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Natural Disasters and Bank Liquidity Creation in Sub-Saharan African Countries: Evidence from Banks Panel Data

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Abstract

This paper investigates the effects of natural disasters on bank liquidity creation in sub-Saharan African during the period 1988-2018. Using bank-level data from more than 30 countries, we find that natural disasters affect negatively the liquidity creation in the region. This impact is mainly channeled through the asset-side activities of banks. We also find heterogeneous impact of natural disasters on bank liquidity creation based on the size of banks, the magnitude of disasters and the income level of countries. Moreover, these effects are mainly observed when disasters strike on a large-scale. On the contrary, there is no significant difference depending on whether or not the disaster is climatic in origin. These results support policies aimed at strengthening the resilience of African financial systems in a context where losses related to natural disasters are likely to increase in the coming years.

Key words

Natural disasters, bank liquidity, Africa

Classification JEL

G21, O16, O55

1. Introduction

Countries around the world are hit by natural disasters. Even if it is not clear that the global number of natural disasters is really increasing (Alimonti and Mariani, 2023), there is no doubt that economic losses following natural disasters tend to increase as a result of demographic growth and increased wealth in exposed areas (Botzen, Deschenes and Sanders, 2019). Econometric studies highlight that extreme events may have a negative impact on economic growth depending mainly on the country's level of development (*e.g.* Cavallo et al., 2013; Klomp, 2016; Klomp, 2014; Panwar and Sen, 2019; Felbermayr and Gröschl, 2014). These adverse consequences are also likely to affect the firm performance, through the losses of their assets. A number of studies have explored the effects of natural disasters on bank activities (lending and deposit behavior) (*e.g.* Alalmaee, 2024; Brei et al, 2019; Do, Phan and Nguyen, 2023; Strömberg, 2007). Yet, little research has been devoted to the relationship between natural disasters and bank liquidity creation. In this paper, we contribute to closing this gap by carefully examining the impact of natural disasters on bank liquidity creation. We do so by focusing on banks operating in Sub-Saharan Africa.

Sub-Saharan African countries provide an ideal setting for several reasons. First, African countries receive little or no attention in natural disasters studies. In fact, even if Asia is more exposed to natural disasters than the rest of the world, vulnerability is greater in Africa. According to the latest EM-DAT report (Delforge et al, 2023), the economic and human impact of natural disasters (drought and flooding) has been higher in Africa than in Asia, even though Asia has suffered disasters on a much larger scale (hurricanes, etc.). Second, Sub-Saharan African countries are known for their low level of financial development.¹ If natural disasters hurt economic agents as revealed in empirical studies, then it is of a paramount interest to document whether such events affect banks and specifically their capacity to create liquidity. Negative impacts on liquidity creation can be detrimental to already financially fragile African economies. Hence, by focusing on Sub-Saharan Africa countries, we aim at documenting the response of banks in creating liquidity when they face natural disasters.

The paper finds several interesting results. Using a large sample of 360 banks over the period 1988-2018, we first show that natural disasters affect negatively bank liquidity creation and this adverse effect tends to persist over time. Second, this impact is mainly driven by the asset-side activities of banks. Third, sensitivity analyses allow us to highlight the heterogeneous impact of natural disasters on bank liquidity creation, depending on the size of the banks, the nature of disasters and exposure to some specific climate areas and economic environment. These findings are robust to different specifications and tests. The study provides new insights to policy makers on the potential adverse effects of natural disasters on bank liquidity creation, which should be accounted when designing appropriate measures to implement during times of natural disasters.

The remainder of the paper is organized as follows. In the next section, we describe the related literature. In Section 3, we present the data and methodology used. Section 4 presents the estimation results for the effect of natural disasters on bank liquidity creation. Section 5 discusses additional issues, followed by concluding remarks.

¹ Financial development is generally considered as a driving factor of economic growth and development: Berger et al. (2020).

2. Natural disasters and bank liquidity creation: the related literature

There is a vast literature on the impact of natural disasters on financial institutions. Most studies start from the premise that natural disasters create uncertainty because they are so unpredictable. Uncertainty is source of asymmetric information that affect banking activities in various ways. Klomp (2014) uses a large panel data on more than 160 countries over the period 1997–2010 and find that large-scale weather-related disasters notably meteorological and geophysical disasters, increase the likelihood of a banks' default. He also finds that this impact depends on the degree of financial development of a particular country but there is no impact on the onset of financial crises. Very recently, the negative impact of natural disasters on the bank stability is confirmed by Alalmae (2024) who use a panel dataset of 1242 banks from 72 countries over the period 1999 to 2018. But contrary to Klomp (2014), Alalmae (2024) banks in middle-income and low-income countries suffer the most from natural disasters. Similar results have been obtained in country studies: using data for domestic and local banks in the USA, Do, Phan and Nguyen (2023) highlight that natural disasters decrease bank stability.

The literature on the impact of natural disasters on bank liquidity creation is rather limited and is only in its infancy. The only study that is close to our is Lee et al. (2022) who document the impact of climate risk on bank liquidity. Using bank level data from the Bankscope database from 56 countries over 1995-2012, they find that sensitivity and exposure to climate risks adversely impact overall liquidity creation. However, their study does not cover any Sub-Saharan country. Moreover, they focus on climate risks using Notre Dame- Global Adaptation Initiative climate risk indexes. We depart from their study using the intensity of natural disasters and document their influence on bank liquidity in Sub-Saharan African countries.

For the purpose of our study, we turn to the literature that examines the main activities that lead to bank liquidity creation. Banks create liquidity by taking in deposits as liabilities and making loans as assets (Berger and Bouwman, 2009). Hence, natural disasters can affect the liquidity creation through various channels with respect to deposits and lending activities. First, frequent extreme weather vents affect banks performance by reducing the total amount of deposits (Brei, et al, 2019) because of bank runs and immediate withdrawals to face damages (Do, Phan and Nguyen, 2023). Specifically, Brei et al, (2019) find that the hurricane strike significantly deteriorates the total deposits of the Eastern Caribbean banks by 8%, mostly driven by the withdrawals from households. Steindl and Weinrobe (1983) provide evidence of an increase of in deposits in the aftermath of a sizeable natural disaster and fail to confirm bank runs in the US. In the same country, Barth et al (2024) analyze the spillover effects of natural disasters on US bank branches and deposit rates during the period spanning from 2008 to 2017 and conclude that the disaster shock raises the deposit rate by 1.5 basis points directly in affected counties. The indirect effects which account for at least two-thirds of the total impact stems from local geographical competition for deposits and social connectedness.

Secondly, as regard to asset-related activities the empirical evidence is mixed. On the one hand, banks' clients who are affected by natural disasters can see their collateral destroyed and their ability to repay their loans decreased in the aftermath of the adverse events. Strömberg (2007) documents that bank lending activities reduce rapidly after a climatic disaster in developing countries. On the other hand, the credit demand is likely to increase in banks operating in the unaffected areas (Koetter, Noth, and Rehbein 2020). Cortés et al. (2017) conclude that during the period 2001-2010 lending increased significantly during the months following disasters in the US, with the maximum increase occurring about six months after the shock. It is noteworthy that the deposit activities and lending activities of banks may be connected, making it difficult to draw a firm conclusion on how bank liquidity creation are spurred or dampened during

natural disasters. During uncertain times, deposits may flow into banks, who may take more risk in lending (Acharya and Naqvi, 2012). This is true in countries where public assistance (governments emergency funds) or insurance mechanisms can be directed toward affected people and firms. Cortés et al. (2017) highlighted that American banks exposed to natural disasters bid up the rates on deposits across in the other markets where they own branches to help fund the unexpectedly high loan demand in the affected markets. They are also increasing their holdings of marketable securities.

