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ECONOMIC RESILIENCE UNDER ENVIRONMENTAL SHOCKS: THE IMPACT OF NATURAL DISASTERS ON ASIAN GROWTH PERFORMANCE

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ABSTRACT

This study examines the impact of natural disasters on economic performance in eight Asian countries—Bangladesh, China, India, Indonesia, Japan, Pakistan, the Philippines, and Vietnam—over the period 2002–2023. Given the increasing frequency and intensity of environmental shocks in Asia, understanding their macroeconomic consequences is important for sustainable development and policy formulation. The study employs panel data techniques to analyse the relationship between real GDP per capita and natural disasters, measured by disaster-related deaths. In addition, government consumption, trade openness, human capital, and foreign direct investment (FDI) are included as control variables. To address unobserved heterogeneity across countries, the Fixed Effects Model is applied, and the Hausman specification test confirms its suitability over the Random Effects Model. The empirical results indicate that natural disasters have a statistically significant negative effect on economic performance, suggesting that higher disaster-related mortality is associated with lower real GDP per capita. Government consumption and human capital are found to positively influence economic performance, highlighting the role of public expenditure and human capital development in supporting economic stability. FDI shows a weak positive effect, while trade openness is statistically insignificant. The findings suggest that strengthening disaster preparedness, improving human capital, and enhancing institutional capacity are essential for mitigating the adverse economic effects of environmental shocks in Asia.

Keywords: *Economic growth, natural disasters, panel data, fixed effects model, Asia*
JEL Codes: *O47, Q54, C33*

1 INTRODUCTION

The world's most frequent and severe natural disasters (NDs) occur in Asia, making the impact of these events on economic growth an important field of research. Policymakers need to understand how much these events affect their economies so they can develop strategies to protect against them in the future and promote sustainable development, which leads to stable economic growth. This means finding out what causes natural disasters to occur more often or become stronger than before, because climate change has been blamed as one such thing by the US Geological Survey.

CRED defines a disaster as "a situation or event that overwhelms local capacity, necessitating a request at the national or international level for external assistance; it is an unforeseen and often sudden event that causes great damage, destruction, and human suffering." This publication includes only disasters attributed to natural hazards, except biological and extraterrestrial hazards, and excludes the technological hazards recorded in EM-DAT. To be included in the database, a disaster must meet at least one of the following criteria:

1. 10 or more people were killed
2. 100 or more people were affected
3. Declaration of a state of emergency
4. A call for international assistance

The disaster subgroups were divided as follows:

1. Earthquakes, volcanic eruptions, and mass movements are examples of geophysical events.
2. Floods, landslides, and wave action are examples of hydrological events.
3. Convective storms, extreme temperatures, fog, tropical cyclones, and droughts are examples of climatic events. Droughts, glacial lake outbursts, and wildfires are examples of climatic phenomena.
4. Animal incidents, diseases, and insect infestations are examples of biological phenomena.
5. Impacts and space weather are examples of extraterrestrial events.

NDs have complicated and varied economic consequences. Some studies propose that such events may promote economic growth through rebuilding and heightened investment. However, most experts agree that these incidents primarily have negative impacts on developing countries. Different areas have been researched, such as the relationship between disaster intensity and economic growth; differential effects across sectors; and socio-economic determinants of vulnerability and resilience.

For example, floods were found to raise agricultural and GDP growth rates in the medium term. However, they can also cause a significant decline in GDP growth, especially when severe or coupled with droughts, in low-income nations (Panwar & Sen, 2019). In another study, higher levels of educational attainment and per capita income were associated with lower ND-related death rates, suggesting that human capital development plays a crucial role in disaster preparedness (Toya & Skidmore, 2006). Research on this topic produced mixed results, with some showing positive relationships between disaster impact and economic growth, while others did not show a significant correlation (Idroes et al., 2023; Shabnam, 2014; Songwathana, 2018). Moreover, robust infrastructure, along with adequate preparedness measures, can greatly help reduce these impacts on economies (Padli, Jaharudin, & Habibullah, 2008).

ND has a significant impact on economic growth, particularly in many countries across Asia. The reason is that NDs disproportionately impact these nations. While many studies have examined the relationship between NDs and economic growth, there is an urgent need for more studies focusing on Asia's worst-affected nations. Using secondary panel data from 2002 to 2023, this research analyses the impacts of NDs on GDP growth across Bangladesh, China, India, Indonesia, Japan, Pakistan, the Philippines, and Vietnam.

Specifically, this research will look at how the No. of deaths and real GDP per capita measure the impact of NDs on GDP growth. Additionally, control variables that may mitigate these impacts include Government Consumption (GC), Trade Openness (TO), Human Capital (HC), and Foreign Direct Investment (FDI). It will also determine if disaster bonds, micro-insurance, or insurance are viable options for mitigating disaster risk.

