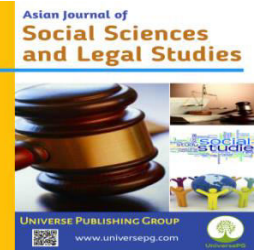




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A Modified Cobb-Douglas Analysis on the Relationship between Natural Disaster Fatalities and Economic Output

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Abstract

This study examines the resilience of macroeconomics in view of growing environmental degradation by estimating the effects of deaths due to natural disasters on economic growth. It criticizes previous literature for its regional focus and reliance on binary variables and suggests an improvement of the multivariate Cobb-Douglas model. The improved framework considers the traditional factor inputs - labor, capital, and energy - alongside an active policy governance dummy and a continuous disaster fatality variable reflecting national-level death percentages caused by natural disasters. This study analyses 44 countries using long time-series data from 1991 to 2023. It deals with econometric risks like structural multicollinearity, time-series overfitting, and residual autocorrelation through the use of ridge regression along with a robust block bootstrap resampling technique. Findings suggest that standard factor inputs tend to conform to neo-classical macroeconomics, acting as statistically significant factors behind positive marginal productivity. However, in case of 11 out of 44 countries, most of which are high-income, there were found to be statistically significant associations between natural disaster fatalities and macroeconomic resilience, demonstrating counter-intuitive positive coefficients. Meanwhile, the other 33 countries have shown no statistical significance. This research reveals a split in macroeconomic resilience between the 11 countries that appear to have been more successful in fast capital mobilization after disasters, thus supporting the Schumpeterian theory of “creative destruction”; and the other 33 countries appearing to be less effective in mobilizing capital, possible due to some systematic bottlenecks. Some among the 33 countries like Bangladesh appear to be able to return to their basic growth rate but seem to lack necessary tools to benefit from destruction to develop any further.

Keywords: Cobb-Douglas, Function, Output, Countries, Sustainability, Natural disaster, and Mobilization.

1. Introduction

With the rise in frequency and intensity of natural disaster occurrence owing to climate change, from burning landscapes to flooded economies, one of the

relevant questions for the 21st Century is whether the economic growth process is going to stay sustainable in light of continued escalation of environmental destruction. The amount of fatalities and economic

losses that occur each year due to natural disasters is measured in thousands of lives and billions of dollars respectively (Alimontia & Mariani, 2023; Yuryeva *et al.*, 2023).

In order to measure the impact of disaster mortality rate on economic production, this study purposefully uses the Cobb-Douglas production function because of its multivariate nature (Cobb and Douglas, 1928). This study employs an extended model of the Cobb-Douglas approach that takes into consideration the functional and institutional limitations. It employs a continuous disaster fatality variable in order to account for the death percentages from natural disasters. It also uses an active policy dummy rather than a passive government dummy in order to assess the impact of activist state frameworks and macroeconomic outcomes on the economy. Employing a rigorous estimation strategy across 44 countries from 1991 to 2023, the study uses ridge regression and robust block bootstrapping techniques in order to reduce the econometric risks inherent in long time series.

2. Review of Literature

The seminal paper by (Cobb and Douglas, 1928), although a revolutionary study on its own, only covered the effects of labor and capital on production. It was not until the 1970s that rising concerns over non-renewable resources led to energy being added as a third explanatory variable (Stiglitz, 1974; Solow, 1974). Many years later, (Cheng and Han, 2014) decided that Cobb-Douglas functions should do better to capture the multifaceted effects on production. They proposed a modified Cobb - Douglas production function model that takes into consideration exogenous non-continuous variables like governance systems, legal policies, and natural disasters. Most of the previous works of research that aimed at establishing the relationship between natural disasters and economic production using Cobb-Douglas production function have been confined to agricultural industries in certain regions.

