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The Relationship Between Natural Disasters, Real Economic Growth, and Public Debt: Cross-Country Empirical Evidence

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Abstract

This study aims to examine the effects of natural disaster damage and real economic growth on the general government's gross debt using empirical evidence from 48 countries. The Two-Stage System Generalised Moments (GMM) method was applied for the period 1965–2024 using five-year data. The empirical findings show that an increase in real economic growth statistically significantly reduces the general government's gross debt level. In contrast, an increase in natural disaster damage statistically significantly increases the general government's gross debt level. It was found that the first lag of the general government's gross debt had an increasing effect on the current debt level.

Key words: Government Gross Debt. Natural Disaster, Disaster Damage, Economic Growth, Two-Stage System GMM Estimator.

JEL Code: C23, H84, Q54.

1. Introduction

There is a broad consensus among experts that climate change is increasing the frequency and intensity of extreme weather events. While not every extreme weather event is directly classified as a natural disaster, there is strong evidence that climate change is increasing the magnitude of economic and social damage caused by natural disasters (Deryugina, 2022: 2). Indeed, changes in global climate systems are increasing both the frequency and destructiveness of natural disasters, creating increasingly significant impacts on the economic and financial structures of countries (Van Aalst, 2006; Ibarrarán et al., 2009; Vasileiadou & Botzen, 2014; NOAA NCEI, 2024).

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The economic impacts of natural disasters are addressed in the literature from various perspectives. Recent studies examine the effects of natural disasters on public support for climate change mitigation policies, revealing how disaster experiences shape societal and political preferences (Liao & Junco, 2022; Shawn, Ian, & Constant, 2024). However, the long-term effects of natural disasters on public finances and debt dynamics have been addressed in a relatively limited number of studies.

The scale of devastation caused by natural disasters worldwide is striking. According to data published by the International Disaster Database (EM-DAT), natural disasters occurring between 1900 and 2024 resulted in approximately US$7.3 trillion in economic damage, led to the deaths of approximately 33 million people, and left more than 180 million homeless (EM-DAT, 2025a). This data reveals that natural disasters are not only a humanitarian crisis but also a critical issue in terms of macroeconomic and fiscal sustainability. Barro (2006) classifies the disasters that profoundly affected economic performance in the 20th century as major economic crises, wars, natural disasters, and epidemics, emphasizing that such events can have lasting effects on long-term growth and fiscal balances. In this context, natural disasters, due to their sudden and unpredictable nature, place significant pressure on public spending, borrowing requirements, and fiscal discipline. EM-DAT defines natural disasters as events that exceed local capacity, require external assistance at national or international levels, and lead to significant loss of life and economic devastation. In the EM-DAT database, disasters are divided into two main groups: natural and technological disasters. Natural disasters are classified under six main categories: climatological, geophysical, meteorological, biological, hydrological, and extraterrestrial, while technological disasters include various industrial, transportation, and other human-caused accidents (EM-DAT, 2025b). Such a comprehensive classification demonstrates the multifaceted nature of natural disasters and their potential to have effects through different economic channels.

This study, unlike the existing literature examining the impact of natural disasters on public finances, addresses the dynamic effects of disaster damage and real economic growth on the gross debt of public administration within a long-term and comprehensive framework. While many studies in the literature focus on the effects of disasters on budget balance, public expenditures, or economic growth, studies that directly analyses the stock size and dynamic structure of public debt are quite limited. This study, using a broad panel dataset covering the period 1965–2024 and including both developed and developing countries, reveals the effects of disasters on public debt dynamics from a comparative and long-term perspective. In this way, empirical findings on the impact of disasters on public debt are presented. The results provide a new and policy-significant perspective to the literature, demonstrating that the effects of natural disasters on public debt are shaped not only by fiscal burden-increasing mechanisms but also through debt management strategies, international financing opportunities, and fiscal adjustment policies.

2. The Effects of Natural Disasters

The Economic Commission for Latin America and the Caribbean (ECLAC) has categorized the material impacts of natural disasters into three categories: 1) impacts on property (direct damage), 2) impacts on the flow of goods and services production (indirect damage), and 3) macroeconomic impacts. Direct damage includes property damage that occurs simultaneously with the disaster itself, as well as the total or partial destruction of physical infrastructure, buildings, facilities, machinery, equipment, means of transport and storage, and furniture, and damage to fields, irrigation facilities, and dams. Direct damage also includes the estimated cost of demolition and cleanup of the affected areas within the scope of the repair and reconstruction budget (ECLAC, 1991: 10-14; ECLAC and International Bank for Reconstruction and Development (The World Bank), 2003: 10-15). In addition to studies investigating how natural disasters affect the private housing market in terms of damage to private buildings (Brody et al., 2007; Davlasheridze & Fisher-Vanden, & Allen Klaiber, 2017); Studies have also been conducted on the effects of natural disasters on the damage to public buildings (Davlasheridze & Miao, 2021; Graham, 2012; Graham, 2020; Hamideh & Rongerude, 2018).