3. Data and descriptive statistics

The study uses of a panel data framework which consists of both time series and cross-sectional data. The panel data make it possible to capture both time and banks individual heterogeneity and control for omitted variable biases. The data combines several datasets covering a sample of more 360 banks during the period spanning from 1988 to 2018. These datasets include information on natural disasters, bank balance-sheet variables and macroeconomic variables. We firstly describe in more detail the data used in the empirical work and then present the descriptive statistics. Table A1 in Appendix summarizes the definition of the variables and their sources.

3.1. Natural disasters

Data on natural disasters comes from the Emergency Events Database (EM-DAT) (Delforge et al, 2023). They are compiled by the Centre for Research on the Epidemiology of Disasters (CRED), at the Université Catholique de Louvain and are collected by diverse organizations: UN agencies, NGOs, insurance companies, research institutes, and press agencies. An event is considered as a natural disaster when at least one of the following criteria is satisfied: (i) ten or more people are reported killed; (ii) 100 people are reported affected; (iii) a state of emergency is declared; or (iv) a call for international assistance is issued. In this study, following the existing empirical studies, we use the number of affected persons (number of people injured, affected, and homeless combined). To calculate our variable of interest, we sum up the total number of people affected for each country in a given year is divided by the population in the year before the disaster. As can be seen in Figure 1(a) the hydrological disasters are more frequent in SSA countries, followed by the meteorological and climatic disasters. Climatic disasters affect more people while hydrological disasters hold the second place (Figure 1(b)). We therefore further decompose the disasters types in two categories: the total affected people due to climate-related disasters (which is the sum of total affected people during climatic, hydrological and meteorological disasters) and the total affected people during non-climate-related disasters (which is the sum of biogeological and geological disasters).² We discard the technological disasters from our analysis since this make less sense for African countries owing to their low level of technological development. Moreover, these disasters are strongly correlated with the level of development and they can hardly be considered as exogenous events. We also do not consider the property damage as this is particularly the most underreported damage (see Delforge et al, 2023; Joens et al. (2022)) and is likely prone to the endogeneity issue. It is important to note that Em-Dat disasters data presents its own limitations; nevertheless, it is actually the only publicly available dataset with a world coverage.

² According to the Em-dat, hydrological disasters including floods and wet mass movements; meteorological disasters concern storms and hurricanes; geophysical disasters entail earthquakes, tsunamis and volcanic eruptions; and climatic disasters including extreme temperatures, droughts and wildfire.

3.2. The bank liquidity creation

The bank liquidity creation data is based on Attila et al. (2024) who adopt Berger and Bouwman (2009)'s to estimate the liquidity creation by African banks. Knowing that banks create liquidity when they hold illiquid items on behalf of the public and offer liquid items to the customers (cf. Berger and Bouwman (2009)), this approach assign positive weights (+1/2) to both illiquid assets and liquid liabilities. Thus, when liquid liabilities (such as deposits) are used to finance illiquid assets (such as loans), liquidity is created. Similarly, negative weights (-1/2) are applied to liquid assets, illiquid liabilities and equity, so that when illiquid liabilities or equity are used to finance liquid assets (such as Treasury bills), liquidity is destroyed.

3.3- Econometric model

To investigate the effect of natural disasters in year t and in country i on the j bank liquidity, Equation (1) is estimated. In this specification, we consider that the effect of a natural disasters is persistent. Hence, we included both natural disasters in year t and natural disasters in year $t - 1$, $t - 2$ and $t - 3$.

$$LIQUIDITY_{ijt} = \alpha_0 + \sum_{k=0} \alpha_{2k} DISASTER_{it-k} + \alpha_3 BANK_{ijt-1} + \alpha_4 MACRO_{it-1} + \mu_i + \pi_j + \eta_t + \epsilon_{ijt} \quad (1)$$

$i = 1, 2, 3, \dots, N$ represent countries, $j = 1, 2, 3, \dots, J$ banks and $t = 1, 2, 3, \dots, T$ the years.

$LIQUIDITY$ is the dependent variable and $DISASTER_{it-k}$ ($k = 0, 1, 2, 3$) the main interest variable. $BANK_{ijt-1}$ represents banking characteristics (bank size and intermediation margin). $MACRO_{it-1}$ represents macroeconomic aggregates. μ_i , π_j , η_t represent country, bank and year fixed effects respectively. ϵ_{ijt} is the idiosyncratic error term with usual properties.

To cope with the serial correlation issue, we use the model developed by Driscoll and Kraay (1998), which handles not only the serial correlation and heteroskedasticity problems but also spatially correlated errors. The model is estimated using the Stata module xtsc (Hoechle, 2007). Some banks are only present in certain countries. Consequently, the main estimates are carried out by controlling for both country, bank and year fixed effects. There is no reason to be concerned about the simultaneity bias as bank liquidity creation cannot affect the occurrence of natural disasters and does not influence the number of killed or affected people. In the same vein, concern about selection bias is considerably reduced thanks to the sample which cover a large panel of banks operating in almost all SSA countries. Notwithstanding these considerations, it is necessary to control for endogeneity resulting from omitted variables bias. We do so by including a large number of control variables and to further minimize problems of endogeneity, we also include lagged explanatory variables in all estimates.

3.4- Control variables

We follow the existing literature on liquidity creation to select the relevant control variables (cf. Berger and Bouwman, 2009). Control variables can be divided in three categories: bank characteristics, economic variables and institutional variables. Banks characteristics include the size and its square and the net interest margin. The creation of liquidity is assumed to be related to the size of banks according to an inverted U curve. The net interest margin reflects bank's capacity to generate profits and therefore this variable is expected to be positively linked to the creation of liquidity. Macroeconomic variables include the quality of institutions, the GDP per capita growth, the public debt ratio, the trade openness, the financial liberalization index, the FDI inflows and the inflation rate. The effect of quality of institutions on the creation of

liquidity is ambiguous. On the one hand, better institutions stimulate economic activity and therefore the demand for credit, but on the other, it increases the constraints on banks and encourages them to restrain the liquidity creation. The stronger the economic growth, the greater the incentive for agents to invest in the most profitable projects, and consequently the greater the creation of liquidity. The creation of liquidity can depend positively on public debt insofar as part of bank financing is destined for the public purse. Inflation is expected to have a negative impact on liquidity creation since it results in a loss of remuneration for savers and investors and therefore a low mobilization of deposits. Trade openness and foreign direct investments could create activities and therefore more liquidity. However, in Africa, a high level of trade openness could be associated with a predominance of mining, oil and gas activities, the financing of which relies heavily on external resources. The effects of financial openness are ambiguous insofar as, while it can also create activities, it can encourage agents to finance themselves abroad, to the detriment of the creation of internal liquidity.

3.5- Descriptive statistics

Table 1 shows the descriptive statistics. The average bank liquidity creation is 0.985.³ Negative values correspond to the liquidity destruction, meaning that some African banks actually hoard more liquidity than other they should instead of financing the economic activities. Countries like Kenya, Tanzania, Ghana, Nigeria or Côte d'Ivoire are among the top liquidity creators. On the opposite side, banks in countries like Benin, Burkina or Togo create less liquidity. Turning to the disasters' ratio, the annual average of total affected people is about 3 percent of the total population. These figures, however, mask the presence of large heterogeneity across countries and over time. Eastern African countries are more severely hit by natural disasters than other countries. Kenya holds the first place in this region with more than 269 events during the study's time period. On the other hand, Western African countries are less affected, with Nigeria being the most hit with about 100 natural hazards occurred during 1988-2018.

