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WORKING PAPER

MACRO-FINANCIAL EFFECTS OF CLIMATE-RELATED DISASTERS: EVIDENCE FROM INDONESIA





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Working Paper by CSIS Indonesia

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Abstract

Climate-related disasters pose significant risks to economic and financial stability. This paper examines their dynamic macro-financial impacts in Indonesia using a local projections approach. The study estimates that disasters have temporary yet detrimental effects on macroeconomic variables. Economic growth contracts due to production disruptions and reduced consumption, while producer price inflation rises more sharply than consumer price inflation, reflecting both supply and demand-side pressures. In contrast, the impacts on financial stability, as reflected by elevated credit risk and lower credit growth, tend to be more persistent, although they emerge with a lag following the disaster shocks. The macro-financial responses vary across disaster types. The findings underscore the need for policies to navigate these challenges.

JEL Classification: C22, E31, E44, E52, E62, Q54

Keywords: Climate Change, Disasters, Macroeconomics, Financial Stability, Local Projections

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Introduction

Natural disasters are becoming increasingly frequent and severe, driven by the accelerating effects of climate change. This trend is particularly evident in Asia and the Pacific, where disaster-prone countries like Indonesia are experiencing heightened risks (Figure 1). These disasters inflict economic and social disruptions, including loss of lives, displacement of affected population, and destruction of infrastructure and physical capital. Disasters disproportionately affect vulnerable sectors like agriculture, with droughts and floods leading to reduced crop yields, increased food prices, and broader consequences for productivity, economic growth, and welfare (Cavallo and Noy, 2009; Dell et al., 2014; Barro, 2009; Raddatz, 2009). These disasters represent a physical climate risk that also pose a threat to financial stability, transmitted through increased credit risk and reduced loan performance (Carney, 2015; Batten et al., 2020; Vollmer, 2022; Schnabel, 2022).

With future projections suggesting a worsening of climate physical risks, it is essential to understand how disasters impact key macroeconomic variables and what policy measures can mitigate these effects (ESCAP, 2023). For policymakers, understanding how climate change impacts the macroeconomy and financial system is essential to effectively assess future physical climate risks and develop resilient fiscal strategies. Central banks, in particular, face the dual challenge of ensuring price stability while managing supply-side shocks that threaten price and financial stability (McKibbin et al., 2020).

This paper examines the case of Indonesia, as the topic is critical given the country's vulnerability to climate change (Republic of Indonesia, 2021). Projections under different climate change scenarios suggest that these risks will only intensify in the coming years (World Bank Group, 2021; World Bank and Asian Development Bank, 2021). This is also confirmed by the INFORM risk index, which shows Indonesia's risk profile is increasing. Indonesia is ranked 27th of 196 countries in terms of natural hazards on the INFORM Risk Index (European Commission, 2025). As pictured in Figure 1, the hazard risk trend is increasing from 5.3 in 2016 to 7.5 in 2025 (out of 10). This hazard risk is significantly higher compared to peer countries in the region and income groups, with average hazard indexes of 4.5 and 3.7, respectively.

Despite a growing body of research on climate-related disasters, most studies focus on micro-level, localized impacts and a specific disaster event (Lu et al., 2025; Hosono et al., 2016; Molnar-Tanaka et al., 2023). By contrast, macro-level assessments, particularly those that focus on a single country, remain limited. Even fewer studies examine the dynamic effects of natural disasters over time or capture how shocks propagate through the sectoral supply-demand channel, the inflation channel, and the credit market. Motivated by these gaps, we develop a framework to study the topic at the macro level. Specifically, this paper addresses three research questions. First, how persistent are the effects of climate-related disaster shocks on macro-financial outcomes? Second, through what mechanisms do climate-related

disaster shocks influence macro-financial performance? Lastly, do different climate-related disasters (e.g., floods and mass movement) have varying impacts on macro-financial outcomes?

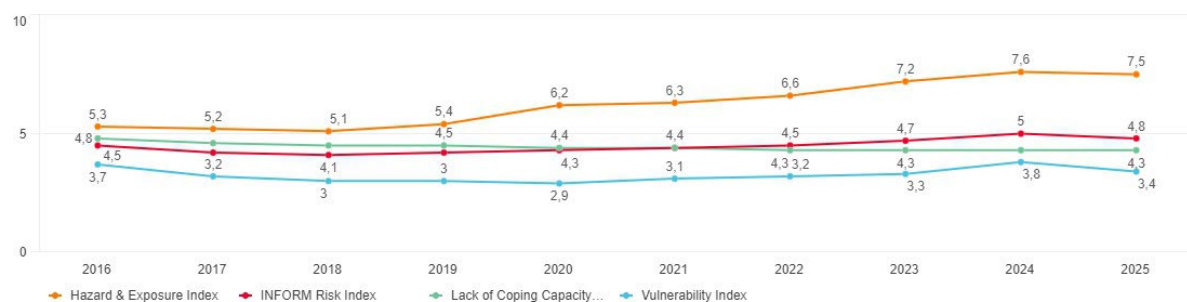


Figure 1. Risk Index: Indonesia

We limit the coverage of climate change to the impact of climate-related disaster shocks. We utilize the Emergency Events Database (EM-DAT), a global disaster database (CRED, 2024), to construct disaster shocks. The first shock is the overall climate-related disaster shock, where we consider the impact of all types of climate-related disasters, such as floods, mass movement, storms, droughts, and wildfires. We also explore the potential heterogeneity impact of different types of disasters; however, due to lower frequency, we can only assess the impact of floods and mass movement. We follow the general assumption that climate-related shocks are exogenous to the economy. Using national-level quarterly data from 2008 to 2019, we investigate the impulse responses of these shocks on key macroeconomic and financial indicators in Indonesia, employing the Local Projection method (Jordà, 2005).

We find that climatic disaster shocks have temporary yet detrimental effects on macroeconomic variables. Following the disaster shock, economic growth contracts by 0.08-0.21 percentage points during five quarters, due to production disruptions and reduced consumption. Disaster shocks also lead to a 1.9-2.3 percentage points spike in the producer price inflation. Inflationary pressures in the initial quarters are due to supply shocks in the agriculture and manufacturing sectors, but these effects are tempered by weakened demand. Interestingly, the inflationary pressure at the consumer level is significantly lower and more temporary (0.2 percentage points) than at the producer level.

We provide the evidence that climate-related disasters risk financial stability. We estimate the heightened credit risks and slower credit growth in the aftermath of disaster shocks. Initially, credit risks, as reflected by non-performing loans (NPLs), are not affected by shocks, enabled through policies from the financial sector authority. But after four quarters, NPLs persistently rise by 0.06-0.14 percentage points. A similar response is estimated for credit growth. After a lag, we see a persistent slowdown in credit growth by 0.7-1.0 percentage points in response to climatic disasters. Lastly, our results confirm the heterogeneity of the macro-financial responses to different types of disasters.

These findings contribute to the growing literature on macro-financial consequences of climate-related disasters, which has highlighted the adverse effects of disasters on output, inflation, and financial stability (Fomby et al., 2013; Cavallo et al., 2013; Klomp, 2014; Parker, 2018; Heinen et al., 2015). Previous studies often examine average impact in a static setting or focus on a specific disaster event. This study offers a more comprehensive and dynamic perspective by estimating how different types of natural disasters affect the key macroeconomic and financial variables over time. We work in a similar approach to Kabundi et al. (2022), although we offer more comprehensive analysis beyond inflation. By tracing the persistence and timing of responses in GDP and inflation components as well as credit conditions, the analysis provides insight that both supply and demand are important mechanisms through which climate physical shocks propagate through the real and financial sectors.

This paper contributes to the empirical literature on disaster-prone countries in the region, including Japan, Turkey, and the Philippines. While all are highly exposed to natural hazards, these countries face a distinct type of disaster beyond climate-related disasters. Japan and Turkey are particularly vulnerable to geological disasters, including earthquakes, whereas the Philippines regularly experiences climate-driven events, including typhoons, floods, and landslides. Prior studies provide evidence on the multifaceted economic consequences of large-scale disasters in these countries, including supply disruptions, labor market and consumption declines, real estate price fluctuations, financial market volatility, and credit capacity constraints (Lu et al., 2025; Mikawa, 2025; Hosono et al., 2016; Dolu and Ikizler, 2023; Sakariyahu et al., 2023; Molnar-Tanaka et al., 2023). In response to disasters, public spending, at both central and local government levels, is deployed to provide temporary relief for the most affected groups and to support recovery and reconstruction (Molnar-Tanaka et al., 2023; Noy et al., 2023). We complement the aforementioned studies by focusing on a comprehensive analysis using a dynamic approach at the macro level.

Beyond disaster-focused studies, this paper also contributes to a broader body of work on macroeconomic responses to climate-related shocks. This paper complements much of the existing work by emphasizing how the long-run trends of climate change, such as gradual temperature and precipitation anomalies, affect the economy (Batten, 2018; Odongo et al., 2022; Iliyasu et al., 2023; Kotz et al., 2023). The findings resonate with Bilal and Känzig (2024), who demonstrate that rising global temperatures can induce persistent output losses and heighten the probability of systemic macroeconomic shocks, and with Fernández-Villaverde et al. (2024), who argue that rare, extreme events like climate disasters must be explicitly modeled within macroeconomic frameworks that account for nonlinearities and uncertainty.

We proceed with the paper as follows: we start with a conceptual framework based on theoretical and empirical studies on the topic in Section 2. In Section 3, we present the data,

introduce the construction of the shocks, discuss the disaster-stylized facts, and describe the employed econometric approach. We discuss the results in Section 4 for the key response variables and the mechanism. Heterogeneity analysis and robustness test are reported in Section 5 and Section 6, respectively. We conclude and discuss policy implications in Section 7.

Conceptual Framework

We study the macro-financial effects of climatic disasters by drawing on a conceptual framework that distinguishes between the direct and indirect effects of natural disasters (Cavallo and Noy, 2009). Following a disaster, the observed direct effects include death and injury to people, as well as damage to homes, infrastructure, livestock, and crops. Beyond their immediate impact, disasters also have indirect effects on the broader economy, including reductions in income, employment, and sectoral production, as well as spikes in inflation. Literature distinguishes between short-run and long-run indirect effects of disasters¹. As we focus on the short-term impact of disasters, this study builds on the general conclusion that, on average, natural disasters have an adverse short-term effect on growth². The disaster shocks are exogenous primarily to short-run economic conditions, allowing us to use them as a causal inference. To measure the impact of disaster, we consider ex-post measures that determine the ultimate severity of disasters. Specifically, we construct our disaster shock from the number of people killed and affected, standardized to the population, as this metric can be applied across different disaster types (Becker and Mauro, 2006).