Indirect damage is the damage to the flow of goods that are not produced or services that are not provided during the rehabilitation and reconstruction phase, which begins immediately after the disaster and is estimated to last up to five years. Indirect damage stems from direct damage to production capacity and social and economic infrastructure. Macroeconomic impacts, on the other hand, are the effects of disasters on the level and growth rate of overall and sectoral Gross Domestic Product (GDP), trade balance, debt and foreign exchange reserves, public finances, and gross investment. The six most important macroeconomic impacts are: 1) Impact on GDP (real value of loss of goods and services production per sector as a result of the disaster and throughout the rehabilitation period), 2) Impact on net investment (ongoing projects suspended due to the disaster and capital stock losses), 3) Impact on balance of payments (decrease in exports of goods and services, increase in imports for reconstruction necessary during the rehabilitation phase, cash or in-kind donations received due to the emergency, and a possible decrease in interest payments on external debt under emergency agreements with creditors), 4) Public finances (decrease in goods and services production, loss of earnings and decreased consumer spending, lower tax revenues due to decreased earnings of public utility companies, increased current expenditures to meet the needs of the particularly affected population and repair damaged public utilities due to the emergency, and increased investment expenditures for the reconstruction phase), 5) Prices and inflation (changes in the price of certain goods and services that will be supplied through alternative means to prevent supply constraints resulting from situations such as the destruction of crops, manufacturing, marketing channels, transportation networks, etc.), and 6) Employment (production This is expressed as the destruction of capacity or social infrastructure and the new demands on manpower during the emergency and rehabilitation process (ECLAC, 1991: 10-14; ECLAC and International Bank for Reconstruction and Development

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(The World Bank), 2003: 10-15). There are also studies on the calculation of direct and indirect damages, or losses (Prihantini (2020); Merz et al. (2010); Wijayanti et al. (2017); Prihantono (2024), Koç, Natho & Thieken (2021), Festa, et al. (2022)).

Natural disasters have four effects on public health in addition to material impacts. These are divided into two categories: direct and indirect effects. Direct effects include direct impacts on public health (injury, death, infectious diseases, acute, chronic, and psychological illnesses) and direct impacts on healthcare services (damage to physical infrastructure such as hospitals, clinics, health centres, and healthcare institutions, and losses among personnel working in these institutions). Indirect effects include indirect impacts on public health (damage to basic healthcare services and normal living conditions) and indirect impacts on healthcare services (damage to electricity, water, natural gas, communication, and transportation resources of healthcare facilities) (Shoaf and Rottman, 2000: 58-61). Divide these effects into four. There are also studies on the effects of natural disasters on public health (Lin et al., 2001: 1596-1597; Bernstein et al., 1980: 24, 27) and how the health system should prepare for natural disasters (Hidalgo & Baez, 2019: 592).

3. The Effects of Natural Disasters

Table 1 summarizes the literature focusing on the determinants of public debt and the effects of natural disasters on debt dynamics, the role of GDP growth on public debt, empirical studies using the System GMM method, and post-disaster fiscal policy and financing mechanisms.

Table 1. Literature Review

Author(s)	Subject	Country / Sample	Period	Methodology	Key Findings
Keskin and Aytüre (2026)	The impact of environmental and natural disasters on stock market indices.	Türkiye	2020: -2024	Event Study	Environmental and natural disasters also have a negative impact on financial markets.
Fisera (2023)	Examines the impact of natural disasters on government borrowing costs.	Low- and middle-income countries in	2000s	Regression Analysis	Disasters increase borrowing costs, especially in developing countries; this can indirectly make debt dynamics more unsustainable.
Kunawotor et al. (2022).	Fiscal balance and policy implications of climate variability and extreme weather events.	African countries	1990–2017	GMM Comparative forecast with FE/RE)	Increased temperature anomalies disrupt fiscal balance; major/severe damage events have a significant impact on fiscal balance. In countries with high institutional

Author(s)	Subject	Country / Sample	Period	Methodology	Key Findings
					capacity/adaptability, the negative impact is more effectively "modulated".
Fan et al. (2021)	This study examines the dynamics of public debt and GDP growth following natural disasters; post-disaster borrowing trends and growth responses are evaluated comparatively.	86 developing countries	1981–2019	“Saturated” Logit Specification	In countries affected by disasters, the rate of public debt growth is higher than in countries without disasters; GDP growth tends to recover more quickly after the collapse in the disaster year. This indicates that borrowing plays a role in financing post-disaster reconstruction.
Keyifli (2021)	The impact of public debt, trade openness, GDP growth, population density, and total cost of losses on budget deficits is examined.	34 OECD countries	2000–2018	Two-Stage System GMM Analysis	It has been found that increases in public debt, trade openness, GDP growth, and total cost of losses increase budget deficits, while increases in population density reduce budget deficits.
Cevik and Nanda (2020)	The effects of variables such as public revenues, non-interest government expenditures, public debt, and GDP growth rate on the Cyclically Adjusted Primary Balance (CAPB) have been examined.	16 Caribbean countries	1980–2018	Fixed Effects Analysis and System GMM Analysis	The first lag in public debt has a positive and significant effect on the CAPB. This result indicates that fiscal policies are effective in terms of short-term borrowing. The insignificant and negative result for the second lag in public debt reveals that these countries' fiscal policies regarding long-term borrowing are inadequate.
Benali et al. (2018)	It examines the impact of disasters on public budgets and debt in high- and middle-income countries.	High and middle-income countries	1990–2013	Panel VAR, Granger Causality Tests	The findings indicate that there are dynamic relationships between disasters, budget revenues, expenditures, and public debt; and that disasters increase the debt-to-GDP