Table 2 presents the pairwise correlation matrix between the main variables of interest. The correlation coefficients between bank liquidity variables and disasters are negative. These correlations are insignificant, however. Net interest margins, which are proxies for the bank performance are negatively associated with total liquidity creation as well as with the liquidity creation at the liability-side of banks' balance-sheet. This observation is consistent with the idea that the performance of banks in SSA is likely destroying the liquidity creation instead of financing economic activities. This observation is consistent with the absence of correlation (even though positive) between net margin interest and the liquidity creation at the asset-side. Regarding the size of banks, banks tend to create more liquidity as their size increases.

³ This high average is due to the fact that the denominator of our ratio is not the gross total asset as suggested by Berger and Bouwman (2009). Data limitation for all banks in our dataset prevents us of using this denominator.

Table 1: Descriptive statistics

	Mean	SD	Min	Max	N
Bank liquidity creation	0.985	0.330	-0.837	5.056	5290
Asset liquidity creation	0.297	0.247	-0.494	1.866	5572
Liability liquidity creation	0.673	0.228	-0.499	3.190	6930
No. affected /total pop.	0.024	0.096	0.000	3.494	6091
No. affected /total pop., climatic events	0.027	0.103	0.000	3.494	5174
No. affected /total pop., non-climatic events	0.001	0.011	0.000	0.249	5174
Small size dummy	0.498	0.500	0.000	1.000	7621
Low-income dummy	0.629	0.483	0.000	1.000	7621
Quality of institutions	0.632	0.171	0.078	0.901	7621
Size	5.098	1.708	-6.001	11.731	7621
Size squared	28.911	18.284	0.001	137.612	7621
Net interest margin	7.032	7.600	-7.320	263.380	6445
GDP per capita growth	1.974	3.932	-47.503	37.535	6087
Public debt/GDP	49.483	34.123	0.070	473.913	6831
FDI inflows	3.209	5.979	-6.370	103.337	6089
Trade openness	56.796	22.011	20.723	165.059	5994
Financial openness	-0.416	1.379	-1.927	2.311	7431
Inflation	18.652	399.462	-10.874	23,773.100	7287

Table 2: correlations matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Bank liquidity creation (1)	1							
Asset liquidity creation (2)	0.783***	1						
Liability liquidity creation (3)	0.680***	0.0758***	1					
No. affected/total pop.(4)	-0.0149	0.0101	-0.0210	1				
No. affected/total pop., climatic events (5)	-0.0136	0.0134	-0.0216	0.995***	1			
No. affected/total pop., non-climatic events (6)	0.00614	0.00468	-0.0000568	0.157***	0.0543***	1		
Bank size (7)	0.147***	-0.0432**	0.291***	-0.0165	-0.0212	-0.0266	1	
Net Interest Margin (8)	-0.194***	0.0220	-0.335***	-0.0217	-0.0289	0.00242	-0.231***	1

Figure 1 (a): Total frequency by year, by disaster type

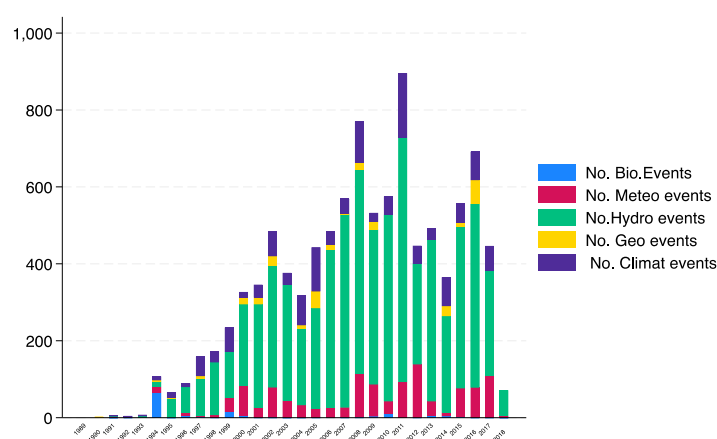


Figure 1(b): Total affected by year, by disaster type

Table 3: natural disasters and liquidity creation: fixed effects models

	(1)	(2)	(3)	(4)
No. affected/Pop.	-0.112*	-0.134**	-0.157**	-0.172**
	(-2.04)	(-2.11)	(-2.35)	(-2.58)
No. affected/Pop. t-1		-0.0970	-0.103	-0.123*
		(-1.70)	(-1.58)	(-2.01)
No. affected/Pop. t-2			-0.117*	-0.113**
			(-1.99)	(-2.56)
No. affected/Pop. t-3				-0.0818
				(-1.68)
Quality of institutions	0.306**	0.301**	0.295**	0.316**
	(2.08)	(2.06)	(2.14)	(2.45)
Size	0.111***	0.112***	0.122***	0.110***
	(3.74)	(3.66)	(3.48)	(3.30)
Size squared	-0.00715**	-0.00711**	-0.00846**	-0.00769**
	(-2.67)	(-2.61)	(-2.48)	(-2.48)
Net interest margin	-0.00556*	-0.00550*	-0.00549**	-0.00664***
	(-2.05)	(-1.96)	(-2.61)	(-3.82)
GDP per capita growth	0.00189	0.00183	0.00210*	0.00173
	(1.32)	(1.25)	(1.73)	(1.51)
Public debt/GDP	0.000148	0.000159	0.000146	0.000191
	(0.37)	(0.41)	(0.36)	(0.49)
FDI inflows	0.00229*	0.00225*	0.00182	0.00131
	(1.92)	(1.88)	(1.65)	(1.27)
Trade openness	-0.00144***	-0.00139***	-0.00128***	-0.00123***
	(-3.26)	(-3.14)	(-3.26)	(-2.87)
Financial openness	-0.0264	-0.0276	-0.0344	-0.0285
	(-1.19)	(-1.25)	(-1.54)	(-1.21)
Inflation	-0.000298	-0.000280	-0.000305	-0.000567
	(-0.95)	(-0.91)	(-1.01)	(-1.58)
Obs	2811	2803	2719	2453
No. banks	379	377	365	340
No. countries	27	27	27	27
R-squared within	0.107	0.110	0.111	0.108
F-test		2.223	2.177	7.591
F-test p-value		0.129	0.116	0.000

Notes: The dependent variable is the bank liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (column (2)), t, t-1 and t-2 (column (3)) and t, t-1, t-2 and t-3 (column (4)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Transmission channels and sensitivity tests

In order to better understanding the impact of natural disasters on bank liquidity, several additional analyses are conducted.

5.1. The transmission channels of natural disasters on bank liquidity creation

To further gauge the channels through which natural disasters might affect liquidity creation credit, we conduct two sets of analyses.

Firstly, we decompose the liquidity creation on the asset-side and the liquidity creation on the liability-side of the balance sheet. For this purpose, we conduct fixed effects models as performed in the previous section. The findings in table 4a and table 4b suggest that the impacts of natural disasters on the liquidity creation are mainly driven by the liquidity destruction on the asset-side of bank balance sheet. We find that the coefficients associated with the number of affected people are negative and significant in Table 4a where the asset-side liquidity creation is used as dependent variable. In the contrast, on the liability-side, the coefficients associated with the number of people affected are mostly not statistically significant, except in column (4) where it is slightly positive and significant. As previously discussed, this latter finding is consistent with the studies which find positive impacts of natural disasters on some liquidity creation components such as bank deposits (Brei et al., 2019), as financial assistance to local population could serve as deposits in banks. It is also possible that the need to reconstruction increase the demand for credit, forcing banks to create more liquidity. For instance, Steindl and Weinrobe (1983) found that deposits increase in financial institutions in the aftermath of natural disasters in the US. In the same vein, Cortés and Strahan (2017) document an increase of bank lending during the months following disasters. Probably, as argued by Acharya and Naqvi (2012) inflows of deposits in banks during negative shocks encourage banks to be more flexible on lending conditions.