Climatic disasters are expected to have an adverse effect on short-term growth. In line with prior work, the decline in GDP is primarily caused by supply-side disruptions as disasters affect economic activity across various sectors (Fomby et al., 2013; Cavallo et al., 2013). The most immediate impact is on agriculture, which is highly vulnerable to floods, droughts, and storms due to its dependence on weather conditions. Disasters also damage infrastructure and disrupt supply chains, resulting in productivity losses in both manufacturing and services. Disasters also negatively affect the demand side of the economy, as they impact the labour market, leading to reduced work hours and increased unemployment, thus decreasing income and reducing consumption (Eickmeier et al., 2024; Molnar-Tanaka et al., 2023). The destruction of physical capital amid constraints in banks' lending potentially reduced firm-level investment (Hosono et al., 2016). Public spending plays a crucial role in supporting economic demand after a disaster. Disaster relief could create a safety net for the affected area and population in the short run (Molnar-Tanaka et al., 2023; Noy et al., 2023). In the longer term, such spending is an essential source of recovery and rebuilding physical capital and infrastructure. Consequently, the economic impact of disasters tends to be more severe in developing economies, where agricultural reliance and limited fiscal space amplify disaster-related losses.

¹ Literature typically defines a period up to three years as short-run and beyond five years as long-run

² There is a debate on the long-run effect of natural disasters due to theoretical ambiguity and methodological challenges. See Cavallo and Noy (2009) for further exploration on this topic

On the price side, there is heterogeneity in the impact of disasters on inflation, depending on the type and severity of the disasters, as well as economic development (Parker, 2018; Kabundi et al., 2022; Heinen et al., 2015)³. The effect depends largely on the interplay between the negative supply and demand effects of disasters on inflation. Disasters can induce inflationary pressures, particularly through supply-side disruptions in food, transportation, and energy. These bottlenecks drive up producer prices quickly, while consumer prices may adjust more slowly depending on demand conditions and be influenced by the central bank's policy. Our framework distinguishes between producer price index (PPI) and consumer price index (CPI) dynamics, allowing us to test whether upstream inflationary pressures translate into consumer price responses.

The effect of climate-related disasters on financial stability is profound, as they increase credit risk and threaten the banking system and financial markets. Disasters lead to a surge in non-performing loans (NPLs) as businesses and households struggle to meet their debt obligations due to income loss and property damage (Klomp, 2014). Financial markets also experience heightened volatility as investors react to uncertainties surrounding the economic damage and potential for lower corporate earnings. Studies indicate that the stock market and bond yields are negatively impacted after severe disasters, leading to tighter financial conditions (Battiston et al., 2017). We therefore expect to observe a deterioration in credit quality and a contraction in loan issuance following disaster shocks.

³Droughts and storms tend to influence inflation more than floods do. Infrequent and severe disasters are also harmful, driving up overall price levels. While it may seem unjust, the inflationary effects of disasters are far more pronounced in less developed countries. On the other hand, research shows that in advanced economies, the impact of such disasters on inflation is either minimal or negligible

Data and Methodology

Data

This study utilizes disaster, macroeconomy, and financial datasets. Climate-related disaster is the impulse, while macro-financial variables are the response variables. Table 1 provides the variables along with the frequency and source of the data. The scope of this study is from the first quarter of 2008 to the fourth quarter of 2019. We intentionally chose the sample to ensure the validity of the disaster data post-disaster management act and to avoid potential structural breaks in the data due to the COVID19 pandemic. This study uses quarterly data; therefore, data with a lower frequency is transformed into quarterly data. We present the statistical descriptive table in Appendix A and a summary of Indonesia's disaster management in Appendix B.

Disaster

The first dataset in this study is the disaster dataset. We use the EM-DAT international disaster database (CRED, 2024). The database collects disaster events, including type, location, and time, and impacts at the country level. The disaster is recorded in this database if the event has at least one of four criteria: ten fatalities, 100 affected people, a declaration of the state of emergency, and a call for international assistance. For the disaster impacts, it reports human impact variables (i.e., people affected and the death toll) and economic impact variables (i.e., total economic damage, reconstruction costs, and insured damage).

This study focuses on climate-related disasters as impulses or shocks. We intend to study the impact of all climate-related disasters, a summation of five types: floods, mass movement, storms, droughts, and wildfires. These types of disasters are classified as climate-related disasters due to their increasing frequency and severity linked to global warming, as highlighted by the IPCC's Sixth Assessment Report (Masson-Delmotte et al., 2021) and supported by World Bank and Asian Development Bank (2021). These disasters are also considered in IMF (2019), emphasizing their long-term fiscal risks. European Central Bank and Network for Greening the Financial System further underline their macroeconomic and financial stability implications (Schnabel, 2021).

Table 1. Disaster and Macro-financial Data

Category	Variable	Frequency	Source
Impulse Variable	Climate-related Disasters	monthly	EM-DAT
Type of Disasters	Flood	monthly	EM-DAT
	Mass movement	monthly	EM-DAT
Key Response Variable	Gross domestic product (GDP) growth	quarterly	BPS
	Consumer Price Index (CPI) inflation	monthly	BPS
	Producer Price Index (PPI) inflation	monthly	BPS
	Non-performing Loans (NPLs)	monthly	BI
	Credit Growth	monthly	OJK
Mechanism: GDP by Expenditure	Consumption	quarterly	BPS
	Government Expenditure	quarterly	BPS
	Investment	quarterly	BPS
	Export	quarterly	BPS
	Import	quarterly	BPS
Mechanism: GDP by Sector	Agriculture	quarterly	BPS
	Mining	quarterly	BPS
	Manufacture	quarterly	BPS
	Transcom	quarterly	BPS
	Services	quarterly	BPS
	Construction	quarterly	BPS
Mechanism: PPI inflation	Agriculture PPI	quarterly	BPS
	Manufacture PPI	quarterly	BPS
Mechanism: CPI inflation	Volatile Food Inflation	monthly	BPS
	Core Inflation	monthly	BPS
	Administered Prices Inflation	monthly	BPS
	Inflation Expectation	monthly	BI

Macro-financial Outcomes

As the key response variable, we first consider real gross domestic product (GDP) growth, an indicator of economic activity or aggregate demand. To further understand the channels through which disasters propagate to economic growth, we extend the analysis to the components of GDP. We analyze GDP by economic sectors as a proxy for the supply side of the economy. Specifically, we use agriculture, mining, manufacturing industry, transportation, and communication (Transcom), services, and construction. In parallel, we examine GDP by expenditure, such as consumption, government consumption, investment, export, and import, to reflect the domestic and external demand side of the economy

Secondly, we focus on inflation. We compare changes in the consumer price index (CPI) inflation and producer price index (PPI) inflation to understand who bears the cost of disasters. To enrich the analysis, we analyze how disasters affect inflation by extending the analysis to the components. For CPI inflation, we explore volatile food (VF) inflation, core inflation, administered prices (AP) inflation, and inflation expectations. We consider the producers' prices in the agriculture and manufacturing sectors for PPI inflation. Lastly, we use NPLs and credit growth as financial indicators, mainly to depict the soundness of the banking system, which is the most significant contributor to Indonesia's financial system.

Identification of Climate-related Shocks

We consider the disaster's impact in the form of its intensity to be the disaster shock. Moreover, the disaster intensity is based on the number of disaster victims following Becker and Mauro (2006). In this study, for each disaster incident, j , of type k that occurred in period t , the intensity is calculated by dividing the sum of fatalities and total affected by the total population multiplied by 100 (Equation 1). The overall impact is computed as the sum of the intensities within each month (Equation 2). J is the total number of disasters, and k is the type and total of climate-related disasters.

$$intensity_{t,j} = 100 \frac{(death_{t,j} + affected_{t,j})}{population_t} \quad (1)$$

Our climate-related shock, denoted by CS_t^k , is the percentage of total disaster victims in the population.

$$CS_t^k = \sum_{j=1}^J intensity_{t,j} \quad (2)$$

Disaster Stylized Facts

To understand the climate-related disaster shocks in this study, we present disaster intensity for all disasters and their distribution in Figure 2 and further disaster intensity of each type of disaster in Figure 3. From Figure 2a regarding disaster intensity for all disasters, we can identify several characteristics of disasters in Indonesia. Disaster events are frequent, as the events occur in almost every quarter during our study. Furthermore, we observe a significant increase in disaster intensity over time. This trend aligns with the broader impact of climate change, which is intensifying extreme weather and disaster risks. Lastly, disaster intensity is small, as indicated by the small percentages of the affected population. On average, disaster intensity is recorded at 0.03% of the population. A similar conclusion is supported by Figure 2b. The kernel density estimate exhibits that most observations cluster near zero, and the distribution is right-tailed. This suggests that small-scale disasters dominate the dataset, and severe disasters, where intensity is higher than 1% of the population, are relatively rare. However, this general trend is punctuated by several notable irregular episodes, showing instances where the percentage of the population impacted exceeded the 0.1 threshold, indicating a moderate-level disaster.