This study plays a crucial role for several reasons: its findings can help policymakers develop effective strategies for disaster prevention and preparedness, which is essential for preserving economic stability in areas exposed to frequent disasters. It is used to mitigate long-term damage to the economy; it is important to understand how NDs will affect it. This knowledge will help with better planning and allocating resources. It helps construct more resilient economies that can better withstand future disasters, which is a potential outcome of this research, by identifying critical factors that lessen the ND's impacts. The study's recommendations will integrate disaster risk reduction into development plans and economic policies, thereby advancing sustainable development.

2 LITERATURE REVIEW

Several studies show various losses from deaths, which may directly affect economic growth in different settings. According to Lorentzen et al. (2008), people's mortality has a strong impact on economic growth through behaviour, fertility, and investment choices, and in Africa, adult mortality has the greatest impact. Similarly, Dutton et al. (2020) pointed out that there is an inverse relationship between mortality rates and the economic changes in the developed OECD countries, proving that changes in the economy impact death rates and, in so doing, influence the lifespan of the population as well as the health status of the citizens. In addition, Sadia (2012) points to the effect of increased foreign aid on economic growth, as revealed by disasters that occurred in Pakistan and other Asian nations, thus supporting the argument that mortality events favour economic growth through the boost from external funds. Each of these results underscores the complexity of the association between deaths and development, underscoring the necessity of holistic approaches to address the mortality costs to the global economy.

This research work is designed to evaluate and analyse the correlation between Foreign Direct Investment (FDI) and Economic Growth. FDI is also very important, as it catalyses production, increases productivity, and brings in technology and new employment opportunities to the economy. Literature on the periodicity of FDI inflows and the GDP of different countries, such as Algeria, Brazil, Nigeria, the United States, and developing countries, supports this hypothesis (Kaddouri & Benelbar, 2024; Fernandes, 2024; Emeka, 2024; Matušovičová & Matušovičová, 2023; Vu & Nguyen, 2023). The effects of FDI differ from one area to another and from one sector to another, with differential spillovers, which imply the need to differentiate policies to harness these effects and promote balance conceptually. Moreover, factors such as institutional quality, governance effectiveness, infrastructure gaps, and policy volatility determine how FDI affordability affects a nation's economic development; therefore, there is a need to put in place a favourable investment environment and sound economic policies to foster economic growth and development (Vu & Nguyen, 2023).

Idroes et al. (2023) explore the relationship between NDs and economic growth by considering the No of people affected as a variable. The evaluation measures the rise in constant 2015 US dollars. In addition, the research takes into account Gross Fixed Capital Formation (GFCF) and labour (including employed individuals and those actively seeking employment). This implies that if we want to ensure people and businesses are better prepared for such events, we need stronger buildings, improvements to early warning systems that make it easier for individuals who may wish to volunteer during emergencies, and for everyone to take up comprehensive insurance cover.

Naoaj (2023) assesses how NDs affect growth in real GDP per capita and agricultural output, using a dummy variable indicating whether an event occurred as the key independent variable. The analysis also controls for population density, the percentage with primary education, inflation, and initial output (GDP per capita). This research employs FEM and Pooled (OLS) estimators on panel data from developed and developing nations between 1970 and 2019, obtained from the EM-DAT database and the IMF, respectively. Results show that, compared with developed countries' agricultural development, that of developing nations is affected 2 times as severely.

Guo et al. (2015) examined the relationship between various disasters and per capita GDP growth rates across China's 30 provinces from 1985 to 2011. This research paper considers three kinds of NDs: geological disasters (GD), meteorological disasters (MD), and floods (ND). It also takes into account such factors as investment growth rate, education level, and openness. The authors use panel Generalised Least Squares (GLS) estimation with a REM for their analysis, utilising data from the EM-DAT database and World Development Indicators (WDI). They perform unit root tests using the ADF and PP methods to ensure the robustness of the results from panel GLS estimation with a random-effects

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model, using data sourced from the EM-DAT and WDI databases. According to their findings, while both types of floods have no significant effect on GDP growth during the first period, in subsequent periods, floods have a positive effect on GDP through human capital investment, whereas earthquakes do not have any significant impact

From 1920 to 2010, Boustan et al. (2020) examined the poverty rate, median family income, net migration rate, median home price, and their association with NDs in US counties. Using data from the Census of Population and Housing and the EM-DAT database, the researchers account for the occurrence and severity of various disasters, including floods, winter storms, tornadoes, hurricanes, and fires. Their estimates exhibit that NDs have a substantial negative influence on economic activity, and they arrive at this conclusion by using several statistical techniques, such as Fixed Effects Regressions, OLS Regressions,

Chakrabarti et al. (2023) examine how NDs affect a country's GDP per capita and the agricultural sector. Data were obtained from the EM-DAT and IMF databases covering the years 1990–2019. In a fixed-effects panel regression with the Hausman test, the country-specific factors were treated as control variables, and a pooled OLS model was also considered. They discovered that agriculture can be severely harmed by severe NDs, with developing nations bearing the greatest burden. That is why, in their view, the government should emphasise disaster preparedness and rapid reaction, while simultaneously guaranteeing long-term resilience development through the establishment of financial reserves to withstand future shocks.

