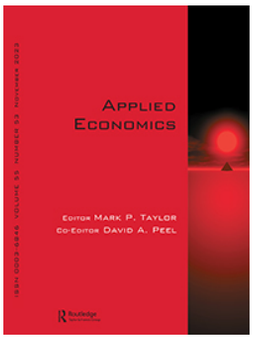

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The impact of natural disasters on bank performance and the moderating role of financial integration

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ABSTRACT

Using a sample of East Asian banks covering the period 1999–2014, this paper analyses the impact of natural disasters on commercial bank performance and how financial integration moderates this relationship. A dynamic GMM model reveals that natural disasters significantly lower deposit ratios but have no contemporaneous relationship with liquidity, credit risk, profitability and default risk. There is also evidence of a lagged effect of disasters, increasing deposits and lowering liquidity one year after the event. Furthermore, foreign banking claims, specifically those extended by regional Asian lenders, help to alleviate the deposits decline in the aftermath of natural disasters. These baseline findings are mainly driven by severely affected countries. Overall, the paper highlights the role of commercial bank deposits and foreign banking claims as sources of finance for post-disaster recovery. In particular, the resilience of Asian foreign claims in the event of natural disasters provides evidence to support intra-regional financial integration in East Asia.

KEYWORDS

Natural disaster; Bank performance; Financial integration; Dynamic GMM; East Asia

JEL CLASSIFICATION

C14; G21; F36; F38

I. Introduction

Asia has been one of the most disaster-prone regions in the world as measured by total economic damage in Figure 1. Specifically, over the past 20 years, Asia has borne almost half of the estimated global economic cost of natural disasters, roughly $53 billion annually (Asian Development Bank 2014); within East Asia, Indonesia, China and the Philippines stand out as highly vulnerable to disasters (Noy 2015). Some of the most prominent disasters in the region over our sampled period include the 2008 Sichuan earthquake in China, the 2013 Haiyan cyclone in the Philippines, and the 2011 flooding in Thailand with each recording economic losses of 3.1%, 4.9%, and 17% respectively and relative to the prior year's national GDP (EMDAT 2018). In particular, the effect of disasters is of growing concern given the evidence that climate change is altering the frequency and severity of natural hazards (Bronstert 2003; Bender et al. 2010; Turco et al. 2014; IPCC 2022). If realized, this projection heralds severe consequences for East Asia because climate change will increase the region's vulnerability to natural disasters.

Several theoretical models of disasters impact (notably the Input-Output and Computable General Equilibrium models) treat disasters as exogenous shocks that destroy physical and human capital, leading to several adverse macroeconomic consequences (Botzen, Deschenes, and Sanders 2020). These models together with empirical evidence from several studies (i.e. Koetter, Noth, and Rehbein 2020; Duqi et al. 2021) further highlight the role of funds in supporting the recovery and reconstruction process as mitigating factors, including banks financing, foreign aid or foreign lending. Given this theoretical background, the paper aims to assess the potential impact of natural disasters on banks in East Asia. The findings of this study are critical to the East Asian banking sector because banks provide an important source of finance in the form of bank deposits and credit for the post-disaster recovery (Skidmore 2001). However, if banks are strongly affected by disasters (perhaps as a result of the magnitude of the disaster or its geographical concentration), the role of banks in the reconstruction process could be

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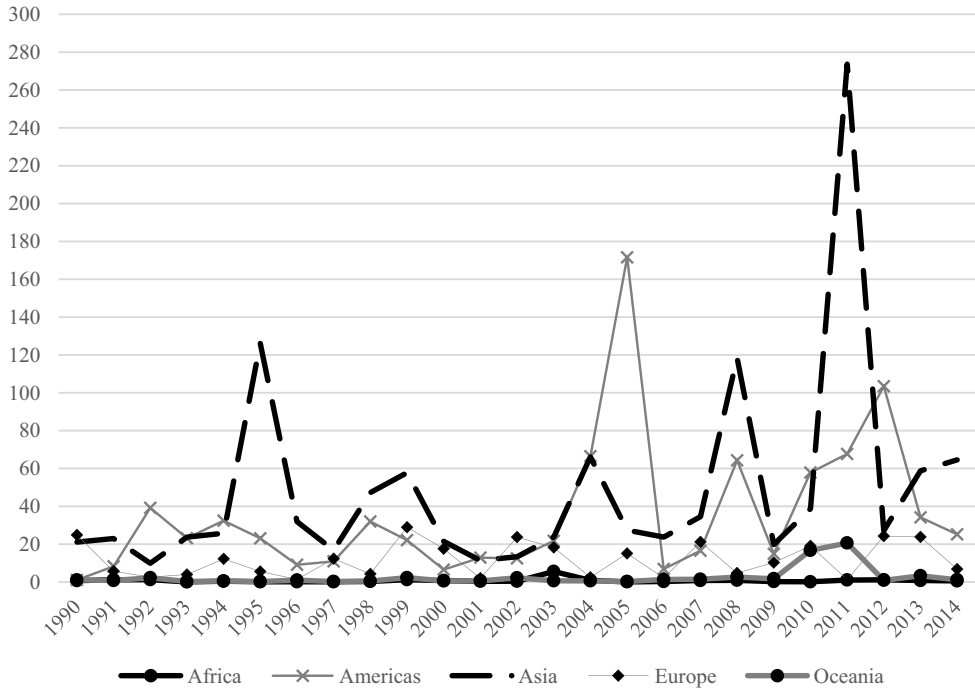

Figure 1. Total economic damage of natural disasters (US$ billion) per continent during 1990–2014. (Source: EMDAT (2018)).

limited. Given the importance of banking to the economy, this paper assesses the impact of disasters on various aspects of bank performance.

The theory regarding impact of disasters on bank performance is ambiguous. On the one hand, endogenous growth models with increasing returns to scale in production predict that firms are adversely affected by disasters (Romer 1986, 1990). At the time of their onset, or shortly thereafter, disasters destroy firms' tangible assets and human capital, which are often referred to as the direct and contemporaneous impact. The direct impacts can lead to short-term or long-term indirect impacts such as business interruptions following disasters (Botzen, Deschenes, and Sanders 2020). This theoretical prediction on firms is also applicable to banks, implying a negative impact of disasters on banks profitability. Furthermore, when disasters occur, both banks' depositors and borrowers are affected. This potentially leads to decreasing sources of funds for banks (i.e. lower liquidity and capital) and declining quality of credit (i.e. higher credit risk) (Klomp 2014). On the other hand, the creative destruction theory of Schumpeter (1934) suggests that there may be a positive effect of disasters on firms when damaged capital stock is replaced and upgraded to the latest technology following disasters. In the case of banks, banks may benefit from positive spillover effects due to higher demand for loans from firms and households during the recovery process (Kousky 2014). Accordingly, in line with this creative destruction theory, disasters impact could be positive.

As previously stated, theoretical models such as the Input-Output and Computable General Equilibrium models suggest that foreign capital could be another source of ex-post recovery as substitution for the destructed capital stocks (Botzen, Deschenes, and Sanders 2020). Historically, inflows of remittances and foreign aid have played an important role in supporting the recovery process (Ebeke and Combes 2013; Strobl, Ouattara, and Kablan 2020) while private foreign capital (such as bank lending and equity) seems to experience 'capital flight' following natural disasters (Yang 2008; David 2011). Evidence of private foreign capital withdrawal post-disasters contrasts with the fact that foreign banking claims on East Asia have been growing substantially during 1999–2014 (as shown by Figure 2). Hence, there is an outstanding question concerning the moderating role of foreign banking capital for the impact of natural disasters on commercial bank's performance.

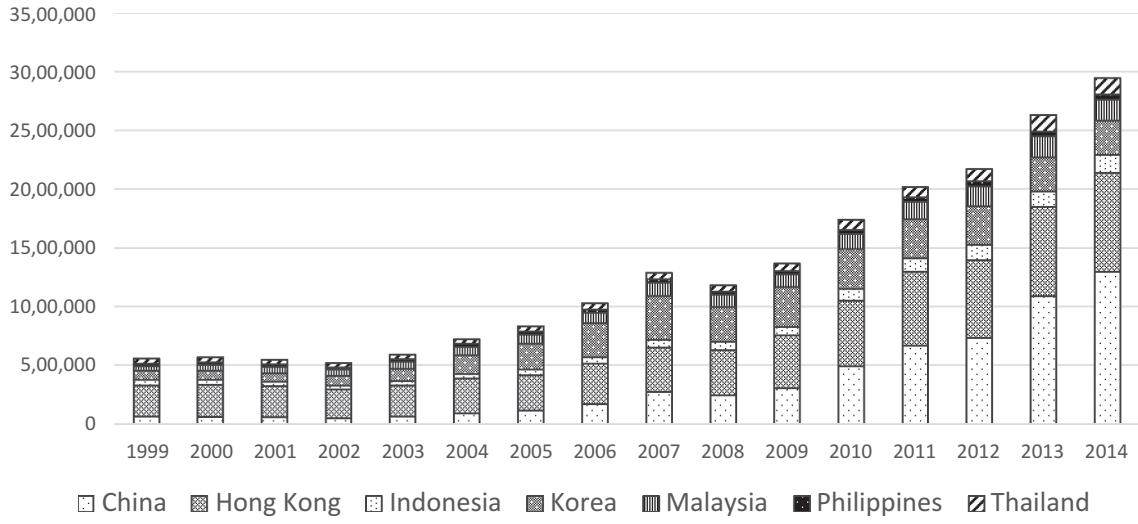

Figure 2. Total foreign banking claims on each country in the sample. Source: BIS Consolidated on Immediate Counterparty basis (CBS-IC), bank type "All excluding 4C banks, excluding domestic position"

This paper examines the impact of natural disasters on a broad range of bank performance measures. Further, it investigates the moderating effect of financial integration on the relationship between natural disasters and bank performance. Finally, it explores whether the moderating role of financial integration varies by the type of integration, classified by the foreign claims' source country and methods of extension.

Specifically, first the paper asks: '*How do natural disasters affect various measures of bank performance, namely deposits ratio, liquidity, credit risk, profitability and default risk?*' Cross-country analyses are rare in the extant literature addressing this question.[1] Discernible prior studies include Klomp (2014) and Brei, Mohan, and Strobl (2019), which both examine the country-level impact of disasters on the aggregated measures of bank performance. Studying the impact of large-scale world-wide natural disasters on financial stability during the period 1997–2010, Klomp (2014) documents the increase in the likelihood of bank default. This study neither provides specific evidence for the East Asian region, nor does it control for the impact of the Asian financial crisis. Investigating the impact of hurricanes on the East Caribbean banking industry during the period 2001–2012, Brei, Mohan, and Strobl (2019) report a reduction in the deposits ratio and other liabilities ratios, suggesting a negative funding shock to banks. This paper augments these studies by examining the impact of all disaster events on bank-level performance in the disaster-prone region of East Asia during 1999–2014, the period following the Asian financial crisis.

Second, the paper explores the moderating role of financial integration and asks: '*How does financial integration moderate the impact of natural disasters on bank performance?*' The literature provides opposing predictions on the moderating role of financial integration on the relationship between natural disasters and bank performance. On the one hand, foreign capital could help to ease financial constraints in host economies by providing access to alternative sources of external financing and compensating for the volatility of domestic credit (Allen et al. 2011). On the other hand, the likelihood of associated international capital outflows (Yang 2008; David 2011) could amplify the impact of disasters on banks. Given these opposing predictions, establishing which of the effects dominates is an empirical question of interest to academic researchers and policymakers alike. To date, there are no empirical studies that examine the moderating role of financial integration on the relationship between natural disasters

[1]Most studies focus on the response of banks around an event window for a specific disaster in one country (i.e. Garmaise and Moskowitz 2009; Nguyen and Wilson 2018; Schüwer, Lambert, and Noth 2018; Koetter, Noth, and Rehbein 2020).

and bank performance. This paper addresses this gap in the literature by using the ratio of the foreign claims for international banks to GDP to proxy for the level of financial integration; and then investigates the significance of the interactions between financial integration and natural disasters.