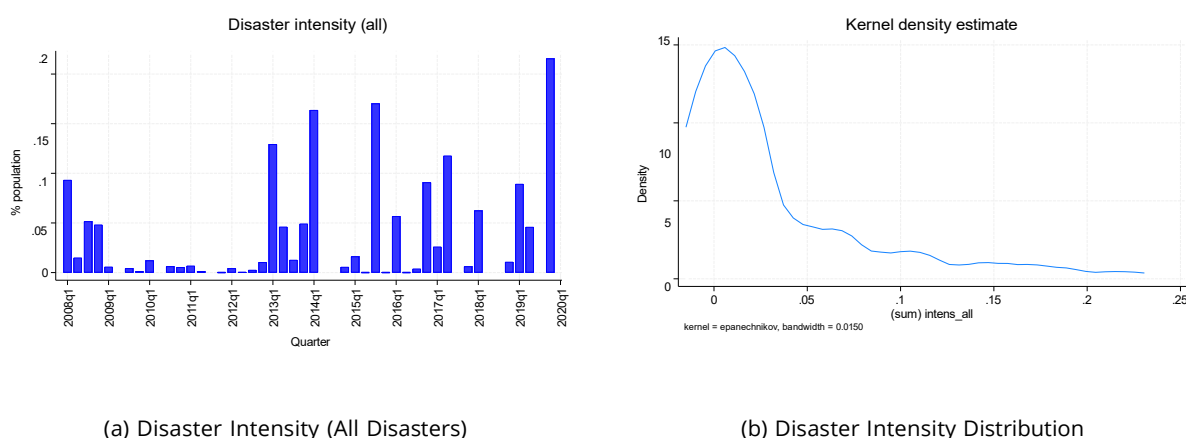


Figure 2. Disaster intensity and distribution (all disasters)

Figure 3 displays the intensity of five types of climate-related disasters. Floods emerge as the most frequent disaster in Indonesia (Figure 3a); thus, floods drive the overall disaster intensity. We observe consistent flood occurrences over time despite varying intensities across quarters. On average, the flood intensity is particularly low (0.03%) and close to the intensity of all disasters. Moderate floods were recorded in the first quarter of 2008, 2013, and 2014, and in the second quarter of 2017. The highest intensity was recorded in the last quarter of 2019, with intensity reaching 0.22%. The second most frequent disaster in Indonesia is mass movements, which, while less frequent, still appear more regularly than other disaster types (Figure 3b). However, its intensity, which only averages at 0.0003%, is significantly lower than the flood intensity. Even the highest intensity of mass movement is only recorded at 0.006% in the first quarter of 2017. The other two types of disasters,

namely storms and droughts, are rare and very small in magnitude. Notably, the average intensity of storms and droughts is below 0.0001%, indicating that these events, when they do occur, are significantly less severe than floods and mass movements (Figure 3c and Figure 3d). The last type of disaster is wildfire. Despite being rare, they can exhibit significant intensity, with the largest wildfire recorded in 2015 reaching an intensity of 0.16% (Figure 3e).

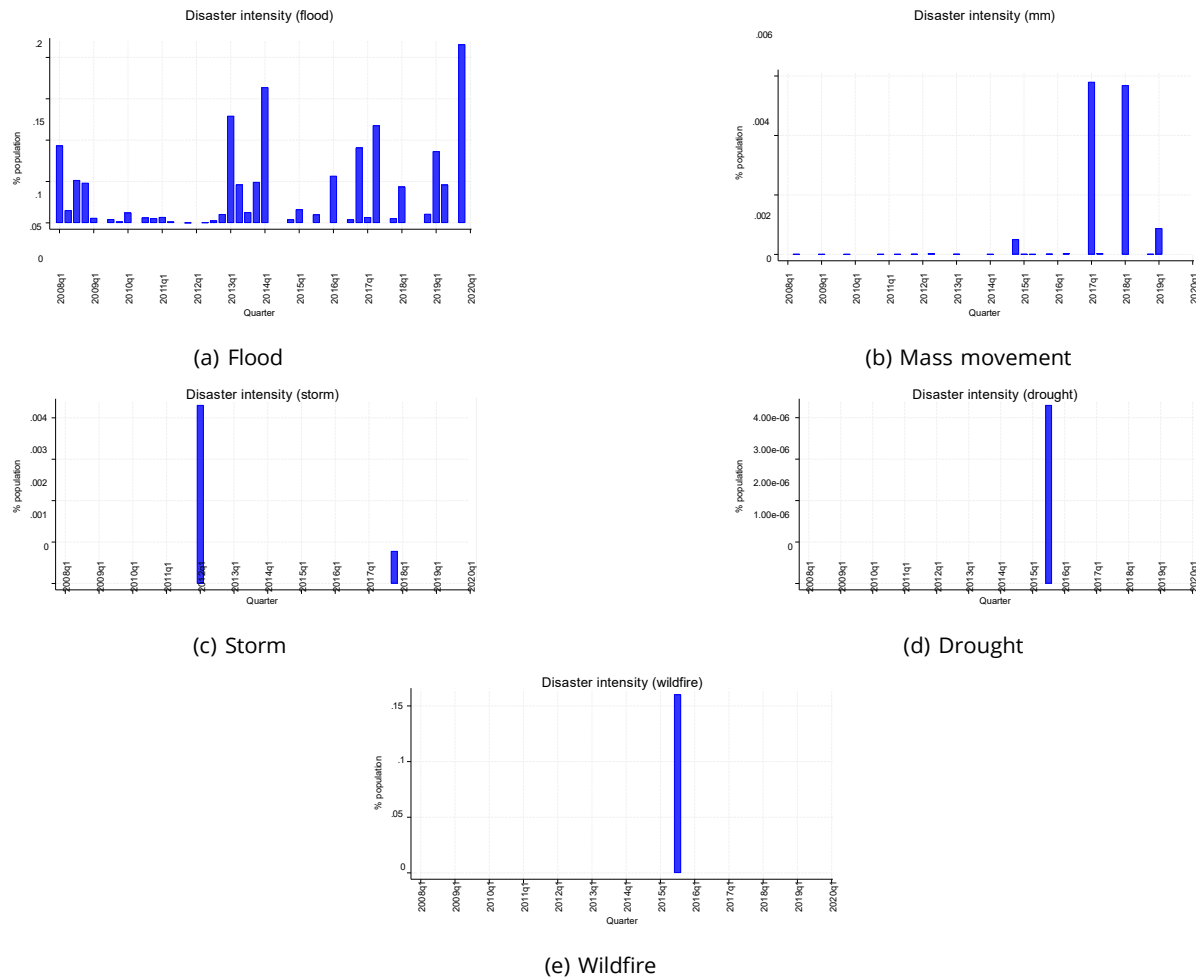


Figure 3. Intensity by type of disaster

Methodology

We employ the local projections (LPs) method proposed by Jordà (2005) to investigate the dynamic impact of climate-related disaster shocks on macro-financial variables. LPs offers more flexibility while remaining robust against misspecification compared to the traditional approach of vector autoregression (VAR). Moreover, the LPs's ability to estimate non-stationary and non-linear specifications has increased its use in calculating impulse response functions of policy and climate-related shocks in recent years (Plagborg-Møller and Wolf, 2021; Kabundi et al., 2022; De Schryder and Opitz, 2021).

Equation 3 illustrates our reference model:

$$y_{t+h} = \beta^h CS^k + \gamma^h(L)X_t + \alpha^h + \varepsilon_{t+h} \quad (3)$$

The variable of interest in this study, or the outcome variable, y_{t+h} , represents macro-financial variables over the LP horizon h for $h = 0, 1, \dots, H$. CS^k , is the shock variable,

namely, the climate-related shock in this study. The superscript k represents the type of disaster that we use. In the baseline scenario, k is all disasters. X_t is the control variable, including lags of response variable y , lags of impulse variable CS^k , and other control variables⁴. α is the intercept, which we allow to differ at each horizon, ε_{t+h} is the error term, and L is the lag term.

Implementation proceeds in three steps. After the first step of dataset preparation and shock identification, we include four quarterly lags (or $L = 4$) and eight quarterly horizons (or $H = 8$) to illustrate disaster shocks' short- to medium-term effects. Finally, we run simultaneous ordinary-least-squares regressions over the horizon. The resulting sequence of estimates, β^h , is then plotted with 90% confidence bands to form the impulse-response function. Therefore, impulse response functions (IRFs) are simultaneously constructed based on the β^h sequence, which captures the dynamic impact of shocks on response variables over the estimation horizon.

⁴ We include several covariates to control from external and domestic macroeconomic forces that may confound the estimation: (i) global commodity price index, to control for external inflation pressures; (ii) Real Effective Exchange Rate (REER), to account for exchange rate pass-through; (iii) policy interest rate, to absorb domestic monetary shocks; and (iv) Eid-ul-Fitr dummy, to capture recurring seasonal effects that affect domestic demand and inflation.

Results and Discussion

Responses of Key Macro-financial Variables

How persistent are the effects of climate-related disaster shocks on macro-financial outcomes? Figure 4 presents impulse response functions (IRFs) for key macro-financial variables following a disaster shock (all disasters). On the horizontal axis, each plot shows the responses at each quarter after the shock. The solid blue line denotes the estimated IRFs relative to a baseline scenario in which no shock occurs, and the shaded gray bands represent the 90% confidence intervals. Across the panels, we find that climate-related disaster shocks have a detrimental impact on macroeconomic performance, primarily through a decline in economic growth and a rise in PPI and CPI inflation, although the effects are short-lived. We also estimate that climatic disaster shocks pose a risk to financial stability, as indicated by increased credit risk, slowed credit growth, and decreased asset prices in the aftermath of climate-related shocks.

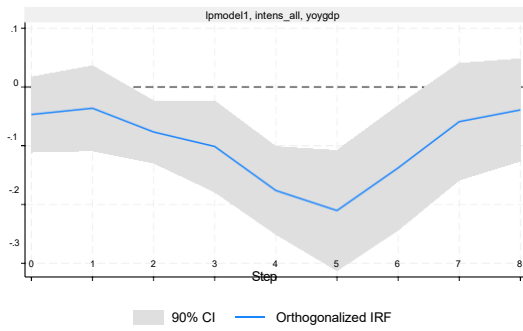
Focusing on GDP growth in Figure 4a, our result estimates that disaster shocks negatively and temporarily impact economic growth. The adverse effects are observed during the second to sixth quarters. By the second quarter, economic growth shows a modest decline of -0.08 percentage points (pp). GDP growth contracts further by 0.1 pp and 0.18 pp in the third and fourth quarters, reaching the lowest point of -0.21 pp in the fifth quarter. Following the trough, economic growth gradually recovers in the sixth quarter. The confidence intervals during these five quarters suggest that the impacts are statistically significant. Moreover, the rebound continues, and GDP growth gradually returns to its baseline. However, the seventh and eighth quarter responses are not statistically significant. This result suggests that the negative impact of disaster shocks is most pronounced in the short term. It is also temporary, with the economy gradually returning to its pre-shock growth trajectory. These results support the argument of the negative impact of climatic disasters on output as argued by Raddatz (2007), Cavallo and Noy (2009), Cavallo et al. (2013), among others.

In contrast, the effects of disaster shock on PPI inflation are immediate and positive but short-lived (Figure 4b). In the quarter of climate-related disaster shock (quarter 0), there is a positive change of 1.9 pp in PPI inflation. This effect remains steady at around 1.9 to 2.3 pp in the following three quarters. The statistically significant responses in the first four quarters reflect cost pressure at the producer level, stemming from possible supply disruptions caused by climatic disasters. However, the effect starts to decline and is insignificant from the fourth quarter onward, indicating that PPI inflation eventually stabilizes.