Cavallo et al. (2022) conducted a study on the effect of NDs on per capita real GDP and its growth. They use a panel dataset covering 203 countries from 1970 to 2019 and measure severity and physical intensity as death rates from these NDs. The authors approximate the impacts using event-study techniques, cross-country regressions, and comparative case studies. Their findings reveal that in the short term, NDs significantly reduce GDP growth, with per capita real GDP growth falling by 2.1-3.7% in the year of the disaster. However, although there is no statistical difference between pre- and post-disaster growth rates, per capita real GDP remains below what it could have been without these NDs. In addition, they suggest stronger building codes, more resilient financial markets, stronger institutions, and better healthcare systems that can mitigate such events while enhancing preparedness for them in the future.

Yun and Kim (2021) examine the impact of NDs on per capita real GDP and growth rates from 1990 to 2020. They do this by using panel data from EM-DAT and the World Bank's WDI, as well as national and regional statistical databases; they also focus on the United States, among other countries hit by NDs. In their study, they employ the Synthetic Control Method (SCM), Fixed Effects Regression Models, and Ordinary Least Squares (OLS) regressions for estimation.

Felbermayr and Gröschl (2014) examine the effect of NDs on GDP per capita growth. They take into account that it is a country-year panel data set covering 108 countries from 1979 to 2010. The GeoMet database, EM-DAT, and WDI were used in this research, which considers physical disaster intensity measures such as the Richter scale, Volcanic Explosivity Index, wind speed, precipitation deviations, and temperature deviations. The paper uses fixed-effects and dynamic panel models. As the investigation found, severe natural disasters dramatically reduce GDP per person. To be more precise, if we talk about disasters in the top 1 percentile of the disaster index distribution, this event leads to no less than a 6.83% reduction in GDP pc, while the top 5-percentile events cause at least a 0.46% reduction in GDP pc. Smaller calamities at the 25th percentile cut off GDP pc by no more than 0.01%. Additionally, in an average year for disasters, economic growth drops approximately by 0.18 percentage points (pp). To minimise these bad consequences, authors suggest, among other things, improving institutional quality; raising openness towards international trade and financial markets; and enhancing response mechanisms for disaster management

To assess the relation between population growth and NDs, Huppert and Sparks (2006) use panel data from 133 countries over the period 1970-2005. The study draws on World Development Indicators (WDI) and United Nations databases for its data, employing Fixed-Effects Models and Generalised Least Squares (GLS) regressions to examine how frequently occurring and severe natural hazards, economic development levels, urbanisation rates, and globalisation influence population growth rates. The results show that annual population growth is reduced by 0.5% due to NDs each year. However, they also find that economic development increases vulnerability to these events through urbanisation, thereby negatively affecting population growth rates. Additionally, city planning should be improved, and more accurate forecasts should be made through scientific advancements and technological innovations; this will help communities better prepare for such catastrophes and protect their environment by conserving or restoring natural barriers such as mangroves and wetlands.

Fomby et al. (2013) assess the impacts of various NDs—droughts, floods, earthquakes, and storms—on GDP growth, agricultural growth, and non-agricultural growth using a panel of cross-country and time series data from 84 countries (60 developing and 24 developed) over the period 1960-2007. Utilising data from the WDI and the Emergency Disasters Database (EM-DAT), the study employs a fixed-effects panel VARX (Vector Autoregressions with Exogenous Variables) model to evaluate these effects. The findings indicate that moderate disasters cumulatively reduce GDP growth by -0.0266, while severe disasters reduce it by -0.0177. More specifically, in the year of the disaster (Year 0), GDP growth is decreased by -0.0092 for moderate disasters and -0.0225 for severe disasters, but their impacts in subsequent years differ. In the case of severe disasters, agricultural growth is greatly affected, cumulatively reducing it by -0.0538, while moderate disasters reduce it by only -0.0159. Non-agricultural growth also declines, with cumulative effects of -0.0106 for severe disasters and -0.0051 for moderate ones. The authors suggest that this can be alleviated by enhancing infrastructure resilience, strengthening emergency response systems, adopting better land-use planning practices, and investing more in disaster risk reduction measures. The other scholars who have worked on this topic are: Ayyubi et al. (2024), Anwar et al. (2024), Zubair et al. (2024), Ahsan et al. (2024), and Iqbal et al. (2025).

Although previous studies have examined the impact of natural disasters on economic growth, limited evidence is available for a panel of highly disaster-prone Asian countries using recent data extending to 2023. This study fills that gap.

3 DATA SOURCES AND METHODOLOGY

This chapter discusses the techniques of analysis and data collection. In this part, we elaborate on our research methodology, which encompasses data gathering, key factor identification, and hypothesis testing. Our study will be more comprehensible if we adopt these steps, hence making our findings valid.