Finally, this paper decomposes the measure of the total foreign claims based on lenders nationality and methods of extension to investigate the moderating role of each type of financial integration. Specifically, the third research question states: '*Do the foreign claims from "neighbours" moderate the impact of natural disasters on bank performance differently from more distant sources of capital?*' Here the paper adopts two definitions of 'neighbouring' lenders: (i) banks from other Asian countries and (ii) foreign banks presence via a full affiliate office in the recipient countries.

Since natural disasters may destroy information on borrowers and collateral values, lending could be more resilient in the case of lenders who possess informational advantages (Chavaz 2014; Cortés and Strahan 2017). Due to its close proximity to borrowers, Asian (regional) foreign banks face less information asymmetry than non-Asian (distant) lenders (Mian 2006; Claessens and Van Horen 2014). Further, in comparison with cross-border claims, the local claims extended via an affiliate presence involve some forms of foreign direct investment in the host country's financial sector (García-Herrero and Martínez Pería 2007), which serves as a way to acquire 'local' knowledge. The informational advantage means that Asian and local claims are more resilient during natural disasters than their counterparts. This advantage helps to alleviate the consequences of disasters. Despite this expectation being highly intuitive, there is no empirical evidence testing the differential impact of these types of foreign banking claims in the context of natural disasters. The paper addresses this gap in the literature.

The paper constructs an unbalanced sample of commercial banks from seven countries in East Asia (China, Hong Kong, Indonesia, Malaysia, the Philippines, Korea, and Thailand) during the period 1999–2014. The two-step system generalized method of moments (GMM) is used to estimate a dynamic panel data model of bank performance ratios under the impact of disasters. Data for disasters damage are sourced from the Emergency Events Database (EM-DAT). The ratio between the total economic loss caused by all natural disasters in a particular country and a given year to the country's previous year GDP is constructed to proxy for the magnitude of damage of each disaster. Data are sourced from the Consolidated Banking Statistics (CBS) published by Bank for International Settlement (BIS) to construct financial integration measures.

The paper finds that natural disasters significantly lower bank deposits ratio. However, bank liquidity, credit risk, profitability and default risk are not contemporaneously affected by disasters. There is also evidence of a lagged effect of disasters, increasing deposits and lowering liquidity one year after the event. Furthermore, foreign banking claims, specifically those extended by regional Asian lenders, help to alleviate the deposits decline in the aftermath of natural disasters. These baseline findings are mainly driven by severely affected. In short, these findings highlight the resilience of 'neighbouring' claims extended by Asian lenders during local shocks and provides evidence to support intra-regional financial integration.

The rest of this paper is structured as follows. Section II reviews the related literature and introduces our hypotheses. The methodology is presented in Section III. Sections IV and 5 present the descriptive and empirical results, respectively. Section VI provides the additional analyses and Section VII concludes our research.

II. Literature review and hypotheses development

With regard to the first research question, the existing empirical literature generally confirms the negative impact of disasters on various aspects of bank performance. One potential impact of disasters is the lowering of deposits ratios and bank liquidity. In an investigation of how people cope with unexpected losses caused by the 1995 Hanshin-Awaji earthquake, Sawada and Shimizutani (2008) conclude that dis-savings were utilized to compensate for the loss to assets while borrowing was used extensively to recover house damage. Given this household response, tightening bank liquidity is expected in the aftermath of

disasters. This argument has been empirically validated for the case of commercial banks in the Eastern Caribbean islands. Following hurricane strikes, these banks faced deposit withdrawals and experienced a negative funding shock (Brei, Mohan, and Strobl 2019).

Natural disasters could also increase bank credit risk due to the deterioration in payment capabilities of affected borrowers (Klomp 2014). The shortage of funding and the increase in credit losses would reduce profitability. As empirically demonstrated by Noth and Schüwer (2018), the occurrence of natural disasters in the US during 1994–2012 is associated with a higher non-performing assets ratios and lower profitability for two years following a natural disaster.

More seriously, natural disasters could affect bank stability. An empirical cross-country analysis by Klomp (2014) suggests that large-scale natural disasters increase the likelihood of a bank's default in emerging countries during the examined period of 1997–2010. Additionally, Brei, Mohan, and Strobl (2019) also report the significant decline in bank distance to default as a consequence of hurricane strikes on the East Caribbean islands. As noted in section I (see also Figure 1 and Noy (2015)), East Asia is a disaster-prone area, Hypothesis 1 (H1) states: '*Natural disasters negatively affect bank performance measures such as the deposits ratio, liquidity, credit risk, profitability and default risk*'.

The second question examines the moderating role of financial integration in the relationship between disasters and bank performance. On the one hand, generally, foreign capital can ease financial constraints in host economies by providing access to alternative sources of external financing and compensating for the volatility of domestic credit (Allen et al. 2011). Additionally, lending behaviour of foreign banks has been shown to be more resilient during local shocks (De Haas and Van Lelyveld 2006; Arena, Reinhart, and Vázquez 2007) as they have access to liquidity and capital injections from their parent banks (Cetorelli and Goldberg 2012). Therefore, in the aftermath of natural disasters, at the country level, the availability of foreign funds helps to speed up the replenishment of capital stock, allowing countries to quickly respond to the shocks (Noy 2009; Felbermayr and Gröschl 2014). From a bank perspective, it can increase its international borrowings to meet the increase in credit demand and disaster relief (for example, bridging loans for periods of lost business).

On the other hand, a likelihood of severe outflows of international capital, especially banking flows, after a disaster can exacerbate the adverse impact of disasters on bank performance. Some prior empirical evidence shows that bank lending flows are more volatile than equity and FDI flows during financial shocks (Levchenko and Mauro 2007; Eichengreen, Gupta, and Masetti 2018). In the aftermath of natural disasters, Yang (2008) and David (2011) consistently find that private flows (such as bank lending and equity) seem to experience 'capital flight' in contrast to the inflows of foreign aid and remittances. Given these findings, it is clear that there are two competing arguments for the moderating effect of foreign capital on bank performance. On balance, considering the weight of the empirical and theoretical literature Hypothesis 2 (H2) states: *'Greater financial integration alleviates the consequence of natural disasters on bank performance'*.

The third question investigates the moderating role of each type of financial integration. Specifically, based on lenders' nationality, foreign banking claims are extended either by Asian neighbours or by distant non-Asian lenders. Considering methods of loan extension, foreign claims may be extended via local affiliates set up by international banks in the recipient countries or by international banks across borders.

The occurrence of natural disasters may destroy information on borrowers and collateral values. Banks that have an advantage in generating tacit information can process this soft information so that they can better distinguish between good and bad credit prospects following a disaster and can therefore maintain or even increase their lending to (selected) affected customers. Several studies such as Chavaz (2014) and Cortés and Strahan (2017) conclude that this informational advantage belongs to the local and small banks. In the context of foreign banking claims, the informational advantage arguably belongs to the 'neighbours' foreign banks, which could be either (i) banks from other Asian countries or (ii) foreign banks presence via a full affiliate office in the recipient countries. In the

former case, the information advantage of regional lenders results from their familiarity with the cultural, legal, political, and economic environments of the recipient countries (Mian 2006; Claessens and Van Horen 2014). In the latter case, the local claims extended via an affiliate presence of an international bank involves some form of foreign direct investment in the host country's financial sector (García-Herrero and Martínez Pería 2007), which could be synonymous to 'local' knowledge acquisition. Additionally, the local claims are funded primarily by local deposits (Cerutti 2015); hence, the local claims could be less volatile than cross-border counterparts. In short, the Asian claims and local claims are expected to be more resilient during natural disasters. Accordingly, the two following hypotheses are developed. Hypothesis 3 (H3) states: '*Foreign claims extended by Asian lenders, as distinct to non-Asian lenders, alleviate the consequence of natural disasters on bank performance*'., and Hypothesis 4 (H4) states: '*Foreign claims extended via local affiliates of international banks, as distinct from cross-border flows, alleviates the consequence of natural disasters on bank performance*'.

III. Research methodology

Model specification

In this section, we employ Equation (1) to examine the contemporaneous impact of disasters on bank performance. We relied on the established literature on the determinants of bank performance (i.e. Berger et al. 2000; Laeven and Levine 2009; Nguyen et al. 2021) to construct a dynamic panel data model as well as a set of relevant control variables. Given the theoretical framework presented in Section I, the impact disasters (i.e. DAMAGE) is included in Equation (1) as an exogenous shock. Additionally, as disasters could exert both short-term and long-term effects, in Equation (1), we first analyse the short-term and contemporaneous relationships. The long-term impact is further discussed in Section 6.2.

$$\begin{aligned} \text{Yijt} = {} & \beta 0\text{Yijt} - 1 + \beta 1\text{DAMAGEjt} + \beta 2\text{INTEGjt} \\ & + \beta k\text{BANKk ijt} + \beta m\text{COUNTRYm jt} + \theta \text{ i} \\ & + \gamma \text{ j} + \mu \text{ t} + \varepsilon \text{ijt} \end{aligned} \tag{1}$$

In this specification, Y_{ijt} is the dependent variable (DEPO-deposits ratio, LIQ liquidity, CRERISK credit risk, ROA profitability and LN(zscore) distance-to-default) for bank *i* in country *j* at time *t* (see Table 1 for detailed definition and construction of all variables). Y_{ijt} is written as a function of its past level (Y_{ijt-1}), disaster damage (DAMAGE), financial integration (INTEG), a vector of *k* bank level variables reflecting the characteristics of each bank *i* (BANK), and a vector of *m* variables reflecting the macroeconomic condition to all banks including bank regulation and supervision (COUNTRY) for any given country *j*. θ_i is the bank-specific fixed effect to control for unobserved factors that do not change over time for each bank. γ_j and μ_t is the country- and time- dummy variables, respectively; ε_{ijt} is the error term. The coefficient of interest is β_1 reflecting the relation between bank response and contemporaneous shocks from disasters occurring in year *t*.

To study the moderating role of financial integration on the relationship between natural disasters and bank performance (H2), the paper retains the model and variables specification in Equation (1), and includes the interaction term created by multiplying the measures of financial integration and disasters impact:

$$\begin{aligned} \text{Yijt} = {} & \beta 0\text{Yijt} - 1 + \beta 1\text{DAMAGEjt} + \beta 2\text{INTEGjt} \\ & + \beta 3\text{DAMAGEjt} * \text{INTEGjt} \\ & + \beta k\text{BANKk ijt} + \beta m\text{COUNTRYm jt} + \theta \text{ i} \\ & + \gamma \text{ j} + \mu \text{ t} + \varepsilon \text{ ijt} \end{aligned} \tag{2}$$

To test H3 and H4, Equation (2) is estimated with the specific measure for each type of foreign banking claims replacing the aggregate measure INTEG.

Estimation method

The empirical analysis employs the two-step System GMM developed by Arellano and Bover (1995) and Blundell and Bond (1998) with finite-sample corrected standard errors as proposed by Windmeijer (2005). The GMM accommodates for possible endogeneity between bank default risk and other covariates in the model, which could affect

Table 1. Definition and specification of variables.