The (Zhang *et al.*, 2020) study focused on analyzing the productivity of crops in agricultural sector in Daqing City in China and the (Entezari *et al.*, 2021) study examined the effects of climate change only in

the agricultural industry in Malaysia. More recently, however, the (Mahmud, 2024) study did conduct a more generalized comparison of how natural disasters fatalities affect GDP, but did so using the modified Cobb-Douglas production function developed by (Cheng and Han, 2014). That particular model assumes all exogenous variables to be the binary dummy variables.

Therefore, the (Mahmud, 2024) study used the same trick with the natural disaster occurrence, setting it up as a binary dummy variable equaling 1 if the number of fatalities caused by natural disasters in any country per year exceeded the arbitrarily defined threshold of 0.01%, and 0 if not. That way, however, the disaster variable lost its meaning completely. It lost almost all of its useful information, which reduced statistical power.

3. Methodology

The Cobb-Douglas function today serves as a vital part of economics and business studies due to its convenience and practicality. It can be applied in a wide range of disciplines, including economics, accounting and finance.

Model Specification

The initial Cobb-Douglas production function that was developed by (Cobb and Douglas, 1928) is given as below:

$$Y = AL^{\beta_1} K^{\beta_2} \dots \dots \dots (1)$$

In the equation above, L denotes labor input. K denotes capital input and Y denotes the output. β_1 and β_2 are the elasticities of labor and capital respectively. A denotes the level of technical progress or total factor productivity (TFP).

More than four decades later, due to growing concerns over non-renewable resources, (Stiglitz, 1974; Solow, 1974) added energy as a factor input to the original Cobb-Douglas function. The new function stood as follows:

$$Y = AL^{\beta_1} K^{\beta_2} E^{\beta_3} \dots \dots \dots (2)$$

E denotes energy input and β_3 represents output elasticity of energy.

Many decades later, (Cheng and Han, 2014) proposed a modified Cobb - Douglas production function which is expressed as:

$$Y = A X_1^{\beta_1} X_2^{\beta_2} \dots X_n^{\beta_n} e^{p_1 D_1 + p_2 D_2 + \dots + p_N D_N} \dots \dots \dots (3)$$

Where, $= \begin{cases} 1 \\ 0 \end{cases}$, Dummy Exogenous Variable

(Mahmud, 2024) used this modified model to recreate a new Cobb-Douglas production function that also includes natural disaster insistence and government as exogenous non-continuous variables. It is as follows:

$$Y_{it} = A_i L_{it}^{\beta_{1i}} K_{it}^{\beta_{2i}} E_{it}^{\beta_{3i}} e^{p_{1i} G_{it} + p_{2i} N_{it}} \dots \dots \dots (4)$$

Where, Y_{it} = Gross Domestic Product for country i in year t , A_i = Long-term Total Factor Productivity for country i , K_{it} = Gross Capital Formation for country i in year t , L_{it} = Total Labor Hours for country i in year t , E_{it} = Primary Energy Consumption for country i in year t , G_{it} = Governing Party Dummy for country i in year t , N_{it} = Natural Disaster Incidence Dummy for country i in year t

However, one major criticism of both the (Cheng and Han, 2014) study and the (Mahmud, 2024) study is that while they both address exogenous non-continuous variables, neither address the possibility of exogenous continuous variables. The (Mahmud, 2024) study assumed the natural disaster incidence dummy to be 1 for any country in any year in which deaths from natural disasters as a share of total deaths in that year in that country was at least a randomly assumed number of 0.01%. The choice of proxy for natural disaster incidence in that study was a convenient one as it helps reveal the impact of economic output from natural disaster not just from the ecological perspective but also a social perspective. However, due to the non-continuous nature of the proxy, it cannot be assumed to be binary.

Moreover, (Mahmud, 2024) also assumed the governing party dummy for any country in any year to be 1 whenever the political party that was in power for most of 2017 in that country was also in power for most of the that year. This dummy fails to take into

account actual party policy and its effects on a country's economic output.