Next, we further distinguish the impacts of the two categories we previously described: climate-related natural disasters and non-climate-related natural disasters. We argue that some types of disasters may result in a tremendous loss not only in terms of human lives but also to the economy. For instance, Klomp (2014) find that large-scale hydrological disasters have the most severe impact in low-income countries, while geophysical disasters have mainly an impact in high-income countries. Figures 1(a) and 1(b) indicate that climatic and hydrological disasters are the most common and hit more people in Sub-Saharan Africa. The estimates in Tables 5a indicate that the two types of disaster, when significant, have a negative impact on liquidity creation: in other words, what matters is the intensity of the disaster, not its origin. We confirm such results when using the asset-side liquidity creation (see tables A2 and A4 in Appendix) as well as liability-side liquidity creation (see tables A3 and A5 in Appendix).

Table 4a: natural disasters and asset-side liquidity creation: fixed effects models

	(1)	(2)	(3)	(4)
No. affected/Pop.	-0.0571 (-1.06)	-0.0746 (-1.25)	-0.0997 (-1.56)	-0.110* (-1.95)
No. affected/Pop. t-1		-0.0858** (-2.20)	-0.0951* (-1.94)	-0.125*** (-2.84)
No. affected/Pop. t-2			-0.139* (-1.91)	-0.122** (-2.20)
No. affected/Pop. t-3				-0.101* (-1.79)
Quality of institutions	0.274*** (3.04)	0.270*** (2.99)	0.286*** (3.19)	0.327*** (3.90)
Size	0.0633*** (3.19)	0.0634*** (3.19)	0.0707*** (3.27)	0.0682*** (3.03)
Size squared	-0.00382 (-1.70)	-0.00372 (-1.65)	-0.00438 (-1.68)	-0.00444* (-1.75)
Net interest margin	0.00332 (1.67)	0.00338 (1.70)	0.00356* (1.89)	0.00317 (1.42)
GDP per capita growth	0.00225 (1.29)	0.00221 (1.25)	0.00227 (1.33)	0.00162 (0.91)
Public debt/GDP	-0.000204 (-0.81)	-0.000199 (-0.82)	-0.000201 (-0.79)	-0.000154 (-0.57)
FDI inflows	0.00245** (2.25)	0.00243** (2.23)	0.00216* (2.02)	0.00208* (2.00)
Trade openness	-0.00132*** (-3.35)	-0.00130*** (-3.26)	-0.00122*** (-3.16)	-0.00116** (-2.75)
Financial openness	-0.00395 (-0.20)	-0.00490 (-0.25)	-0.00961 (-0.49)	-0.00448 (-0.22)
Inflation	0.000147 (0.54)	0.000163 (0.60)	0.000190 (0.69)	-0.000102 (-0.28)
Obs	2941	2932	2847	2567
No. banks	387	384	372	346
No. countries	27	27	27	27
R-squared within	0.096	0.097	0.096	0.098
F-test		2.640	1.460	2.953
F-test p-value		0.091	0.249	0.041

Notes: The dependent variable is the asset-side bank liquidity creation. The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (column (2)), t, t-1 and t-2 (column (3)) and t, t-1, t-2 and t-3 (column (4)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 4b: natural disasters and liability-side liquidity creation: fixed effects models

	(1)	(2)	(3)	(4)
No. affected/Pop.	0.00606 (0.23)	0.00816 (0.30)	0.00887 (0.31)	0.0179 (0.51)
No. affected/Pop. t-1		0.0139 (0.72)	0.0167 (0.67)	0.0144 (0.60)
No. affected/Pop. t-2			0.0259 (1.20)	0.0455* (2.04)
No. affected/Pop. t-3				0.0120 (0.66)
Quality of institutions	-0.0478 (-0.84)	-0.0493 (-0.87)	-0.0719 (-1.32)	-0.0883 (-1.52)
Size	0.0573*** (6.22)	0.0586*** (6.03)	0.0631*** (4.89)	0.0564*** (3.99)
Size squared	-0.00404*** (-7.36)	-0.00414*** (-7.71)	-0.00480*** (-5.99)	-0.00387*** (-4.72)
Net interest margin	-0.00853*** (-6.70)	-0.00852*** (-6.44)	-0.00833*** (-6.95)	-0.00881*** (-5.86)
GDP per capita growth	-0.00104 (-1.18)	-0.00103 (-1.19)	-0.000759 (-0.86)	-0.000675 (-0.69)
Public debt/GDP	0.000148 (0.83)	0.000156 (0.89)	0.000164 (0.86)	0.000174 (0.86)
FDI inflows	0.0000276 (0.05)	0.0000157 (0.03)	-0.000233 (-0.41)	-0.000979 (-1.65)
Trade openness	-0.0000132 (-0.06)	0.0000204 (0.01)	-0.00000312 (-0.01)	0.0000998 (0.43)
Financial openness	-0.0208** (-2.55)	-0.0208** (-2.52)	-0.0216** (-2.78)	-0.0205** (-2.22)
Inflation	-0.000555*** (-4.07)	-0.000561*** (-4.26)	-0.000597*** (-5.08)	-0.000497*** (-2.92)
Obs	3591	3582	3474	3116
No. banks	429	428	413	380
No. countries	28	28	27	27
R-squared within	0.086	0.087	0.084	0.077
F-test		0.268	0.592	1.509
F-test p-value		0.767	0.626	0.231

Notes: The dependent variable is the liability-side bank liquidity creation. The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (column (2)), t, t-1 and t-2 (column (3)) and t, t-1, t-2 and t-3 (column (4)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 5a: climate-related disasters and liquidity creation: fixed effects models

	(1)	(2)	(3)	(4)
No. affected/Pop., climate-related disasters	-0.108*	-0.140*	-0.211***	-0.203**
	(-1.83)	(-2.00)	(-3.38)	(-2.58)
No. affected/Pop., climate-related disasters t-1		-0.145**	-0.170**	-0.231***
		(-2.32)	(-2.14)	(-3.43)
No. affected/Pop., climate-related disasters t-2			-0.176***	-0.191***
			(-3.92)	(-4.07)
No. affected/Pop., climate-related disasters t-3				-0.0583
				(-1.22)
Quality of institutions	0.545***	0.573***	0.467***	0.859**
	(4.53)	(5.21)	(3.03)	(2.74)
Size	0.114***	0.115***	0.143***	0.119**
	(3.46)	(2.84)	(3.13)	(2.44)
Size squared	-0.00749**	-0.00739**	-0.0104**	-0.00923**
	(-2.59)	(-2.19)	(-2.44)	(-2.23)
Net interest margin	-0.00480	-0.00529	-0.00444**	-0.00773***
	(-1.58)	(-1.68)	(-2.12)	(-2.95)
GDP per capita growth	0.00119	0.000605	0.00118	-0.000526
	(0.77)	(0.33)	(1.19)	(-0.48)
Public debt/GDP	0.000211	0.000167	-0.0000764	-0.000411
	(0.43)	(0.32)	(-0.19)	(-0.92)
FDI inflows	0.00168	0.00128	0.00153	0.000677
	(1.33)	(1.06)	(1.38)	(0.60)
Trade openness	-0.00108**	-0.000802	-0.000822	-0.000613
	(-2.26)	(-1.51)	(-1.47)	(-1.07)
Financial openness	-0.0198	-0.0275	-0.0662**	-0.0889
	(-0.85)	(-0.94)	(-2.36)	(-1.59)
Inflation	-0.000137	-0.0000253	-0.000000432	0.000286
	(-0.44)	(-0.08)	(-0.00)	(0.57)
Obs	2442	2166	1881	1536
No. banks	374	358	334	297
No. countries	27	26	24	24
R-squared within	0.110	0.106	0.111	0.126
F-test		2.706	7.896	9.691
F-test p-value		0.089	0.001	0.000