Variables	Definition	Data Source
Dependent Variable		
DEPO	Deposits ratio = total customers deposits/total assets (%)	Bankscope
ROA	Profitability = Net Income/Total assets (%)	Bankscope
CRERISK	Credit risk = Non-Performing loans/Gross loans (%)	Bankscope
LIQ	Liquidity = Liquid assets/deposits and short-term funding (%)	Bankscope
LN(zscore)	Natural logarithm of bank Z-SCORE. Z-SCORE is equal to [ROA+ (Total Equity/Total assets)]/[Std. (ROA)]. The Std. (ROA) is calculated over a three-year rolling window.	Bankscope
Bank-level control variables		
SIZE	Natural logarithm of total assets	Bankscope
CAP	Equity ratio = total equity/total assets (%)	Bankscope
INC_DIV	Income diversification = (non-interest income/total income) (%)	Bankscope
COST	Overhead cost = Total non-interest operating expenses/total assets (%)	Bankscope
CHARTER	Charter value = Customer demand deposit/total assets (%)	Bankscope
LOANS	Loans to assets = gross loans/total assets (%)	Bankscope
CON	Market concentration =top 3 largest banks assets/total banks assets (%)	Bankscope
ODUM	Foreign ownership equal 1 otherwise	Claessens and Van Horen (2015)
Variables of interest		
DAMAGE	Economic loss caused by all disasters = Economic losses of all events in one country in a given year/a country's last year GDP	EM-DAT
CLAIM	Foreign claims of international banks to GDP of a country (%)	CBS- Immediate Counterparty
ASIAN	Foreign claims extended by international banks in Asia/GDP (%)	CBS IC
NON_ASIAN	Foreign claims extended by international banks in NON- Asian countries/GDP(%)	CBS IC
CROSS	Foreign claims extended across border by international banks/GDP (%)	CBS Ultimate Risk
LOCAL	Foreign claims extended via foreign branches of international banks/GDP (%)	CBS- UR
Country control variables		
IFL	Inflation rate = $(CPI_t–CPI_{t-1})/CPI_t$ (%)	GFD-WB
GDP	GDP growth rate = $(GDP_t- GDP_{t-1}/GDP_{t-1}$ (%)	GFD-WB
PRICRE	Private credit to GDP =Bank credit to private sector/GDP (%)	GFD-WB
INT	Real interest rate (%)	World Development Indicator (WDI-WB)
CRISIS	Dummy variable that takes a value of 1 for the year of the financial crisis	Laeven and Valencia (2012)
INS	Dummy to proxy for the deposit insurance coverage of a country: takes a value of 1 when the country has explicit deposit insurance and 0 otherwise	Demirgüç-Kunt, Kane, and Laeven (2014)
ACT	Overall restrictions on banking activities index measures the degree to which banks are allowed to engage in securities, insurance, real estate investment, and ownership of non-financial firms. Higher values indicate more restrictiveness.	Barth, Caprio, and Levine (2013)
SUP	Supervisory power index measures if the supervisory authorities have the authority to take specific actions to prevent and correct problems. Higher value denotes that supervisory agencies are authorized more oversight power.	Barth, Caprio, and Levine (2013)
PRIMON	Private monitoring index measures the degree of private monitoring which requires banks to release accurate and comprehensive information to the public. Higher value indicates greater regulatory empowerment of the monitoring of banks by private investors.	Barth, Caprio, and Levine (2013

the interpretation of the empirical results. For instance, contemporaneous bank-level regressors ($BANK_{ijt}$) are treated as being endogenous. Financial integration ($INTEG_{jt}$) and bank regulation and supervision variables are treated as being predetermined. Disaster damage ($DAMAGE_{jt}$) is treated as an exogenous variable as the occurrence of natural disasters are exogenous shocks to bank performance. Finally, other macro-economic variables, time dummies and country dummies are treated as exogenous variables.

Several pre- and post-tests are carried out to ensure the GMM estimation. The pre-tests include a Fisher test for the time series stationarity, the Durbin-Wu-Hausman (DWH) test for endogeneity of bank-level control variables. The post-tests are the second-order Arellano-Bond (i.e. the AR(2)) autocorrelation test, the Hansen J-statistics test for the joint validity of the full instrument set, and the Difference-in-Hansen test for the validity of the subset of instruments.

Variables

The measurement of disaster damage

Data for disasters damage are sourced from EM-DAT which is collected by the Centre for Research on the Epidemiology of Disasters (CRED). The EM-DAT database has a world-wide coverage; the

earliest events were recorded from 1900. This explains why it has been the most popular source of data for disaster damage to date in the literature (Noy 2009).

The EM-DAT database publishes three measures of disaster damage, which could serve as proxies for the magnitude of the disaster. They are (i) the number of people killed, (ii) the number of affected population and (iii) the amount of direct damage (measured in U.S. dollars). The paper uses the last measure, specifically the economic loss caused by all disaster events. When damages from all events are aggregated, the measure could reflect both magnitude and frequency of disasters. The economic loss, then, is aggregated at the country level and annual level. Finally, following Noy (2009), the disaster damage variable (DAMAGE) is constructed as the ratio of the total economic loss to the country prior year GDP. In short, DAMAGE represents the total economic loss caused by all disasters in a particular country, in a given year, and scaled by the country's prior year GDP.

Financial integration variables

To address research questions 1 and 2 (i.e. the H1 and H2), an overall measure of financial integration is constructed based on the foreign claims extended by international banks to the sampled (recipient) countries. The statistics are sourced from the Consolidated Banking Statistics (CBS) on Intermediate Counterparty basis (IC) published by the Bank for International Settlement (BIS).[2] In detail, foreign claims are reported in their outstanding amount (in million USD) on a quarterly basis. The paper constructs the annual claims by using the stock data on the last quarter of each year in the sampled period. Bilateral claims of a source-recipient country pair are then aggregated by the recipient country. After these steps, the year- and country-level claims on each of the sampled countries are obtained. As these claims are extended by all lenders regardless of their nationality or methods of extension, the obtained value of claims after all these steps is regarded as the total foreign claims. The total foreign claims is then scaled by the GDP of the corresponding sampled (recipient) countries (CLAIM). CLAIM is relevant to assess the size of the international banking activities of one country in comparison with its GDP; higher values of CLAIM are associated with more participation in the international banking market and greater financial integration.

Research question 3 and H3 specifically test the moderating role of the foreign claims classified by lenders nationality. To do so, the total foreign claims measure is classified by the nationality of the lenders to compute the foreign claims extended by Asian banks (or Asian claims, for short) and the foreign claims extended by non-Asian banks (or non-Asian claims, for short).[3] These statistics are then scaled by the GDP of the sampled countries (to construct ASIAN and NON_ASIAN, respectively). The break-down by nationality reflects the difference not only in geographic location but also in the source country characteristics, including culture and institutional quality.

H4 investigates the foreign claims broken-down by the methods of extension. The data for this break-down are sourced from the CBS on Ultimate Risk basis (CBS-UR) rather than the CBS-IC, as the latter does not provide a clear-cut distinction between cross-border claims and local claims. In a similar approach to earlier, measures of cross-border claims and local claims are scaled by the GDP of the sampled countries (to obtain CROSS and LOCAL, respectively).[4]

Bank-level variables

The paper examines the impact of natural disasters on several aspects of bank performance, specifically deposits ratio (DEPO), liquidity (LIQ), credit risk (CRE), profitability (ROA), and default risk (LN(zscore)). In line with the extant literature on the determinants of bank risks and profitability (such as Athanasoglou, Brissimis, and Delis 2008; Laeven and Levine 2009; Ghosh 2015; Brei, Mohan, and Strobl 2019), standard explanatory variables are included in Equation (2). For instance, Athanasoglou, Brissimis, and Delis (2008) found that higher capitalization, lower credit risk, higher

[2]See Appendix 1 for a detailed discussion of this data.
[3]Asian source countries include Australia, Chinese Taipei, Hong Kong SAR, India, Japan, (South) Korea, and Singapore. Non-Asian lenders mainly include European and North American advanced countries, such as the US, UK, Germany, France, etc. (see Appendix 1).
[4]See Appendix 2 for the difference in the available time periods and reporting basis between CBS-IC and CBS-UR.

operating efficiency, and lower market concentration are associated with higher banks profitability. Additionally, macro-economic factors such as inflation rate and interest rate positively affect banks profitability. Findings from Ghosh (2015) suggest several internal determinants of bank credit risks such as bank size, capitalization, cost efficiency, loans to assets ratio, and income diversification. Laeven and Levine (2009) emphasize the importance of controlling for deposit insurance coverage as well as bank regulation and supervision scheme on studying determinants of banks default risks. Table 1 provides the detailed definition and construction of all variables.[5]

Bank sample

The study examines an unbalanced sample of 2,219 commercial bank-year observations (379 banks) from seven countries in East Asia (China, Hong Kong, Indonesia, Malaysia, the Philippines, Korea, and Thailand) over the period 1999–2014. Bank-level data are obtained from Bankscope. [6]Banks with less than three consecutive years of available financial data for all bank-specific variables are excluded. All bank-level data are winsorized at the top and bottom 0.5% percentile.

IV. Descriptive statistics

Table 2 presents the descriptive statistics of all variables included in the regression. The measures of bank performance LN(zscore), CRERISK, LIQ, ROA and DEPO contain a wide range of values, highlighting the substantial variation in performance across banks in the sampled period.

The ratio of disaster loss to GDP (DAMAGE) has a mean of 0.46 and standard deviation of 1.52. It is clear that majority of events have a small-scale impact with economic losses being lower than 1% GDP. Figure 3 graphs DAMAGE for each sampled country. China, Indonesia, the Philippines, and Thailand experienced more damaging disasters while Korea, Hong Kong and Malaysia suffer losses to a lesser extent.

Table 3 reports the Pearson pairwise correlation coefficients. Overall, the bank-level variables and macro-economic variables are found not to be highly correlated with each other, implying that the joint inclusion of these variables is unlikely to lead to concerns about multi-collinearity (confirmed by low Variance Inflation Factor (VIF) statistics of all models run as reported at the end of Table 4).

V. Empirical results

Impact of natural disasters on bank performance ratios

Table 4 presents the impact of natural disasters on various measures of bank performance to test H1. Several pre- and post-estimation tests are also reported at the end of this table.[7] With regard to pre-diagnostic tests, the DWH test for endogeneity confirms the endogenous relationship between bank-level covariates and the dependent variable. With regard to the post-estimation tests, the AR(2) test is statistically insignificant, confirming the absence of the second-order serial correlation. The high p-values for the Hansen J-statistics and the Difference-in-Hansen tests suggest that the full set of instruments and each subset of instruments are valid (for a detailed list of instruments please refer to the note in Table 4).[8,9]

Moving to the impact of disasters on bank performance, as seen in column 1 of Table 4, disasters significantly lower deposits ratio. The result is consistent with evidence of deposit withdrawal in the small Eastern Caribbean islands following disasters found in Brei, Mohan, and Strobl (2019). The finding implies that depositors in East Asian countries withdraw cash from banks to cope with losses.