Addressing these limitations, this study proposes a new model which is as follows:

$$Y_{it} = A_i L_{it}^{\beta_{1i}} K_{it}^{\beta_{2i}} E_{it}^{\beta_{3i}} e^{p_{1i} G_{it} + p_{2i} D_{it}} \dots \dots \dots (5)$$

Where G_{it} is a dummy reflecting the party policy of the ruling power in country i in year t and D_{it} is a continuous disaster fatality variable reflecting the percentage share of deaths from natural disasters as a share of total deaths in country i in year t . G_{it} is 1 if ruling party goals for country i for majority of time t include social transfers, public employment, or strategic intervention and 0 if otherwise.

Both sides of equation (iv) underwent log transformations in order to be converted into a linear form:

$$\ln Y_{it} = \ln A_i + \beta_{1i} \ln L_{it} + \beta_{2i} \ln K_{it} + \beta_{3i} \ln E_{it} + e^{p_{1i} G_{it} + p_{2i} D_{it} + \epsilon_{it}} \dots \dots \dots (6)$$

Unit-root tests (augmented Dickey-Fuller and Phillips-Perron) applied to each country's series also revealed non-stationary log-level variables for countries like Argentina. Disaster fatality (D_{it}) and government (G_{it}), however, were confirmed to be stationary, most likely due to their construction or the nature of their low-frequency variations. Rarely has deaths from disasters exceeded 0.1% of total deaths in any country at any given time. Differencing a binary variable or a variable with low variation would distort the interpretability of the results.

Thus, this study has adopted a partial first-difference transformation for all countries, which are as follows:

$$\Delta \ln Y_{it} = \beta_{1i} \Delta \ln L_{it} + \beta_{2i} \Delta \ln K_{it} + \beta_{3i} \Delta \ln E_{it} + e^{p_{1i} G_{it} + p_{2i} D_{it} + \epsilon_{it}} \dots \dots \dots (7)$$

The intercept $\ln A_i$ was dropped out under the assumption that there is no deterministic trend in the differenced dependent variable. Thus, for this study, L_{it} , K_{it} , E_{it} and G_{it} will serve as control variables while D_{it} will serve as the key variable.

Data

Data for this study was collected from various credible sources. 44 countries were chosen for the study as

necessary data from 1991 to 2023 was mostly available for those countries.

'Total Labor Hours' was calculated using the following formula:

$$\text{Total Labor Hours} = \text{Population aged 15-64} \times (1 - \text{Unemployment Rate}) \times \text{Working hours per year} \dots (5)$$

Data for the population aged 15-64 and working hours per year for each of the countries was obtained from the 'Our World in Data' website. Data for the unemployment rate was obtained from the 'Macro trends' website. Data for gross capital formation, primary energy consumption and the number of deaths from natural disasters as a share of total deaths were also collected from the 'Our World in Data' website.

Statistical Technique Specification

Research was done using the R programming language.

After first-differencing log-level data for all countries, this study continued to experience a few more problems.

Firstly, even datasets with no unit roots experienced first-differencing. Normally, that would lead to a negative moving-average component of order one (MA(1)) in the error terms for those datasets.

Secondly, there were only 33 years of data available for each country. Considering that there were 5 different independent variables, there was a significant risk of overfitting.

Thirdly, VIF values during multicollinearity tests were occasionally exceeding 5, suggesting highly correlated dependent variables. That could be due to a strong tendency of log-level variables to be correlated in growth rates.

This study solved the first two issues by utilizing block bootstrap with 500 replications. Block bootstrap tends to be robust to any finite-order autocorrelation. Thus, through block bootstrap, it is possible for the same transformation to data for all countries to ensure

cross-country consistency without compromising on research validity. Block bootstrap also solves issues related to heteroskedasticity if there are any.

Finally, to address the issue of multicollinearity, this study employed ridge regression (Hoerl & Kennard, 1970). The penalty parameter λ was selected for each country by 10-fold cross-validation, choosing the value that minimized the mean-squared prediction error for each country.

Ridge regression, however, does not provide closed-form standard errors. This issue was to be solved with the block bootstrap. That is why, the ridge estimator was computed on the original (non-pre-whitened) data because the subsequent bootstrap was intended to address any residual dependence.