Data Sources

This study aims to discuss the relation between NDs and economic growth in eight Asian nations, namely Bangladesh, China, India, Indonesia, Japan, Pakistan, the Philippines, and Vietnam, using panel data from 2002 to 2023. The variables of interest include: GDP per capita (constant), government consumption, trade openness, human capital, and FDI.

Data for GDP (constant)per capita, government. Consumption, trade openness, human capital, and FDI were collected from sources such as the World Development Indicators (WDI), the World Governance Indicators (WGI), and the Penn World Tables (PWT). ND data were obtained from the EM-DAT International Disaster Database, which records several deaths from disasters, among others. Table 1 shows the descrition of the dependent and independent variables.

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Table 1: Description of the Variables

Variable Name	Symbol	Proxy / Measurement Used	Unit / Formula	Data Source
Economic Growth	LPC	Real GDP per capita	Constant GDP per capita	World Development Indicators (WDI)
Natural Disasters	LND	The number of deaths caused by natural disasters such as floods, earthquakes, typhoons, and tsunamis	Total deaths from natural disasters	EM-DAT International Disaster Database (CRED)
Government Consumption	LGC	Government final consumption expenditure as a percentage of GDP	General government final consumption expenditure / GDP × 100	World Development Indicators (WDI)
Trade Openness	LTO	Sum of exports and imports as a percentage of GDP	(Exports + Imports) / GDP × 100	World Development Indicators (WDI)
Human Capital	HCI	Human Capital Index based on years of schooling and returns to education	Human Capital Index	Penn World Table (PWT)
Foreign Direct Investment	FDI	Foreign Direct Investment inflows as a percentage of GDP	FDI inflows / GDP × 100	World Development Indicators (WDI)

Real GDP per capita (LPC) is widely used as a proxy for economic growth in studies by Albala-Bertrand (1993), Naoaj (2023), and Panwar & Sen (2019). Natural disasters (LND), measured through disaster-related deaths, are commonly applied in the works of Noy & Vu (2010), Toya & Skidmore (2006), and Shabnam (2014). Government consumption (LGC) as a share of GDP is used in analyses by Idroes et al. (2023) and Hallegatte & Dumas (2009). Trade openness (LTO), defined as total trade relative to GDP, is employed in studies by Panwar & Sen (2019) and Cavallo et al. (2013). Human capital (HCI), based on education and skill accumulation indices, follows the frameworks of Romer (1986), Lucas (1988), and Idroes et al. (2023). Finally, foreign direct investment (FDI) as a percentage of GDP is commonly used in the work of Noy & Vu (2010) and Jaramillo (2009).

Rationale Behind Selection of Asia and Eight Specific Countries (Sample Size)

NDs significantly affect regions worldwide, with their frequency and severity varying across regions. Asia experiences the highest No. of NDs, accounting for 38.6% (4,390 disasters), followed by the Americas at 23.5% (2,673 disasters), Africa at 21.1% (2,397 disasters), Europe at 13.0% (1,472 disasters), and Oceania at 3.8% (433 disasters). Asia also suffers the highest human toll, with 54.6% of total deaths (918,198 deaths) and 50.7% of total injuries (3,855,558 injuries) occurring in the region.

This study centres on the most affected countries in Asia: Bangladesh, China, India, Indonesia, Japan, Pakistan, the Philippines, and Vietnam. This is due to the high frequency and severe impact of NDs in this region. Countless NDs have struck these nations, causing devastating damage to their economies and taking the lives of many more. For instance, in 2007, there were 20 NDs in China, 18 in India, 16 in the Philippines, 16 in Indonesia, 9 in Pakistan, and 8 in Japan. Nearly 17,000 people lost their lives, and 211 million were impacted by NDs in that year (Padli et al., 2008).

NDs pose significant economic challenges. According to Padli, Jaharudin, and Habibullah (2008), the ten nations hit hardest suffered economic losses of around US$60 billion due to the ND. This highlights the importance of effective disaster preparedness and mitigation policies in reducing the human and economic losses caused by NDs. This research aims to offer detailed insights and policy recommendations to enhance disaster resilience and mitigate future risks in the sample countries.

Model Specification

To examine the effect of NDs on economic growth in the selected eight Asian countries, this study employs a panel-data regression model. The model examines the relationship between GDP (constant) per capita (dependent variable) and NDs, alongside other control variables such as government consumption, openness of trade, human capital, and FDI.

In econometric models, the functional form determines how the regressand variable is related to the regressors. The way in which they are combined to forecast an outcome is stated by it. Utilising a panel-data regression model, this research investigates the effects of NDs on economic growth across eight Asian nations. The LPC (economic growth, measured by real GDP per capita) is considered the regressand, whereas NDs (indicated by deaths) and the government are the regressors. Consumption, trade openness, human capital, and FDI are treated as independent variables.