[5]See point 1 in Appendix 3- Methodological notes.
[6]The paper examines the moderating role of financial integration on the relationship between disasters and bank performance in the East Asian region. As presented in Section I, those countries are among the most vulnerable to natural hazards. Additionally, those sampled countries are integrating further into the global financial markets, with China standing out as the newly emergent key player in the international banking markets (World Bank 2018; Nguyen et al. 2021). Other countries are pro-actively promoting intra-regional integration with several cooperative initiatives (Asian Development Bank 2008). These features highlight the sampled countries as an important group to examine and are an ideal match with the research focus of the paper.
[7]See point 2 in Appendix 3- Methodological notes.
[8]See point 3 in Appendix 3- Methodological notes.
[9]We also employ the Difference-GMM developed by Arellano and Bover (1995) as a robust check. The results remain quantitatively unchanged and provided in Appendix 4.

Table 2. Descriptive statistics.

	Mean	Std.	Min	Max	N
LN(zscore)	3.642	1.228	−2.377	7.895	2,219
LIQ (%)	31.197	22.592	4.230	133.590	2,219
CRERISK (%)	5.399	9.171	0.010	70.780	2,219
ROA (%)	1.115	1.132	−8.970	8.840	2,219
DEPO (%)	69.547	15.732	14.374	93.270	2,219
CAP (%)	10.204	7.214	1.520	81.300	2,219
INC_DIV (%)	13.722	10.456	0.100	69.444	2,219
COST (%)	1.962	1.614	0.050	23.423	2,219
CHARTER	32.692	24.891	0.153	100.000	2,219
LOANS (%)	53.927	16.407	0.493	99.210	2,219
CON (%)	43.599	7.274	29.789	78.151	2,219
IFL (%)	4.204	3.218	−3.953	20.489	2,219
GDP(%)	13.068	10.443	−13.044	47.368	2,219
PRICRE (%)	91.278	47.153	19.909	233.663	2,219
INT (%)	3.016	3.524	−3.903	13.347	2,219
ACT	8.687	2.416	3.000	12.000	2,080
SUP	12.261	2.612	7.000	16.000	1,126
PRIMON	9.437	1.085	7.000	11.000	1,785
DAMAGE (%)	0.464	1.521	0.000	17.053	2,219
CLAIM (%)	25.043	33.933	3.357	290.071	2,219
ASIAN(%)	4.431	0.644	5.762	50.360	2,219
NON_ASIAN	14.148	1.718	24.155	189.181	2,219
LOCAL (%)	13.071	1.446	25.906	186.572	1,673
CROSS (%)	7.443	1.761	6.891	50.262	1,673

The table reports descriptive statistics for the variables used in the empirical analysis. There are 2,219 bank-year observations (about 379 banks) for seven sampled countries (including China, Hong Kong, Indonesia, Malaysia, the Philippines, Korea, and Thailand) during 1999–2014. For the definition and construction of the variables, see Table 4.1. Mean refers to the average value for each variable. Std. refers to standard deviation. Min and Max are the minimum and maximum observations for each variable in the sample. N refers to the number of observations.

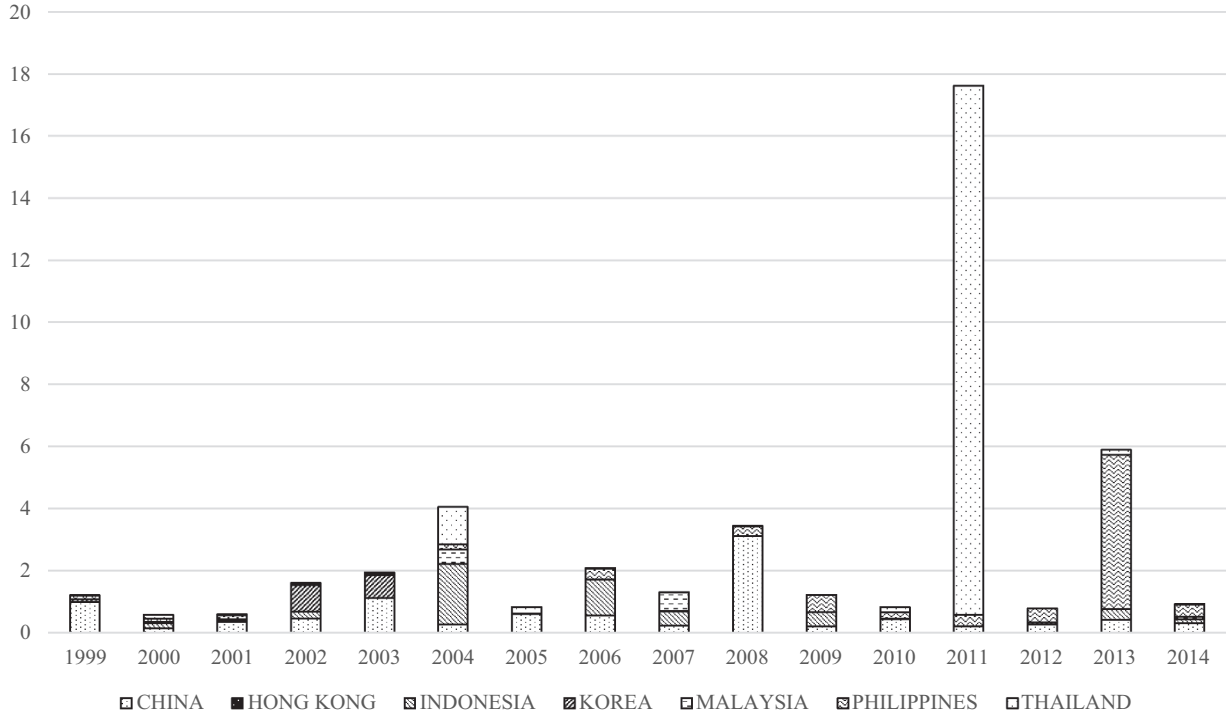

Figure 3. DAMAGE (%) for each country in the sample.

Skidmore (2001) reports that there is a higher propensity to save money in disaster vulnerable countries. This is certainly the case for the sample of East Asian countries in this study; many of whom have experienced substantial losses from disasters (as shown in Figure 1). Deposit withdrawals triggered by catastrophic events is a form of self-insurance and is essential in countries where the insurance markets cannot provide a sufficient level of protection against possible disaster losses

(Nguyen and Wilson 2018). In terms of economic impact, a one percentage point increase in DAMAGE is associated with 0.7% point decrease in deposits ratio.[10]

Columns 2 to 5 of Table 4 report no significant impact of disasters on liquidity (LIQ), credit risk (CRERISK), profitability (ROA), and default risk (LN(zscore)). This is contrary to the prior evidence of a lower profitability and credit quality in the US sample (Noth and Schüwer 2018), a tighten liquidity in the Caribbean sample (Brei, Mohan, and Strobl 2019) and a higher bank default risk in the world-wide sample (Klomp 2014). This result should be interpreted with caution. In the context of the dynamic model, the result indicates that these ratios do not show a *contemporaneous* response towards natural disasters. Furthermore, the regression approach provides an assessment of an overall condition, i.e. central tendency or 'on average'. In this sense, the negative impact will not be detected unless all banks (or a large number of them) are impacted.

Explaining from banking perspectives, the Asian banking system has undergone important reforms following the Asian financial crisis (Asian Development Bank 2008). Examining the period of 1999–2014, the paper possibly captures the positive impact of these reforms via the banking system's resilience against disasters. Additionally, it has been shown that banks that belong to a geographically diversified banking group are better able to withstand the adverse impact of disasters (Koetter, Noth, and Rehbein 2020). Thus, the insignificant impact of disasters on several bank ratios may be due to bank lending diversification (by sectors and regions). Overall, H1 is accepted for the deposits ratio only.

The moderating role of financial integration and its components

Table 5 presents the baseline result on the moderating role of financial integration to address H2 (see Section II). Table 5 also explores the variation of this moderating role that can be attributed to the lenders' nationality (Asian claims vs non-Asian claims as articulated in H3) and the methods of extension (local claims vs cross-border claims as per H4).[11]

As seen in Column 1, the coefficient of the interaction term between CLAIM and DAMAGE is significant and positive, indicating that the total foreign banking claims help to alleviate the bank deposits decline during the aftermath of disasters. The result implies that foreign banking claims serve as an alternative source of finance (in addition to banks deposits) to support the post-disaster recovery of households and firms. Overall, the evidence strongly supports H2.

Columns 2 and 3 present the evidence of the moderating effect of foreign claims extended by Asian and non-Asian lenders. As seen in Column 2, the coefficient for the interaction term between ASIAN and DAMAGE is significant and positive. This is in contrast to the insignificance of Non-Asian claims found in Column 3. The significant Asian interaction term suggests that Asian claims help to alleviate the decline in bank deposits ratio following disasters. The result lends support to H3 and favours the 'neighbouring' claims extended by the Asian lenders.

Columns 4 and 5 provide the result when the total foreign banking claims are classified into local claims and cross-border claims. The coefficient for the interaction term between LOCAL and DAMAGE reported in Column 4 is positive as expected; however, the standard error is quite large, making the coefficient insignificant. This could be due to the lack of variation in the response of local claims to natural disasters. The coefficient of the interaction term between CROSS and DAMAGE given in column 5 is also insignificant. Overall, the evidence on the moderating role of both local and cross-border claims is unclear, leading to the rejection of H4.

VI. Additional analyses

Sub-sample analysis of severely versus lightly-affected countries

It is reasonable to expect that the impact of disasters on bank performance is likely to be more

[10]The interpretation is more meaningful in the context of specific disasters. For instance, the Sichuan earthquake in 2008 (China) with reported DAMAGE of 3.1% GDP is associated with a 2.17% points (pp) reduction in the deposits ratio. The Haiyan cyclone in 2013 (the Philippines) with DAMAGE of 4.9% results in a reduction of 3.5 pp in the deposits ratio. The 2011 flooding in Thailand with resulting DAMAGE of 17% leads to a reduction of 12.7 pp in the deposits ratio.
[11]See point 4 in Appendix 3- Methodological notes.

Table 3. The pair-wise correlation among variables.

	ZSCORE	LIQ	CRERISK	ROA	DEPO	CAP	INC_DIV	COST	CHARTER	LOANS	CON	DAMAGE	CLAIM	IFL	GDP	PRICRE	INT	ACT	SUP	PRIMON
ZSCORE	1.00																			
LIQ	−0.02	1.00																		
CRERISK	−0.23*	0.17*	1.00																	
ROA	0.11*	0.14*	−0.17*	1.00																
DEPO	−0.01	−0.27*	−0.07*	−0.03	1.00															
CAP	0.15*	0.42*	0.18*	0.20*	−0.46*	1.00														
INC_DIV	−0.03	0.25*	0.15*	0.16*	−0.23*	0.25*	1.00													
COST	−0.18*	0.07*	0.23*	0.03	0.05*	0.21*	0.11*	1.00												
CHARTER	0.09*	0.14*	−0.02	0.04*	0.09*	−0.13*	−0.08*	−0.25*	1.00											
LOANS	−0.01	−0.57*	−0.06*	0.00	0.01	0.00	−0.21*	0.12*	−0.21*	1.00										
CON	−0.12*	0.08*	0.09*	0.02	0.17*	−0.03	−0.05*	0.00	0.16*	−0.04*	1.00									
DAMAGE	0.05*	−0.07*	−0.04	−0.04	−0.14*	0.05*	0.03	−0.05	−0.11*	0.09*	−0.03	1.00								
CLAIM	0.01*	0.13*	0.00	0.03	−0.06*	0.09*	0.26*	−0.06*	−0.20*	−0.08	0.29*	0.05*	1.00							
IFL	−0.16*	0.18*	0.07*	0.18*	0.11*	0.15*	−0.08*	0.30*	−0.12*	−0.03*	0.22*	−0.06*	−0.14*	1.00						
GDP	−0.07*	0.07*	−0.01	0.06*	0.12*	−0.09*	−0.14*	−0.06*	0.22*	−0.11	0.09*	−0.01	−0.23*	0.26*	1.00					
PRICRE	0.19*	−0.18*	−0.26*	−0.19*	−0.09*	−0.24*	−0.11*	−0.54*	0.24*	0.01*	−0.14*	0.15*	0.27*	−0.61*	−0.10*	1.00				
INT	−0.05*	0.02	0.12*	−0.01	−0.01	0.08*	0.06*	0.15*	−0.18*	0.01	0.11*	−0.10*	0.11*	0.05*	−0.43*	−0.17*	1.00			
ACT	−0.03	−0.06*	−0.16*	−0.01	0.11*	−0.16*	−0.42*	−0.24*	0.36*	0.04	0.02	−0.03	−0.55*	0.16*	0.45*	0.14*	−0.40*	1.00		
SUP	0.00	0.17*	−0.07*	0.14*	0.00	0.19*	−0.02	0.10*	−0.11*	0.00	−0.15*	0.02	−0.12*	0.31*	0.31*	−0.32*	−0.28*	0.52*	1.00	
PRIMON	0.00	−0.22*	−0.26*	−0.15*	−0.01	−0.19*	−0.24*	−0.26*	0.27*	0.25*	−0.12*	0.02	−0.27*	−0.15*	0.16*	0.29*	−0.13*	0.37*	0.04	1.00

The table reports the Pearson rank correlation coefficients among variables. * indicate statistical significance at the 5% level.