For the bootstrap, the length of each block was chosen as follows:

$$b = [n^{1/3}] \dots (vii)$$

Where, n stands for the number of time periods.

For each bootstrap replication from a total of 500 replications, blocks consisting of consecutive observations were sampled with replacement while keeping their order intact in each individual block. Then, the bootstrapped sample was re-estimated with the help of the same procedure as ridge regression (including cross-validation to re-select λ). Coefficients were stored for each successful replication.

From the set of bootstrap estimates, bootstrapped standard errors for each country were calculated as the standard deviation of the replicated coefficients. Then, using the original point estimates from the full-sample ridge regression, the z-values and two-tailed p-values were derived to determine statistical significance.

4. Results and Discussion

The estimated factor exponents and coefficients for each of the 44 selected countries along with their combined returns to scale are shown in **Table 1**.

Table 1: Estimated figures for selected countries.

Countries	α ($\Delta \ln L$)	β ($\Delta \ln K$)	γ ($\Delta \ln E$)	$\alpha+\beta+\gamma$	D	G
Argentina	0.2830 (0.2142)	0.1363*** (0.0332)	0.5385*** (0.1424)	0.9578	0.1119 (0.5845)	0.0018 (0.0066)

Australia	0.7936*** (0.2092)	0.0895** (0.0411)	0.1847 (0.1504)	1.0679	0.5662** (0.2714)	0.0069** (0.003)
Austria	0.4584** (0.1908)	0.2388*** (0.0527)	0.1099 (0.081)	0.8071	0.2840* (0.1452)	0.0086*** (0.0033)
Bangladesh	0.2183 (0.389)	0.4171*** (0.0953)	0.0730** (0.0299)	0.7085	0.026 (0.0282)	0.0124* (0.0071)
Belgium	0.2344 (0.143)	0.1061** (0.0527)	0.0710* (0.0408)	0.4114	0.4868 (0.5979)	0.0129*** (0.0024)
Brazil	0.1796 (0.1344)	0.0723*** (0.0238)	0.5305*** (0.083)	0.7824	0.0349 (0.1404)	0.0067** (0.0034)
Canada	0.3449*** (0.1021)	0.1385*** (0.0279)	0.1820** (0.0811)	0.6654	0.6025** (0.2442)	0.0131*** (0.0022)
Chile	0.2862** (0.1256)	0.0966*** (0.0259)	0.3952*** (0.084)	0.778	0.0203 (0.0784)	0.0215*** (0.0052)
China	0.1087 (0.187)	0.1542 (0.1675)	0.202 (0.2234)	0.4649	0.0093 (0.4599)	0.0000 (0)
Colombia	0.2303** (0.1023)	0.1163*** (0.0264)	0.2708*** (0.0448)	0.6174	0.1004*** (0.0359)	0.0218*** (0.006)
Costa Rica	0.2301** (0.0946)	0.0740*** (0.0268)	0.2884*** (0.049)	0.5925	0.0422 (0.0648)	0.0225*** (0.0032)
Denmark	0.4457** (0.1942)	0.1293*** (0.0419)	0.0668** (0.0309)	0.6419	1.8327* (1.0623)	0.0106*** (0.0022)
Dominican Republic	0.4912** (0.2252)	0.1327*** (0.0453)	0.0817* (0.0432)	0.7055	-0.0174 (0.0538)	0.0303*** (0.01)
Finland	0.1542 (0.3879)	0.2091*** (0.0563)	0.1646*** (0.057)	0.528	1.0949 (0.8126)	0.0180*** (0.0062)
France	0.6231*** (0.1806)	0.1583*** (0.0504)	0.0695 (0.0591)	0.8509	1.1110*** (0.2076)	0.0130*** (0.0035)
Germany	0.2730 (0.2242)	0.2029*** (0.0358)	0.0991* (0.0596)	0.5749	0.6169** (0.2879)	0.0167*** (0.0032)
Greece	0.5010*** (0.186)	0.1092*** (0.033)	0.2197** (0.0888)	0.83	0.1567 (0.4495)	0.0086 (0.0087)
Hungary	0.0717 (0.2074)	0.1145* (0.0595)	0.1514 (0.0966)	0.3377	0.8767 (1.0399)	0.0123** (0.006)
Iceland	0.0478 (0.2856)	0.0061 (0.0364)	0.0199 (0.1169)	0.0738	0 (0.1178)	0.0013 (0.0061)
India	0.9174* (0.4731)	0.0481 (0.0356)	0.6686*** (0.2226)	1.6342	0.0603 (0.0692)	-0.0019 (0.005)
Indonesia	0.0823 (0.2925)	0.0221 (0.13)	0.0402 (0.195)	0.1446	0.0002 (0.0745)	0.0026 (0.0065)
Ireland	0.4806* (0.2736)	0.0386 (0.0703)	0.2598* (0.1566)	0.7791	3.1439** (1.5846)	0.0346*** (0.0125)
Italy	0.4076** (0.1728)	0.1331*** (0.0376)	0.1329 (0.1102)	0.6736	0.0143 (0.2072)	0.0101*** (0.0029)
Japan	-0.3284* (0.1911)	0.2521*** (0.0906)	0.3315*** (0.1187)	0.2551	0 (0.0769)	0.0063 (0.004)
Luxembourg	0.5880* (0.3164)	0.0955 (0.067)	0.0275 (0.0813)	0.711	0.6849* (0.392)	0.0000 (0)
Malaysia	0.5686* (0.3221)	0.0708** (0.031)	0.3123*** (0.0943)	0.9517	0.1066 (0.1204)	0.0143 (0.0113)
Mexico	0.4884*** (0.1225)	0.1745*** (0.0507)	0.2270** (0.1072)	0.8898	0.079 (0.0906)	-0.0001 (0.0033)
Netherlands	0.8403*** (0.2389)	0.1137*** (0.0405)	-0.0701 (0.0989)	0.8839	1.3493* (0.7152)	0.0227*** (0.0059)
New Zealand	0.2124 (0.1782)	0.0401 (0.0632)	0.0499 (0.0949)	0.3024	0.0062 (0.1694)	0.0052 (0.0055)
Norway	0.4108	0.0166	0.0203	0.4477	0.2804	0.0109*