Author(s)	Subject	Country / Sample	Period	Methodology	Key Findings
					ratio, especially in middle-income countries.
Koetsier (2017)	This study investigates the average and median impact of natural disasters on government debt; the impacts are examined through both output and public finance position.	163 countries	1971–2014	Panel Synthetic Control Method	Following major natural disasters, the government debt-to-GDP ratio increases by an average of around 11.3%, with a median impact of approximately 6.8%. In more severe disasters, the increase can exceed 20%. This increase is spread over the long term.
Klomp and Valckx (2016)	The impact of disasters on economic growth has been investigated.	140 countries	1992–2008	Meta-regression Analysis	While natural disasters negatively impact economic growth in the short term, in the long term, economic growth returns to its original growth path.
Acevedo (2014)	The effects of natural disasters on both growth and the debt-to-GDP ratio are examined within the context of the Caribbean.	12 Caribbean economies	1970–2009;	Panel VAR	While disaster types such as storms and floods negatively impact growth, the debt-to-GDP ratio tends to increase in the short term; post-shock debt dynamics respond differently depending on the type of disaster.
Loayza et al. (2012).	The effects of various types of natural disasters and public debt on economic growth and agricultural, industrial, and service growth have been investigated.	A total of 94 countries, including 26 developed and 68 developing countries.	1961-2005	GMM	Various disasters have different effects on economic growth depending on different sectors or the level of development of groups of countries. Increased public debt harms both overall economic growth and the growth of specific sectors.
Melecky and Raddatz (2011)	It assesses the impact of natural disasters on government expenditures	High and middle-income countries.	1975–2008	Panel VAR	Government spending increases while tax revenues decrease following disasters, leading to wider budget deficits. This effect is

Author(s)	Subject	Country / Sample	Period	Methodology	Key Findings
	and revenues, as well as on public debt and the budget balance.				particularly strong in countries with low insurance penetration. Furthermore, while the real impact is more limited in countries with advanced financial markets, budget deficits still increase.
Lugay and James (2010)	The study tests the relationship between natural disasters, public debt accumulation, and GDP growth through the lens of small island economies.	Eastern Caribbean Currency Union (ECCU) countries	1993–2011	Fixed Effects Panel Regression	When damage caused by disasters exceeds 2% of GDP, the debt-to-GDP ratio increases by approximately 6.7 percentage points. This large increase in debt is typically associated with a loss of growth and increased government spending.
Lis and Nickel (2010)	The impact of large-scale extreme weather events on changes in budget balances.	138 countries	Unspecified	GMM (Blundell–Bover)	Extreme weather events are reported to disrupt budget balances (negative impact); the magnitude of the impact varies by country group, with a stronger impact in developing countries (impact range 0.23%–1.4% of GDP).

The effects of natural disasters on economic growth and regional economic growth have been examined in the literature, and empirical studies in this area point to different results. Some prominent studies in this context are discussed below. Farzanegan & Fischer (2025) analysed the impact of the 2003 Bam earthquake in Iran on the local economy in 366 counties during the 1992-2013 period using the Synthetic Control Method (SCM). The analysis found that approximately seven years after the earthquake, the damage from natural disasters positively affected local economic growth.

Tran & Wilson (2024) analysed the impact of natural disaster damage on personal income for US states during the 1980-2017 period using the Impulse Response Functions (IRFs) method. The analysis found that in states affected by natural disasters, the damage from natural disasters positively affected personal income, especially in the long term.

Dolu and İkizler (2024) analyzed the impact of the 2020 İzmir earthquake on 128 firms in İzmir using a survey and multivariate regression method. The analysis revealed that large firms were more resilient to natural disaster damage, while small businesses experienced significant operational and financial disruptions after natural disasters.

Díaz, Paniagua & Larroulet (2024) analysed the impact of earthquake damage in Chile and New Zealand during 2010-2011 on economic growth using the SCM method. The analysis of the Canterbury region of New Zealand found that the earthquakes had a positive impact on economic growth. An analysis of the Maule region in Chile revealed that earthquakes negatively impacted economic growth. Based on this, it was concluded that while natural disasters like earthquakes positively affect economic growth in developed countries, they negatively impact economic growth in developing countries.