$\ln GDPPC_{it}=f(\ln ND_{it}, \ln GC_{it}, \ln TO_{it}, HC_{it}, FDI_{it})$

Econometric Model

$$LPC_{it} = \alpha + \beta_1 lND_{it} + \beta_2 lgc_{it} + \beta_3 lto_{it} + \beta_4 hci_{it} + \beta_5 fdi_{it} + \epsilon_{it}$$

Where:

- α : The intercept term represents the baseline level of lpc when all regressors are zero.
- lpc_{it} Log of real GDP per capita for the country i in year t.
- lND_{it} : Log of deaths caused by NDs where i represents an entity(country) and t represents time (year).
- lgc_{it}: Log of govt. consumption where i represents entity(country) and t represents time (year).
- lto_{it}: Log of openness of trade where i represents entity(country) and t represents time (year).
- lhc_{it} t: Log of human capital where i represents entity(country) and t represents time (year).
- $lfdi_{it}$ t: Log of FDI (FDI) for where i represents entity(country) and t represents time (year).

Panel data, which is also called time-series cross-sectional data, combines cross-sectional and time-series dimensions. They are usually made up of observations on many entities over several periods so that behaviour can be studied across both time and space (Hsiao, 2007). Logarithmic transformation was applied to reduce skewness, minimize heteroscedasticity, and allow coefficient interpretation in elasticity terms.

Modelling Framework in Panel Data

This study applies different panel-data estimation methods to investigate the correlations among GDP (constant) per capita, NDs (measured in terms of deaths), government consumption, trade openness, human capital, and FDI. The main models employed include FEM, REM, and Pooled (OLS). The choice among FEM, REM, and Pooled OLS depends on the nature of the data and the specific hypotheses being tested. FEM is appropriate when there is a correlation between unobserved individual effects and explanatory variables. On the other hand, REM is suitable where these two are uncorrelated. Pooled OLS is the simplest model, but it may be less relevant when individual-specific effects are large.

Pooled (OLS) or Common Intercept Model

The Pooled OLS model pools all observations by assuming a common intercept and slope across cross-sectional units, thereby ignoring the panel

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structure of the data. It is problematic because the method does not account for individual-specific effects, which could lead to biased estimates solely because of their presence.

The Pooled OLS model is specified as:

$$Y_{it} = \alpha + \beta X_{it} + \in \cdots \ldots \ldots . (ii)$$

Where:

- Y_{it} is the dependent variable for unit i at time t
- X_{it} represents the independent variables for unit i at time t
- α is the common intercept term.
- β is the vector of coefficients.
- ϵit is the error term for unit i at time t
-

Fixed Effects Model (FEM)

One of the models this article will discuss is the FEM Model. It can be used if you are looking to see how things like GDP (constant)per capita, NDs measured by deaths, and government. Consumption (LGC), openness of trade (LTO), human capital (HC), and FDI interact with each other. What makes FEM special compared to other models is that it controls for unobserved individual characteristics that do not change over time and may be associated with explanatory variables. This is done by adding a separate constant term for every panel unit.

The term "fixed effects" refers to the fact that the intercept for each entity varies across cross-sectional units but remains constant over time (Greene, 2012; Gujarati, 2009; Baltagi, 2008).

Consider the model given below:

$Y_{it} = \beta_0 + \beta_1 X_{1it} + \beta_2 Z_i + \varepsilon_{it}$................. (iii)

Where:

Z_i = (the country-specific unobserved effects are included).

I = 1......n (represents the cross-sectional units),

Here, our goal is to compute β_1 which is the average change in Y_{it} due to a change in X_{1it}

To do this, let's consider:

$\alpha_i = \beta_0 + \beta_2 Z_i$, Substituting in the model to obtain:

$Y_{it} = \alpha_i + \beta_1 X_{1it} + \varepsilon_{it}$............ (iv)

The following is the general form of the FE estimator:

$Y_{it} = \alpha_\iota + \beta_1 X_{1it} + \cdots \ldots \ldots + \beta_\kappa X_{\kappa it} + \varepsilon_{it}$ ... ... (v)

The above model is the FE Regression, where α_ι intercept, the subscript i on the term intercept indicates that each cross-sectional unit varies across countries, such that, time-invariant but does not do so across time.

Random Effects Model (REM)

The REM considers that the unobserved individual effect is uncorrelated with the regressors. REM is particularly useful when the variation across entities is assumed to be random and uncorrelated with the predictors in the model.

The REM is specified as:

$$y_{it} = \beta_0 + \beta_1 x_{it} + \mu_i + \varepsilon_{it} \ldots \ldots \ldots (vi)$$

- y_{it} is the dependent variable for entity i at time t
- x_{it} represents the independent variables for entity i at time t
- α is the overall intercept term.
- β is the vector of coefficients.
- μ_i is the individual-specific random effect.
- ε_{it} is the error term for entity i at time t

Diagnostic Tests: F-Test

The F-test (also known as the redundant fixed effects test) is used to choose between the Pooled POLS model and FEM. It checks if individual-specific effects are significant enough to be included in the model. (Baltagi 2008; Greene 2012; Hsiao 1979).