	(0.3334)	(0.0393)	(0.0323)		(0.2655)	(0.0063)
Pakistan	0.0646 (0.2906)	0.0085 (0.0815)	0.0141 (0.0967)	0.0871	0.0003 (0.0709)	0.0008 (0.0066)
Peru	0.7954*** (0.2469)	0.1032*** (0.0229)	0.2677*** (0.0801)	1.1663	0.0269 (0.0329)	0.0100* (0.0058)
Philippines	0.2769 (0.2098)	0.0460* (0.0240)	0.2208** (0.1069)	0.5436	0.0107 (0.0237)	0.0138* (0.0077)
Portugal	0.6746*** (0.2407)	0.0700* (0.0403)	0.0728 (0.0460)	0.8174	0.1950 (0.3307)	0.0148*** (0.0036)
Singapore	0.7367*** (0.2714)	0.0757 (0.0514)	0.2801** (0.1363)	1.0925	0.0000 (0.0000)	0.0000 (0.0000)
South Korea	0.1891 (0.1655)	0.1266*** (0.0388)	0.5927*** (0.0639)	0.9083	0.1711 (0.1056)	0.0183*** (0.0034)
Spain	0.4178*** (0.1173)	0.0693 (0.0467)	0.3292*** (0.0947)	0.8163	0.1572 (0.4803)	0.0125*** (0.0045)
Sweden	0.4915*** (0.1843)	0.1170** (0.0474)	0.0591 (0.0465)	0.6677	0.3406 (0.5613)	0.0172*** (0.0028)
Switzerland	0.4722* (0.2504)	0.0078 (0.0448)	0.0409 (0.0342)	0.5209	0.6139*** (0.1424)	0.0029 (0.0048)
Thailand	0.4584*** (0.1622)	0.0682*** (0.0235)	0.5051*** (0.1380)	1.0317	-0.0058 (0.0712)	0.0181*** (0.0059)
Turkey	0.3608* (0.2057)	0.1411** (0.0575)	0.4579*** (0.1662)	0.9597	0.0038 (0.0280)	0.0002 (0.0080)
United Kingdom	0.6086** (0.2643)	0.2446*** (0.0583)	0.0406 (0.0460)	0.8937	-0.6034 (0.4152)	0.0169*** (0.0031)
United States	0.0931 (0.1343)	0.0353 (0.1028)	0.0501 (0.0722)	0.1785	0.0428 (0.5109)	0.0050 (0.0053)
Uruguay	0.3960 (0.2757)	0.1234* (0.0675)	0.0993* (0.0508)	0.6187	0.2199 (0.5686)	0.0256*** (0.0044)