Naoaj (2023) analysed the impact of natural disaster frequency on agricultural and economic growth during the 1970-2019 period using a fixed effects panel data analysis method. The analysis found that both agricultural and economic growth decreased in both developed and developing countries due to the increase in the frequency of natural disasters.

Khan et al. (2023) investigated the impact of natural disasters on economic growth in 98 countries during the 1995-2019 period using a two-stage Generalised Method of Moments (GMM) method and found that human capital losses resulting from natural disaster damage reduced national income.

Cuaresma (2022) analysed the impact of natural disaster damage on economic growth in 123 countries during the period 1970-2019 using bivariate regression and cross-country regression methods. The bivariate regression method showed that increases in natural disaster damage, total natural disasters per kilometre, and climatic disasters per kilometre had a positive impact on economic growth, while the cross-country regression method indicated that natural disaster damage had no statistically significant effect on economic growth.

Cang, Xu & Wang (2022) investigated the impact of natural disaster damage on economic growth in China during the period 1995-2018 using Linear and Nonlinear ARDL Model methods. The analysis revealed that low-intensity natural disaster damage positively impacted economic growth, while high-intensity natural disaster damage negatively impacted it.

González, London & Santos (2021) analysed the impact of natural disaster damage on economic growth in Argentina during the period 1992-2013 using pooled regression methods. The analysis revealed that the increase in natural disaster damage negatively impacted economic growth.

Cavallo, Becerra & Acevedo (2021) analysed the impact of natural disaster damage on economic growth in the country groups of Europe & Central Asia, Middle East & Africa, South-East Asia & Pacific, Latin America and the Caribbean, and North America using cross-country regression and comparative case studies methods during the period 1970-2019. The analysis revealed that natural disaster damage negatively impacts economic growth, and this negative impact is even greater in poorer countries.

Atsalakis et al. (2021), in their study, analysed the impact of natural disaster damage on economic growth in 108 countries during the period 1979–2010 using the quantile-on-quantile (QQ) regression method. The analysis found that in the short term, natural disaster damage negatively impacts economic growth. In the long term, however, it was determined that natural disaster damage has different effects on economic growth depending on certain quantiles or certain country groups.

Fomby, Ikeda, and Loayza (2013) present a comprehensive empirical study examining whether the effects of natural disasters on economic growth differ depending on the type of disaster. Using annual panel data from 1960–2007 covering numerous developed and developing countries, the study analyses the dynamic effects of different disaster types, such as drought, floods, earthquakes, and storms, on per capita GDP growth. The authors applied dynamic analyses based on panel VAR and local projection methods to reveal the short- and medium-term effects of disaster shocks on growth. The findings show that the effects of natural disasters on economic growth differ significantly depending on both the type of disaster and time. Accordingly, earthquakes and storms negatively impact growth in the short term, but these effects weaken over time; droughts, on the other hand, lead to more permanent and long-term growth losses. The results highlight the non-homogeneous economic impacts of natural disasters and the need for disaster-specific policy designs.

Noy (2009) investigated the impact of natural disaster damage on economic growth and other variables in 109 countries (categorised as developing, developed (OECD), and small economies) during the period 1970-2003 using the Hausman–Taylor three-step estimation methodology. The analysis revealed that while increases in natural disaster damage negatively impacted economic growth in all countries and in developing countries, they positively impacted economic growth in OECD countries.

Skidmore and Toya (2002) examined the effects of natural disasters on long-term economic growth in an international context and presented findings suggesting that disasters not only cause destructive consequences but can also promote growth under certain conditions. The study conducted using data from approximately 90 countries covering the period 1960–1990, analyzed the relationships between the frequency of natural disasters and per capita income growth, total factor productivity, and human capital using multiple linear regression (OLS). The results indicate that natural disasters may have a positive long-term relationship with

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economic growth through total factor productivity and human capital accumulation channels. The authors explain these findings through a "creative destruction" mechanism, where disasters lead to the destruction of old and inefficient capital, accelerating the adoption of more modern technologies and institutional learning. However, the study acknowledges that disasters cause significant economic losses in the short term and emphasizes that the positive effect is limited to long-term structural adjustment processes.

4. Development of Natural Disaster Data by Country

This section contains current data for the period 2020-2025.[3] The total number of people who lost their lives in natural disasters that occurred during the period, the total number of people affected by natural disasters, the material damages caused by natural disasters, and the number of natural disasters that occurred and caused material damage during the relevant period were collected. The data in Tables 2 and 3 are current. The main purpose of using this current data is to present a comparative analysis of the humanitarian and economic impacts of natural disasters on countries. In this context, Table 2 shows the number of people who lost their lives and were affected by natural disasters, while Table 3 presents the monetary value of material damages and the total number of disasters, ranked from largest to smallest, for each country. However, in order to obtain a broader time perspective in the empirical analysis part and to examine the long-term relationships between the variables more thoroughly, the period 1965-2024 was used as the basis. Table 2 shows the total number of people who lost their lives in natural disasters and the total number of people affected by natural disasters during the 2020-2025 period. These numbers are listed in descending order.

