase in GDP is associated with a decrease in lending to MSMEs more for TBs than for RCBs, significant at the 0.1% level across both lags, and more for UKBs than for RCBs, significant at the 1% and 0.1% level across both lags.