The inflationary pressure on CPI inflation is significantly more temporary than that on PPI inflation (Figure 4c). We estimate that a one-percentage-point increase in disaster intensity

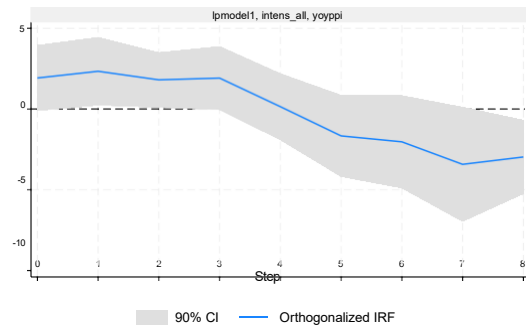
is associated with a rise of 0.2 pp in consumer price inflation in the third quarter after the shock. Price rigidities and price stabilization policies influence this delayed response. The inflationary pressure is transitory, and CPI inflation normalized from the fifth quarter onward. Consistent with previous studies, these findings reaffirm the positive and temporary impact of climatic disasters on consumer-level inflation, as documented by Eickmeier et al. (2024), Parker (2018), and Kabundi et al. (2022).

The stronger and more immediate response of PPI inflation compared to CPI inflation is consistent with the nature of supply-side shocks, price rigidities, and potential policy intervention. Climatic disasters primarily affect upstream production sectors by damaging production and disrupting distribution, thereby raising input costs at the producer level. The transmission of these producer price hikes to CPI inflation is more complex. Weaker household demand and purchasing power in the aftermath of a disaster can limit retailers' ability to pass on higher input costs. In many developing economies, including Indonesia, government-administered price controls or subsidies on staple food and other essential items further limit price fluctuation at the consumer level. Moreover, the CPI basket typically includes a broader mix of services and non-tradables, which adjust more slowly and are less directly exposed to disaster-related supply disruptions. As a result, CPI inflation in our study understates underlying cost pressures that are already evident in PPI inflation. This divergence raises the need for monetary authorities to monitor PPI inflation alongside CPI inflation, as an early detection of inflationary pressures, and to strengthen the timeliness of policy responses.



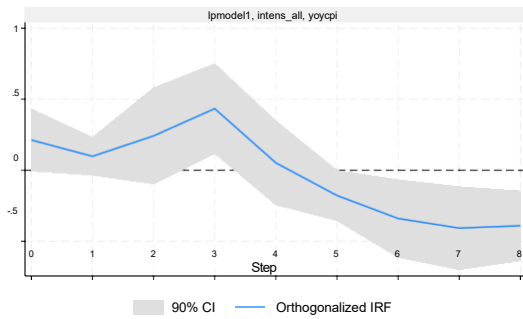
Graphs by irfname, impulse variable, and response variable

(a) GDP growth



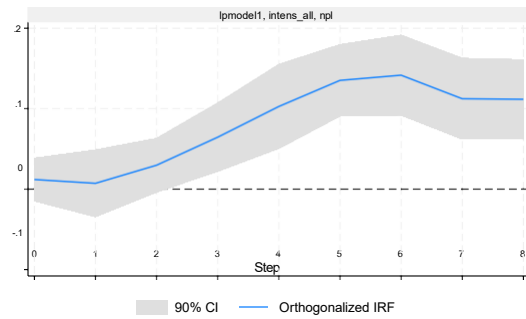
Graphs by irfname, impulse variable, and response variable

(b) PPI Inflation



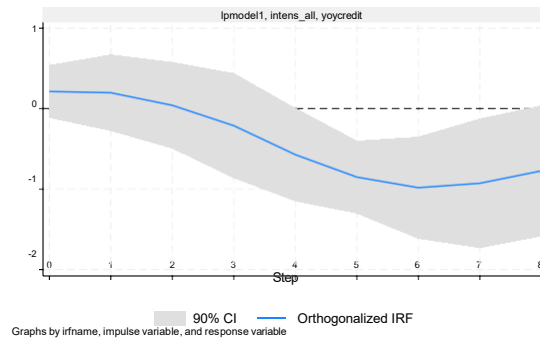
Graphs by irfname, impulse variable, and response variable

(c) CPI Inflation



Graphs by irfname, impulse variable, and response variable

(d) NPLs



Graphs by irfname, impulse variable, and response variable

(e) Credit growth

Figure 4. Impulse response functions of key macro-financial variables to disaster shock (all disasters)

Beyond the macroeconomic consequences discussed above, we estimate potential financial instability induced by climate-related shocks. Starting from the credit risk indicated by the level of NPLs. Figure 4d shows a delayed but prolonged effect in NPL levels following a disaster shock. The pronounced effects occur from the third quarter, where NPLs increase by 0.06 points. The IRF remains positive and peaked in the sixth quarter at 0.14 before gradually tapering off thereafter. This trajectory suggests financial distress among borrowers emerges with lags. This delayed result could be attributed to policy interventions or short-term relief that helped ease the loan repayment burden in the early quarters after a disaster. The eventual rise in NPL around one year after the shock indicates that loan repayment challenges become more evident as the interventions phase out, particularly in the sectors facing slower recovery.

Notable related policies to support our findings are Bank Indonesia Regulation (PBI) No. 8/15/PBI/2006, which allows loans restructured due to a natural disaster to be classified as Current (Lancar) from the time of restructuring until a specified period. Following this, Financial Services Authority Regulation (POJK) No. 45/POJK.03/2017 introduced a more flexible approach to loan classification, particularly for loans affected by natural disasters. Under this regulation, loans that are restructured following a disaster can be classified as Current (Lancar) regardless of past due days, ensuring that temporary payment difficulties do not automatically degrade loan quality. Additionally, restructured loans due to a disaster are classified as Current (Lancar) from the moment of restructuring until a period determined by the Financial Services Authority (OJK). A more recent policy, Financial Services Authority Regulation (POJK) No. 19 of 2022, further expands this flexibility by increasing the loan ceiling to IDR 10 billion. Similar to previous regulations, loan classification is determined based on the ability to pay principal and/or interest, without immediately downgrading loans based on arrears.

Meanwhile, the negative and significant impact of disaster shock on credit growth can be confirmed from Figure 4e. In the short term, regulations like PBI No. 8/15/2006, POJK No. 45/2017, and POJK No. 19/2022 provide temporary relief by preventing disaster-hit borrowers from being classified as non-performing, sustaining credit flow. However, as these temporary measures expire, banks tighten lending standards, and rising NPLs force them to increase provisioning, reducing their capacity to lend. Additionally, slow economic recovery in affected areas weakens credit demand. As a result, despite initial support, credit growth declines significantly after several quarters, highlighting the medium-term challenges of post-disaster credit growth and prospect.

Mechanism from Climate-related Disaster Shocks to Macro-financial Performance

Through what mechanisms do climate-related disaster shocks influence macro-financial performance? To identify the transmission mechanisms of disaster shocks, we adopt a decomposition strategy that reflects supply, demand, and prices. Specifically, we use GDP by sector to represent supply-side disruptions, as disasters often affect sectoral production differently. GDP by expenditure components captures demand-side responses from the domestic sector (consumption, investment, and government spending) and the external sector (exports and imports). Finally, we use CPI and PPI sub-indices to trace the price mechanism, distinguishing between upstream cost pressures and consumer-level price dynamics. These macroeconomic aggregates offer broader national coverage and higher policy relevance than survey-based leading indicators, as they reflect realized economic outcomes rather than expectations or sentiment.

Empirically, we estimate the same reference LPs equation as in equation 3, but we substitute the dependent variable y with sectoral GDP growth to capture supply-side effects, expenditure-side GDP to reflect demand-side adjustments, and PPI and CPI sub-indices to examine price dynamics.

Supply Side of the Economy

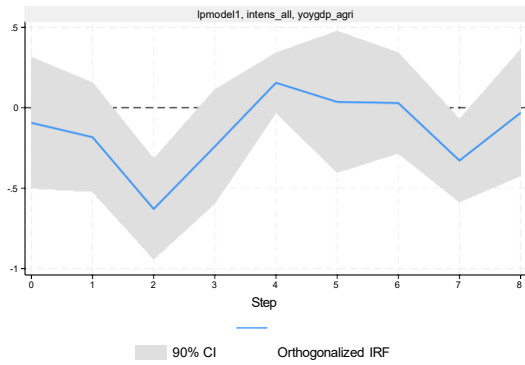
Which sector contributes to the temporary decline in economic growth? We complement the analysis of GDP growth by exploring the impact of climate-related disasters on the economic sectors. The IRFs in Figure 5 show distinct sectoral responses to climatic disasters. We find that a drop in the agriculture, manufacturing, services, and construction sectors contributes to the decline in economic performance. However, a surge in the transportation and communication (Transcom) sector balances the effect. Meanwhile, the mining sector is unaffected by the climate-related shock.

Climatic disasters negatively impact the agriculture sector, with a significant effect in the second quarter (Figure 5a). The disruption primarily stems from direct damage to agricultural production and possible secondary effects on soil or other supporting systems needed for agricultural production. The effect is estimated to be temporary as the responses become insignificant in the following quarters. This detrimental impact is in line with related literature, which concludes that the agriculture sector is vulnerable to climate-related shocks, including climatic disasters (i.e., Fomby et al. (2013)).

The manufacturing, services, and construction sectors experience detrimental responses to climatic disaster shocks. The IRFs of the manufacturing sectors in Figure 5b indicate that adverse effects emerge in the first quarter after the disaster event and persist afterwards. The persistent impact indicates that the recovery for this sector appears slower, reflecting the time needed to rebuild this sector's physical capital. In addition, the pro-longed effect

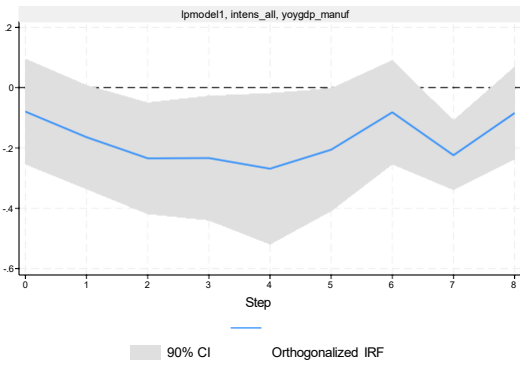
can also be linked to decreased consumption starting from the fourth quarter after the disaster, which in turn reduces demand for manufactured goods. Distinct negative responses are estimated in the service sectors (Figure 5e). We see an immediate negative impact in the quarter of disaster, indicating direct supply-chain disruption in this sector. However, this early effect is short-lived. The services sector rebounds quickly in the next two quarters. While immediate disruptions are temporary, we observe a second drop in the third to sixth quarters, which is explained by demand-driven contraction. Meanwhile, for the construction sector in Figure 5f, we observe a delayed negative impact in the third and fifth quarters after the shock. Interestingly, the transportation and communication sector positively and significantly respond to disaster shocks (Figure 5d). This outcome could be linked to increased demand for these services during and after disasters. Immediately after a disaster, transportation and communication services are crucial for relief efforts, so demand for these sectors surges. This argument has also been supported by literature such as Khaled and Mcheick (2019) that underscores the heightened demand for reliable communication networks post-disaster, as they are essential for coordinating relief efforts and disseminating information to affected populations.