Table 2. Total Number of People Who Lost Their Lives and Total Number of People Affected by Natural Disasters During the Period 2020-2025

Total number of people who lost their lives		**Total number of people affected by the natural disaster**		**Total number of people who lost their lives**		**Total number of people affected by the natural disaster**	
Türkiye	53.750	Philippines	94.174.037	Thailand	822	Fiji	3
Italy	50.418	India	61.746.287	Papua New Guinea	776	Malaysia	3
Spain	26.825	Pakistan	43.268.313	Republic of Korea	671	Australia	3
Germany	21.090	China	42.601.414	Colombia	657	USA	2

[3] This table was created using data from 53 countries for the period 01.01.2020-19.12.2025.

Greece	13.772	Indonesia	28.149.563	Iran	624	Panama	2
India	12.825	Türkiye	16.773.484	Bolivia	572	El Salvador	2
France	12.020	South Africa	12.300.032	Madagascar	562	Paraguay	2
Romania	10.009	Mozambique	11.420.993	Algeria	438	Chile	2
United Kingdom	8.465	Kenya	10.314.561	United States of America (USA)	423	Canada	2
Pakistan	6.219	Thailand	10.168.235	Senegal	383	Republic of Korea	1
Portugal	4.613	Iran	6.265.028	Ecuador	375	Algeria	1
Indonesia	3.568	Bolivia	6.192.874	Malaysia	347	Tonga	1
Haiti	3.462	Brazil	5.730.765	Honduras	214	Belgium	1
China	3.302	Honduras	5.689.304	Chile	187	Greece	1
Philippines	2.850	Nepal	4.347.234	Panama	166	Senegal	1
Belgium	2.737	Sri Lanka	3.811.686	El Salvador	136	Papua New Guinea	1
Hungary	2.250	Haiti	3.491.774	Australia	107	Spain	1
Nepal	1.693	Madagascar	3.000.395	Jamaica	71	Italy	1
Brazil	1.611	Jamaica	2.560.400	Mongolia	36	Portugal	0
Kenya	1.405	Colombia	2.537.915	Paraguay	36	New Zealand	0
South Africa	1.309	Ecuador	1.701.704	Bahamas	17	Romania	0
Mexico	1.203	Costa Rica	1.641.489	New Zealand	16	United Kingdom	0
Japan	1.073	Mexico	1.446.190	Fiji	15	Germany	0
Sri Lanka	1.047	Mongolia	1.061.951	Costa Rica	11	Bahamas	0
Peru	932	Japan	890.433	Tonga	4	Hungary	0
Mozambique	895	Peru	833.712	Samoa	0	Samoa	0
Canada	893	France	609.629				

Source: The aggregated data presented in this table were organised by the authors based on data obtained from the EM-DAT database (https://public.emdat.be/data, Access Date: December 19, 2025).

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Table 2 shows that the countries with the highest total number of deaths from natural disasters between 2020 and 2025, in order of size, are Turkey, Italy, Spain, Germany, Greece, India, France, Romania, the United Kingdom, and Pakistan. Conversely, the countries with the lowest number of deaths from natural disasters during the same period, in order of size, are Samoa, Tonga, Costa Rica, Fiji, New Zealand, the Bahamas, Paraguay, Mongolia, Jamaica, Australia, El Salvador, Panama, and Chile.

Table 2 also shows that the countries with the highest total number of people affected by natural disasters between 2020 and 2025 are the Philippines, India, Pakistan, China, Indonesia, Turkey, South Africa, Mozambique, Kenya, and Thailand. Conversely, the countries with the lowest number of people affected by natural disasters during the same period, in order of size, are Samoa, Hungary, the Bahamas, Germany, the United Kingdom, Romania, New Zealand, Portugal, Italy, Spain, Papua New Guinea, and Senegal.

Table 3 shows the material damage caused by natural disasters during the 2020-2025 period. This damage is caused in USD and in real terms. These numbers are sorted from largest to smallest.

Table 3. Real Amount of Material Damage Caused by Natural Disasters in the Period 2020-2025 (1,000 USD)

Material Damage from Natural Disasters		**Total number of natural disasters that caused material damage.**		**Material Damage from Natural Disasters**		**Total number of natural disasters that caused material damage.**	
USA	643.478.175	USA	131	Jamaica	1.008.000	Malaysia	3
China	112.417.692	Philippines	43	Nepal	562.197	Nepal	3
Germany	53.236.062	China	38	United Kingdom	526.656	Pakistan	3
Japan	48.376.764	Brazil	26	Portugal	520.000	El Salvador	2
India	45.922.371	Mexico	18	Ecuador	377.855	Haiti	2
Türkiye	37016026	India	16	Colombia	355.717	Jamaica	2
Brazil	31.550.194	Indonesia	15	Kenya	315.129	Kenya	2
Pakistan	17.907.734	Australia	14	El Salvador	284.870	Panama	2
Australia	17.900.762	Japan	14	Tonga	261.017	Tonga	2
Mexico	16.761.031	Canada	13	Panama	123.332	Belgium	1
Spain	16.646.264	Türkiye	10	Bolivia	112.120	Bolivia	1