Table 4. Impact of disasters on bank performance ratios.

	(1) DEPO	(2) LIQ	(3) CRERISK	(4) ROA	(5) LN (zscore)
L.Y	0.694***	0.443***	0.683***	0.303***	0.408***
	(0.06)	(0.10)	(0.10)	(0.07)	(0.05)
CAP	0.197*	0.582**	−0.218*	0.018	0.061***
	(0.12)	(0.27)	(0.13)	(0.02)	(0.02)
CRERISK	0.108*	0.229*		−0.004	−0.005
	(0.06)	(0.13)		(0.01)	(0.01)
INC_DIV	−0.079	0.199	0.192*	0.008	−0.023*
	(0.10)	(0.15)	(0.11)	(0.01)	(0.01)
COST	−0.579	−0.033	−0.021	−0.131	−0.167**
	(0.72)	(1.06)	(0.34)	(0.15)	(0.08)
ROA	2.414**	−0.438	0.749		0.105
	(1.00)	(1.83)	(0.79)		(0.10)
LOANS	0.013	−0.638***	0.115**	0.012	
	(0.07)	(0.18)	(0.05)	(0.01)	
CHARTER			0.113**	0.007	0.006
			(0.05)	(0.02)	(0.01)
CON	−0.606	−0.254	−0.242	0.131*	0.087*
	(0.44)	(0.37)	(0.22)	(0.07)	(0.05)
IFL	−0.055	0.643	0.226	0.035	−0.025
	(0.24)	(0.47)	(0.18)	(0.04)	(0.04)
GDP	−0.090	0.359*	0.034	−0.009	−0.028*
	(0.09)	(0.19)	(0.08)	(0.02)	(0.02)
PRICRE	0.191	0.410*	0.035	−0.055*	−0.052**
	(0.12)	(0.23)	(0.10)	(0.03)	(0.02)
INT	−0.025	0.736**	0.136	−0.020	−0.041*
	(0.18)	(0.30)	(0.12)	(0.03)	(0.02)
INS	9.344***	8.890*	−0.178	−1.441*	−0.553
	(2.81)	(4.61)	(2.02)	(0.77)	(0.54)
DAMAGE	−0.720**	−0.207	−0.171	0.060	0.034
	(0.28)	(0.35)	(0.15)	(0.04)	(0.03)
CLAIM	−0.195	−0.237	−0.122	0.072**	0.079***
	(0.21)	(0.27)	(0.14)	(0.03)	(0.03)
ACT	0.592	1.798	−1.044	0.164	0.306**
	(1.32)	(1.48)	(0.80)	(0.15)	(0.15)
SUP	−0.627	−3.538**	0.705	0.193	0.139
	(0.57)	(1.46)	(0.48)	(0.15)	(0.12)
PRIMON	−3.862	−2.880	−0.188	0.728	0.790**
	(2.62)	(2.58)	(1.63)	(0.45)	(0.35)
ODUM	−3.645**	−0.868	−0.224	−0.160	−0.087
	(1.52)	(1.80)	(0.79)	(0.20)	(0.11)
CRISIS	5.849	12.165	6.968	−2.761*	−1.695*
	(8.09)	(7.91)	(5.05)	(1.49)	(1.01)
Constant	69.839	46.556	4.606	−12.158	−8.760
	(44.76)	(38.20)	(24.88)	(7.45)	(5.36)
#Obs.	810	810	810	810	810
# banks.	194	194	194	194	194
# IV	95	103	103	103	103
AR(2) test (p value)	0.196	0.876	0.168	0.101	0.504
Hansen-J test (p value)	0.653	0.164	0.862	0.494	0.465
Diff-In-Hansen test (p value):					
GMM instruments for level	0.620	0.161	0.742	0.763	0.368
GMM instruments for the lagged dependent var.	0.673	0.128	0.89	0.689	0.633
GMM instruments for endogenous bank-level var.	0.684	0.129	0.756	0.609	0.375
GMM (IV) instruments for regulation and financial integration var.	0.796	0.38	0.827	0.318	0.512
IV instruments for other exogenous var.	0.664	0.256	0.935	0.742	0.444
DWH endogeneity test	0.00	0.00	0.00	0.00	0.00
Mean (maximum) VIF	2.23 (4.34)	2.23 (4.34)	2.24 (4.39)	2.25 (4.36)	2.24 (4.39)

The table presents the impact of disasters on various bank ratios as in Equation (1): $Y_{ijt} = \beta_0 Y_{ijt-1} + \beta_1 DAMAGE_{jt} + \beta_2 INTEG_{jt} + \beta_k BANK^k_{ijt} + \beta_m COUNTRY^m_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt}$ (1).

The dependent variables are ratios of deposits (DEPO), liquidity (LIQ), credit risk (CRERISK), and distance to default (LN(zscore)). Disaster damage is proxied via the ratio of economic loss to a country's previous year GDP (DAMAGE). For the definition and construction of other control variables, see Table 1. Bank fixed effect, country and time dummies are included, but not reported to save space.

All models are estimated by the system GMM. For the dependent variable and endogenous bank-level control variables, their second and third lagged values are used as instruments in the transformed equation and the first lag of their differenced values are used as instruments in the level equation. Financial integration (CLAIM) and regulation variables (ACT, SUP and PRMON) are treated as pre-determined variables in all the cases except for deposits ratio (DEPO) in column 1, where they are treated as exogenous variables. For these pre-determined variables, their first and second lagged values are used as instruments in the transformed equation; their differenced values are used as instruments in the level equation. Other variables (including disaster damage (DAMAGE) and other country-level control variables) are treated as exogenous ones. Accordingly, their differenced values are used as instruments in the transformed equation; their level values are used as instruments in the level equation. *Collapse* option are used in specifying instruments for the endogenous and predetermined variables. As there are gaps in the sample panel, the forward orthogonal deviations transform (*orthogonal* option) is used instead of first differencing to maximize the sample size. *Twostep* along with the *robust* option is used to obtain the finite sample corrected two-step covariance matrix following Windmeijer (2005) correction. *Small* option is to adjust the estimates for small-sample and report t-statistics instead of z-statistics.

Insignificant value of AR(2) tests confirm the absence of the serial correlation in the second order. Similarly, insignificant value of Hansen J-statistics test and Difference-in-Hansen test ensures the validity of the instruments. The robust standard errors are reported in the parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

Table 5. The moderating of financial integration and its forms on the impact of disasters on deposits ratio.

	(1) DEPO	(2) DEPO	(3) DEPO	(4) DEPO	(5) DEPO
L.Y	0.699***	0.709***	0.695***	0.725***	0.684***
	(0.06)	(0.06)	(0.07)	(0.11)	(0.09)
DAMAGE	−6.739***	−3.725**	−1.573	−3.782*	−0.765
	(1.68)	(1.53)	(0.98)	(2.10)	(3.59)
CLAIM	−0.599**				
	(0.26)				
DAMAGE_CLAIM	0.243***				
	(0.06)				
ASIAN		−0.698**			
		(0.29)			
DAMAGE_ASIAN		0.294*			
		(0.16)			
NON_ASIAN			0.061		
			(0.44)		
DAMAGE_NONASIAN			0.121		
			(0.11)		
LOCAL				−0.971**	
				(0.48)	
DAMAGE_LOCAL				0.189	
				(0.14)	
CROSS					−0.196
					(0.41)
DAMAGE_CROSS					0.026
					(0.61)
Control variables	Yes	Yes	Yes	Yes	Yes
#Obs.	810	810	810	589	589
# banks.	194	194	194	148	148
# IV	96	96	96	75	75
AR(2) test (p value)	0.191	0.172	0.120	0.209	0.18
Hansen-J test (p value)	0.738	0.665	0.590	0.674	0.552
Diff-In-Hansen test (p value):					
GMM instruments for level	0.816	0.804	0.674	0.888	0.868
GMM instruments for the lagged dependent var.	0.791	0.510	0.527	0.543	0.317
GMM instruments for endogenous bank-level var.	0.717	0.869	0.626	0.97	0.941
IV instruments for regulation and financial integration var.	0.905	0.664	0.874	0.802	0.57
IV instruments for other exogenous var.	0.751	0.791	0.521	0.94	0.809

The table presents the moderating role of financial integration (i.e. CLAIM) and its various forms (i.e. ASIAN, NON_ASIAN, LOCAL and CROSS) on the impact of disasters on bank deposits ratio as in Equation (2): $Y_{ijt} = \beta_0 Y_{ijt-1} + \beta_1 DAMAGE_{jt} + \beta_2 INTEG_{jt} + \beta_3 DAMAGE_{jt} * INTEG_{jt} + \beta_k BANK^k_{ijt} + \beta_m COUNTRY^m_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt}$ (2). The dependent variables is the ratio of customers deposits to total assets (DEPO). Disaster damage is proxied via the ratio of economic loss to a country's last year GDP (DAMAGE). Other variables and the system GMM model specification remains unchanged from Table 4. The robust standard errors are reported in the parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.

pronounced among severely- affected countries (Klomp 2014). To test this conjecture, we split the sampled countries into two groups. Specifically, the severely- affected countries are classified to have its DAMAGE being greater than the median level of DAMAGE constructed from all countries within the same year, and otherwise. Then we estimate Equation (1) and (2) for these two sets of countries separately. The results are presented in Table 6.

Panel A presents the impact of disasters on bank performance for the two sub-sample. Across this panel, only the coefficient of DAMAGE on deposits ratio is negative and significant at 10% level under the highly- affected group in Column 6. Panel B documents the moderation impact of financial integration and its various forms. As seen in Column 6 and 7, the coefficients of the interaction terms between CLAIM and DAMAGE as well as between ASIAN and DAMAGE are positive and significant again only under the highly- affected group. These findings are congruent to Section V's and further suggest that our baseline results are mainly driven by the severely- affected countries.