Finally, the mining sector displays statistically insignificant IRFs, indicating that disaster shocks do not meaningfully impact their performance (Figure 5c). This lack of significant results is due to the nature of these sectors, which are less sensitive to domestic demand shocks caused by disasters. The mining sector demand value-added relies more on global demand and commodity prices.



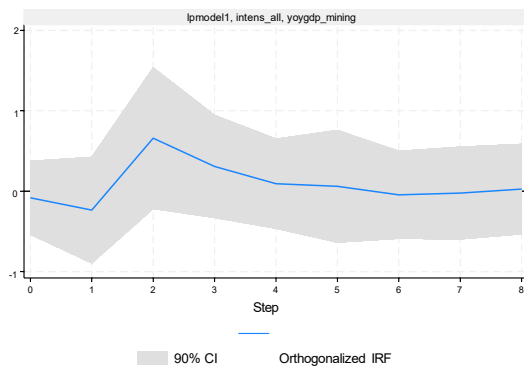
Graphs by irfname, impulse variable, and response variable

(a) Agriculture



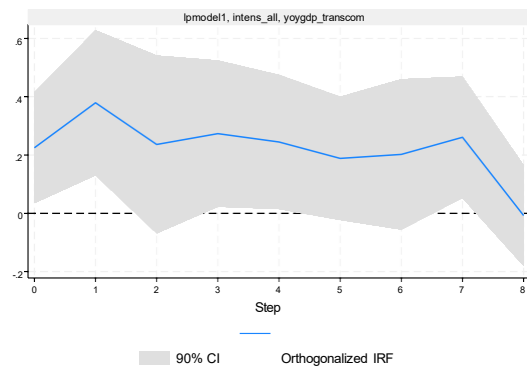
Graphs by irfname, impulse variable, and response variable

(b) Manufacture



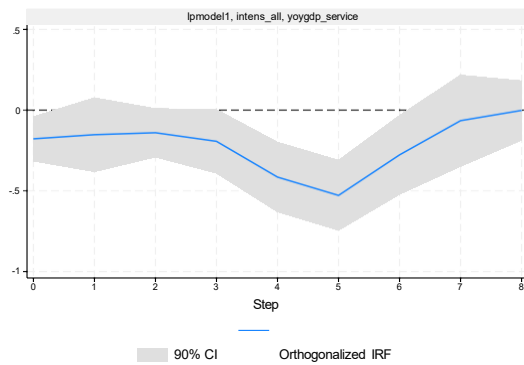
Graphs by irfname, impulse variable, and response variable

(c) Mining



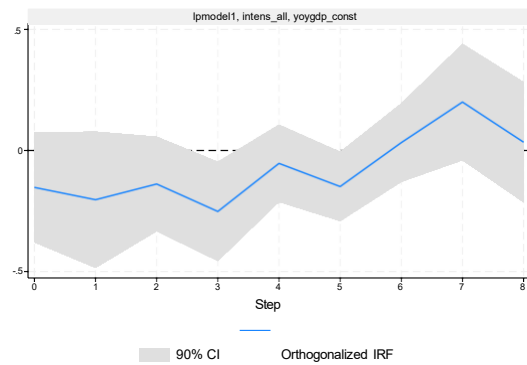
Graphs by irfname, impulse variable, and response variable

(d) Transcom



Graphs by irfname, impulse variable, and response variable

(e) Services



Graphs by irfname, impulse variable, and response variable

(f) Construction

Figure 5. Impulse response functions of GDP by sector to disaster shock (all disasters)

Demand Side of the Economy

How can we explain the impact of climate-related disasters from the expenditure side? Figure 6 shows the IRFs of GDP by expenditure to disaster shocks. We estimate that reduced consumption is the main channel through which disasters affect real economic growth. Demand contraction is channeled through reduced sectoral production to investment, exports, and imports. Moreover, the absence of significant effects is estimated for government expenditure.

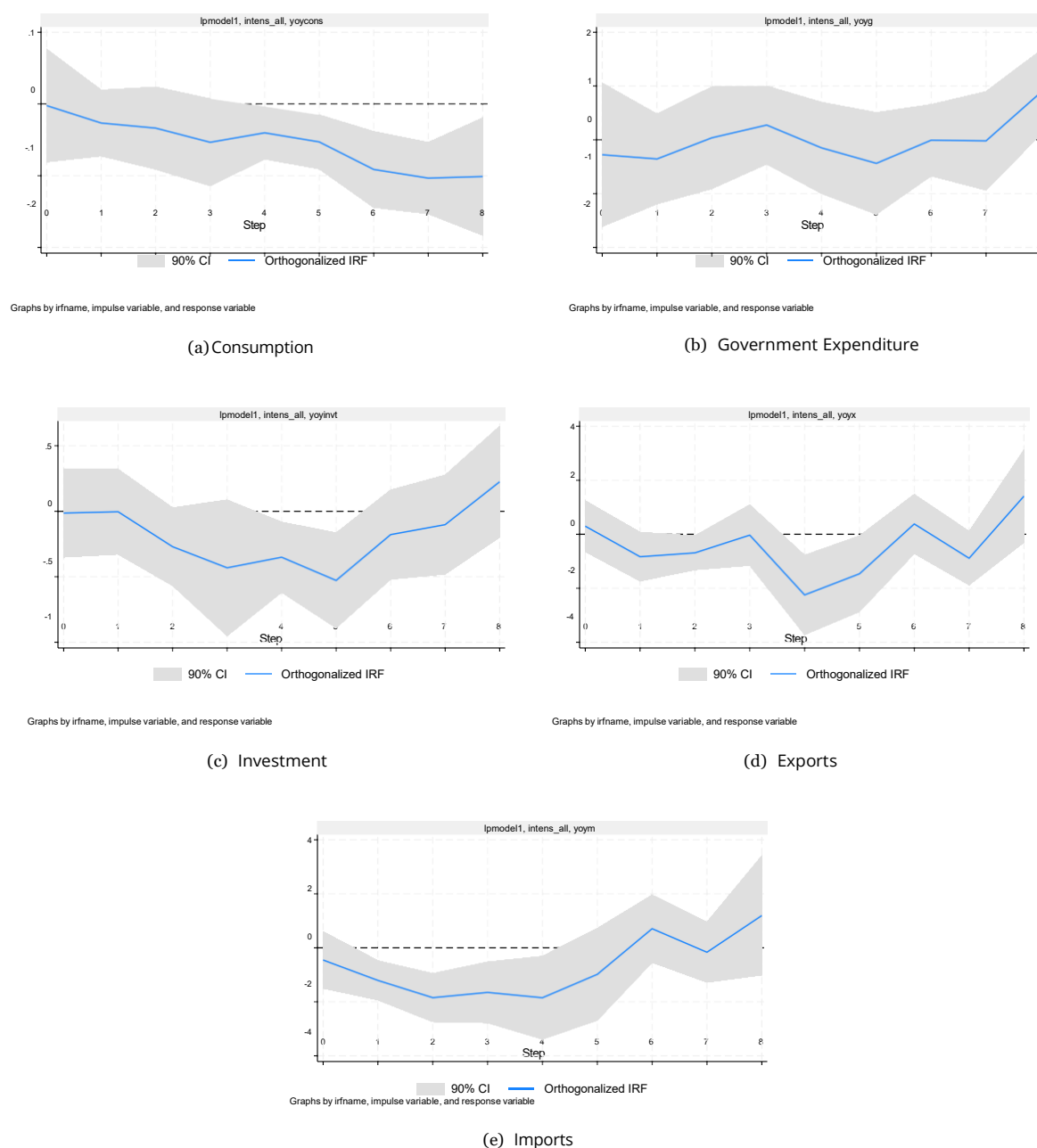


Figure 6. Impulse response functions of GDP by expenditure to disaster shock (all disasters)

Figure 6a shows that, immediately after the shock, consumption modestly declines. However, the confidence intervals in quarter 0 and the three quarters after the shock imply

that the result is not statistically significant. A sharp decline is recorded starting from the fourth quarter onward. The insignificant result at the beginning of the period points to possible consumption smoothing using income buffers sourced from savings or disaster relief. Overall, the negative impact suggests that disasters reduce household income due to disruptions in economic activity and reduced agricultural and industrial output, affecting working hours or job losses. Subsequently, lower income levels constrain household demand, leading to a decline in aggregate consumption. Decreased demand can also be explained by the risk-aversion behaviour of households and firms in the aftermath of natural disasters, as mentioned in Cantelmo et al. (2022).

In general, investment shows an insignificant result, except for negative and temporary effects recorded in the fourth and fifth quarters (Figure 6c). Severe disasters cause considerable damage to physical capital (buildings, machinery, and infrastructure), thus creating a need for investment. However, the reconstruction often spreads over time, delaying the visible impact on aggregate investment, particularly in the short term (Cavallo et al., 2013). Furthermore, contraction in the sectoral performances contributes to the decline in investment.

In Figure 6d and 6e, we display the impact of climatic disasters on the external sector. Figure 6d estimates show that exports generally do not react significantly to disaster shocks, except for a drop in the fourth quarter. We view this result from two perspectives: First, the disaster impacts are localized and cause minimal disruption to exportable goods. Second, exports depend more on external demand. By contrast, imports are negatively affected by climatic disasters. The IRFs in Figure 6e demonstrate the negative and temporary impact on imports, as imports are influenced by reduced domestic demand and production.

Government spending remains resilient from climate-related shocks. As displayed in Figure 6b, the IRFs appear to be not statistically significant along the estimation horizon. We view that there are three possible explanations for this result. First, the relatively small share of disaster-related expenditures in central government spending. Central government budgets are typically comprised of recurring expenditures, such as salaries, social programs, and debt servicing, limiting other spending, including disaster spending, to a minor fraction. Taking an example from the budget report in 2019 (Badan Pemeriksa Keuangan, 2020), spending on social assistance for disaster management reached IDR7.6 trillion or 0.5% of the total central government budget. Second, as disasters often have geographically localized impacts, a significant portion of the response and recovery expenditure is financed by local government budgets, rather than reflected in aggregate central government spending. This decentralization of fiscal responsibility further mutes the effect of disaster shocks at the national level.