Canada	15.044.227	Iran	9	Romania	103.023	Costa Rica	1
Italy	10.366.393	New Zealand	9	Madagascar	87.740	Mongolia	1
France	9.955.311	France	8	Papua New Guinea	60.000	Papua New Guinea	1
New Zealand	5.292.621	Spain	8	Fiji	55.487	Portugal	1
Chile	5.129.144	Chile	7	Senegal	21.817	Romania	1
Philippines	4.247.547	Greece	7	Mongolia	2.060	Senegal	1
South Africa	4.085.959	Colombia	6	Costa Rica	980	United Kingdom	1
Iran	3.743.296	Italy	6	Algeria	0	Algeria	0
Republic of Korea	2.681.952	South Africa	6	Bahamas	0	Bahamas	0
Belgium	2.315.306	Thailand	6	Honduras	0	Honduras	0
Haiti	2.307.868	Peru	5	Hungary	0	Hungary	0
Greece	2.232.044	Republic of Korea	5	Mozambique	0	Mozambique	0
Thailand	1.884.829	Ecuador	4	Paraguay	0	Paraguay	0
Malaysia	1.698.673	Fiji	4	Samoa	0	Samoa	0
Indonesia	1.346.399	Germany	4	Sri Lanka	0	Sri Lanka	0
Peru	1.270.851	Madagascar	3				

Source: The aggregated data presented in this table were organised by the authors based on data obtained from the EM-DAT database (https://public.emdat.be/data, Access Date: December 19, 2025).

As shown in Table 3, the countries where natural disasters caused the most material damage during the 2020-2025 period are: the USA, China, Germany, Japan, India, Turkey, Brazil, Pakistan, Australia, Mexico, Spain, and Canada. The countries with the highest total number of natural disasters causing material damage during the relevant period are: the USA, Philippines, China, Brazil, Mexico, India, Indonesia, Australia, Japan, Canada, and Turkey.

The countries where natural disasters caused no material damage and therefore no material damage occurred during the relevant period are: Sri Lanka, Samoa, Paraguay, Mozambique, Hungary, Honduras, the Bahamas, and Algeria.

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5. Methodology

This study investigates the impact of average material damage from natural disasters and Real Gross Domestic Product (RGDP) growth rate on general government gross debt. This study is a multidimensional study and differs from other studies because it covers a total of 12 periods and a total of 60 years, using data from 5 years in the period 1965-2024 and includes a total of 48 countries 34 developing and 14 developed. The reason for collecting 5 years of data in the study is that natural disasters do not occur every year, and when they do, they do not always cause material damage. China, Mongolia, Mozambique, Romania, and Tonga could not be included in the analysis due to missing data on gross government debt. Therefore, the analysis was conducted for 48 countries. The classification of countries was done using data from the International Monetary Fund (IMF)'s World Economic Outlook (WEO) database. The data of general government real gross debt was obtained from the IMF's official website. The data on the average value of GDP growth rate was obtained from the World Bank's official website. The data on the real amount of average damage caused by natural disasters was obtained from EM-DAT's official website. Stata 14 software was used for the analysis. The variables used in the analysis, their descriptions, and the sources from which they were obtained are given in Table 4.

Table 4. Variables Used in the Analysis, Their Descriptions, and Sources

Variables	Descriptions of Variables	Sources
GD	Real Gross Debt, General Government (Per cent of GDP) Average Value (total / 5)	International Monetary Fund (IMF)
GDP	Average Value of GDP Growth Rate (%) (total/5)	The World Bank
DAMAGE	The Real Amount of Average Damage Caused by Natural Disasters (US$1,000)	International Natural Disaster Database (EM-DAT)

As shown in Table 4, gross government debt is taken as the dependent variable and abbreviated as GD. RGDP growth rate is taken as one of the independent variables and abbreviated as GDP. DAMAGE, which is the abbreviation for total damage caused by natural disasters, is also taken as an independent variable. Descriptive statistics for the variables are given in Table 5.

Table 5. Descriptive Statistics

Variables	Mean Value	Standard Deviation	Minimum	Maximum	Number of Observations (N) / Number of Observed Groups
GD	53.010	36.272	1	247.367	576/48
LNGD	3.667	0. 967	0	5.511	
GDP	3.714	2.370	0.012	13.942	
LNGDP	1.048	0.891	-4.402	3.413	
DAMAGE	9.761.129	$4.01e^{7}$	1	$4.72e^{8}$	
LNDAMAGE	11.693	5.317	0	19.973	

Source: Authors' calculations

Table 5 shows a very large difference between the minimum and maximum values of both the dependent and independent variables. Therefore, the difference between the minimum and maximum values was reduced by taking the logarithm of all variables.