Hypotheses:

- H_o: Pooled OLS.
- H_1: FEM.

$$F(N-1, NT-N-K) = \frac{\frac{R^2_{FEM} - R^2_{Pooled}}{N-1}}{\frac{1-R^2_{FEM}}{NT-N-K}} \quad (vii)$$

- k = No. of parameters
- N = No. of cross-sectional units
- T = No. of periods

Hausman Specification Test

The Hausman Specification Test checks whether an estimator is consistent with another, less efficient estimator. In other words, this test can be used in panel data analysis to decide between an FEM and an REM. (Hausman, 1978).

Hypotheses:

- H_o: REM
- H_1: FEM

Test Statistic:

$$H = \left(\beta^{FE} - \beta^{RE}\right)'\left[\mathrm{Var}\left(\beta^{FE}\right) - \mathrm{Var}\left(\beta^{RE}\right)\right] - 1\left(\beta^{FE} - \beta^{RE}\right) \text{----(viii)}$$

Where
β_{FE} = calculated parameter of FEM
β_{RE} = estimated coefficient value of REM
ν_{FE}= covariance matrix of FEM
And ν_{RE} = covariance matrix of REM
Study Result: Regarding this study, the F-test and Hausman specification test both reject the null hypothesis (H0), indicating that the FEM is the appropriate model for examining the relationship between openness to trade, and economic growth among the chosen Asian nations.

4 DISCUSSION

The preceding segment provided an elaborate discussion about the data, data sources, variables, panel data modelling framework, model design, and diagnostic tests applied to evaluate the study hypotheses. The empirical findings—including tables, graphs, and the estimated model (the Fixed Effects Model)—and their interpretation are presented in this part, along with descriptive statistics and a correlation matrix.

The analysis begins with the presentation of the, highlighting the relationships between key variables such as real GDP per capita, deaths due to NDs (deaths), government consumption (LGC), trade openness, human capital, and foreign direct investment (FDI).

The FEM was chosen as a more appropriate model based on the results of the F-test and Hausman specification test, both of which rejected the null hypotheses in favour of FEM. This model controls for time-invariant unobserved individual characteristics and provides more efficient and consistent parameter estimates.

Descriptive Statistics

The descriptive statistics, including the number of observations, mean, standard deviation, minimum, and maximum values, are shown in Table 2 for the variables in this study.

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Table 2: Descriptive Statistics

Variable	Observation	Mean	Std. Dev.	Min	Max
LPC	176	8.032	1.088	6.521	10.521
LND	176	6.466	1.47	1.946	12.025
LGC	173	-2.263	.383	-2.991	-1.533
LTO	175	-.948	.524	-1.809	-0.58
HCI	144	.852	.228	0.693	1.386
FDI	165	.272	1.015	-4.742	2.268

Source: author's own estimation

Real GDP per capita has a mean score of 8.032 and a standard deviation of 1.088, with values ranging from 6.521 to 10.521. The average No. of deaths resulting from NDs is 6.466, with a 1.47 standard deviation and a range of 1.946 to 12.025. With values ranging from -2.991 to -1.533, government consumption (LGC) has a mean of -2.263 and a standard deviation of 0.383. Trade openness ranges from -1.809 to 0.580, with a mean of -0.948 and a standard deviation of 0.524. The values of human capital range from 0.693 to 1.386, with a mean of 0.852 and a standard deviation of 0.228. Lastly, the range of foreign direct investment (FDI) is -4.742 to 2.268, with a central value of 0.272 and a std—dev of 1.015. According to these figures, there are no data outliers, which provides a strong basis for additional research.

The panel dataset is unbalanced due to missing observations for some variables, particularly human capital and FDI. Consequently, the final regression estimation includes 141 observations after listwise deletion. Missing observations for human capital and FDI resulted in an unbalanced panel. The final estimation was based on 141 observations after listwise deletion.

Matrix of Correlations

Table 3 analyses the cross-correlation of the variables used in the study.

Table 3: Matrix of Correlations

Variable	LPC	LND	LGC	LTO	HCI	FDI
LPC	1.000					
LND	-0.348	1.000				
LGC	0.783	-0.053	1.000			
LTO	-0.177	-0.129	-0.306	1.000		
HCI	0.751	-0.377	0.592	0.022	1.000	
FDI	-0.339	0.150	-0.198	0.636	-0.273	1.000

Source: author's own estimation

The variable LPC (real GDP per capita) is positively correlated with LGC (government consumption) and HCI (human capital), with correlation coefficients of 0.783 and 0.751, respectively. This indicates that greater levels of government consumption and human capital are associated with higher real GDP per capita. Conversely, LPC is negatively correlated with LND (No. of deaths due to NDs) and FDI (foreign direct investment), with coefficients of -0.348 and -0.339, respectively, suggesting that large numbers of deaths are associated with lower real GDP per capita. The variable LND shows a negative correlation with most variables, except FDI, with which it shows a positive correlation of 0.150. Government consumption shows a positive correlation with LPC and HCI (0.592) but a negative correlation with trade openness and FDI. Trade openness has negative associations with LPC, LND, and LGC, but a strong positive association (0.636) with FDI. Human capital has a negative correlation with LND and FDI, but a positive correlation with LPC and LGC. Lastly, trade openness and foreign direct investment (FDI) are positively associated, whereas LPC, LGC, and HCI are negatively associated. These correlations shed light on the connections and possible effects between these important economic variables.