Notes: The dependent variable is the bank liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (column (2)), t, t-1 and t-2 (column (3)) and t, t-1, t-2 and t-3 (column (4)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 5b: non-climate-related disasters and liquidity creation: fixed effects models

	(1)	(2)	(3)	(4)
No. affected/Pop., non-climate-related disasters	0.0318 (0.07)	-0.0655 (-0.15)	0.00529 (0.01)	-0.269 (-0.39)
No. affected/Pop., non-climate-related disasters t-1		-0.654* (-1.89)	-0.838*** (-3.22)	-1.244*** (-3.11)
No. affected/Pop., non-climate-related disasters t-2			-1.230*** (-4.25)	-1.643*** (-4.85)
No. affected/Pop., non-climate-related disasters t-3				-1.068*** (-2.97)
Quality of institutions	0.543*** (4.41)	0.576*** (5.36)	0.471*** (3.28)	0.948*** (3.12)
Size	0.114*** (3.46)	0.118*** (2.91)	0.146*** (3.19)	0.122** (2.43)
Size squared	-0.00752** (-2.61)	-0.00770** (-2.31)	-0.0108** (-2.54)	-0.00954** (-2.25)
Net interest margin	-0.00471 (-1.57)	-0.00512 (-1.66)	-0.00441** (-2.24)	-0.00854*** (-3.11)
GDP per capita growth	0.00110 (0.67)	0.000556 (0.30)	0.000946 (0.83)	-0.000578 (-0.49)
Public debt/GDP	0.000172 (0.36)	0.000101 (0.20)	-0.000138 (-0.34)	-0.000397 (-0.87)
FDI inflows	0.00167 (1.29)	0.00137 (1.08)	0.00149 (1.15)	0.00102 (0.81)
Trade openness	-0.00107** (-2.24)	-0.000858 (-1.61)	-0.000857 (-1.40)	-0.000910 (-1.36)
Financial openness	-0.0207 (-0.89)	-0.0276 (-0.93)	-0.0685** (-2.34)	-0.111* (-1.93)
Inflation	-0.000128 (-0.42)	-0.0000264 (-0.09)	0.0000145 (0.04)	0.000428 (0.90)
Obs	2442	2166	1881	1536
No. banks	374	358	334	297
No. countries	27	26	24	24
R-squared within	0.109	0.102	0.103	0.119
F-test		2.555	6.104	8.580
F-test p-value		0.101	0.003	0.000

Notes: The dependent variable is the bank liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (column (2)), t, t-1 and t-2 (column (3)) and t, t-1, t-2 and t-3 (column (4)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.2. Sensitivity analyses

It is possible that the results presented so far are determined by the heterogeneity of the sample. The banking system varies widely in African countries where economic and social environments are heterogeneous. It is possible that some banks are affected by natural disasters while others are not. We perform two sets of tests using the OLS fixed effects model. First, we split our sample according to the size of banks.⁴ Bigger banks are likely more resilient to natural hazards. Because they are more diversified geographically, they are able to manage their risks by compensating losses in some markets (in affected countries) with profits from other markets. The results of Table 6 demonstrate that natural disasters have a larger and significant negative impact on liquidity creation in smaller banks than in big banks. The impact of natural disaster in big banks are negative but not significant.

Next, in addition to studying heterogeneity by bank size, we split our sample according to the incidence of disasters. Following Cavallo et al. (2013), we define a disaster as large when the total affected persons in a given country in a year is greater than the pooled mean of the entire sample. The regressions coefficients are reported in table 7 and emphasize two contrasting findings. Low-scale disasters tend to increase bank liquidity while large-scale disasters decrease liquidity creation. This contrasting effect of natural disasters is not surprising. Cortés and Strahan (2017) document such an increase in banking lending during the months following natural disasters. What is new in our study is the fact that only small scale-disasters produce such positive effects on liquidity creation. Certainly, large disasters produce negative influence on liquidity creation as they influence in a similar way economic activities (see Cavallo et al, 2013).

As final sensitivity test, we explore how our results in the baseline vary with the income level. It is likely that banks that operate in rich countries may suffer less severely from negative shocks as they can adopt anticipatory measures to limit the effects of these shocks. To gain greater insight on this point, we split our sample according to the income level. Low-income countries are those with the GDP per capita lower than the sample average. The FE regressions results in Table 8 are in line with our expectations. We find that natural disasters severely hit banks that operate in low-income countries.

⁴ A bank is considered small when its total asset is smaller than the sample average of total assets.

Table 6: Natural disasters and liquidity creation: small banks versus big banks

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Small banks				Big banks			
No. affected/Pop.	-0.187** (-2.69)	-0.234*** (-3.63)	-0.287*** (-3.70)	-0.246*** (-3.52)	-0.0317 (-0.49)	-0.0550 (-0.69)	-0.0764 (-0.92)	-0.120 (-1.41)
No. affected/Pop. t-1		-0.147*** (-2.86)	-0.187*** (-3.35)	-0.211*** (-2.84)		-0.0864 (-1.17)	-0.0886 (-1.04)	-0.120 (-1.54)
No. affected/Pop. t-2			-0.222* (-1.85)	-0.163 (-1.43)			-0.101* (-2.01)	-0.144*** (-3.71)
No. affected/Pop. t-3				-0.0647 (-0.99)				-0.0730 (-1.27)
Quality of institutions	0.724** (2.24)	0.735** (2.26)	0.698* (2.02)	0.676 (1.67)	0.0147 (0.14)	0.00501 (0.05)	-0.00360 (-0.03)	-0.00753 (-0.06)
Net interest margin	-0.00889* (-1.97)	-0.00900* (-1.99)	-0.00955** (-2.40)	-0.0111** (-2.57)	-0.00374 (-1.46)	-0.00383 (-1.56)	-0.00376 (-1.66)	-0.00431* (-2.03)
GDP per capita growth	0.00369** (2.39)	0.00359** (2.29)	0.00371** (2.16)	0.00365** (2.43)	-0.0000397 (-0.02)	-0.0000876 (-0.05)	0.000313 (0.21)	-0.000478 (-0.33)
Public debt/GDP	0.00107*** (3.25)	0.00109*** (3.34)	0.00121*** (3.28)	0.00129*** (3.10)	-0.000625 (-1.09)	-0.000610 (-1.08)	-0.000761 (-1.47)	-0.000771 (-1.62)
FDI inflows	0.00506*** (3.26)	0.00503*** (3.24)	0.00453*** (3.03)	0.00262* (1.93)	-0.000647 (-0.54)	-0.000631 (-0.53)	-0.000828 (-0.76)	-0.000605 (-0.60)
Trade openness	-0.00334*** (-4.49)	-0.00333*** (-4.60)	-0.00342*** (-4.55)	-0.00344*** (-4.23)	-0.000461 (-0.92)	-0.000412 (-0.81)	-0.000264 (-0.56)	-0.000249 (-0.53)
Financial openness	0.00200 (0.16)	0.00242 (0.20)	-0.00599 (-0.50)	-0.00409 (-0.32)	-0.0414 (-1.36)	-0.0444 (-1.46)	-0.0493 (-1.59)	-0.0403 (-1.10)
Inflation	0.00206* (2.06)	0.00216** (2.24)	0.00240** (2.59)	0.00218 (1.59)	-0.000482* (-2.00)	-0.000482* (-2.02)	-0.000440* (-1.96)	-0.000744** (-2.57)
Obs	1110	1106	1064	903	1701	1697	1655	1550
No. banks	237	234	227	201	211	211	205	196
No. countries	26	26	26	26	23	23	23	23
R-squared within	0.137	0.139	0.150	0.156	0.107	0.109	0.117	0.118
F-test		8.687	6.287	3.579		1.187	3.417	5.677
F-test p-value		0.002	0.003	0.021		0.322	0.033	0.002