Econometric Method

Dynamic panel data models, unlike static panel data models, contain lagged values. Dynamic panel models are divided into two types: autoregressive panel data models and distributed lagged panel data models. In autoregressive panel data models, the lagged value(s) of the dependent variable are included as independent variables, while in distributed lagged panel data models, the lagged value(s) of the independent variable(s) are included as independent variables (Yerdelen Tatoğlu, 2020: 353; 364). In the model used in this study, since the first lag (β_t $LNGD_{t-1}$) of the dependent variable LNGD is significant, it is included in the model as an independent variable, and thus an autoregressive panel data model is established as follows:

$$LNGD_t = \alpha + \beta_1 LNGD_{t-1} + \delta_1 LNDAMAGE_t + \delta_2 LNGDP_t + u_t \quad (1)$$

In the Dynamic Panel Model, pre-tests include tests for the validity of the instruments, autocorrelation tests, and tests for cases where the time dimension (T) is small and the unit dimension (N) is large. These pre-tests were tested sequentially.

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Tests for Vehicle Selection (Over-Identification Restrictions)

To test whether the instrumental variables used in GMM estimation are valid, in other words, whether there are any over-definition constraints, the Arellano and Bond (1991) Sargan test and the difference Sargan test are performed. If the instruments used are exogenous, the error term is uncorrelated with the independent variables (Yerdelen Tatoğlu, 2023: 173). Table 6 shows the results of the Arellano and Bond (1991) Sargan test and the difference Sargan test.

Table 6. Results of the Over-Identification Restrictions Test

Over-identification Restrictions Tests		Chi_2	Probability Value (p)
Arellano ve Bond (1991) Sargan Testi		8.11	0.423
Difference Sargan Tests	Testing the externalities of the tools used in GMM	6.57	0.475
	Testing the externalities of the System GMM tools	1.54	0.214
	Testing the externality of vehicles without vehicle variables (IV)	6.01	0.538
	(IV) Testing the externality of the vehicles	2.10	0.147

Source: Authors' calculations

According to Arellano and Bond (1991), the Sargan test results in Table 6, the p-value is greater than 0.05, thus the hypothesis that "over-definition constraints apply" cannot be rejected. Therefore, over-definition constraints are valid. The variables are exogenous, and consequently, the residuals are not correlated with the dependent variable. The difference-Sargan test results also show that the instruments used in GMM and system GMM are exogenous, and the presence or absence of IVs does not affect the exogeneity of the instruments. Thus, it has been determined that all instruments used are exogenous.

Autocorrelation Test

Arellano and Bond (1991) proposed a test to examine autocorrelation in dynamic panel data models. For the GMM estimator to be effective, the absence of second-order autocorrelation $[E[\Delta u_{it} - \Delta u_{it-2}]]$ is important (Yerdelen Tatoğlu, 2023: 175). Table 7 shows the result of Arellano and Bond (1991)'s autocorrelation test.

Table 7. Autocorrelation Test Results

Arellano and Bond (1991) Autocorrelation Test	z-value	Probability Value (p)
Autocorrelation Test for AR(1) Process in First Differences	-2.97	0.003
Autocorrelation Test for AR(2) Process in First Differences	1.33	0.182

Source: Authors' calculations

According to the autocorrelation test results in Table 7, the hypothesis, which states "there is no autocorrelation," is rejected at the first order but accepted at the second order. Thus, it is concluded that there is autocorrelation at the first order but not at the second order.

The Time Dimension (T) is Small, and the Unit Dimension (N) is Large

The Two-Stage System GMM developed by Roodman (2006) is used in panels with a small-time dimension (T) and a large unit dimension (N). Since T is 12 periods and N is 48 countries, this criterion is also validated. After deciding that all criteria are suitable, it was deemed appropriate to use the Robust Two-Stage System GMM Estimator by Arellano and Bover/Blundell and Bond.

6. Findings

Arellano and Bover/Blundell and Bond's Two-Stage System GMM Estimator

FCI dynamics may be interpreted as changes in the financial conditions that are exogenous to the business cycle. In macroeconomic theory, these exogenous financial conditions should capture investors' preferences for liquidity, i.e. they reflect the changes in the LM curve. These variations are not induced directly by central banks' money supply shifts and may be considered endogenous for income. If investors' liquidity preferences upturn is triggered by exogenous shocks, it will be more difficult for businesses and households to obtain financing, so we assume that financial conditions are tightening. This translates into an increase in FCI and into the LM curve moving to the left. Arellano and Bover (1995) and Blundell and Bond (1998) proposed an efficient instrumental variable estimator using the "forward orthogonal deviations" or "orthogonal deviations" method due to the loss of data for some units with the first difference transformation. Instead of taking the difference between the current and previous periods, the difference of the average of the future values of a variable is taken, thus minimizing data loss due to first differences in unbalanced panel datasets. In this estimator, a two-system equation consisting of the original and transformed equations is established and estimated as a system. Therefore, this estimator is also called GMM. In this study, Arellano and Bover/Blundell and Bond's Two-Stage System GMM Estimator (Yerdelen Tatoğlu, 2023: 161, 163) was used. Table 8 presents the results of this estimator.