***, **, * represent 1%, 5% and 10% significance levels respectively. The brackets are bootstrapped standard errors.

Interpretations of factor exponents and combined returns to scale

27 out of 44 countries studied had significant labor exponents; 12 were significant at the 1% level, 8 at the 5% level, and 7 at the 10% level. 17 countries showed no significant results. Most countries had positive labor exponents, except Japan, which had a statistically significant negative coefficient at the 10% level. These suggest that for most countries, labor demonstrates consistency with the neoclassical prediction of positive marginal productivity of labor (Felderer & Homburg, 1992). India demonstrated the highest labor exponent (0.9174), followed by the Netherlands (0.8403), Peru (0.7954) and Australia (0.7936). These outcomes all appear to be influenced by two common factors: the prominence of labor-intensive informal sectors and the skill levels of the labor force (Mehrotra, 2019; Amodio *et al.*, 2024; Mandal & Taku, 2025). Emerging economies, while dominated by informal sectors, often feature less skilled workers than advanced economies, affecting

the overall labor exponent determined by these opposing forces. The final exponents are ultimately determined by which of these forces dominates within a given economy. Finally, Japan's negative labor coefficient may be attributed to aging or technological changes (Asao *et al.*, 2025).

Meanwhile, capital is found to significantly boost economic growth in the 44 countries. Out of those, 31 countries have meaningful capital effects, with 22 at the 1% level and 5 at the 5% level. Only 13 countries show little or no capital impact. The magnitude of capital elasticity varies widely across the countries. Bangladesh exhibits the highest capital exponent (0.4171), followed by Japan (0.2521). All their exponents are statistically significant at the 1% level. While Japan's high capital exponent may be explained by its high value services and technology-intensive sectors, Bangladesh's case may be more perplexing given its overwhelmingly dominant informal sector (Fukao *et al.*, 2020; Islam *et al.*, 2022). One possible

explanation for Bangladesh might be the country's rapid industrialization process helping it generate strong capital returns from scarce capital (Rahman *et al.*, 2021). Conversely, Iceland showed the lowest capital exponent (0.0061) followed by Switzerland (0.0078). For those countries, low capital exponents may indicate possible reliance on other non-capital growth factors. Insignificant coefficients in 13 countries point to structural issues in developing economies and varying importance of intangible assets in advanced ones (Acemoglu *et al.*, 2005; Corrado *et al.*, 2009).

Energy significantly influences economic output, with 26 countries demonstrating notable energy exponents: 14 at the 1% level, 7 at the 5% level, and 5 at the 10% level. In contrast, 18 countries, including advanced economies, exhibit non-significant energy coefficients. The highest energy elasticities are found in nations with substantial industrial bases or energy-intensive exports, such as India (0.6686), South Korea (0.5927), Argentina (0.5385), Brazil (0.5305), and Thailand (0.5051), indicating that a 1% increase in primary energy consumption correlates with a 0.5–0.67% GDP growth. This underscores the importance of energy as an input in production (Stern, 2011). On the other hand, developed countries have very low or insignificant energy exponents implying a capability to separate GDP growth from energy use through technological progress, structural economic changes and robust policies (Abbas, 2025). The Netherlands is one of the countries with a negative but insignificant energy coefficient. There is no country with a significantly negative energy exponent.