Notes: The dependent variable is the bank liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (columns (2) and (6)), t, t-1 and t-2 (columns (3) and (7)) and t, t-1, t-2 and t-3 (columns (4) and (8)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7: Natural disasters and liquidity creation: large disasters

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low disasters				Large disasters			
No. affected/Pop.	31.38*	31.87*	31.00*	32.85*	-0.121	-0.139*	-0.166**	-0.192**
	(1.77)	(1.78)	(1.79)	(1.93)	(-1.67)	(-1.86)	(-2.28)	(-2.26)
No. affected/Pop. t-1		0.0491	0.0557	0.0145		-0.120*	-0.169*	-0.205**
		(0.74)	(0.50)	(0.10)		(-1.88)	(-1.78)	(-2.20)
No. affected/Pop. t-2			0.0130	-0.000389			-0.246***	-0.223***
			(0.09)	(-0.00)			(-2.84)	(-3.24)
No. affected/Pop. t-3				-0.225				-0.0729*
				(-1.23)				(-1.94)
Quality of institutions	-0.102	-0.102	-0.103	-0.0339	0.477***	0.460**	0.558***	0.787***
	(-0.60)	(-0.60)	(-0.64)	(-0.21)	(2.86)	(2.80)	(2.86)	(4.30)
Size	0.0531	0.0548	0.0530	0.0740	0.129***	0.134***	0.146***	0.0816*
	(1.19)	(1.24)	(1.26)	(1.46)	(3.11)	(3.12)	(2.94)	(1.88)
Size squared	-0.00305	-0.00315	-0.00277	-0.00394	-0.00870**	-0.00903**	-0.0111**	-0.00727*
	(-0.87)	(-0.90)	(-0.83)	(-1.02)	(-2.35)	(-2.40)	(-2.38)	(-1.93)
Net interest margin	-0.00958***	-0.00951***	-0.00768***	-0.00642**	-0.00559*	-0.00525	-0.00546*	-0.00718***
	(-3.12)	(-3.11)	(-3.00)	(-2.11)	(-1.85)	(-1.66)	(-2.02)	(-3.95)
GDP per capita growth	0.00495***	0.00491***	0.00488***	0.00461***	-0.00196	-0.00221	-0.00192	-0.00183
	(3.84)	(3.83)	(3.99)	(3.34)	(-0.69)	(-0.77)	(-0.80)	(-0.95)
Public debt/GDP	0.00144***	0.00143***	0.00146***	0.00187***	-0.000368	-0.000345	-0.000412	-0.000644
	(4.17)	(4.22)	(3.76)	(4.95)	(-0.65)	(-0.63)	(-0.75)	(-1.10)
FDI inflows	-0.000562	-0.000577	-0.000458	-0.00180	0.00295**	0.00287**	0.00204*	0.00193*
	(-0.20)	(-0.21)	(-0.16)	(-0.58)	(2.55)	(2.49)	(1.83)	(1.91)
Trade openness	-0.000291	-0.000270	-0.000261	0.0000408	-0.00186***	-0.00174***	-0.00151***	-0.00140***
	(-0.48)	(-0.45)	(-0.43)	(0.05)	(-6.45)	(-5.46)	(-4.75)	(-4.14)
Financial openness	-0.0365**	-0.0361**	-0.0329**	-0.0341**	-0.0483	-0.0497	-0.0698**	-0.0692*
	(-2.57)	(-2.51)	(-2.21)	(-2.27)	(-1.43)	(-1.45)	(-2.23)	(-1.81)
Inflation	-0.000789	-0.000779	-0.000759	-0.00112	-0.0000958	-0.0000991	0.0000165	0.000183
	(-1.14)	(-1.11)	(-1.09)	(-1.57)	(-0.22)	(-0.23)	(0.04)	(0.45)
Obs	1233	1230	1195	1078	1578	1573	1524	1375
No. banks	290	289	280	261	323	322	312	283
No. countries	27	27	27	27	25	25	24	24
R-squared within	0.136	0.137	0.130	0.139		0.139	0.151	0.154
F-test		1.806	1.355	9.058		1.930	5.504	4.178
F-test p-value		0.185	0.279	0.000		0.169	0.006	0.013

Notes: The dependent variable is the bank liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (columns (2) and (6)), t, t-1 and t-2 (columns (3) and (7)) and t, t-1, t-2 and t-3 (columns (4) and (8)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8: Natural disasters and liquidity creation: Low-income countries versus medium-income countries

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Low-income countries				Medium income countries			
No. affected/Pop.	-0.123** (-2.26)	-0.130** (-2.14)	-0.160** (-2.45)	-0.172** (-2.58)	-0.139 (-0.94)	-0.148 (-1.14)	-0.0776 (-0.45)	-0.0667 (-0.30)
No. affected/Pop. t-1		-0.0306 (-0.72)	-0.0637 (-1.37)	-0.0724 (-1.50)		-0.0647 (-0.39)	0.368 (1.45)	0.443 (1.62)
No. affected/Pop. t-2			-0.146*** (-3.30)	-0.114*** (-2.87)			-0.0591 (-0.27)	-0.0154 (-0.07)
No. affected/Pop. t-3				-0.0225 (-0.46)				-0.138 (-1.68)
Quality of institutions	0.129 (0.90)	0.129 (0.90)	0.128 (0.86)	0.127 (0.83)	0.498 (1.65)	0.490 (1.70)	0.459 (1.56)	0.512* (1.81)
Size	0.195*** (4.83)	0.195*** (4.76)	0.196*** (4.63)	0.195*** (4.19)	0.0355 (0.46)	0.0367 (0.46)	0.0105 (0.14)	0.0158 (0.18)
Size squared	-0.0158*** (-3.66)	-0.0156*** (-3.53)	-0.0156*** (-3.35)	-0.0156*** (-3.10)	-0.00223 (-0.43)	-0.00243 (-0.45)	-0.00209 (-0.39)	-0.00275 (-0.46)
Net interest margin	-0.00341 (-1.01)	-0.00324 (-0.94)	-0.00314 (-1.13)	-0.00343 (-1.12)	-0.00215 (-0.44)	-0.00331 (-0.75)	-0.00490 (-0.97)	-0.00630 (-1.19)
GDP per capita growth	0.00421** (2.51)	0.00418** (2.46)	0.00418** (2.47)	0.00414** (2.42)	0.00259 (0.99)	0.00232 (1.00)	0.00317 (1.24)	0.00243 (0.58)
Public debt/GDP	0.000354 (0.87)	0.000364 (0.90)	0.000374 (0.90)	0.000449 (1.04)	-0.00218** (-2.33)	-0.00209** (-2.12)	-0.00218** (-2.63)	-0.00207** (-2.44)
FDI inflows	0.00338** (2.56)	0.00336** (2.55)	0.00303** (2.40)	0.00247* (1.87)	0.000971 (0.55)	0.00108 (0.63)	0.00215 (1.24)	0.00336* (1.87)
Trade openness	-0.00190*** (-2.97)	-0.00188*** (-2.90)	-0.00185*** (-2.86)	-0.00200*** (-2.87)	-0.000455 (-1.10)	-0.000384 (-0.85)	-0.0000626 (-0.11)	0.000404 (0.84)
Financial openness	-0.0426 (-1.67)	-0.0428 (-1.68)	-0.0465* (-1.74)	-0.0461 (-1.67)	0.0975** (2.63)	0.0926** (2.17)	0.0699 (1.28)	0.0452 (0.67)
Inflation	0.000196 (0.17)	0.000223 (0.19)	0.000445 (0.38)	0.000297 (0.21)	0.000177 (0.56)	0.000119 (0.39)	-0.0000277 (-0.08)	-0.000352 (-0.74)
Obs	2203	2199	2143	1937	608	604	576	516
No. banks	296	295	287	266	120	119	114	104
No. countries	23	23	23	23	7	7	7	7
R-squared within	0.147	0.148	0.147	0.142	0.204	0.209	0.213	0.232
F-test		3.421	5.256	7.604		1.772	1.635	2.416
F-test p-value		0.049	0.006	0.000		0.196	0.213	0.085