Lastly, it is important to note that the budget resiliency is also attributable to fiscal policy

as outlined in the National Disaster Risk Finance and Insurance (DRFI) Strategy launched in October 2018 (Badan Kebijakan Fiskal, 2018). According to the document, the central and local government budgets are directed to small-scale disasters. Furthermore, to cushion the budget from unexpected shocks from severe disasters, the government maintains contingency funds and emergency reserves. For example, education reserve funds are managed through the Indonesia Endowment Fund for Education (LPDP) to support the rehabilitation of damaged school infrastructure (Badan Pemeriksa Keuangan, 2020). Moreover, the government is building a pooling fund scheme and transferring risk through insurance to finance disasters that rarely occur but have a major impact on losses.

PPI inflation

Our estimation in Figure 7 reveals that the price rise in agriculture and manufacturing contributes to increased PPI inflation following a disaster. The IRF for agriculture PPI inflation shows a significant increase immediately at quarter 0. The positive increase remains in the next four quarters. This can be attributed to disruptions in agricultural production caused by disasters, as discussed in 4.2.1. These disruptions reduce supply and drive up prices in the agriculture sector, subsequently impacting overall PPI inflation.

Similarly, the IRFs for PPI inflation in manufacturing indicate a positive and significant response to disaster shocks. This result is connected with its sectoral production. This suggests that manufacturing firms prefer to pass the short-term supply disruptions on the price of their products.

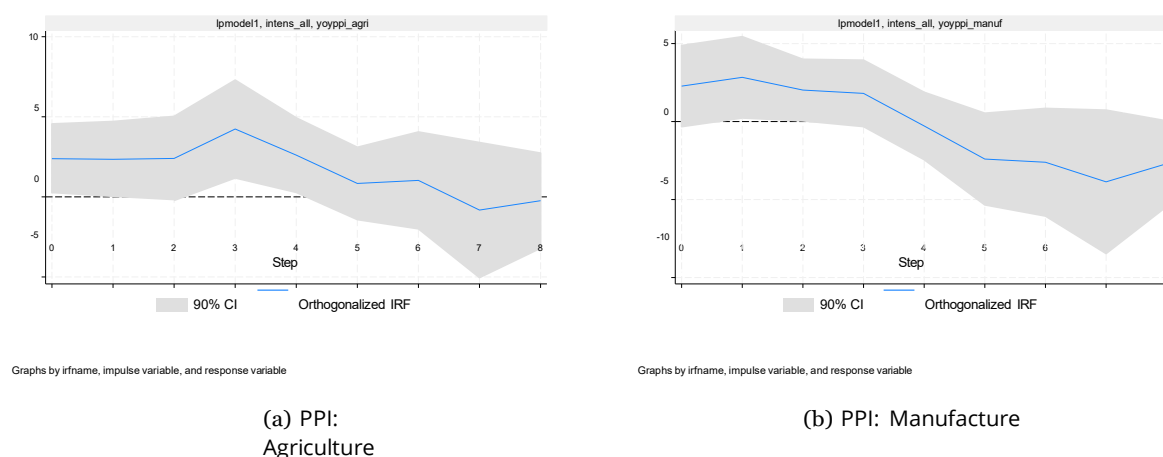


Figure 7. Impulse response functions of component of PPI inflation to disaster shock (all disasters)

CPI Inflation

Explaining the positive and temporary increase in CPI inflation is complex. It reflects the push and pull of opposing forces: disrupted supply chains drive prices upward, while weakened demand, stemming from income losses, exerts downward pressure on prices. As a measure of consumer-level prices, CPI inflation is subject to government and central bank policy interventions. Furthermore, as CPI inflation occurs at the bottom of the pricing chain, it is heavily influenced by pass-through behaviour from upstream price changes.

Starting with volatile food inflation (Figure 8a). As the disaster shock constrains agriculture production and increases prices at the producer level (PPI agriculture), the typical expectation of such supply disruptions would drive up food prices at the consumer level. However, volatile food inflation shows a muted response to disaster shock in quarter 0 and three quarters afterwards. The temporary negative impact in the next four quarters follows it, returning to the baseline in the eighth quarter. The muted reaction of volatile food inflation in the first four quarters amidst an increase in the PPI inflation for the agriculture sector reflects these upstream cost pressures, which do not fully translate into higher volatile food inflation, possibly due to government interventions at the consumer level and demand contraction.

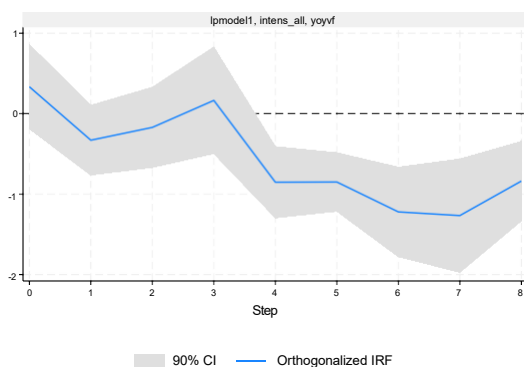
Muted response to disaster shock is estimated for core inflation (Figure 8b). The IRFs show insignificant reactions in the first five quarters before experiencing a temporary negative effect in the sixth quarter. This suggests that the prices of goods and services in the core basket, CPI's more stable components, are unaffected by climatic disasters. This stable core inflation is also influenced by central bank policy. As stated in Warjiyo and Juhro (2019), Bank Indonesia's mandate on price stability is operated through core inflation. Thus, core inflation is heavily influenced by the monetary policy of Bank

Indonesia. Furthermore, weakened aggregate demand explains the temporary decline in core inflation in the sixth quarter.

Administered prices (AP) inflation increases temporarily before tapering off (Figure 8c). AP basket in Indonesia includes government-regulated goods and services, such as fuel and electricity tariffs, which remain unchanged after disasters as the government ensures that these essential goods and services are not subject to immediate cost pressures. Therefore, a temporary spike can be explained as increased transportation costs in line with high demand in the transportation sector.

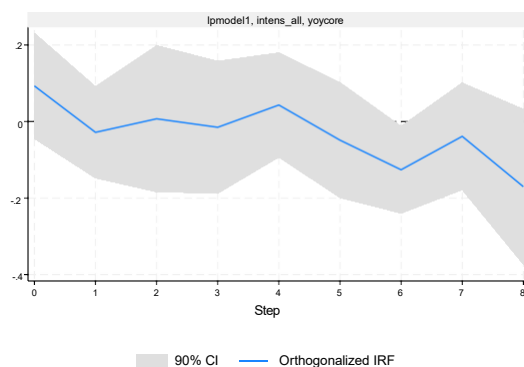
Interestingly, the IRFs for inflation expectations display mute responses in the first four quarters before declining sharply in the following quarters (Figure 8d). This reflects the anchored expectations, supported by core and VF inflation stability. Meanwhile, the decline

in expectations from the fifth quarter onward is attributed to weak demand.



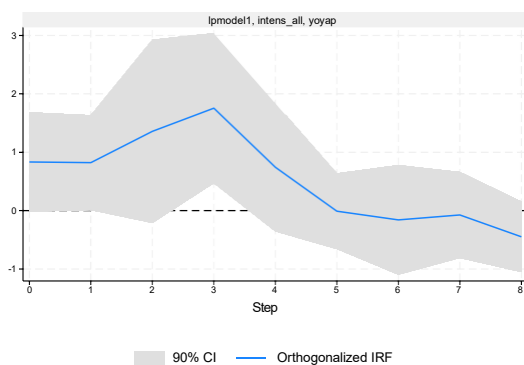
Graphs by irfname, impulse variable, and response variable

(a) CPI: Volatile Food



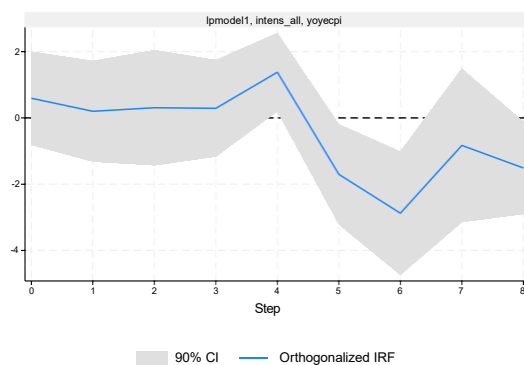
Graphs by irfname, impulse variable, and response variable

(b) CPI: Core



Graphs by irfname, impulse variable, and response variable

(c) CPI: Administered Prices



Graphs by irfname, impulse variable, and response variable

(d) CPI: Inflation Expectation

Figure 8. Impulse response functions of component of CPI inflation to disaster shock (all disasters)

Heterogeneity Analysis

Do different climate-related disasters (e.g., floods and mass movement) have varying impacts on macro-financial outcomes? This section explores the third research question, the heterogeneity in the response of macro-financial indicators to different climate-related disasters. We use the reference set-up in Equation (3) where the disaster shock CS^k is the intensity of disaster with k are two types of climate-related disasters: flood and mass movement, the two most frequent disasters in Indonesia⁵. We report the result in Figure 9, 10, 11, 12, and 13. In Panel (a) of each figure, we reference the IRFs for an all-disaster shock. We conclude that the macro-financial responses vary by type of disaster. These results align with previous literature highlighting the heterogeneity of the responses to natural disasters (Kabundi et al. (2022) and Fomby et al. (2013)).

GDP Growth

The IRFs in Figure 9 reveal variations in how different types of disasters impact economic growth. Starting with floods, the IRF for floods closely resembles the IRF for all disasters. Following a flood shock (Figure 9b), real economic growth experiences an immediate decline in quarter 0. Economic contraction will worsen in the following quarters, bottoming in the fifth quarter. After the trough, a recovery is recorded, suggesting that the effect is short-lived. The negative and temporary impact of floods on economic growth is in line with Fomby et al. (2013)

A disaster shock in the form of mass movement is also contractionary to economic growth, although the effect is far more short-lived compared to floods. Figure 9c demonstrates an immediate negative impact on the gross production in quarter 0. This response is similar in magnitude to floods, suggesting that floods and mass movement cause severe economic disruptions. However, the impact diminishes after three quarters with economic growth gradually recovering, indicating a temporary effect.