The one-year lagging impact of past disasters

The economics of disasters suggest that the impact could be either contemporaneous or delayed as it may take time for a bank to experience the full impact of disaster damage (Botzen, Deschenes, and Sanders 2020). We augment Equation (1) and (2) with lagged impact (L.DAMAGE) to investigate the one-year lagging effect of past disasters:

$$Yijt = \beta 0Yijt - 1 + \beta 1DAMAGEjt + \beta 2L.DAMAGEjt + \beta 3INTEGjt + \beta kBANKk\ ijt + \beta mCOUNTRYm\ jt + \theta\ i + \gamma\ j + \mu\ t + \varepsilon\ ijt \quad (3)$$

$$Yijt = \beta 0Yijt - 1 + \beta 1DAMAGEjt + \beta 2INTEGjt + \beta 3DAMAGEjt * INTEGjt + \beta 4L.DAMAGEjt * INTEGjt + \beta\ kBANKk\ ijt + \beta mCOUNTRYm\ jt + \theta\ i + \gamma\ j + \mu\ t + \varepsilon\ ijt \quad (4)$$

Panel A of Table 7 presents the results for Equation (3). In Column 1, the response of deposits ratio towards the contemporaneous impact of disasters remains unchanged with coefficient of DAMGE being−0.830 and significant at 1% level. More interestingly, in the period following disasters, deposits ratio rebounds, reflected in a positive and significant coefficient of L.DAMAGE (i.e. 0.710). Furthermore, banks liquidity also declines in the same period reflected via a negative and significant at 10% coefficient of L.DAMAGE (i.e.−0.458), reported in Column 2. This finding suggests that households may deposit their insurance payment, aid, or remittances into banks, leading to an increase in bank deposits. Bank liquidity is measured as the ratio between liquid assets to deposits and short-term funding; hence, following the impact of deposit growth or the extension of recovery loans, banks liquidity declines. This finding also confirms the evidence of the delayed impact of disasters on bank liquidity. As seen in Column 3, 4, 5, the baseline finding is robust in the case of credit risk, profitability, and stability; these measures do not respond both to the contemporaneous as well as one-year lagged impact of disasters.

Panel B of Table 7 presents results for Equation (4) with the dependent variable being deposits ratio (DEPO). In Columns 1 and 2, the coefficients of the interaction term between CLAIM and DAMAGE as well as between ASIAN and DAMAGE are

Table 6. Sub-sample analysis for severely versus lightly affected countries.

	Lightly affected countries					Severely affected countries				
	DEPO (1)	LIQ (2)	CRERISK (3)	ROA (4)	LN(zscore) (5)	DEPO (6)	LIQ (7)	CRERISK (8)	ROA (9)	LN(zscore) (10)
Panel A: The impact of disasters on bank performance										
L.Y	0.846***	0.600***	0.587***	0.300***	0.397**	0.647***	0.443***	0.680***	0.392***	0.487***
	(0.14)	(0.12)	(0.15)	(0.11)	(0.15)	(0.09)	(0.09)	(0.12)	(0.12)	(0.06)
DAMAGE	−11.195	−13.939	−5.132	−0.270	0.982	−1.490**	−0.679	−0.393	−0.034	0.103
	(10.02)	(8.68)	(5.41)	(2.63)	(2.35)	(0.65)	(1.10)	(0.40)	(0.09)	(0.10)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	587	587	587	587	587	223	223	223	223	223
No. of banks	175	175	175	175	175	102	102	102	102	102
No. of IV	100	100	100	100	100	77	77	77	77	77
AR(2) test	0.187	0.195	0.691	0.843	0.818	0.278	0.647	0.367	0.192	0.366
Hansen test	0.364	0.240	0.124	0.649	0.238	0.761	0.161	0.261	0.316	0.529
Panel B: The moderating effect of financial integration and its various forms on deposits ratio (DEPO)										
	Slightly affected countries					Highly affected countries				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
DAMAGE_CLAIM	−0.443					0.313**				
	(1.15)					(0.14)				
DAMAGE_ASIAN		3.093					2.077*			
		(11.96)					(1.06)			
DAMAGE_NONASIAN			−0.350					−0.352		
			(1.82)					(0.30)		
DAMAGE_LOCAL				1.145					−1.006	
				(2.57)					(0.77)	
DAMAGE_CROSS					4.752					−0.076
					(10.76)					(0.25)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of obs	587	587	587	462	462	223	223	223	127	127
No. of banks	175	175	175	145	145	102	102	102	73	73
No. of IV	92	92	92	74	74	77	77	77	55	55
AR(2) test	0.256	0.887	0.434	0.494	0.476	0.119	0.341	0.491	0.630	0.498
Hansen test	0.339	0.388	0.437	0.435	0.433	0.740	0.814	0.778	0.574	0.673

Panel A presents the impact of disasters damage on various measures of banks performance. The model is presented as follows: $Y_{ijt} = \beta_0\ Y_{ijt-1} + \beta_1\ DAMAGE_{jt} + \boldsymbol{\beta_2\ L.DAMAGE_{jt}} + \beta_3\ INTEG_{jt} + \beta_k\ BANK^k_{ijt} + \beta_m\ COUNTRY^m_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt.}$ The sampled countries are divided into groups using the median level of DAMAGE as the threshold; countries with their DAMAGE being greater than the median level of DAMAGE is classified as severely affected countries and otherwise. Panel B reports the moderating role of financial integration and its various forms on the impact of disasters on bank deposits ratio (DEPO). Other variables and the system GMM specification remain unchanged (as reported in Table 4). The robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7. The one-year lagging impact of past disasters.

	(1) DEPO	(2) LIQ	(3) CRERISK	(4) ROA	(5) LN(zscore)
Panel A: The impact of disasters on bank performance					
L.Y	0.719***	0.446***	0.681***	0.304***	0.411***
	−0.06	−0.1	−0.09	−0.07	−0.05
DAMAGE	−0.830***	−0.33	−0.167	0.04	0.029
	−0.27	−0.34	−0.16	−0.04	−0.03
L.DAMAGE	0.710**	−0.458*	−0.021	−0.014	0.007
	−0.33	−0.28	−0.11	−0.03	−0.03
Control variables	Yes	Yes	Yes	Yes	Yes
No. of obs	810	810	810	810	810
No. of banks	194	194	194	194	194
No. of IV	96	104	104	104	104
AR(2) test	0.393	0.827	0.163	0.119	0.561
Hansen test	0.681	0.197	0.884	0.517	0.45
Panel B: The moderation of financial integration on the impact of disasters on DEPO					
	(1) DEPO	(2) DEPO	(3) DEPO	(4) DEPO	(5) DEPO
DAMAGE_CLAIM	0.199**				
	−0.08				
L.DAMAGE_CLAIM	0.04				
	−0.06				
DAMAGE_ASIAN		0.494**			
		−0.2			
L.DAMAGE_ASIAN		0.35			
		−0.29			
DAMAGE_NONASIAN			0.139		
			−0.11		
L.DAMAGE_NONASIAN			−0.081		
			−0.1		
DAMAGE_LOCAL				−0.069	
				−0.3	
L.DAMAGE_LOCAL				−0.12	
				−0.13	
DAMAGE_CROSS					−0.132
					−0.63
L.DAMAGE_CROSS					−0.702
					−0.44
Other control variables	Yes	Yes	Yes	Yes	Yes
No. of obs	810	810	810	589	589
No. of banks	194	194	194	148	148
No. of IV	98	98	98	78	78
AR(2) test	0.193	0.173	0.192	0.195	0.218
Hansen test	0.701	0.623	0.7	0.264	0.326
Panel C: The moderation of financial integration on the impact of disasters on LIQ					
	(1) LIQ	(2) LIQ	(3) LIQ	(4) LIQ	(5) LIQ
L.DAMAGE_CLAIM	−0.061				
	−0.07				
L.DAMAGE_ASIAN		−0.013			
		−0.3			
L.DAMAGE_NONASIAN			−0.107		
			−0.11		
L.DAMAGE_LOCAL				0.179	
				−0.22	
L.DAMAGE_CROSS					−0.377
					−0.45
Other control variables	Yes	Yes	Yes	Yes	Yes
No. of obs	810	810	810	589	589
No. of banks	194	194	194	148	148
No. of IV	98	98	98	78	78
AR(2) test	0.854	0.829	0.961	0.765	0.612
Hansen test	0.142	0.215	0.162	0.138	0.326

Panel A presents the one-year lagged impact of disasters damage on various measures of banks performance. The model is presented as follows: $Y_{ijt} = \beta_0 Y_{ijt-1} + \beta_1 DAMAGE_{jt} + \mathbf{\beta_2 L.DAMAGE_{jt}} + \beta_3 INTEG_{jt} + \beta_k BANK^k_{ijt} + \beta_m COUNTRY^m_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt}$. Panel B reports the moderation of financial integration and its forms on the one-year lagged impact of disasters on bank deposits ratio (DEPO). The interaction terms are created by multiplying the measures of integration and one-year lagged impact of disasters. Panel C documents the moderation of financial integration on the one-year lagged impact of disasters on bank liquidity ratio (LIQ). The interaction terms are created by multiplying the measures of integration and one-year lagged impact of disasters. Other variables and the system GMM specification remain unchanged (as reported in Table 4.4). The robust standard errors are reported in parentheses. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

positive and significant at 5% level, being consistent with the baseline ones. This indicates that the total foreign banking claims specifically those obtained from Asian lenders help to alleviate the decline of bank deposits during the aftermath of disasters. However, the coefficients of the interaction terms between CLAIM (as well as various forms such as ASIAN, NON_ASIAN, CROSS and LOCAL) and L.DAMAGE are insignificant, implying that there is no moderation effect of financial integration on the relationship between the lagged impact of past disasters and the deposits ratio.

As Panel A of Table 7 confirms the delayed impact of disasters on bank liquidity, we only examine the moderating impact of financial integration on the relationship between past disasters and liquidity ratio. Panel C of Table 7 presents the corresponding results. All coefficients of the interaction terms between financial integration measures and L.DAMAGE are insignificant. This suggests that financial integration exerts no moderating effect on the delayed impact of past disasters on bank liquidity. Taken the findings from Panels B and C together, we reach the same conclusion as the baseline findings that financial integration moderates the contemporaneous impact of disasters on banks deposits ratio.

VII. Conclusions

The paper adds to the literature on the impact of natural disasters on bank-level performance using cross-country evidence from East Asia. Specifically, the onsets of natural disasters significantly lower bank deposits ratio, suggesting that depositors withdraw cash from banks to cope with disaster losses. However, bank liquidity, credit risk, profitability and default risk are not contemporaneously affected by disasters. Furthermore, foreign banking claims, specifically those extended by regional Asian lenders, help to alleviate the deposits decline in the aftermath of natural disasters. A further analysis reveals that one year after the onset of the disaster, banks experienced higher deposits and lower liquidity ratios. With regard to the moderating role of financial integration, foreign banking claims, specifically those extended by regional Asian lenders, help to alleviate the deposits decline in the aftermath of natural disasters. These baseline findings are mainly driven by the severely- affected countries.[12]

The paper has implications in terms of managing the impact of natural disasters on banks in the context of financial integration. The results highlight that bank deposits and foreign banking claims (specifically Asian claims) serve as sources of funds to support the post-disaster recovery. Together with other sources such as bank credit, government support, remittance and foreign aid, these provide multiple channels for households and firms to obtain the relatively immediate access to finance, which is fundamentally important for recovery post-disaster.

As the occurrence of natural disasters may destroy information on borrowers and collateral values, information advantage is crucial for lenders to maintain their credit supply. This makes disasters a special context to test the preference of the two definitions of 'neighbours' banking who may have this informational advantage (i.e. being either (i) banks from other East Asian countries or (ii) foreign banks presence via a full affiliate office in the recipient countries). The results highlight the resilience of the foreign claims extended by Asian lenders in the event of local shocks, which is not present for foreign claims extended via local affiliates of foreign banks. This provides evidence to support intra-regional financial integration in East Asia.