Notes: The dependent variable is the bank liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (columns (2) and (6)), t, t-1 and t-2 (columns (3) and (7)) and t, t-1, t-2 and t-3 (columns (4) and (8)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6. Concluding remarks

As other developing countries, the Sub-Saharan African countries are hit severely by natural disasters. Natural disasters cause economic and huge social damages. In this paper, we have explored the consequences on the banking sector focusing on their liquidity creation function. To this end, we merge bank level data with country level data over the period 1988-2018 on a sample of more than three hundred banks and thirty countries.

Our findings suggest that natural disasters intensity affect negatively the bank liquidity creation. This effect is persistent over time. We further documented that this negative impact is mostly driven by their asset-side (lending) activities. Our results also suggest that the effect of natural disasters depends to some extent on the size of the banks, the nature of disasters and exposure to some specific climate areas and economic environment.

Our study is one of the first to capture the negative impact of natural disasters on the bank liquidity creation in SSA. The results indicate that failing to account for such effects can potentially undermine the banking stability and disrupt the financing of the affected economies. Not only can natural disasters immediately affect the well-being of populations, but by having a negative impact on the creation of liquidity, they can cause lasting disruption to the economic system and delaying post-disaster reconstruction. Strengthening the resilience of African banking systems to natural disasters is therefore a priority both for the national authorities and the international organizations.

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Appendices

Table A1 : Definition of variables and their sources

Variables	Definitions	Sources
Dependent variables		
Bank liquidity creation	Total bank liquidity creation normalized by total asset	Fitchconnect and authors' calculation
Asset-side liquidity creation	Bank liquidity created through assets	Fitchconnect and authors' calculation
Liability-side liquidity creation	Bank liquidity created through liabilities	Fitchconnect and authors' calculation
Independent variables		
No. affected /total pop.	Annual sum of people injured, homeless, and otherwise affected during natural disasters (excluding technological disasters) divided by total population in the previous year.	Emdat (Delforge et al, 2023) and authors' calculation
No. affected /total pop., climatic events	Annual sum of people injured, homeless, and otherwise affected during climatic disasters divided by total population in the previous year. Climatic disasters include climatic, meteorological and hydrological disasters.	Emdat (Delforge et al, 2023) and authors' calculation
No. affected /total pop., non-climatic events	Annual sum of people injured, homeless, and otherwise affected during non-climatic disasters divided by total population in the previous year. Non-climatic disasters include biological and geological disasters.	Emdat (Delforge et al, 2023) and authors' calculation
Control variables		
Quality of institutions	Measure of property rights (v2xcl_prpty): includes the right to acquire, possess, inherit, and sell private property, including land. Limits on property rights may come from the state which may legally limit rights or fail to enforce them; customary laws and practices; or religious or social norms.	Vdem 13 (Coppedge et al., 2023)
Size	Logarithm of a bank's total assets	Fitchconnect and authors' calculation
Net interest margin	Net interest margin: difference between the interest income generated by banks and the amount of interest paid out to their lenders.	Fitchconnect and authors' calculation
GDP per capita growth	Annual percentage growth rate of GDP per capita based on constant local currency. GDP per capita is gross domestic product divided by midyear population.	World Development Indicators
Public debt/GDP	The gross debt of the general government as a percentage of GDP	World Development Indicators
FDI inflows	Net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments. Divided by GDP	World Development Indicators
Trade openness	Trade is the sum of exports and imports of goods and services measured as a share of gross domestic product.	World Development Indicators
Inflation	Measured by the consumer price index reflect the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals, such as yearly.	World Development Indicators
Financial openness	The extent of openness in capital account transactions (KAOPEN)	Chin and Ito (2008) updated
Additional variables		
Small size dummy	Equal to 1 if the (log) total asset for a given bank in a year is lower than the sample average, 0 otherwise	Fitchconnect and authors' calculation
Low-income dummy	Equal to 1 if the GDP per capita for a given country in a year is lower than the sample average, 0 otherwise.	WDI and authors' calculation

Table A2 : Climate-related natural disasters and asset-side liquidity creation

	(1)	(2)	(3)	(4)
No. affected/Pop., climate-related events	-0.0580 (-1.00)	-0.0938 (-1.46)	-0.140** (-2.43)	-0.0963** (-2.18)
No. affected/Pop., climate-related events t-1		-0.121** (-2.82)	-0.158** (-2.82)	-0.195*** (-4.01)
No. affected/Pop., climate-related events t-2			-0.165** (-2.77)	-0.152** (-2.62)
No. affected/Pop., climate-related events t-3				-0.0473 (-1.04)
Quality of institutions	0.486*** (3.93)	0.484*** (4.60)	0.426*** (3.44)	0.793*** (3.16)
Size	0.0584*** (2.82)	0.0604** (2.74)	0.0758** (2.50)	0.0654* (1.79)
Size squared	-0.00356 (-1.59)	-0.00357 (-1.49)	-0.00490 (-1.55)	-0.00456 (-1.52)
Net interest margin	0.00364* (1.76)	0.00277 (1.36)	0.00224 (1.13)	-0.0000656 (-0.02)
GDP per capita growth	0.00210 (1.11)	0.00232 (1.23)	0.00248* (1.77)	0.00106 (0.58)
Public debt/GDP	-0.000150 (-0.51)	-0.0000860 (-0.27)	-0.000222 (-0.84)	-0.000179 (-0.58)
FDI inflows	0.00216* (2.01)	0.00202* (2.01)	0.00205** (2.49)	0.00208** (2.57)
Trade openness	-0.00110*** (-3.06)	-0.00108*** (-3.56)	-0.00103*** (-3.18)	-0.00141*** (-3.54)
Financial openness	0.000663 (0.03)	-0.000629 (-0.02)	-0.0224 (-0.90)	-0.0344 (-0.97)
Inflation	0.000355 (1.51)	0.000426* (1.91)	0.000482 (1.66)	0.000624 (1.46)
Obs	2570	2288	1997	1637
No. banks	382	365	341	306
No. countries	27	26	24	24
R-squared within	0.102	0.098	0.094	0.104
F-test		4.612	3.294	4.697
F-test p-value		0.021	0.040	0.007

Notes: The dependent variable is the asset-side bank liquidity creation. The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (column (2)), t, t-1 and t-2 (column (3)) and t, t-1, t-2 and t-3 (column (4)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. *t* statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A3 : Climate-related natural disasters and liability-side liquidity creation