Table 8. Results of Arellano and Bover/Blundell and Bond's Robust Two-Stage System GMM Estimator

Dependent Variable: LNGD		
Independent Variables	**Coefficient**	**z statistic (p-value)**
$LNGD_{t-1}$ (First Lag of the $LNGD_t$ Variable)	1.054	17.48 (0.000)
LNDAMAGE	0.056	3.32 (0.001)
LNGDP	-0.605	-2.44 (0.015)

Source: Authors' calculations

Table 8 shows that a 1% increase in LNGDt-1, the first lag of the dependent variable (LNGDt), which is included in the model as an independent variable, increases LNGDt by approximately 1.05%. This result indicates that the general government debt from the previous period affected the public borrowing of this period.

A 1% increase in the LNDAMAGE variable leads to an approximately 0.06% increase in the LNGD variable. This result indicates that the increase in material damage due to natural disasters increases general government borrowing. A 1% increase in the LNGDP variable leads to an approximately 0.6% decrease in the LNGD variable. This result suggests that the increase in the GDP growth rate reduces general government borrowing.

Central government spending is crucial for the recovery of disaster-stricken areas following natural disasters (Coffman & Noy, 2011: 198; Barone & Mocetti, 2014: 60; DuPont and Noy, 2015: 789; Best & Burke, 2017: 1661). Given that a significant portion of natural disaster damage is covered by public spending, it is evident that these expenditures are financed through public borrowing.

The United Nations develops strategies and takes actions to reduce the risk of natural disasters, outlining these strategies in its strategic plans (Haklaj, 2023: 92-105). To minimize the damage caused by natural disasters, the public and private sectors, central and local governments, should work together to control the quality and quantity of materials used in workplaces and buildings constructed in disasterprone areas, from the construction phase to completion. At the same time, local governments should issue building permits after inspecting the areas where construction will take place.

7. Conclusions

The empirical findings of this study reveal that general government public debt is strongly affected by its lagged value during the period examined. The positive and statistically significant first lag of the debt variable indicates a clear continuity in public debt dynamics and shows that the debt stock can create lasting effects, especially after natural disaster shocks. This finding is consistent with the results of Cevik and Nanda (2020) and Koetsier (2017), which emphasize the decisive role of past debt levels in debt sustainability. However, it was found that the increase in material damage due to natural disasters significantly increases general government borrowing. The expansion of public spending in the post-disaster period, temporary decreases in tax revenues, and the fact that the financing needs of reconstruction activities are largely met through borrowing constitute the main transmission channels of this relationship. This result is consistent with the findings of Fan et al. (2021), Benali et al. (2018), and Lugay and James (2010), which reveal the increasing effect of natural disasters on public debt. In contrast, this study differs from Lis and Nickel (2010), who argue that the impact of disasters on budget balances is limited or temporary, and Loayza et al. (2012), who suggest that the debt effect is weak in some country groups. Furthermore, the study's findings reveal that the impact of natural disaster damage on real economic growth should not be assessed solely through the lens of destruction. Increased public spending in the post-disaster period, material and moral support provided by local governments and households, and reconstruction and infrastructure investments rapidly initiated following the search and rescue process stand out as important mechanisms supporting economic recovery. However, it can be argued that financial and technical support provided by international organizations such as UNESCO and the United Nations, as well as international aid, can play a complementary role in closing the post-disaster financing gap and accelerating the reconstruction process. Such external resources can partially alleviate pressure on public debt in the short term, while in the long term, they can indirectly contribute to economic growth through the restoration of production capacity.

From a policy perspective, the findings indicate that financial resilience to disasters should be strengthened not only through post-disaster responses but also through preventative policies before disasters. Regular inspections of the existing building stock and production facilities, ensuring that new construction meets disaster-resilient standards, and strengthening emergency infrastructure in high-risk areas are among the key policy tools that can reduce the long-term burden on public finances. In addition, increasing institutional capacity and strengthening public awareness of disasters through training and drills can play a complementary role in limiting both the financial and social costs of disasters.

While the findings of this study offer significant contributions, they also have some limitations. The analysis used average values of material damages from natural disasters, and heterogeneous effects between disaster types and severity levels could not be separated. Future studies could examine whether the effects on public debt and economic growth differ using indicators disaggregated based on disaster type and magnitude. Furthermore, analysing how debt dynamics differ between central and local governments could provide more detailed implications for policy design. Finally, the inclusion of factors such as international financing, insurance penetration, and institutional capacity in the model and analyses using micro-level datasets would contribute to a better understanding of the mechanisms shaping the post-disaster debt relationship.

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