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[12]See point 5 in Appendix 3- Methodological notes.

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References

Allen, F., T. Beck, E. Carletti, P. R. Lane, D. Schoenmaker, and W. Wagner. 2011. *Cross-Border Banking in Europe: Implications for Financial Stability and Macroeconomic Policies*. https://cepr.org/voxeu/columns/cross-border-banking-europe-implications-financial-stability-and-macroeconomic ..

Arellano, M., and O. Bover. 1995. "Another Look at the Instrumental Variable Estimation of Error-Components Models." *Journal of Econometrics* 68 (1): 29–51. doi:10.1016/0304-4076(94)01642-D.

Arena, M., C. Reinhart, and F. Vázquez. 2007. The Lending Channel in Emerging Economics: Are Foreign Banks Different?. National Bureau of Economic Research Working paper.

Asian Development Bank. 2008. Emerging Asian Regionalism- a Partnership for Shared Prosperity. Accessed via https://www.adb.org/sites/default/files/publication/159353/adbi-emerging-asian-regionalism.pdf

Asian Development Bank. 2014. Insuring Against Asia's Natural Catastrophes. Theme chapter in Asian Economic Integration Monitor April 2014. Accessed via https://aric.adb.org/pdf/aeim/AEIM_2014April_ThemeChapter.pdf

Athanasoglou, P. P., S. N. Brissimis, and M. D. Delis. 2008. "Bank-Specific, Industry-Specific and Macroeconomic Determinants of Bank Profitability." *Journal of International Financial Markets, Institutions and Money* 18 (2): 121–136. doi:10.1016/j.intfin.2006.07.001.

Barth, J. R., G. Caprio Jr, and R. Levine. 2013. "Bank Regulation and Supervision in 180 Countries from 1999 to 2011." *Journal of Financial Economic Policy* 5 (2): 111–219. doi:10.1108/17576381311329661.

Bender, M. A., T. R. Knutson, R. E. Tuleya, J. J. Sirutis, G. A. Vecchi, S. T. Garner, and I. M. Held. 2010. "Modeled Impact of Anthropogenic Warming on the Frequency of Intense Atlantic Hurricanes." *Science* 327 (5964): 454–458. doi:10.1126/science.1180568.

Berger, A. N., S. D. Bonime, D. M. Covitz, and D. Hancock. 2000. "Why are Bank Profits so Persistent? The Roles of Product Market Competition, Informational Opacity, and Regional/Macroeconomic Shocks." *Journal of Banking & Finance* 24 (7): 1203–1235. doi:10.1016/S0378-4266(99)00124-7.

Blundell, R., and S. Bond. 1998. "Initial Conditions and Moment Restrictions in Dynamic Panel Data Models." *Journal of Econometrics* 87 (1): 115–143. doi:10.1016/S0304-4076(98)00009-8.

Botzen, W. W., O. Deschenes, and M. Sanders. 2020. "The Economic Impacts of Natural Disasters: A Review of Models and Empirical Studies." *Review of Environmental Economics and Policy* 13 (2): 167–188. doi:10.1093/reep/rez004.

Brei, M., P. Mohan, and E. Strobl. 2019. "The Impact of Natural Disasters on the Banking Sector: Evidence from Hurricane Strikes in the Caribbean." *The Quarterly Review of Economics and Finance* 72: 232–239. doi:10.1016/j.qref.2018.12.004.

Bronstert, A. 2003. "Floods and Climate Change: Interactions and Impacts. Risk Analysis." *An International Journal* 23 (3): 545–557. doi:10.1111/1539-6924.00335.

Cerutti, E. 2015. "Drivers of Cross-Border Banking Exposures During the Crisis." *Journal of Banking & Finance* 55: 340–357. doi:10.1016/j.jbankfin.2014.08.021.

Cetorelli, N., and L. S. Goldberg. 2012. "Banking Globalization and Monetary Transmission." *The Journal of Finance* 67 (5): 1811–1843. doi:10.1111/j.1540-6261.2012.01773.x.

Chavaz, M. 2014. Riders of the Storm: Economic Shock & Bank Lending in a Natural Experiment. Working Paper.

Claessens, S., and N. Van Horen. 2014. "Location Decisions of Foreign Banks and Competitor Remoteness." *Journal of Money, Credit, and Banking* 46 (1): 145–170. doi:10.1111/jmcb.12100.

Claessens, S., and N. Van Horen. 2015. "The Impact of the Global Financial Crisis on Banking Globalization." *IMF Economic Review* 63 (4). doi:10.1057/imfer.2015.38.

Cortés, K. R., and P. E. Strahan. 2017. "Tracing Out Capital Flows: How Financially Integrated Banks Respond to Natural Disasters." *Journal of Financial Economics* 125 (1): 182–199. doi:10.1016/j.jfineco.2017.04.011.

David, A. C. 2011. "How Do International Financial Flows to Developing Countries Respond to Natural Disasters?" *Global Economy Journal* 11 (4). doi:10.2202/1524-5861.1799.

De Haas, R., and I. Van Lelyveld. 2006. "Foreign Banks and Credit Stability in Central and Eastern Europe. A Panel Data Analysis." *Journal of Banking & Finance* 30 (7): 1927–1952. doi:10.1016/j.jbankfin.2005.07.007.

Demirgüç-Kunt, A., E. J. Kane, and L. Laeven, (2014). Deposit Insurance Database. National Bureau of Economic Research (NBER) Working Papers No. 20278.

Duqi, A., D. McGowan, E. Onali, and G. Torluccio. 2021. "Natural Disasters and Economic Growth: The Role of Banking Market Structure." *Journal of Corporate Finance* 71: 102101. doi:10.1016/j.jcorpfin.2021.102101.

Ebeke, C., and J. L. Combes. 2013. "Do Remittances Dampen the Effect of Natural Disasters on Output Growth Volatility in Developing Countries?" *Applied Economics* 45 (16): 2241–2254. doi:10.1080/00036846.2012.659347.

Eichengreen, B., P. Gupta, and O. Masetti. 2018. "Are Capital Flows Fickle? Increasingly? Does the Answer Still Depend on Type?" *Asian Economic Papers* 17 (1): 22–41. doi:10.1162/asep_a_00583.

EMDAT. 2018. The International Disaster Database by Center for Research on the Epidemiology of Disasters. Accessed via https://public.emdat.be/ .

Felbermayr, G., and J. Gröschl. 2014. "Naturally Negative: The Growth Effects of Natural Disasters." *Journal of Development Economics* 111: 92–106. doi:10.1016/j.jdeveco.2014.07.004.

García-Herrero, A., and S. M. Martínez Pería. 2007. "The Mix of International banks' Foreign Claims: Determinants and Implications." *Journal of Banking & Finance* 31 (6): 1613–1631. doi:10.1016/j.jbankfin.2006.11.002.

Garmaise, M., and T. Moskowitz. 2009. "Catastrophic Risk and Credit Markets." *The Journal of Finance* 64 (2): 567–707. doi:10.1111/j.1540-6261.2009.01446.x.

Ghosh, A. 2015. "Banking-Industry Specific and Regional Economic Determinants of Non-Performing Loans: Evidence from US States." *Journal of Financial Stability* 20: 93–104. doi:10.1016/j.jfs.2015.08.004.

IPCC. 2022. Climate Change 2022: Impacts, Adaptation and Vulnerability. Accessed via https://www.ipcc.ch/report/sixth-assessment-report-working-group-ii/

Klomp, J. 2014. "Financial Fragility and Natural Disasters: An Empirical Analysis." *Journal of Financial Stability* 13: 180–192. doi:10.1016/j.jfs.2014.06.001.

Koetter, M., F. Noth, and O. Rehbein. 2020. "Borrowers Under Water! Rare Disasters, Regional Banks, and Recovery Lending." *Journal of Financial Intermediation* 43: 100811. doi:10.1016/j.jfi.2019.01.003.

Kousky, C. 2014. "Informing Climate Adaptation: A Review of the Economic Costs of Natural Disasters." *Energy Economics* 46: 576–592. doi:10.1016/j.eneco.2013.09.029.

Laeven, L., and R. Levine. 2009. "Bank Governance, Regulation and Risk Taking." *Journal of Financial Economics* 93 (2): 259–275. doi:10.1016/j.jfineco.2008.09.003.

Laeven, L., and F. Valencia, (2012). Systemic Banking Crises Database: An Update. International Monetary Fund Working paper No. WP/12/163.

Levchenko, A. A., and P. Mauro. 2007. "Do Some Forms of Financial Flows Help Protect Against "Sudden stops"?" *The World Bank Economic Review* 21 (3): 389–411. doi:10.1093/wber/lhm014.

Mian, A. 2006. "Distance Constraints: The Limits of Foreign Lending in Poor Economies." *The Journal of Finance* 61 (3): 1465–1505. doi:10.1111/j.1540-6261.2006.00878.x.

Nguyen, D. T. T., I. Diaz-Rainey, H. Roberts, and M. Le. 2021. "Loans from My Neighbours: East Asian Commercial Banks, Financial Integration, and Bank Default Risk." *International Review of Financial Analysis* 74: 101659. doi:10.1016/j.irfa.2021.101659.

Nguyen, L., and J. O. Wilson. 2018. "How Does Credit Supply React to a Natural Disaster? Evidence from the Indian Ocean Tsunami." *The European Journal of Finance* 26 (7-8): 802–819.

Noth, F., and U. Schüwer. 2018. Natural Disaster and Bank Stability: Evidence from the US Financial System. SSRN Working paper.

Noy, I. 2009. "The Macroeconomic Consequences of Disasters." *Journal of Development Economics* 88: 221–231. doi:10.1016/j.jdeveco.2008.02.005.

Noy, I. 2015. "Natural Disaster and Economic Policy for ASEAN and the Pacific Rim: A Proposal for a Disaster Risk Reduction 'Seal of Approval' Fund." In *Resilience and Recovery in Asian Disasters*, edited by D. Aldrich, S. Oum and Y. Sawada. Vol. 18, 219–237. Tokyo: Springer.

Romer, P. M. 1986. "Increasing Returns and Long-Run Growth." *The Journal of Political Economy* 94 (5): 1002–1037. doi:10.1086/261420.

Romer, P. M. 1990. "Endogenous Technological Change." *The Journal of Political Economy* 98 (5): S71–102. Part 2. doi:10.1086/261725.

Sawada, Y., and S. Shimizutani. 2008. "How Do People Cope with Natural Disasters? Evidence from the Great Hanshin-awaji (Kobe) Earthquake in 1995." *Journal of Money, Credit, and Banking* 40 (2-3): 463–488. doi:10.1111/j.1538-4616.2008.00122.x.

Schumpeter, J. A. 1934. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*. Vol. 46. Havard Economic Studies. MA, USA: Havard University Press.

Schüwer, U., C. Lambert, and F. Noth. 2018. "How Do Banks React to Catastrophic Events? Evidence from Hurricane Katrina." *Review of Finance* 23 (1): 75–116. doi:10.1093/rof/rfy010.

Skidmore, M. 2001. "Risk, Natural Disasters, and Household Savings in a Life Cycle Model." *Japan and the World Economy* 13 (1): 15–34. doi:10.1016/S0922-1425(00)00056-6.