Diagnostic Test Results

Table 4 summarises the test results, which will be discussed below. The F-test and the Hausman specification test were two crucial diagnostic tests conducted to assess the precision and reliability of the econometric model used in this investigation.

Table 4: Diagnostic Test Results

Tests applied	Null hypotheses	Statistic	Probability	Decision
F test	Pooled OLS	107.36	0.000	Reject H0
Hausman test	REM	24.284	0.000	Reject H0

Source: author's own estimation

The F-test is conducted to compare the Pooled OLS model with the Fixed Effects Model (FEM). The probability value of 0.000 and the large F-statistic value of 107.36 point to a robust rejection of the null hypothesis. This implies that the FEM, which takes individual-specific effects into account, is a better fit and that the Pooled OLS model is inappropriate. The null hypothesis is rejected, indicating that the individual effects are important and require control—something the Pooled OLS model is unable to provide.

The Hausman specification test rejects the null hypothesis, indicating that the random effects model is not appropriate due to correlation between the unobserved country-specific effects and the explanatory variables. As a result, the Fixed Effects Model is preferred because it produces consistent estimates by accounting for these time-invariant differences across countries. In addition, the F-test rejects the pooled OLS model, confirming that country-specific effects are statistically significant and should be controlled for in the analysis.

Table 5: Estimation Results

Variables	Coefficient	Std. Error	t Statistic	p Value	95% Confidence Interval	Significance
LND	-0.042	0.016	-2.69	0.008	[-0.073, -0.011]	***
LTO	-0.093	0.095	-0.99	0.325	[-0.281, 0.094]	
LGC	0.454	0.171	2.65	0.009	[0.115, 0.793]	***
HCI	0.905	0.163	5.55	0.000	[0.583, 1.228]	***
FDI	0.049	0.027	1.80	0.074	[-0.005, 0.103]	*
Constant	8.372	0.500	16.75	0.000	[7.383, 9.360]	***

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

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The regression results indicate that the dependent variable, real GDP per capita (LPC), has a mean value of 7.926 with a standard deviation of 1.065 across 141 observations. The model explains a moderate proportion of the variation in economic growth, with an R-squared value of 0.438. The overall model is statistically significant, as indicated by an F-statistic of 19.924 and a probability value of 0.000, confirming that the explanatory variables jointly explain variations in GDP per capita. Model selection criteria further support the robustness of the specification, with Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values of -59.203 and -41.510, respectively, suggesting an efficient model fit relative to alternative specifications.

The minimum level of real GDP per capita when all independent variables are zero is represented by the model's constant term, which is 8.372. With a p-value of 0.000, this is also statistically significant.

The relationships between the log-transformed real GDP per capita and some independent variables are shown in Table 5, the regression analysis. A 1 unit increase in disaster-related deaths is associated with a 0.042% decline in GDP per capita. The coefficient for deaths is -0.042, suggesting a negative correlation. This indicates that there is a 0.042% drop in real GDP per capita for every 1unit increase in deaths. With a p-value of 0.008, this relationship is statistically significant at the 1% level.

Government consumption is represented by the variable LGC, which has a positive coefficient of 0.454. This implies that the real GDP per capita increases by 0.454% for every 1% increase in government consumption. Using a p-value of 0.009, this relationship is also statistically significant at the 1% level.

Trade openness has no statistically significant effect on GDP per capita in the estimated model.

For HCI, the human capital index, the coefficient is 0.905, indicating a strong positive relationship. 1 unit increase in the human capital index is associated with a 0.905% increase in real GDP per capita. This relationship is highly significant.

Lastly, the variable FDI, representing foreign direct investment, has a coefficient of 0.049. This positive relationship means that a 1 unit increase in foreign direct investment is associated with a 0.049% increase in real GDP per capita. This relationship is significant at the 10% level (p-value = 0.074).

Overall, the model diagnostics indicate that, with an R-squared of 0.438, the independent variables account for 43.8% of the variability in real GDP per capita. With a p-value of 0.000 and an F-test value of 19.924, the model is statistically significant overall. The model's validity and good fit are further supported by the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) values of -59.203 and -41.510, respectively, and by the Chi-square test value of 24.284 with a p-value of 0.000.

5 CONCLUSION AND POLICY RECOMMENDATIONS

Conclusion

This study aimed to analyse the impacts of NDs on economic growth in eight Asian countries: Bangladesh, China, India, Indonesia, Japan, Pakistan, the Philippines, and Vietnam. Over the period from 2002 to 2023, the countries included are Bangladesh, China, India, Indonesia, Japan, Pakistan, the Philippines, and Vietnam. The study applied panel data techniques to estimate the nexus between the growth rate of real GDP per capita and NDs, proxied by deaths. Also, the roles of government consumption, Trade openness, human capital, and FDI in the growth of the economy were analysed.