	(1)	(2)	(3)	(4)
No. affected/Pop., climate-related events	0.00626 (0.23)	0.00703 (0.24)	-0.00719 (-0.23)	-0.0102 (-0.33)
No. affected/Pop., climate-related events t-1		-0.0105 (-0.62)	-0.00181 (-0.08)	-0.0179 (-0.52)
No. affected/Pop., climate-related events t-2			0.00840 (0.32)	0.0240 (1.00)
No. affected/Pop., climate-related events t-3				0.00741 (0.57)
Quality of institutions	-0.0401 (-0.71)	0.00385 (0.06)	-0.0439 (-0.57)	-0.0161 (-0.12)
Size	0.0656*** (7.14)	0.0705*** (4.73)	0.0911*** (3.86)	0.0987*** (3.70)
Size squared	-0.00460*** (-8.82)	-0.00478*** (-7.23)	-0.00658*** (-4.23)	-0.00661*** (-4.04)
Net interest margin	-0.00817*** (-5.78)	-0.00769*** (-4.76)	-0.00699*** (-4.40)	-0.00709*** (-3.04)
GDP per capita growth	-0.00136 (-1.44)	-0.00187* (-1.83)	-0.00184 (-1.63)	-0.00251* (-1.84)
Public debt/GDP	0.000170 (0.85)	0.000108 (0.48)	0.0000507 (0.22)	-0.000110 (-0.43)
FDI inflows	-0.000116 (-0.21)	-0.000335 (-0.52)	-0.000634 (-1.07)	-0.00169*** (-3.61)
Trade openness	0.0000361 (0.15)	0.000236 (0.73)	0.000231 (0.80)	0.000608** (2.20)
Financial openness	-0.0209** (-2.37)	-0.0267** (-2.74)	-0.0356*** (-3.15)	-0.0495** (-2.23)
Inflation	-0.000573*** (-3.44)	-0.000524*** (-3.28)	-0.000574*** (-4.03)	-0.000386* (-1.75)
Obs	3140	2795	2440	2001
No. banks	420	400	375	337
No. countries	27	26	24	24
R-squared within	0.086	0.086	0.089	0.092
F-test		0.300	0.036	0.529
F-test p-value		0.744	0.991	0.716

Notes: The dependent variable is the liability-side bank liquidity creation. The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 13.0 (Coppedge et. Al., 2023). Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table A1 in appendix. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). The F-tests refer to Wald tests as the sum of the coefficients of natural disasters variables in t and t-1 (column (2)), t, t-1 and t-2 (column (3)) and t, t-1, t-2 and t-3 (column (4)). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A4 : Non-Climate-related natural disasters and asset-side liquidity creation

	(1)	(2)	(3)	(4)
No. affected/Pop., non-climate-related events	0.133	-0.0222	-0.0283	-0.219
	(0.69)	(-0.09)	(-0.13)	(-0.63)
No. affected/Pop., non-climate-related events t-1		-0.450	-0.565**	-0.909***
		(-1.69)	(-2.77)	(-3.09)
No. affected/Pop., non-climate-related events t-2			-1.058***	-1.418***
			(-5.30)	(-6.69)
No. affected/Pop., non-climate-related events t-3				-0.814***
				(-3.26)
Quality of institutions	0.482***	0.487***	0.428***	0.869***
	(3.81)	(4.45)	(3.28)	(3.31)
Size	0.0585***	0.0622**	0.0776**	0.0670*
	(2.83)	(2.80)	(2.61)	(1.84)
Size squared	-0.00358	-0.00377	-0.00523	-0.00483
	(-1.61)	(-1.59)	(-1.68)	(-1.62)
Net interest margin	0.00369*	0.00292	0.00234	-0.000448
	(1.81)	(1.48)	(1.27)	(-0.17)
GDP per capita growth	0.00206	0.00234	0.00239	0.00127
	(1.08)	(1.24)	(1.61)	(0.71)
Public debt/GDP	-0.000172	-0.000129	-0.000252	-0.000149
	(-0.59)	(-0.40)	(-0.89)	(-0.47)
FDI inflows	0.00215*	0.00209*	0.00209**	0.00245**
	(1.98)	(2.04)	(2.28)	(2.76)
Trade openness	-0.00109***	-0.00112***	-0.00109***	-0.00167***
	(-3.06)	(-3.81)	(-3.15)	(-3.78)
Financial openness	-0.000115	-0.000857	-0.0244	-0.0556
	(-0.01)	(-0.03)	(-0.92)	(-1.52)
Inflation	0.000360	0.000427*	0.000491*	0.000750*
	(1.56)	(1.95)	(1.75)	(1.85)
Obs	2570	2288	1997	1637
No. banks	382	365	341	306
No. countries	27	26	24	24
R-squared within	0.101	0.095	0.087	0.099
F-test		2.390	9.621	25.031
F-test p-value		0.115	0.000	0.000

Notes: The dependent variable is the bank liability liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al, 2023). Quality institutions (property of institutions) is retrieved from the Vdem 3.0. Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table 1. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table A5 : Non-climate-related natural disasters and liability liquidity creation

	(1)	(2)	(3)	(4)
No. affected/Pop., non-climate-related events	-0.0402 (-0.23)	-0.0277 (-0.17)	0.0509 (0.28)	0.0506 (0.24)
No. affected/Pop., non-climate-related events t-1		-0.184 (-1.42)	-0.198 (-1.67)	-0.332* (-2.05)
No. affected/Pop., non-climate-related events t-2			0.0476 (0.21)	-0.0199 (-0.11)
No. affected/Pop., non-climate-related events t-3				-0.159 (-1.35)
Quality of institutions	-0.0396 (-0.70)	0.00408 (0.07)	-0.0441 (-0.57)	-0.0137 (-0.10)
Size	0.0656*** (7.08)	0.0707*** (4.76)	0.0910*** (3.95)	0.0986*** (3.72)
Size squared	-0.00459*** (-8.80)	-0.00480*** (-7.38)	-0.00658*** (-4.37)	-0.00659*** (-4.11)
Net interest margin	-0.00817*** (-5.77)	-0.00769*** (-4.76)	-0.00700*** (-4.42)	-0.00710*** (-3.03)
GDP per capita growth	-0.00135 (-1.46)	-0.00186* (-1.83)	-0.00185 (-1.67)	-0.00254* (-1.89)
Public debt/GDP	0.000173 (0.91)	0.000112 (0.52)	0.0000393 (0.18)	-0.000145 (-0.59)
FDI inflows	-0.000112 (-0.20)	-0.000316 (-0.48)	-0.000628 (-1.03)	-0.00166*** (-3.54)
Trade openness	0.0000353 (0.14)	0.000229 (0.70)	0.000230 (0.78)	0.000600** (2.24)
Financial openness	-0.0207** (-2.31)	-0.0266** (-2.68)	-0.0361*** (-3.17)	-0.0508** (-2.28)
Inflation	-0.000573*** (-3.43)	-0.000528*** (-3.28)	-0.000575*** (-4.14)	-0.000393* (-1.78)
Obs	3140	2795	2440	2001
No. banks	420	400	375	337
No. countries	27	26	24	24
R-squared within	0.086	0.086	0.089	0.091
F-test		1.159	1.425	1.931
F-test p-value		0.332	0.262	0.143

Notes: The dependent variable is the bank liability liquidity creation, calculated following Berger and Bouwman (2009). The bank level data are taken from the Fitch Connect database. The natural disasters data are taken EM-DAT (Delforge et al. 2023). Quality institutions (property of institutions) is retrieved from the Vdem 3.0. Financial openness is taken from Chinn and Ito (2008). GDP per capita growth, FDI inflows, trade openness and inflation are extracted from the WDI database. A complete description of all the variables is provided in Table 1. The method of estimation is fixed effects regressions with Driscoll and Kraay (1998). All regressions include bank fixed effects, year fixed effects and country fixed effects. Standard errors. t statistics in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.



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