Strobl, E., B. Ouattara, and S. A. Kablan. 2020. "Impact of Hurricanes Strikes on International Reserves in the Caribbean." *Applied Economics* 52 (38): 4175–4185. doi:10.1080/00036846.2020.1731411.

Turco, M., M. C. Llasat, J. von Hardenberg, and A. Provenzale. 2014. "Climate Change Impacts on Wildfires in a Mediterranean Environment." *Climatic Change* 125 (3): 369–380. doi:10.1007/s10584-014-1183-3.

Windmeijer, F. 2005. "A Finite Sample Correction for the Variance of Linear Efficient Two-Step GMM Estimators." *Journal of Econometrics* 126 (1): 25–51. doi:10.1016/j.jeconom.2004.02.005.

World Bank, 2018. Bankers Without Borders. Global Financial Development Report 2017/2018. Accessed via https://www.cbd.int/financial/2017docs/wb-banking2017.pdf.

Yang, D. 2008. "Coping with Disaster: The Impact of Hurricanes on International Financial Flows, 1970-2002." *The BE Journal of Economic Analysis Policy* 8 (13). doi:10.2202/1935-1682.1903.

APPENDIX 1: Some caveats about BIS consolidated statistics

CBS provides the credit exposures (termed as "foreign claims") of banks headquartered in 31 BIS-reporting (source) countries to over 200 counterparties (recipient) countries on bilateral basis. CBS are structured on the nationality (not the location) of reporting banks. Specifically, Asian source countries include Australia, Chinese Taipei, Hong Kong SAR, India, Japan, (South) Korea, and Singapore. Non-Asian lenders include Austria, Belgium, Brazil, Canada, Chile, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Mexico, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States.

To illustrate the reporting basis of CBS, take Singapore as an example of a country reporting to BIS. There are four types of reporting banks located in Singapore:

(i) domestic banks (controlled by parent entities with the same country code as the reporting country), for instance: OCBC bank, United Overseas Bank, etc.;
(ii) banks located in the reporting country, but controlled by parent entities located in non-reporting countries, for instance: an affiliate of Bank of China;
(iii) banks located in the reporting country, but controlled by parent entities located in reporting countries; for instance: an affiliate of HSBC;
(iv) banks controlled by parent entities located in the reporting country but not consolidated by their parent.

These reporting banks will report their claims extended to counterparties in a recipient country (i.e. the sampled East Asia). In the case of the total "foreign claims" data (to construct CLAIM), three types of reporting banks, including (i), (ii), and (iv) are considered.

When "foreign claims" are broken down by lender nationality (to construct ASIAN and NON_ASIAN), only the first type of reporting banks (i.e. domestic banks) are considered. This is to clarify that the affiliates of distant international banks set up in Singapore (such as an affiliate of HSBC in Singapore) are not considered to construct Asian claims. The claims extended by an affiliate of HSBC in Singapore will later be consolidated by their parent bank HSBC (UK); the claims then become non-Asian claims.

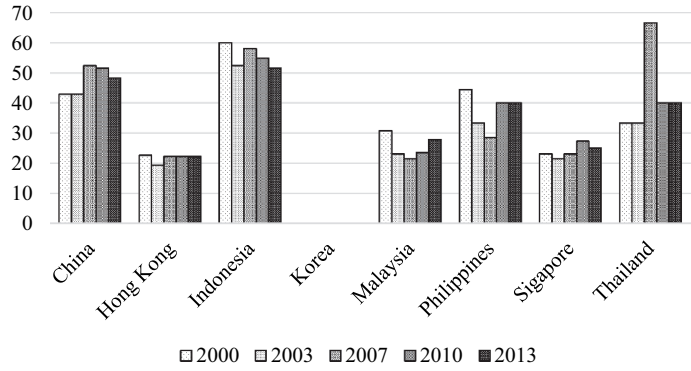
When "foreign claims" are broken down by methods of extension (to construct CLAIM and CROSS_BORDER), only the first type of reporting bank (i.e. domestic banks) are considered. Specifically, United Overseas Bank (Singapore) sets up its branch in China and extends claims to counterparties in China via this branch; this is the case of local claims. Alternatively, United Overseas Bank (Singapore) books its claims outside China (by either extending from its head office in Singapore or from its branch located in another country); this is the case of cross-border claims.

With regard to the reporting basis of Immediate Counterparty (IC) and Ultimate Risk (UR), the former considers parties directly involved in lending contracts, while the latter takes into account the credit risk transferring from one counterparty to another via collaterals or guarantees. For example, a Singapore bank extends a loan to a company in China and the loan is guaranteed by a Hong Kong bank. On an IC basis, the Singapore bank would report the loan as a claim on China. On an UR basis, the loan would be reported as a claim on Hong Kong instead.

APPENDIX 2: Notes on the difference in the available time periods and reporting basis between CBS-IC and CBS-UR

The difference in the available time periods and reporting basis between CBS-IC and CBS-UR prevents the analysis of local claims and Asian claims in a full parallel fashion. However, there is one scenario when local claims and Asian claims measure the same thing, which is when the majority of foreign affiliates/branches in the sampled countries are owned by Asian banks. To demonstrate this is not the case, the database from Claessens and Van Horen (2015) on bank ownership is employed to examine the origin of foreign banks in the sampled East Asian countries. First, the total number of foreign banks in these countries is computed. Then, the number of foreign banks owned by Asian BIS-reporting countries is calculated. In Korea, there are no foreign banks with origin from Asian BIS-reporting countries. The ratio of Asian foreign banks to total foreign banks varies among the rest of the group (as reported in figure below). For instance, in Thailand, Indonesia, and China, nearly 50% of their foreign banks are Asian foreign banks, while in Hong Kong and Singapore, the proportion is around 23%. In short, the data presented in this figure give confidence that the two measures 'local claims' and 'Asian claims' are distinctive but related measures of 'closeness' or 'neighbours'.

Figure 4: The ratio of Asian foreign banks to total foreign banks in East Asian sampled countries (%).



This figure presents the ratio of Asian foreign banks to total foreign banks in East Asian (%). The denominator is the total number of foreign banks in these sampled countries. The numerator is the number of foreign banks owned by Asian BIS- reporting countries. Source: Claessens and van Horen (2015).

APPENDIX 3:

Methodological notes

(1) GDP per capital is often included in the economic growth and natural disaster literature (i.e. see Felbermayr and Gröschl, 2014) since this variable proxies for economic development and is highly correlated to the country-level insurance penetration data and government spending, which could affect the ex-post recovery process. However, the paper could not include this variable (in the form of natural logarithm of GDP per capital) as the variable contains unit roots in its time series. The paper attempts to control for GDP per capita by using the country dummies in the regression.
(2) With regard to the (unreported) unit root test, the null of non-stationary is rejected at the 1% level for all variables used in the baseline regression. SIZE is dropped from the regression due to the presence of a unit root.
(3) In the case of liquidity (LIQ), credit risks (CRERISK), profitability (ROA) and default risk (Ln(zscore)) being the dependent variable, regulation and financial integration are treated as pre-determined variables. However, in the case of deposits ratio (DEPO) in the first column, the Hansen test and Difference-in-Hansen test indicate that regulation and financial integration should be treated as an exogenous variable. When these variables are treated as pre-determined one, the Hansen test and the Difference-in-Hansen test are both lower while the number of instruments is higher than the baseline. Therefore, the baseline results report when these variables are treated as exogenous. The robust check's result when regulation and financial integration are treated as pre-determined variables are available upon request.
(4) In Table 5, the interaction terms are created by multiplying the measures of financial integration and disasters damage. To ease the concern of multi-collinearity, it is suggested that these variables should be demeaned before their relevant interaction terms are created. Either the approach provides similar findings with the significance level of all the interaction terms being unchanged. These results are available upon request.
(5) Some words about the limitations of the paper are warranted. The ex-post measure of economic loss (i.e. DAMAGE) constructed from the EM-DAT database could be endogenous to other country-control variables such as inflation or economic growth (Noy, 2009; Klomp, 2014). The paper employs the system GMM, which uses the valid internal instrument variables, and could relieve this endogeneity concern. An absolute solution to the endogeneity concern is using an index of disaster intensity, which is constructed from the physical characteristics of the disaster. A notable example is the Ifo Geological and Meteorological Events (Ifo-GAME) database of disaster events and their physical intensities index. However, the data is only publicly updated to 2010; the aggregated disaster index at country and year level only represents the physical magnitude of the single largest event of each type of disasters (not for all disasters).

Due to the unavailability of data, the paper could not track the specific locations of banks and match these to the affected areas by disaster events for the sampled banks. Therefore, the paper could not employ other estimation techniques such as Difference-in-Difference (as employed in Nguyen and Wilson (2018); Schüwer, Lambert, and Noth (2018) to compare the response of affected and unaffected banks around the event window of a disaster. The availability of such data would allow the analysis to test if a bank's financial condition is significantly different after a disaster.

APPENDIX 4: Robustness check with Difference-GMM

	(1) DEPO	(2) LIQ	(3) CRERISK	(4) ROA	(5) LN(zscore)
Panel A: Impact of disasters on bank performance					
L.Y	0.526***	0.390***	0.667***	0.300***	0.424***
	(0.10)	(0.10)	(0.13)	(0.11)	(0.06)
DAMAGE	−1.164***	0.207	−5.132	0.020	0.034
	(0.42)	(0.32)	(5.41)	(0.04)	(0.03)
Control variables	Yes	Yes	Yes	Yes	Yes
No. of obs	616	616	616	616	616
No. of banks	150	150	150	150	150
No. of IV	67	71	71	71	71
AR(2) test	0.104	0.838	0.177	0.189	0.483
Hansen test	0.173	0.128	0.313	0.389	0.107
Panel B: The moderation of financial integration					
	(1) DEPO	(2) DEPO	(3) DEPO	(4) DEPO	(5) DEPO
L.Y	0.540***	0.560***	0.505***	0.426***	0.694***
	(0.10)	(0.09)	(0.11)	(0.10)	(0.10)
DAMAGE	−5.900***	−4.485**	−2.053**	−0.694	−3.391
	(1.77)	(1.94)	(0.91)	(5.13)	(2.32)
DAMAGE_CLAIM	0.191***				
	(0.07)				
DAMAGE_ASIAN		0.342*			
		(0.20)			
DAMAGE_NONASIAN			0.133		
			(0.10)		
DAMAGE_LOCAL				0.152	
				(0.16)	
DAMAGE_CROSS					−0.081
					(0.88)
Control variables	Yes	Yes	Yes	Yes	Yes
No. of obs	616	616	616	589	589
No. of banks	150	150	150	148	148
No. of IV	68	68	68	75	75
AR(2) test	0.203	0.271	0.209	0.143	0.178
Hansen test	0.177	0.178	0.182	0.113	0.692

Panel A presents the impact of disasters damage on various measures of banks performance. The model is presented as follows: $Y_{ijt} = \beta_0\, Y_{ijt-1} + \beta_1\, DAMAGE_{jt} + \boldsymbol{\beta_2\, L.DAMAGE_{jt}} + \beta_3\, INTEG_{jt} + \beta_k\, BANK^{k}_{ijt} + \beta_m\, COUNTRY^{m}_{jt} + \theta_i + \gamma_j + \mu_t + \varepsilon_{ijt.}$ Panel B reports the moderating role of financial integration and its various forms on the impact of disasters on bank deposits ratio (DEPO). The model is estimated using the Difference GMM method. Other variables specification remains unchanged from Table 4. The robust standard errors are reported in the parenthesis. ***, **, and * indicate statistical significance at the 1%, 5% and 10% levels, respectively.