The FEM analysis yielded the following findings regarding the empirical outcomes of the current study. First, as the analysis presented shows, there is a statistically significant negative association between NDs and real GDP per capita; this suggests a negative effect of NDs on economic growth. This result is consistent with earlier research by Noy & Vu (2010), who also found a negative effect of ND on economic growth.

Second, the paper also found that government consumption has a positive and significant impact on real GDP per capita, suggesting that increased government expenditure will boost economic growth, especially during a calamity. The result corresponds with Hallegatte and Dumas (2009), who conclude that effective reconstruction and adaptive capacities are necessary to limit the negative impact of disasters.

Third, the variable trade openness was also included in this analysis, but it did not show a strong relationship with economic growth in the study. Thus, the result obtained in this study stands in contrast to the aforementioned literature, suggesting that the role of trade openness in economic growth may be more nuanced and contingent on the specifics of a given country's environment.

Fourth, human capital entered with a positive sign, suggesting that higher levels of education and the accumulation of skill capital are very important for economic growth. This supports the endogenous development hypothesis formulated by Romer (1986) and Lucas (1988), which posits that human capital is a potent factor supporting long-run economic development.

In the last step, the results indicated that FDI had a positive but very close to zero effect on real GDP per capita; this implies that although FDI enhances growth, it is constrained by other factors, such as institutional quality and market characteristics.

Policy Recommendations

The governments of the eight selected Asian countries, Bangladesh, China, India, Indonesia, Japan, Pakistan, Philippines, and Vietnam, should strongly focus on Disaster preparedness and response interventions to reduce the initial and future fiscal effects of disasters. Key investments should include:

- Early Warning Systems: Organizing a disaster response plan that includes an early warning system to help in identifying disasters and offer adequate and reliable information on when the disasters may occur. These systems should harness recent technologies to identify ND incidents and enable countermeasures, including evacuation. For instance, Japan has established a highly advanced earthquake early warning system that has helped save many lives and reduce damage by giving out between a few seconds and a few minutes' warning of when the most intense shaking would occur.

Emergency Response Plans: Drawing adequate and concise emergency plans to ensure that all the needed resources and workforce can be deployed as soon as a disaster occurs. These plans need to be reviewed and replenished, and should be proven through exercise and training. Indonesia has upgraded, or at least enhanced, its disaster management plans compared to the period of the 2004 tsunami.

Public Awareness Campaigns: Organizing public education campaigns to pass information on disasters and precautionary measures to the people. Such campaigns can help people at risk adopt self-protection measures and safeguard their property, thereby minimizing the effects of disasters. For example, Bangladesh has made significant progress in community-based disaster preparedness measures, and as a result, cyclones are not taking as many lives as before.

Disaster management in these examples has revealed the No. The deaths that would be caused could be controlled, there would be less impact on the economy, and overall, quicker rehabilitation and reconstruction would be achieved. Thus, by focusing on the sampled investments, the countries can increase their ability to cope with NDs and protect their economies.

The governments of Bangladesh, China, India, Indonesia, Japan, Pakistan, the Philippines, and Vietnam should consider formulating and implementing strategies, including risk assessment, risk management, and risk transfer mechanisms. These strategies should include:

Risk Assessment: Defining and assessing risks and threats that may threaten people and their commonwealth. This consists of identifying areas prone to disasters and evaluating the consequences of different NDs. For example, China today has achieved a relatively sophisticated disaster risk assessment, including hazard maps for earthquakes, floods, and typhoons, as well as vulnerability assessments.

Mitigation Strategies: They include measures that minimize the quantity and quality of disaster impacts and those that do not require the building of structures. Structural measures refer to actions such as constructing stronger public works, for example, dikes, well-constructed houses for earthquakes, and storm surge barriers. Non-structural measures such as land-use regulation, better urban planning, and ecosystem-based risk reduction. Standard construction requirements and land-use zoning have limited the impact of disasters such as earthquakes and tsunamis in Japan.

Risk Transfer Mechanisms: Insurance and financial risk spreading for the economic consequences of NDs. This entails creating and marketing non-life insurance products, disaster risk insurance, and related disaster risk insurance solutions, and putting in place business structures such as catastrophe bonds or disaster risk financing structures. Currently, the Philippines is piloting a parametric insurance policy for local government units, especially for disaster response, to enable the government to access quick, easily accessible cash.

Thus, the adoption of advanced risk management approaches can help these countries better protect themselves against various disasters. Hence, such strategies increase community and economic resilience against disasters and consequently contribute to sustainable economic development. Every natural calamity requires preparedness, response, and risk management to minimize the negative economic consequences. The following policies will be implemented to ensure the above-named sampled countries develop capacity and achieve long-lasting economic stability.

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