PPI Inflation

The response of PPI inflation to disasters varies significantly by type (Figure 10). PPI inflation exhibits relatively muted responses to floods and mass movement shocks, with broadly

⁵Although we include the other types of disasters, namely storms, drought, and wildfire, in the all-disaster shock, we could not conclude the individual analysis due to the limited occurrence of these disasters and leave the analysis for future research

insignificant results during the estimation periods. Combined with production decline, these muted responses highlight the resilience of producers' supply chains to the more frequent climatic events. However, the shapes of the IRFs are different. In particular, the IRFs of mass movement (show deflationary pressures, with PPI inflation decreasing in the second and third quarters (Figure 10c). We argue that this pattern is potentially caused by localized demand contractions outweighing supply constraints in the event of a mass movement, such as landslides. Comparing these results to the IRFs of all disasters in Figure 10a, we can imply that inflationary pressure at the producer level is driven by other types of disasters (storms, droughts, and wildfires).

CPI Inflation

CPI inflation responses following floods and mass movement disasters exhibit distinct dynamics (Figure 11). Responding to floods, CPI inflation initially rises, peaking in the third quarter before gradually declining (Figure 11b). The confidence interval suggests that the impact is significant for the inflationary pressure, particularly a temporary rise due to supply disruptions. By contrast, the CPI inflation response is relatively muted following mass movement (Figure 11c). It is then followed by a negative response from the fourth quarter onward, which is driven by their impact on demand dynamics.

NPLs

The effects of different disasters on the NPLs over time is shown in Figure 12. It shows that NPLs increase come with time lag after disasters, reflecting rising credit risk as borrowers struggle with repayments. This aligns with the pattern where short-term regulatory relief (such as POJK and PBI policies) cushions the immediate impact, but credit quality deteriorates in the medium term. NPLs tend to rise gradually after a disaster, with a stronger and more persistent increase when considering all disasters combined (Figure 12a), while floods (Figure 12b) likely lead to a delayed but significant rise in NPLs, as affected households and businesses face prolonged financial strain. In contrast, mass movement disasters (Figure 12c) cause an initial spike in NPLs, which then stabilizes and sustained in the medium run.

Credit Growth

The credit growth response to disasters shows a negative and persistent decline over time (Figure 13). This supports the idea that, despite short-term regulatory relief, medium-term credit tightening occurs as banks reassess risk exposure. The impact of floods on credit

growth (Figure 13b) follows a similar pattern, with a clear downward trend. This suggests that floods lead to a sustained contraction in credit growth, likely due to higher NPLs in the medium term that drive banks to become more risk-averse. Meanwhile, credit growth drops sharply, but then starts to recover after several periods following incident of mass movement (Figure 13c). This suggests that while mass movement and disrupt credit expansion in the short run, their effects may be more localized, allowing for a quicker financial recovery compared to widespread disasters like floods.

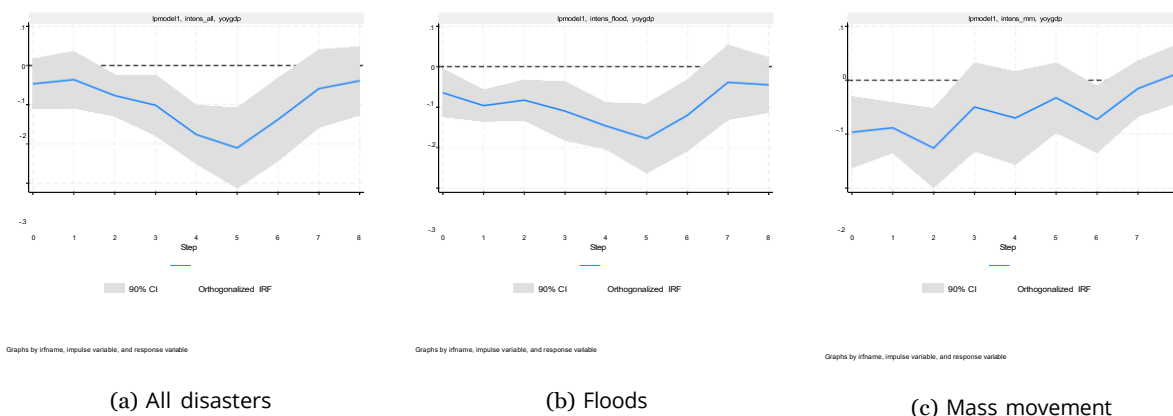


Figure 9. IRFs of GDP by type of disaster

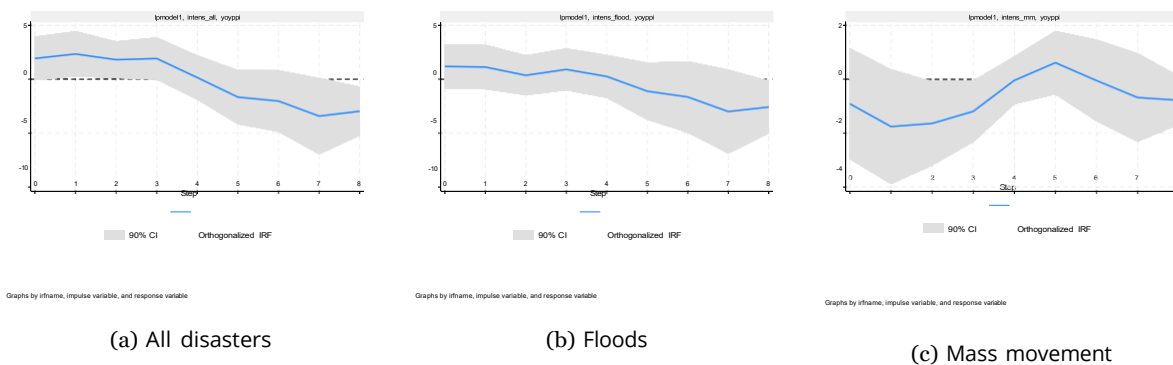
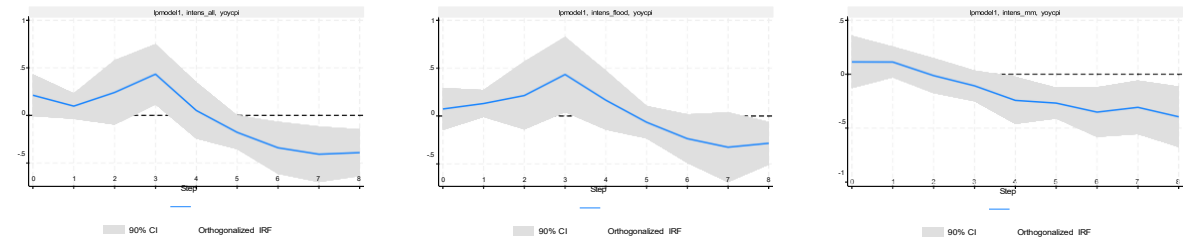


Figure 10. IRFs of PPI by type of disaster

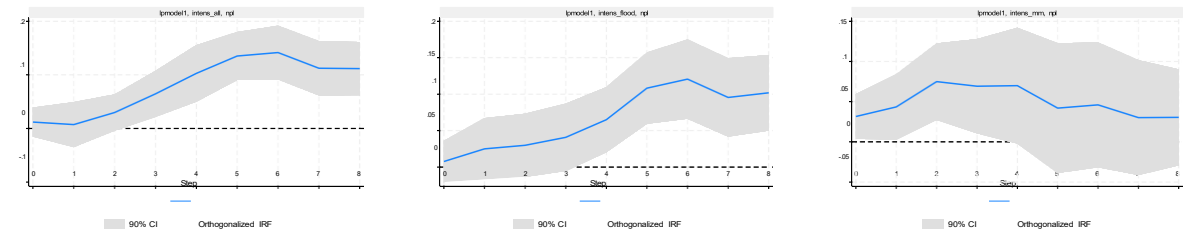


(a) All disasters

(b) Floods

(c) Mass movement

Figure 11. IRFs of CPI inflation by type of disaster

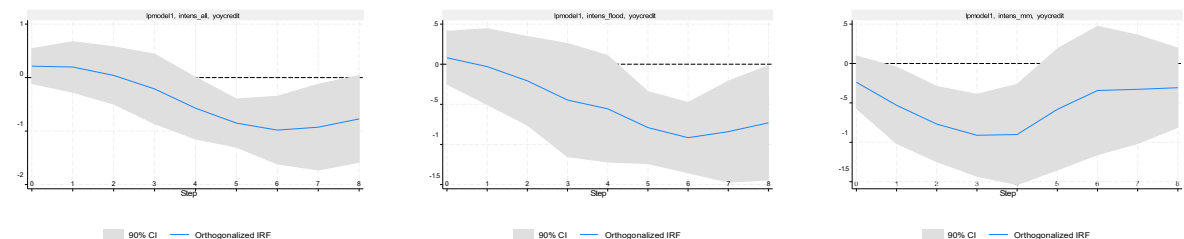


(a) All disasters

(b) Floods

(c) Mass movement

Figure 12. IRFs of NPLs by type of disaster



(a) All disasters

(b) Floods

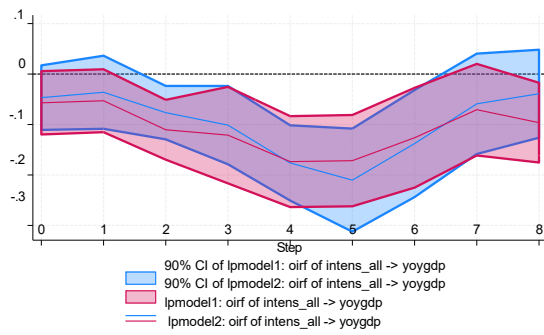
(c) Mass movement

Figure 13. IRFs of Credit Growth by type of disaster

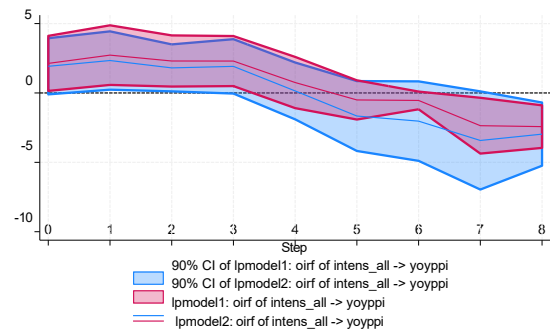
Robustness Check

We conduct a robustness check of our estimation using additional control variables. We include infrastructure as a control variable, given that the quality of infrastructure often affects the impact of disasters. By controlling for infrastructure, we aim to isolate the pure effect of disaster-related shocks on the outcomes. We use the total length of the road, sourced from CEIC, as a proxy for infrastructure and run the LPs model in equation 3 with the infrastructure variable in the control variable.