Summing the labour, capital, and energy exponents ($\alpha + \beta + \gamma$) reveals that most countries have returns to scale below 1, indicating short-term decreasing returns. Notably, only five countries - Australia, India, Peru, Singapore and Thailand-exceed 1.00, indicating increasing returns. All five were found to have high labor and energy exponents. Conversely, Iceland, Pakistan, and Indonesia show very low elasticities, suggesting output may not be fully captured by traditional inputs, possibly due to omitted variables or measurement errors (Mankiw *et al.*, 1992). The prevalence of decreasing returns, especially, in the

short run, is not necessarily indicative of policy failure, as it may reflect periods of high-capacity utilisation between 1991 and 2023 where additional inputs yield diminishing returns (Burnside *et al.*, 1995).

Interpretations of the 'Disaster' variable

Overall significance pattern reveals that out of 44 countries, only 11 showed a statistically significant coefficient for the disaster variable. Among these, 4 were significant at the 10% level (Austria, Denmark, Luxembourg and the Netherlands), 4 at the 5% level (Australia, Canada, Germany and Ireland), and 3 at the 1% level (Colombia, France and Switzerland). The remaining 33 countries display no statistically discernible relationship between disaster fatality share and economic growth. Interestingly, all statistically significant disaster coefficients are positive. The Dominican Republic, United Kingdom, and Thailand have negative results, but they are not statistically significant. In relation to the potential of the world's climate compromised future, this contrast represents a critical divide when it comes to macroeconomic resilience and adaptability.

All the significant positive associations appear counter-intuitive at first glance. One might expect higher disaster fatalities to reduce economic output through destruction of human capital, disruption of supply chains, and diversion of public funds toward relief and reconstruction. However, a growing body of research offers a few explanations for a potential positive coefficient in a differenced growth model:

- Creative destruction and capital renewal: In those 11 countries, catastrophic events act as grim but powerful catalysts for modernization. Major disasters dismantle aging, inefficient, and obsolete capital stock. This Schumpeterian "creative destruction" process can temporarily boost measured GDP growth in the years following a disaster (Schumpeter, 1942).
- Reconstruction-led demand surge: Following a disaster, government and private spending on reconstruction can stimulate aggregate demand, leading to multiplier effects that raise GDP above its pre-disaster trend (Hallegatte & Dumas, 2009). The large positive coefficients for Ireland (3.14),

Denmark (1.83), and Netherlands (1.35) are consistent with this interpretation, as these are high-income countries with robust institutional capacity to mobilise reconstruction resources quickly.

In contrast, the 33 countries with statistically insignificant disaster coefficients appear to present a less optimal scenario for a world facing increasing climate volatility.

Firstly, the lack of a statistically significant growth response signals an inability to promptly mobilize new, improved capital to replace what has been lost.

Secondly, for emerging economies like Bangladesh, Pakistan and the Philippines, this reflects less effective institutions and severe capital constraints (Khan *et al.*, 2023). This is especially astonishing for Bangladesh, given that the country is normally seen as a textbook example of a disaster-resilient nation due to its capacity to minimize mass casualties (Zaman *et al.*, 2022). This study's statistically insignificant coefficient proves that Bangladesh merely rebounds back to its baseline but lacks the institutional mechanism to convert its devastations into forward-leaping economic transformations.

This study's use of a continuous fatality share variable represents a clear advancement over the (Mahmud, 2024) study, that forewent statistical power and information by dichotomising disaster incidence at an arbitrary 0.01% threshold. That study found very few significant disaster effects; the current analysis, by preserving the continuous nature of the variable, identifies a meaningful set of countries (11 out of 44) where disaster fatalities do relate to growth, albeit in a positive direction. This underscores the importance of functional form and measurement in disaster-economics research.