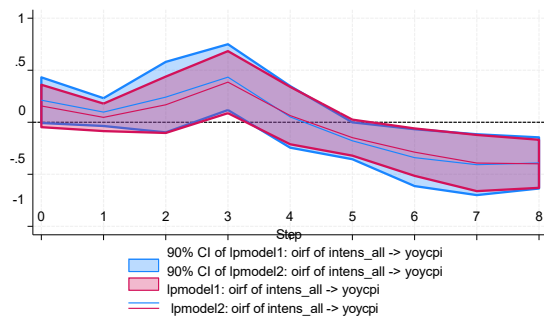
We report the comparison between the reference model (lpmodel1) and the model with infrastructure (lpmodel2) for GDP growth, PPI inflation, CPI inflation, NPLs, and credit growth in Figure 14. The blue and red lines represent the IRFs of lpmodel1 and lpmodel2, respectively. Meanwhile, the shaded blue and red areas are the respective 90% confidence intervals of the estimations. Our estimations show that the IRFs comparing the two models reveal consistent results across key response variables. In each panel, the responses of lpmodel2 closely align with those of lpmodel1, with overlapping confidence intervals and similar trajectories over the estimation horizons. For GDP growth (Figure 14a), PPI inflation (Figure 14b), CPI inflation (Figure 14c), and credit growth (Figure 14e), the results for both the responses and confidence intervals are similar. Meanwhile, the IRFs for NPLs (Figure 14d) show that the two models' trajectories and magnitudes remain nearly identical. At the same time, the confidence interval is narrower in lpmodel2, indicating reduced uncertainties. Overall, these consistencies support the robustness of the estimated effects.



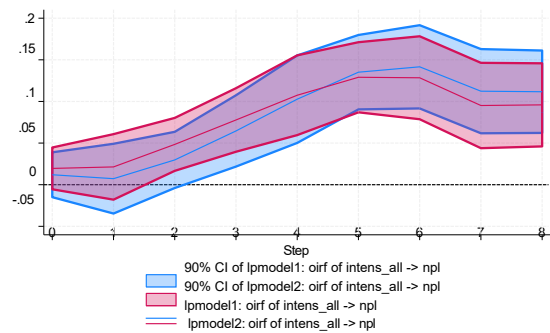
(a) GDP



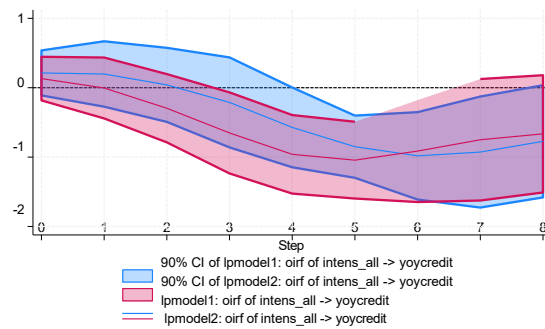
(b) PPI



(c) CPI



(d) NPLs



(e) Credit growth

Figure 14. IRFs Key response variable (lpmodel1 and lpmodel2)

Conclusion and Policy Implication

The paper has investigated climate-related disaster shocks and their dynamic impact on macro-financial outcomes in Indonesia. The results estimate that climate-related disaster shocks have a detrimental effect on macroeconomic performance, primarily through a decline in economic growth and a rise in PPI and CPI inflation, although the effects are short-lived. Economic growth contracts due to production disruptions, particularly in agriculture, manufacturing, services, and construction, as well as reduced consumption. Meanwhile, inflation rises initially due to supply chain shocks in agriculture, but it is tempered by weakened demand.

The findings also indicate that natural disasters have a negative and persistent impact on credit growth, particularly in the medium term. While short-term regulatory interventions help mitigate immediate financial distress by allowing more flexible loan classification and restructuring, their effectiveness appears temporary. Once these relief measures expire, credit tightening follows, as banks reassess risk and increase provisioning due to rising NPLs in the medium term. These findings and the potential increasing frequency and severity of natural disasters due to climate change highlight significant challenges for policymakers.

These findings carry important implications for fiscal policy in disaster-prone economies. Disasters, particularly moderate and severe ones, often require significant government spending on recovery and rebuilding efforts, while simultaneously reducing tax revenues due to economic disruptions. This dual pressure can widen fiscal deficits, forcing governments to cut spending elsewhere or borrow more. Countries with limited fiscal space face even greater challenges in responding to disasters, which can delay recovery. In response, many governments are shifting towards proactive fiscal strategies focusing on climate resilience and disaster preparedness to balance the short-term for disaster relief and long-term goals in fiscal sustainability (Pigato and Pigato, 2019; Dabla-Norris et al., 2021).

In this context, the government needs to prioritize disaster risk reduction measures, such as resilient infrastructure and climate-smart production practices, to reduce the cost of recurring shocks. For Indonesia, we highlight the need for more effective disbursement of dedicated contingency funding and social safety nets to ensure rapid support for affected households and businesses, protecting vulnerable populations and stabilizing consumption. Moreover, in an era of constrained fiscal capacity, enhancing coordination with domestic and international partners and expanding access to disaster insurance instruments will be vital for sustaining fiscal resilience in the face of increasingly frequent climate shocks.

The implications for the central bank are more complicated, as monetary policy is traditionally a demand management policy. The first challenge comes from the potential difficulties in forecasting output gaps and inflation, the essential components of the policy rule (McKibbin et al., 2020). The direct implication comes from the inflationary pressure of disasters and other climate physical risks (Schnabel, 2022). Moreover, persistent supply

shocks challenge monetary policy, as policy tightening to lower inflationary pressure from disasters may harm the economy. Our findings call for careful consideration in the policy framework. Authorities should stabilize post-disaster economies by monitoring inflation dynamics and coordinating with the government to support recovery without undermining longer-term stability.

From the financial stability perspective, further efforts can be directed towards enhancing disaster risk financing and resilience-building measures to reduce the long-term adverse effects of disasters on financial stability. Banks could be encouraged to develop risk-based pricing models for disaster-prone areas, while authorities could expand insurance-backed credit schemes to help mitigate systemic risks. Financial regulators may need to implement stress tests and stricter oversight to ensure the economic system can withstand climate-related shocks. These adjustments are essential to safeguard macroeconomic stability and foster long-term resilience against the growing threat of climate-related disasters.

Lastly, further research is needed to explore infrequent but severe disasters, such as droughts, storms, and wildfires, to understand their unique channels and policy implications. Another research gap is exploring micro-level data and the long-term effects of natural disasters. Finally, evaluating diverse climate finance instruments could highlight pathways to strengthen resilience in a limited fiscal space.

Appendix

Descriptive Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
intens.all	48	0.03	0.05	0.00	0.22
intens.flood	48	0.03	0.05	0.00	0.22
intens.mm	48	0.00	0.00	0.00	0.01
intens.storm	48	0.00	0.00	0.00	0.00
intens.drought	48	0.00	0.00	0.00	0.00
intens.wildfire	48	0.00	0.02	0.00	0.16
yoygdp	48	5.39	0.60	4.10	6.80
yoyppi	48	2.66	16.72	-59.74	25.44
yoycpi	48	4.96	2.10	2.44	10.94
npl	48	2.79	0.58	1.85	4.07
yoycredit	48	15.26	6.92	6.35	30.36
yoygdp.agri	48	4.35	2.05	1.24	11.53
yoygdp.manuf	48	4.11	1.18	1.21	6.81
yoygdp.mining	48	1.79	2.77	-6.47	6.64
yoygdp.transcom	48	9.41	2.60	6.00	15.52
yoygdp.services	48	5.81	1.28	3.67	8.83
yoygdp.construction	48	6.71	1.16	4.21	10.40
yoycons	48	5.11	0.39	3.90	6.00
yoyg	48	4.89	6.03	-7.40	18.80
yoyinv	48	6.49	2.71	2.00	13.90
yoyx	48	4.16	8.46	-18.70	21.30
yoym	48	3.85	10.83	-24.40	22.60
yoyppi.agri	48	8.86	17.06	-37.34	42.57
yoyppi.manuf	48	0.31	19.83	-76.25	26.04
yoyvf	48	6.89	3.82	0.00	15.73
yoycore	48	4.15	1.34	2.31	8.43
yoyap	48	5.81	5.88	-5.56	20.73
yoyecpi	48	0.80	10.01	-22.91	24.49
yoyreer	48	-0.14	6.38	-12.28	17.43
birate	48	6.53	1.28	4.00	9.67
eid	48	0.25	0.44	0.00	1.00
road	48	0.20	0.01	0.18	0.21
yoyglobal.prices	48	-3.89	30.66	-99.81	46.61

Indonesia Disaster Management

Indonesia's regulatory framework for disaster management is robust on paper, as outlined in Table 2. Law No. 24/2007 provides a legal foundation by mandating clear roles for national and regional governments and establishing the National Disaster Management Agency (BNPB), Indonesia's primary disaster management agency. Its implementation is further regulated by Presidential Regulation No. 8/2008 and Government Regulation No. 21/2008. Disasters can have significant financial consequences; therefore, Government Regulation No. 22/2008 regulates the financial mechanisms that aim to ensure the availability of funds for disaster prevention, response, and recovery. BNPB works along with other central government agencies, i.e., National Armed Forces (Tentara Nasional Indonesia/TNI), National Police (Kepolisian Negara Republik Indonesia/POLRI), Ministry of Social Welfare, Ministry of Health, and local governments, including regional and provincial BNPDs. Indonesian authorities have allowed the participation of international agencies in disaster management as ruled by Government Regulation No. 23/2008.

Table 2. Disaster Management Regulations in Indonesia

Number of Regulation	Concerning	Policy Summary
Law No. 24/2007	Disaster Management	Establishes a comprehensive disaster management framework, defining national and regional government roles and establishing BNPB. Covers preparedness, mitigation, response, and recovery.
Presidential Regulation No. 8/2008	National Agency Disaster Management	Defines BNPB's organizational structure, roles, and responsibilities, including disaster management, emergency response, and rehabilitation coordination. Provides guidelines for collaboration with local governments.
Government Regulation No. 21/2008	Disaster Management	Provides a detailed structure for disaster risk reduction plans, including risk assessments, emergency procedures, and local government preparedness activities. Includes guidelines for public participation.
Government Regulation No. 22/2008	Disaster Aid and Financing and Management	Establishes funding mechanisms for disaster management, including emergency funds, rehabilitation budgets, and recovery financing. Encourages public and private sector contributions. Defines allocations for prevention, emergency response, and recovery phases.
Government Regulation No. 23/2008	Participation of International Institutions and Foreign Non-Governmental Institutions in Disaster Management	Establishes guidelines for the involvement of international organizations and foreign NGOs in disaster-related activities in Indonesia. It ensures that their participation is coordinated, aligned with national priorities, and respectful of Indonesia's sovereignty.

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