Under no circumstance, however, should the positive disaster coefficients be misinterpreted as "disasters are good for growth." Rather, they indicate that in high-income countries with strong reconstruction institutions, the post-disaster rebound may more than offset the immediate output loss, resulting in a net positive growth anomaly in the years following a catastrophic event. For most emerging countries (e.g.,

Bangladesh, Indonesia, Pakistan, Philippines), the coefficients are not significantly different from zero - suggesting that disasters there do not trigger the same reconstruction-led growth surge, possibly because of less effective institutions (Toya & Skidmore, 2007; Friedman, 1962; Felbermayr & Gröschl, 2014).

Interpretations of the 'Government' variable

Although the 'government' variable is a control variable and not the key variable of interest of this study, some insights are going to be provided on the latter variable. The government dummy (G) equals 1 when the ruling party's policy orientation of the major part of the year t includes active social transfers, public employment programmes, or strategic industrial intervention, and 0 otherwise. The measurement of the activist approach of the government instead of simple partisan identification. Out of 44 countries, only 28 show statistically significant government coefficients (21 at the 1% level, 3 at the 5% level and 4 at the 10% level). All of the coefficients are positive, ranging from 0.0067 (Brazil) to 0.0346 (Ireland). This indicates that, on average, years when interventionist government was in power had a modestly higher GDP growth - usually within 0.5 to 3.5 percentage points using the semi-log form of equation (5).

Positive coefficient for G is justified in the context of Keynesian and developmental state theories, where the activation of fiscal policies, public employment, and strategic industrial policies can help to stabilise the demand and boost up the growth, especially during recessions (Rodrik, 2004; Mazzucato, 2013). On the other hand, there are several countries such as India, Mexico, Turkey and Pakistan for which the government coefficient is insignificant or close to zero, implying that in such situations, the ruling party's political orientation does not matter for growth. It may be the result of policy paralysis, poor implementation capabilities or countervailing forces (Andrews *et al.*, 2017). Notably, there is no negative government coefficient among 44 countries which is contrary to strong neoliberal claims that any activist government is harmful to growth (Muna *et al.*, 2023).

5. Conclusion

This paper addresses fundamental shortcomings in the existing disaster economy literature by replacing a

binary disaster fatality variable with a continuous one in an amended multi-variate Cobb-Douglas function. Through application of Ridge regression and the use of block bootstrap method, this research easily overcomes typical econometric constraints like structural multicollinearity, short time-series overfitting, and residual autocorrelation within 44 distinct nations. In the majority of the economies studied, labor, capital, and energy conform strictly to the tenets of neoclassical macroeconomics, performing mostly as statistically significant factors for positive marginal productivities. Examination of the correlation between natural disaster fatalities and economic production showed that 11 countries, mostly high income, demonstrated a statistically significant positive coefficient. This empirical evidence supports the theories of Schumpeterian "creative destruction" and demand increases due to reconstruction. With the statistically significant positive disaster coefficients, the economies have proved that it is possible to utilize the disasters to get rid of outdated infrastructure and deploy very advanced capital quickly, resulting into net positive growth anomalies. Conversely, the other 33 countries had coefficients that are not statistically different from zero. Those countries might not have the capability of mobilizing and introducing highly advanced capital into the affected areas as effectively as the 11 following a disaster. Those countries have bottlenecks that prevent them from converting destruction into modernization. Finally, statistically significant positive coefficients of the governance dummy were identified in 28 countries. Thus, it seems that the economies fit into Keynesian and developmental state theories rather than the neoliberal theory that state government interventions are always unproductive.

6. Ethical Clearance

No human and animals were involved and no private data were used. Thus, no ethical approval was needed.

7. Author Contributions

A.M.: Conceptualization of the study, collection and analysis the data, composition and writing of the manuscript's initial draft and contribution to proof-reading. M.A.M: Contribution to both data collection and proofreading.

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9. Conflicts of Interest

The authors have declared no potential conflicts of interest with respect to their research work.

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